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"TAXONOMY, BIOLOGY AND ALFALFA POLLINATING POTENTIAL OF CANADIAN LEAF-CUTTER BEES--GENUS MEGACHILE LATREILLE (HYMENOPTERA: MEGACHILIDAE)"

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FACULTY ADVISOR: PROFESSOR D. K. McE. KEVAN

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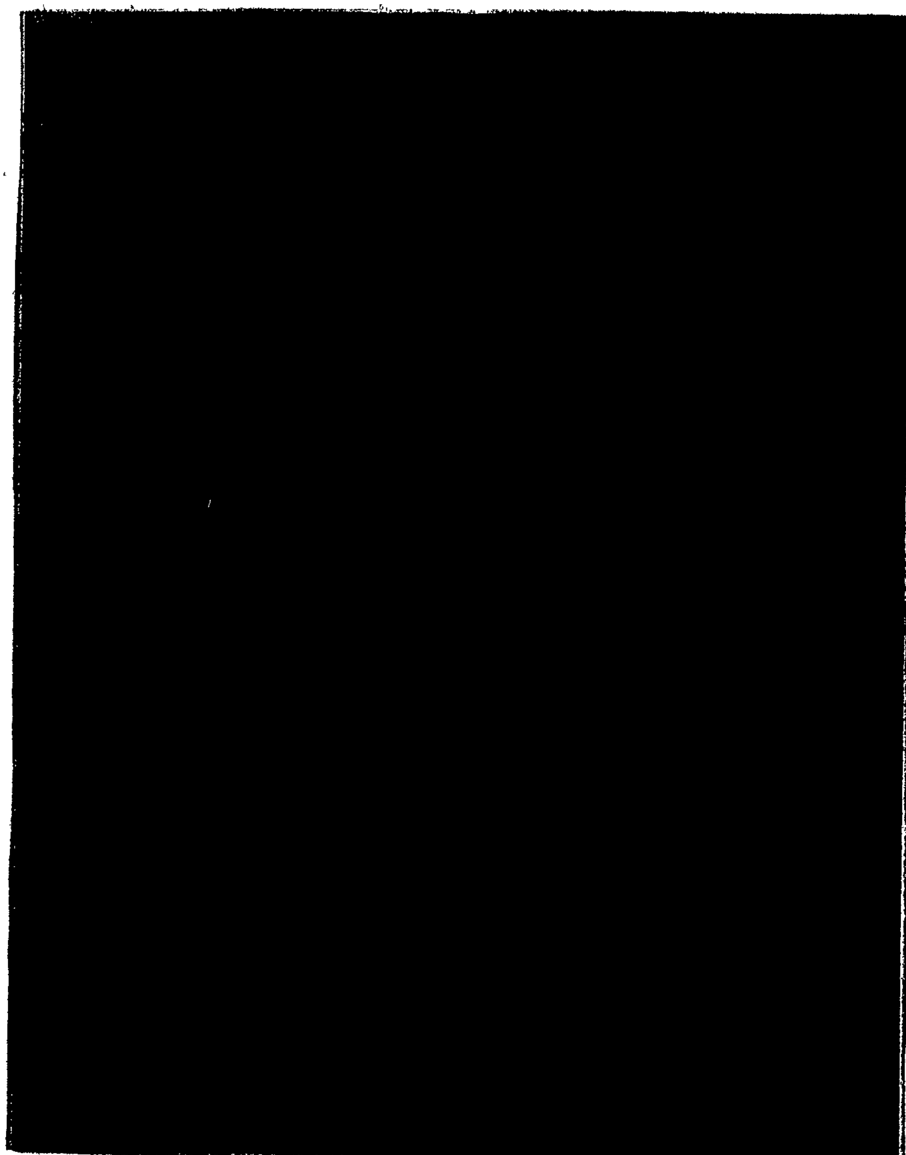

Fig. 1. *Megachile frigida* tripping alfalfa.

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ABSTRACT

The importance of Leaf-cutter Bees in Alfalfa seed production is examined, in view of the severe (87%) decline in yield, coupled with the sharp (809%) increase in the price of seed. Twenty-eight species of Leaf-cutter Bees present in Canada are investigated as possible pollinators of Alfalfa. The distinctive life styles, morphology and the attributes that may have given rise to the development of specialized structural modifications are examined; keys are formulated, diagnostic and distinctive characters are described and illustrated. Species distribution, flowers visited, biology, insect enemies and the alfalfa pollinating potential of each species are given and discussed. Keys to distinguish the parasites and predators, together with a brief account of the means by which the major groups destroy Leaf-cutter Bees, are presented.

RESUME

L'importance des abeilles coupeuses de feuilles, dans la production de semence de luzerne, est examinée en vue de la diminution marquée (87%) de son rendement accompagnée de la hausse gigantesque (809%) du prix de la semence de luzerne. Cet ouvrage enquête sur vingt-huit espèces d'abeilles coupeuses de feuilles que l'on retrouve au Canada comme agents possibles de pollinisation de la luzerne. Il examine les différents modes de vie, la morphologie particulière et les attributs qui peuvent avoir engendré des modifications structurelles spécialisées. De plus il formule des clefs, décrit et illustre des caractéristiques distinctives et diagnostiques. La distribution géographique des espèces, les fleurs butinées, la biologie, les insectes ennemis et les possibilités de pollinisation de la luzerne sont énumérés et traités par espèce. Des clefs permettant de classifier les parasites et les prédateurs ainsi qu'un court historique des moyens par lesquels les principaux groupes détruisent des abeilles coupeuses de feuilles sont présentées.

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"TAXONOMY, BIOLOGY AND ALFALFA POLLINATING POTENTIAL OF CANADIAN LEAF-CUTTER BEES--GENUS MEGACHILE LATREILLE 1802 (HYMENOPTERA: MEGACHILIDAE)"

I. INTRODUCTION

The progressive shift to larger, more mechanical farms has gradually wiped out peripheral boundaries and hedges, which served as nesting sites for native bees, to form uniformly large fields. The drift to modernized farming with larger, more intensely cultivated fields, more effective chemical control of weeds and insects, has resulted not in greater but in greatly diminished yields of alfalfa seed, both in North America and around the world.

Long before recorded time, the vigorous, rapid and competitive growing ability of alfalfa was progressively selected and imprinted upon the genetic code. The floral structure with its intricately co-ordinated locking and tripping mechanisms, to achieve maximal heterogeneity, was gradually devised and perfected. Physiological and structural processes of attracting pollinators and the coevolution of structures mutually beneficial to both, have contributed to preferences, specialized structures and the obligatory dependence of alfalfa upon its pollinators.

The destruction of habitats and economically expedient importation and production of alfalfa to meet the growing human demand for beef and dairy products, without regard for the inherent dependence of alfalfa upon its contingent of pollinators, have and will continue to generate an acute shortage of alfalfa seed around the world unless more effective measures are set in place to stem the tide.

In North America, temporary relief to alfalfa pollinating inadequacy was gained through an accidentally introduced pollinator -- Megachile rotundata -- which farmers observed abounded in relatively large numbers, effectively pollinating alfalfa and nesting in cracks or nail holes in old lumber. Elaborate nesting devices were soon manufactured on a commercial scale and the accidentally introduced pollinator was soon propagated across vast alfalfa growing regions in North America.

Investigations conducted eighteen years ago revealed that, in spite of relatively large local populations of M. rotundata, no predators were observed to devour this pollinator (Stephen and Torchio, 1961). Currently, over thirty parasites and predators, which have become adapted to preying upon the introduced pollinator, impose a mortality of over 75%. Emergence of additional threats, such as chalk brood disease, undermine further the well-being of the single accidentally introduced pollinator and inadvertently the economic stability of the alfalfa and livestock industry, not only in Canada but also in the United States.

In this paper, the native Canadian leaf-cutter bees (which are most efficient at pollinating alfalfa) are investigated. Through a study of Mitchell's work on Nearctic _Megachile_ (1934 to 1937) and _Megachile_ of eastern United States (1962), the taxonomy of the genus _Megachile_, its 10 subgenera and 28 species occurring in Canada are described and keyed. An endeavour is made to define, assemble, and engage structural differences which will most clearly differentiate and promote recognition of each species.

Under the heading "DISTRIBUTION", the general north to south and east to west distribution in North America of each species of Canadian leaf-cutter bees is presented. The particular place, date and flower (when listed) on which each specimen was collected, together with a map plotting their distribution in Canada, are provided.

Location and dates are compiled from an examination of the specimens in the Canadian National Collection, or specimens borrowed from Universities or Research Stations across Canada (p. xix). Some of the specimens had been examined previously and are referred to by Mitchell (1934 to 1937), and Buckell (1950) who published a record of specimens from British Columbia.

Under "FLOWERS VISITED" the scientific name of the flower, which a specific leaf-cutter bee species has been observed to visit, is entered in alphabetical order; the common name is given in brackets. A letter or letters indicating the source of information follows each entry. The letters used to indicate sources are as follows: (H) Hobbs; (L) Label associated with specimen; (M) Mitchell; (Me) Medler; (ML) Medler and Lussenhop; (PB) Peck and Bolton; (P) Pengelly. Only genera or species of flowers, upon which the bee may forage, occurring in regions where the bee is also present, are listed.

Consideration is given under "BIOLOGY" to structural deviations of the bees and how these deviations enable the group or species to carry out its particular life-style.

Biological information is derived from biologists and naturalists who recorded their observations in various publications extending over nearly three-quarters of a century.

Under "PARASITES AND PREDATORS", destroyers which have been observed to prey upon various species of leaf-cutter bees are cited. A key to distinguish the pests, together with a brief account of their behaviour, is given.

Finally, under "ALFALFA POLLINATING POTENTIAL", consideration is given to nesting habits: the more promising species, nesting in plants above ground, which might be readily transferred to alfalfa fields requiring pollination, and the less adaptable species, excavating and nesting in underground burrows; leaves used in cell construction; population density; pollen preferences; species distribution and synchronization of adult flight period with the opportune alfalfa flowering time frame, which will permit the seed to develop and mature before fall frost.

II. ECONOMIC IMPORTANCE OF LEAF-CUTTER BEES

Practical and scientific evidence prove that inadequate pollination is the principal limiting factor to the production of alfalfa seed (Stephen, 1955; Kozin, 1972; Torchio and Parker, 1975; and others). Leaf-cutter bees are the most efficient pollinators of alfalfa; however, their populations are too low to provide profitable seed set. Honey-bees which are commonly used for pollinating crops are ineffective and uneconomic pollinators of alfalfa, particularly in the northern regions of North America (Hobbs and Lilly, 1955; Stephen, 1955; Parker and Torchio, 1975; and others).

A half a century ago, when alfalfa was produced on small fields surrounded by native vegetation, with undisturbed habitats to sustain wild bees, highly profitable yields of up to 1,100 kg per hectare were reported. Measures to increase production by expanding field size; by intensifying cultivation and by applying insecticides to control insect pests, brought about adverse results. Yields of alfalfa seed dropped to unprofitable yields of 85 kg per hectare (Peck and Bolton, 1946; Pengelly, 1953; Stephen, 1955).

Perhaps because alfalfa has developed such an intricate floral structure to ensure self-sterility, it may have achieved, as a result of it, a level of heterogeneity and hybrid vigour that enables alfalfa to be the fastest growing, high yielding forage crop, which not only produces high protein hay, but also enriches the soil in which it grows.

Alfalfa is a herbaceous perennial which grows from a tiny hard-coated seed. It develops rather slowly the first year, permitting a companion crop or competitive weeds to surpass its growth. During the second and following years, after a deep and extensive root system develops, the growth of alfalfa surpasses and smothers competing weeds.

A third-year stand of alfalfa, grown in the Central Experimental Farm in Ottawa, was observed to have produced plants with up to 60 stems, one metre in height, by June 13, 1978. Alfalfa roots have been found to penetrate the soil to depths of 7 metres (Heinrichs, 1968). The roots bear nodules which contain nitrogen fixing bacteria (Rhizobia) that provide the plant with nitrogen, one of the critical growth elements commonly lacking in the soil. In field tests conducted at Guelph, Ontario, McLaughlin (1978) states that alfalfa outyields legumes such as red clover and birds-foot trefoil; produces more protein and digestible nutrients than grasses, and is strongly recommended for dairy cattle.

The use of alfalfa will likely continue to expand for the following reasons:

1. Grains currently used to supplement hay in livestock feeding will likely be used for human food to meet growing nutritional requirements; while rich livestock feed will likely be obtained from such forage crops as alfalfa.

2. With the development of technology to dehydrate and compact alfalfa into small pellets, it is now possible economically to transport alfalfa internationally. Accordingly, the demand for alfalfa pellets is rapidly growing in such places as Hawaii and Japan which have a high human population but do not have enough pasture land to feed their poultry, beef and dairy herds. Iran recently made an enquiry to purchase 10,000 tons of alfalfa from North America (Canadian Export Association Review and Digest Bulletin, July 1978).

3. As the solids become more depleted and price benefits from growing high priced crops diminish, more consideration will inevitably be given to incorporating soil improvement crops such as alfalfa in the crop rotation program. Farmers

in the Outlook irrigation area of Saskatchewan report that after growing alfalfa, one or two grain crops can be produced with a minimum amount of fertilizer and without having to use herbicides to kill weeds (Lyster, 1978).

In addition to being the principal pollinators of alfalfa, leaf-cutter bees also supplement pollination of such economic crops as blueberry, sainfoin, vetch, alsike, sweet clover, sunflower and rape.

The use of wild bees to supplement pollination of crops which are effectively pollinated by honey bees is recommended by apiculturists (Free, 1970; McGregor, 1976), since there is a progressive decrease in both the amount of honey produced and pollinating benefit from each additional hive, as increasing numbers of honey-bees seek out diminishing numbers of unfertilized flowers.

There may be other intrinsic benefits from large populations of wild bees, such as maintenance of natural balances. Cross-pollinated herbs and shrubs produce fruits and berries which build up the migratory energy reserves of birds during the autumn. Large bird populations devour enormous numbers of insect pests, particularly throughout the rapid growing period of young birds during spring and summer. Thus, indirectly, leaf-cutter bees might serve to subdue large populations of insect pests.

1. Declining Alfalfa Seed Production despite growing Demand and increasing Price

Despite strong demand and good prospects for increased use of alfalfa seed, Canadian production has progressively declined to far below seed requirements. Currently, Canada produces less than half the alfalfa seed it uses, and the cost of seed to the consumer since 1960 has risen by over nine times (See Table I, p.11)

The cost of seed to plant 1 ha of alfalfa at average rate (10-20 lb. per acre, McGregor, 1976) has risen from \$8.25 in 1960, to \$75.00 in 1979, an expenditure which could be recovered only under optimal growing conditions. With increasing numbers of parasites, predators and diseases arising to prey upon the domesticated leaf-cutter bee, prospects for improved seed production are diminishing

2. Use of Honey Bees for Pollination of Alfalfa

For reasons which are not understood, about 50% of the honey bees in southern California and Arizona collect pollen

TABLE I

ECONOMICS OF ALFALFA IN CANADA 1948-1976[a]

	1948 (x 000kg)	1958 (x 000kg)	1968 (x000kg)	1976[b] (x000kg)
Production	9,079	1,623	854	1,218
Consumption	656	3,400	2,966	3,848
Imports	0[c]	2,397	1,460	2,428
Exports	9,051	1,880	127	233

[a] Calculated from data taken from Plant Products Division, Department of Agriculture, Ottawa.

[b] Last year for which figures are currently available

[c] No imports 1944-1950

The following may be noted:

Decrease in production of seed during the past 30 years....................87%

Decrease in exports....................96%

Increase in consumption....................487%

Increase in imports from 0 kg 1944-1950 to 2,428,000 kg 1976

Increase in price to consumer from 55¢/kg 1960 to $5.00/kg 1978....................809%

and 2-3% trip alfalfa flowers; in Canada, none collect pollen and less than 0.2% (2 bees out of 1,000) trip alfalfa (Torchio and Parker, 1975). Pollen collecting and tripping rates by honey-bees decline progressively in more northern alfalfa growing regions. When a colony of honey bees was forced to forage upon alfalfa in Manitoba, the acquisition of pollen fell off sharply and the strength of the colony progressively diminished (Stephen, 1955). On the other hand, even with 5 colonies per 0.4 ha, unprofitable yields of 64.4 and 72.5 kg per ha were produced in two test plots situated in large fields where the honey bees could not be attracted to other flowering plants. Hobbs and Lilly (1955) stated that honey bees cannot be conditioned to gather pollen from alfalfa, even by caging and compelling them to do so, as was attempted in Alberta. They concluded that beyond accidental tripping, honey bees cannot be used to pollinate alfalfa, in order to produce profitable yields of seed (Figs. 2, 3).

Temperature, humidity, rate of evaporation and plant transpiration affect the volume and concentration of nectar produced which in turn influences the alfalfa flower's attractiveness to honey bees. Environmental factors also influence osmotic and the turgal pressure exerted by the

Opposite p. 13

Alfalfa Raceme

Fig. 2. Unfertilized and aborted ovules.

Fig. 3. Cross-pollinated raceme with curled seed pods.

staminal column to tear apart the connate keel petals and trip the alfalfa florets more readily (intensified sunlight, focused by means of a magnifying glass, tends to trip the alfalfa flower). It appears that honey bees can set economic seed yields in the arid areas of Arizona and southern California, which are under irrigation (Stephen, 1955).

Whatever the explanation is for the tripping or non-tripping of the florets, economic reality asserts itself in that honey bees pollinate alfalfa in southern California to the extent that most of the alfalfa seed imported into Canada is produced in southern California. Some alfalfa seed is also imported from Washington and Oregon and occasionally from Argentina. Alfalfa seed production in Washington and Oregon is, however, dependent upon pollination by the accidentally introduced alfalfa leaf-cutter bee Megachile rotundata whose populations are currently being depressed by rapidly increasing parasites, predators and diseases. When M. rotundata was first introduced to the states of Oregon and Washington across the Rocky Mountains, Stephen and Torchio (1961) investigated and found that despite high population densities it had no imminent enemies. Six years later, Eves and Johansen (1967) found 30 species of insect enemies preying upon M. rotundata, with up to 78.5% mortality in 1971 (Torchio, 1972). Consequently, prospects of continued alfalfa seed production in those states are declining.

3. Selecting a Compatible Alfalfa Pollinator - Coevolution

Selection of bees for the pollination of alfalfa should not only take into account the floral structure, pollinating mechanisms, colour, odour, and proportion of nectar/pollen produced, but also the range of plant species which will develop pollen grains that a particular growing bee larva can digest and assimilate.

Buckwheat flowers, for example, bear large, prolific and semi-exposed nectariferous glands. They also have short petals mounted on stout peduncles which regulate the opening or closing of the petals in response to humidity, concentration and viscosity of the nectariferous fluid produced. In the cool damp morning when flow of nectar commences, the petals are everted, exposing it to the air. The fluid nectar is evaporated by the wind, to a concentrated, viscose substance, highly preferred by honey bees. To prevent excess evaporation during the hot, dry periods, the petals are drawn inward and firmly pressed against each other along the median length, forming a minute median tunnel. Honey bees, which are genetically, physiologically and nutritionally programmed to metabolize stored honey and huddle to maintain critical body temperatures throughout the winter, are naturally attracted to plants such as buckwheat, producing nectar with a high sugar concentration. When nectar with a low sugar concentration is collected, it must be fanned by the wings of the bees inside the hive to evaporate the excess liquid and transform it into honey which can be stored and eaten during the winter.

Alfalfa, unlike buckwheat, has a minute nectariferous gland which is deeply concealed within the corolla tube. The small semi-circular nectar chamber at the base of the corolla tube is semi-concealed from the opening to the outside by a robust and elongate staminal column which encloses the ovary. Along with this, a connate sepal cylinder tube provides a secondary enclosure around the corolla tube. Thus, the nectar produced by the minute nectariferous gland is almost entirely protected from evaporation. Bees which hibernate throughout the winter do not need to accumulate nectar for winter consumption, hence nectar(which has a low sugar content)is adequate for being mixed with the pollen grains to provision the cells, or being ingested by the female and male for maintenance.

Since males do not require the proteinaceous pollen grains (which are thrust against the hypostomal region of the head when the sexual column is tripped), specialized structures, such as the hypostomal concavity and tubercle, and the ventral mandibular tooth with a tuft of outwardly curved bristles at the apex, have evolved to brush away and catapult the pollen grains every time the mandible closes.

4. Feasibility of Using Leaf-Cutter Bees in Large Scale Alfalfa Seed Production

Leaf-cutter bees are the most efficient pollinators of alfalfa, tripping and effectively cross-pollinating over 90% of the flowers they visit (Michener, 1953; Pengelly, 1953, 1958; Bohart, 1957; and others). Many species biologically lend themselves to alfalfa pollination since the adult flight period is approximately synchronous with the flowering period of alfalfa.

Hobbs and Lilly (1954) observed that, "No species of *Megachile* emerges before alfalfa comes into bloom in southern Alberta." On the one hand, this indicates that a large population of a native species would not emerge and disperse or perish in a large alfalfa field before it began to blossom. On the other hand, it also exposes concern that early alfalfa blossoms might pass their fertility period before adult pollinators emerged. To coincide and synchronize more closely the alfalfa flowering with adult Megachile emergence, Hobbs (1956) proposed that the blossoming period of alfalfa might be delayed by "clipping" or the flight period of the bee might be advanced by selecting and reproducing earlier emerging adult strains which can usually be collected at various localities. Hobbs and Lilly also noted that in Alberta, flowers tripped after August 5 in 1950 and August 15 in 1951 were destroyed by frost before they had time to mature. Thus, a desirable adult flight period might extend from approximately mid-June to mid-August. A slightly advanced alfalfa flowering period occurs in Ottawa where a few plants begin to blossom in early June with blossoming becoming more general by mid-June. Since adults live for about 1 month, earlier and later varieties or species might be selected to finish adequate populations throughout the opportune flowering time frame of alfalfa.

5. Implementation of a Long Range Bee Management Program

A. Providing nesting domiciles

The main limiting factor to economic pollination of alfalfa is an acute shortage in the numbers of leaf-cutter bees. The principal remedial step to increase population size is to fabricate or provide acceptable nesting domiciles.

For species nesting above ground (in stems or wood), such as Megachile relativa, M. centuncularis, M. inermis, M. frigida, M. mendica and others, domiciles similar to those described by Hobbs (1973) which are currently used for M. rotundata; or bundles of herbaceous or woody stems such as sunflower stalks or sumac twigs; or clusters of white spruce or poplar poles riddled with short holes leading to a semidecomposed interior core, could be provisioned. For species such as M. frigida which contributed to a near record yield of 1,069 kg of alfalfa seed per ha, on a patchy 12-year-old alfalfa field in Manitoba, Stephen (1955) recommended that after 14 to 19 years, a felled log was adequately decayed to permit M. frigida to excavate nesting holes. He also observed that the M. frigida nested in "...straw-stack bottoms, old sawdust from mill waste and in 1/4-inch brass pipe...". In Ottawa, the author observed females of M. frigida inhabit practically every available crack in 10 x 30 cm (4 x 12 inch) white spruce guard rails of a large, car parking area, the west side of the Biosystematics Research Institute

(Neatby Building). A female did not exhibit any repulsive or aggressive tendency toward another female inhabiting a similar crack in the guard rail. Two females which entered the same crack, excavated tunnels in opposite directions. In the excavation process the particles of wood chiselled out and pushed backward by one female would spill over into the tunnel being excavated by the cohabiting female. The alternate pushing of wood particles from one tunnel into the other did not interfere with their central aim of chiselling a tunnel and pushing the wood particles backward. Unfortunately, the nearest blossoming alfalfa field was cut for experimental purposes, and the number of the bees diminished soon after the alfalfa was cut. Bees which nest in plants above ground can be transferred in their domicile during the larval (autumn) or pupal (spring) stage to prospective alfalfa fields which will require pollination. Species which dig burrows and nest in the soil, such as *Megachile melanophaea*, *M. perihirta*, *M. dentitarsus*, *M. latimanus*, *M. texana* (Fig. 10), *M. parallela*, *M. wheeleri* and others require to have firm, uncultivated, well drained, sandy to gravelly soil in which to make their nest. Sladen (1918) observed *M. perihirta* to nest gregariously in a new gravel railway embankment at Cochrane, Ontario, and at Invermere, British Columbia he noticed the same species nesting in a nearly new gravel road. Sladen (Apiarist of the Dominion Experimental Farms) noticed considerable numbers of these bees effectively tripping alfalfa at Medicine Hat and Lethbridge, Alberta. He concluded that there might be "...some hope that *perihirta* might be encouraged to breed in the vicinity of alfalfa fields by spreading gravel and making it firm by rolling." Salt (1940) noted that leaf-cutter bees nested in firm undisturbed soil along the borders of creeks and rivers, headlands, uncleared brush, shelter belts, and strips along fences. He suggested that alfalfa should be grown in long strips along uncultivated land which might be suitable for nesting sites. In conclusion, he proposed that "If plenty of nesting places were available, the bees would probably multiply to keep pace with the increasing food supply."

A restriction to the use of ground nesting species is that they cannot be readily transferred. When a field of alfalfa requires to be rejuvenated periodically and flowers are not available, an alternate field with blossoming alfalfa must be available within relatively short flying range to sustain the population.

B. Establishment of secondary plants for cell construction

Megachile rotundata uses alfalfa leaves for building its nests. Michener (1953) noted that the native North American species M. brevis cut alfalfa leaves for cell construction. Similarly, Pengelly (1955) recorded M. frigida to use alfalfa leaves. Hobbs (1956) on the other hand, stated that lack of plants from which sections of leaf could be cut for cell construction forced M. perihirta to use leaves of Prunus virginiana (Chokecherry). It is probable that, for the majority of Canadian species, suitable secondary plants might have to be planted and made available, to produce leaves which leaf-cutter bees could use for building cells.

In the southern part of central Eurasia, where alfalfa probably originated (Bohart, 1972), and where the accidentally introduced alfalfa leaf-cutter bee (M. rotundata) may have emigrated from, it is estimated that there may be up to 140 species of Megachile belonging to the subgenus Eutricharaea (Parker et al, 1976). They are closely related to M. rotundata and may also use alfalfa leaves to build their cells. Importation of selected pollinators might eliminate the need for a secondary plant. There are reports (Parker et al, 1976) that these bees are providing good pollination service in such countries as Poland.

C. Annual access to flowering alfalfa

To maintain high and effective alfalfa pollinating populations of leaf-cutter bees, an adequate supply of flowering alfalfa pasture, within short flying distance, would have to be available annually. Absence of an adequate alfalfa flowering pasture for one season would cause the bees to disperse and perish.

To rebuild or restore a population would take more than a half dozen years. Unlike social honey bees which maintain a relatively large worker population by huddling and feeding upon the stored honey, solitary bees have a relatively low reproductive rate. Each female in Canada with a single generation per year can optimally produce about 30 adults for the following year. Leaf-cutter bees often have a high male ratio of 2 or 3 males per female. They also have a high mortality rate imposed by various insect parasites and predators. Based upon a study of emergence and mortality of 214 cocoons of seven species of leaf-cutter bees, Pengelly (1958) estimated a 4-fold annual reproduction rate. Bohart (1972) reported that farmers using the domesticated leaf-cutter bee, *M. rotundata*, were satisfied with an annual doubling of the population even in good years.

During the rejuvenation period of an alfalfa crop, portable domiciles could be moved to fields which are due to blossom and require pollination. Fixed domiciles such as those along road allowances could have alternating flowering crops on each side of the road or nesting strip.

D. Propagating Uncontaminated Breeder Stock

Pupae used for breeder stock could be examined to ensure that none are contaminated with parasites and predators. Pest-free stock might be propagated in large cultivated areas which do not have suitable habitats to sustain hosts or prey, with isolate fields planted to alfalfa. A contaminated population could be destroyed and replaced by healthy pest-free breeder stock.

E. Maintenance of Populations of Several Species

Factors affecting fluctuations in population densities of solitary species of leaf-cutter bees have not been ascertained, nor can they be readily moderated. Thus instead of being entirely dependent upon the well-being of a single species of leaf-cutter bee for sustaining an economically viable alfalfa seed industry, several species should be maintained as alternate pollinating reserves to ensure adequate annual pollination.

III. SYSTEMATICS OF LEAF-CUTTER BEES

Family MEGACHILIDAE

Leaf-cutter bees belong to the genus Megachile and are contained within the family Megachilidae. Biologically and structurally, the family differs from all other bees in the following ways:

1. Females collect and carry pollen on the ventral side of the abdomen, instead of on the hind legs, and have a brush of stiff bristles between which the pollen grains are inserted and compacted. Thus, abdominal sterna II-VI serve as the pollen carrying basket, called the scopa.

2. Front wing with only two, approximately equal sub-marginal cells (Fig. 48), marginal cell either rounded distally, or if acute, then slightly bent away from the costa; first and second recurrent veins opening onto the second sub-marginal cell; basal vein approximately straight.

3. Subantennal suture arising on the outer side of the antennal socket. In all other families of bees, except Andrenidae, the suture arises on the inner side of the socket. Andrenidae differs by having two subantennal sutures, one on the inner and the other on the outer side

of the socket.

4. Labrum usually longer than wide, and normally inflexed beneath the mandibles, which come very near to the clypeus when closed, thereby concealing most of the labrum beneath. In other families of bees, the median section of the apical margin of the clypeus is more distant from the mandibles when closed, thus all, or a greater portion of the basal section of the labrum is exposed.

5. Along with other specialized families of bees, the tongue in Megachilidae is long and slender; 1st and 2nd segments of the labial palpus are greatly elongated and flattened while the apical segments are short. The galea of the maxilla is also greatly elongated while the maxillary segments of the palpus at the base of the galea are much reduced in size and number.

Genus: MEGACHILE Latreille 1802

This genus contains a large number of subgenera and species and is present in all the major land masses around the world. In Canada, Megachile is represented by 10 subgenera and 29 species. Species belonging to Megachile can be separated from all other genera of bees, except Coelioxys and Chelostomoides, by the absence of an arolium (Fig. 53), a distinct pad projecting between the tarsal claws, and usually extending beyond half the length of the claw. Coelioxys, a closely related parasitic genus in which the female has lost its scopa, can be separated by the hairy eyes in which the length of the hair is much greater than the distance which separates them, and the prominent, posteriorly projecting, lateral spine which both males and females bear on the scutellum. Chelostomoides is also a closely related genus in which the female uses resin, instead of cut sections of leaves, to construct its cells. Females of Chelostomoides can be separated by the absence of a cutting edge on the inner side of the mandibles. They also have a conspicuous pair of polished and rounded median tubercles at the apex of the clypeus. Males can be recognized by the three exposed sterna, with sternum IV and the following sterna retracted and concealed beneath sternum III.

All the species of _Megachile_ are entirely black, although the males frequently bear highly elaborate and coloured front legs, ranging from ferruginous to white and conspicuously contrasting with the black integument on the rest of the body. Usually, _Megachile_ are short, robust bees with the propodeum shortened and the dorsal side of the metanotum steeply sloped beneath the large scutellum. Thus, the posterior aspect of the thorax is nearly vertical in lateral view.

In males and females of _Megachile_, the apical rim on both the front and the middle tibiae each bear two prominent teeth and a polished, semi-ovate posterior field. A strong, apically rounded anterior tooth, dorsad to the tibial spur, is followed posteriorly by a second acutely angulate tooth, formed by a sharp carina branching from the apex of the angulation and directed obliquely toward the base of the tibia; the length of the sharp carina which also borders the semi-ovate posterior field is usually subequal to the distance between the two teeth.

When the front leg is brought forward with the tarsus angledposteriorly, the two teeth at the apex of the front tibia, are positioned ~~just~~ posterior to the mandible and may serve to dig into and shift posteriorly the wood, soil, resin and other particles loosened by the mandible; alternately, the teeth also wedge against the tunnel wall to provide the grip to thrust the body anteriorly to achieve a progressively deeper mandibular bite. The polished semi-ovate or spatulate field with a brush of bristles at the base, serves to push the loosened particles posteriorly. The teeth at the apex probably enable the males and females to chew their way out of the pupal case and out of the nesting tunnel. In the females, they may also serve in excavating nesting tunnels.

Females (Fig.48)

1. Abdominal modifications to facilitate pollen collecting

Transfer of the pollen load from the hind legs to the scopa, on the ventral side of the abdomen, has brought about a number of structural modifications to the more specialized females. To facilitate collecting, inserting and compacting of pollen grains, the abdomen has achieved a great deal of dorso-ventral flexibility. In all Megachile, the first abdominal tergum has a broad concavity anteriorly, which accommodates the convexity of the propodeum to permit the abdomen to become strongly elevated. The anterior concavity on tergum I is bordered by a weak, semi-circular suture dorsally which morphologically approaches a minute carinate rim in some subgenera or a narrow flexible semi-membranous suture in others. The telescoping ability of abdominal terga is greatly increased with the apex of the preceding tergum sliding over the following tergum. Median lengths of terga I to V have decreased and the basal transverse grooves have deepended and shifted posteriorly to form the gradual grooves near middle of terga II to V allowing the apex of the preceding tergum to slide into the transverse furrow and permit the abdomen to become sharply upcurved. The basal sterna are also shortened longitudinally, with sternum I bearing a protruberant postmedian angulation and having oblique lateral arms extending toward the apico-lateral angles of the sternum, thereby bordering an inflexed crescent-shaped preapical field. Sternum II is shortened by having a crescent-shaped, median emargination along the anterior margin. The shortened basal sterna permit the abdomen to become downcurved more sharply. The median longitudinal abbreviations of the terga and sterna render a short broad outline to the more specialized Megachile, when they are examined in dorsal view.

2. Leaf-cutting and nest construction

The cutting of oblong or rounded sections of leaves for making cup-shaped cells is unique to leaf-cutter bees. The use of sections of leaf to build a cell yields distinct bionomic advantage which might be compared with building a house out of large sheets of plyboard instead of making it out of handfuls of mud or cement. Closely related genera such as Chelostomoides, which is morphologically similar and was included as a subgenus of Megachile by Mitchell (1937, 1962), uses plant resin intermixed with pebbles for constructing and moulding the cell (Michener, 1962).

A wide range of nesting sites in which to build the cells is selected by the females, depending largely upon their habits and mandibular structure. Heavily shaded, damp areas are avoided, and the tunnel opening is usually exposed to direct sunlight. Some subgenera and species, such as inermis and frigida, bear pointed outer mandibular teeth with which they are able to excavate tunnels in rotting wood; others clean out and occupy tunnels made by other insects or wedge their way into crevices in wood, such as between and underneath a shingle in the roof. Frequently,

Opposite p. 31

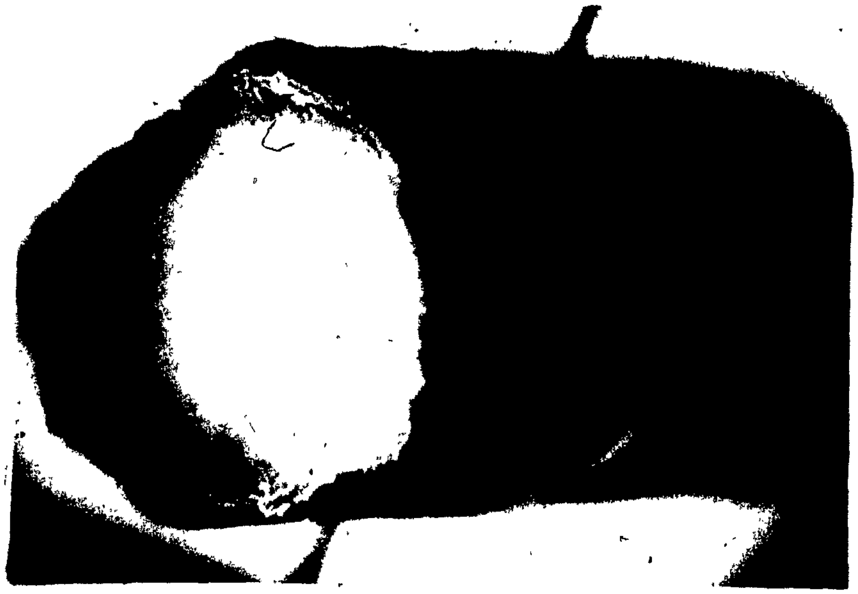

Fig. 4. Completed and sealed cell, containing both pollen and nectar provisions and an egg.

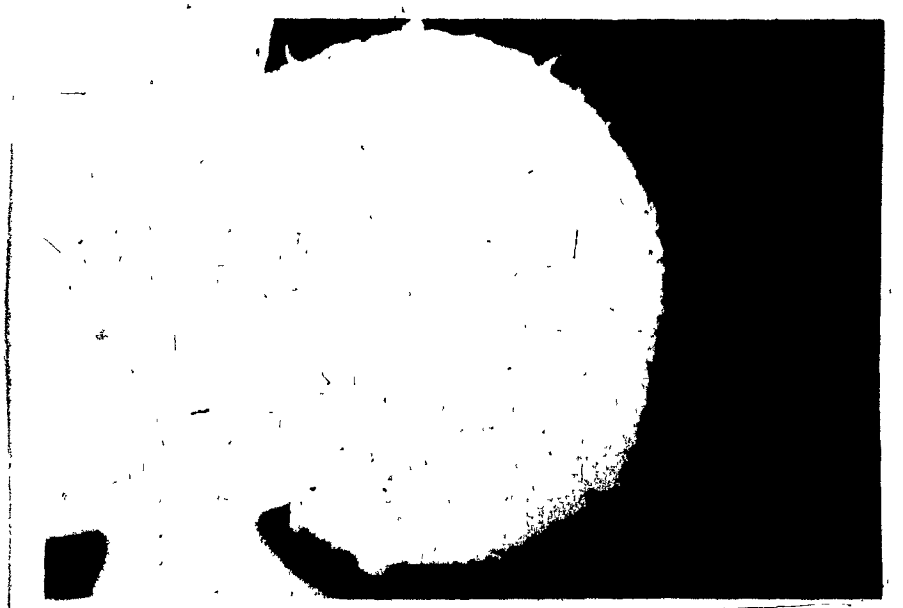

Fig. 5. Circular leaf section cut out to cap and seal the cell.

nests are made in broken, hollow or pithy stems or shrubs or herbaceous plants. Some subgenera excavate a tunnel in the ground beneath a stone or clump of grass and still others expeditiously make their nests in such fragile sites as dried rolled leaves. The tunnels vary from 5 to 10 mm in diameter and 10 to 100 mm in length. Large crevices or openings are filled with sections of leaves or petals to form a rounded tunnel of appropriate diameter. One to a dozen cells are constructed one on top of another in the tunnel or burrow.

Six to a dozen oblong sections of leaf are moulded and cemented along the margins with salivary secretions into a somewhat parallel-sided oblong cup. This is filled about two-thirds full with a mixture of pollen and nectar. A single egg is laid on top of the provisions and the cell is sealed with precisely cut circular lids of a size which snugly covers the end of the cell. The lid is firmly pushed in, forming a slight concavity while the edges are firmly pressed against and securely glued to the wall (Figs. 4, 5). Extra, usually extensive, precautions are taken to seal off the exit opening and thereby provide additional safety to the entire series of cells within the burrow. Sometimes, an extra, empty or vestibular cell is made on top of the pro-

Opposite p. 32

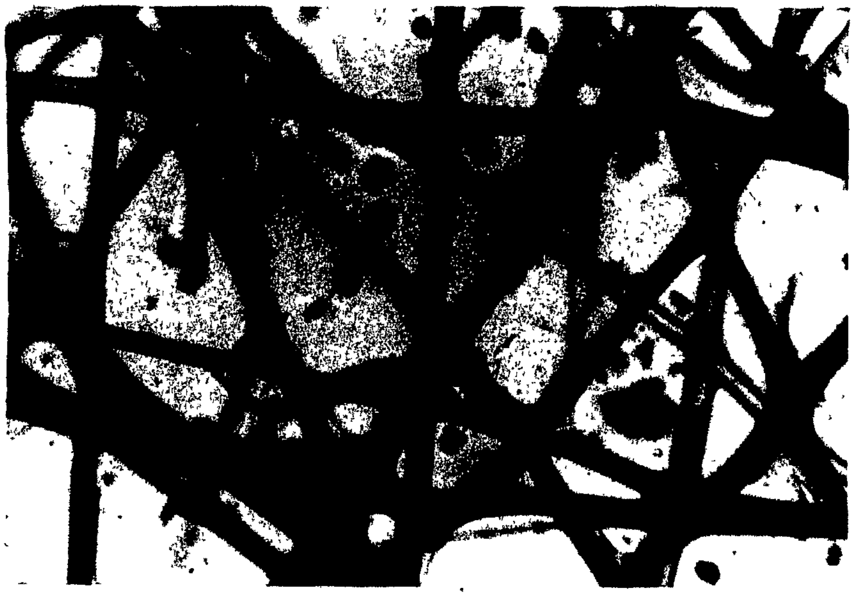

Fig. 6. Salivary strands inside leaf cell, forming the framework for the impermeable gelatinous capsule.

Fig. 7. Overwintering larva, within the leaf cell and gelatinous capsule produced by the larva.

visioned cells. The last cell is often capped or plugged with up to 30 sections of leaf alternated with masticated leaf or wood fragments, very distasteful and tough terpenes, resin or soil particles. It has been proposed that, after burrowing through the thick plug, the empty cell would dissuade predators from further pursuit. The empty space may also place the last larva, beyond the length of the ovipositor of such parasites as Sapyga or Monodontomerus (Figs. 86, 92, 93).

The egg hatches soon after oviposition, with the larva becoming fully developed upon the pollen and nectar provisions. Strong gelatinous strands are woven to form a net between the larva and the fecal pellets on the outside (Figs 6, 7) followed by the formation of an impermeable and waterproof capsule. The larva orientates itself with its head toward the opening of the tunnel (since the adult is unable to turn itself around in the cell), and remains in the diapause stage in the capsule within the cell until the following summer, when the larva pupates and emerges as adult a couple of weeks later. Some species such as M. brevis may have more than one generation per year, with the development from egg through larva and pupa to adult taking place in about a month (Michener, 1953).

In spite of the egg in the cell, at the base of the burrow, being oviposited first, the adult within it cannot pass the series of succeeding cells placed on top, to make its exit. It may be that, following pupation, the adults spend a number of days firming and hardening up within the cell. Perhaps, primed by suitable weather conditions, maturation pheremones and vibrations generated in the process of the adult chewing its way out of the pupal case and leaf cell, all the adults within the tunnel may become aroused to make spontaneous exit. Each adult chews the lid, which covers its cell and the entire tunnel containing all the adults becomes open to the outside. Males placed in outer cells often emerge a few days ahead of the female (Medler and Lussenhop, 1968). Sometimes up to 2 or 3 males develop for every female (Torchio and Parker, 1975). Adults live for about a month.

In species such as M. inermis, in which the females are distinctly larger than the males, wider burrows with larger cells are made and provisioned for the development of females. Thus, the mother appears to harbour the premonition and design, at the time excavation of the burrow commences, to either make a larger hole for the subsequent development of a series of females, or a smaller hole for the development of males. For example, a fertilized egg, which will develop into a female, is deposited into a larger cell with more provision in the series of cells made in the larger burrow. Occasionally, both males and females may emerge from the same burrow (Fye, 1965). In other species, in which the males and females are of approximately equal size, males are normally deposited in the outer cells. Males usually have a sharply pointed outer tooth which might be adapted for chewing through the enlarged outer plug.

3. Mandibular morphology (Figs. 54-83)

The tasks of leaf-cutting and burrowing have brought a progression of mandibular modifications on the inner and outer cutting edges, as well as denticular shapes and emarginations, to the extent that the cutting side of the mandible, provides one of the main areas of morphological diversity, by which females belonging to the various subgenera and species can be recognized.

Since the two mandibular condyles at the base of each mandible provide a rigid axis or pivot and since the mandibles may alternate in having the left mandible slide over right or right over left, achieving a single co-ordinated cutting edge on a wedge-shaped mandible is impossible, This can be observed by alternating the wedge-shaped blades on scissors and attempting to cut while operating on the same axis. To compensate for the separation that develops as the wedge-shaped mandibles slide past each other, a secondary cutting edge develops on the inner side of the mandible.

In the closely related genus Chelostomoides which makes it cells out of resin, a secondary inner cutting edge is absent and only an obtuse angulation is present on the inner side of the mandible. In M. montivaga (Fig. 59), one of the more primitive species of Megachile, (which makes use of cut sections of flowers which are easier to cut), the more obtuse angulation, which is present in the more primitive Chelostomoides, develops into a distinct inner carinate cutting edge. The inner cutting edge is, however, low and can scarcely be seen when the mandible is examined from the outside. In the more advanced species, such as M. wheeleri (Fig. 64) or M. addenda (Fig. 61), the inner cutting edge is highly developed and elevated to reach the summit of the basal denticle and to completely occupy the emargination between the 3rd and inner denticles (Fig. 64).

Another mandibular modification is the eversion of the outer denticles to become nearly perpendicular to the axis of the mandibular condyles and the flattening and expansion of the outer tooth. In the more primitive species, such as M. montivaga (Fig. 59) or M. inermis (Fig. 60), alignment of mandibular denticles is nearly parallel with the axis of the mandibular condyles, thereby forming a scoop-shaped mandible with pointed outer denticles which can chisel into and excavate holes in wood. Stephen (1956) observed M. inermis excavating a tunnel in a rotting tree. In more specialized species, such as M. wheeleri (Fig. 64) and M. melanophaea (Fig. 63), the outer denticles are everted and flattened. Thus, the mandibular denticles form a nearly straight blade and are aligned approximately perpendicular to the axis of the condyles producing a scissor-like formation which provides greater leaf-cutting ability at the expense of excavating competence. Future observations may confirm that these species are incapable of making excavations in wood. Accordingly, M. melanophaea has been observed to nest in the soil (Hobbs and Lilly, 1954). The mandibles are probably used to loosen the soil, while the legs may eject the particles out of the burrow.

4. Bionomics - Strategic deployment of time and energy to propagate life

The question arises as to whether the propagation of life is advanced bionomically by excavating a deep secure tunnel (Stephen, 1956), which takes 3 hours 40 minutes, in the trunk of a rotten tree, or whether some advantage could be achieved by building and provisioning extra cells instead, in such fragile and hazardous sites as a rolled dried leaf, or the broken stalk of a hollow herbaceous plant.

It appears that climatic conditions play a significant role in determining behavioral patterns. In more southern regions such as Kansas, where persistent hot dry winds accelerate and shorten the flowering periods of plants, tiny species such as M. brevis predominate. They have small bodies, are swift fliers and perpetually engage in extended flight (6.44 km - Michener, 1953) searching for fleeting, flowering pastures and expeditiously building one or two cells in fragile sites along the way. In cool, humid and more northern Canadian regions, where a smaller diversity of plants blossom over an extended period of time, larger species such as M. inermis predominate. They often excavate holes in rotting wood, about 10 cm in depth, then build and provision about 10 cells end-to-end. The final cell is securely capped with 10-30 circular layers of leaf, which are alternately and variously filled with chopped leaves, wood particles, resin, terpene, moss, soil and sand grains, to ensure that no prey will penetrate the opening hole.

Optimally, the female has about 30 days time to propitiously deploy her strategies. It is active at temperatures about 20°C and usually commences activity about 10:00 A.M. and ceases working at about 6:00 P.M. During the 8 hours of activity, the female is usually able to fully complete one cell per day (Fig. 4).

The following average times are required to perform the essential functions:

	hr. min.
- Excavate burrow, 10 cm deep, in rotten wood to accommodate about 10 cells placed end to end (Stephen, 1956)	3. 40.
- Construct cell or cup, with 6-12 oblong sections of leaf, moulded and cemented with salivary secretions around the margins to form the cell................	2. 30.

- Provision cell with pollen and nectar, 15-18 loads; each load accumulated from about 200 flowers at approximately 4 seconds per flower. Total number of flowers visited 3000-3600...............	3.40
- Lay egg....................................	.06
- Cap cell, with 10-30 leaf caps............	.30
Time per cell at optimal conditions less excavation time	6.46

During her lifetime, the female can optimally produce about 30 adults but rarely produces more than 20. With a sex ratio of about 2 or 3 males per female, 5-10 females and 13-22 males may be produced. Taking into account environmental deterrents and hazards, such as climatic conditions (temperature, cloud, wind and rain); birds, mice, diseases, predators, and parasites, which sometimes impose a toll of up to 78.5% mortality, the behaviour of the female must be genetically, strategically programmed and charged with activity to perpetuate the species.

Males (Fig. 49)

1. Morphology

In males, the first 4 abdominal sterna are sclerotized and fully exposed, while sterna V-VIII are partially membranous or atrophied and retracted beneath sternum V. To compensate for the retracted apical sterna and shortened sternal length, tergum VI is strongly curved downward to form the apex of the abdomen, and a prominent postmedian transverse carina develops to simulate a terminal aspect for the abdomen. Tergum VII lies anterior to VI and tergum VIII is partially atrophied and not exposed. The tergum and sterna have an elevated basal rim called "gradulus"; they also have a reflexed apical rim called "duplication" folded beneath the segment. Thus, the duplication at the apex of one segment slides over the gradulus at the base of the succeeding segment. The apical section of tergum VI is directed anteriorly; however, the duplication on it, which usually has two pairs of tubercles, is reflexed posteriorly to permit the apex of sternum IV to slide over the duplication. Sometimes, as in M. inermis, the lateral tubercle is notched at the base on the inner side, and serves to anchor the apico-lateral section of sternum IV. Sterna V and VI which are withdrawn beneath sternum IV, are usually highly modified and often bear specialized and distinctly variable hairs.

2. Functional Modifications

Males exhibit a progression of structural developments which (i) facilitate disposal of pollen grains and (ii) aid the establishment of male supremacy.

Pollen grains, which are the essential food of larvae and play a vital role in female performance, are a nuisance to the males. Males require nectar, which is essential for their sustenance; however, when obtaining nectar, specialized floral mechanisms in some leguminous plants thrust pollen grains against the hypostomal region which males must brush away, since the proteinaceous pollen grains are unnecessary for them.

The progressive development of structures such as the polished hypostomal concavity, with an elevated hypostomal tubercle to delimit its posterior extension, together with the development of a ventral mandibular denticle, with a brush of bristles directed outwardly at its apex to clean out and catapult the pollen grains every time the mandible closes, is best seen in such highly evolved species as *M. perihirta* and *M. frigida*. This structural development is almost entirely absent in such species as M. brevis and M. mendica, and weakly developed in the M. relativa.

Progression of structural developments which serve to promote establishment of male territoriality are: coloration, dilation and elaborations on front legs; development of the front coxal spines and bristles, just anterior to the spines; development of a fourth mandibular denticle and the elongation and broadening of the ventral mandibular denticle to protect essential mouth parts. These male structures are highly developed in such species as M. frigida and M. melanophaea. In New Brunswick, a male M. melanophaea was observed occupying a bare section of ground on an anthill of Formica fusca Linnaeus (which was strongly cemented with salivated particles to prevent slave-making ants from getting in to raid the nest). When another male M. melanophaea alighted upon the anthill, the male that was perched upon it, almost with lightning speed, violently attacked the intruder. Such a strong and deliberate defence of preferred areas indicates territoriality. In cool, damp regions, such as the Maritimes, high temperatures of over 20°C are infrequent in the early part of the day, hence, bare black earth which absorbs the sunlight warms up first and serves to activate and arouse the males. Coincidentally, it has also been recognized that the alfalfa leaf-cutter bees land on bare soil to warm themselves and bare patches of land are now being provided by farmers to activate M. rotundata (Bohart, 1972). The more primitive species, such as M. relativa and M. centuncularis, exhibit entirely undeveloped or weakly developed offensive or defensive structural mechanisms. The need to defend and warm themselves on bare ground, may be less essential for such species as M. brevis which inhabit warmer regions, and which may be more sparsely distributed than other species inhabiting cooler regions where flowers blossom over a longer period of time.

IV. SPECIES OF MEGACHILE PRESENT IN CANADA

CLASSIFICATION

There are species groups within the genus Megachile which exhibit definite morphological and biological affinities. However, the morphological differences in either the male or the female are insufficiently differentiated to engage morphological differences to segregate distinctive genera. To overcome the limitations imposed by lack of distinctive structural characters in either sex, and yet segregate groups which exhibit positive structural and biological relationships, a subgeneric classification is employed. A subgeneric classification was used by Mitchell (1934 to 1937) in his treatment of Nearctic Megachile; however, in his more recent revision of Megachile of the eastern United States (1962), subgeneric characteristics are not defined.

To facilitate identification of specimens which do not bear distinct characters by which they could be distinguished to subgeneric level, two sets of keys are provided. One key classifies the genus Megachile directly to species; the other set of keys first distinguishes to subgeneric level. Additional keys are provided to determine each subgenus to species.

Species within each subgeneric group generally share similar characteristics. Accordingly, these characters are described under each subgenus. Following subgeneric descriptions, only characters which are characteristic of the species are taken into account under the species description. Thus, to gain a more comprehensive, overall concept of the species, both the species and the subgeneric descriptions should be considered.

1. KEY TO SPECIES OF CANADIAN MEGACHILE

Ventral side of abdomen with six exposed sterna bearing a dense brush of stout scopal hairs (Fig. 48). Tergum VI without a prominent postmedian transverse carina. Antenna 12-segmented (Fig. 50)..........FEMALE (p. 45)

Ventral side of abdomen with only four exposed sterna bearing moderately short slender hairs (Fig. 49). Tergum VI with a prominent postmedian transverse carina. Antenna 13-segmented (Fig. 51)....MALE (p. 56)

FEMALES

1. Abdominal sterna II-V with dense, white, apical fasciae beneath the scopa (Fig. 15). Tergum II with an opaque, ovate wing pad laterally.........................*M.* *(Eutricharaea)* *rotundata* (p.113)

   Abdominal sterna II-V without apical fasciae. Tergum II uniformly polished and punctate laterally, without trace of an opaque ovate wing pad.........2

2. Posteroventral aspect of cheek with a prominent robust tubercle protruding downward (Fig. 35)............ ....M.(Sayapis) pugnata (p.316)

Posterior aspect of cheek uniformly convex, without tubercle.......................................3

3. Abdominal terga without white apical fasciae. Terga I and II usually with dense, white pubescence, conspicuously contrasting with the black pubescence on the following terga (Fig. 23)................4

Abdominal terga with white apical fasciae, the fasciae sometimes reduced and limited to the apical terga laterally. Dorsal aspect of abdomen not conspicuously white and black...................5

4. Inner mandibular tooth rounded with a small excision at its summit (Fig. 63). Scopa usually amber in colour, sometimes infuscated peripherally in eastern specimens.....M.(Delomegachile) melanophaea (p.215)

Inner mandibular tooth broadly truncate (Fig. 62).
Scopa usually entirely black, occasionally amber in western specimens...M. (Delomegachile) gemula (p.186)

5. Mandible 5-dentate, with the 4th tooth approximately parallel-sided throughout its midlength (Fig. 67). Deep oblique emargination between the 3rd and 4th denticles much deeper than the emargination between the 2nd and 3rd denticles........................6

Mandible 3-5 dentate; when 5-dentate the 4th tooth is strongly tapered from base to apex, and the emargination between the 3rd and 4th teeth is subequal to or shallower than the emargination between the 2nd and 3rd denticles...........................9

6. Width of emargination between the 3rd and 4th denticles about 3 times as great as the width of the 4th tooth at midlength (Fig. 31). Apical border of sternum VI thickened, weakly upcurved and extending a little beyond the apical tergum.................................M. (Phaenosarus) fortis (p.297)

Width of emargination between 3rd and 4th denticles subequal to the width of the 4th tooth at mid-length (Figs. 28, 67). Apical border of sternum VI not thickened or upcurved, nor extending beyond the apical margin of tergum VI....................7

7. White, apical fasciae on abdominal terga, broad and dense, usually not interupted medially. Pubescence on terga I and II dense and white. Present only in Alberta.........M. (Xanthosarus) dentitarsus (p.290)

Abdominal fasciae less dense and usually interrupted medially on the anterior terga. Pubescence on terga I and II less dense and yellowish...........8

8. Black pubescence usually occupying posterior half of mesoscutum and extending to scutellum. Clypeus with more or less impunctate median longitudinal line. Usually found west of the 100th meridian but, occasionally, present as far east as Ontario.... ....M. (Xanthosarus) perihirta (p.279)

Black pubescence on mesoscutum scarcely occupying half of mesoscutum and usually not extending to the scutellum. Clypeus usually without a longitudinal impunctate median band. Usually found east of the 100th meridian, occasionally present as far west as Alberta.................................... *M.* *(Xanthosarus)* *latimanus* (p.268)

9. Third mandibular tooth without a trace of bevelled cutting edge extending into the emargination between the 2nd and 3rd teeth (Figs. 16, 59). Mandible short and parallel-sided, with a small but distinct protruberance at base, just beyond abductor swelling..*M.* *(Megachile)* *montivaga* (p.127)

Third mandibular tooth with a bevelled edge extending from outer margin and usually occupying about half the emargination between the 2nd and 3rd teeth (Fig. 62). Mandible longer and not parallel-sided, protruberance just beyond abductor swelling absent. 10

10. Inner mandibular tooth broadly truncate (Fig. 62)...... ....*M.* *(Delomegachile)* *frigida* (p.195)

Inner mandibular tooth rounded or acutely angulate...11

11. Mandible 5-dentate (Figs. 52, 58, 60)..............12

Mandible 3 or 4-dentate (Figs. 27, 54-57, 61-66).....15

12. Sixth abdominal sternum with black scopal hairs, contrasting with the pale hairs on preceding sterna... ....<u>M.</u> (<u>Megachile</u>) <u>nivalis</u> (p.170)

Scopa with uniformly pale hairs throughout, except occasionally at the extreme apical rim...........13

13. Tergum VI with short, uniformly appressed brown hairs throughout its median length. Apical margin of clypeus semicircularly emarginate on each side of the broad median protruberance and the small sublateral tubercle (Fig. 19)......................... ....<u>M.</u> (<u>Megachile</u>) <u>inermis</u> (p.133)

Entire surface of tergum VI with numerous long, erect hairs scattered throughout the appressed hairs. Apical margin of clypeus approximately truncate to weakly emarginate medially, without any sublateral emarginations...............................14

14. Pubescence on tergum VI with conspicuously golden and black hairs......M. (Megachile) relativa (p.153)

Pubescence on tergum VI uniformly black...............................M. (Megachile) centuncularis (p.145)

15. Mandible 4-dentate, without greatly elongated emargination extending from the inner tooth to the 2nd tooth (Figs. 54-57, 61-63, 66)..................16

Mandibel 3-dentate with a greatly elongated emargination extending from the inner tooth to the second tooth; the emargination bordered on both the inner and outer sides by a sharp cutting edge (Figs. 26, 65).......................................26

16. Sternum VI distinctly extending beyond tergum VI and curved sharply upward; the upcurved apical rim bare and polished......M. (Argyropile) parallela (p.303)

Sternum and tergum VI subequal in length, with the apical margin of sternum VI usually fringed with hairs..17

17. Emargination between the inner and 3rd denticles approximately semicircular, with the greatest depth in the emargination, subequally distant between the inner and 3rd denticles (Figs. 54-56) 18

Emargination between the inner and 3rd denticles distinctly oblique with the greatest depth in the emargination much closer to the inner tooth than to the 3rd tooth (Figs. 17, 61, 63, 64).........23

18. Apical margin of clypeus evenly truncate, without prominent tubercles or emarginations...........19

Apical margin of clypeus with prominent tubercles and emarginations (Figs. 34, 37)....................25

19. Tergum VI nearly straight in profile with short, uniformly appressed brown hairs throughout its median length. Emargination in the outer cutting edge between the inner and 3rd denticles with an angulation approaching a weakly developed 5th tooth, occupying the proximal half of the emargination (Figs. 9, 55)..<u>M.</u> <u>(Litomegachile)</u> <u>mendica</u> (p. 96)

Tergum VI concave in profile, with numerous long, erect hairs scattered throughout the appressed hairs. Emargination in the outer cutting edge between the inner and 3rd denticles approximately arcuate exposing the straight inner edge, when the mandible is examined from the outer side (Figs. 11, 54, 56).............................20

20. Abdomen examined from above with numerous stout black hairs laterally on terga II to V.................. ....*M.* (*Litomegachile*) *texana* (p.103)

Abdomen examined from above with few, if any, black hairs laterally on terga II to V.................21

21. Graduli on abdominal terga II to V distinct and carinate. Tergum VI weakly concave in profile, with the pubescence subappressed and entirely black..... ....*M.* (*Litomegachile*) *coquilletti* (p. 93)

Graduli on abdominal terga II to V weakly developed; gradulus on the tergum V, if present, not carinate medially. Tergum VI strongly concave in profile, with scattered erect hairs throughout the appressed pale tomentum.....................................22

22. Scopal hairs on sternum VI entirely black..............
............M. (Litomegachile) onobrychidis (p. 90)

Scopal hairs on sternum VI not entirely black..........
..................M. (Litomegachile) brevis (p. 78)

23. Graduli on terga II to V strongly elevated and projected posteriorly, permitting mites to inhabit the space beneath the overhanging carinae. Tergum VI strongly concave in profile, with dense appressed hairs concealing the apical area...................
.... M. (Delomegachile) addenda (p.233)

Graduli on terga II to V weakly elevated and not projected posteriorly to form overhanging carinae; gradulus on tergum V scarcely, if at all, perceptible. Tergum VI weakly concave in profile........24

24. Scopa entirely black................................
...............M. (Xeromegachile) subnigra (p.252)

Sterna II-IV and usually the basal half of sternum V with white scopal hairs............................
...............M. (Xeromegachile) wheeleri (p.244)

25. Lateral clypeal tubercles approximately parallel-sided, greatly protracted antero-medially and decurved subapically (Fig. 37). Legs ferruginous................ M. (Sayapis) fidelis (p.325)

Lateral clypeal tubercles strongly tapered apically and not protracted antero-medially. Tibiae and femorae mostly black and conspicuously contrasting with the bright ferruginous tarsi.................. ....M. (Sayapis) mellitarsus (p.328)

26. Tegula ferruginous. Tergum V with white bristles laterally and tergum VI with some white bristles laterally.........M. (Derotropis) subanograe (p.259)

Tegula dark brown. Bristles on terga V and VI, laterally, entirely black........................... ....M. (Derotropis) anograe (p.257)

MALES

1. Front legs highly elaborate, with front basitarsus dilated and excavated along the anterior margin (Figs. 22, 24, 25, 30, 36); usually conspicuously coloured - white to ferruginous....................2

   Front legs unmodified, with front basitarsus slender and simple; usually uniformly black with the rest of the body......................................16

2. Basitarsus of middle leg strongly protruberant and polished ventrally. Middle tibia without an apical spur......................................3

   Mid basitarsus not enlarged ventrally, and uniformly covered with a brush of bristles. Middle tibia with an apical spur...............................5

3. Mesosternum with a slender polished spine just in front of middle coxa................................ ....*M. (Xanthosarus) dentitarsus* (p. 290)

   Mesosternum without a spine in front of middle coxa....4

4. Protruberance on ventral side of middle basitarsus narrow and keel-shaped............................ ....M. (Xanthosarus) perihirta (p.280)

Protruberance on ventral side of middle basitarsus robust, quadrate and polished...................... ....M. (Xanthosarus) latimanus (p.268)

5. Postmedian transverse carina on tergum VI emarginate medially, with the emargination sometimes obscured by dentations (Fig. 12)...........................6

Postmedian transverse carina on tergum VI rounded or obtusely angulate medially (Fig. 13)............12

6.- Mandible 4-dentate (Figs. 77, 78, 79). Abdomen robust with apical fasciae on tergum V usually absent (present in M. giliae). Tarsal claw without a small basal tooth..............................7

Mandible 3-dentate (Figs. 55, 92). Abdomen elongate, usually with well-developed fasciae on terga II to V. Tarsal claw with a small basal tooth.........10

7. Apical third of front femur with a sharp, longitudinal carina extending along its dorso-lateral side. Basal half of front femur with 2 longitudinal brown bars on yellowish anterior side............. ....M. (Delomegachile) frigida (p.196)

Apical third of front femur without any carina on the dorso-lateral side. Basal half of front femur without any longitudinal brown bars on the anterior side..8

8. Distal rim of front tibia with a strongly flattened and rounded tubercle projecting posteriorly. Front basitarsus distinctly narrowed towards the base.........M. (Delomegachile) melanophaea (p.217)

Distal rim of front tibia with a short and strongly tapered spine. Front basitarsus approximately parallel-sided.................................9

9. Front tarsi brown to black. Apical fascia on tergum V absent...........M. (Delomegachile) gemula (p.188)

Front tarsi entirely yellow. Apical fascia on tergum V present..........M. (Delomegachile) giliae (p.180)

10. Tergum V without a white apical fascia. Boat-shaped dilation on anterior side of front basitarsus greatly elongated apically and extending to the apex of the 3rd tarsal segment.................... ....M. (Sayapis) mellitarsis (p.329)

Tergum V with a white apical fascia. Boat-shaped dilation on anterior side of front basitarsus not extending to the apex of 3rd tarsal segment......11

11. Brush of dark bristles on front basitarsus, not extending beyond its basal third. Apical third of boat-shaped dilation on anterior side of front basitarsus entirely covered on the outer side with dense appressed hairs..M.(Sayapis) pugnata (p.317)

Brush of dark bristles on front basitarsus, extending to near the apex. Apical third of boat-shaped dilation on anterior side of front basitarsus, mostly bare and polished......M. (Sayapis) fidelis (p.326)

12. Ventral mandibular tooth truncate apically (Fig. 71). Anterior side of front basitarsus polished but flat, not deeply excavated. Apical margin of sternum IV with a small median tubercle........................ ....M. (Phaenosarus) fortis (p.298)

Ventral mandibular tooth pointed apically (Fig. 80). Anterior side of front of basitarsus with a shallow boat-shaped excavation (Fig. 22). Apical margin of sternum IV without a median tubercle............13

13. Second segment of labial palpus may be slightly longer than first. Gradulus on sternum V may have a robust median spine-like projection directed posteriorly....*M.* (*Derotropis*) *anograe* and *subanograe*[1] (p.255)

First and second segments of labial palpus subequal in length. Gradulus on sternum V without a robust median spine-like projection..........................14

14. Mesosternum with a prominent, flattened, carina-like spur just behind the front coxa.....................
.................*M.* (*Xeromegachile*) *wheeleri* (p.245)

Mesosternum without a carinate protruberance...........
.... *M.* *subnigra* (p.252)

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1 The males of the two species of Canadian *Derotropis*, *anograe* and *subanograe* have not yet been described, but they may key out as indicated. The couplet is taken from Mitchell's (1936) "Key to *Megachile* subgenera related to *Megachiloides*" and is based on the morpholoy of other species in this subgenus.

15\. Abdominal tergum II with an opaque, ovate wing pad laterally. Apical margin of tergum VI narrowly reflexed apically and without any tubercles extending from the margin........................ .... M. (Eutricharaea) pacifica (p.114)

Abdominal tergum II uniformly punctate and polished throughout, without any trace of an opaque ovate area laterally. Apical margin of tergum VI more broadly reflexed and with 1 or 2 pairs of tubercles arising from its apex...........................16

16\. Front coxal spine entirely absent, or developed as a weak protruberance, no higher than wide; largely represented by a minute but dense tuft of setae..17

Front coxal spine well developed, much longer than wide at the base (Fig. 49)...........................20

17\. Anterior side of front coxa without tubercle. Apical margin of clypeus often with a median tubercle beneath the beard..............................18

Anterior side of front coxa with a small tubercle surmounted by a dense but short tuft of setae. Apical margin of clypeus without median tubercle beneath the beard..19

18. Apical margin of clypeus with a prominent median tubercle. Terminal denticle on posterior claw as sharp as the terminal denticle on anterior claw.... .... M. (Megachile) relativa (p.154)

Apical margin of clypeus without a prominent median tubercle. Terminal denticle on posterior claw much more rounded apically than the terminal denticle on the anterior claw........................ ....M. (Megachile) centuncularis (p.145)

19. Distance from the apex of the middle denticle, nearly twice as great to the apex of the inner denticle, as that to the apex of the outer denticle (Fig. 76). Lateral ocellus much nearer to the eye than to vertex. Tergum VI weakly protruberant medially above the transverse carina and obscurely punctate....... ....M. (Megachile) inermis (p.134)

Distance from the apex of the middle denticle to the apices of either the inner or outer denticles, subequal. Lateral ocellus subequally distant to vertex and to eye. Tergum VI strongly protruberant, medially (above the transverse carina) and densely, but distinctly punctate .... M. (Megachile) montivaga (p.128)

20. Mandible 3-dentate (Fig. 72)..........................21

Mandible 4-dentate (Figs. 32, 81)....................25

21. Tergum V without an apical fascia. Submedian tooth at apical margin of tergum VI, closer to the alternate median tooth than to the lateral tooth............................. M. (Litomegachile) mendica (p. 97)

Tergum V with an apical fascia (Fig. 12). Submedian tooth at apical margin of tergum VI, closer to the lateral tooth than to the alternate median tooth..22

22. Front tarsal segments 2-4 yellow, conspicuously contrasting with the black first tarsal segment......................M. (Litomegachile) coquilletti (p. 93)

First segment of front tarsus not conspicuously darker than the following segments..............23

23. Postmedian transverse carina on tergum VI deeply emarginate medially (Fig. 12)....................
.................M. (Litomegachile) texana (p.104)

Postmedian transverse carina on tergum VI weakly emarginate medially, with the emargination sometimes scarcely distinguishable from the irregular lateral crenulations..........................24

24. White tomentum on tergum VI dense and conspicuous medially, concealing most of the surface beneath (cf. Fig. 12)....M. (Litomegachile) brevis (p.79)

White tomentum on tergum VI reduced to a very fine, pale pruinescence which does not significantly obscure the surface beneath.....................
...........M. (Litomegachile) onobrychidis (p. 90)

25. Front coxa pubescent without a patch of red bristles anterior to the spine. Apical margin of tergum VI with two pairs of prominent teeth directed posteriorly..........M. (Argyropile) parallela (p.304)

Front coxa with a dense patch of red bristles just anterior to the spine. Apical margin of tergum VI without prominent posteriorly projecting teeth..... ....M. (Delomegachile) addenda (p.234)

2. KEY TO SUBGENERA OF CANADIAN MEGACHILE

FEMALES

1. Abdominal sterna II-V with dense, white apical fasciae beneath the scopa (Fig. 15). Tergum II with an opaque, ovate wing pad laterally.......... ....Eutrichareae (p.113)

Abdominal sterna II-V without apical fasciae. Tergum II uniformly polished and punctate, without any trace of an opaque, ovate wing pad...............2

2. Mandible 5-dentate with the 4th mandibular tooth parallel-sided throughout its mid-length. Deep oblique emargination on the basal side of the 3rd tooth much deeper than on the distal side (Figs. 28, 31, 67).....................................3

Mandible 3-5 dentate; when 5-dentate, the 4th tooth is strongly tapered from base to apex. Emargination on the basal side of 3rd tooth subequal to, or shallower than the excision on the distal side....4

3. Width of emargination between 3rd and 4th denticles subequal to the width of the 4th tooth at mid-length (Figs. 28, 67). Apex of sternum VI not thickened or upcurved, and not extending beyond the apical margin of tergum VI...<u>Xanthosarus</u> (p.261)

Width of emargination between the 3rd and 4th denticles fully 3 times as great as the width of the 4th tooth at mid-length (Fig. 31). Apex of sternum VI thickened, weakly upcurved and extending a little beyond the apical tergum.......... ....<u>Phaenosarus</u> (p.297)

4. Anterior border of clypeus with prominent tubercles (Figs. 34, 37). Mandible 4-dentate, without an inner cutting edge between the 3rd and 4th denticles (Figs. 68-70). (In <u>M.</u> (<u>Sayapis</u>) <u>pugnata</u> a weakly developed tooth is sometimes present between the 3rd and 4th denticles; however, it can be easily recognized by the prominent tubercle on the lower posterior angle of cheek (Fig. 35)..... .... <u>Sayapis</u> (p.310)

Anterior border of clypeus without prominent tubercles. (In M. (Megachile) inermis small tubercles are present; however, it can be recognized by the 5-dentate mandible (Figs. 19, 60).) When the mandible is 4-dentate, an inner cutting edge is present between the 3rd and 4th denticles.........5

5. Mandible 3-dentate, with a long oblique emargination between the 2nd and 3rd denticles; emargination bordered on inner and outer sides by sharp cutting edges (Figs. 27, 65)............... .... Derotropis (p.255)

Mandible 4 or 5-dentate, without an elongated emargination extending from the summit of the inner tooth to the 2nd tooth.......................6

6. Mandible 5-dentate (Figs. 16, 18, 52, 58-60. In montivaga the 4th tooth between the 3rd and inner denticles scarcely develops; however, it can be recognized by the short, parallel-sided mandible, or the absence of a bevelled edge on the outer side of the 3rd tooth (Figs. 16, 59)............. .... Megachile (p.122)

Mandible 4-dentate with the inner tooth either broadly truncate (Fig. 62); or minutely excised at the summit (Fig. 63); or narrowly rounded or acutely angulate at apex (Figs. 9, 11, 54-56, 61, 64, 66)..7

7. Inner mandibular tooth broadly truncate (Fig. 62) or broadly rounded, with a minute but distinct excision at its summit (Fig. 63) or narrowly rounded with a large oblique emargination between the 3rd and 4th denticles (Figs. 17, 61)..Delomegachile (p. 175)

Inner mandibular tooth acutely angulate (Figs. 9, 11, 55, 56, 64, 66)....................................8

8. Apical rim of abdominal sternum VI extending a little beyond tergum VI and sharply upcurved; upcurved section glabrous and polished...Argyropile (p. 303)

Sternum VI not extending beyond tergum VI; sternum VI approximately straight to the apex with a fringe of setae extending slightly beyond the apex..9

9. Emargination in the outer cutting edge between the 3rd and 4th denticles deep and oblique, with the greatest depth much closer to the summit of the 4th tooth than to the 3rd (Fig. 64)..Xeromegachile (p.240)

Emargination in the outer cutting edge between the 3rd and 4th denticles approximately semicircular with the greatest depth approximately equidistant between the summit of the 4th and 3rd denticles (Figs. 9, 11, 54-56)..........Litomegachile (p. 75)

MALES

1. Postmedian transverse carina on tergum VI emarginate medially; denticulations along apical border sometimes obscure the emargination (Fig. 12)......2

Postmedian transverse carina on tergum VI obtusely angulate or rounded apically (Fig. 13)............8

2. Mandible 4-dentate (Figs. 32, 77-79, 81)..............3

Mandible 3-dentate (Figs. 20, 21, 72-76. 82, 83)......4

3. Patch of stout, reddish bristles just anterior to front coxal spine. Fourth tooth not too widely separated from 3rd tooth (Figs. 77-79).. Delomegachile (p.175)

Patch of bristles absent, with only slender, elongate, pale pubescence anterior to front coxal spine. Fourth tooth widely separated from 3rd by a space subequal to the distance between the apices of the 1st and 3rd denticles (Fig. 32)..Argyropile (p.303)

4. Basitarsus on front leg pale white to reddish, conspicuously contrasting with the black integument on mid basitarsus and on the rest of the body. Front basitarsus dilated, with a longitudinal furrow extending throughout its antero-ventral side...5

Front basitarsus similar to mid basitarsus in colour, size and form..6

5. Basitarsus on middle leg strongly protruberant and polished ventrally. Mid tibia without an apical spur.................................. Xanthosarus (p.261)

Mid basitarsus not enlarged ventrally; uniformly covered with a brush of hairs. Mid tibia with an apical spur.......................Sayapis (p.310)

6. Front coxal spine entirely absent, or developed as a weak protruberance which is not higher than wide and largely represented by a small but dense tuft of short bristles......*Megachile* (p.22)

Front coxal spine well developed and much longer than wide at base (Fig. 49.).....................7

7. Abdominal tergum II with an opaque, ovate wing pad laterally. Apical margin of tergum VI narrowly reflexed apically and without any tubercles extending from the margin..*Eutricharaea* (p.113)

Tergum II uniformly punctate and polished throughout, without any trace of an opaque, ovate wing pad laterally. Apical margin of tergum II more broadly reflexed, with 1 or 2 pairs of tubercles arising from its apex........*Litomegachile* (p. 73)

8. Ventral mandibular tooth truncate apically; anterior side of front basitarsus polished but flat, not excavated. Apical margin of sternum IV with a small median tubercle..........*Phaenosarus* (p.297)

Ventral mandibular tooth tapered apically. Anterior side of front basitarsus with a shallow boat-shaped excavation. Apical margin of sternum IV without a median tubercle.............................9

9. Mesosternum with a prominent crescent-shaped spur just behind front coxa; or terga III-V without white, apical fasciae.........Xeromegachile (p.240)

Mesosternum without a prominent crescent-shaped spur and terga III-V probably with white, apical fasciae........................ Derotropis (p.255)

Note: The males of the two species of Canadian Derotropis anograe and D. subanograe have not yet been described, but they may key out as indicated.

Subgenus LITOMEGACHILE Mitchell

Figures 8-12, 40-43, 54-56, 72

Litomegachile Mitchell, 1934:301 (new subgenus)

Megachile (Litomegachile); Mitchell, 1935:9 (taxonomy, biology); Hobbs and Lilly, 1954:459 (ecology)

FEMALES. Length 9-14 mm. Mandible 4-dentate; inner cutting edge extending from near the apex of the 4th (inner) tooth to 3rd tooth, straight or weakly concave; usually well developed and elevated a little above the outer cutting edge. Outer cutting edge forming an arcuate or semidentate emargination between the 3rd and 4th denticles; outer edge descends from the apex of the 4th tooth at an angle of about 75° to the inner margin of mandible, to form an acute inner tooth. Outer margin of mandible curved upwardly toward the apex; first (outer) tooth usually reflexed posteriorly along the outer margin and narrowed apically. Clypeus uniformly truncate apically. Gradular grooves and carinae on abdominal terga II-IV variable, more distinctly developed on anterior terga; present or absent on posterior terga. Tergum V varying from nearly straight to strongly convex in profile. Colour of scopal hairs ranging from white to amber; hairs on sternum V and, sometimes, on apical part of IV, black in some species.

MALES. Length 8-13 mm. Mandible 3-dentate with the inner tooth more distantly separated from the middle tooth than outer. Ventral tooth tapered apically, with an apical brush of hairs directed outwardly. Hypostomal tubercle absent;hypostomal concavity absent to weakly indicated by a flattened, sparsely punctate,and subpolished area, bordered by a band of crowded punctures in M. texana. Robust front coxal spine well developed (Fig. 49). Small, scattered, reddish bristles just anterior to front coxal spines (Fig. 42). Front basitarsus dark and simple with a band of shortened bristles (bordered on each side by longer bristles) extending along the anteroventral side. White,apical fasciae on terga II-V usually present. Gradular grooves and carinae variously developed on anterior terga, present or absent on various species, on posterior terga. Tergum VI just above postmedian transvers carina, often covered with dense, appressed, plumose hairs, interspersed with slender, elongate, erect hairs; occasionally with minute slender hairs, interspersed with elongate, erect hairs which do not conceal the integument beneath. Tergum VII reduced in length, usually with a transverse carina bearing a tubercle medially.

COMMENT. Females belonging to this subgenus can be recognized by the following combination of characters: mandible

4-dentate with an acutely angulate inner tooth; emargination between the 3rd and 4th denticles, with the outer cutting edge arcuate or semidentate, and the nearly straight inner cutting edge elevated a little above the outer edge (Figs. 54-56). M. Argyropile (Fig. 66) has a somewhat similar mandibular formation; however, it can be readily separated by the upcurved, glabrous and polished apex on sternum VI.

Males can be distinguished by the following combination of characters: front basitarsus slender, dark, and simple, similar in colour, size and shape to mid basitarsus; front coxal spine well developed, with inconspicuous reddish bristles anterior to the coxal spine; mandible 3-dentate with the inner tooth much more distant from the apex of the middle tooth than the distance between the apices of the outer and middle denticles; tergum II without an opaque, ovate wing pad laterally.

Key to species of the subgenus Litomegachile

Females

1. **Tergum VI nearly straight in profile with short, uniformly appressed brown hairs throughout its median length. Emargination in the outer cutting edge**

between the inner and 3rd denticles with an angulation approaching a weakly developed 5th tooth, occupying the proximal half of the emargination (Fig. 9, 55)....... M. mendica (p. 96)

Tergum VI concave in profile, with numerous long, erect hairs scattered among the appressed hairs over the entire surface. Emargination in the outer cutting edge between the inner and 3rd denticles approximately arcuate exposing the straight inner edge when the mandible is examined from the outer side (Figs. 54, 56)...............2

2. Abdomen examined from above with numerous stout black hairs laterally on terga II-V.....M. texana (p.103)

Abdomen examined from above with few if any black hairs laterally on terga II-V....................3

3. Graduli on abdominal terga II-V elevated and carinate. Tergum VI weakly concave in profile, with the pubescence subappressed and entirely black.. M. coquilletti (p. 93)

Graduli on abdominal terga II-V weakly developed; that on tergum V, if present, not carinate medially. Tergum VI strongly concave in profile, with scattered erect hairs among some appressed pale tomentum..4

4. Scopal hairs on sternum VI entirely black..............
.... M. onobrychidis (p. 90)
Scopal hairs on sternum VI not entirely black..........
.... M. brevis (p. 78)

Males

1. Tergum V without a white, apical fascia. Submedian tooth at apical margin of tergum VI, closer to the alternate median tooth than to the lateral tooth.............................. M. mendica (p. 97)
Tergum V with a white, apical fascia (Fig. 12). Submedian tooth at apical margin of tergum VI, closer to the lateral tooth than to the alternate median tooth.....................................2

2. Front tarsal segments 2-4 yellow, conspicuously contrasting with the black first tarsal segment.......
.... M. coquilletti (p. 93)
First segment of front tarsus not conspicuously darker than the following segments.........................3

3. Postmedian transverse carina on tergum VI deeply emarginate medially (Fig. 12)........ M. texana (p.104)

Postmedian transverse carina on tergum VI weakly emarginate medially, with the emargination sometimes scarcely distinguishable from the irregular lateral crenulations............................4

4. White tomentum on tergum VI dense and conspicuous medially, concealing most of the surface beneath (cf. Fig. 12)................... M. brevis (p. 79)

White tomentum on tergum VI reduced to a very fine, pale pruinescence which does not significantly obscure the surface beneath... M. onobrychidis (p. 90)

MEGACHILE (LITOMEGACHILE) BREVIS SAY

Figures 54, 72; Map 1

Megachile brevis Say, 1837:207 (new species)
Megachile brevis; Michener, 1953:1057 (larva)
Megachile brevis; Michener, 1953:1659-1748 (biology)
Megachile (Litomegachile) brevis; Pengelly, 1955:26 (biology)
Megachile (Litomegachile) brevis brevis; Mitchell, 1962:114 (description, distribution and flower records)

FEMALE. Megachile brevis is one of the smallest native species of leaf-cutter bees, with females ranging from 9-12 mm in length. First mandibular tooth, which is incurved posteriorly along the outer margin, is narrow and wedge-shaped when viewed perpendicular to the outer side of the mandible (Fig. 54). Arcuate emargination between 3rd and 4th mandibular teeth deepest at a point a little closer to the 3rd tooth than to the 4th. Nearly straight distal half of inner margin of 4th mandibular tooth meeting emargination between 3rd and 4th denticles at an angle of about 75°, to form the acutely angulate inner tooth. Apical margin of clypeus broadly truncate with a narrow impunctate and polished band, extending a little over half the distance to the lateral margin. Graduli on terga II-V weakly developed, not carinate apically. Erect pubescence on discs of terga III-VI mostly black. Apical fasciae on terga I-V moderately narrow, but usually complete. Subappressed brown pubescence on tergum VI beyond the transverse concavity, longer and denser than the pubescence preceding the concavity. Apical margin of sternum VI with a dense fringe of dark brown hairs extending a little beyond the posterior border of the sternum.

MALE. Males of M. brevis, like the females, are the smallest native leaf-cutter bees, ranging from 7-9 mm in length.

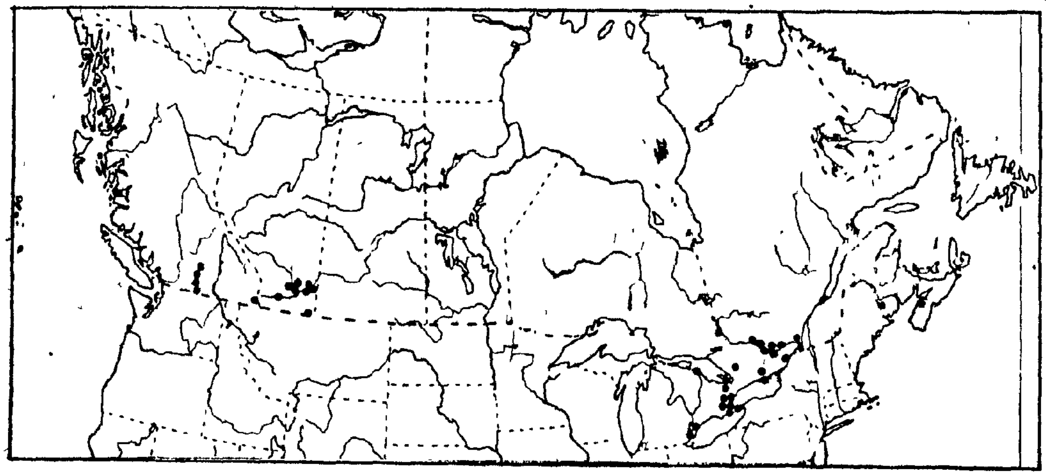
Third mandibular tooth flattened and expanded inwardly with the distance between the apices of the 1st and 3rd teeth subequal to the distance between the apex of the 3rd tooth and base of mandible. Hypostomal region nearly evenly convex, without a concavity or tubercle. Lengths of scape and first flagellar segments subequal to each other, their length combined subequal to 2nd flagellar segment. Apical segment of flagellum a little longer than the preceding segment and noticeably flattened terminally. Apically, margins of terga III-V weakly depressed, without a distinctly elevated, vertical and dorsally carinate wall preceding the depression.

COMMENT. The female of M. brevis can be recognized by the following combination of characters: mandible 4-dentate with the outer cutting edge between the 3rd and 4th denticles arcuately emarginate; emargination of the outer cutting edge descending a little below the inner cutting edge, thereby exposing the almost straight inner edge, which can be seen when the mandible is viewed from the outer side (Fig. 54); bevelled edge between 2nd and 3rd denticles extending from the outer side of the 3rd tooth and occupying about half the emargination between them; apical border of clypeus truncate, without prominent tubercles; sterna II-V without dense white, apical fasciae beneath the scopa; tergum VI with a strong, transverse concavity just beyond the middle; terga II-V without sharply carinate and overlapping graduli; terga II and III without prominent black bristles laterally; scopal hairs on sternum VI mostly pale.

The introduced species of M. rotundata approaches M. brevis morphologically. Unlike in M. brevis, sterna II-V in M. pacifica (Fig. 15) are apically fringed with fasciae and tergum II has an opaque ovate wing pad laterally. Emargination between the 3rd and 4th mandibular teeth is also arcuate in M. parallela (Fig. 66); however, M. parallela can be recognized and separated by sternum VI which extends a little beyond tergum VI, is upcurved, thickened and bare apically.

The males of M. brevis can be recognized by the following characters: front tarsal segments, usually black to brown and simple, with basitarsus much narrower and shorter than its tibia, usually without a longitudinal furrow along its antero-ventral side; front coxal spine well developed, sometimes obscured by elongate pubescence; tergum II without an opaque, ovate wing pad laterally; apical margin of tergum VI with the submedian tooth nearer to the lateral tooth than to the alternate submedian tooth; mandible 3-dentate; terga II-V usually with white, apical fasciae; postmedian transverse carina on tergum VI weakly emarginate medially, not sharply differentiated from the lateral crenulations; area above the transverse carina on tergum VI usually with dense and conspicuous white tomentum medially, which largely conceals the integument beneath (cf. Fig. 12).

DISTRIBUTION. Nova Scotia: Kings County, 31 July 1930. New Brunswick: St. Croix, 23 June 1976, 1 M. Quebec: Aylmer, 21 June 1915, 1 M. Covey Hill, July 1921, 1 F; 24 Aug. 1921, 1 F. Fort Coulonge, 27 June 1919, 1 M. Hull, 26 Aug. 1894, 1 F; 31 Aug. 1907, 1 F; 13 Aug. 1913, 1 F; 14 June 1914, 1 M; 1 July 1914, 1 M. St. Jean, 28 Sept. 1915, 1 F. Shawbridge, 20 July 1930, 1 F. Terrebonne, 29 July 1931, 1 F. Ontario: Arkell, 25 July 1952, 1 M; 19 Aug. 1952, 2; 4 July 1953, 2; 11 Aug. 1953, 1 M; 6 Aug. 1963, 1 M. Brittania, 14 Aug. 1913, 1; 1 Sept. 1913, 2 F. Cayuga, 6 Aug. 1952; 25 Aug. 1952, 3. Chatham, 24 Aug. 1913, 1 F. Crown Point, 1 July 1931, 1 M. Dorset, 20 July 1961, 2 F. Dyers Bay, 28 July, 1951, 1 M, 1 F; 4 Sept. 1951, 5; 5 Sept. 1951, 2, 2 M; 8 July 1952, 1 M; 10 July 1952, 2; 28 July 1952, 2; 23 Aug. 1952, 1; 8 July 1953, 1; 14 July 1953, 1; 15 July 1953, 1; 16 July 1953, 1; 31 July 1953, 1; 8 Aug. 1953, 1; 18 Aug. 1953, 1 M; 9 July 1954, 1 M; 16 July 1954, 3; 17 July 1954, 2; 18 July 1954, 3; 20 July 1954, 1 M; 22 July 1956, 1 M. E. Ontario, 15 July 1957, 1. Galt, 8 Aug. 1952, 1 M. Guelph, 14 June 1952, 1 M; 8 June 1964, 1 M; 19 July 1965, 1 M. Haileybury, 4 July 1916, 1 M. Harrow, 28 Aug. 1952, 1 F. Jordan, 4 Aug. 1914, 1 M; 22 Aug. 1914, 1 M. Marmora, 6 July 1939, 1 F; July 1946, 1 F; 23 June 1974, 1; 16 July 1976, 1. Midland, 23 June 1974, 1 M. Milgrove, July 1949, 1. Ottawa, 14 Aug. 1884, 1; 1 July 1913, 1; 11 July 1913, 1; 12 July 1913, 1; 14 Aug. 1913, 1; 15 Aug. 1913, 1; 30 Aug. 1913, 1; 1 Sept. 1913, 1; 12 Aug. 1914, 2, 1 M; 23 Aug. 1914, 1; 12 Sept. 1914, 1. Primrose, 17 July 1938, 1; 17 July 1956, 1. Quarries, 13 July 1946, 1. Speedside, 8 July 1965, 1. Spencerville, 17 July 1938, 1; 17 Aug. 1938, 1; 22 Aug. 1938, 1; 12 July 1939, 1 M. Wellington, 28 Aug. 1954, 1 M. Alberta: Irwine, 1 Aug. 1952, 1 F. Lethbridge, 3 July 1952, 1 F; 25 June 1962, 1 F. McGrath, 14 Sept. 1951, 1. Medicine Hat, 23 Aug. 1919, 1. Rolling Hills, 20 July 1946, 1 F; 10 Aug. 1946, 1 F. Scandia, 4 Aug. 1948, 1 F; 26 July 1951, 1 F; 13 July 1956, 1 M. Seven Persons, 1 Aug. 1952, 1 F. Tilley, 8 July 1939, 1 F. Wild Horse, 15 July 1931, i F; 4 Aug. 1952, 1 M. British Columbia: Fairview, 21 Aug. 1919, 1 M. Oliver, 23 Aug. 1953, 1. Osoyoos, 10 June 1919, 1 M. Penticton, 22 June 1919, 1 M; 9 Aug. 1916, 1 M; 10 Aug. 1916, 2 M; 1917, 1 M; 20 July 1917, 1 M; 20 July 1917, 1 M. Vernon, 8 June, 1 M.



Map 1. Canadian distribution of Megachile brevis.

FLOWERS VISITED. Allium cepa (Leek),(P); Amorpha, (ML); Asclepias (Milkweed), (M); Aster, (M, ML); Astragalus (Milk-Vetch), (M); Bidens (Bur-Marigold), (M); Campanula (Harebell),(M); Ceanothus (Redroot), (M); Cephalanthus (Buttonbush), (M); Chrysanthemum (Chrysanthemum), (M); C. leucanthemum, (P); Cichorium (Chicory), (CL); Cicuta (Water Hemlock), (M); Coreopsis (Coreopsis), (M); Cornus (Dogwood), (M); Cynoglossum (Hound's Tongue), (M); Desmodium (Tick-Trefoil), (M); Dianthera (Water-Willow), (M): Echium (Vipers Bugloss), (L); Epilobium (Frieweed),)L); Erechtites (Fireweed), (M); Erigeron (Fleabane), (M); Eupatorium (Thoroughwort), (M); Fagopyrum (Buckwheat), (M); Gerardia (Gerardia), (M); Grindelia (Gumweed), (L); Helenium (Sneeze-weed), (M); Helianthus (Sunflower), (M, ML); Hieracium

(Hawkweed), (M); Heliopsis (Ox-Eye), (M); Hibiscus (Rose-Mallow), (M); Hydrophyllum (Waterleaf), (M); Hypericum (St. John's-wort), (M); H. perforatum, (P); Impatiens (Balsam), (M); Inula helenium (Elecampane), (P); Lactuca (Lettuce), (M); Lespedeza (Bush-Clover), (M); Linaria (Toad-flax), (M); Lippia (Ontario only), (M); Lobelia (Lobelia), (M); Ludvigia (False Loosestrife), (M); Lupinus (Lupine), (M); Lycopus (Bugleweed), (M); Marrubium (Horehound), (M); Medicago sativa (Alfalfa), (L, M, ML, P); Melilotus (Sweet Clover), (L, M, P); M. alba, (P); M. officinalis, (P); Nepeta (Catmint), (M); Oenothra (Evening Primrose), (M); Penstemon (Beard-Tongue), (M, ML); Petalostemum (Prairie-Clover), (M); Phystostegia (False Dragonhead), (M); Polygonum (Knotweed), (M); Potentilla (Cinquefoil), (L); P. recta, (P); Psoralea (Scurf-Pea), (M); Pycanthemum (Mountain-Mint), (M); Ratibida (Prairie Coneflower), (M); Rhus (Poison-Ivy), (M); R. typhina, (P); Ribes (Currant), (ML); Rosa (Rose), (M, ML); Rubus (Bramble), (M); Rudbeckia (Coneflower), (M); R. serotina (Black-eyed Susan), (ML); Ruellia (Ruellia), (M); Sabatia (Sabatia), (M); Sagittaria (Arrowhead), (M); Salvia (Sage), (M); Scutellaria (Skullcap), (M); Silphium (Rosinweed), (M); Solidago (Goldenrod), (M, ML, P); Spiraea (Spiraea), (ML); Stachys (Hedge-Nettle), (M); Strophostyles (Wild Bean), (M); Teucrium (Germander), (M); Tradescantia (Spiderwort), (M); Trifolium (Trefoil), (ML); Verbena (Vervain), (M).

BIOLOGY. Extensive studies of M. brevis were carried out in Kansas by Michener (1953) and in southern Ontario by Pengelly (1955). It appears that biologically and morphologically, these bees have adapted to inhabiting warmer regions where persistent, hot, dry winds, such as in Kansas, hasten and curtail prolonged blossoming periods of wild plant species. Females fly over long distances, as far as several kilometres (Michener, 1953) constantly seeking out new areas with flowering plants. Expeditiously, they construct cells in preexisting holes or cavities in the stems of woody, herbaceous plants such as sumac, sunflower, thistle or cornstalks, or such fragile sites as a rolled leaf of a plum tree. In Kansas, they are the most common leaf-cutter bee; producing several generations, foraging upon a wide range of flowers and persisting from mid-June until autumn frost. In southern Ontario, Pengelly (1955) reported one generation per year, with nesting sites in cracks and crevices in the soil, under rocks and basal leaves of growing plants. Some tunnels under rocks were 7-20 cm in length. One to three cells, made with 50-103 sections of leaves and petals, were constructed at the base of the tunnel.

Males do not have elaborate front legs for defending territories, such as favoured perches with bare black soil, on which they land to warm up in the morning (Bohart, 1954). It may be that in warmer and drier regions, where this species is most prevalent, the need to defend such territories is less important than in cool, damp, northern regions.

PARASITES AND PREDATORS. Expeditious nesting habits of building cells in pre-existing cavities and hollows in prostrate plant stems, or cracks and crevices in the soil are easily penetrated or subject to invasions of ants, beetles and other arthropods. Thus, the increased reproductive rates arising from acceptance of fragile and hazardous nesting sites and the production of several generations per year, may be offset by an increased rate of mortality. Pengelly (1955) observed abandoned nests and reported that a female did not return to a nest which was raided and looted by ants. M. brevis has been observed to have been parasitized by Coelioxys octodentata Say (Hicks, 1926; Michener, 1953 and Pengelly, 1955).

ALFALFA POLLINATING POTENTIAL. Numerous reports indicate that M. brevis is a highly efficient pollinator of alfalfa, visiting around 15 flowers per minute, tripping and cross-pollinating over 95% of the flowers visited (Peck and Bolton, 1946; Michener, 1953; Pengelly, 1953, 1955; Bohart, 1957). The adult life of M. brevis female, emerging in mid-June and persisting until autumn, coincides with the flowering period of alfalfa grown in Canada. Michener (1953) in Kansas and Medler and Lussenhop in Wisconsin, observed M. brevis to adopt pre-existing hollows or cavities in various plant stems, such as sunflowers, thistles and cornstalks, in which to make their nests. Man-made nesting sites, constructed of sheaves or bundles of stems of such plants, could be mounted on legs coated with a greasy substance to prevent ants from crawling into them, and to facilitate their transport to alfalfa field requiring pollinators.

In southern Ontario, Pengelly (1955) reported leaves and petals taken from the following plants for cell construction: Acer nigrum (Black Maple); Apocynum androsaemifolium (Spreading Dogbane); Chrysanthemum leucnathemum (Ox-eye Daisy); Fragaria vesca (Strawberry); Fraxinus pennsylvanica (Green Ash); Gaillardia (Blanket-flower); Hypericum perforatum (St. John's-wort); Potentilla recta (Cinquefoil); Prunus americana (Chokecherry); Rhus typhina (Staghorn Sumac); Rosa (Wild Rose); Viola tricolor (Pansy). In Kansas, Michener (1953) observed M. brevis to select 12 families of plants from which leaves or petals were used to make the cells. Since the wide range of plants used included alfalfa, it may be that this species might be propagated without having to grow a secondary plant for cell construction.

Limitations to the propagation of M. brevis as an alfalfa pollinator may arise from its distribution pattern. It is sparsely scattered along the extreme southern parts of Canada. Whether it could be propagated in more northern regions is unknown. Another disadvantage to using M. brevis may be its attraction to a wide variety of flowering plants, including common field weeds such as thistles.

MEGACHILE (*LITOMEGACHILE*) *ONOBRYCHIDIS* COCKERELL

Map 2

Megachile onobrychidis Cockerell, 1908:266 (new species)

Megachile (*Litomegachile*) *brevis* var. *onobrychidis*; Mitchell, 1936:18 (description, distribution and flower records)

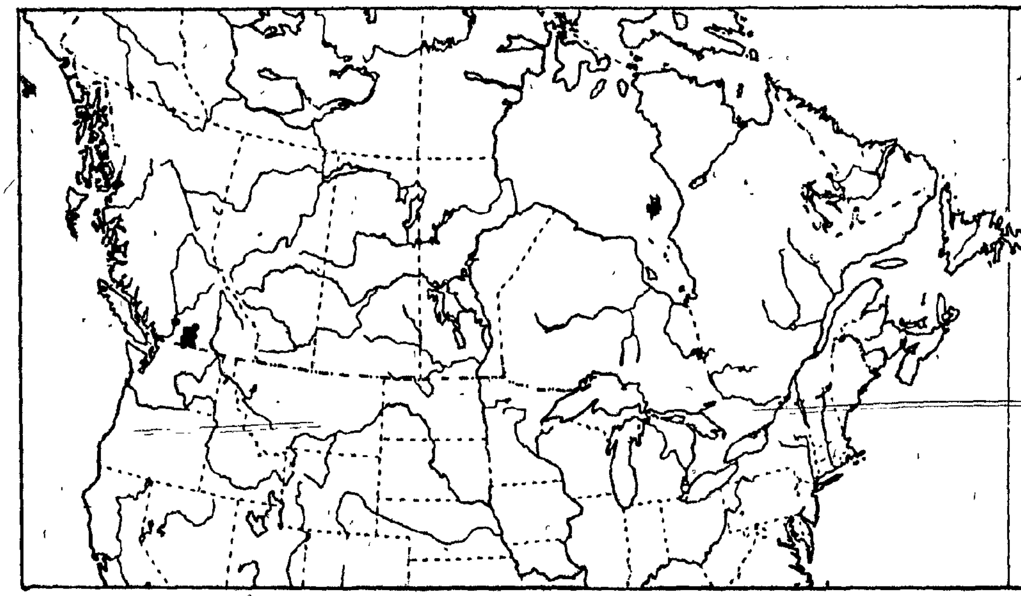
FEMALE. Length 10-11 mm. Mandibular emargination between 3rd and 4th denticles evenly arcuate or semicircular, with its greatest depth at midpoint. Apical margin of clypeus slightly reflexed and truncate medially. Gradulus on tergum V indistinct or absent medially. Discal pubescence on terga I and II entirely white, both medially and laterally; on terga III-V intermixed with black, and with black bristles on tergum V laterally.

MALE. Length 9 mm. Apex of clypeus slightly concave medially, beneath the elongate clypeal beard. Longitudinal row of short hairs on antero-ventral side of front basitarsus weakly developed. Front coxa with a minute patch of bristles scattered among the elongate, plumose pubescence just anterior to the coxal spine.

COMMENT. Females of this species closely resemble, and can be recognized by the same combination of characters given for *M. brevis* except that in *M. onobrychidis* the scopal hairs on sternum VI are entirely black. *M. onobrychidis* also approaches *M. coquilletti* in that both species lack black bristles laterally on terga II-IV and in having black hairs on both tergum and sternum VI; however, *M. onobrychidis* does not have carinate graduli on terga II-IV, which are present in *M. coquilletti*. *M. onobrychidis* is also generally slightly smaller with the front wing ranging from 6-7 mm while in *M. coquilletti* this ranges from 8-9 mm.

Males of *M. onobrychidis* also closely resemble the males of *M. brevis* and can be distinguished by the same combination of characters given for *M. brevis*, except that the pale tomentum which obscures the integument, just above the transverse carina on tergum VI, is absent in *M. onobrychidis* and occupied by a mixture of slender and minute plumose hairs which do not obscure the integument beneath.

DISTRIBUTION. British Columbia: Summerland, 9 July 1916, 1 M. Fairview, 7 Aug. 1919, 1 M. Vaseaux L., 14 June 1919, 1 M. Okanagan Falls, 21 July 1917, 1 F.



Map 2. Distribution of Megachile onobrychidis.

FLOWERS VISITED. Mendicago (Alfalfa).

BIOLOGY. M. onobrychidis is rarely collected and little is known about its biology. It is believed that it nests in soil cracks under clods of earth and stones, and prefers foraging on alfalfa (Bohart, 1957).

MEGACHILE (LITOMEGACHILE) COQUILLETTI COCKERELL

Map 3

Megachile mendica coquilletti Cockerell, 1915:535
(new subspecies)

Megachile (Litomegachile) coquilletti; Mitchell, 1935:21,
(description and distribution)

FEMALE. Length 11-12 mm. Mandible 4-dentate; emargination of the outer cutting edge between the 3rd and 4th denticles not evenly arcuate, with the basal half of the emargination nearly straight to slightly convex. Ventral profile of mandible gently curved, with the outer (1st) tooth weakly reflexed posteriorly, and relatively distant from 2nd tooth. Lateral ocellus nearly subequally distant between posterior margin of vertex and eye, to a little closer to vertex than to eye. Scutellum, black, pubescent medially. Gradular carina on tergum V well developed and not interrupted medially. Tergum VI weakly concave in profile with appressed and scattered, suberect brown hairs. Sternum VI with brown to black scopal hairs.

MALE. Length 10-11 mm. Front tarsal segments beyond the first, conspicuously yellowish-ferruginous, strikingly contrasting with dark brown basitarsus. Anterior side of front basitarsus flattened, occupied by a band of short, slender setae bordered on each side by dense, distinctly longer bristles. Gradular grooves in terga II-V deeply impressed with gradular carinae well developed. Postmedian transverse carina on tergum VI medially emarginate.

COMMENT. The female can be recognized by the combination of characters given for M. brevis except that the terga II-V bear distinct, gradular carinae; both tergum and sternum VI are entirely black, pubescent; postmedian transverse depression on tergum VI is less pronounced than in M. brevis. The species M. coquilletti and M. onobrychidis are transitional between M. mendica and M. brevis. M. coquilletti can be separated from M. onobrychidis by the presence of a distinct, gradular carinae on tergum V, which is absent in M. onobrychidis. It can be separated from M. mendica by the absence of a distinct angulation in the outer cutting edge between the 3rd and 4th denticles (although a minute angulation or convexity is present) and tergum VI, which is more distinctly concave in profile in M. coquilletti.

The male can be recognized by the narrow and distinctly yellowish-ferruginous tarsal segments 2-4 on front leg, which contrast conspicuously with the dark brown first tarsal segment. Males resemble and can be differentiated by the same combination of characters given for M. brevis.

DISTRIBUTION. British Columbia: Okanagan Falls, 21 July, 1917, 1 F, 1 M. (Map 3).

FLOWERS VISITED. Mendicago (Alfalfa), Eriogonum (Umbrella-Plant), (M).

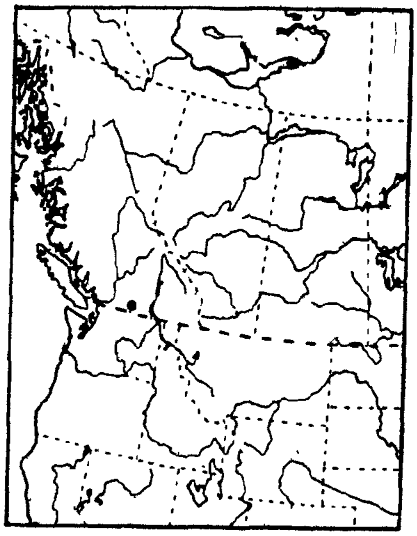
BIOLOGY. Bohart (1957) proposed that M. coquilletti probably nests in the soil.

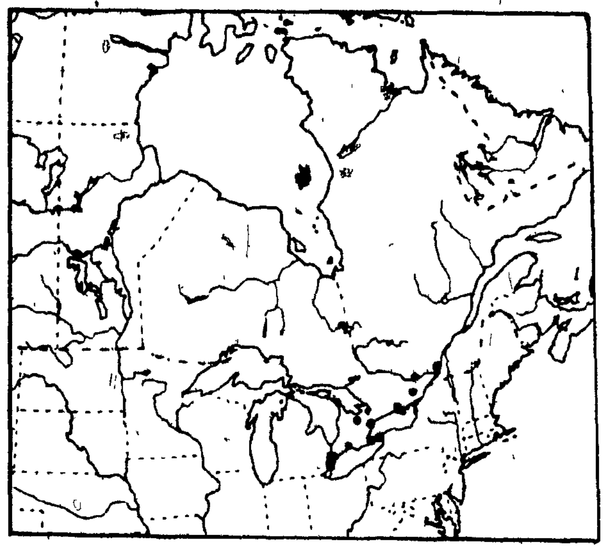
ALFALFA POLLINATING POTENTIAL. The species trips about 98% of the alfalfa flowers it visits (Bohart, 1957) and emerges in mid-June (an appropriate time for alfalfa pollination). However, it occurs only in southern British Columbia and is rarely collected.

Opposite p. 96

Fig. 8. M. mendica, F.
Face View

Fig. 9. M. mendica, F.
Mandible.





Map 3. Distribution of Megachile coquilletti (left).

Map 4. Distribution of Megachile mendica (right).

MEGACHILE (LITOMEGACHILE) MENDICA CRESSON

Figures 8, 9, 55; Map 4

Megachile mendica Cresson, 1878:126 (new species)

Megachile (Litomegachile) mendica; Mitchell, 1962:117 (description, distribution and flower records)

Megachile mendica; Medler, 1965:113 (biology)

Megachile mendica; Krombein, 1967:322 (biology)

FEMALE. Length 11-13 mm. Mandible 4-dentate, with the basal half of the emargination between the 3rd and 4th denticles occupied by the elevated outer cutting edge extending outwardly from the 4th tooth (Fig. 55). Outer margin of 1st tooth reflexed posteriorly and tapered apically to a sharply rounded point. Apical margin of clypeus thickened, polished and broadly truncate. Last two antennal segments subequal in length. Mesoscutum and scutellum mostly black pubescence. Terga II-VI with erect, black hairs laterally. First tergum with elongate, suberect and entirely pale pubescence; tergum II with pale pubescence medially. Discs of terga III-V with brown to black pubescence. Apical fasciae present on terga II-V usually absent medially on the more anterior terga.

MALE. Length 9-11 mm. Hypostomal concavity, just posterior to lower mandibular condyle, weakly depressed, occupied by short hairs and bordered posteriorly by dense, elongate pubescence. Median third of apex of clypeus protracted a little ventrally and truncate to slightly concave medially; apical border of clypeus impunctate and shining beneath the dense overhanging pubescence. Anterior side of front basitarsus with a longitudinal band of short, slender setae, bordered on each side by long, dense bristles. Ventral mandibular tooth triangular and acute terminally, with a dense tuft of bristles at its apex. Gradular carinae on terga II-IV projecting posteriorly to narrowly overlap the anterior margins of the gradular grooves. White, apical fasciae present on terga II-IV, absent on tergum V. Postmedian transverse carinae on tergum VI semicircularly emarginate medially (cf. Fig. 12); area above the carina concealed beneath dense, appressed, plumose pubescence medially.

COMMENT. The female can be recognized by the following combination of characters: Mandible 4-dentate with the apical half of the inner margin of mandible approximately straight to the apex of the 4th tooth, forming an acute angle with the outer cutting edge; outer cutting edge extending halfway from the 4th to the 3rd tooth, and forming an angle at mid-point between the two teeth. Outer side of 3rd mandibular tooth with an extended bevelled edge occupying about half the emargination between the 2nd and 3rd teeth; apical border of clypeus truncate without prominent tubercles; abdominal sterna II-V without white apical fasciae beneath the scopa; tergum VII nearly straight in lateral view, with a broad median longitudinal area consisting of uniformly short, brown appressed pubescence, which partially obscures the surface.

Megachile mendica resembles M. montivaga; however, M. mendica can be separated by the presence of a bevelled edge extending from the outer side of the 3rd mandibular denticle and occupying the proximal half of the concavity between the 2nd and 3rd denticles. M. mendica also approaches M. rotundata morphologically; however M. rotundata can be separated by the presence of white, apical fasciae on sterna II-V beneath the scopa, and the opaque ovate wing pad laterally on tergum II.

The male can be recognized by the following combination of characters: front tarsus dark and simple with basitarsus much narrower and shorter than its tibia; front coxal spine well developed, although sometimes partly hidden by the elongate pubescence; tergum II without an opaque, ovate wing pad laterally; tergum V not usually fasciate apically; median teeth on the apical margin of tergum VI subequally distant, or nearer to each other, than to the lateral teeth; sternum IV not retracted beneath sternum III; postmedian transverse carina on tergum VI deeply emarginate medially; disc of tergum VI just above postmedian transverse carina, covered with dense pale tomentum which conceals the integument beneath; tergum VII carinate, without a distinct spine medially.

Males within the subgenus Litomegachile do not bear distinctive morphological characters by which the various species can be readily differentiated. The males of M. mendica resemble the males of M. texana by the distinct semicircular emargination in the postmedian transverse carina on tergum VI; however, M. mendica can be separated by the distance between the median and lateral teeth at the apex of tergum VI with the median teeth being closer or as far away from each other as the distance between the median and lateral tooth.

DISTRIBUTION. Quebec: Old Chelsea, 16 Sept. 1958, 1 F. St-Anne's, 20 Aug. 1939, 1 M. Ontario: Bellevile, 1 July 1950, 1 F. Chatham, 24 Aug. 1913, 1 F. Dyers Bay, 24 July 1954, 1 F. Grimsby, 11 July 1955, 1 F. Perth, 25 Aug. 1957, 1 F. Point Pelee, 23 Aug. 1951, 1 M; 8 Sept. 1954, 1 F, 1 M; 9 Sept. 1964, 4 F, 1 M. Primrose, 22 July 1955, 1 F. St. Thomas, 15 Aug. 1924, 1 F. Sambra, 15 July 1952, 1 F. Toronto, 25 Aug. 1893, 1 F. Vineland, June 1956, 1 F.

FLOWERS VISITED. Agastache (Giant Hyssop), (M); Amorpha, (M, ML); Apios (Groundnut), (M); Aralia (Angelica-Tree), (M); Asclepias (Milkweed), (M, ML); Aster (Aster), (M); Baptisia (False Indigo), (M); Bidens (Bur-Marigold), (M); Blephilia (Wood-Mint), (M); Borrichia (Sea Ox-Eye), (M); Brassica nigra, (ML); Camassia (Wild Hyacinth), (M); Ceanothus (Redroot), (M); Chrysanthemum (Chrysanthemum), (M); Chrysopsis (Golden Aster), (M); Cicuta (Water-Hemlock), (M); Cirsium (Thistle), (M); C. muticum (Swamp-Thistle), (ML); Clematis (Clematis), (M); Cosmos (Cosmos), (M); Crataegus (Hawthorn), (M);

Daucus (Carrot), (M); Desmodium (Tick-Trefoil), (M); Erigeron (Fleabane), (M); Eriogonum (Umbrella-Plant), (M); Eupatorium (Thoroughwort), (M); Gaura Gerardia (Gerardia), (M); Helianthus (Sunflower) (M); Heliopsis helianthoides (Sweet), (ML); Hypericum (St. John's-Wort), (M); Ilex (Holly), (M); Impatiens (Balsam), (M); Itea (Virginia-Willow), (M); Lespedeza (Bush-Clover), (M); Lotus corniculatus (Birdsfoot-Trefoil), (P); Lycopus (Bugleweed), (M); Lythrum (Loosestrife), (M); Medicago (Alfalfa), (M); Melilotus (Sweet Clover), (M); Monarda (Horsemint), (M); M. fistulosa (Wild Bergamot), (ML); Nepeta (Catmint), (M); Nyssa (Sour Gum), (M); Oenothera (Evening-Primrose), (M); Opuntia (Indian Fig), (M); Polygonum (Knotweed), (M); Prunella (Selfheal), (M); Psedera (Virgina Creeper), (M); Pycnanthemum (Mountain Mint), (M); Ratibida (Prairie Coneflower), (M); Rhus (Poison Ivy), (M); Rosa (Rose), (M); Rubus (Bramble), (M); Rudbeckia (Coneflower), (M); R. serotina (Black-eyed Susan), (ML); Salix (Willow), (M); Senecio (Groundsel), (M); Silphium (Rosinweed), (M); Solidago (Goldenrod), (M, ML); Specularia (Venus's Looking-Glass), (M); Spiraea, (M); Stachys (Hedge-Nettle), (M); Strophostyles (Wild Bean), (M); Symphoricarpus (Snowberry), (M); Tephrosia (Hoary Pea), (M); Teucrium (Germander), (M); Trifolium (Trefoil), (M); Vaccinium(Blueberry), (M); Verbena (Vervain), (M); Veronica (Ironweed), (M); Veronicastrum *virginicum* (Culver's root), (ML); *Vicia* (Vetch), (M); *Zinnia* (Zinnia), (M).

BIOLOGY. In Wisconsin, *M. mendica* inhabits experimental trap-nests attached to isolated trees in meadows, or to trees at the edges of woods bordered by large fields. This species nests in tunnels made in wood and is attracted to nesting in sumac stems (Medler, 1965). The tunnels contain about six cells with females deposited first on the inner cells and males on the outer cells. Males which are deposited last in the outer cells, emerge a few days ahead of the females.

PARASITES. *Coelioxys octodentata*, *C. sayi* and *Anthrax* sp. (Medler, 1965; Krombein, 1967).

ALFALFA POLLINATING POTENTIAL. Females have been collected on alfalfa and in Iowa it is an important pollinator of alfalfa (Bohart, 1957). Since they inhabit man-made holes in wood 5-8 mm in diameter, they may inhabit nests similar to those currently being used for *M. rotundata*, which would facilitate transport to fields requiring pollination. Currently, however, their distribution is limited to the extreme southern parts of Ontario and Quebec, and even there they are rarely found (Pengelly, 1955).

Opposite p. 103

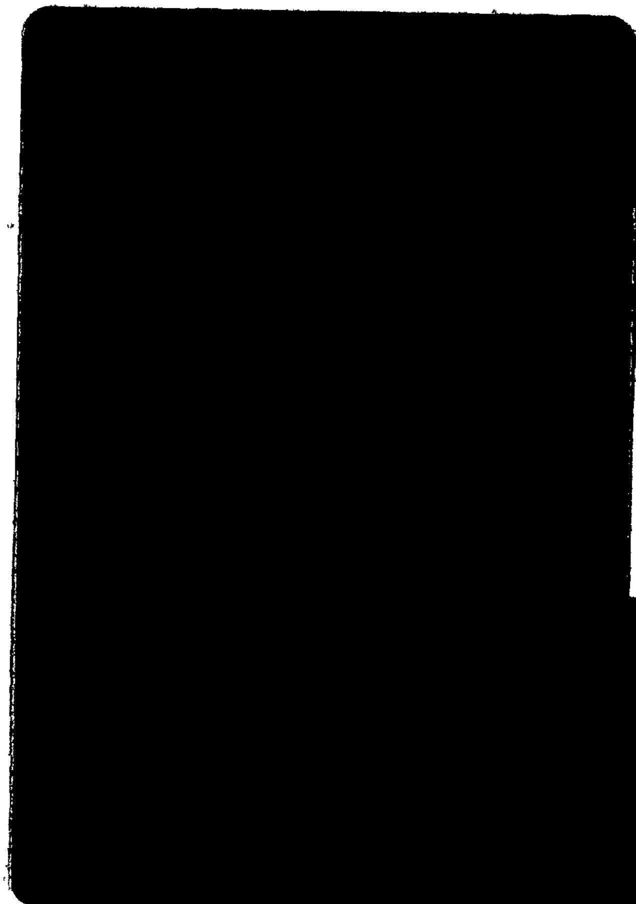


Fig. 10. *M. texana*, F. Mandible worn down from digging nesting burrows.

Fig. 11. *M. texana*, F. Complete mandible of a young female.

MEGACHILE (LITOMEGACHILE) TEXANA CRESSON

Figures 10-12, 40, 42, 56; Map 5

Megachile texana Cresson, 1878:125 (new species)

Megachile (Litomegachile) texana; Mitchell, 1935:32 (description, distribution and flower records)

Megachile (Litomegachile) texana var. cleomis; Mitchell, 1935:36 (description and distribution)

Megachile (Litomegachile) texana; Pengelly, 1955:68 (biology); Mitchell, 1962:118 (description, distribution and flower records)

FEMALE. Length 11-14 mm. First mandibular tooth reflexed along the outer side, flattened and aligned to form a nearly straight line with the succeeding teeth. Moderately flattened 1st tooth usually a little wider at the base than the 2nd tooth. Arcuate emargination between 3rd and 4th mandibular teeth deepest at midpoint of slightly nearer to the 4th tooth. Apical margin of clypeus broadly truncate, weakly reflexed; polished and impunctate median band, extending a little over half the distance to the lateral margin. Erect pubescence on terga II-V mostly black, with enlarged and conspicuous black bristles laterally; apical bands bearing the white fasciae strongly depressed laterally. Tergum VI strongly depressed just beyond the middle, usually with scattered,

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Fig. 12. M. texana, M. Postmedian transverse carina on tergum VI emarginate medially.

Fig. 13. M. wheeleri M. Postmedian transverse carina on tergum VI obtusely angulate or rounded apically.

long, erect, brown hairs, intermixed with brown and white, suberect and short, appressed hairs. Scopal hairs usually black laterally on sternum V and mostly black on sternum VI. Dorsal side of hind femur with a lanceolate patch of short, dense pubescence.

MALE. Length 10-12 mm. Hypostomal concavity weakly depressed just behind the posterior mandibular condyle, the concavity occupied by short plumose hairs and bordered posteriorly by much longer pubescence. Antero-ventral side of front basitarsus with a longitudinal row of short hairs bordered on each side by a distinctly longer brush of bristles (cf. Fig. 41) Front coxa with scattered bristles, beneath the long plumose hairs just anterior to the spine. Apical border of tergum V strongly depressed, producing a prominent vertical wall anteriorly, which is more pronounced laterally, but is also usually present medially. Terga II-VI with sharply carinate graduli projecting posteriorly and overhanging the transverse basal grooves.

COMMENT. The female of <u>M. texana</u> can be recognized by the 4-dentate mandible, with the outer cutting edge between the 3rd and 4th teeth arcuately emarginate; emargination descending a little below and exposing the almost straight inner cutting edge, which can be seen when the mandible is viewed from the outer side (Figs. 11, 56); emargination between the 2nd and 3rd teeth usually with a bevelled edge extending from the outer side of the 3rd tooth; apical border of clypeus truncate, without prominent tubercles; terga II-VI with prominent black bristles laterally; terga II-V usually with small carinate graduli projecting posteriorly and narrowly overhanging the transverse basal grooves; tergum VI with a strongly impressed transverse concavity just beyond the middle; abdominal sterna II-V without dense, white, apical fasciae beneath the scopa.

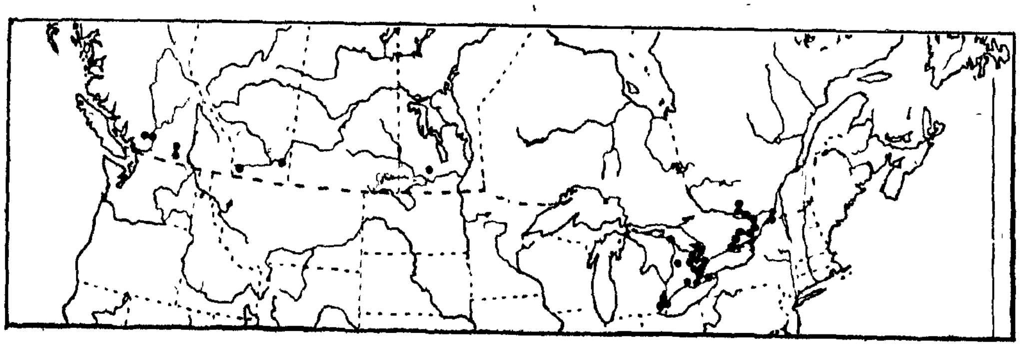
Females of M. texana approach M. mendica in having black hairs laterally on terga II-VI; however, M. mendica can be separated by the straight profile of tergum VI and the angulation in the outer cutting edge between the 3rd and 4th denticles (Fig. 55). It also approaches M. rotundata: however, M. rotundata can be separated by the apical fasciae beneath the scopa on sterna II-V (Fig. 15).

Males of M. texana can be recognized by the following combination of characters: front tarsi brown to black and simple, with the basitarsus much narrower and shorter than its tibia; mandible 3-dentate with the apex of the median denticle a little closer to the outer tooth than to the inner tooth; postmedian trasnverse carina on tergum VI with a deep median semi-circular emargination (Fig. 12); front coxal spine well developed, although sometimes partly concealed by elongate pubescence; median teeth on apical margin of tergum VI a little nearer to the lateral denticles than to each other; second abdominal tergum without an opaque, ovate wing pad laterally; terga II-V with white, apical fasciae; area above the transverse carina on tergum VI with dense white tomentum medially, which mostly conceals the integument beneath (Fig. 12). Megachile (Litomegachile) texana variety cleomis Cockerell is synonymized with Megachile (Litomegachile) texana Cresson. The female of the variety cleomis is distinguished by the entirely white pubescence on tergum I. An examination of the type specimen revealed that some black hairs were also present on tergum I. Since the density of black hairs on tergum I is highly variable in M. texana, there does not appear to be any distinguishable criterion by which the variety cleomis merits segregation.

DISTRIBUTION. Quebec: Aylmer, 4 July 1924, 1 M. Covey Hill, July 1921, 1 M; 12 July 1924, 2 F. Hull, 28 June 1915, 2 M. Isle Jesus, 10 July 1932, 1 M. Kazabazua, 3 July 1913, 1 M; 4 Aug. 1913, 3F, 1M. Kirks Ferry, 13 July 1913, 1 F. Low, 2 Aug. 1948, 1 M. Montreal, 14 July 1885, 1 M; 20 Aug. 1928, 1 M; 16 July 1929, 1 M; 9 Aug. 1930, 1M; 24 Aug. 1930, 1 M;

11 Aug. 1932, 1 F. Ste.Anne de Bellevue, 3 Aug. 1938, 1 M; 10 July 1939, 1 F; June, 1964, 1 F; 4 Aug. 1965, 1 F; 9 Aug. 1965, 1 F; 28 Aug. 1967, 1 M. Ontario: Belleville, 1 July 1950, 6 M. Camp Borden, 22 July, 1952, 4 F. Chatham, 24 Aug. 1913, 1 M. Cheltenham, 24 July 1951. Dunedin, 22 July 1952. Dyer Bay, 5 Sept. 1951, 1 F; 10 July 1952, 1 F; 21 July 1952; 28 July 1952, 2 F, 1 M; 29 July 1952, 1 F; 12 Aug. 1952, 1 F; 8 July 1953, 1 M; 21 July 1953, 1 M; 25 July 1953; 29 July 1953, 1 M; 31 July 1953, 1 F; 25 Aug. 1953, 1 F; 1 July 1954, 1 M; 13 July 1954, 1 M; 14 July 1954 1 M; 17 July 1954, 1 M; 24 July 1954. Grimsby, 11 July 1955, 4 M. Guelph, 19 July 1965, 1 M; 8 July 1974, 1 M; 19 July 1974. Kinburn, 26 July 1957, 1 M. Maple, 18 July 1884, 1 F. Marmora, 18 July 1957, 1 F. Merivale, 16 Aug. 1930, 1 F. Midland, 14 July 1924; 14 July 1974. Milgrove, May 1949, 1 M. Normandale, 30 June 1956, 1 M. Orangeville, 9 July 1954, 1 M. Ottawa, 10 July 1912, 1 F; 1 July 1913; 26 July 1913, 1 F; 14 June 1915, 1 M; 29 July 1955, 1 F; 15 July 1957, 1 F; 28 June 1962, 1 M; 14 July 1962, 1 M; 13 June 1963, 1 M; 15 July 1968, 1 F; 17 July 1968, 3 F; 23 Aug. 1968, 2 F; 9 June 1969, 2 M; 20 Aug. 1969, 1 F. Perth Road, 25 Aug. 1957. Point Pelee, 9 July 1920, 7 F; 13 July 1920, 5 F, 1 M; 26 July 1920, 2 F; 15 Aug. 1920, 1 F; 4 July 1927, 2 F; 8 Sept. 1954, 1 F, 3 M; 9 Sept. 1954, 1 F; 23 Aug. 1961. Primrose, 22 July 1953, 1 M; 30 June 1955, 1 M; 17 July 1956,

1 M. Puslinch, 8 Aug. 1951. Rosseau, 7 Sept. 1963, 1 F. St. Thomas, 15 Aug. 1924, 2 M. Sambra, 15 July 1952, 5 M. Scuttle Hole, 5 July 1942, 1 F. Spencerville, 12 July 1939, 1 F. Toronto, 24 Aug. 1890, 1 F; 21 Jan. 1891, 1 F; 11 July 1893, 1 M; 25 Aug. 1893, 1 M; 10 Aug. 1957, 1 F. Turkey Point, 13 Aug. 1968, 1 M. Tweed, 6 July 1944, 1 F, 1 M. Manitoba: Aweme, 15 July 1915; 15 July 1916, 1 M; 1 Aug. 1925. Bald Head Hills, 31 July 1958, 1 F. Douglas, 27 July 1958, 1 F. Onah, 4 Aug. 1925, 1F; Alberta: Lethbridge, 28 June, 1914; 4 Aug. 1914, 1F; 28 July 1916, 1F, 1M; 28 July 1918; 28 July 1952, 1F; 30 July 1952; 31 July 1952, 2F; 15 July 1959, 1F. Medicine Hat, 15 July 1917, 1M: 1 Aug. 1917, 1F, 1M. British Columbia: Hatziq Lake, 24 July 1953, 1F. Lillooet, 20 June 1926, 2F; 26 June 1950. Penticton, 19 June 1918, 1F. Seton Lake, 28 June 1926, 1F. Summerland, 20 July 1917, 2F. Vernon, 26 July 1920, 1M; 10 July 1950, 1F.



Map 5. Distribution of *Megachile texana*

FLOWERS VISITED. *Amorpha canescens* (Leadplant), (ML); *Aster*, (M); *Asclepias* (Milkweed), (M,ML); *Baptisia* (False Indigo), (M); *Blephilia* (Wood-Mint), (M); *Cirsium* (Plumed Thistle), (ML); *Dianthera* (Water Willow), (M); *Eupatorium* (Thoroughwort), (M); *Fagopyrum sagittatum* (Buckwheat), (P); *Helianthus* (Sunflower), (M); *Heliopsis helianthoides* (Ox-Eye), (ML); *Inula helenium* (Elecampane), (P); *Liatris* (Button snakeroot), (M); *Medicago* (Alfalfa), (M); *M. sativa* (Alfalfa), (M); *Melilotus* (Sweet Clover), (M); *M. alba* (White Sweet Clover), (P); *M. officinalis* (Yellow Sweet Clover), (P); *Nepeta* (Catmint), (P); *Opuntia* (Prickly Pear), (M); *Petalostemum* (Prairie Clover), (M, ML); *Potentilla recta* (Cinquefoil), (P); *Primula* (Primrose), (L); *Psoralea* (Scurf Pea), (M); *Pycnanthemum* (Mountain Mint), (M); *Rhus* (Poison Ivy), (M); *Rubus* (Bramble), (M); *Silphium* (Rosinweed), (M); *Sonchus arvensis* (Sow-Thistle), (P); *Spiraea*, (ML); *Stachys* (Hedge Nettle), (M); *Strophostyles* (Wild Beam), (M); *Tephrosia* (Hoary Pea), (M); *Trifolium* (Clover), (M); *T. hybridum* (Alsike Clover), (ML, P), *T. repens* (White Clover), (M); *Verbena* (Vervain), (M); *Vicia* (Vetch), (M).

BIOLOGY. M. texana occurs in areas with wild uncultivated land. It excavates, burrows and makes its nests in the soil, under flat rocks, roots of plants (Pengelly, 1953, 1955) or in damp sand (Krombein, 1953). The burrows are about 10 cm. deep and are usually trough-shaped, making use of the stone as the ceiling. It is uncertain whether it will adopt a ready-made burrow, or is committed to digging one of its own. The strongly abraded cutting side of the mandible with the teeth totally worn down (Fig.10) indicates that the mandibles were worn down from grinding and excavating burrows in sandy or gravelly soil.(1)

One to three cells are constructed and provisioned within the burrow. Pengally (1955) observed that leaves from the following plants were used for constructing the cells: Acer nigrum (Sugar Maple), A. rubrum (Red Maple), Apocynum androsaemifolium (Spreading Dogbane), Corylus cornuta (Beaked Hazel), Fagus grandifolia (Beech), Lonicera tartarica (Honey-suckle), Rhus typhina (Staghorn Sumac) and Tilia americana (Basswood). Construction of the cylindrical cell in which circular sections of leaf (instead of oblong sections

(1) It is proposed that females which dig burrows in the soil cannot alternately chisel and excavate tunnels in wood with worn down and rounded mandibular teeth. The specimen was collected by the author on Asclepius (Milkweed) near Dows Lake, Ottawa, 27 July 1979.

drawn in to form the bottom) are used at base of the cup compares with the cell construction design used by M. parallela. Three to nine circular sections alternated with 9 to 26 oblong sections are used to form the bottom and walls of the cell. The margins of the outer leaves are not cemented with oral secretions but firmly appressed against the soil wall. Five to fifteen circular sections, slightly larger than the inner diameter of the cell, are firmly pressed in at the top to cap the cell.

About 10 loads of pollen, filling the 8 mm inner diameter of the cell to a depth of about 8 mm, are used to provision the cell (Pengelly, 1955). An egg approximately 0.5 mm in diameter and 3.5 mm in length is inserted on top of the provisions at an angle of 45^{o}. The egg hatches in about 3-1/2 days and the 1st to the 4th larval instars develop rapidly upon the provisions. The 4th or final instar spins a silken cocoon and overwinters within the cell (cf.Fig.7). Pupation and adult emergence which commences in mid June is probably regulated by spring and summer temperatures.

PARASITES AND PREDATORS. The common parasites of M. texana are: Coelioxys moesta, C. sodalis, C. octodentata and C. rufitarsis (Pengelly 1955).

Ants and crickets have been observed to invade the tunnels and rob the cells of M. texana of their provisions. Pengelly (1955) observed ants carrying pollen between their mandibles out of a nest belonging to this species. He also observed a cricket to occupy a burrow while the bee was out to secure leaf sections. As the bee endeavoured to re-enter her burrow, she was literally kicked out by the cricket several times by a distance of up to 30 cm.

ALFALFA POLLINATING POTENTIAL. M. texana species prefers to forage on alfalfa (Bohart 1957), visiting flowers at the rate of 16-22 per minute and tripping 85-95% of the flowers visited (Pengelly 1953, 1955; Bohart 1957). The beginning of adult emergence in mid June is close to or not far behind the beginning of the flowering period of alfalfa. The soil nesting habits exposes the species to the hazards of invasions by arthropods dwelling in the soil and also the limitations of not being able to transfer nests to nearby flowering alfalfa fields. The species might, however, be introduced to nest in road banks or strips of uncultivated land, with alfalfa planted alternate years to ensure an annual supply of blossoming alfalfa.

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Fig. 14. M. rotundata (The Domesticated Leaf-cutter Bee) M. Lateral view.

Fig. 15. M. rotundata, F. White, apical fasciae beneath the scopal hairs on sterna II-V.

MEGACHILE (EUTRICHARAEA) ROTUNDATA (FABRICIUS)

Figures 14, 15, 49, 51, 57, 73; Map 6

Apis rotundata Fabricius, 1787: 303 (new species) (= M. centuncularis Linnaeus)

Megachile (Eutricharaea) rotundata; Stephen and Torchio 1961: 85 (biology); Mitchell, 1962: 122 (description, distribution and flower records); Stephen, 1962: 2 (propagation and biology); Torchio, 1963: 70 (parasite); Waters, 1966: 1 (parasites, predators and nest destroyers); Torchio, 1972: 1 (parasite biology and control); Hobbs, 1973: 1 (biology and management); Eves and Johansen, 1974 (larval mortality); Parker et al, 1976 (assessment of usefulness, utilization of additional species).

FEMALE. Length 8-10 mm, the smallest introduced leaf-cutter bee currently present in Canada. Mandible 4-dentate. Angulate, bevelled, cutting edge extending from the outer side of the 3rd tooth to about the centre of the emargination between the 2nd and 3rd teeth absent. Outer cutting edge extending from the 4th to the 3rd tooth and forming an angle which approaches formation of a 5th tooth, at approximately mid-point between the two teeth (Fig. 57). Clypeus with a sparsely, punctate and subpolished median longitudinal band, terminating in a narrow impunctate border apically. Ovate, opaque and impunctate wing pad, laterally on tergum II. Discal pubescence on terga II - VI brown to black. Tergum VI weakly concave preapically with longer, suberect hairs scattered throughout the slender, short, appressed hairs; apex of tergum without a distinct, dense, apical fringe of hairs. Scopa, white on sterna II - V; black on sternum VI and often black laterally and apically on sternum V; sterna II - V with distinct white, apical fasciae beneath elongate and overhanging scopal hairs. Sternum I with an elevated and carinate preapical rim.

MALE. The male of M. rotundata like the female is smaller than any endemic Canadian species, ranging from 7-8 mm in length. Mandible 3-dentate, with the inner tooth flattened and extended inwardly; distance between the apices of the middle and inner teeth much greater than the distance between the apices of the middle and outer teeth (Fig. 73). Hypostomal tubercle just behind the posterior mandibular condyle not distinctly elevated. Apical margin of clypeus weakly emarginate medially. Front coxal spine well developed, with a patch of small brown bristles, on the anterior side, near the base. Front basitarsus dark and simple, much narrower and shorter than its tibia. Second tergum laterally, with an impunctate and opaque, ovate wing pad, bearing minute pubescence. Pubescence on tergum I reduced laterally in the wing rest region, just anterior to the opaque, ovate area on tergum II. Hind femur with a lanceolate patch of dense, short pubescence dorsally.

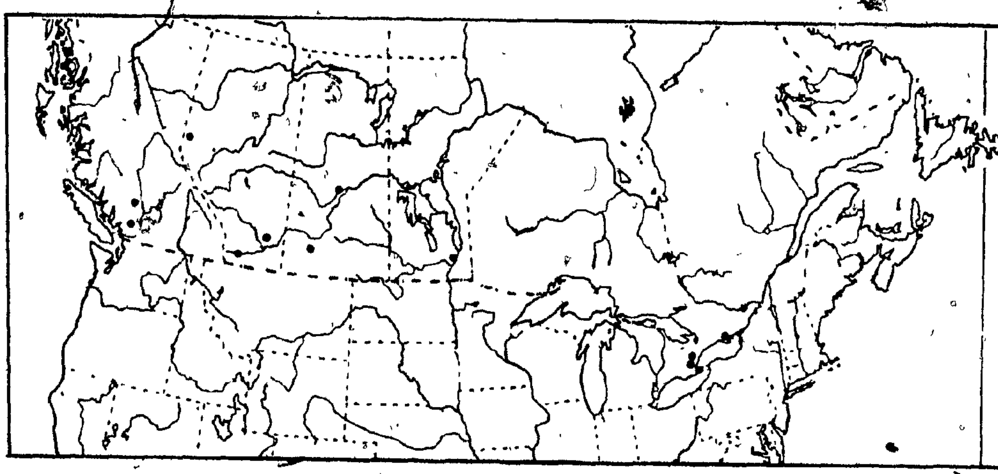
COMMENT. The female can be recognized by the distinct, white, apical fasciae on sternaII-V, beneath the scopal hairs (Fig.15); or by the opaque, ovate wing pad laterally on tergum II; both characters are absent on all endemic North American species.

The mandible in *M. rotundata* (Fig. 57) resembles that of *M. mendica* (Fig.55) in the angulation formed by the outer cutting edge between the 3rd and 4th denticles. The third mandibular tooth in *M. rotundata* differs from all other Canadian species except *M. montivaga* (Fig.59), in not having a bevelled edge extending from its outer side.

The male can be recognized by the opaque ovate wing pad situated laterally on tergum II, which is not present on any Canadian species. Sixth abdominal tergum is narrowly reflexed apically and without distinct denticles arising from its margin. *M. rotundata* approaches *M. brevis* in size, presence of front coxal spine, and unmodified front basitarsus; however *M. rotundata* can be separated by the opaque wing pad on tergum II and absence of denticles along the posterior rim of tergum VI.

DISTRIBUTION. Megachile rotundata was unknowingly introduced into the eastern United States from the southern part of central Eurasia, around 1930. It crossed the Rocky Mountains about 1950 and became established in the western states (Torchio and Parker 1975), from where it spread into the southern part of British Columbia. Currently, it is present throughout the northern United States and extends to southern Ontario as far as Ottawa.

The domesticated leaf-cutter bee has been purchased at approximately 1¢ per bee, for pollinating alfalfa at various places across Canada. Since the species cannot overwinter throughout most of Canada, the specimens which are present in collections may have dispersed from purchased material and may or may not be able to overwinter in the localities listed. Ontario: Belleville, 9 July 1969, 1 M. Cayuga, 3 July 1963, 1 M. Guelph, 16 Aug. 1962, 1 F; June 1964, 3 M, 6 F; Aug. 1964, 2 M, 9 F; 11 Oct. 1964, 4 F; 1 July 1974, 1 F; 12 Oct. 1974, 4 M. Louisville, 24 June 1962, 7 F. Ottawa, 14 July 1962, 1 M; 3 Sept. 1962, 1 F; 1966, 5 M, 4 F; 10 July 1968, 1 M; 15 July 1968, 2 M; 9 June 1969, 2 F; 7 July 1970, 1 F; 16 Aug. 1973, 1 M. Manitoba: Winnipeg, 27 July 1976, 2 M, 2 F. Saskatchewan: Prince Albert, 19 Aug. 1974, 3 M. Swift Current, 1 Sept. 1963, 3 M. Alberta: Beaverlodge, 1976, 6 F, 6 M. Brooks, 6 M, 6 F. Lake Newell, 12 Aug. 1974, 4 M. Lethbridge, 15 June 1962, 8 M, 7 F; 17 Oct. 1964, 1 M; 17 April 1967, 1 M; 18 April 1967, 1 F; 2 May 1967, 1 F; 28 July 1967, 1 M; 30 July 1971, 2 F; 2 July 1974, 1 M. Melfort, 6 M, 6 F. British Columbia: Ashcroft, 24 July 1964, 2 F.



Map 6. Distribution of Megachile rotundata

FLOWERS VISITED. Asclepias (Milkweed), (M); Medicago (Alfalfa), (M); Melilotus (Sweet Clover), (M); Polygonum (Knotweed), (M); Solidago (Goldenrod), (M); Veronica (Speedwell), (M).

BIOLOGY. Megachile rotundata does not excavate its own nesting tunnels, but seeks out ready-made holes of its preferred size. The species readily adopts a wide variety of nesting sites, such as abandoned beetle burrows, cracks or holes in wood, hollow plant stems, drinking straws, or metal tubing. The holes are cleaned and the angular or enlarged sections are rounded or reduced by means of chewed leaf filling to a suitable shape and size of 5-6 mm in diameter. Usually, 8-17 oblong leaf sections are used to make the cup and 3-6 circular sections serve as a lid to seal the cell. The nesting burrow containing the series of cells is plugged with 8-15 circular leaves (Stephens and Torchio 1961). Under field conditions, females produce about 12 offspring (Eves and Johansen 1974), and live for an average of 20 days (Torchio and Parker 1975).

PREDATORS, PARASITES AND DISEASE. When M. rotundata first immigrated into North America, it experienced a rapid increase in population, which may have been due to its escape from its natural parasites and predators. In spite of dense localized populations, Stephen and Torchio (1961) did not observe any insect enemies on M. rotundata in 1961. However, about 10 years later, 30 species of predators and parasites had become adapted to preying upon M. rotundata (Bohart 1972). The most common and specialized parasites which prey upon leaf-cutter bees do not appear to prey upon M. rotundata. It may be that the provisions of pollen and nectar supplied for the small larva of M. rotundata, which is distinctly smaller than endemic leaf-cutter bees, is inadequate for the development of North American Coelioxys species.

(a) Parasites: Sapyga pumila Cress. (Fig. 86) has been reported to parasitize up to 78.5% of the domesticated leaf-cutter bee (Torchio 1972); Monodontomerus obscurus (Westw.) (Figs. 92, 93), up to 50% parasitism (Hobbs and Krunic, 1971; Eves and Johansen, 1974); Melittobia chalybii Ashm. (Figs. 90, 91) (Torchio, 1963; Peck 1969); Dibrachys maculipennis (Szel.) (Fig. 94) (Peck 1969); Pteromalus venustus Wlkr. (Peck 1969); Leucospis affinis Say (Figs. 88, 89) (Bohart 1972).

(b) Predators, Scavengers, Nest Destroyers: Ants of various species (Fig. 95), Formica fusca L. one of the most common ants in Canada; European earwig (Forficula auricularia) (Bohart 1972); at least 10 species of dermestid beetles, the most important of which are - Trogoderma glabrum (Hbst.) (Fig. 96); Anthrenus pimpinellae Fab. (Fig. 97); Megatoma variegata Horn. (Fig. 98); Attagenus sp. (Fig. 99); flour beetles - Tribolium castaneum (Hbst.) (Fig. 101); Tribolium madens audax (Halst.) (Fig 102); checkered flower beetle - Trichodes ornatus Say (Fig. 100); and dried fruit moth - Vitula edmandsii Pack. (Fig. 103) (Bohart 1972).

(c) Diseases: Chalk brood disease resulting in 60-70% mortality.(Allen Brinkerhoff, Lovelock, Nevada, Alfalfa Seed Producer, and George Bohart, personal communications, 1978).

ALFALFA POLLINATING POTENTIAL. *Megachile rotundata* probably co-evolved with alfalfa in the southern part of central Eurasia. It may be the only species currently in Canada which can survive entirely upon alfalfa, using the flowers for pollen and nectar and the leaves for cell construction, although Michener (1953) observed *M. brevis* to also use alfalfa leaves. As populations of *M. rotundata* increased in the United States and farmers observed its usefulness as a pollinator and its habits of nesting in cracks and nail holes in old wood, they drilled holes in wood to provide more nesting space (Eves and Johansen, 1974). Following reports on pollinating performance of these bees, commercial use started in 1961 (Torchio 1975). In 1962, Gordon Hobbs at the experimental station at Lethbridge, imported *M. rotundata* for pollinating alfalfa in Canada (Hobbs, 1972).

The female trips up to 16 alfalfa flowers per minute and visits an average of 200 flowers to obtain a pollen load. Provisions for one cell, which is usually completed in one day, requires 15-18 pollen loads (Parker and Torchio 1975). Thus, 3,000-3,600 flowers are visited and cross pollinated by each female in a day. Appropriate apparatus for large scale management of *M. rotundata* have been devised (Bohart 1962; Hobbs 1965, 1967 and 1973). Up to 50,000 bees per hectare have been recommended for good pollination (Hobbs 1973).

By bringing *M. rotundata* indoors throughout the winter to avoid cold temperatures and by employing various techniques for destroying the parasites and predators, various farmers continue to use this species for pollinating alfalfa (Jerry Freundel, partner in an alfalfa seed farm at Brooks, Alberta, personal communication 1978).

Potential limitations to use of *M. rotundata* as an alfalfa pollinator are: high larval mortality; relatively low tripping rate and high male sex ratio (Parker et al 1976). Over 30 parasites, predators and diseases have become adapted to preying upon and destroying *M. rotundata*. Up to 78.5% mortality has been reported (Torchio 1972). Instead of producing surplus bees, many growers must augment most of their bee stocks annually (Parker *et al.* 1976). Thus, reliance upon the single species *M. rotundata* for improved alfalfa seed production in Canada, does not hold much promise. Torchio and Parker (1975) advise that since lack of pollination is the most frequently identified cause of low seed yields, scientists should seek out additional species of bees which will effectively pollinate alfalfa.

Subgenus MEGACHILE Robertson

Figures 67, 69

Megachile Robertson, 1924:374 (new subgenus)

Anthemois; Mitchell, 1935:155 (description and biology).

FEMALES. Length 10-20 mm. Mandible 5-dentate with the emarginations on each side of the 3rd tooth subequal in depth (Figs. 67, 69). In M. montivago the tooth between the 3rd and 4th denticles narrow and oblique. Inner cutting edge extending from near the apex of the 5th tooth to the base of the 2nd tooth, not strongly elevated, and usually not seen with the mandible closed. First (outer) mandibular tooth reflexed posteriorly along the outer margin and tapered apically. White, apical fasciae usually present on terga II-V, sometimes interrupted medially on the more anterior terga.

MALES. Length 8-15 mm. Mandible 3-dentate, with the apex of the middle denticle subequally distant between the apices of the inner and outer denticles; except in M. inermis in which the inner tooth is distinctly more distant from the middle tooth. Hypostomal concavity distinctly impressed, and more sparsely punctate, than the densely punctate elevated ridge on the posterior side of the concavity. Front coxal spine absent, or weakly indicated by a dense tuft of short setae at apex of a rounded tubercle. Reddish bristles at just anterior to the coxal spine absent. Front basitarsus dark and simple, similar to mid basitarsus; without a shortened band of hairs along the anterior side bordered by dense, elongate bristles on each side. White, apical fasciae usually present on terga II-V, frequently interrupted medially on the more anterior terga. Area above the postmedian transverse carina on tergum VI not concealed beneath dense, appressed, plumose pubescence.

COMMENT. Females belonging to this subgenus can be distinguished by the presence of a 5-dentate mandible, in which the emargination on each side of the 3rd tooth is subequal in depth (Figs. 67, 69), except in M. montivaga, which can be recognized by the absence of a bevelled edge on the outer side of the 3rd tooth (Fig. 68). The first tooth is reflexed posteriorly along the outer rim and strongly tapered apically, to form a scoop-shaped mandible adapted for chiselling nesting tunnels in partly decomposed wood.

The males can be recognized by the simple, dark front basitarsus, without a shortened band of hairs along the anterior side and by the absence of front coxal spines. The level of development of the hypostomal concavity and tubercle; the simple front basitarsus and the absence of the front coxal spine are the most unifying morphological characteristics in males belonging to the subgenus Megachile.

Key to Species of the Subgenus Megachile

Females

1. Scopal hairs on sternum VI black........ M. *nivalis* (p. 170)

   Scopal hairs uniformly pale................................2

2. Third tooth without a bevelled edge arising from its distal side (Fig.68). Sixth tergum concave in lateral view with uniformly short, appressed, silvery pubescence throughout its median length..M. *montivaga* (p. 127)

   Third tooth with a bevelled cutting edge arising from its distal side. Sixth tergum approximately straight in lateral view with either appressed dark brown pubescence or with erect as well as appressed pubescence..3

3. Apical margin of clypeus emarginate sublaterally, between the broad median protruberance and the lateral tubercle. Sixth tergum with uniformly appressed dark brown pubescence throughout its median length.....M. *inermis* (p. 133)

   Apical margin of clypeus approximately truncate, without sublateral emarginations. Sixth tergum with scattered, long, erect as well as appressed pubescence.............4

4. Pubescence on sixth tergum with conspicuous golden hairs toward the apex.......................*M. relativa* (p. 153)
Pubescence on 6th tergum entirely dark brown to black..... ....*M. centuncularis* (p. 145)

Males

1. Anterior side of front coxa without tubercle. Apical margin of clypeus usually with a median tubercle beneath the beard.......................................2
Anterior side of front coxa with a small tubercle surmounted by a dense but short tuft of setae. Apical margin of clypeus without a median tubercle beneath the beard...3

2. Apical margin of clypeus with a prominent median tubercle. Terminal denticle on posterior claw as sharp as the terminal denticle on anterior claw...*M. relativa* (p. 153)
Apical margin of clypeus without a prominent median tubercle. Terminal denticle on posterior claw more rounded apically than the sharp terminal denticle on the anterior claw...................*M. centuncularis* (p. 145)

3. Distance from the apex of the middle tooth nearly twice as great to the apex of the inner tooth, than to the

apex of the outer tooth (Fig. 84). Lateral ocellus much nearer to eye than to vertex. Sixth tergum weakly protruberant medially, above the transverse carina and obscurely punctate........*M. inermis* (p.133)

Distance from the apex of the middle tooth to the apices of either the inner or outer teeth, subequal. Lateral ocellus subequally distant to vertex and to eye. Sixth tergum strongly protruberant, medially (above the transverse carina) and densely, but distinctly punctate ....*M. montivaga* (p.127)

Opposite p. 127

Fig. 16. M. montivaga, F. Parallel-sided, scoop-shaped mandible with tapered outer tooth.

Fig. 17. M. addenda, F. Flattened mandible with reflexed and rounded outer tooth.

MEGACHILE (MEGACHILE) MONTIVAGA CRESSON

Figures 16, 59, 75; Map 7

Megachile montivaga Cresson, 1878:124 (new species).

Megachile (Megachile) montivaga Mitchell, 1962:127 (description, distribution and flower records).

FEMALE. Length 11-13 mm. Mandible 4-dentate with a weakly developed 5 tooth sometimes present between the 3rd and the inner tooth. Mandible short and broad shaped in the form of a parallelogram, with the length of the cutting edge subequal to basal width. Postero-ventral corner of mandible with a prominent polished elevation succeeding the distinct opaque furrow just beyond the lower mandibular condyle. Mandible 4-dentate, with a small 5th denticle sometimes arising between the 3rd and inner teeth. Mandibular denticles short and acute, progressively smaller toward the base. Mandible with a prominent inner cutting edge extending from second tooth to the extreme apex of the inner tooth; thus the outer and inner cutting edges of the mandible border an elongate wedge shaped trough extending from 2nd to inner denticles. Clypeus bulging medially and distinctly appressed subapically. Abdominal terga II-V with white, apical fasciae, the fasciae interrupted medially on the more basal terga. Sixth tergum evenly concave in lateral view, surface densely punctate with minute, appressed hairs arising from the punctures medially; short, subappressed, plumose hairs sparsely scattered medially, becoming longer and more numerous laterally; integument not distinctly obscured by pubescence. Sixth sternum with a dense apical fringe of setae extending a little beyond margin; median subapical area without punctures or scopal hairs.

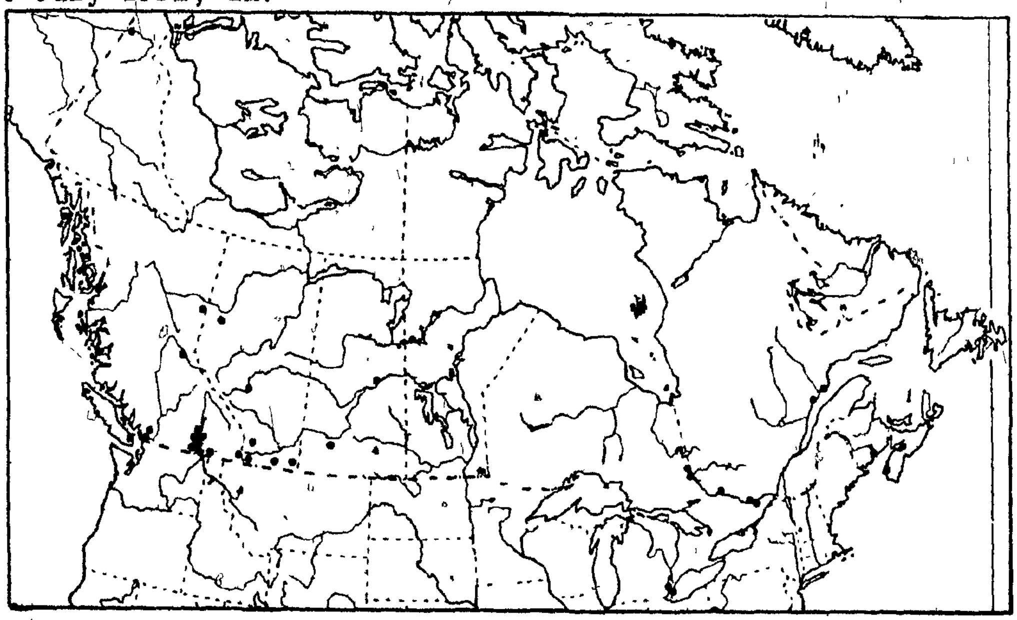
MALE. Length 10-11 mm. Mandible 3 dentate with the distance between the apex of the middle and apical denticle slightly greater than that between the middle and basal denticles. Ventral mandibular denticle strongly curved inwardly near the apex. Anterior side of front coxa with a scarcely perceptible tubercle surmounted by a minute, but dense tuft of short setae. Hypostomal tubercle and concavity weakly developed: tuberculate region elevated, broadly rounded, and strongly punctate with dense elongate pubescence; concavity weakly punctate with subpolished interspaces and with scattered pubescence subequal in length to that on the tubercle. Posterior distal claw more broadly rounded apically than the sharply pointed anterior claw. Graduli on terga III-V with posteriorly projecting carinae overlapping the strongly depressed transverse basal grooves. Sixth tergum strongly protruberant medially; densely punctate with inconspicuous short hairs and sparsely scattered long hairs arising from the punctures. Apical rim of tergum VI with a prominent sublateral tubercle, and an elongate submedian carina, seventh tergum with a submedian transverse carina.

COMMENT. The female can be recognized by the absence of bevelled cutting edge on the outer side of the 3rd tooth. In other <u>Megachile</u> a bevelled edge usually projects from the outer side of the 3rd tooth and occupies about half the proximal concavity between 2nd and 3rd teeth.

The male of <u>M. montivaga</u> can be recognized by the following combination of characters: anterior side of front coxa with a very short blunt tubercle (not higher than wide at base) surmounted by a minute, but dense tuft of short setae; lateral ocellus approximately equidistant to eye and to vertex. Front basitarsus dark and simple, much narrower and shorter than its tibia; without a trace of a longitudinal furrow or shortened row of hairs along the antero-ventral side. Second abdominal tergum without an opaque ovate wing pad laterally. Examination of <u>Megachile montivaga</u> Cresson LectoTYPE, no. 2440 revealed that it is a male belonging to the same species as the female, <u>Megachile relativa</u> Cresson, LectoTYPE no. 2447. The male and the female were both collected in Colorado, have similar labels but were described as separate species by Cresson in 1878.

DISTRIBUTION. Nova Scotia: Kings Co., 20 July 1931, 1F, Epilobium. Painsec, 4 Aug. 1914, 3M. Smiths Cove, 15 July 1914, 2F. New Brunswick: St.John, 21 July 1901, 1F. Quebec: Forestville, 9 Aug. 1950, 1F; 10 July 1950, 1M. Fort Coulonge, 21 Aug. 1917, 1F. Franquelin, 28 July 1963, 1F. Hull, 19 Sept. 1894, 1F. Ontario: Agama Bay, 1 Aug. 1959, 1F. Ontario(East), 2F. Graham, 8 July 1916, 1M. Haileybury, 7 July 1916, 2M. Ottawa, 1 July 1913, 3M; 1F, 1M. Point Pelee, 8 Sept. 1954, 1F. Thornloe, 8 July 1917, 1M; 8 Aug. 1917, 1F, 1M; 9 Aug. 1917, 1F. Windsor, 1 July 1895, 1F. Manitoba: Aweme, 12 July 1916, 2F. Wanless, 19 Aug. 1955, 3F, Fireweed. Saskatchewan: Love, 27 July 1944, 1F. Swift Current, 20 Aug. 1916. Alberta: Calgary, 18 July 1917, 1M. Claymont, 23 June 1936, 1M. Edmonton, 1 July 1919, 1M. Faivrett, 20 June 1932, 1M. Lethbridge, 26 Aug. 1927, 1F. Medicine Hat, 17 July 1917, 2F, 1M. Vauxhall, 26 July 1951, 1F. British Columbia: Agassiz, 8 July 1914, 1M. Armstrong, 8 July 1931, 1F. Lytton, July 1913, 1F. Manning Park, 1F. McIntyre Road, 29 May 1958, 1M. Oliver, 9 July 1943, 2M. Osoyoos, 7 July 1953, 2M. Peachland, 2 Aug. 1909, 1F. Pinewoods 4000', 7 Aug. 1953. Prince George, 2 Aug. 1946, 1F. Robson, 23 Aug. 1948, 1F. Rolla, 23 July 1927, 1F. Salmon Arm, 26 June 1955, 1M. Sidney, 1M. Spalachean, 25 July 1913, 1F. Summerland, 8 July 1950, 1F. Vernon, 24 July 1917, 2F, 1M; 23 July 1920, 3F, Sphaeralcea; 26 July 1920, 14F; 27 July

1920, 5F; 28 July 1920, 2F, 1M; 3 Aug. 1920, 9F; 9 Aug. 1920, 2F. Wasa, 3 Aug. 1960, 3F. Yukon Territory: Rampart House, 10 July 1951, 1M.



Map 7. Distribution of *Megachile montivaga*

FLOWERS VISITED. *Brauneria* (Purple Coneflower), (M); *Dianthera* (Water Willow), (M); *Monarda* (Horsemint), (M); *Onopordum* (Scotch Thistle), (M); *Oenothera* (Evening-Primrose), (M); *Pentstemon* (Beard-Tongue), (M); *Rudbeckia* (Coneflower), (M); *Scrophularia* (Figwort), (M); *Silphium* (Rosinweed), (M); *Sphaeralcea* (False Mallow), (L, M).

BIOLOGY. It appears to nest in pith of woody and herbacious plants. Rau (1934) found a nest in a sumac twig. In addition to sealing each cell, a heavy plug was also made to seal the outside opening, to ensure that no parasite could get into the burrow. Five adults emerged from the nest. It has also been found to nest in old mullein and sunflower stems and to build its cells with petals and pith (Hicks 1926).

ALFALFA POLLINATING POTENTIAL. This species has been collected on alfalfa. It is, however, rather sparsely distributed. Hobbs (1954) reported that in the mixed prairie region it is restricted to river valleys and other areas where trees are present, indicating that it nests in wood. Provision of appropriate above ground nesting sites in plant stems, suitable leaves and petals for cell construction, and a continuous annual access to blossoming alfalfa, might serve to build up populations of M. montivaga.

Opposite p. 133

Fig. 18. M. inermis, F.
Inner side of mandible.

Fig. 19. M. inermis, F.
Face view.

MEGACHILE (MEGACHILE) INERMIS PROVANCHER

Figures 18, 19, 21, 60, 76; Map 8

Megachile simplex Provancher, 1882:229 (new species)

Megachile inermis Provancher, 1888:323 (new name for M. simplex)

Megachile (Megachile) inermis; Mitchell, 1962:126 (description, distribution and flower records).

Megachile (Megachile) inermis; Pengelly, 1955:121 (biology)

Megachile inermis; Stephen, 1956:95-101 (biology)

Megachile inermis; Koerber and Medler, 1958:56 (biology)

Megachile inermis; Medler, 1958:325-327 (biology)

FEMALE. Megachile inermis is one of the largest common species of leaf-cutter bees, with females ranging from 15-20 mm in length. Mandible 5-dentate, with the emarginations on both sides of the 3rd tooth subequal in depth (Fig. 60); 3rd tooth with a bevelled edge projecting from the outer side and occupying about half the emargination between the 2nd and 3rd teeth. Apical margin of clypeus with a distinct, truncate median elevation bordered on each side by small, semicircular emargination and a broadly rounded tubercle laterally (Fig. 19). Apical border of labrum concave; anterior side of labrum weakly concave throughout its length. Lateral ocellus closer to eye than to posterior border of vertex. Temple deep, nearly twice as wide as eye in lateral view (providing space for the attachment of large adductor muscles which exert the necessary mandibular pressure to chisel tunnels in wood). Sixth tergum nearly straight in lateral view; short appressed, brown to black hairs extending throughout the median length, with scattered long, erect, dark hairs laterally; integument partly obscured by pubescence.

MALE. Length 10-15 mm. Mandible 3-dentate with a wide, oblique arc between the middle and inner mandibular teeth (Figs. 21, 76); distance between the apices of the middle and inner teeth 1.5 times as great as the distance between the apices of the middle and outer teeth. Ventral mandibular tooth broadly rounded and strongly incurved apically. Hypostomal tubercle elevated as a blunt crest with deep, dense punctures on the elevated region and polished on the side facing the mandible; hypostomal concavity subpolished with minute, sparse punctures; pubescence arising from the punctures in the concavity distinctly more sparse and minute than the long, dense pubescence on the tubercle. Lateral ocellus much nearer to the eye than to the posterior border of vertex. Front coxal spine weakly developed as a scarcely perceptible tubercle with a minute tuft of dense setae at its apex. Basitarsus on front leg, dark and simple, narrower and shorter than its tibia; without a trace of a longitudinal furrow or short row of hairs along the antero-ventral side. White, apical fasciae present on terga II-V, sometimes interrupted medially on the more anterior terga; discs of terga II-V sparsely punctate and subpolished. Postmedian transverse carina on tergum VII much nearer to apex than to basal carina, with a depressed, transverse, ovate area bordered by the postmedian and basal carinae.

COMMENT. The females of M. inermis can be recognized by the distinctly 5-dentate mandible in which the emarginations on both sides of the 3rd denticles are subequal in depth, combined with the absence of erect hairs throughout the median length of the sixth tergum, and the uniform amber coloured scopal hairs which are also present on the sixth sternum.

The males of inermis can be recognized by the weakly developed front coxal spine which is much shorter than wide at base, with a minute, dense, short tuft of setae at its apex. The males in this species are usually considerably smaller than the females. They are often reared separately from the females in smaller tunnels and are highly variable in size, ranging from 10-15 mm. in length.

DISTRIBUTION. Nova Scotia: Kings Co., 31 July 1929, 1F; 24 July 1930; 15 July 1931, 1M; 20 July 1931, 1F. Smith Cove, 15 July 1914, 1M, 1F. New Brunswick: Dalhousie, 24 July 1915, 1F, 1M. Fredericton, 16 Aug. 1948, 1M; 14 Aug. 1951, 1F. St.Anderson, 3 Aug. 1957, 1F. St.John, 8 July 1899; 11 July 1901, 1M. Prince Edward Island: Canadian National Park, Dalvay House, 19 Aug. 1940, 1F. Quebec: Aylmer, 15 June 1913, 1M. Bondville, 10 July 1906, 1F; 20 July 1960, 1F. Cape Rouge, 4 July 1953, 1M. Charlevoix Co., 11 Aug. 1916, 1F. Chelsea, 5 July 1912, 1M. Fort Coulonge, 20 July 1917, 1F; 13 Aug. 1917, 1F; 21 Aug. 1917, 1F; 17 June 1919, 1F; 21 June 1919, 1F; 26 June 1919, 2F; 19 July 1919, 1F. Hull, 15 Aug. 1894; 14 June 1914, 2M. Ile de Montreal, 19 Aug. 1906, 1M. Lakeside, 7 July 1929, 1M; 2 Sept. 1929, 2F. Lanoraie, 28 Aug. 1926, 1F; 12 Aug. 1931, 3F. Lowe, 2 Aug. 1948, 1M. Mont Joli, 9 Aug. 1954, 1M. Montreal, 12 March 1924, 1F; 3 July 1927, 1M; 16 July 1927, 1M; 28 Aug. 1928, 1F; 1 Sept. 1928, 1F; 2 July 1929, 1F; 21 July 1930, 1M; 31 Aug. 1930, 1F. Oxford Lake, 21 Aug. 1895, 1F; 23 July 1921, 1F. St.Anne's, 30 July 1907, 1F. Ste.Anne de Bellevue, 27 June 1964, 1M; 21 July 1965, 1F; 28 July 1965, 5F; 20 Aug. 1965, 4F; 1 Sept. 1965, 21F; 3 Sept. 1965, 13F, 1M; 15 Aug. 1966, 1M; 27 Aug. 1966, 1F; 6 Aug. 1967, 1M. St.de la Pocatiere, 7 Aug. 1914, 2F; 8 Aug. 1914. Ste.Foy, 17 June 1963, 1F, 1M, Prunus pennsylvanica; 19 June 1963, 1M, Prunus pennsylvanica. St.Hilaire, 6 Sept. 1920, 1F; 26 Aug. 1926, 2F; 28 Aug. 1926, 1F; 14 July 1927, 1M; 26 July 1927, 1M; 28 July 1927, 2M; 26

Aug. 1927, 1F; 22 July 1928, 1M; 7 Aug. 1929, 1F; 14 Aug. 1931, 1F. St.Johns Co., 5 July, 1M. St.Martin, 29 July 1926, 1F. Shawbridge, 26 Aug. 1926, 1F. Terrebonne, 30 Aug. 1926, 1F. Ontario: Arkell, 24 July 1951, 1F, Scotch Thistle; 24 July 1951, Fireweed; 25 July 1952, 1M, Fireweed; 3 Sept. 1962, 1F; 22 July 1974, 2F. Barrie, 4 Aug. 1913, 1F. Belleville, 1 Aug. 1917, 1F. Bell's Corners, 4 July 1970, 1F; 10 July 1970, 1M. Belwood, 8 July 1965, 1M; 21 July 1965, 1M. Blackburn County Hastings, 16 Aug. 1902, 1M. Blackburn, 9 June 1939, 1M. Black Sturgeon Lake, 13 July 1963, 1M; 15 July 1963, 2M; 16 July 1963, 1M; 18 July 1963, 2F; 18 March 1964, 4M; 3 Feb. 1965, 2M, reared in lab. Cheltenham, 14 July 1951, 1F. Cochrane, 25 July 1973, 1F. Cornwall, 29 June 1925, 1M. Dundas, 6 June 1975, 1M; 4 July 1975, 3F, 1M; 15 July 1975, 1F; 15 July 1975, 2F; 22 July 1975, 1F. Dunedin, 22 July 1952, 1F. Dyer Bay, 31 July 1953, 1F; 14 Aug. 1953, 1M. Elsinore, 2Aug. 1945, 1F, 1M. Eramosa, 19 July 1959, 3F; 25 July 1959, 1F; 16 Aug. 1959, 2F. Guelph, 5 Aug. 1935, 1F; 8 Apr. 1938, 1M; 10 Aug. 1951, 1M, 1F; 28 Aug. 1951, 1M; 7 Aug. 1952, 1F; 14 July 1959, 1F; 12 Aug. 1961, 1F; 8 July 1974, 1M; 25 July 1974, 1F; 27 July 1974, 1F. Hogs Back, 26 July 1947, 1F. Kinburn, 18 July 1957, 1F. Leith, 31 July 1970, 1F. Maberly, 21 July 1961, 1F. Macdiarmid, 12 Aug. 1922. Marmora, 10 July 1952, 1F. Merivale, 12 July 1930, 1F; 16 Aug. 1930, 1F. Mississauga, 13 June 1949, 1M. Mount Pleasant, 21 July 1955, 1F. Muskoka, 18 Aug. 1887, 1F. Ontario(East), 1M. Orangeville, 19 Aug. 1954, 1F. Orillia, 25 July 1924, 1M. Ottawa, 7 Oct. 1913, 1F; 28 July 1962, 1F. Perth Road, 25 Aug. 1957, 1M. Primrose, 22 July 1952, 1F; 30 June 1955, 1M. Purple Valley, 25 July 1961, 1M. Rockwood, 1 Aug. 1951, 1F; 8 July 1955, 2M. Spanish, 20 July 1957, 1F. Speedside, 4 Aug. 1965, 1M; 20 Aug. 1965, 1F; 6 Sept. 1965, 1F. Sudbury, 25 Aug. 1889, 1F; 21 July 1957, 1F. Thor Lake, 20 Aug. 1927, 1M. Thornloe, 9 Aug. 1917, 4F, 1M. Toronto, 25 Aug. 1888, 1F; 23 Aug. 1893, 1F; 9 Aug. 1894, 1F; 21 Aug. 1894.

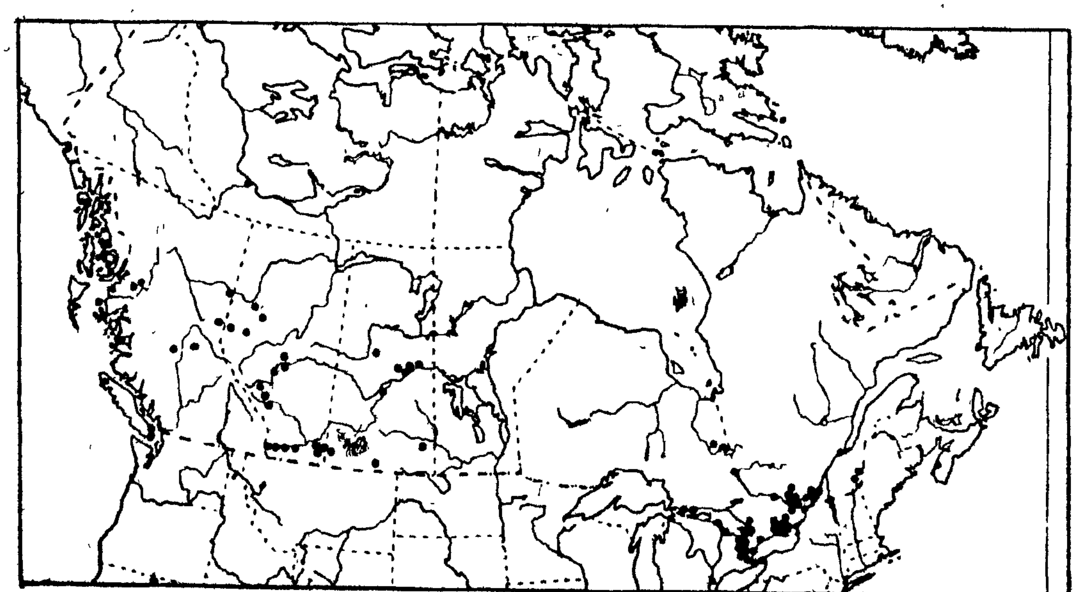
Manitoba: Aweme, 24 July 1913, 1F; 24 July 1914, 1F; 15 July 1916, 1M; 14 July 1923, 1F; 26 July 1924, 1F; 14 Aug. 1924, 1F; 17 June 1925, 1M; 17 June 1926, 1M; 22 July 1926, 1F; 1 Aug. 1926, 2F; 19 July 1947, 1F; 23 June 1950, 1M. Brandon, 20 Aug. 1948, 1F. Carberry, 10 Aug. 1948, 1F. Clear Lake, 24 Aug. 1948, 1F. Cormorant Lake, 20 June 1927, 2M; 1 July 1927, 1M. Dauphin, 23 June 1913, 1M. Hargrave, 8 July 1945, 1F. Hilton, 1F. Morden, 11 Aug. 1940, 1F. Manitoba Agriculture College, 16 Sept. 1922, 2F; 12 July 1924, 1F; 7 June 1951, 1M; 1951, 1F; 27 June 1952, 1F; 29 June 1952, 1F. Oberon, 3 Sept. 1954, 1F. Pikwitonei, 29 July 1949, 1F. Rosenberg, 4 July 1962, 1F. Riding Mountain National Park, 11 July 1949, 1M. Sprague, 9 July 1948, 1F. Teulon, 10 July 1922, 1M; 14 July 1922, 1F; 18 July 1922, 1F; 1 June 1923, 1M; 20 July 1923, 1F; 22 July 1924, 1M; 30 July 1924, 1M. Victoria Beech, 9 July 1921, 1M. Wanless, 29 June 1954, 6M;

2 July 1954, 2M; 5 July 1954, 1M; 6 July 1954, 1M; 9 July 1954, 2M; 27 July 1954, 1F; 15 Aug. 1958, 1M. Winnipeg, 29 July 1926, 2F; 30 July 1935, 1F; 30 July 1935, 1F; 9 Aug. 1935, 2F; 10 Aug. 1935, 1F. Saskatchewan: Attons Lake, 8 July 1940, 1M. Beaupre Lake, 7 July 1948, 1M. Big River, 14 July 1973, 1M. Cypress Hills, 30 July 1949, 1F. Dollard, 18 June 1947. Indian Head, Aug. 1914, 1M; 24 July 1926, 1F. Love, 3 July 1944, 1M, 1F; 27 July 1944, 1M; 29 July 1944, 1M; 3 Aug. 1944, 1F. Snowden, 15 July 1944, 1F; 28 July 1944, 2F; 28 July 1944, 6F; 28 July 1944, 1F. St. Louis, June 1898. St. Victor, 27 June 1955, 1M. Torch River, 29 June 1944, 1M; 3 Aug. 1944, 4F. Waskesiu, 27 July 1939, 1F. White Fox, 11 July 1943, 2F; 4 July 1944, 2F; 21 July 1944, 3F; 25 July 1944, 1M. Alberta: Aspen Beach, 22 Aug. 1922, 1F. Beaverlodge, 19 July 1931, 1M; 20 Aug. 1960, 1F; 1976, 1F. Cypress Hills, 10 Aug. 1939, 2F; 13 July 1949. Delbume, 17 Aug. 1962, 7F. Donnelly, 8 Aug. 1937, 1M. Dutch Creek, 31 July 1958, 1F, alsike clover. Edmonton, 16 Apr. 1926, 1F; 11 June 1926, 1M; 24 June 1933, 1M; 13 Jan. 1934, 1F, rose leaf nest in wood. Elkwater Park, 1 Aug. 1949, 1F; 30 July 1952, 2F; 12 Aug. 1952, 1F; 15 Aug. 1952, 1M; 18 July 1956, 1F. Lamont, 12 July 1972, 1M; 2 Aug. 1972, 1F; 6 Aug. 1972, 3F; 10 Aug. 1972, 1F. Lethbridge, 28 July 1916; 24 Mar. 1960, em. in lab; 18 July 1960, 1M.

Lundbreck, 18 Aug. 1963, 1F. Peace River, 1M. Pincher Creek, 6 Aug. 1925; 5 July 1960, 1F. Prairie Bluff Mt., 6 July 1960, 1M; 4 July 1970, 1F; 7 July 1970, 2F; 12 July 1970, 1F; 12 July 1970, 1F; 19 July 1970, 1F, Agoseris glauca; 24 July 1970, 1F, Agoseris glauca; 24 July 1970, 1F, Solidago decumbens; 29 July 1970, 1F, Epilobium angustifolium; 29 July 1970, 1F, Cirsium hookerianum; 3 July 1971, 1M; 12 July 1971, 1F, 1M; 14 July 1971, 1F; 22 July 1971, 1F, Cirsium hookerianum; 23 July 1971, 5F; 25 July 1971, 1F; 25 July 1971, 4F; 26 July 1971, 8F; 29 July 1971, 1M; 2 Aug. 1971, 1F; 3 Aug. 1971, 1F, 1M; 4 Aug. 1971, 1F, 1M; 5 Aug. 1971, 1F, Cirsium hookerianum; 5 Aug. 1971, 1F; 9 Aug. 1971, 1F; 27 July 1975, 1M. McMurray, 29 June 1953, 1M; 6 July 1953, 2F, 1M. Ralston, July 1950, 1F. Shaftsbury, 18 Aug. 1915, 1F. Sturgeon Lake, 1 Aug. 1959, 1F. The Gap, 8 Aug. 1959, 1F; 8 Aug. 1959, 1F; 8 Aug. 1959, 1F. Waterhole, 18 Aug. 1915, 1F. British Columbia: Chilcotin, 16 July 1921, 1F. Respberry Creek, 26 June 1953, 1F. Rolla, 2 July 1927, 1F; 17 July 1927, 1F; 21 July 1927, 1F. Saanichton, 27 June 1937, 1F. Sidney, 31 Aug. 1965, 1F. Smithers, 4 Aug. 1944, 2F. Victoria, 4 Sept. 1964, 1F. Northwest Territories: Fort Simpson, 22 July 1950, 1M. Garrick, 15 June 1943, 1M.

FLOWERS VISITED. Agoseris (M); Arctium (Burdock), (M); Carduus (Plumeless Thistle), (M); Cerastium (Chickweed), (M);

Cirsium (Canada Thistle), (M); C. hookerianum, (L); Echium (Blueweed), (M); Epilobium (Fireweed), (M); E. angustifolium (L); Geranium (Cranesbill), (M); Inula, (M); Lathyrus (Wild Pea), (M); Lupinus (Lupine), (M); Medicago (Alfalfa), (L,M,P, PB,ML); Nepeta (Catmint), (M); Onopordum (Scotch Thistle), (M); Penstemon (Beard-Tongue), (M); Polymnia (Leafcup), (M); Prunus pennsylvanica (Pin-Cherry), (L); Rubus (Bramble), (M); Rhododendrun (M); Rudbeckia (Coneflower), (M); Sanicula (Black Snakeroot), (M); Solidaga (Goldenrod), (M); S. decumbens, (L); Sonchus (Sow-Thistle), (M); Taraxacum (Dandelion), (M); Tephrosia (Hoary Pea), (M); Trifolium (Alsike Clover), (M); Vernonia (Ironweed), (M).



Map 8. Canadian distribution of Megachile inermis

BIOLOGY. Females have been observed to burrow holes and make their nests in decaying popular wood (Stephen 1956). Medler (1958) set out sumac-stick trap nests and was able to get females to nest in the soft, central core of these sticks. Females will inhabit holes about 8 mm in diameter and 125 mm in length made in wood by burrowing insects or by man. Peck and Bolton (1946) observed neat and blocky cells of _M. inermis_ made from poplar leaves, tightly cemented together. Two females were observed to work cooperatively on the same nest (Stephen, 1956), with one female digging and removing sawdust and the other making frequent collecting trips. Pengelly (1955), observed a female to cut a piece of leaf from _Epilobium_ for constructing a cell. About six cells are provisioned in a burrow. Exit holes are securely capped with thick plugs, variously moulded together with circular sections of leaf alternated with clay, sawdust, moss, sand, chewed leaf, resin and other materials.

PARASITES. _Coelioxys funeraria_ and _Leucospis affinis_ (Medler, 1958a).

ALFALFA POLLINATING POTENTIAL. Hobbs and Lilly (1954) found _M. inermis_ in the aspen parkland and mixed prairie regions but not in the open prairie regions and concluded that their absence in the open prairie regions was due to the absence of log nesting materials. It may be that by providing ready made holes in logs or boards such as those presently provided for M. rotundata would eliminate the obstacle that currently restricts their presence as potential pollinators on the Canadian prairies.

Peck and Bolton (1946) saw M. inermis actively pollinating alfalfa in northern Saskatchewan. They observed that it was slower in its movements, pollinating fewer flowers per minute than other species. This restriction may be imposed by its larger size, and might be compensated by the much larger pollen load it is able to carry, with reduced numbers of trips, carried over longer distances.

Pengelly (1953, 1955) observed M. inermis to pollinate 16-22 flowers per minute with 95% tripping efficiency. Pengelly also noted that while M. inermis is relatively common in most parts of Ontario, yet it is usually not found on alfalfa. Examination of the pollen grains on the scopa of some females, taken on an alfalfa field, showed that a portion of the pollen load consisted of pollen grains taken from such plants as Sow Thistle, Canadian Thistle and Fireweed. This species appears to have a preference for these plants, and advances an uncertainty on whether foraging in clean alfalfa fields upon an exclusive diet of alfalfa pollen would fulfil the nutritional requirements of the larva. The current absence of this species on the open prairie, indicates no reserves of specific parasites and predators in these regions, a condition which might result in rapid proliferation of introduced, uncontaminated breeder stock.

MEGACHILE (MEGACHILE) CENTUNCULARIS (LINNAEUS)

Figures 45, 46; cf. 58, 74; Map 9.

Apis centuncularis Linnaeus, 1758:575 (new species).

Megachile centuncularis;Medler, 1959: 113 (biology).

Megachile (Megachile) centuncularis; Pengelly, 1955: 102 (biology): Mitchell, 1962:124 (description distribution and flower records).

Megachile centuncularis;Krombein, 1967:325 (biology).

FEMALE. Length 11-12 mm. Mandible 5-dentate, with the emarginations on each side of the 3rd tooth subequal in depth (cf. Fig. 58). Emargination between the 4th and 5th denticles arcuate and distinctly shallower than the oblique emargination between the 3rd and 4th denticles; angle of obliqueness describing the cutting path of the mandibles as they slide past each other. Outer margin of first mandibular tooth inflexed posteriorly, tapered and pointed apically. Bevelled cutting edge projecting from the outer side of the third mandibular tooth, usually extending to about half the distance to the second tooth and occupying nearly half the emargination between the 2nd and 3rd denticles. Inner cutting edge (which can be seen with the mandible opened) arising from the base of the 2nd tooth and extending on the inner side along the bases of the 3rd and 4th teeth to the inner 5th tooth. Apical margin of clypeus approximately truncate, without prominent tubercles. Lateral ocellus slightly nearer to posterior border of vertex than to eye. Clypeus rather strongly convex medially; apical margin without prominent tubercles. Tergum VI weakly concave in lateral view, with the short appressed hairs and the scattered, elongate, suberect hairs uniformly brown to black. Scopal hairs amber coloured on all sterna, including the sixth, except for a dense fringe of short brown bristles along the apical rim; apical fringe of bristles usually interrupted medially and overlying a narrow glaborous posterior band.

MALE. Length 9-10 mm. Mandible 3-dentate with the distance from the apex of the middle denticle to either the apex of the basal or apical denticles subequal. Short, robust, hypostomal tubercle present, with hypostomal concavity weakly polished along the tubercles; pubescence in the concavity slightly less dense than the pubescence on the tubercle, but of nearly equal length. Clypeal margin slightly protruberant medially. Apical tooth on posterior claw more rounded and blunt at apex than the sharply pointed apical anterior claw. All basitarsi slender and simple, shorter than their tibiae; tarsal segments beyond the first not conspicuously rufous. Basal groove on tergum V usually with a band of appressed white tomentum. Sixth tergum subpolished with minute micropunctures from which arise short, slender, decumbent hairs, and with scattered larger punctures, with slightly elevated rims, from which arise long erect, brown hairs. Subapical transverse carina on tergum VI, usually only slighly emarginate medially. Seventh tergum with a median tubercle slightly closer to the anterior carina than to the posterior rim, a small polished depression often present between tubercle and basal carina.

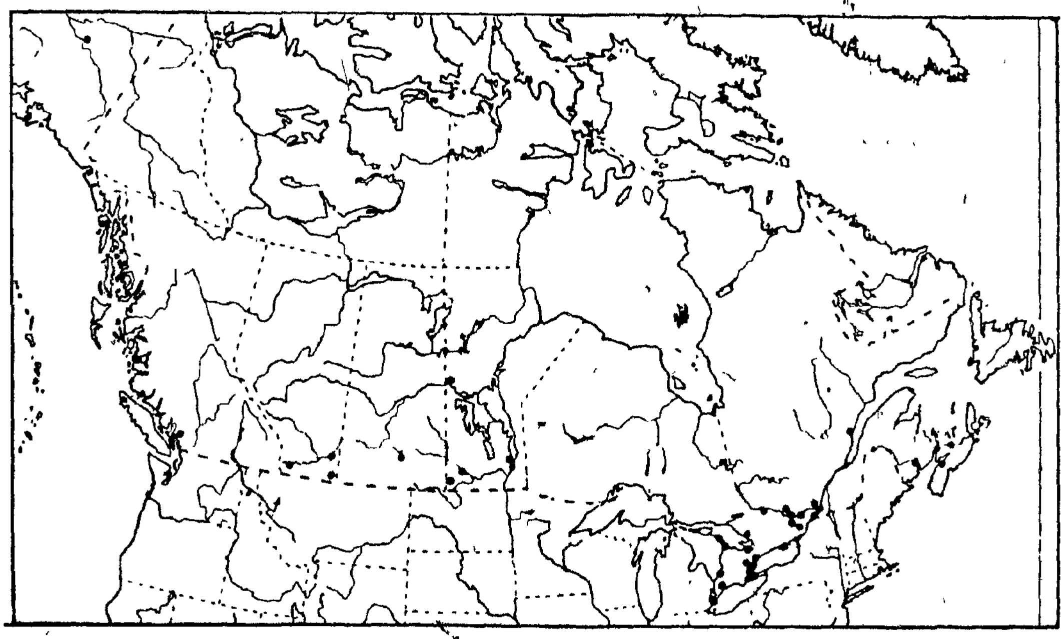
COMMENT. The female of M. centuncularis can be recognized by the 5-dentate mandible in which the emarginations on each side of the 3rd tooth are subequal in depth (Fig. cf. 58); the uniformly dark brown to black erect and decumbent hairs on tergum VI and the amber coloured scopa on sternum VI which is similar to that on the preceding sterna.

The males of M. centuncularis can be separated from all other Megachile by the complete absence of a front coxal spine, and in not having a robust median tubercle at the apical margin of clypeus.

DISTRIBUTION. Newfoundland: St.John's, 17 May 1967, 3F. Nova Scotia: Kentville, 30 Aug. 1914, 1F. King's County, 16 July 1929. Nappan, 5 Aug. 1914, 1F. Pictou, 1 Aug. 1914, 1M. Quebec: Chelsea, 12 June 1916, 1F. Hemmingford, 12 July 1913, 1M; 24 May 1914, 1M; 24 May 1914, 1M; 28 June 1915, 1F; 22 July 1924, 1F. Lakeside, 14 Aug. 1929, 1M; 14 June 1930, 1F. Montreal, 14 June 1919, 1F; 26 July 1919, 1F; 1 July 1926, 1F; 10 Sept. 1927, 1F; 29 June 1930, 1F; 28 June 1931, 1M; 28 Aug. 1947, 1M; 14 July 1950, 1F. Ste. Anne de Bellevue, 31 May 1931, 1M; 8 June 1931, 1M; 28 July 1931, 1M; 30 Aug. 1963, 1M; 17 Aug. 1965, 1F; 17 Aug. 1965, 1F; 17 Aug. 1965, 1M; 27 June 1966, 1F. Ste.Anne de la Pocatirene, 7 July 1914, 1M; 7 Aug. 1914, 1F. St.Hilaire, 25 July 1926. Strawbridge, 24 July 1926, 1M. Tadoussac, 24 July 1926, 1M. Ontario: Ancaster, 6 Sept. 1936, 1F, 1M. Agincourt, 29 June 1962, 1F. Arkell, 23 July 1951, 1M. Belleville, 30 July 1913, 1F; 30 July 1913, 1F. Cayuga, 6 Aug. 1952, 1F; 17 April 1963, 3F. Clinton, 27 Aug. 1954, 1F. County Hastings, 1895, 1M. Dundas, 6 June 1975, 1M. Dyer Bay, 10 July 1952, 1F; 21 Aug. 1953, 1F; 1 July 1954, 1F. Fonthill, 1 Sept. 1954, 1F, 1M. Golden Lake, 10 Sept. 1965, 1M. Grand Bend, 6 Sept. 1954, 1M; 6 Sept. 1954, 1M. Guelph, 27 Aug. 1913, 1F, 2M; 5 July 1952, 1F; 11 June 1954, 1F, 1M; 15 March 1955, 1F; June 1960, 1F; Aug. 1964, 1M; 20 Aug. 1965, 1F. Harrow, 19 July 1973, 1F. Hepworth, 13 Aug. 1975, 1F. Jordan, 28 July 1914, 1F;

8 Aug. 1914, 1F; 8 Aug. 1914, 1F; 27 Aug. 1914, 1F; 9 Sept. 1914, 1F; 16 Sept. 1914, 1F; 8 Sept. 1915, 2F; 25 July 1919, 1F; 25 July 1919, 1F. Kingsville, 27 June 1973, 1F. Leaside, 2 June 1961, 1F. Markham, 21 Aug. 1913; 21 Aug. 1913, 1F; 21 Aug. 1913, 2F. Minesing, 14 July 1954, 2F. Mount Pleasant, 21 July 1955, 1F. Muskoka, no date, 1F. Ottawa, 28 Aug. 1912, 1F; 28 Aug. 1912, 1F; 4 June 1913, 1M; 17 June 1913, 1M; 18 June 1913, 1F; 24 June 1913, 1F; 26 June 1913, 1F; 1 July 1913, 1F; 29 July 1913, 1M; 11 Aug. 1913, 1F; 12 Aug. 1913, 1F; 16 Sept. 1913, 1M; 14 June 1914, 1F; 17 June 1914, 1M; 9 July 1914, 1F; 12 Aug. 1914, 1F; 19 June 1915, 1M; 23 July 1915, 1F; 15 July 1957, 1F; 9 Sept. 1969, 1F. Paris, 5 June 1959, 1F. Port Dover, 18 June 1959, 1F. Portsmouth, 4 May 1926, reared (with cells), 3M. Quarries, 13 July 1946, 2F, tripping alfalfa; 12 July 1966, 1F, tripping alfalfa. St. Pascal, Aug. 1940, 1M; Aug. 1940, 1M. Spencerville, 10 July 1939, 1F. Strathroy, 30 July 1888, 1M; 6 Aug. 1888, 1F; 14 June 1890; 18 Aug. 1890, 1M; 30 June 1914, 1M; 27 June 1916, 1F; 24 June 1924, 1M. Trenton, 8 June 1899, 1M. Vineland, 25 Aug. 1936, 1F; June 1956, 2F. Wheatley, 3 July 1959, 1F. <u>Manitoba</u>: Brandon, 18 June 1958, 1M; 7 July 1958, 1F. Reston, 12 July 1948, 1F. Stonewall, 22 June 1919, 1F. Teulon, 16 June 1920, 1F. Wanless, 15 Aug. 1958, 1F. White Pine, 7 June 1922, 1M. Winnipeg, 7 June 1922, 1M; 8 June 1953, 1F. <u>Saskatchewan</u>: Regina, 4 Sept. 1909, 1F.

Alberta: Lethbridge, 26 July 1954, 2F; 22 Feb. 1955, 3F. in hose reared in lab; 7 June 1956, 1F. Medicine Hat, 1 Aug. 1917, 1M; 1 Aug. 1917, 1M. British Columbia: Squamish Diamond Head Trail, 3,200', 9 Aug. 1953, 1F. Alaska: Fairbanks, 25 June, 1952, 1M.



Map 9. Canadian distribution of Megachile centuncularis

FLOWERS VISITED. Carduus (Plumeless Thistle), (M); Centaurea (Star-Thistle), (M); Epilobium (Fireweed), (M); Grindelia (Gumweed), (M); Helianthus (Sunflower), (M); Inula, (M); Medicago (Alfalfa), (M); Melilotus (Sweet Clover), (M); Psoralea (Scurf-Pea), (M); Solidago (Goldenrod), (M); Taraxacum (Dandelion), (M); Trifolium (Clover), (M).

BIOLOGY. The species exhibits a great deal of versatility in its adoption of nesting sites; it has been attracted to nest in sumac stick trap nests hung on wires or posts in open pastures (Medler 1959); nests have also been found between cavities in stone walls or crevices in the roof or walls of buildings (Pengelly 1955, 1958); at Rampart House, Yukon Territory, adults were taken flying in and out of burrows excavated in a river bank. The female appears to have an affinity for cutting extra sections of leaves for cell construction. Medler (1959) reported a female, which had been observed for 20 days, used about 1,000 pieces of leaves to construct 30 cells. In Europe, leaves of hardwood trees, especially beech, were used to make the cells (Medler 1959). In southern Ontario, Pengelly observed leaves of the following plants used for constructing cells: Chenopodium album (Lamb's quarters); Lychnis alba (White Cockle); Malva neglecta (Roundleaf Mallow) and Melilotus officinalis (Yellow Sweet Clover).

PARASITES. Coelioxys moesta, Dibrachys maculipennis, Melitobia megachilis, Monodontomerus montivagus. (Medler and Lussenhop 1968).

ALFALFA POLLINATING POTENTIAL. Pengelly (1953) reported M. centuncularis to visit 26-28 flowers per minute with 99-100 tripping efficiency. The author observed a female to inhabit a hole made in wood. Nests similar to those used for M. rotundata (Hobbs 1973) might be used for M. centuncularis. Although the species is currently widely distributed across Canada, it is not commonly collected.

Fig. 20. M. relativa, M. Mandible with apex of middle tooth at approximately midpoint between the inner and outer denticles.

Fig. 21. M. inermis, M. Mandible with apex of middle tooth closer to outer than inner tooth.

MEGACHILE (MEGACHILE) RELATIVA CRESSON

Figures 20, 38, 58, 74; Map 10

Megachile relativa Cresson, 1878: 126 (new species).

Megachile (Megachile) relativa; Pengelly, 1955:124 (biology).

Megachile relativa; Medler and Keorber 1958: 337 (biology).

Megachile (Megachile) relativa; Mitchell, 1962:129 (description, distribution and flower records).

Megachile relativa; Fye, 1965: 875 (biology).

FEMALE. Length 10-12 mm. Mandible 5-dentate with the emargination on each side of the 3rd tooth subequal in depth (Fig. 58). Outer margin of first mandibular tooth inflexed posteriorly, tapered and pointed apically. Bevelled cutting edge projecting from the outer side of the third mandibular tooth, and occupying nearly half of, the emargination between the 2nd and 3rd teeth. Emargination between the 4th and 5th teeth usually shallow and arcuate, while the emargination between the 3rd and 4th teeth is distinctly deeper and oblique, the angle of obliqueness describing the cutting path of the mandibles as they slide past each other. Inner cutting edge (which can be seen when the mandible is opened) arising from the base of the 2nd tooth and extending on the inner side along the bases of the 3rd and 4th teeth to the inner,5th tooth. Apical margin of clypeus approximately truncate, without prominent tubercles; weakly emarginate medially, with a polished anterior border, and two oblong clusters of setae arising from the extreme, incurved apical rim. Lateral ocellus nearer to posterior border of vertex than to eye. Sixth tergum nearly straight in lateral view, with short appressed hairs of approximately uniform length, along with scattered, erect longer hairs becoming more numerous laterally. Pubescence on sixth tergum usually brown to black basally, golden apically.

MALE. Lenght 9-11 mm. Mandible 3-dentate with the apex of the middle tooth subequally distant to either the 1st or 3rd denticles. Apex of clypeus with robust sub-polished median tubercle beneath the overhanging beard. Short hypostomal tubercle and a weakly depressed, hypostomal concavity present; sculpture and pubescence not distinctly differentiated on the concavity and tubercle. Front basitarsus not modified, dark and simple, similar in colour and shape to mid-basitarsus; tarsal segments beyond the basitarsus often somewhat ferruginous. Front coxal spine entirely absent. Apical tooth on posterior tarsal claw tapered and pointed, similar to the apical tooth on anterior claw. Sixth tergum polished, with minute punctures from which arise short, slender, decumbent hairs and scattered larger punctures, with long erect hairs. Apical margin of sixth tergum with a straight sublateral tooth, preceded by a carinate angulation about midpoint between the lateral margin and centre of apical rim. Seventh tergum with median transverse carina closer to the apical rim than to gradulus; carina usually tuberculate medially; transverse, ovate area between median carina and gradulus usually depressed, subpolished and bordered by carinae.

COMMENT. The female of M. relativa can be recognized by the 5-dentate mandible, in which the emargination on each side of the 3rd tooth is subequal in depth, and by the golden pubescence, on tergum VI. M. relativa is closely related to and resembles M. centuncularis; however, they can be differentiated by the pubescence on tergum VI,. which is brown basally and golden apically, with a few erect hairs medially, in M. relativa, and uniformly dark brown to black with numerous erect hairs medially in M. centuncularis. The shape of the mandible in M. relativa also resembles that in M. nivalis. However, in M. nivalis, the scopal hairs on the sixth sternum are black and conspicuously darker than the scopal hairs on the preceding sterna, while in M. relativa, the scopal hairs on all sterna are of a uniformly amber colour.

The male of M. relativa can be recognized by the complete absence of a front coxal spine and the prominent, robust, median tubercle at the apex of the clypeus, beneath the beard.

DISTRIBUTION. It is widely distributed in North America extending from the Northwest Territories to California, east to Nova Scotia. In Canada, M. relativa has been collected from the following localities (Map 10): Nova Scotia: Freeport, 29 July 1960, 1M. Kings Co., 23 July 1930, 1M on Epilobium; 31 July 1930 on Epilobium; 30 July; 15 July 1931, 1M; 20 July 1931, 2M on Epilobium; 18 Aug. 1932, 1F, Solidago. Lunenburg Co., 3 July 1931, 1M, Epilobium Painsec; 4 Aug. 1914, 1F. Springhill, 30 July 1976, 1F. New Brunswick: Acadia, Sunbury Co., 28 June 1976, 1F; 5 July 1976, 1F; 5 July 1976, 2M; 7 July 1976, 2M; 16 July 1976, 2M; 16 July 1976, 2F. Fredericton, 7 Aug. 1914, 2F; 16 Aug. 1922, 1F; 6 Aug. 1925, 1F; 20 Sept. 1948, 1F. Lawrence Station, Charlotte County, 23 June 1976, 1F. McAdam, York County, 17 June 1924, 2M. Priceville, 12 July 1972, 3F; 19 July 1972, 3F; 27 July 1972, 1F. St.Croix, Charlotte County, 17 June 1924, 1M; 23 June 1976, 1F. St.John, 30 Aug. 1898, 1M; 13 July 1901, 1M. Prince Edward Island: Dalvay House, Canadian National Park, 10 Aug. 1940, 1F; Quebec: Aylmer, 21 June 1915, 4M. Aylmer, Queen's Park, 23 July 1924, 1M; 15 Aug. 1924, 2F. Aylmer, 17 Aug. 1926, 1F. Beauharnois, 18 June 1962, 1F. Bondville, 19 July 1917, 1F. Brome County, 2 July 1917, 1M; 11 Aug. 1917. Cap Rouge, 4 July 1953, 2M. Charlevoix County, 17 Aug. 1918, 1F. Chelsea, 5 July 1912, 1M. Covey Hill, 4 July 1913, 1M. Forestville, 14 July 1950, 2M; 8 Aug. 1950, 4F, 1M; 11 Aug. 1950, 2F, 1M; 11 Aug. 1950, 1F. Fort Coulonge, 21 Aug. 1917, 2F; 21 Aug. 1917, 1M; 24 June 1919, 1M; 19 July 1919, 1F. Gatineau, 25 July 1966, 1F. Hemmingford 21 June 1916, 1M. Hull, 10 June 1889, 1M; 13 Aug. 1913, 1F. Kazabazua, 3 July 1913, 1F; 4 Aug. 1913, 1F; 9 Aug. 1913, 1F. Kingsmere, 16 Aug. 1949, 1 F. Lac Sam, 21 July 1968, 1F. Lakeside, 29 July 1928, 1M. Laniel, 20 July 1930, 1F; 10 June 1931, 1M; 4 July 1931 1M; 14 July 1931, 1M; 14 July 1932, 2F, 2M; 19 July 1932, 1M; 21 July 1932, 1F; 3 July 1935, 2 F; 23 July 1935, 1F; 24 July 1935, 2F; 1 Aug. 1935, 1F, 1M: 14 Aug. 1935, 1F, 2M; 14 Aug. 1935, 1F. Lanoraie, 3 Sept. 1925, 1F; 2 July 1932, 1M. Lanordal, 3 Sept. 1925, 1F. Laurentians, Terrebonne County, 7 July, 1M. Montfort, 4 July, 1916, 1F, 1M; 11 July 1916, 1M. Mont Joli, 5 Aug. 1954, 1M. Montreal, 15 Aug. 1920, 1F; 5 Aug. 1921, 1F; 1 Sept. 1925, 1F; 5 Sept 1925, 1F; 11 July 1927, 1M; 6 Sept. 1930, 1F. Outremont, 10 July 1917, 1F.

Quebec City, 8 Aug. 1914, 1F. Place Reca, 14 Aug., 1M. Ste Anne de la Pocatien, 7 Aug. 1914, 2F, 1M; 8 Aug. 1914, 2F. Ste Anne's, 9 July 1938, 1M. St Calixte, 18 June 1931, 1M; 11 June 1933, 1M. St Hilaire, 25 July 1927, 1F; 5 Aug. 1927, 1F; 7 Aug. 1927, 1F; 20 Aug. 1927, 1F; 28 Aug. 1927, 1F; Aug. 1930, 1F. St. Martin, 29 Aug. 1925, 1F; 17 July 1926, 1M; 4 Sept. 1926; 1F. Ste Anne de Bellevue, 2 June 1964, 1F; 7 June 1964, 1M; 27 Aug. 1964, 1M; 1 Sept. 1965, 1F; 3 Sept. 1965, 1F; 21 June 1966, 1M; 27 June 1966; 14 July 1967, 1F; 24 Aug. 1967, 1F; 24 Aug. 1967, 1F; 24 Aug. 1967, 1M; 26 Aug. 1967, 1F; 1 Sept. 1967, 1M; 1 Sept. 1967, 1F; 5 Sept. 1967, 1F; 5 Sept. 1967, 1F. Shawbridge, 24 Aug. 1921, 1F; 19 July 1926, 1M; 3 Aug. 1927, 1F; 7 Aug. 1927, 1F; 24 Aug. 1929. 1F. Tadoussac, 2 July 1932, 1M; 21 July 1932, 1F; 23 Aug. 1932, 1M; 23 Aug. 1932, 1F. Tenega, 26 Aug. 1949. Ontario: Acton, 8 July 1955, 1F. Algonquin Park, 6 Aug. 1961, 1F; 9 Aug. 1961, 1M. Arkell, 24 June 1952, 1F. Blueweed, 15 July 1952, 1F. Asqua Bay, 2 Aug. 1959, 1F. Black Sturgeon Lake, 27 June 1961, 1F, 1M, mating pair; 1 Aug. 1962, 1F, nest in Elderberry twig; 2 Aug. 1962, 1F; 6 July 1962, 1M; 18 July 1962, 1M; 19 July 1962, 1M; 23 July 1962, 1M; 26 July 1962, 1M; 12 July 1963, 1M (insectory); 13 July 1963, 2M (insectory); 18 July 1963, 3F. Bonville, 1913, 1F. County Hastings, 22 June 1901, 1M. Cochrane, 9 Aug. 1917, 1F Coehill, 28 June 1942, 1M. Dorset, 18 July 1961, 1M. Dyers Bay, 24 June 1953, 1F; 15 July 1953, 1F; 20 July 1953, 1M; 17 Aug. 1953, 1F, Goldenrod; 23 Aug. 1953, 1F; 12 July 1954, 1F; 20 July 1954, 1F, 1M; 24 July 1954, 1F. Emo, 3 July 1917, 1F. Gananoque, 24 July 1965, 1F. Go Home Bay, 11 July 1932, 1M. Glengarry, 4 July 1941, 1F. Grand Bend, 6 Sept. 1954, 1F, Aster. Graham, 5 July 1916, 1M. Guelph, 15 July 1965, 1F; 24 June 1965, 1M. Haileybury, 7 July 1916, 1F, 2M. Hawk Lake, 28 June, 1938. Hurkett, 9 Aug. 1960, 1F, Epilobium angustifolium. Kendal, 29 July 1961, 1F. Macdiarmid, Lake Nipigon, 31 July 1922, 1F; 13 Aug. 1922, 5 F. Marmora, 6 July 1939, 1F; 5 July 1952, 1F; 8 July 1952, 1M; 19 July 1952, 1M; 1 Aug. 1961, 1F. Nipigon, 25 June 1895, 1M. Ogoki, 16 July 1952, 1M. Ottawa, 24 Sept. 1908, 1F; 20 Aug. 1912, 1F; 20 Aug. 1912, 1F; 24 Sept. 1912, 1F; 9 June 1913, 1M; 27 June 1913, 1M; 1 July 1913, 1M; 8 July 1913, 1M; 28 July 1913, 1F; 29 July 1913, 1F; 5 Aug. 1913, 1M; 6 Aug. 1913, 1F; 16 Aug. 1913, 1F; 12 Aug. 1914, 1F; 14 Aug. 1914, 1F, 1M; 15 Aug. 1914, 1F; 7 June 1915, 1F; 29 June 1915, 1M; 2 June 1968, 1F; 24 July 1969, 1F, Fireweed; 20 Oct. 1971, 1F, reared from cell in wood; 21 Oct. 1971, 2M, reared from cell in wood; 22 Oct. 1971, 1M, reared from cell in wood. Presqu'ile, 28 July 1963, 1F. Primrose, 22 July 1952, 1F, Chicory. Quarries, 17 June 1946, 1M, Raspberry. Rousseau, 12 Oct. 1963, 1F; Sault Ste Marie, 20 July 1963, 1F. Scuttle Hole, 5 July 1942, 1F. Sioux Lookout, 16 July 1929, 1M. Spencerville, 21 Aug. 1939, 1F; 31 Aug. 1939, 1F. Sudbury, 1890. 1F; 1892, 1F . Thornloe, 9 Aug. 1917, 2F. Toronto Island, 1887, 1F. Toronto, 1 Apr. 1893, 1M. Vermillion, 30 July 1962, 1F; Vineland Station, 8 Sept. 1936, 1F. Ware Township, July 1961, 1F, reared. Manitoba: Agricultural College, 6 July 1923, 1F. Aweme, 5 Aug. 1915, 1F; 26 June 1916, 1F; 12 July 1916, 2F, 2M; 13 July 1916, 1F, 3M; 15 July 1916, 1M; 19 July 1916, 1F; 28 July 1916, 1M; 20 June 1917, 1M; 24 June 1924, 1M; 4 July 1925, 1F. Boggy Creek, 5 July 1962, 2F. Brandon, 4 Apr. 1948, 1F; 20 Aug. 1948, 3F. Carberry, 10 May 1948, 1F. Clear Lake, 24 Aug. 1948, 1F. Cormorant Lake, 20 June 1927, 2M. Dauphin, 17 July 1916, 1M. Delta, 17 July 1971, 1F. Douglas, 30 July 1924, 1F. Emerson, 15 July 1916, 1M. Erickson, 12 Aug. 1975, 1M; 17 Aug. 1975, 1F. Gillan, 19 July 1950, 2M. Hoela Lake, 19 July 1962, 1M. Mile 332 H.B.R., 14 July 1917, 1F. Morden, 11 July 1952, 1F. Ninette, 12 June 1958, 1M, Maple, Elm floodplain community. Pikwitonei, 1Aug. 1949, 1M; 2 Aug. 1949, 2M. Riding Mountain National Park, 1 Aug. 1963, 1F; 1 Aug. 1963, 1M. Roblin, 30 Apr. 1946, 1F, stovewood.

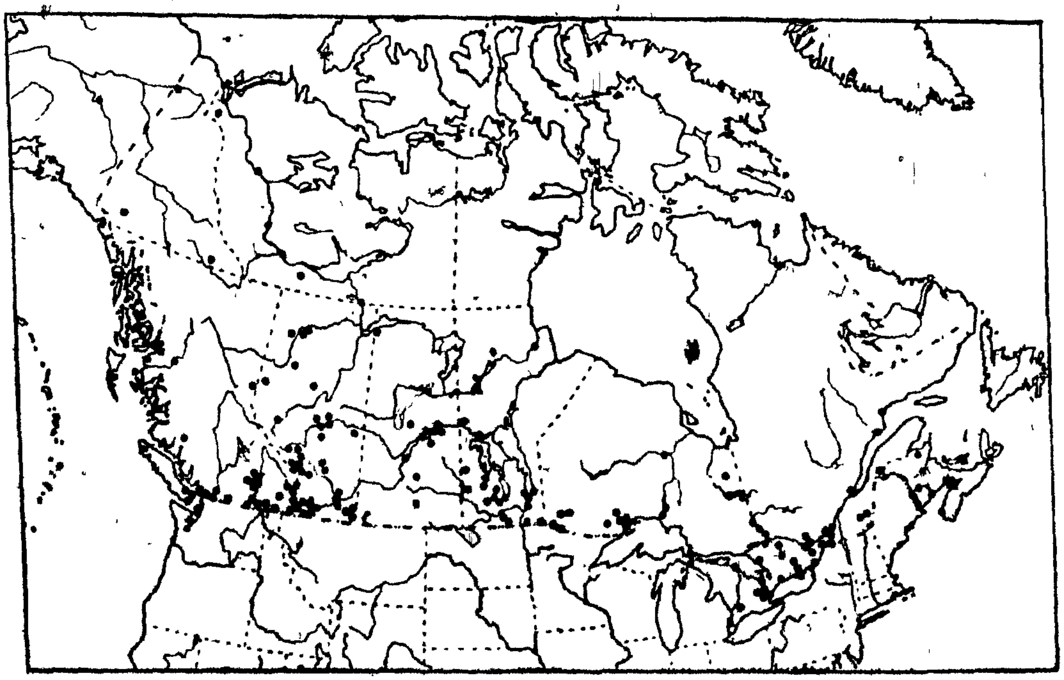
St. James, 19 Aug. 1962, 1F. Selkirk, 5 Aug. 1916, 1M. Sprague, 7 July 1948, 1F; 9 July 1948, 2F. Teulon, 23 June 1920, 4M; 30 July 1924, 1F. Victoria Beach, 20 July 1924, 1F. Wanless, 30 July 1953, 1F, Yarrow; 17 Aug. 1953, 4F; 19 Aug. 1953, 2F; 21 Aug. 1953, 1F; 3 Aug. 1954, 1F, Fireweed; 27 July 1955, 1F, Fireweed; 27 July 1955, 1F; 1 Aug. 1955, 1F, collected in car; 27 July 1956, 1F, 1M, emerged from Poplar log; 28 July 1956, 3M, emerged from Spruce log; 1 Aug. 1956, 1M, emerged from Spruce log; 4 Aug. 1956, 4M, on dead Brome grass; 30 July 1957, 2F, Fireweed; Aug. 1957, 1F, lab. reared; 17 July 1958, 1F, Daisy; 15 Aug. 1958, 2F. Winnipeg Beach, 16 July 1916, 1F, 4M. Winnipeg, 25 June 1926, 1M; 24 June 1930, 1M; 30 July 1935, 1F; 31 July 1935, 3F; 21 Aug. 1935, 2F. Saskatchewan: Choiceland, 12 Aug. 1943, 1M. Codette, 5 July 1938, 1F, Alfalfa. Cypress Hills, 30 July 1949, 1F. Love, 3 July 1944, 2F, Alfalfa; 3 July 1944, 1M in Poplar stump; 27 July 1944, 5F, Fireweed. Melfort, 20 July 1916, 2F, 1M. Nipawin, 20 July 1944, 1F, Alfalfa. Regina, 24 Aug. 1907, 1F; 7 Sept. 1907, 1F; 11 July 1909, 1M. Saskatoon, 14 July 1924, 2F; 14 Aug. 1939, 1F. Smeaton, 2 Aug. 1944, 1F, Alfalfa and Sow Thistle. Snowden, 15 July 1934, 1F, Alfalfa; 13 June 1943, 1M; 14 July 1944, 1M, tripping Alfalfa; 15 July 1944, 5M, flying in Alfalfa field; 15 July 1944, 4M, ex. hole in log stub; 15 July 1944, 1F, Alfalfa; 28 July 1944, 15F, Fireweed; 28 July

1944, 5F, Sow Thistle; 28 July 1944, 1F. Strasbourg, 25 July 1949, 1F, from Ash borer hole. Swift Current, 1 Oct. 1963, 1F. Torch River, 19 June 1944, 1M, from hole in log. Waskesiu Lake, 22 June 1939, 1M; 20 July 1939, 4M; 26 July 1939, 1F; 27 July 1939, 3M; 2 Aug. 1939, 1F. White Fox, 25 July 1934, 1M; 28 June 1944, 1M; 4 July 1944, 1F, Dandelion; 28 June 1944, 1F; 1944, 8M, reared, not fully developed. Alberta: Abee, 10 Aug. 1972, 1F. Alberta, 2 Aug. 1920, 2 F emerged from cell. Aspen Beach, 25 Aug. 1944, 1F, Sow Thistle; 1971, 1F, in fuel line of airplane - Cessna accident. Banff, 24 June 1914, 3M; 7 Aug. 1915, 1M; 3 July 1922, 1M; 14 Aug. 1922, 1F; 30 Aug. 1922, 1F; 12 Sept. 1924, 1F. Bean Lake, 18 Aug. 1915, 2F. Beaver Lodge, 6 July 1931, 2M; 12 July 1931, 1F. Bowden, 15 Aug. 1962, 1F. Calgary, 29 July, 1916, 1M; 18 July 1917, 1F, 1M. Cypress Hills, 10 July 1931, 1F. Delbaine, 17 Aug. 1962, 1F. Della, 22 July, 1931, 1F. Edmonton, 5 June 1915, 1M; 28 June 1915, 1M, Yellow Sweet Clover; 27 July 1915, 1F; 4 Aug. 1915, 1F; 15 July 1916, 1M; 1 July 1925, 1M; 28 May 1926, 1M; 29 May 1926, 1M; 16 June 1926, 2M; 20 June 1926, 1M; 31 July 1927, 1F; 13 July 1929, 1F; 9 June 1932 1M; 3 Apr. 1934, 1M; 15 June 1937, 1M; 20 June 1937, 1M; 1 July 1937, 1M; 27 June 1939, 1M; 27 Aug. 1950, 1F; 29 Aug. 1959, 1F, Fireweed; 16 May 1967, 3F, 2M, emerged in lab from Megachile rotundata hive. Elkwater, 1 Aug. 1949, 1M; 23 July 1952, 3M; 18 July 1956, 1M; 20 July 1956, 1F. Falher, 21 March 1949, 1M, reared. Fawcett, 20 June 1932, 1F; 20 June 1932, 2M; 10 June 1934, 1M. Fort Vermillion, 8 Aug. 1957, 3F, Wild Mint; 8 Aug. 1957, 6F; 31 Jan. 1963, 2M, emerged in lab. Frank, 15 Aug. 1926, 1F. Golden Spike, 11 July 1957, 1F. Grassy Lake, 15 June 1967, 1F; 16 June 1967, 2F. Greencourt, 22 July 1920, 1F. Irvine, 9 July 1952, 1M. Jasper Park, Sept. 1916, 1F. Keg River, 5 Aug. 1959, 1F, on log. Lamont, 27 July 1972, 1F; 2 Aug. 1972, 4F; 6 Aug. 1972, 1F; 9 Aug. 1972, 4F; 15 Aug. 1972, 1F. Lethbridge, 28 June 1914, 4M; 19 July 1914, 1F; 5 Aug. 1914, 1F; 26 Aug. 1914, 1F; 18 June 1929, 1M; 24 June 1948, 1M; 8 July 1949, 3F, Fireweed; 3 June 1952, 1M, Senecio; 7 July 1952, 1F, Alfalfa; 23 July 1952, 2F, Alfalfa; 23 July 1952, 1F, Ratibada columnifera; 30 July 1952, Alfalfa; 24 June 1956, 1M; 14 Sept. 1964, 1F. Medicine Hat, 17 July 1917, 1M; 23 Aug. 1919, 1F. McMurray, 24 June 1953, 1M; 27 June 1953, 2F; 30 June 1953, 1M; 11 July 1953, 1M; 6 July 1953, 1F. Morrin, 28 July 1931, 1F. Nordegg, 21 July 1926, 1F, 3M; 25 July 1936, 1M; 27 July 1936, 1M. Prairie Bluff, 8 July 1970, 1F, Achillea Millefolium; 19 July 1970, 3F, Erigeron; 29 June 1971, 1F; 12 July 1971, 1F; 14 July 1971, 1F; 23 July 1971, 1F, 1M; 24 July 1971, 1F; 26 July 1971, 1F, on Geranium; 26 July 1971, 1F, 2M; 27 July 1971, 1M; 29 July 1971, 5F; 3 Aug. 1971, 2F; 2 Aug. 1971, 1F; 4 Aug. 1971, 2M; 5 Aug. 1971, 1F, 1M; 22 June

1974, 1F; 27 July 1975, 1F. Red Deer, 22 July 1921, 2F; 22 July 1926, 1F. Rolling Hills, 31 July 1951, 1F. Canada Thistle. Scandia, East of settlement, 26 July 1951, 1F, Fireweed. Scandia, 14 July 1952, 1F, Epilobium; 1961, 2F, emerged in lab. from artificial domicile. Shaftesbury, 18 Aug. 1915, 1F. Shawinigan Lake, 7 July 1914, 1F. Shaughnessy, 27 April 1967, 2F, emerged in lab. Slusoap Lake, 31 July 1961, 1F. Spring Coulee, 1961, 6F, 6M, emerged in lab from artificial domicile. Sylvan Lake, 8 June 1918, 1M. Vermilion, 13 July 1947, 1F, Spruce. Wabamun, 2 Aug. 1926, 1F; 1 July 1927, 1M; 14 Aug. 1929, 1M; 22 July 1936, 1F; 2 July 1938, 1F; 2 Aug. 1938, 1F; 3 July 1939, 1M; 14 July 1939, 1M. Waterton, 13 Aug. 1922, 1M; 2 July 1924, 1M; 26 July 1952, 1F, Aster. White Mud, Peace River District, 16 July 1932, 1F. British Columbia: Agassiz, 27 June 1923, 1F. Choiceland, 19 June 1943, 1F, Dandelion. Creston, 8 Sept. 1923, 1F; 10 Sept. 1923, 1F; 11 Aug. 1927, 2M. Fairview, 18 May 1919, 2M. Fort Steele, 20 June 1922, 1M. Harrison Mills, 16 July 1953, 1F. Hazelton, 20 June 1925, 1M. Invermere, 30 June 1914, 5M. Lac le Jeune, 21 Aug. 1959, 1F, Epilobium. Kamloops, 19 July 1942, 1M. Kaslo, 3 June 1906, 1M; 10 June 1906, 1M; 14 June 1906, 1M; 30 June 1906, 1M; 24 July 1906, 1F, 3M; 3 Aug. 1916, 2M; 3 Aug. 1916, 1M. Keremeos, 18 June 1919, 1F, 1M. Lardo, 26 Sept. 1913, 1M. Lower Post, 17 June 1948, 1M. Manning Park (Pinewoods, 4000'), 7 Aug. 1953, 3M;

8 Aug. 1953, 1F. Milner, 26 May 1932, 1F. Mission City, 24 July 1953; 27 July 1953, 1F. Nanaimo, 15 July 1965, 1F. Oliver, 24 July 1953, 1M. Osoyoos, 10 June 1919, 1M; 15 July 1953, 1M; 21 July 1953, 1M. Peachland, 2 Aug. 1909, 1F; 7 Aug. 1909, 1M. Penticton, 7 June 1919, 2M; 21 June 1919, 1M; 22 June 1919, 1M. Revelstoke Mountain (6,000'), 12 Aug. 1923, 1F; 17 July 1931, 1F, 1M; 4 Aug. 1952, 1F; (5,400'), 13 Aug. 1952, 1F. Robson, 18 Aug. 1948, 1F; 30 Aug. 1948, 1F; 31 Aug. 1948, 1F; 6 Sept. 1948, 1F; 8 Sept. 1948, 1F; 13 Sept. 1948, 3F; 14 Sept. 1948, 1F; 16 Sept. 1948, 1F. Rolla, 2 July 1927, 1F, 1M. Salmon Arm, 4 July 1914, 1M. Shawinigan, V.I., 7 July 1914, 2F; 7 July 1914, 1M; 7 July 1914, 1F, 1M. Shuswap Lake, 15 July 1965, 1F. Shuswap Narrows, 31 Aug. 1943, 1F. Spillemachine, 3 July 1914, 4M. Sidney, 15 Aug. 1916, 1M. Squamish, Diamond Head Trail, 1 Aug. 1953, 1F; 3 Aug. 1953, 2F, 1M; 5 Aug. 1953, 4M; 6 Aug. 1953, 1M; 7 Aug. 1953, 3M; 9 Aug. 1953, 2M; 10 Aug. 1953, 1M; 12 Aug. 1953, 2M; 13 Aug. 1953, 8M; 15 Aug. 1953, 1M; 30 Aug. 1953, 1F. Taft, 18 Aug. 1952, 1F. Terrace, 10 Aug. 1964, 1F. Vancouver, 6 July 1902, 1M; 12 Aug. 1916, 1M. Vernon, 12 Aug. 1916, 2M; 24 July 1917, 1M; 31 July 1923, 1M; 2 Aug. 1923, 1M; 28 Aug. 1923, 1F. Victoria, 28 Aug. 1924, 1F. Northwest Territories: Fort McPherson, 1 July 1957, 1M; 3 July 1957, 1M; 9 July 1957, 1M; 10 July 1957, 1M. Fort Smith, 14 July 1967, 1M. Fort Simpson, 25 June 1922, 1M; 25 June 1950, 1M;

15 July 1950, 1F; 8 Aug. 1950, 3F; 9 Aug. 1950, 1M; 12 Aug. 1950, 3F. Fort Wrigley, Mackenzie River, 23 July 1922, 1M; 25 July 1922, 1F. Hay River, 4 Aug. 1951, 1F; 27 Aug. 1951, 1F. Norman Wells, 23 July 1949, 1F; 27 July 1949, 1M. Padley, 9 Aug. 1950, 1M. Yellowknife, 30 June 1949, 1M; 23 July 1949, 1M; 29 July 1949, 1M; 2 Aug. 1949, 1F; 4 Aug. 1949, 1F; 4 Aug. 1949, 1F; 10 Aug. 1949, 1F. Yukon Territories: Dry Creek, 23 July 1948, 1F, 2M. Marsh Lake, 10 July 1948, 1F. Rampart House, 7 July 1951, 4F; 7 July 1951, 2F, 1M; 9 July 1951, 2F, 1M; 10 July 1951, 2F; 10 July 1951, 1F; 12 July 1951, 1F, 5M. Watson Lake, 17 June 1948, 1M; 10 July 1949, 1F; 19 July 1949, 1F. Whitehorse, 2 July 1948, 3M; 5 July 1948, 1M; 7 July 1948, 1F. Alaska: Big Delta, 30 June 1951, 1M. Fairbanks, 25 June 1952, 2M.



Map 10. Canadian distribution of *Megachile relativa*

FLOWERS VISITED. Achillea (Yarrow, (L, M); A. millefolium, (L); Aster, (L, M); Brassica (Mustard), (M); Cichorium (Chicory), (L, M); Cirsium (Common Thistle), (M); C. arvense (Canada Thistle), (L); Chrysanthemum (Chrysanthemum, White Daisy), (L, M); Echium (Viper's Bugloss), (M); E. vulgare (Blueweed), (L); Epilobium (Fireweed), (L, M); E. angustifolium, (L); Erigeron (Fleabane), (L, M); Geranium (Cranes-bill), (L, M); Houstonia (Bluets), (M); Melilotus (Sweet Clover), (M, L); M. officinalis (Yellow Sweet Clover), (L); Mentha (Mint), (M); M. arvensis (Wild Mint), (L); Physallis (Ground Cherry), (M); Ranunculus (Buttercup), (M); Ratibada (Prairie Coneflower), (L, M); R. columnifera, (L); Rhododendron (Rosebay), (M); Rosa (Rose), (M); Rubus (Raspberry), (L, M); Rudbeckia (Coneflower), (M); Senecio (Groundsel), (L, M); Solidago (Goldenrod), (L, M); Sonchus (Sow-Thistle), (L); Taxacum (Dandelion), (L); Trifolium (Clover), (M); Vicia (Vetch), (L, M).

BIOLOGY. In southern Alberta, Hobbs (1954) noted that M. relativa is restricted to treed areas of river valleys. At Rampart House, Yukon Territories, it was taken from burrows dug into a river bank. In Wisconsin, M. relativa was observed along edges of woodlands, and was attracted to nest in sumac traps at preferred heights of about 2 meters above ground (Medler 1958). It is highly versatile in its range of nesting sites and will readily inhabit holes in wood (several adults have been reared from Ash, Spruce and Poplar), concrete or plastic. About 8 cells are made in a burrow, females occupy the inner cells, and males develop in the outer or succeeding cells. Cells are made with about 10 oblong leaves and capped with about 3 circular leaves. Pengelly (1955), observed females to cut leaves from *Fragaria vesca* and *Apocynum androsaemifolium* for cell construction. Generally, the exit hole of the burrow is securely plugged with extra leaves, alternated with empty spaces, chewed leaves, clay or resin.

PARASITES. *Coelioxys funeraria*, *C. octodentata*, *C. porterae* and *C. moesta*; *Leucospis affinis* and *Dibrachys maculipennis* (Medler and Lussenhop, 1968).

ALFALFA POLLINATING POTENTIAL. *Megachile relativa* can tolerate a wide range of environmental conditions and is one of the most common species of leaf-cutter bees across most of Canada. Adults begin to emerge in mid June when alfalfa usually begins to blossom. It has been collected on alfalfa and is reported to be a fast and efficient pollinator of alfalfa (Peck and Bolton, 1946). Currently it is unknown whether *M. relativa* could construct its cells from alfalfa leaves or whether suitable secondary plants would have to be grown for this purpose. The author has identified specimens taken from nests constructed commercially for *M. rotundata*. It may be that *M. relativa* could be reared in such nests. If a pest-free population of breeder stock were selected and bred, a 5 to 7 fold annual reproductive rate might be achieved. Light weight domiciles bearing *M. relativa* in the pupal stage could then be transferred to any alfalfa field requiring pollinators in North America. Such domiciles could be erected in alfalfa fields and maintained with minimal annual care.

MEGACHILE (MEGACHILE) NIVALIS FRIESE

Figure 52; Map 11.

Megachile nivalis Friese, 1903:246 (new species, female only).

Megachile (Megachile) nivalis; Mitchell, 1962:129 (description, distribution and flower records).

FEMALE. Length 12-14 mm. Mandible 5-dentate, with the emargination on each side of the 3rd tooth subequal in depth. First mandibular tooth reflexed posteriorly, tapered and pointed apically. Emargination between the 4th and 5th denticles shallowly arcuate, distinctly oblique between the 3rd and 4th teeth. Apical rim of clypeus polished and impunctate, usually with a shallow but noticeable emargination medially. Sixth tergum nearly straight in lateral view, with uniformly brown to black pubescence; moderately dense, short, appressed hairs partially obscuring the integument beneath, along with scattered, elongate, erect hairs becoming more numerous and robust laterally. Scopal hairs, usually black along the apical and lateral margins on sternum V; entirely black on sternum VI.

MALE. The male which belongs to the female or M. nivalis has not been determined. Megachile collected from tunnels which they dug into a river bank at Rampart House, Yukon Territory contained M. nivalis, M. giliae, M. montivaga,

M. relativa and M. frigida. The females and males of the latter three species have been associated. However, the presence of M. nivalis which has not been linked with its male and M. giliae which has not been linked with the female lends support to the belief that the females of M. nivalis and the males of M. giliae belong to the same species. On the other hand, Peck and Bolton (1946) collected 29 M. nivalis from Torch River, White Fox, Love and Snowden, Saskatchewan, but they did not collect any M. giliae.

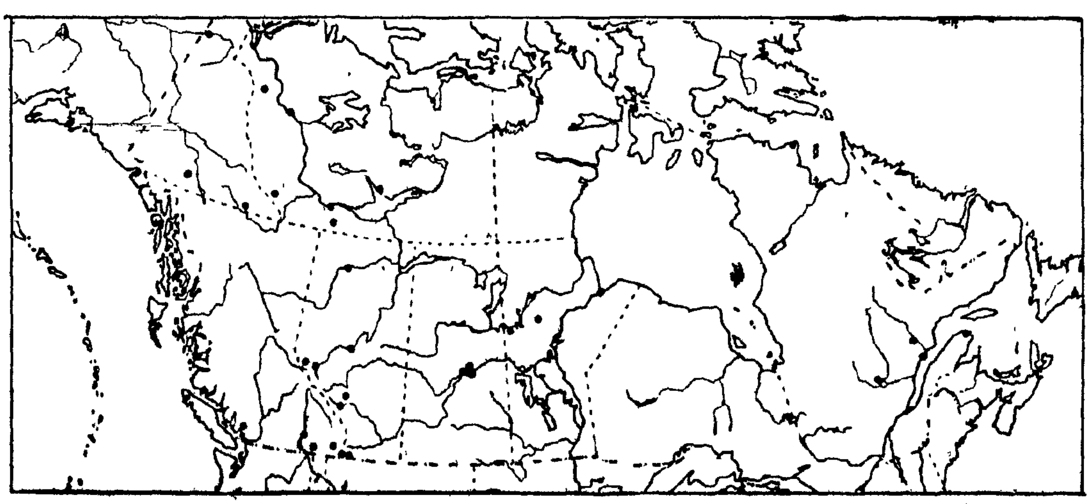
COMMENT. The female can be recognized by the entirely black scopal hairs on the sixth sternum (which contrast conspicuously with the amber scopal hairs on the preceding sterna), and the 5-dentate mandible, in which the emargination between the 3rd and 4th teeth is not deeper than the emargination between the 2nd and 3rd teeth (Fig. 52).

Morphologically M. nivalis resembles M. relativa and M. centuncularis in the shape of the mandible, clypeus, and the concavity and pilosity of the sixth tergum, however, neither of these two species have the scopal hairs on the sixth sternum entirely black.

DISTRIBUTION. M. nivalis occurs mainly in the northwestern part of North America, extending from the Northwest

Territories south to Colorado and east to Quebec. In Canada, specimens have been collected from the following localities (Map 11): Quebec: Forestville, 9 Aug. 1950, 1F. Gaspe, 24 Aug. 1932, 1F. Indian House Lake, 8 July 1954. Mistassini, 10 Aug. 1956, 1F; 28 Aug. 1926, 1F. Manitoba: Churchill, 14 July 1948, 1F. Ft.Vermillion, 8 Aug. 1957, 1F; 10 Aug. 1949, 1F. Wabowden, 1 Aug. 1937, 1F; 2 Aug. 1937, 1F; 4 Aug. 1937, 1F. Wanless, 20 Aug. 1953, 1F; 4 Aug. 1954, 1F; 5 Aug. 1954, 1F; 18 Aug. 1954, 1F, on Alfalfa; 23 Aug. 1954, 1F; 12 Aug. 1955, 1F; 31 Aug. 1956, 1F, Em. Spruce log; 26 Aug. 1957, 1F; Aug. 1957, 3F; 20 Aug. 1958, 1F. Saskatchewan: Love, 3 July 1943, 1F, tripping Alfalfa; 3 July 1943, 1F; 3 July 1944, 1F, tripping Alfalfa. Snowden, 15 July 1943, 1F, on Alfalfa; 13 July 1944, 1F; 14 July 1944, 2F, tripping Alfalfa; 28 July 1944, 1F, Fireweed; 28 July 1944, 1F, Sow Thistle. Torch River, 29 June 1944, 4F, taken in a log hole; 4 July 1944, 8F, nesting in log; 31 July 1944, 1F, nesting in log. White Fox, 1944, 7F. Alberta: Banff, 7 Aug. 1915, 1F; 7 Aug. 1917, 1F. Bowdon, 12 Aug. 1962, 1F. Edmonton, 29 July 1959, 1F, on Fireweed. Fort Vermilion, 8 Aug. 1957, 1F, on mint; 31 Jan. 1963, 1F, reared in lab. Jasper Park, Sept. 1916, 1F. Nordeg, 25 July 1936, 1F. Prairie Bluff Mt., 3 Aug. 1971, 2F. Waterton, 14 Aug. 1921, 1F. British Columbia: Cranbrook, 21 June 1926, 1F. Diamond Head Trail, 9 Aug. 1953, 1F; 10 Aug. 1953, 2F; 15 Aug. 1953, 1F. Invermere, 19 May 1915, 1F;

27 May 1915, 1F; 1 June 1915, 1F. Raspberry Cr., 21 June 1953, 1F. Robson, 29 July 1913, 1F; 30 Aug. 1948, 1F; 4 Sept. 1948, 1F. Squamish, 1F. Vernon, 1 Aug. 1923, 1F; 2 Aug. 1923, 1F. Northwest Territories: Cameron Bay, 6 July 1937, 1F. Fort Simpson, 25 June 1950, 1F. Fort Wrigley, 1F. Great Bear Lake, 15 July 1937, 2F; 21 July 1937, 1F; 27 July 1937, 1F; 28 July 1938, 1F. Hay River, 15 July 1951, 1F; 27 July 1951, 4F; 28 July 1951, 1F; 4 Aug. 1951, 9F. McKenzie River, 20 July 1922, 5F; 15 July 1922. Norman Wells, 8 July 1949, 1F; 9 July 1949, 1F; 20 July 1949, 1F; 23 July 1949, 2F; 27 July 1949, 2F; 29 July 1949, 1F. Slave Lake, 15 Aug. 1915, 1M. Yellowknife, 23 July 1949, 1F; 6 Aug. 1949, 1F; 12 Aug. 1949, 1F. Yukon Territory: Mackenzie Delta, 11 July 1948, 4F; 14 July 1948, 1F; 15 July 1948, 2F. Rampart House, 7 July 1951, 46F; 9 July 1951, 23F; 10 July 1951, 54F; 11 July 1951, 7F; 12 July 1951, 35F; 14 July 1951, 1F. Watson Lake, 25 June 1948, 1F.



Map. 11. Canadian distribution of Megachile nivalis

FLOWERS VISITED. Eleagnus (Oleaster), (M); Epilobium (Fireweed), (L, M); Medicago (Alfalfa), (L, M); Mentha (Mint), (M); Psoralea (Sainfoin), (M); Sonchus (Sow Thistle), (L, M); Taraxacum (Dandelion), (M).

BIOLOGY. Megachile nivalis has been collected from spruce and poplar logs. The strong, scoop-shaped mandibles with the inflexed and pointed outer teeth, indicate that this species may be able to excavate holes in rotten wood or the soft pith or herbaceous shrubs. Nests are made from poplar leaves, firmly pressed together and cemented with saliva, making neat and blocky cells, which resemble those of M. inermis (Peck and Bolton 1946). At Rampart House, Yukon Territory, large numbers of females were collected from burrows in the river bank.

ALFALFA POLLINATING POTENTIAL. In northern Saskatchewan, Peck and Bolton (1946) observed M. nivalis to be an efficient pollinator of alfalfa and to show some preference for alfalfa over Sow Thistle. Females are commonly found nesting in logs; it may be that they would also inhabit man-made holes in wood. The species has a predominantly northern distribution and might, in more northern Canadian regions, pollinate alfalfa at lower temperatures.

Subgenus DELOMEGACHILE Viereck

Figures 17, 23-25, 39, 61-63, 77-79

Megachile (Delomegachile); Mitchell, 1934:300 (new subgenus)

FEMALES. Length 11-15 mm. Mandible 4-dentate; fourth (inner) tooth truncate as in M. frigida and M. gemula (Fig. 62), or rounded with a pit at its summet as in M. melanophaea (Fig. 63), or rounded with a large oblique emargination between the 3rd and 4th denticles as in M. addenda (Fig. 61); outer margin of mandible inflexed posteriorly with the 1st tooth tapered and pointed apically, as in M. frigida and M. gemula (Fig.62), or with the outer margin of the mandible reflexed and flattened, with the first tooth rounded apically, as in M. addenda and M. melanophaea (Figs. 61, 63). Abdominal terga without white, apical fasciae and conspicuously black beyond the second tergum, as in M. melanophaea and M. gemula (Fig. 23), or with distinct white apical fasciae on terga II-V.

MALE. Length 10-14 mm. Mandible 4-dentate with the inner tooth sometimes greatly expanded inwardly. Hypostomal concavity and tubercle varying from weakly developed in M. addenda as a weakly elevated ridge bordering a small concavity to a prominent projection overlapping the ventral mandibular tooth in M. frigida. Front basitarsus dark and simple with only a weak trace of shortenedhairs along the anterior side, to pale and strongly dilated with prominent boat-shaped excavation along the anterior side. Front coxal spine well developed with a patch of stout reddish bristles just anterior to the coxal spine. Mid-tibia with a prominent tibial spur. Postmedian transverse carina on tergum VI with a distinct median emargination; area above the carina with slender, brown to silvery hairs which do not obscure the integument beneath.

COMMENT. Females can be distinguished by the 4-dentate mandible with the 4th tooth either truncate, or broadly rounded with a pit at the apex, or narrowly rounded with a large oblique emargination between the 3rd and 4th denticles.

Males can be recognized by the 4-dentate mandible, along with the presence of a patch of reddish bristles just anterior to the front coxal spine.

The most distinctive shared and unifying characteristic is the 4-dentate mandible borne by the males and the greatly dilated and elaborated front basitarsus present on males of most of the species. Morphologically and biologically, however, species belonging to this subgenus are highly variable.

The simple and dark front basitarsus which compares with mid basitarsus in the male of M. addenda imposes distinct deviation from the morphological design exhibited by other species within this subgenus. In females, the varied configuration of the mandible as listed above, is accompanied by differences in biological patterns such as burrowing and nesting in the soil, or chiselling holes in wood and nesting in the stems of plants. These morphological and biological differences may underlie major phylogenetic groups.

Key to the Species of Subgenus DELOMEGACHILE

Females

1. Abdominal terga without white, apical fasciae. Terga I and II usually with dense, white pubescence, conspicuously contrasting with the black pubescence on the following terga (Fig. 23)........................2

   Abdominal terga with white, apical fasciae; the fasciae sometimes interrupted medially on the more anterior terga. Dorsal aspect of abdomen, not conspicuously white and black..3

2. Inner mandibular tooth rounded with a small excision at its summit (Fig. 63). Scopa usually amber in color, sometimes infuscated peripherally in eastern specimens........................*M. melanophaea*(p.215)

   Inner mandibular tooth broadly truncate (Fig. 62). Scopa usually entirely black, occasionally amber medially in western specimens................*M. gemula* (p.186)

3. Inner mandibular tooth broadly truncate (Fig. 62). Gradular carinae on abdominal terga II-V weakly developed and not overlapping the gradular grooves.... ....*M. frigida*(p.195)

   Inner mandibular tooth narrowly rounded (Fig. 61). Gradular carinae on terga II-V highly developed and overhanging the gradular grooves.....*M. addenda*(p.233)

Males

1. Apical third of front femur with a sharp, longitudinal carina extending along its dorso-lateral side. Basal half of front femur with two longitudinal brown bars on the yellowish-white anterior side................ ....*M. frigida*(p.196)

   Apical third of front femur without any carina on the dorso-lateral side. Basal half of front femur without longitudinal brown bars on anterior side............2

2. Distal rim of front tibia with a strongly flattened and, in dorsal view, rounded tubercle projecting posteriorly. Front basitarsus narrowed toward the base....................M. melanophaea (p. 217)

Distal rim of front tibia with a short, strongly tapered spine. Front basitarsus approximately parallel-sided, or slightly narrowed toward the apex..3

3. Front basitarsus dark and simple, similar to mid basitarsus, without an excavated and polished longitudinal furrow along the anterior side..................................M. addenda (p. 234)

Front basitarsus modified and distinctly different from mid basitarsus, with an excavated and polished longitudinal furrow along the anterior side........4

4. Front tarsus brown. White, apical fascia on tergum V absent.............................M. gemula (p.188)

Front tarsus yellowish-white. White, apical fasciae on tergum V present...............M. giliae (p. 195)

MEGACHILE (DELOMEGACHILE) GILIAE COCKERELL

Figure 78; Map 12

Megachile (Delomegachile) giliae; Mitchell, 1935:186 (description, distribution and flower records).
Megachile giliae Cockerell, 1906:452 (new species)

FEMALE. The female belonging to the male of M. giliae has not been determined (see p. 170).

MALE. Length 10-11 mm. Mandible 4-dentate with the 3rd tooth weakly developed (Fig. 78). Broad, glabrous and subpolished hypostomal concavity, bordered on the posterior side by a prominent, crescent-shaped hypostomal ridge, which unites with the hypostomal carina to encircle the concavity. Glabrous and subpolished band, bordered by copious, white pubescence on cheek, extending posteriorly from the lower corner of the eye. Terminal antennal segment flattened and enlarged. Front basitarsus with a broad, polished, longitudinal excavation extending along its anterior side, basitarsus in dorsal view, about as wide as its tibia and about 0.6 as long. Apex of front tibia and tarsus yellowish-white, contrasting with the black integument on the rest of the body. White, apical fasciae present on terga II-V, usually interrupted medially on the more anterior terga.

Postmedian, transverse carina on tergum VI short, with a small median emargination.

COMMENT. The male can be recognized by the following combination of characters: front basitarsus yellowish-white with a shallow excavation along its anterior side; width of basitarsus in dorsal view subequal to its tibia; presence of a white, apical fascia on tergum V, and the 4-dentate mandible.

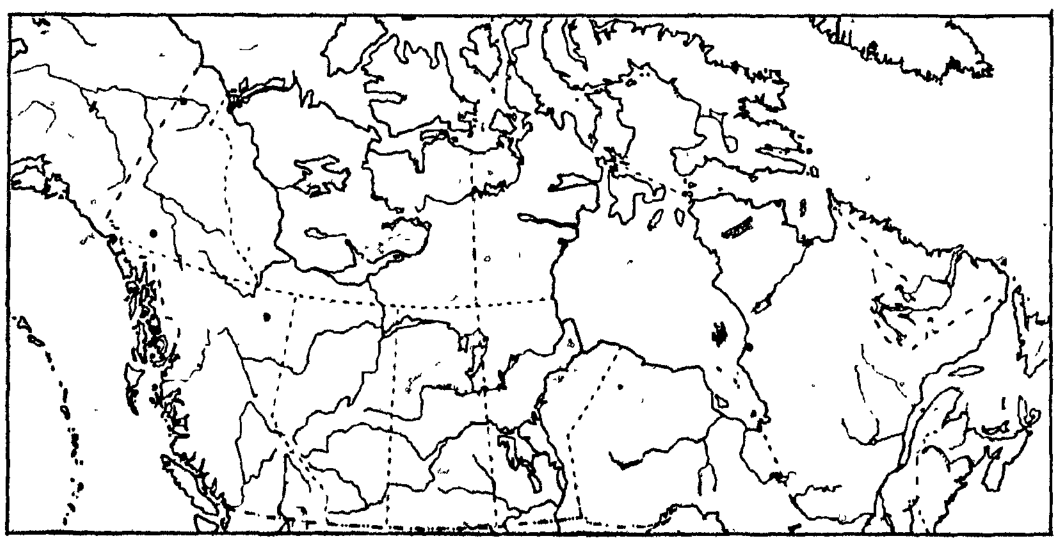
The male of M. giliae resembles the males in M. gemula and M. frigida, but can be separated from them by the presence of a white apical fascia on the fifth tergum, which is usually present on the 4th but absent on the 5th tergum, in M. gemula and M. frigida. Additionally, front basitarsus in M. gemula is infuscated and usually brown, and the apical margin of clypeus is emarginate medially, with conspicuous polished tubercles on each side of the emargination; in M. giliae front basitarsus is a little more dilated, entirely yellowish-white, and the apical margin of clypeus is truncate or slightly convex. Males of M. frigida can be separated by the sharp longitudinal carina, on the dorso-lateral side of the apical third of front femur, which is absent in M. giliae.

The male of M. giliae bears distinctive characters, which conform with those borne by males belonging to the subgenus Delomegachile. The unassociated female M. nivalis, on the other hand, bears characters which resemble those present in females of the subgenus Megachile.

The distinctive male characters in M. giliae which relate it to Delomegachile are: the prominent front coxal spine with a dense, tuft of fulvous bristles on the bare area just anterior to the spine; polished hypostomal concavity with a prominent crescent-shaped hypostomal tubercle just posterior to the concavity; bare subpolished stripe, bordered by copious white pubescence on the cheek, extending posteriorly from the lower corner of the eye; enlarged and flattened apical antennal segment; apical margin of sixth tergum with conspicuous carinate submedian projections and indistinct lateral teeth.

DISTRIBUTION. Extends from the Yukon Territory south to Colorado and east to Quebec. Distribution of M. giliae compares with M. nivalis, however, many localities are not represented by males of M. giliae and females of M. nivalis in collections. In Canada, males of M. giliae were collected from the following locations (Map 12): Quebec: Great Whale

River, 27 July 1949, 1M. Indian House Lake, 8 July 1954, 1M. Saskatchewan: Saskatoon, 29 June 1943, 1M, on Alfalfa; 25 May 1949, 1M; 9 June 1950, 2M, Caragana. Alberta: Banff 1400m, 11 July 1955, 2M; 23 Aug. 1955, 1M. British Columbia: Fort Nelson, 10 June 1948, 6M; 12 June 1948, 2M. Invermere, 19 May 1915, 1M; 27 May 1915, 1M; 1 June 1915, 1M. Northwest Territories: Mackenzie Delta, 11 July 1948, 4M; 14 July 1948, 1M; 15 July 1948, 2M. Reindeer Depot, 10 July 1948, 2M. Yukon Territory: Rampart House, 7 July 1951, 9M; 9 July 1951, 5M; 10 July 1951, 4M; 11 July 1951, 2M; 12 July 1951, 6M. Whitehorse, 2 July 1948, 2M; 4 July 1948, 1M; 10 July 1948, 1M; 27 June 1949, 1M; 6 Aug. 1949, 1M.



Map 12. Canadian distribution of Megachile giliae

FLOWERS VISITED. Caragana (Caragana), (M); Medicago (Alfalfa), (L); Tephrosia virginiana (Goats-Rue), (M).

ALFALFA POLLINATING POTENTIAL. Despite the northern distribution of M. giliae, flight periods indicate early adult emergence. In 1915, adults were collected at Invermere, B.C. on the 19th of May, nearly a month ahead of the average mid-June commencement of alfalfa flowering in Canada. Hobbs (1958) pointed out that an effective pollinating species would have to emerge 70 days before killing frosts occur. In southern Alberta, the estimated alfalfa pollinating period occurs between June 15 to July 1 and ends between August 5 to 20 (Hobbs, 1973).

It may be that since there is a shorter and cooler growing season in remote northern regions, bees are conditioned to emerge at lower temperatures and after a shorter warm spring period. If this species could be successfully transplanted into more southern regions, its pupal development may respond to cooler temperatures and result in earlier adult emergence. Thus earlier emergence of adults for alfalfa pollination might arise from this species.

Both M. giliae and M. nivalis have been collected on alfalfa. On June 29, 1943, A.R. Brooks collected M. giliae on an alfalfa field in Saskatoon, Saskatchewan. Peck and Bolton (1946) observed M. nivalis to prefer and pollinate alfalfa "rapidly".

Southern species of leaf-cutter bees became inactive and ineffective at temperatures below 20°C (Hobbs 1973). Currently sun porches consisting of bare ground are provided (Bohart 1972) to permit M. rotundata to warm up in the sunshine in the mornings and cooler periods, before effective foraging can commence. It is proposed that this northern species will probably be able to forage at lower temperatures than southern species; this might permit a longer foraging period during the day, particularly during cool days in the more northern alfalfa growing regions.

It has been proposed by Dr. C. Loan who, together with J.E.H. Martin, collected a large series of M. giliae and M. nivalis from the Porcupine River bank at Rampart House, Yukon Territory, that the habitat and bees would likely still be there as they were on the 7-12 July 1951, when both species were collected. A test tube placed over the burrow from which M. giliae emerge would not only confirm the true female belonging to M. giliae, but might also provide breeder stock for pollinating alfalfa. The stock could be safely transported at temperatures of about 15°C when they become moderately inactive and released in saran cloth cages 6 x 6 x 2 m in size similar to those being currently used by Parker *et al* (1976).

MEGACHILE (DELOMEGACHILE) GEMULA CRESSON

Figures cf.23, 62, 78; Map 13

Megachile gemula Cresson, 1878:118 (new species).

Megachile (Delomegachile) gemula var. *fulvogemula* Mitchell, 1936:185 (new var., description of female and distribution).

Megachile (Delomegachile) gemula; Peck and Bolton, 1946: 395 (biology).

Megachile (Delomegachile) gemula; Mitchell, 1962:134 (description, distribution and flower records).

Megachile gemula; Fye, 1965:876 (biology).

Megachile gemula; Medler and Lussenhop, 1968:22 (biology, flowers visited).

FEMALE. Length 12-15 mm. Integument including tegulae and legs, uniformly black. All abdominal terga without white apical fasciae. Pubescence on terga III-VI dark brown to black, conspicuously contrasting with the white pubescence on terga I and II; occasionally terga II and III with varying admixtures of brown or white pubescence, respectively. Pubescence on clypeus and cheeks variously mixed with brown and white; on legs dark brown, except on front coxa laterally and on posterior side of front femur where it varies from white to brown. Scopa usually uniformly infuscated or brown, occasionally brown peripherally and orange or fulvous medially. Inner mandibular tooth broadly truncate, as in M. frigida (Fig. 62), with the length of truncation subequal to the distance which separates it from the 3rd tooth. Outer mandibular tooth inflexed along the outer margin and pointed apically. Inner mandibular cutting edge (which can be seen with the mandible opened) extending from near the apex of the 4th tooth to the base of the 2nd tooth, usually with a distinct ridge on the inner side along the base of the 3rd tooth. Apical margin of clypeus usually with a small median indentation, bordered by a narrow subpolished and impunctate band. Preapical band on terga III-V (from which the apical fasciae normally arise) weakly depressed, sparsely punctate and subpolished. Tergum VI weakly concave in lateral view, with erect, long hairs intermixed with short subappressed barbed hairs which tend to obscure the integument toward the apex.

MALE. Length 8-12 mm. Integument including tegulae and most of front legs black. Anterior side of front basitarsus with a prominent, glabrous and polished boat-shaped excavation extending throughout most of its length; excavation bordered on each side by a dense row of bristles; maximum width of basitarsus not surpassing width of front tibia; mostly brown, sometimes converging to light brown or whitish along posterior and distal borders. Front tarsal segments beyond basitarsus usually not infuscated, ranging in colour from white to orange. Mandible 4-dentate with a moderately deep U-shaped emargination between the inner and 3rd denticles. Inner side of mandible with a deep concavity for the reception of the apical part of the alternate mandible when the mandibles close. Ventral mandibular tooth greatly expanded and extended basally beyond lower mandibular condyles. Apex of ventral tooth with a dense brush of plumose hairs which sweeps through the glabrous and polished hypostomal concavity and catapults pollen grains outwardly as the mandible closes. Hypostomal tubercle elevated as a prominent disc just below the sweep of the ventral mandibular tooth; apical and posterior side of tubercle with elongate white pubescence, anterior side concave, glabrous and polished. Diagonal, transverse, glabrous band above hypostomal tubercle weakly polished and not distinctly bordered on each side by a row of dense pubescence. Apex of clypeus with a small median notch, which is accentuated by a blunt tubercle on each side. Terminal, antennal segment flattened and polished apically on the posterior side. Front coxa sparsely pubescent on anterior side, except for a dense patch of stout, reddish bristles just above the coxal spine. Apical fasciae usually present laterally on terga II-IV, but absent on tergum V. Apical margin of tergum VI with median and lateral denticles subequal in size.

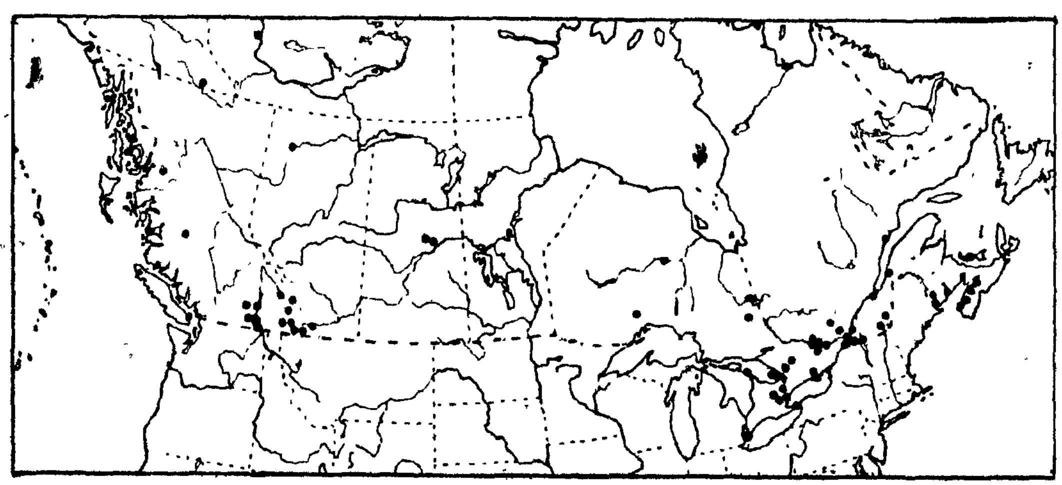
COMMENT. The female can be recognized by the broadly truncate inner mandibular tooth (Fig. 62), and the absence of white apical fasciae on all terga. The distinctive broadly truncate inner mandibular tooth is similar to that present in M. frigida; however, M. gemula can be distinguished by the absence of apical fasciae on the terga, which are clearly present in M. frigida.

The male can be recognized by the front basitarsus which remains strongly infuscated (brown) and is no broader than its tibia, although it is specialized, with a broad polished furrow extending throughout its length. With the front leg folded, the glabrous furrow lies just anterior to the outer tooth of the mandible, with the transverse convexity of the outer mandibular tooth corresponding with concavity of the furrow along the anterior side of the front basitarsus. It is proposed that with the mandibles partially opened, the outer tooth can be slid through the furrow by drawing the apex of the femur posteriorly, thereby contributing to the pollen disposal process.

DISTRIBUTION. Broadly distributed in North America, extending from the Northwest Territories, south to California, east to Georgia and Nova Scotia. In Canada _M. gemula_ was collected from the following localities (Map 13): _Nova Scotia_: Annapolis County, 8 Aug. 1923, 1F. Hants County, 22 June 1931, 1F, Rubus; 10 June 1930, 1F, Blueberry; 8 July 1931, 1M, _Trifolium_; 13 July 1931, 2F, 1M, _Diervilla_. Kings County, 15 July 1931, 1M, _Centaurea_; 1F; 20 July 1931, 1F, _Epilobium_; 25 June 1931, 1M. Lunenburg County, 3 July 1931, 2F, _Epilobium_; 4 July 1931, 1F, _Trifolium_. Wolfville, Acadia University, 28 June 1976, 1M; 5 July 1976, 1M. _New Brunswick_: McAdam, 17 June 1924, 2F, 1M. St.Andrews, 30 Aug. 1913, 1F. St.Croix, 17 June 1924, 1F, 1M. St.John, 23 June 1901, 1F; 13 July 1901, 2M. _Prince Edward Island_: Stanhope National Park, 12 July 1964. _Quebec_: Abbotsford, 23 Aug. 1933, 1F; 9 Aug. 1934. Cap Rouge, 8 July 1953, 1M; 11 July 1953, 1M. Covey Hill, July 1921, 1M. Forestville, 8 July 1950, 1F; 10 July 1950, 1F. Hemmingford, 2 July 1922, 1F. Hull, 14 June 1914, 1F. Ironside, 27 June 1916, 1M. Knowlton, 1 July 1936, 1F.

Lac Sam, 21 July 1968, 1F. Caouis, 8 Aug. 1965, 1M. Lanoraie, 2 July 1932, 1M. Montreal, 8 July 1885, 1F; 15 July 1916;9 July 1922, 1M;24 June 1926; 3 July 1926, 2M; 15 July 1926, 1F; 2 July 1927, 1M; 8 July 1927, 1F; 2 Aug. 1927, 1M; 5 July 1929, 1M; 15 July 1929, 1F; 12 July 1930, 1F, 1M; 10 Aug. 1930, 1M; 3 July 1931, 1M. Kamouraska County, 26 Aug. 1957, 1F. Philipsburg, 1 July 1961, 1M. Queens Park, Aylmer, 14 July 1926, 1F. Rupert House, 19 July 1949, 1F; 1 Aug. 1949, 1F. Ste.Anne de Bellevue, 28 July 1939, 1M; 15 Aug. 1965, 1F; 12 June 1966, 1M. Ste.Foy, 26 June 1959, 1F. Ste.Hilaire, 25 July 1926, 1F; 10 July 1927, 1F; 25 July 1927, 1F. Ste.Isidore, 22 July 1935, 1F. Ste.Therese Isl., 7 July 1916, 1M. Shawbridge, 7 Aug. 1927, 1F, 1M. Ontario: Black Sturgeon Lake, 2 July 1963, 3M; 3 Feb. 1965, 2M, emerged in lab. Burks Falls, 14 July 1926, 1F. Dyer Bay, 29 July 1953, 1F; 15 July 1954, 1M; 22 July 1956, 1F. Guelph, 14 June 1972, 2M. Jordan, 8 Sept. 1915, 1F. Macdiarmid, 21 June 1922, 1M; 25 June 1923, 1M. Marmora, 23 July 1957, 1F. Merivale, 23 June 1953, 1M, 1F. Midland, 14 July 1974, 1M. Minden, 30 July 1957, 1M. Ogoki, 16 July 1952, 1M. Ottawa, 30 June 1912, 1F; 16 June 1913, 1F; 5 July 1969, 1F; 24 July 1969, 2M; 23 June 1913, 1M; 15 Aug. 1913, 1M; 13 July 1946, 1F; 18 Aug. 1946, 1F, tripping Alfalfa. Pelee Island, 31 July 1946, 1M. Point Pelee, 9 July 1920, 1M; 2 June 1929, 1F. Speedside, 26 June 1965, 1F; 28 June 1965, 1F. Timmins, 6

Sept. 1955, 1F. Toronto, 2 July 1888, 3F; 21 July 1895, 1F; 1 Sept. 1895, 2F. Manitoba: Gillam, 14 July 1950, 1M; 15 July 1950, 1M. Wanless, 28 Aug. 1954, 1F, dead in Poplar; 7 Aug. 1956, 1F, in Poplar. Saskatchewan: Smeaton, 2 Aug. 1944, 1F, Alfalfa. Alberta: Lethbridge, 7 July 1952, 1F, Alfalfa. Prairie Bluff Mt., 14 July 1971, 1F. British Columbia: Chilcotin Lake, 13 June 1929, 1F. Fitzgerald Cr., 23 June 1922, 1M. Golden, 17 May 1915, 1M. Invermere, 27 May 1916, 1M, Sainfoin. Kamloops, 8 Aug. 1943, 1M. Kaslo, 10 May 1906. Kelowna, 9 July 1918, 1F; 14 July 1943, 1M. Langford, 20 July 1962, 1M. Mt.Revelstoke, 9 Aug. 1952, 1F. Okanagan Lake, 28 May 1904, 1M. Oliver, 24 July 1953, 1M. Osoyoos, 10 June 1919, 1F. Salmon Arm, 25 June 1925, 1F; 27 June 1925, 1M. Sidney, 7 July 1914, 1M, hirta type. Spillemachine, 3 July 1914, 1M. Summerland, 4 June 1919, 1M. Vernon, 23 July 1920. Northwest Territories: Fort Wrigley, 23 July 1922, 1F. Yukon Territory: Watson Lake, 24 July 1949.



Map. 13. Canadian distribution of Megachile gemula.

FLOWERS VISITED. Apocynum (Dogbane), (M); Asclepias (Milkweed), (M); Baptisia (False Indigo), (M); Campanula (Bellflower), (M); Centaurea (Star Thistle), (L); Chrysanthemum, (M); Clematis, (M); Coreopsis, (M); Diervilla (Honeysuckle), (L); Epilobium (Fireweed), (L); Geranium (Cranesbill), (M); Gerardia, (M); Medicago (Alfalfa), (L); Philadelphus (Mock-Orange), (M); Psoralea (Sainfoin), (L); Pycanthemum (Mountain-Mint), (M); Rhododendron, (M); Rubus (Bramble), (L, M); Rudbeckia (Coneflower), (M); Solidago (Goldenrod), (M); Trifolium (Clover), (L, M); Vaccinium (Blueberry), (M); Vicia (Vetch), (M).

BIOLOGY. In northern Saskatchewan, Peck and Bolton (1946) observed a female to nest in poplar; two females were observed to actively trip and cross-pollinate alfalfa flowers and a single female was found on Fireweed. In northwestern Ontario, Fye (1965) reared two females and a male from a nest made by binding together bundles of sumac twigs, with a longitudinal hole in each twig. In similar trap nests in Wisconsin, Medler and Lussenhop (1968) found nests in two sumac twigs. A twig occupied in 1956 had a series of 8 cells from which a single female emerged. The nest was plugged with circular sections of leaf and a layer of fine wood chips. The other twig, inhabited in 1961, contained seven cells; two males emerged from the outer cells (nearest to the exit) and five females from the remaining inner cells.

ALFALFA POLLINATING POTENTIAL. Although M. gemula is widely distributed across Canada, specimens are rarely collected and the factors which repress their populations, are unknown. Its presence in such far northern regions as Fort Wrigley in the Northwest Territories, suggests that M. gemula is active at lower temperatures and may have the potential to pollinate alfalfa grown in northern areas. A female collected by Peck at Nipawin, Saskatchewan, has the scopa loaded with pollen collected from alfalfa. Peck (1946) observed females actively tripping alfalfa flowers in northern Saskatchewan and Bohart (1957) states that in Minnesota 11.4 alfalfa flowers were reported to be tripped per minute.

MEGACHILE (DELOMEGACHILE) FRIGIDA SMITH

Figures 1, 25, 44. 62, 77; Map 14

Megachile frigida Smith, 1853:193 (new species, United States, Canada).

Megachile (Delomegachile) frigida; Peck and Bolton, 1946: 402 (ecology).

Megachile (Delomegachile) frigida frigida; Pengelly, 1953:111 (biology).

Megachile (Delomegachile) frigida; Hobbs and Lilly, 1954: 459 (biology).

Megachile (Delomegachile) frigida frigida; Pengelly, 1955:128 (biology).

Megachile frigida; Stephen, 1955:545 (alfalfa pollination); Stephen, 1956:95 (biology).

Megachile (Delomegachile) frigida frigida; Mitchell, 1962:133 (description, distribution and flowers visited).

FEMALE. Length 13-16 mm. Inner mandibular tooth truncate, with length of truncation subequal to the distance to the preceding third tooth. Outer mandibular tooth inflexed along the outer margin and tapered apically. Inner cutting edge (which can be seen when the mandible is opened) extending from near the apex of the inner angle of the truncate 4th tooth to the base of the 2nd tooth. Apex of clypeus with a narrow, polished and impunctate transverse median band. Cheek distinctly wider than eye when examined in lateral view. Vertex, mesoscutum and scutellum with erect, fuscous hairs medially. Transverse gradular grooves on terga II-IV weakly depressed, without overlapping gradular carinae; gradular groove on tergum V usually obliterated medially. Apical bands of terga III and IV distinctly depressed, with white fasciae laterally; tergum V usually with the white apical fascia complete (not interrupted medially). Discs of terga III-V with copious, mostly pale, pubescence; terga III-V with fine, brown pubescence medially, the hairs becoming larger laterally and approaching the size of the scopal hairs along the extreme lateral border on terga IV and V. Tergum VI weakly concave in lateral view, with abundant suberect, branched, black hairs(Fig.cf.46)intermixed with shorter suppressed fuscous hairs which, combined, obscure the black integument beneath.

MALE. Length 12-15 mm. Front legs and mandibles greatly elaborated. Front tarsus creamy white and conspicuously dilated; basitarsus approximately as broad as long, with a deep boat-shaped excavation extending along the anterior side; the glabrous excavation bordered by dense, stout setae along the entire posterior side and basal third of anterior side.

Tarsal segments 2-4 about twice as broad as long; last segment about three times as long as wide and deflected posteriorly at base. Distal end of outer side of front tibia white, with a tapered spine at the postero-distal angle and a dense, curved tuft of hairs at the antero-distal corner. Anterior or flexor side of front femur with three infuscate basal bands extending distally. Front coxal spine strongly elongated; approximately semicircular in cross section; the flat upper side of spine bearing a row of bristles extending along the outer side of the distal two-thirds of the spine. Conspicuous, dense patch of stout, fulvous bristles on anterior side of front coxa directed toward the coxal spine. Basal half of ventral margin of mandible strongly expanded postero-medially, forming an angulation at approximately midpoint between the apices of the ventral tooth, near the base of the mandible, and the 1st tooth. Inner side of mandible deeply hollowed out for the reception of the distal half of the alternate mandible, when mandibles close. Cheek just above hypostomal concavity and tubercle, with a subpolished glabrous band, bordered on each side by a row of white pubescence. Terminal antennal segment distinctly flattened and expanded; subpolished and glabrous on posterior side and with dense, short, pilosity on anterior side. Apical margins of terga II and III depressed and fasciate laterally; fascia present on tergum IV and usually absent on tergum V. Apical margin of tergum VI with a weakly developed lateral tubercle, but with a prominent carinate submedian projection. Tergum VII usually with a distinct tapered, median tubercle.

COMMENT. The female of M. frigida can be distinguished from all other species of Megachile by the broadly truncate, inner mandibular tooth (Fig. 62); the presence of white apical fasciae on abdominal terga II-V and the uniformly fulvous scopa. The truncate inner mandibular tooth is also present in M. gemula; however, the two species can be separated by the colour of the scopa which is uniformly fulvous in M. frigida and piceous in M. gemula.

The male of M. frigida can be distinguished from all other species of Megachile by the sharp, longitudinal, carinate edge along the postero-dorsal side of the distal third of front femur. The elongated hypostomal tubercle which overhangs the glabrous and polished hypostomal concavity, permits the ventral mandibular tooth to slide between the tubercle and occiput as the mandible closes. Thus, the pollen grains which are tripped by the flower against the hypostomal region of the male bee are, in turn, catapulted outwardly by the dense brush of hairs at the apex of the ventral tooth extending a little beyond the lower mandibular condyle, as the mandible closes.

DISTRIBUTION. Widely distributed across North America, particularly in the more northern regions; extending from the Northwest Territories, south to Arizona, east to Newfoundland. In Canada specimens of M. frigida have been collected from the following locations (Map):

Newfoundland: Bay of Islands, 19-24 July 1907, 2M; 26-29 July 1907, 1F. Campbellton, 28 Mar. 1949, 1F. Carbonier, 2 Aug. 1925, 1F. Codrey Valley, 7 Aug., 1M. Gander, 19 July 1949, 1M; 29 July 1949, 1M; 2 Aug. 1949, 1F. Humber River, 24-26 July 1907, 1M. St.Georges, 25 Aug. 1953, 1F. St.John's, 23 Aug. 1958, 1F; 10 July 1972, 1M. Swift Current, 8 July 1963, 1F; 8 Aug. 1963, 2M. Nova Scotia: Baddeck, 23 July 1936, 1M. Hants County, 22 June 1931, 1M, 1F; 25 June 1932, 1M. Kent Ville, 30 July 1914, 1F. Kings County, 8 Aug. 1929, 1F; 31 July 1930, 6F; 13 July 1931, 1F; 20 July 1931, 2F, 5M; 21 July 1931, 1F. Lunenburg County, 4 July 1931, 1M. Picton, 1 Aug. 1914, 1F, 1M; 4 Aug. 1914, 1F. Truro, 10 Aug. 1923, 3M. New Brunswick: Acadia, 7 July 1976, 2F. Delhousie, 24 July 1915, 1M. Fredericton, 7 Aug. 1914, 1M; 10 Aug. 1922, 1F. Painsec, 4 Aug. 1914, 1F. Red Rapids, 23 July 1913, 2M. St.Croix, 17 June 1924, 1M; 23 June 1976, 2F, 2M. St.Stephen, 15 July 1910, 1F. University of New Brunswick, Fredericton, 10 July 1961, 1F; 3F; 1M. Prince Edward Island: Charlottetown, 3 Aug. 1914, 1M. Dalvay House, Canadian National Park, 19 July 1940, 1M. Dundee, 13 July 1964, 1F. Quebec:

Anticosti Island, 13 July 1915, 1F. Aylmer, 1 July 1924, 1F. Cap Rouge, 4 July 1953, 1F. Cascapedia R., 10 July 1934, 1M. Charlevoix County, 5 Aug. 1918, 1F; 11 Aug. 1918, 1M. Covey Hill, 12 July 1927, 1M. East Coast James Bay, July 1920, 2F, 3M. Forestville, 8 July 1950, 5F, 1M; 10 July 1950, 9M; 13 July 1950, 1F; 14 July 1950, 2M; 8 Aug. 1950, 1F, 1M; 9 Aug. 1950, 1F. Franquelin, 28 July 1963, 1M. Gaspe Penn, 22 July 1934, 1M. Great Whale River, 24 July 1949, 1F. Hemmingford, 10 Aug. 1916, 1F; 4 July 1931. Hull, 14 June 1914, 1M. Joliette, 19 July 1917, 1M. Kazabazua, 21 Aug. 1914, 1M. Lac J. Cartier, 3 July 1947, 1F. Lac Vision, 4 July 1954, 6M. Lakeside, 22 July 1931, 1M. Laniel, 10 June 1931, 1M; 10 July 1931, 1F; 4 July 1933, 1F; 23 July 1935, 1M. Lanoraie, 3 Sept. 1925, 1F; 2 July 1932, 1F. LeRelais, 2 Aug. 1947, 1M. Levis, 1F, 3M. Lowe, 12 Aug. 1948, 3F. Mistassini Post, 3 July 1956, 2M; 6 Aug. 1956, 1F; 7 Aug. 1956, 1M; 10 Aug. 1956, 4F, 1M. Mt.Albert, 4 July 1954, 6M. Montfort, 12 July 1961, 1M. Mont Joli, 29 July 1954, 2F; 2 Aug. 1954, 1F; 6 Aug. 1954, 1F; 9 Aug. 1954, 1F. Montreal, July 1884, 1F; 10 Aug. 1884, 1F; July 1885, 1M; 14 July 1888, 1F; 26 June 1916, 1M; 8 June 1918, 1F; 10 Aug. 1921, 1F; 3 July 1926, 1M; 24 July 1926, 1M; 11 Sept. 1926, 1F; 16 July 1927, 1F; 30 July, 1928, 1F; 14 Aug. 1928, 1F; 1 Sept. 1928, 1F; 4 Aug. 1930, 1F; 17 Aug. 1930, 1F. New Richmond, 6 Aug. 1954, 1F.

Perce, 2F. Rivington, 5 July 1929, 2M. Rupert House, 14 Sept. 1921, 1F; 7 Aug. 1949, 1F. Ste.Anne de Bellevue, 23 July 1961, 1F; 28 June 1964, 1F; 4 Aug. 1965, 1F; 15 Aug. 1965, 1F; 16 Aug. 1965, 1F; 17 Aug. 1965, 1F; 27 June 1966, 2F, 1M; 19 June 1967, 1F; 14 July 1967, 1F. Ste.Anne des Monte, 4 July 1954, 4M. Ste.Anne de la Pocatiere, 8 Aug. 1914, 2F. St.Hilaire, 1 July 1908, ; 28 July 1927, St.Martin, 29 Aug. 1925, ; 17 July 1926, . Shawbridge, 1 July 1929, 1M; 7 July 1930, 1F. Tadoussac, 7 Aug. 1919, 1F; 12 Aug. 1919, 1F; 21 July 1932, 1F; 4 Aug. 1932, 1F.

<u>Ontario</u>: Agawa Bay, 21 Aug. 1959, 1F. Algonquin Park, 19-21 June 1922, 1F; 6 Aug. 1961, 1M. Belleville, July 1943, 1F. Blackburn, 9 June 1939, 1F. Calabogie, 13 July 1969, 1M; 1F, 1M. Cedar Lake, 28 June 1962, 1M. Cochrane, 8 Aug. 1917, 2F. Dunedin, 22 July 1952, 1F. Dyers Bay, 9 July 1952, 1M; 28 July 1952, 1F, 1M; 29 July 1952, 1M; 30 July 1952, 1F; 6 July 1953, 2M; 8 July 1953, 3M; 10 July 1953, 1F; 11 July 1953, 2F; 12 July 1953, 1F; 13 July 1953, 1M; 16 July 1953, 1F; 19 July 1953, 1F; 1 July 1954, 1M; 12 July 1954, 1M; 13 July 1954, 1M. Grove Bay, 16 July 1960, 1M. Guelph, 1M. Jordan, 4 June 1915, 1F; 12 June 1919, 1F. Leaside, 28 July 1961, 1F. London, 19 July 1967, 1F. Marmora, 6 July 1939, 2M. Merivale, 30 July 1930, 1M. Mississauga, 12 June 1949, 1M; 13 June 1949, 1M; 17 June 1949, 1M. Moosonee, 19 July 1934, 1M. Nepigon, 9 July 1898, 1M. Ogoki, 18 July 1952, 1M;

1 Aug. 1952, 1M. Ottawa, 24 June 1913, 1M; 27 June 1913, 1M; 7 July 1913, 1F; 14 June 1914, 1M; 18 Aug. 1917, 1F; 15 June 1952, 1F; 3 July 1954, 2F; 29 June 1955, 1F; 8 June 1962, 1M; 9 June 1962, 1M; 28 July 1962, 1F; 16 June 1963, 1F; 1F, 2M. Peninsula, 27 July 1943, 1F. Quarries, 13 July 1946, 1M; 18 July 1946, 2F. Sand Lake, 29 June 1926, 1M. Smoky Falls, 8 July 1934, 1F. Sudbury, 7 July 1889, 1M; 25 Aug. 1889, 1F; 1893, 1F; 23 June 1925, 1M; 10 July 1925, 1M; 11 July 1925, 1F; 21 July 1957, 1M. Thessalon, 31 July 1957, 1F. Thornloe, 9 Aug. 1917, 2F, 2M. Toronto, 2 July 1888, 1F, 1M; 6 July 1890; 16 Sept. 1891, 1F; 18 Sept. 1891, 1F; 1 Sept. 1893, 1F; 2 July 1894, 1M; 18 JUly 1898, 1F. Vineland, July 1956, 1F. Manitoba: Brandon, 4 April 1948, 5F. Carberry, 7 Aug. 1948, 1M. Clear Lake, 2 July 1951, 1F. Erickson, 16 Aug. 1975, 1F. Gillan, 22 July 1949, 1F, 1M; 14 July 1950, 3M; 15 July 1950, 1M; 19 July 1950, 4M; 21 July 1950, 1F; 28 July 1950, 1F. Hecla, 26 July 1962, 1F. Sprague, 5 July 1947, 1M; 6 July 1948, 2M; 7 July 1948, 5F, 3M; 22 June 1950, 1M; 17 July 1950, 2M. Teulon, 19 June 1920, 1M; 23 June 1920, 2F, 4M; 24 July 1922, 1F. Wanless, 19 July 1951, 2M; 15 July 1952, 2F, 2M; 23 July 1952, 1F, 1M; 18 July 1953, 1F; 30 July 1953, 2F; 1 Aug. 1953, 1F; 20 July 1954, 1M; 27 July 1954, 3F; 15 July 1955, 1M; 18 July 1955, 1F; 19 July 1955, 4F; 1 Aug. 1955, 2F; 4 July 1956, 1F; 5 July 1956, 1F; 5 July 1957, 1M; 19 July 1957, 1M; 21 July 1957, 1M; 27 July 1957, 1F; 26 July 1958, 1M.

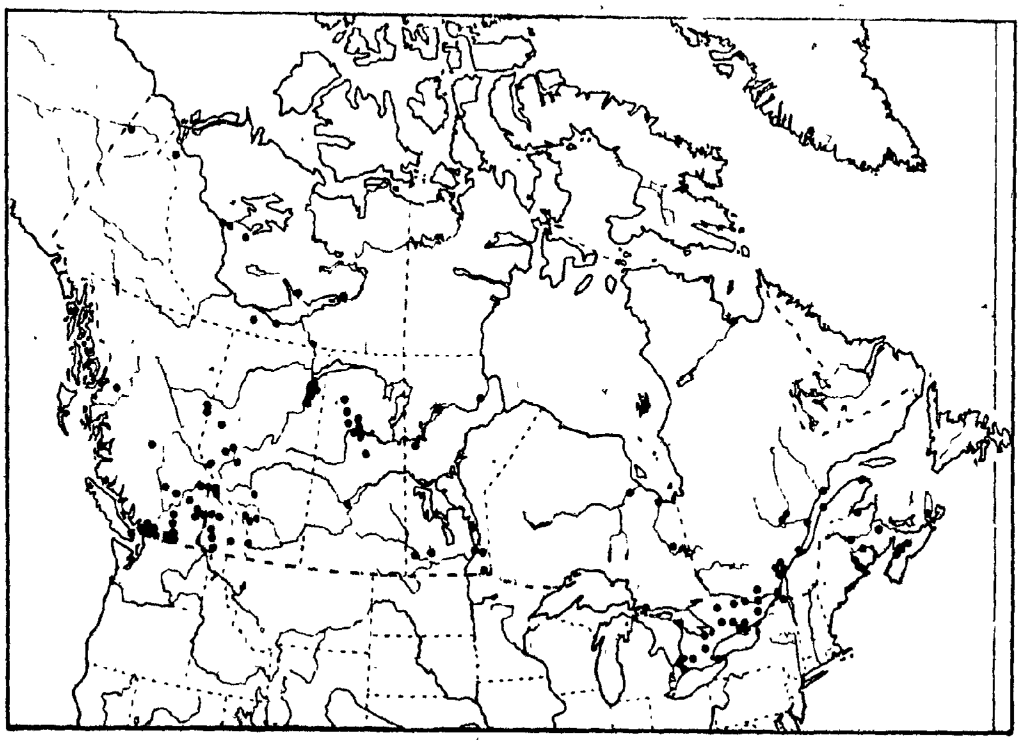
Saskatchewan: Christopher Lake, 19 June 1939, 1M; 21 June 1939, 1F, 1M; 4 July 1939, 2M; 27 July 1939, 1M. Love, 3 July 1944, 5F, 5M; 27 July 1944, 17F, 2M; 29 July 1944, 8F; 3 Aug. 1944, 4F. Nipawin, 30 June 1944, 2F; 1 July 1944, 1F, 2M; 18 July 1952, 1F. Rosthern, 17 July 1914, 1M. Smeaton, 2 Aug. 1944, 2F. Snowden, 14 July 1944, 9F; 28 July 1944, 22F; 15 July 1944, 2F, 2M; 20 July 1944, 1F; 2 Aug. 1944, 4F, 1M. Tisdale, 1F; Torch River, 29 June 1944, 4F, 9M; 31 July 1944, 4F; 3 Aug. 1944, 7F, 1M; 30 Aug. 1944. Waskesin Lake, 2 Aug. 1939, 1M. White Fox, 27 June 1944, 1F; 21 July 1944, 11F; 1 Aug. 1944, 2F. Alberta: Aspen Beach, 25 Aug. 1944, 2F. Banff, 25 July 1910, 1M; 5 Aug. 1915, 2F; 11 Aug. 1916, 2F; 17 July 1922, 1F; 27 July 1922, 1M; 3 Aug. 1925, 1M; 18 July 1950, 1F; 1 Sept. 1950, 1F. Beaver Dam, 20 Aug. 1915, 1F. Beaverlodge, 11 June 1931, 1F; 21 June 1931, 1M; 6 July 1931, 3M; 17 July 1931, 1M; 31 July 1961, 1F. Ben Lake, 18 Aug. 1915, 2F. Calgary, 29 July 1916, 1F; 18 July 1917, 1F; 2 Sept. 1946, 7F; 10 Sept. 1948, 1F; 1M. Cherhill, 8 July 1952, 2M; 5 Aug. 1952, 3F, 1M. Clymont, 23 June 1936, 3M. Delburne, 12 July 1959, 1M. Edmonton, 12 June 1915, 1M; 23 June 1915, 1F; 26 July 1915, 1M; 28 Aug. 1915, 1F; 28 July 1916, 1M; 20 April 1918, 1F; 24 July 1925, 1M; 29 July 1959, 1F. Elkwater, 20 July 1956, 1F. Fort Vermillion, 7 Aug. 1959, 1F. Frank, 15 Aug. 1926, 1M. Jasper Park, Sept. 1916, 2F. Judah, 12 July 1914, 1M. Lemont, 27 Aug. 1972, 1F. Lethbridge, 28

July 1914, 1F; 31 July 1914, 1F; 28 July 1916, 1F; 18 July 1917, 1M; 6 Aug. 1923, 1F; 16 Aug. 1923, 1F; 30 July 1926, 1F; 26 Aug. 1927, 5F; 13 Aug. 1940, 1F; 19 Aug. 1948, 1F; 8 July 1949, 1F; 28 Aug. 1950, 2F; 14 Aug. 1951, 2F; 15 Aug. 1951, 2F; 17 Aug. 1951, 1F; 20 Aug. 1951, 6F; 7 July 1952, 3F; 9 July 1952, 2F; 16 July 1952, 1F; 23 July 1952, 1F; 25 July 1952, 1F; 28 July 1952, 4F; 30 July 1952, 2F; 31 July 1952, 4F, 1M; 18 Aug. 1952, IF; 28 Aug. 1952, 3F; 31 Aug. 1952, 1F; 19 July 1953, 3M; 4 July 1956, 1M; 19 July 1960, 1F; 18 June 1963, 1F; 13 Aug. 1963, 1F. Macleod, 21 Aug. 1951, 1F. Manitou, 14 June 1959, 1M. McMurray, 6 July 1953, 1M; 29 July 1953, 1M. Medicine Hat, 15 July 1917, 2F; 1 Aug. 1917, 1M. Moraine, 7 Aug. 1927, 1M; 17 Aug. 1927, 1M. Nordegg, 21 July 1926, 3M; 27 July 1936, 2M. Pibroch, 1948, 1M. Pincher Creek, 12 Sept. 1963, 1F. Port Hill, 23 July 1954, 1F. Prairie Bluff Mountains, 4 July 1970, 1F, 1M; 7 July 1970, 1F; 19 July 1970, 1F, 2M; 31 July 1970, 1F; 14 July 1971, 1F; 23 July 1971, 1M; 25 July 1971, 1F; 26 July 1971, 1F; 27 July 1975, 1F, 3M. Redcliffe, 1 Aug. 1917, 1F. Red Deer, 22 July 1926, 1F. Sangudo, 12 July 1939, 1F. Scandia, 20 July 1946, 4F; 16 May 1949, 1M; 18 May 1949, 3F, 1M; 19 May 1949, 1F; 20 May 1949, 2F; 21 May 1949, 3F; 23 May 1949, 2F; 24 May 1949, 3F; 26 May 1949, 3F; 28 May 1949, 1F; 21 June 1949, 1F; 18 July 1950, 2F; 26 July 1951, 4F; 6 Aug. 1951, 1F; 19 June 1952, 1M; 20 June 1952, 1M; 14 July 1952, 2F;

7 July 1953, 1M; 1949, 1F; 1M. Seven Persons, 8 July 1952, 1M. Vauxhall, 8 Aug. 1950, 1F; 20 July 1951, 1F; no date, 1F. Wabamun, 7 July 1931, 3M; 28 June 1936, 1M. Waterton, 14 Aug. 1921, 1M; 8 July 1923, 1F. White Mud R., 15 July 1932, 1M. British Columbia: Agassiz, 8 July 1914, 1F. Alaska Highway, 3 Aug. 1959, 1F; 11 Aug. 1960, 1F. Charlie Lake, 3 Aug. 1959, 1F. Chase, 30 July 1943, 1M. Chilcotin, 17 July 1920, 1M; 25 July 1920, 1M; 1 July 1929, 1F; 29 July 1930, 1M. Cranbrook, 1 July 1963, 1F, 1M. Forbidden Plat, 13 July 1935, 1M. Francis Lake, 5 July 1924, 1M. Golden, 17 May 1915, 1M. Huntington, 30 June 1953, 1M. Invermere, 30 June 1914, 3M. Kamloops, 13 June 1943, 1M; 25 July 1943, 1F. Kaslo, Fl June 1905, 1M; 20 June 1905, 1M; 1 July 1905, 2F, 2M; 7 May 1906, 1M; 3 June 1906, 1M; 5 June 1906, 1F; 10 June 1906, 1F; 30 June 1906, 1M; 23 July 1906, 1M; 24 July 1906, 1F, 2M; 26 Aug. 1906, 1M; 24 July 1907, 1F; 11 June 1910, 1M. Kimberly, 20 Aug. 1953, 3F. Lillooet, 4 July 1916, 1F. Monte Creek, 7 July 1929, 2F. Mt.McLaine, 12 July 1926, 1M. Mt. McLean, 20 Aug. 1920, 1F. Mt. Revelstoke, 15 July 1931, 2M; 14 July 1952, 1F; 31 July 1952, 1F. Nicola, 26 July 1925, 1M. Okanagan, Aug., 1M. Okanagan Falls, 3 June 1919, 1F, 1M. Oliver, 24 July 1953, 1M. Pitt Meadows, 9 July 1953, 2F. Robson, 20 July 1950, 1M. Rolla, 14 July 1927, 1M; 17 July 1927, 4F; 23 July 1927, 1M. Ruskin, 17 July 1953, 1F. Salmon Arm, 6 June 1925, 1M. Shuswap Lake, 31 July 1961, 1M. Sicamous, 11 July

1914, 2M. Smithers, 1 Sept. 1915, 1F. Spillemachine, 3 July 1914, 2M. Squamish, 1 Aug. 1953, 6F, 14M; 2 Aug. 1953, 7F, 2M; 3 Aug. 1953, 4F, 1M; 5 Aug. 1953, 1F, 6M; 6 Aug. 1953, 2F, 4M; 8 Aug. 1953, 4F, 2M; 9 Aug. 1953, 6F, 8M; 10 Aug. 1953, 10F, 3M; 12 Aug. 1953, 2F, 3M; 13 Aug. 1953, 12F, 4M; 14 Aug. 1953, 1M; 15 Aug. 1953, 1M; 18 Aug. 1953, 3F, 1M; 31 Aug. 1953, 2F. Steelhead, 31 May 1933, 1M; 24 July 1933, 1F; 9 May 1934, 1F. Summerland, 10 Aug. 1916, 1M. Vancouver, 2 July 1903, 1M; 12 Aug. 1916, 1F, 2M; 15 Aug. 1916, 1F; 13 July 1965, 1M. Vernon, 28 July 1920, 1F; 18 Aug. 1923, 1F. Victoria, 13 Aug. 1916, 1F. <u>Northwest Territories</u>: Cameron Bay, 28 July 1937, 1F. Fort McPherson, 20 July 1957, 2M; 25 July 1957, 1F. Fort Norman, 29 June 1922, 1M; 23 July 1922, 1M; 27 July 1922, 1F; 6 Aug. 1922, 1M; 11 Aug. 1922, 1F; 15 Aug. 1922, 1F. Fort Smith, 20 June 1950, 1M; 12 July 1950, 1M; 22 July 1950, 1M; 8 Aug. 1950, 1F; 12 Aug. 1950, 1F. Hay River, 27 July 1951, 2F; 28 July 1951, 1F; 4 Aug. 1951, 3F; 12 Aug. 1951, 1F. Norman Wells, 22 July 1949, 1M; 23 July 1949, 1F; 27 July 1949, 1M. Reliance, July 1936, 1F. Yellowknife, 26 July 1949, 2F; 11 Aug. 1949, 1M. <u>Yukon Territory</u>: Rampart House, 4 July 1951, 1M; 7 July 1951, 2F, 5M; 9 July 1951, 2F, 2M; 10 July 1951, 3F, 6M; 12 July 1951, 2F, 6M. <u>Alaska</u>: Amherst, July 1917, 1F. Anchorage, 31 July 1951, 1M. Big Delta, 26 June 1951, 1F.

FLOWERS VISITED. Apocynum (Dogbane, Indian Hemp), (M); Aster, (ML); Astragalus (Milk-Vetch), (M); Campanula (Bellflower), (M); Cirsium (Common Thistle), (ML); Epilobium (Willow-Herb), (H, M, ML, PB): Hypericum perforatum (St. John's-wort), (P); Lotus corniculatus (Birdsfoot-Trefoil), (P); Malvastrum (False Mallow), (M); Medicago sativa (Alfalfa) (H, M, ML, P, PB); Melilotus alba (Sweet Clover), (P); Monarda fistulosa (Horsemint), (P); Pentstemon (Beardtongue), (M); Prunella vulgaris (Selfheal), (P); Ranunculus (Buttercup), (P); Rhus typhina (Sumac), (P); Rosa (Rose), (M); Sonchus arvensis (Sow-Thistle), (PB); Trifolium (Clover), (M); Verbena (Vervain), (P); Vicia (Vetch), (M, ML).



Map. 14. Canadian distribution of Megachile frigida.

BIOLOGY. The pointed and inflexed outer mandibular tooth, which does not become abraded or dulled in older female bees (Fig.62), and the large, adductor muscles housed in the broad temple behind the eyes, enable the female to bite into and excavate nesting holes in decayed wood. Stephen (1956) observed a female excavate a tunnel over 10 cm deep in 3 hours and 40 minutes in a small poplar log lying in a barn in Manitoba. In southern Ontario, Pengelly (1953) found a piece of wood containing 26 cells and in Alberta, Hobbs and Lilly (1954) reported at least 3 females nesting gregariously in a rotten log containing 51 cells.

Nests have been found in poplar, willow, maple, cedar and elm (Pengelly, 1955). In laboratory rearings, Stephen (1956) found a high rate of larval mortality. In Manitoba, M. frigida is the most abundant species and is commonly found in decaying poplar wood. Preferred levels of wood decay occur 4-7 years after the tree is felled; the wood remains suitable for habitation for 7-15 years, rarely lasting for more than 20 years. Tunnels made by emerging wood boring insects are sometimes used by the bee to penetrate the firm outer surface of the wood. Generally, the bee does not follow the exit passage of the wood borer for more than half an inch (1.2 cm) (Stephen, 1955), but excavates a tunnel of its own preferred size and slope in the softer, inner part of the wood. Entrance tunnels into the wood are also made in decayed areas around knot holes or the open ends of logs (Stephen 1955).

After the excavation of the tunnel is completed, 1 to 26 cells may be constructed and provisioned within that nest (Pengelly, 1955). Leaves from the following variety of plants are commonly used for constructing the cells: Rubus idaeus (Wild Raspberry), (P); Fragaria vesca (Wild Strawberry), (P): Acer nigrum (Sugar-Maple), (P); Cornus stolonifera (Red Osier), (P); Ribes (Gooseberry), (H); Verbascum thapsus (Mullein), (P); Ostrya virginiana (Hop-Hornbeam), (P); Fagus grandifolia (American Beech), (P); Salix (Willow), (H); Polygonum (Knotwood), (H); Epilobium (Fireweed), (H); Trifolium pratense (Red Clover), (P); and Medicago sativa (Alfalfa), (P).

Following construction, provisioning and deposition of the egg in each cell in the tunnel, extra precautions are taken to securely seal the nest with an elaborate plug against parasites, predators and nest destroyers. Pengelly (1955) observed a plug to be constructed alternately of circular leaf discs and sawdust as follows: disc of sawdust 1-1/2 mm thick placed on top of the leaf cap; 2 round leaf-pieces (5-6 mm in diameter completely covering the opening); sawdust plug 2 mm thick; 3 round leaf-pieces sawdust plug 2 mm thick and finally 22 round leaf-pieces.

PARASITES AND PREDATORS. Species of *Coelioxys* which have been reported to be parasitic on *M. frigida* are: *C. funeraria* Smith, *C. moesta* Cresson and *C. sodalis* Cresson (Medler and Lussenhop, 1968).

ALFALFA POLLINATING POTENTIAL. In a study of alfalfa seed production in northern Saskatchewan, Peck and Bolton (1946) found that in areas where decaying poplar logs were available for nesting sites, *M. frigida* was the most common and by far the most important pollinator of alfalfa. Similarly, in Manitoba, Stephen (1955) stated that *M. frigida* and *M. latimanus* were exceptionally efficient and showed preference for alfalfa even when there was an abundance of competing wild flowers such as Fireweed adjacent to the alfalfa field. In southern Ontario, Pengelly (1953, 1955) recorded females visiting 20-26 flowers per minute and tripping 100% of the flowers visited. Pengelly found, however, that populations of *Megachile* were much too low to set profitable alfalfa seed crops. He could not find any leaf-cutter bees on a 30-acre (12.141 ha) alfalfa field near Georgetown, Ontario, which he examined seven times during 1951 and 1952. Similarly, in southern Alberta, Hobbs and Lilly (1954) seldom found leaf-cutter bees on alfalfa fields. On one occasion, they found M. frigida to be an important pollinator in an isolated alfalfa field in a river valley. They attributed the scarcity of M. frigida to be due to the absence of rotting logs which could serve as nesting sites.

Simple and practical nesting sites for leaf-cutter bees were devised by Mr. W.D. Clarke, an alfalfa grower at Nipawin, Saskatchewan (Peck and Bolton, 1946). Holes 1/4 inch in diameter and 4 inches long (.635 cm in diameter and 9.16 cm long) were drilled into logs, at a slight incline toward the base to prevent water from flowing into them. The holes were drilled on sides exposed to sunlight and according to Peck and Bolton (1946) "...almost immediately leaf-cutter bees investigated the holes and began carrying in pieces of leaf" for constructing cells. Placing a log along the edge of the field and having nearly all of the 80 holes drilled into the log occupied by bees, persuaded the authors to foresee this as a sound practise for providing nesting sites and achieving adequate cross pollination for alfalfa.

The rapid rates of occupancy of the holes in logs at Nipawin were probably due to the high density of native leaf-cutter bees in the region. In other locations, such as Georgetown, Ontario, or large, intensely cultivated regions in the Prairie provinces, populations are depleted to the extent that even if a number of leaf-cutter bees could be found, it would take at least six years with an ample supply of nesting sites and continuing supply of flowering alfalfa, to build up an effective pollinating population.

To study the species inhabiting the holes made in the logs at Nipawin, Peck and Bolton (1946) brought sections of the logs into Ottawa. While other species of leaf-cutter bees came out of the logs, no adults of M. frigida emerged. The authors presumed that exclusion of M. frigida may have been due to more aggressive appropriationing of tunnels by nivalis and inermis. Pengelly (1955) reported that three-eighths of an inch (9.5 mm) holes drilled into stove-wood were thoroughly explored by M. frigida but were not adopted as nesting sites. Neither Fye (1965) in northwestern Ontario, nor Medler and Lussenhop (1968) in Wisconsin, reared any M. frigida from their bundles of sumac nest traps. It is proposed that this species cannot chisel holes in sound wood, but that decomposed wood is essential to enable them to excavate appropriate nesting sites. It has also been suggested (Pengelly, 1955) that M. frigida nest under stones or in underground burrows. Species excavating underground burrows develop strongly abraded mandibles (Fig.10) which would be ineffective (too dull) in subsequent tunneling in wood. Since the mandibles in *M. frigida* remain pointed even in older females (Fig.62), it is proposed that this species is limited to the excavation of tunnels and nesting in rotting wood.

Rotten wood is an integral part of nest excavation, cell partitioning and plug formation. According to Stephen (1955), the forest surrounding the alfalfa field has to be managed to provide a continuum of dead and adequately decayed trees. Thus, it may be that the strips of uncultivated land proposed by Salt (1940) would not essentially fulfil the decayed wood-nesting requirements essential for maintaining high population densities of *M. frigida*.

Stephen (1955) observed nests of *M. frigida* in decayed wood and old sawdust from mill waste. It is proposed that rotten pieces of wood with holes drilled through the harder outer layer, could be assembled to serve as nesting sites similar to those now provided for *M. rotundata* (Hobbs, 1973). Or, wood particles (sawdust) could be compressed into timbers, similar to particle plyboard, and adapted as nesting sites for these bees.

The principal factor which contributes to the constriction and destruction of populations of *M. frigida* in alfalfa growing regions, is the absence of appropriate nesting sites. If *M. frigida* could be induced to nest in the rotting wood or particle boards which could be economically provided for them; and if they would utilize alfalfa leaves to build their cells (as has been observed and reported by Pengelly (1955)), then the bee populations which once contributed to producing over 1000 lb. of alfalfa seed per acre could be expanded to produce similar yields in any alfalfa producing region in Canada, at negligible care and cost to the producer.

Thus, *M. frigida*, which in the earlier, pioneer days coincidentally inhabited the rotting felled logs which were a part of land clearing and breaking, could again contribute to the export of alfalfa seed for which there is currently in very strong, world-wide demand.

MEGACHILE (DELOMEGACHILE) MELANOPHAEA SMITH

Figures 23, 24, 39, 63, 79; Map 15

Megachile melanophaea Smith, 1853:191 (new species).

Megachile (Delomegachile) melanophea var. *calogaster*; Mitchell 1935:195 (description of female and distribution).

Megachile (Delomegachile) melanophaea; Peck and Bolton, 1946:412 (biology); Pengelly, 1953:111 (Alfalfa pollination); Hobbs and Hilly, 1954:459 (ecology, pollination); Pengelly, 1955:166 (biology and Alfalfa pollination); Stephen, 1955:546 (biology).

Megachile (Delomegachile) melanophoe melanophoea; Mitchell, 1962:138 (description, distribution and flowers visited).

Megachile (Delomegachile) melanophoea submelanophoea; Mitchell, 1962:140 (description of female and flowers visited).

FEMALE. Length. 12-14 mm. Head, thorax and first two abdominal segments, in dorsal view, predominantly with copious yellowish-white pubescence mostly obscuring the black integument beneath; mesoscutum medially and abdominal segments beyond the second, with sparse, black to brown pubescence, not obscuring the black integument, thereby exposing striking colour contrast. Scopa varying from orange to occasionally mostly black peripherally with some reddish reflections medially. Pubescence on cheek, vertex, front femur and mesopleura varying from dark brown to pale or intermixed with brown and yellowish-white. Mandible flattened with the outer tooth expanded and obliquely rounded apically; inner cutting edge (seen with the mandible opened) not extending outwardly beyond the 3rd denticle. Inner mandibular tooth with a distinct cavity at apex formed by the inner and outer cutting edges attaining the same elevations and fusing along the rounded basal border. Following the formation of the inner tooth (with the cavity), the outer cutting edge descends abruptly to form a relatively large, oblique emargination, which remains occupied by the inner cutting edge that extends approximately at the same elevation to the 3rd tooth. Apical margin of clypeus truncate and crenulated along the border; minute median tubercle at apex, bordered on each side by an ovate pit occupied by a cluster of short setae. Terminal antennal segment flattened apically, glabrous and polished on the posterior side. Dorsal side of hind femur without an elongate post median field of short dense pubescence. All abdominal terga without white apical fasciae. Gradular groove on tergum II with or without a band of white pubescence. Terminal tergum nearly straight in lateral view; pubescence subappressed, with longer, more erect hairs intergrading with

Opposite p. 217

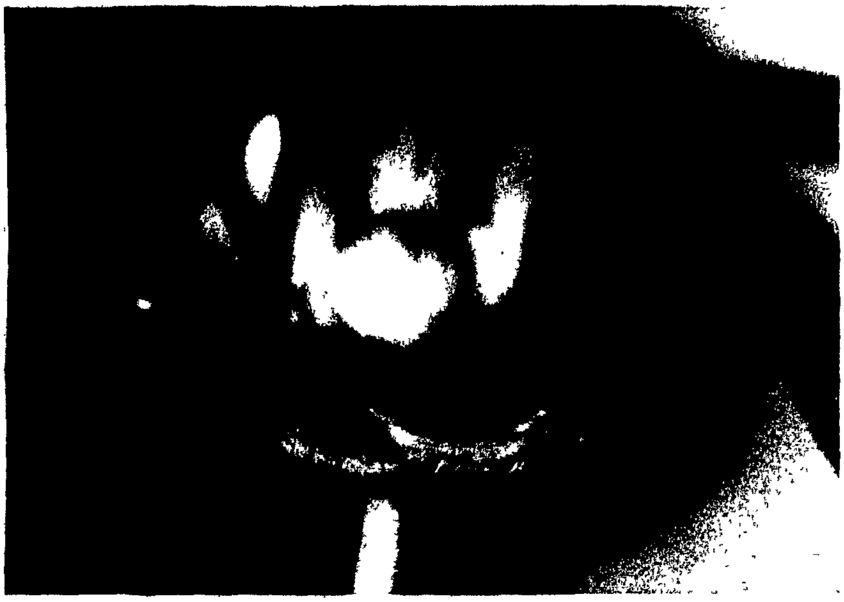


Fig. 24. M. melanophaea, M. Face view, with boat-shaped excavation on front basitarsus.

Fig. 25. M. frigida, M. Expanded and elaborate front basitarsus, associated with territoriality and defence.

shorter, more appressed hairs.

MALE. Length 10-13 mm. Head, thorax and first two abdominal segments in dorsal view with copious elongate whitish to yellowish-white pubescence, mostly obscuring the black integument beneath; pubescence on abdominal segments beyond the second, brown to black, less dense and not concealing the conspicuously contrasting black integument. Mandible 4-dentate, with the distance between the apices of the inner and its adjacent outer tooth subequal to the distance between the apices of the outer tooth and its adjacent inner tooth. Inner side of mandible with a deep concavity, shaped to receive the apical section of the alternate mandible when the mandibles close. Ventro-lateral border of mandible obtusely angulate medially. Ventral mandibular tooth broadly fused with mandible, its union extending from near the lower mandibular condyle to a little beyond the middle of the mandible (Fig.79). Apex of ventral mandibular tooth with a dense brush of hairs, extending into the glabrous and polished hypostomal concavity. Hypostomal concavity bordered by a carinate wall on the mandibular side and a prominent crescent-shaped tubercle on the posterior side; an elongate tuft of hairs arises from the apex of the tubercle, curves anteriorly and overhangs the concavity; the concavity extends laterally and opens to the outside by way of a semicircular excision situated just above the lower mandibular condyle. Narrow, glabrous, subpolished band, bordered on each side by a strip of white pubescence, extends from near the ventral margin of the eye to the posterior border of cheek; a black, pilose patch separates the strips of white pubescence below, from the elongate, white pubescence extending above the upper half of cheek. Front coxa, with a robust coxal spine, mostly glabrous anteriorly, except for a dense patch of reddish bristles just above the spine. Part of front femur, apex of tibia and tarsus yellowish-testaceous; strikingly contrasting with the black integument on the rest of the body and appendages. Front tarsal segments 1-4 strongly dilated and densely fringed with elongate hairs, subequal to the width of their segments. Front basitarsus distinctly broadened apically and deeply excavated to form a glabrous boat-shaped concavity along the antero-ventral side. All terga usually without apical fasciae, sometimes with scattered white hairs along the depressed apical border. Apical margin of tergum VI deeply rounded medially and bordered on each side by a prominent submedian denticle followed by small lateral denticles. Apical margin of tergum VII with a robust and strongly tapered median tubercle.

COMMENTS. The female can be recognized by the small but distinct cavity at the apex of the rounded inner (4th) mandibular tooth (Fig. 63). Since the inner and outer cutting edges surrounding the pit are of about equal elevation, the cavity can be seenbest with the mandible opened. Another distinctive female character is the absence of white, apical tergal fasciae which combined with the sparse, black to brown pubescence on terga III-VI exposes a strikingly black integument on the apical half of the abdomen contrasting with the copius yellowish-white on the anterior dorsal aspect of the body. A conspicuously black, apical half of the abdomen is also present in the M. gemula, however, M. gemula can be separated by the truncate inner mandibular tooth (Fig.62).

The male can be distinguished by the flattened and apically rounded tubercle at the apex on the postero-dorsal side of front tibia. Another diagnostic character is the 4-dentate mandible, combined with the dilated, yellowish-testaceous front basitarsus and the prominent submedian tubercles at the apex of tergum VI.

Females in M. melanophaea exhibit a great deal of variation in hair colour in different climatic regions. The most striking progression of melanism is evident in the colour of the scopal hairs which range from entirely bright orange, to infuscated and brown peripherally, to almost entirely dark brown with some reddish reflections medially. It has been noted that the colour of the scopal hairs complies with the preponderant composition of flowers visited in different regions and the colour of the scopal pollen load. It appears that the pollen loads carried by this species in damp cool regions, such as the eastern Maritime Provinces, is darker than the pollen grains collected in the hot dry areas in the Prairie Provinces. Combined with infuscation or darkening of the scopal hairs, pubescence on other parts of the body such as pleura, vertex, mesonotum and legs acquire a corresponding shift in colour pattern. Since males do not collect pollen grains, the various varieties which have been segregated in M. melanophaea do not exhibit any consistent, perceptible colour or morphological variation across Canada.

Thus, the varieties M. melanophaea submelanophaea and M. melanophaea calogaster are suppressed as phenotypic clines which are genotypically compatible with M. melanophaea.

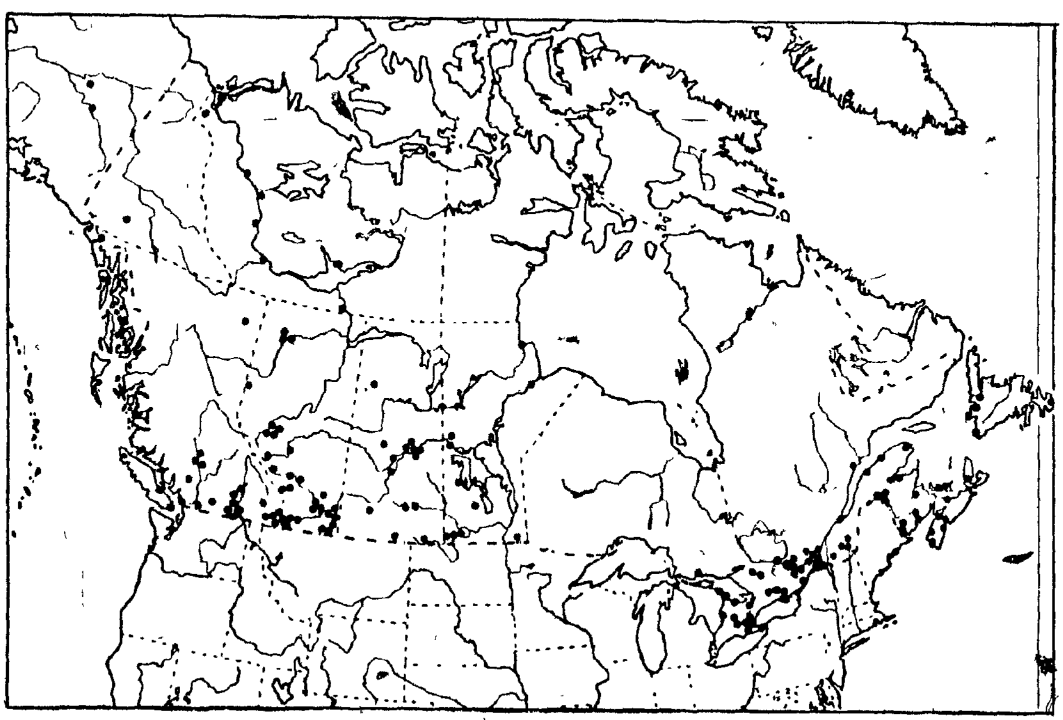
DISTRIBUTION. M. melanophaea is widely distributed across North America; extending longitudinally from coast to coast and latitudinally from New Mexico to the Northwest Territories. In Canada, specimens have been collected from the following localities (Map 15): Newfoundland: Corner Brook, 31 July 1976, 1F. Deer Lake, 26 July 1907, 1M. Little River, Codroy, 10-18 July 1907, 1F. St.John's, 12 July 1957, 1M; 14 July 1957, 1M; 10 July 1972, 1M. Sable Island: Sable Island, 19 July 1976, 2F; 21 July 1976, 1M; 23 July 1976, 1M. Nova Scotia: Baddeck, 23 July 1926, 1M. Digby, 29 June 1932, 5M, Diervilla. Halifax, 10 July 1916, 1M. Kentville, 30 July 1914, 1F; 26 July 1924, 1F. Kings Co., June 1929, 1F; 8 July 1929, 2F; 9 July 1929, 1F; 16 July 1929, 1F; 8 Aug. 1929, 1F; June 1930, 1F; 12 July 1930, 1F, Rosa; 16 July 1930, 1F, Rosa; 18 July 1930, 1F, Rosa; 21 July 1930, 1F, Raphanus; 28 July 1930, 1F, Raphanus; 18 June 1931, 1M; 8 July 1931, 4M, Raphanus, 5M, Trifolium; 3M, Rubus, 1F, Kalmia; 13 July 1931, 5M, 4F, Diervilla, 1F, Trifolium; 15 July 1931, 1F, Lichorium, 1F, Centauria; 24 July 1931, 1F, Hieracium; 16 June 1932, 1M, Apple; 23 June 1932, 1M, Rubus; 12 July 1950, 1M. Kentville, 30 July 1914, 1F; 29 July 1924, 1F. Lunenburg, 4 July 1931, 1F, Trifolium. Pictou, 1 Aug. 1914, 1F. Smiths Cove, 15 July 1914, 2F. Ohio, Yarmouth Co., 17 July 1962, 1F. Truro, 14 July 1913, 1F. Wilmont, 1F. Prince Edward Island: Brackley Beach, 2 Aug. 1940, 1F. Dalvay House, Can. Nat.Park, 19 July 1940, 1M. Stanhope, 12 July 1964; 22 July 1964, 1F. New Brunswick: Acadie Siding, 28 June 1976, 1F, 1M; 29 June 1976, 3F; 7 July 1976, 1F. Dalhousie, 24 July 1915, 2M. Jacquet Head, Field Station, Restigouche Co., 17 Aug. 1956.

Lawrence Station, 17-24 June, 1F; 23 June 1976, 3F, 1M. Little Forks, 19 June 1963. McAdam, York Co., 10-17 June, 2M; 18 June, 1M; 17-24 June, 9F. Nictau, 8 July 1956, ;flying around carrion. Red Rapids, 23 July 1913, 1M. Ripples, 5 July 1976, 1M. St.Croix, 10-17 June, 3M; 17-24 June 1976, 4F. St.John, 8 July 1900, 1F; 1932, 1F. Quebec: Abbotsford, 21 June 1933, 1M. Aylmer, 25 June 1887; 15 July 1924, 1F; 16 July 1926, 1M. Cap Chat, 8 July 1954, 1M; 29 July 1954, 1F. Cap Rouge, 10 July 1953, 1F. Chapeau, 8 July 1966, 1M, Jack pine stand. Charlevoix Co., 13 Aug. 1918; 14 Aug. 1918. Chelsea, 5 July 1912, 1M. Cheticamp, Aug. 1917. Clova, 19 July 1959. Covey Hill, 28 June 1924, 1F; 6 June 1925, 1M; 9 June 1926, 1M, Plum. Forestville, 8 July 1950, 1F; 13 July 1950, 2F. Fort Coulonge, 8 July 1917, 1F. Great Whale River, 31 July 1949, 1F; 14 Aug. 1949, 1F; 16 Aug. 1949, 1F; 28 Aug. 1949, 1F. Harrington Lake, 24 June 1954, 1F. Hemminggord, 22 June 1916, 1F; 5 June 1922, 1M; 28 June 1929, 1F. Hull, 14 June 1914, 1F, 1M, marginal Caligaster. JamesBay, 19 July 1920, 1F. Kazabazua, 3 July 1913, 2M, 1F, Melanoph; 17 July 1913, 1F; 22 June 1915, 1M, 1F, Caligaster; 30 July 1953, 1M. Knowlton, 20 June 1929, 3M; 22 June 1929, 1F; 6 July 1929, 1F. Lakeside, 22 June 1929, 1F. Lanoraie, 13 July 1930. Levis. Meach Lake, 30 July. Mistassini, lac St. John, 16 July 1975, 1F. Montfort, 12 July 1916. Mont Joli, 28 July 1954, 2F; 29 July 1954, 1F. Montreal, 26 June 1916, 1M; 1 July 1918; 10 June 1920, 1F; 30 June 1926, 1M; 1 July 1926, 2M; 3 July 1926, 1M, 1F; 15 July 1926, 2F; 20 July 1926, 1F; 24 July 1926, 2F; 16 July 1927, 1F; 16 June 1932, 1M, Carina; 10 June 1933, 1F. Parké Reserve, 14 July 1957, 1M, Heracleum. Perce, 1F. Rawdon, 21 June 1931, 1M; 4 July 1965. Rivington, 5 July 1929, 2M, Pubese; 15 July 1929. Ste.Anne's, 7 June 1940, 1F; 7 June 1941. Ste.Anne de Bellevue, 14 June 1966, 2F. Ste.Anne des Monte, 18 June 1954, 1M; 4 July 1954, 1M. St.Faustin, 23 June 1967, 1M. St. Hilaire-de-Dorset, 25 July 1926, 1F; 10 July 1927, 1F; 6 July 1965, 1M. St.Martin, 17 July 1926. St.Methode, 20 June 1962, 1F; 13 June 1963, 1M. Shawbridge, 6 July 1926; 7 Aug. 1926, 1M; 8 July 1928; 11 July 1929; 15 July 1929, 1M; 26 June 1930, 1F; 30 July 1930. Tadoussac, 2 July 1932; 20 July 1932, 1M, 6F. Temagāmi, 3M. Wakefield, 24 July 1946, 1M. Wilmont, 10 July 1918. Ontario: Algoma District, 26 June 1965. Algonquin Park, 9 June 1959, 1M. Atwood, 25 June 1952, 1F. Belleville, 1M. Black Sturgeon, 16 July 1961, 1F, Trifolium hybridum. Calabogie, 13 July 1969, 1F. Clear Lake, 9 July 1969, 1F. Cobalt, 7 July 1940, 1M. Cyprus, 30 June 1974, 1M. Dyer Bay, 8 July 1952, 2F, 2M; 9 July 1952, 4F; 10 July 1952, 1M, 1F, Alsike; 24 June 1953, 2M; 7 July 1953, 1F; 19 July 1953, 1M; 21 July 1953, 1M. Elmira, 3 June 1959, 1M. Gananoque, 19 June 1965, 1M; 20 June 1965, 1M, 1F; 22 June 1965, 1F. Goderich, 28 June 1955, 1F. Guelph, 15 June 1916, 1M; 13 June 1960, 1M. Hepworth, 4 July 1954, 1F, black scopa. Kirkwood, 5 July 1960, 1F, Red pine plantation ground cover. Leith, 21 Aug. 1955, 1F, red scopa. Limehouse, 22 June 1974, 1M. Marmora, 6 July 1939, 6M; 19 June 1952, 1F; 6 July 1960, 1F. Meaford, 27 July 1953, 1F, Red scopa. Miller Lake, 1 July 1963, 1M. Nipigon, 11 July 1907, 1M. Newmarket, 24 June 1936, 1F, 24 June 1966, 1F. Ontario East, 1F, 1M. Ottawa, 30 June 1912, 1F; 12 June 1913, 1F; 16 June 1913, 1M; 17 June 1913, 3M; 18 June 1913, 1F, 1M; 23 June 1913, 1F; 27 June 1913, 1F, 1M; 19 Sept. 1913, 1M; 13 June 1914, 2F, 1M; 7 June 1915, 1M; 19 June 1915, 1F, 1M; 14 June, 1M; July 1952, 1F; 15 July 1969, 1F. Spencerville, 3 July 1939, scopa dark reddish. Stirling, 7 June 1963, 1M. Sudbury. Thunder Bay, 17 July 1920, 1F. Toronto, 21 June 1888, 1F; 1 July 1888, 1M; 26 June 1891, 1F; 1 July 1892, 1M; 10 July 1892, 1M; 22 June 1908, 4M. Trenton, 21 June 1901, 1F. Walsh, 2 July 1915, 1F. Manitoba: Awme, 1 July 1904, 1M; 15 July 1916, 3M; 24 June 1925; 1 July 1925, 1F; 2 July 1925, 1M; 4 July 1925, 1F, Scopa light orange. Brandon, 11 July 1916, 1F; 29 June 1948, 1F, Churchill, 10 July 1948, 1F. Carberry, 6 May 1948, 1M; 8 May 1948, 1M; 10 May 1948, 2M; 20 May 1948, 1M; 23 May 1948, 1M; 24 May 1948, 1M; 18 June 1948, 1M; 21 June 1948, 1M; 7 July 1948, 1M; 21 July 1948, 1M; 15 Aug. 1948, 1F; 21 Sept. 1948, 1M. Erickson, 29 July 1926, 1F. Gillam, 21 July 1950, 1F. Hasavick, 3 July 1950, 1F.

Sandilands Res., 5 J , 1938. Sclater, 6 July 1950, 1M. So. Junction, 9 July 1948, 1F. Sprague, 7 July 1948, 2F, 4M; 8 July 1948, 2F, 1M; 22 June 1950, 1M. The Pas, 28 June 1953, 1F. Wanless, 7 Aug. 1953, 1F; 15 Aug. 1958, 1F. Saskatchewan: Big River, 24 July 1973, 1F. Indian Head, 31 May 1915, 1F, 1M. Love, 3 July 1944, 1F, Alfalfa; 22 July 1944, 1F, Alfalfa; 27 July 1944, 1F, Alfalfa; 3 Aug. 1944, 1F, Alfalfa; pale orange scopa. Melford, 20 July 1916, 1F. Nipawin, 18 July 1952, 5F. Prince Albert, 22 July 1916, 2F, 1M. Regina, 8 July 1906, 1F; 9 July 1916, 1F. Roche Percee, 4-8 July 1927, 1F, 2M. Rosthern, 29 May 1915, 1F. Snowden, 28 July 1944, 1F. St.Victor, 27 June 1955, 1F. Swift Current, 20 Aug. 1916, 1F. Torch River, 4 July 1944, ;popular stub. White Fox, June 1944, 1F. Alberta: Aden, 28 June 1956, 5F. Banff, 19 July 1909, 1M; 24 July 1911, 1M; 23 June 1922; 7 Aug. 1927, 1M; 11 July 1955, 1F; 14 July 1955, 2F; 4 Aug. 1955, 2F. Beaverlodge, 21 June 1931, 1M; 6 July 1931, 4F; 12 July 1931, 3F; 29 July 1931, 1F; 2 Aug. 1960, 1F, 1M. Brooks, 11 July 1930, 1F. Calgary, 1 Aug. 1909, 1M; 29 July 1916, 1M; 18 July 1917, 1F; 14 July 1965, , plumose hairs. Cypress, 13 July 1949, 5F; 30 July 1949. Delburne, 11 July 1959, 1F. Edmonton, 30 July 1919, 1M; 30 July 1936, 1F; 15 June 1937, 6F, 1M, Hedysarum Mackenzie; 3 July 1971, 1F. Elkwater, 1 Aug. 1949, 2F. Evansburg, 30 June 1938, 1F. Fawcett, 20 June 1932, 1M. Fort Vermillion, 8 Aug. 1957, 1F, Alfalfa.

Hays, 9 July 1953, 2F, cutting <u>Thermopsis</u>; 10 July 1955, 1F, <u>Astragulus</u>. Key River, 6 July 1955, 1F. Lethbridge, 8 Aug. 1909, 1M; 28 June 1913, 1M; 28 June 1914, 4M, 1M, with teretoid; 31 July 1914, 1F; 18 July 1919, 1F; 30 June 1921, 1F; 25 June 1922, 1M; 6 July 1922, 1F; 23 June 1924, 1M; 20 Aug. 1930, 1F; 20 Aug. 1951, 1F, Alfalfa; 10 June 1952, 1F, Yellow Sweet Clover; 9 July 1952, 1F, Alfalfa; 23 July 1952, 1F, Alfalfa; 6 July 1956, 1F; 7 July 1956, 2F. Lost River, One Four, 2 June 1956, 1M; 3 June 1956, 1M; 13 June 1956. Magrath, 3 July 1949, 2F. Manyberries, 8 July 1952, 2F. McMurray, 3 July 1953, 1F. Medicine Hat, 17 July 1917, 1M, Alfalfa; 9 June 1940, 2M; 10 June 1940, 1M. Morrin, 20 June 1930, 1F. Nordegg, 17 July 1926, 2F; 10 July 1955, 1F, ground nesting. Opal, 23 June 1956, 1M. Pincher, 15 Aug. 1958, 1F. Rocky Lane, 6 Aug. 1959, 2F, Alfalfa. Rolling Hills, 20 July 1946, 1F, firewood; 29 July 1952, 1F, cleome. Scandia, 6 July 1953, 2M; 9 July 1956, 1F. Seven Persons, 8 July 1952, 1F, Alfalfa beside Sweet Clover. Steveville, 2 Aug. 1949, 1F. Wabamun, 27 June 1936, 1F, mosonotum; 28 June 1936, 1M; 3 July 1939, 1F; 4 July 1939, 1M. Waterton Park, 1 July 1923, 1F; 12 July 1925, 1M; 21 Aug. 1951, , monarda sp. <u>British Columbia</u>: Atlin, 4 June 1955, 2F, 1M; 4 July 1955, 1M; 7 July 1955, 1F. Bear Flats, 3 Aug. 1959, 1F, Alfalfa. Bowser, 8 July 1955, 2M. Chase, 6 June 1937. Chilcotin, 29 May 1920, 1M; 13 July 1920, 1F; 16 June 1920, 1M; 1 Aug. 1920, 1F; 20 June 1926, 1F, 1M; 13 June 1929, 1M; 14 June 1929, 1M, 7F; 3 June 1930, 1M; 5 June 1930, 2M; 26 June 1930, 1M; 29 July 1930, 3F. Copper Mountain, 21 July 1928, 1M. Fairview, 7 Aug. 1919, 1F. Fitzgerald, 21 June 1922, 1M. Fish Lake, Summerland, 26 May 1931, 1F. Fort Nelson, 10 June 1948, 2F. Hat Creek, 26 June 1943, 1F, 1M; 27 June 1943, 3M. Hedley 5000, Nickel Plate, 16 July 1953, 1F; 17 July 1953, 1M. Hill's Gale, 26 June 1971, 1F. Invermere, 30 June 1914, 6F, 4M; 9 May 1915, 1M; 27 May 1915, 1M, Sainfoin; 1 June 1915, 2F. Kamloops, 24 June 1937, 1F; 11 July 1937, 1M; 13 June 1943, 1M; 8 July 1943; 18 July 1943, 1M. Kaslo, 7 May 1906, 1M; 28 May 1906, 1M; 30 May 1906, 1F; 3 June 1906, 1M; 5 June 1906, 2F; 11 June 1910, 2F. Keremeos, 18 June 1919, 1M; 11 July 1953, 1M; 29 July 1953, 1F. Lac de Bois, 19 June 1946, 1F. Lillooet, 2 July 1920, 1F. Manning 6000', 10 Aug. 1953, 1M. Manning Park, Blackwall 6000', 11 Aug. 1953, 1F, 4M; 12 Aug. 1953, 1M; 14 Aug. 1953, 8M. Mara, 12 July 1920. 100 Mile, 1 July 1943, 1M. New Castle, 29 June 1926, 1M. Okanagan, Aug., 1F. Okanagan Falls, 3 June 1919, 1F, 2M; 29 May 1953, 2F, 5M. Okanagan Lake, 31 May 1901, 1M; 28 May 1904, 1M. Oliver, 24 July 1953, 1M. Osoyoos 2500', 7 July 1953; 15 July 1953, 3M, 9M. Osoyoos 3500', 21 July 1953, 1M. Osoyoos 4000', 15 July 1953, 1F, 9M; 21 July 1953, 3M; 27 July 1953, 1F. Pavilion Lake, 5 July 1950, 2M. Penticton, 7 Aug. 1910, 1F; 19 June 1918, 1F; 5 June 1919, 1M; 7 June 1919, 1F, 4M; 22 June 1919, 1F, 1M; 29 June 1919, 1M. Salmon Arm, 4 July 1914, 2F, 1M; 27 June 1925, 1M. Shawnigan V.I., 7 July 1914, 1F, 1M. Summerland, 10 July 1917, 1M. University B.C., 15 April 1920, 1M. Vancouver, 12 July 1916, 1F; 12 Aug. 1916, 1F. Vaseaux, 12 June 1919, 1F; 14 June 1919, 1M. Vernon, 21 June 1903, 1F; 31 May 1929, 1M; 25 May 1930; 2 July 1930, 1F; 29 May 1953, 1F, 1M. Victoria, 17 June 1917, 1F; 20 July 1965, 1F. Victoria Beach, 1 July 1918, 1M. Wasla Lake, 2 July 1960, 3F. Northwest Territories: Fort McPherson, 10 July 1957, 1F. Fort Norman, 29 June 1922, 1M; 25 July 1922, 1F; 6 Aug. 1922, 1F. Fort Simpson, 14 July 1946, 1F; 12 July 1950, 1M; 23 July 1950, 1F; 6 Aug. 1950, 1F. Fort Smith, 25 June 1950, 1F; 31 July 1950, 1M. Fort Wrigley, 23 July 1922, 1F, 1M; 31 July 1922, 1F. Norman Wells, 9 July 1949; 12 July 1949. Reindeer Depot, 2 July 1948, 1F; 10 July 1948, 1F; 11 July 1948, 1F; 12 July 1948, 2F; 18 July 1948, 1F; 19 July 1948, 1F; 1 Aug. 1948, 1F. Yellowknife, 6 Aug. 1949, 2F. Alaska: Big Delta, 3 July 1951; 15 June 1951, 1M; 24 June 1951, 1F; 26 June 1951, 1F. Can, 1F. Firth River, 31 July 1956, 1F; 2 Aug. 1956, 1F. Yukon Territory: Whitehorse, 4 July 1948, 1F; 5 July 1948, 1F; 11 July 1948, 1F; 27 June 1949, 1F; 13 July 1949, 1F.

FLOWERS VISITED. Agastache (Giant Hyssop), (M); Apocynum (Dogbane, Indian Hemp), (M); Astragalus (Milk-Vetch), (M); Azalea (see Pentanthera), (M); Campanula (Bellflower), (M); Cypripedium (Lady's-Slipper, etc.), (M); Epilobium (Willow-Herb), (M); Helianthus (Sunflower), (M); Lupinus (Lupine), (M); Medicago (Alfalfa), (M); Phacelia (Scorpion-Weed), (M); Psoralea (Scurf-Pea), (M); Ranunculus (Buttercup), (M); Raphanus (Radish), (M); Rhodora (species of Rhododendron), (M); Rosa (Rose), (M); Rubus (Bramble), (M); Rudbeckia (Cone-flower), (M); Symphoricarpus/(carpos) (Snowberry), (M); Taxaxacum (Dandelion, etc.), (M); Trifolium (Clover), (M); Vicia (Vetch), (M).



Map 15. Canadian distribution of Megachile melanophaea.

BIOLOGY. The flattened, disc-shaped mandible, with the outer tooth expanded and obliquely rounded is incapable of chiselling holes in wood, but is adapted for burrowing nesting tunnels in the soil. Graenicker (1905) reported finding cells in the soil 6-9 cm deep. Pengelly (1955) watched a female excavate a burrow in the soil by entering head first, then backing and dragging dirt out with her front legs. A tunnel which was examined, led vertically downward for 1.25 cm, then curved and extended horizontally for about 10 cm. Cells were constructed with 11-22 oblong sections of leaves, while 5-18 circular sections were used to cap the cell. Leaf sections for constructing the cells were taken from the following plants: _Corylus cornuta_ (Beaked Hazelnut); _Ostrya virginiana_ (Hop-Hornbeam); _Rosa_ sp. (Wild Rose); _Prunus serotina_ (Black-cherry); _Acer nigrum_ (Sugar Maple); _Tilia americana_ (Basswood). Cells are provisioned with 9-13 loads of pollen. The time required to collect a load of pollen varied from 14-39 minutes. On good days, at temperatures above 33°C (60°F), females are generally active from 7:00 A.M. until 6:00 P.M. Adults emerge around mid June and remain active until the early part of August, with peak activity during the first three weeks in July. Females live for about 50 days (Pengelly, 1955).

PARASITES. Coelioxys sodalis (reported as C. ribis, a synonym) (Pengelly, 1955); C. rufitarsus (Graenicher, 1905; Pengelly, 1955); Semiotellus cupraeus Prov. (Peck and Bolton, 1946).

ALFALFA POLLINATING POTENTIAL. In northern Saskatchewan, Peck and Bolton (1946) estimated that a female of M. melanophaea visited an average of 15 alfalfa flowers per minute and tripped a high percentage of the flowers visited. In southern Manitoba, Stephen (1955) observed that in areas where Fireweed and volunteer clovers were scarce, up to 60.9% of the alfalfa florets were tripped; however, when an abundance of competing blossoms were available, then these bees were of little benefit. In southern Ontario, Pengelly (1955) reported 13 to 16 alfalfa florets visited per minute with 100% tripping efficiency. In Alberta, Hobbs and Lilly (1954) found that adults of M. melanophaea were active about ten days earlier than M. perihirta and noted that it might be a valuable pollinator on early blooms, if it were more common.

Since M. melanophaea nests in the soil, transportable, perforated, wooden nesting sites, similar to those currently used for the domesticated leaf-cutter bee would not likely be adopted. Thus, since the nesting sites could not be moved and strategically situated in blossoming alfalfa fields, permitting crop rotation, cultivation and establishment of new alfalfa crops, this species has distinct functional limitations. Salt (1940) observed that some leafcutter bees nested in firm, undisturbed soil--such as found along borders of fields, creeks and rivers. He proposed that strips of uncultivated land along roadsides, shelterbelts and fences be made to serve as nesting sites for native alfalfa pollinating bees. He also estimated that if ample nesting sites were available, native bee populations would probably increase in accordance with the availability of food supply that could be derived from a nearby flowering alfalfa field. Two additional conditions that also have to be met are:

(i) continued access to a nearby flowering alfalfa field annually, without interruption for establishment of new stands every 5-to-10 years. This condition might be met by alternating alfalfa production on the two sides of the uncultivated strip.

(ii) since there is no published evidence that M. melanophaea uses alfalfa leaves for cell construction, a suitable secondary plant chosen from those listed previously might have to be planted in the uncultivated strip.

MEGACHILE (DELOMEGACHILE) ADDENDA CRESSON

Figures 17, 61; Map 16

Megachile addenda Cresson, 1878:124 (new species, Mass., N.J., Ga., Ill., Col., Tex.).

Megachile (Delomegachile) addenda; Mitchell, 1962:131 (description, distribution, flower records).

FEMALE. Length 11-14 mm. Body shiny black with conspicuous, dense, white apical fasciae present on terga II-V. Mandible 4-dentate with a large, oblique emargination in the outer cutting edge between the 3rd and 4th denticles; the emargination fully occupied by the inner cutting edge, which is elevated to the summit of the 4th tooth and extends outwardly to near the apex of the 3rd tooth (Fig.61); inner cutting edge effaced beyond the 3rd denticle, not extending to base of 2nd tooth. Outer mandibular tooth flattened, broadly expanded and obliquely rounded apically. Apical margin of clypeus truncate with large, deep punctures along the ventral rim from which arise clusters of elongate hairs; the deep punctures form a crenulate apical border with a minute median tubercle, when the clypeus is examined face view. Terga II-V with broad, deep and polished transverse gradular grooves, overlapped along the anterior margin by extended gradular carinae beneath which, mites are usually present. Discs of

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Fig. 32. M. parallela, M.
Four dentate mandible.

Fig. 33. M. parallela, F.
Face view.

terga II-V with strongly convex preapical bands extending from the gradular groove to the depressed band, bearing the copious apical fascia. Dense, robust, black bristles laterally on terga II-V. Tergum VI strongly depressed sublaterally and approximately truncate apically, with a weakly elevated median band which is accentuated by a dense, elongate strip of black hairs which expand to cover most of the tergum apically. Apical fringe on sternum VI with dense, elongate black hairs extending some distance beyond the sternum laterally and notably shortened medially. Scopal hairs on sternum VI deep black, strikingly contrasting with the white scopal hairs on preceding sterna.

MALE. Length 11-14 mm. Integument including legs and tegulae entirely black. Mandible 4-dentate; outer (1st) mandibular tooth elongated and narrowed basally; inner tooth forming an angle of 90°. Ventral mandibular tooth elongated, longer than wide at base; without a dense brush of hairs at apex. Hypostomal concavity broadly, but not deeply, excavated. Hypostomal tubercle represented by an elevated ridge bordering the posterior margin of the concavity; inner margin of concavity bordered by an elevated hypostomal carina; concavity punctate and occupied by pubescence which is shorter and less dense than the pubescence on and behind the hypostomal ridge.

Labrum elongated, nearly twice as long as wide at base; narrowed, and curved anteriorly toward the apex, with a distinct preapical transverse ridge. Anterior side of front coxa with short, sparse pubescence, except for a transverse patch of dense, reddish bristles just anterior to the coxal spine. Front basitarsus simple, not dilated and infuscated; distinct row of short hairs extending throughout its length on the anterior side; the row of short hairs bordered on each side by longer bristles. Terga II-V uniformly black and subpolished, conspicuously contrasting with the copious white apical fasciae. Gradular grooves on terga II-IV strongly depressed with prominent gradular carinae overhanging the grooves. Transverse carina on tergum VI expanded laterally, broadly emarginate medially. Apical margin of tergum VI with lateral, but scarcely perceptible submedian tubercle. Tergum VII with a robust preapical tubercle, strongly tapered distally.

COMMENTS. The female can be recognized by the large oblique emargination in the outer cutting edge, between the 3rd and inner denticles, which is nearly fully occupied by the elevated inner cutting edge (Fig.61), and the strongly elevated and posteriorly projecting gradular carinae on terga II-V. A similar large oblique emargination between the 3rd and inner mandibular denticles is also present in

M. wheeleri, however, M. addenda can be separated by the prominent overhanging gradular carinae which are absent in M. wheeleri.

The male can be distinguished by the 4-dentate mandible, the infuscated and simple front basitarsus (which is narrower than its tibia) and the absence of submedian denticles at the apex of tergum VI. A 4-dentate mandible combined with an infuscated and narrow front basitarsus is also present in M. gemula and M. parallela. However, M. gemula can be separated by the broad glabrous and subpolished longitudinal furrow on anterior side of front basitarsus, which is represented by a weakly distinguishable shortened row of hairs in M. addenda; M. parallela can be segregated by the absence of a dense patch of reddish bristles just anterior to the front coxal spine, which is present in M. addenda.

DISTRIBUTION. Ontario: Goderich, 28 June 1955, 2F; 28 June 1955. Toronto, July 1957, 1F; July 1957, 1F. Quebec: Ste. Anne de Bellevue, 1 Aug. 1972, 1F.

FLOWERS VISITED. Amorpha (Leadplant), (M); Asclepias (Milkweed), (M); Baptisia (False Indigo, etc.), (M); Coreopsis (Coreopsis), (M); Dianthera (Water-Willow), (M); Gillenia (Indian-Physic), (M); Hieracium (Hawkweed), (M); Hypericum

(St.John's-Wort), (M); Oenothera (Evening Primrose), (M); Opuntia (Indian Fig), (M); Pentstemon (Beard-Tongue), (M); Polycodium (Sleumer), (M); Psoralea (Scurf-Pea), (M); Rosa (Rose), (M); Rubus (Bramble), (M); Tephrosia (Hoary Pea), Vaccinium (Blueberry, Billberry, Cranberry), (M).

BIOLOGY. There is little published information on the biology of M. addenda. The flattened mandible, with the outer tooth expanded and obliquely rounded, suggest that it nests in the soil. Medler and Lussenhop (1968) state that in Wisconsin it might be collected in sandy localities. It is proposed that the species may nest in sandy soil beneath clumps of grass, under stones or other covering objects.

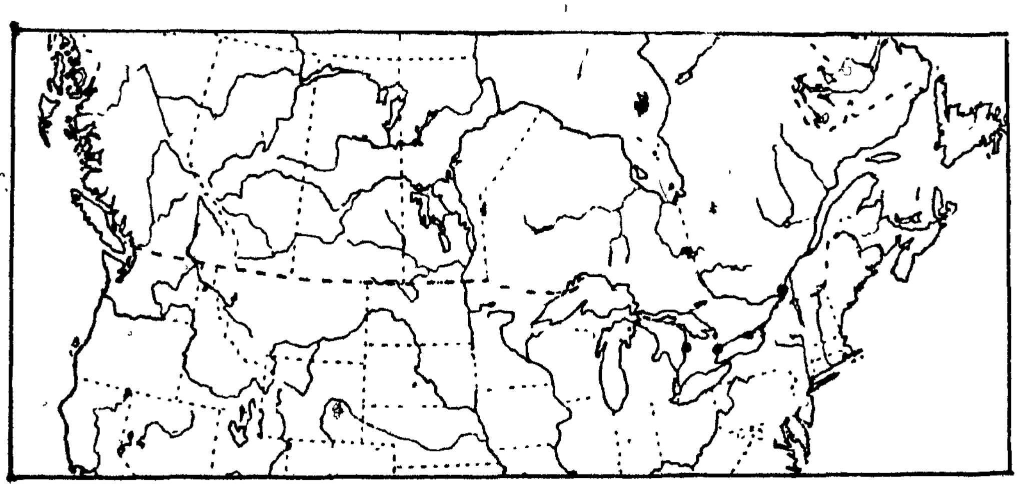
Distinctive morphological elaborations which indicate convergent evolution and complex symbiotic relations are the strongly depressed gradular grooves and the broadly overhanging carinae, which appear to serve as specialized acarinid chambers. In the female observed, up to twenty deutonymphs are attached to and concealed beneath the overhanging carinate rim on each of the terga III-V. Pubescence on the broad and deep gradular grooves is uniformly shortened to permit the deutonymphs to pass over this area into the deeply recessed acarinid chamber. In males, the elongate hairs in the gradular groove restrict passage of deutonymphs and accordingly no deutonymphs are present beneath the overhanging gradular carinae in males.

Specialized gradular cavities which serve as abodes or acarinaria for deutonymphs are also present in xylopid bees and eumenine wasps. The greatly extended carina on tergum II of the eumenine wasp Panancistrocerus closely resembles the acarinaria on terga II-V in M. addenda. The advantages the symbiotic alliance would provide to the deutonymph appear relatively clear; the winged hymenopterous host provides means of transport (dispersion) and a secure semiconcealed abode.

The survival advantages which the deutonymph provides for the bee are entirely unresolved. Yet, it is evident that the presence of the mite provides distinct selective survival advantage for the bee. Bees bearing structures which offered the best accommodation for the deutonymph had the benefit of deutonymphs; thus the deutonymph in turn promoted the survival of the bee with the best acarinaria.

In Panancistrocerus (Eumeninae) Evans observed the transfer of deutonymphs from the male acarinaria on tergum II to the female genital chamber along with seminal fluid during copulation. It is, therefore, likely that the active migration of the deutonymphs to the female genital chamber promotes transmission of the male seminal fluid to fertilize the female. However, the presence of the deutonymphs on the female, rather than on the male, in M. addenda does not denote a corresponding function. Additional study would be required to understand the bee-deutonymph alliance.

ALFALFA POLLINATING POTENTIAL. Publications on hand, do not indicate that M. addenda has been collected on, or observed to visit alfalfa. The species has been collected on blueberries, an economic crop whose yield is improved by cross-pollination. The species is rarely collected and occurs only in the extreme southern parts of Ontario and Quebec. Only 4 specimens have been collected in southern Ontario and Quebec.



Map 16. Canadian distribution of *Megachile addenda*.

Subgenus XEROMEGACHILE Mitchell

Figures 13, 22, 64, 80.

Xeromegachile Mitchell 1937:325 (new subgenus)

FEMALES. Length 10-13 mm. Pubescence white to yellowish-white. Vertex and mesoscutum medially usually occupied by predominantly black hairs. Scopa mostly white, black apically or entirely black. Mandible 4-dentate and flattened with the outer tooth reflexed, expanded and elongated (Fig. 64) (apices of mandibular denticles worn down in older females); large, strongly oblique emargination in the outer cutting edge between the 3rd and 4th denticles; distance between the apex of 3rd tooth and base of emargination approximately three times as great as the distance from the apex of the inner tooth to base of emargination; sharply inclined outer cutting edge slope and inner margin of mandible forming an acute 4th tooth with an angle of about 10°. Apical border of clypeus uniformly truncate, glabrous and impunctate, somewhat thickened and reflexed forming a weak transverse furrow just above the apical rim. Spur on the posterodorsal side at apex of front tibia, much more acutely angulated than the corresponding spur on mid-tibia;

angle made by the spur on front tibia less than 45^{o}; angle of spur on middle tibia much more than 45^{o}. White apical fasciae on terga II-V usually broad and distinct, sometimes worn down and obliterated medially on the more anterior terga.

MALES. Length 9-12 mm. Pubescence on head and thorax white to yellowish-white. Front tarsi and apex of front tibia white, strikingly contrasting with the black to brown integument on the rest of the body. Front basitarsus with a polished boat-shaped excavation extending throughout its length, on the anteroventral side; basitarsus about as wide as its tibia. Front femur dilated a little beyond the base, keel-shaped, largely glabrous and subpolished, with distinct punctures on the posterior side. Front coxa mostly glabrous and polished anteriorly with a greatly enlarged and strongly flattened coxal spine, which is conspicuously extended and evenly curved anteriorly. Mandibles 3-dentate with the apex of the inner tooth forming an angle of about 90^{o}; distance between the apices of the middle and inner teeth nearly twice as great as the distance between the apices of the middle and outer teeth. Ventral mandibular tooth greatly enlarged; broad at base, strongly tapered apically, with a dense brush of short hairs curved outwardly, extending into and sweeping through the hypostomal concavity as the mandible closes. Postmedian transverse carina on tergum VI in dorsal view, usually crenulated along the apical margin and rounded or obtusely angulated medially, without a distinct median emargination. Tergum VII with a robust, postmedian tubercle.

COMMENT. Females belong to this subgenus can be recognized by the 4-dentate mandible with an enlarged oblique emargination in the outer cutting edge between the 3rd and 4th denticles defining an acutely angulate (10°) inner tooth; inner cutting edge strongly elevated to form the summit of the inner 4th tooth and extended outwardly to occupy most of the space defined by the emargination of the outer cutting edge between the 3rd and 4th denticle.

Males can be distinguished by the obtusely angulate or rounded apical rim of the postmedian transverse carina on tergum VI, combined with the white front basitarsus bearing a longitudinal excavation along the anteroventral side, and the 3-dentate mandible

BIOLOGY. The restricted biology and the diverse morphology of the large number of species in this subgenus, imposes an enigma. According to Mitchell (1937), "The majority of the species appear to be adapted to sandy and often more or less arid regions..." foraging upon a "...narrow range of flowers. ..." over a relatively short period of time. In Alberta, Hobbs and Lilly (1954) observed that "It (M. wheeleri) is confined to the mixed prairie and its flight period coincides with the blooming of Gumweed".

Thus, there is a tendency for the species of Xeromegachile to become specialized and limited to a constricted habitat; restricted to a narrower range of flowers, and confined to a shorter blossoming period. Yet, despite these limitations, there is proliferation of species, with the males, in particular, exhibiting a highly diverse morphology, ranging from the most plesiomorphic characters to highly elaborated apomormic structures. Although there are only two species of Xeromegachile in Canada, the males within the 43 species presented by Mitchell (1937) exhibit a progressive continuum in the development and elaboration of such structures as: mandibular dentation; front tarsi; hypostomal tubercle and concavity; mesosternal spur and front coxal spine.

Key to species of the Subgenus Xeromegachile

Females

Scopa mostly white, black on apical half of sternum V and VI. Abdominal terga with white apical fasciae...
....................................M. wheeleri (p. 244)

Scopa entirely black. Abdominal terga beyond the second without white apical fasciae.......M. subnigra (p. 252)

Males

Mesosternum with a robust crescent-shaped spur, just behind front coxa. Abdominal terga with white apical fasciae.....................M. wheeleri (p. 245)

Mesosternum without any spur behind front coxa. Abdominal terga without white apical fasciae..M. subnigra (p. 252)

MEGACHILE (XEROMEGACHILE) WHEELERI MITCHELL

Figures 13, 22, 64, 80; Map 17

Megachile vernonensis Cockerell, 1912:355 (new species).
Megachile wheeleri Mitchell, 1927:107 (new name)
Megachile (Xeromegachile) wheeleri; Mitchell, 1937:355 (description, distribution, flower visited); Hobbs and Lilly, 1954:461 (ecology).

Opposite p. 245

Fig. 22. M. wheeleri, M.
Face view.

Fig. 23. M. melanophaea,
F. Dorsal view, with the
white pubescence on the
two anterior terga,
contrasting with the
black on the following
terga.

FEMALE. In addition to the characters described for the females of Xeromegachile, the following apply more specifically to M. wheeleri: head, thorax and first two abdominalterga with predominantly white pubescence; vertex, mesoscutum and scutellum medially with brown to black pubescence. White, apical fasciae on terga II-V, usually dense and conspicuous, occasionally interrupted medially on the more anterior terga. Scopa white on sterna II-IV; on sternum V variable, from mostly white with a few black hairs apically to mostly black with a few white hairs basally; sternum VI with black or brown scopal hairs, terminating in a dense fringe of short setae along the apical rim. Scattered, suberect, black bristles on terga III-VI. Tergum VI weakly concave in lateral view; brown to silvery, short, subappressed hairs (more dense than the scattered, elongate, suberect, black hairs) becoming more dense and silvery apically to terminate in a dense silvery apical fringe. Lateral ocellus nearer to vertex than to eye. First flagellar segment a little longer than the subequal segments on each side.

MALE. See also characters described for males of Xeromegachile. The following characters are more restricted to this species: white, apical fasciae on terga II-V usually dense and conspicuous, occasionally interrupted medially on anterior terga. Terminal antennal segment flattened, but scarcely dilated, much longer than wide. Hypostomal concavity mostly glabrous and subpolished with a distinct, triangular tubercle on the anterior side, just behind the lower mandibular condyle, and a well developed overlapping hypostomal tubercle on the posterior side, with a dense brush of white pubescence at its apex; anterior side of hypostomal tubercle mostly glabrous and subpolished, posterior side with elongate white pubescence.

Robust, crescent-shaped spur on anterior side of mesosternum just behind front coxa; vertical side anterior to the spur, glabrous, punctate and subpolished; horizontal side posterior to the spur usually thinly pubescent, minutely punctate and polished. Sternum I with a prominent preapical keel-shaped protruberance medially. Outer (dorsal) side of hind tarsi mostly glabrous and subpolished; the segments somewhat dilated. Apical margin of tergum VI with a small lateral but prominent submedian carinate tooth. Apical margin of sternum V, which is usually concealed beneath sternum IV, with an acute median spine.

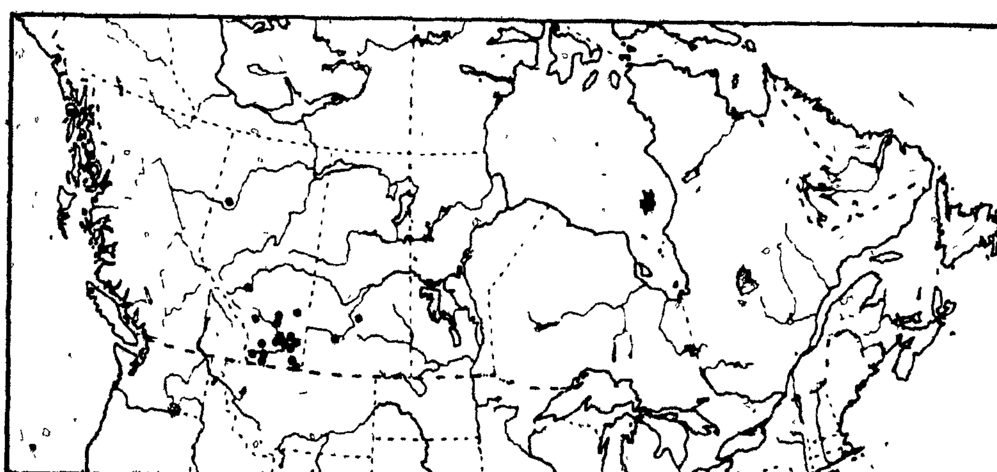
COMMENT. The female can be recognized by the 4-dentate mandible with the broad, deep and oblique emargination between the 3rd and 4th denticles. The emargination, which extends to very near the inner border of the mandible, forms an acute 4th tooth with an angle of about 10^{o} near its apex. A large and oblique emargination, between the 3rd and 4th denticles, is also present in M. addenda; however, M. addenda can be separated by the much thicker basal tooth which is rounded at the apex and the prominent overhanging gradular carinae on terga II-IV which are undeveloped in M. wheeleri. It can be separated from M. subnigra by the white scopa on sterna II-IV which is uniformly black in M. subnigra.

The male can be easily distinguished by the large robust spur on the anterior side of mesosternum, just behind front coxa; the rounded or obtusely angulate apical border of the postmedian transverse carina on tergum VI.

DISTRIBUTION. British Columbia south to California and east to Saskatchewan and Colorado.

In Canada they were found as follows (Map 17): Saskatchewan: Davidson, 21 Aug. 1907, 1 F. Rickethall, 4 Aug. 1955, 1 F. Swift Current, 20 Aug. 1916, 4 M; 23 Aug. 1916, 1 M, 1 F; 23 Aug. 1916, 1 M; 23 Aug. 1916, 2 M; 23 Aug. 1916, 2 F; 23 Aug. 1916, 1 M. Alberta: Brant, 5 Aug. 1921, 1 F; Brocker, 13 Aug. 1948, 1 M, 1 F; 17 Aug. 1950, 1 M, 1 F; 5 Aug. 1957, 3 M, 2 F; 5 Aug. 1957, 1 M, 1 F; 5 Aug. 1957, 2 M, 2 F; 5 Aug.

1957, 1 M, 1 F; 5 Aug. 1957, 2 M, 2 F; 5 Aug. 1957, 1 M, 1 F, sl. Brooks, 5 Aug. 1921, 1 M. Drummond, 8 Sept. 1954, 3 M, 2 F. Lake Newell, 3 Aug. 1974, 1 F. Lethbridge, 22 July 1916, 1 M; 22 July, 1916, 2 M; 10 July 1926, 1 M; 20 July 1929, 1 M; 20 Aug. 1930, 1 M; 15 Aug. 1939, 1 M; 21 Aug. 1939, 1 M; 8 Sept. 1939, 1 M; 13 Aug. 1940, 1 M, 1 F; 21 Aug. 1940, 4 M; 28 July 1942, 1 M, 4 F; 28 July 1941, 1 M, 1 F; 15 Aug. 1941, 3 M, 1 F; 10 Aug. 1948, 2 F; 12 Aug. 1948, 2 M, 3 F; 13 Aug. 1948, 3 M, 2 F; 14 Aug. 1948, 5 M; 17 Aug. 1948, 1 F; 19 Aug. 1948, 2 F; 2 Sept. 1948, 1 M, 1 F; 2 July 1950, 1 F; 17 Aug. 1950, 7 M, 5 F; 19 Aug. 1950, 4 M; 21 Aug. 1950, 1 M; 28 Aug. 1950, 1 M; 30 Aug. 1950, 1 M; 16 July 1951, 1 M; 7 Aug. 1951, 1 F; 9 Aug. 1951, 1 M, 3 F; 10 Aug. 1951, 1 M; 14 Aug. 1951, 1 M, 2 F; 14 Aug. 1951, 1 M, 1 F; 14 Aug. 1951, 1 M; 1 Sept. 1951, 1 M; 18 Aug. 1952, 1 M, 3 F. McGrath, 14 Sept. 1951, 5 M. Medicine Hat, 20 Aug. 1916, 1 M; 23 Aug. 1919, 7 M; 9 Aug. 1924, 1 F; 29 July 1929, 1 M; 7 July 1929, 1 M; 7 Aug. 1930, 2 M, sl; 23 July 1932, 1 F; 3 Aug. 1932, 1 M; 16 Aug. 1932, 1 M; 7 Aug. 1929, 1 M, 1 F. Orion, 22 Aug. 1930, 1 F; 24 Aug. 1931, 1 M. Oyen, 24 Aug. 1931, 1 M. Ralston, Aug. 1950, 1 M. Redcliffe, 1 Aug. 1917, 1 F. Rolling Hills, 11 Aug. 1958, 2 M, 2 F; 11 Aug. 1958, 5 M, 2 F, 1 sl; 11 Aug. 1958, 1 M, 1 F; 11 Aug. 1958, 1 M, 1 F; 11 Aug. 1958, 8 M, 2 F; 11 Aug. 1958, 5 M. Scandia, 8 Aug. 1946, 1 M; 16 Aug. 1948, 8 M; 26 July 1951, 1 F; 31 Aug. 1950, 5 M; 21 Aug. 1950, 1 M, 1 F; 17 Aug. 1951; 5 Sept. 1951, 1 M; 6 Sept. 1951, 4 M; 23 Aug. 1963, 2 M, 1 sl. Seven Persons, 1 Aug. 1952, 1 M; 1 Aug. 1952, 1 F; 20 Aug. 1952, 1 F; 27 July 1953, 1 M; 3 Aug. 1953, 1 F; 29 Aug. 1957, 1 M, 1 F; 29 Aug. 1957, 1 M, 1 F. Stavely, 7 Aug. 1949, 1 F. Vauxhall, 21 Aug. 1950, 2 M. Welling, 10 Sept. 1939, 1 M. Whitla, 4 Sept. 1922, 1 M; 5 Sept. 1922, 1 M. White Horse, 4 Aug. 1952, 1 M.



Map 17. Canadian distribution of Megachile wheeleri.

FLOWERS VISITED. Chrysopsis (Golden Aster), (M): Chrysothamnus (Rabbitbrush), (M): Grindelia perennis, (M); G. squarrosa (Gumweed), (L); Medicago sativa (Alfalfa), (M, L): Solidago (Goldenrod), (L).

BIOLOGY. See also biology for Xeromegachile.

In the mixed prairie regions in Alberta, Hobbs and Lilly (1954) found M. wheeleri to be the most abundant species of Leaf-cutter bees. Females have been observed to cut sections of rose leaves for cell construction at Scandia and Seven Persons, Alberta. Nesting sites of M. wheeleri have not been discovered, however the flattened and disc-shaped mandible with the outer denticle reflexed and expanded precludes this species from being able to chisel holes in wood. The worn down apices of the mandibles suggest that nesting burrows are dug in the soil. In North Carolina, Sivik (1954) observed M. rubi (a species belonging to Xeromegachile) excavate nests in sandy loam soil.

Burrows of M. wheeleri ~~entered the~~ soil at an angle of 45° for about 4 cm., then curved and extended horizontally for about 9 cm. Two or three cells were constructed, provisioned and sealed in each burrow. The cup was constructed of 8-10 sections of Birch leaves while the cap was made with 4-5 circular sections. The larva developed in about 11 days, without consuming all the provisions of pollen and nectar, and spun its cocoon in a day.

ALFALFA POLLINATING POTENTIAL. Sladen (1918), Apiarist, Dominion Experimental Farm, listed M. manifesta as occurring in alfalfa fields tripping alfalfa. Since no specimens of M. manifesta have been observed from Alberta, and since the females of M. manifesta morphologically resemble M. wheeleri, to the extent that they are scarcely distinguishable, it is proposed that the specimens in question belonged to M. wheeleri. Hobbs and Lilly (1954) also report that they did not find any specimens of M. manifesta in Alberta. A single male of M. manifesta present in the Canadian National Collection was collected at Roundup, Montana by H. L. Seamans on September 3, 1924.

Hobbs and Lilly (1954) note that even if M. wheeleri "...could be induced to gather pollen from alfalfa its flight period is so late that its services would be of little use." Collection records indicate that the earliest record of emergence of 3 females was on July 1, 1929, at Kamloops, B.C. Most of the collections of adults, however, were made during August with some taken during September. Thus, the alfalfa pollinating potential of M. wheeleri appears to be deterred by its late adult flight period, probable soil nesting habit, requirement for a secondary plant for cell construction, and its questionable preference for foraging on alfalfa.

MEGACHILE (XEROMEGACHILE) SUBNIGRA CRESSON

Map 18

Megachile subnigra Cresson, 1879:208 (new species)

Megachile (Xeromegachile) subnigra; Mitchell, 1938:364 (description and distribution)

FEMALE. See also characters described for females in Xeromegachile. The following apply more specifically to M. subnigra. Vertex, mesoscutum and scutellum mostly white, pubescent. Mesopleurum black,pubescent, ventrally, white dorsally. First and second terga white,pubescent, with some black pubescence on tergum II laterally. Terga beyond the second, uniformly black, without white apical fasciae. Scopa entirely black. Lateral ocellus subequally distant from eye and edge of vertex.

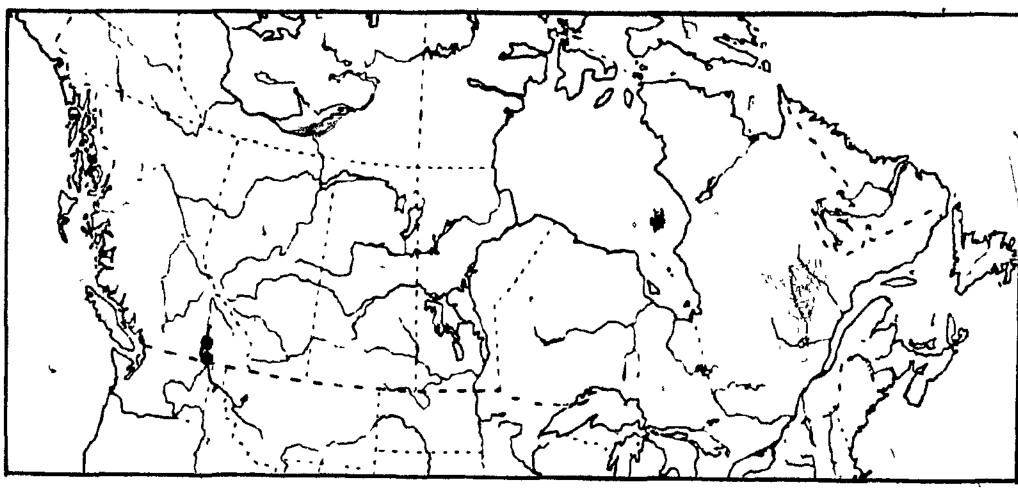
MALE. See also description of males in Xeromegachile. Terga beyond the second uniformly black without white, apical fasciae. Pubescence on middle and hind legs infuscated or brown, conspicuously darker than pubescence on tergum I. Terminal antennal segment flattened and rounded, nearly as long as wide. Ventral mandibular tooth well developed, with a preapical brush of hairs. Hypostomal concavity shallowly excavated, with reduced and inconspicuous pubescence. Hypostomal tubercle weakly elevated and blunt apically, with an elongate tuft of pubescence arising from its apex. Anterior side of mesosternum without a spur, just behind front coxa.

Apical margin of sternum IV sometimes emarginate medially. Apical margin of sternum V, which is usually concealed beneath sternum IV, with a dense and pointed cluster of setae medially.

COMMENT. The female can be recognized by the 4-dentate mandible with a large, oblique emargination between the 3rd and 4th denticles; the emargination extends to very near the inner margin of mandible and forms an acute 4th tooth at an angle of about 10° near the apex (Fig.64). Combined with this, the scopa is entirely black and the white apical fasciae on terga III-V are absent.

The male can be distinguished by the circular or obtusely angulate apical margin of the postmedian transverse carina on tergum VI, coupled with the absence of a spur on the anterior part of the mesosternum, just behind the front coxa and the brown pubescence on the middle and hind legs, which is much darker than the pubescence on tergum I.

DISTRIBUTION. British Columbia south to California and east to Colorado. In Canada it has been collected as follows (Map 18): British Columbia: Osoyoos, 22 June 1953, 1 M; Penticton, 7 June 1919, 2 M.



Map 18. Canadian distribution of Megachile subnigra.

ALFALFA POLLINATING POTENTIAL. Unlike M. wheeleri (the only other species in the subgenus Xeromegachile which occurs in Canada) the three males of M. subnigra which were collected on June 7 and June 22 indicate that this species has a much earlier adult flight period than M. wheeleri which has an unusually late flight period. Factors which restrict its distribution, population density and pollinating preferences are currently unknown.

Subgenus DEROTROPIS Mitchell

Figures 26, 27, 65.

Derotropis Mitchell, 1936:156 (new subgenus)

Of the two species of Derotropis which occur in Canada only the females are known. It is probable that with further collections in the areas in which females have been found, the associated males will be discovered. The unknown males will probably resemble the males in Xeromegachile, with the apical border of the postmedian transverse carina on tergum VI rounded or obtusely angulate medially (not emarginate). They will readily be differentiated from the most common M. (Xeromegachile) wheeleri by the absence of a robust spur on the anterior side of the mesonotum, just behind the front coxa.

FEMALES. Length 10-13 mm. White pubescence on head, thorax and first two abdominal segments. Terga III-V with white apical fasciae. Short, sparse pilosity on tergum VI similar to the pilosity on terga III-V. Scopa white on sterna II-IV; black on sterna V and VI. Mandible 3-dentate with a greatly elongated emargination between the 2nd and 3rd denticles; distance between the apices of the 2nd and 3rd denticles three times as great as the distance between the 1st and 2nd denticles; inner cutting edge, between the 2nd and 3rd denticles a little more highly elevated basally than the outer cutting edge; inner and outer cutting edges forming a lanceolate concavity tapering toward the 2nd tooth (Fig. 65). Apical third of clypeus truncate, with an arcuate groove along the ventral rim. First flagellar segment longer than either one of the flanking segments.

MALES. Unknown for both species occurring in Canada.

COMMENT. Females belonging to this subgenus can be easily distinguished by the 3-dentate mandible in which the apex of the middle tooth is about three times as far away from the inner tooth as it is from the outer tooth (Figs. 27, 65).

BIOLOGY. The reflexed and expanded outer tooth and the worn down denticles which are present in older females suggest that these species excavate nesting burrows in the ground.

Key to Species of the Subgenus *Derotropis*

Tegula dark brown. Mesoscutum uniformly punctate.........
...................................*M. anograe* (p. 257)

Tegula ferruginous. Mesoscutum more sparsely punctate medially than laterally...........*M. subanograe* (p. 259)

Opposite p.257

Fig. 26. M. anograe, F.
Face view.

Fig. 27. M. anograe, F.
Three dentate mandible
with a large lanceolate
emargination between
2nd and 3rd denticles.

MEGACHILE (DEROTROPIS) ANOGRAE COCKERELL

Figures 26, 27, 65; Map 19

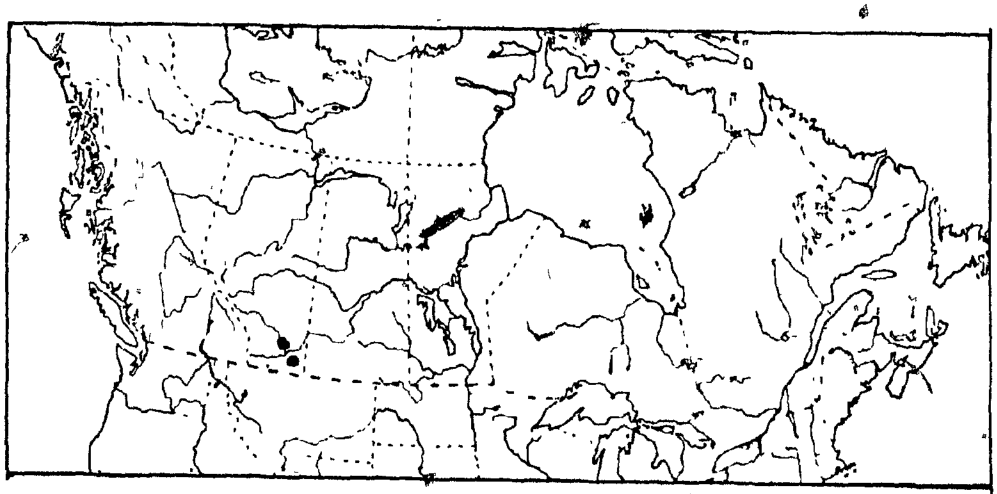
Megachile anograe Cockerell, 1908:261 (new species).
Megachile (Derotropis) anograe; Mitchell, 1936:158 (description and distribution); Hobbs and Lilly, 1954: 461 (ecology).

FEMALE. Tegula, scopa, mandible and legs, chocolate brown. Punctures on tegula deep and distinct, separated by a distance subequal to their diameter. Mesoscutum uniformly punctate, the punctures separated by a distance less than diameter of puncture.

COMMENT. M. anograe can be recognized easily by the 3-dentate mandible with the elongated emargination between the 2nd and 3rd denticles, in which the inner and outer cutting edges form a prominent carinate ridge, bordering a large lanceolate concavity (Fig. 65), combined with the chocolate brown tegula and the uniformly punctate mesoscutum.

DISTRIBUTION. Alberta southeast to Colorado. In Alberta, a female was collected at Scandia, 14 July 1952 on Epilobium and another at Seven Persons, 8 July 1952.

FLOWERS VISITED. Astragulus (Milk-Vetch), (M); Cleome serrulata (Spider Flower), (M); Epilobium (Fireweed), (L, M); Opuntia (Prickly Pear), (M).



Map 19. Canadian distribution of *Megachile anograe*.

BIOLOGY. Mitchell (1973) observed *M. anograe* build jug-shaped cells of whole petals of *Oenothera* in burrows excavated in the sandy soil. Pollen was collected from *Opuntia*, and a species related to *Coelioxys piercei*, which was in flight nearby, was suspected of being parasitic on *M. anograe*.

ALFALFA POLLINATING POTENTIAL. *M. anograe* is rarely collected; Hobbs and Lilly (1954) report that there is no record of it having been observed on alfalfa. The adult flight period indicates that it might be of some benefit as an alfalfa pollinator, however, its scarcity and its probable soil nesting habit limits its usefulness as a pollinator of alfalfa.

MEGACHILE (DEROTROPIS) SUBANOGRAE MITCHELL

Figures cf. 26, 27, 65; Map 20

Megachile (Megachiloides) subanograe Mitchell, 1934:344 (new species).

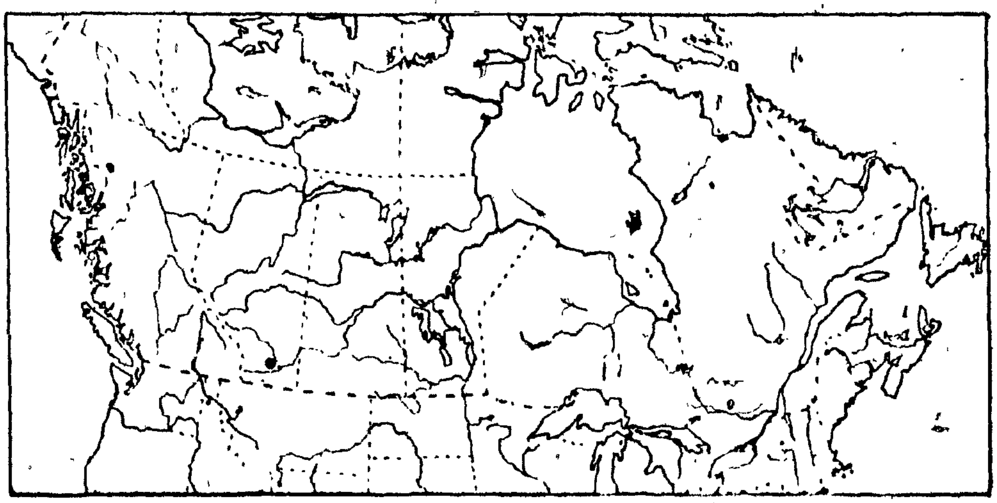
Megachile (Derotropis) subanograe; Mitchell, 1934:163 (comment).

FEMALE. Tegula, antenna along with the scape, mandible and legs ferruginous. Punctures on tegula shallow and indistinct, separated by a distance greater than the diameter of puncture. Mesoscutum more densely punctate peripherally, with punctures separated by less than their diameter; more sparsely punctate medially with some punctures separated by a distance greater than the diameter of puncture.

COMMENT. M. subanograe can be recognized by the 3-dentate mandible (Fig. cf. 65), the ferruginous tegula and the sparsely punctured mesoscutum medially.

DISTRIBUTION. Alberta southeast to Wyoming. In Canada, it has been collected at Hays, Alberta, 15 June 1954, 1F, on Cirasium villosa (Map 20).

ALFALFA POLLINATING POTENTIAL. Similar to M. anograe, this species also probably burrows nesting sites in the soil; may have a preference for Compositae and is extremely rare.



Map 20. Canadian distribution of Megachile subanograe.

Subgenus XANTHOSARUS Robertson

Figures 28, 29, 30, 48, 50, 67, 82

Xanthosarus Robertson, 1903:172 (description)

Xanthosarus; Mitchell, 1936:120 (description and biology)

FEMALES. Length 12-16 mm. Mandible 5-dentate; outer tooth reflexed along the ventral side and expanded. Outer cutting edge, defining the 4th tooth, parallel-sided for most of its length (Fig. 67). Emargination in the outer cutting edge between 3rd and 4th denticles strongly oblique and deeper than wide, with the distance between the apex of the 3rd tooth and the base of emargination 1.3 times as great as the distance between the apices of the 3rd and 4th denticles; apex of 4th tooth equidistant between the apex of the 3rd tooth and the base of the deep emargination between them. Bevelled cutting edge on 3rd tooth projecting toward 2nd tooth, reduced, occupying less than half the emargination between the two denticles. Gradular carinae on terga II-V developed and narrowly overhanging the gradular groove along the base; gradular groove deep, anteriorly, gradually inclined posteriorly and extending over three-quarters of the tergal disc. Tergum VI nearly straight in lateral vein; erect, elongate, golden hairs, scattered medially, becoming more dense laterally; short appressed hairs intermixed with the elongate hairs, partially obscuring the integument beneath and terminating in a dense apical fringe.

MALES. Length 12-14 mm. Front legs dilated, mostly yellowish or testaceous, strikingly contrasting with the black integument on the rest of body and appendages. Front basitarsus wider at base than apex; broad, polished, longitudinal excavation extending throughout its antero-ventral side; excavation bordered on each side with a row of bristles; bristles along the anterior side becoming progressively shorter apically and not extending beyond half the length of the basitarsus. Anterior side of front femur translucent, with a narrow, infuscated or brown border. Front coxal spines well developed, anterior side reddish brown, mostly glabrous, without a patch of stout bristles just above the coxal spine. Mesosternum bearing a broad subpolished field with minute sparsely scattered hairs which are usually shorter than the distance between punctures; slender, pointed spine on posterior border of the field, just in front of mid coxa; present in _M. dentitarsus_ and absent in _M. latimanus_ and _M. perihirta_. Mid-femur greatly enlarged, much thicker than hind femur. Middle tibia without apical spurs;basitarsus with a robust, polished and glabrous protruberance on the ventral side; the shape and size of the protruberance are distinctive for each of the three species and can be used to differentiate them. Mandible 3-dentate, mostly black with the posterior side yellowish; inner side deeply excavated and shaped for the reception of the apex of the alternate mandible when closed. Ventral mandibular tooth parallel-sided preapically, with a dense brush of hairs on the oblique apical side, directed outwardly. Hypostomal tubercle strongly elevated, bordering a large, glabrous and polished hypostomal concavity, which accommodates the sweep of the brush at the apex of the ventral tooth, as the mandibles close. Glabrous, subpolished, diagonal band extending from just above the lateral opening of the hypostomal concavity (adjacent to the ventral mandibular condyle) to the posterior border of cheek; upper side of the glabrous band conspicuously bordered by a row of short, white, pubescence and the ventral side bordered by a field of white pubescence extending to and covering the posterior side of the hypostomal tubercle. Vertex, mesoscutum medially, and abdomen uniformly clothed in yellowish-white pubescence. Postmedian transverse carina on tergum VI semicircular in dorsal view with a small median notch along the apical border.

COMMENT. This is a homogeneous subgenus represented by three species in Canada. Morphologically, the females belonging to the three species do not reveal any consistent, perceptible characters by which they can be positively differentiated. Males, on the other hand, bear distinctive structural characters by which the species can be separated, hence the female species can also be determined by associating them with their males. Females of M. latimanus can usually be separated from M. dentitarsus and M. perihirta by the geographic region which they inhabit. Generally, M. latimanus occurs east of the 100th meridian, while the other two species inhabit western regions. There is, however, considerable overlap with M. perihirta occurring as far east as Ontario and M. latimanus occasionally found as far west as Alberta. M. dentitarsus is more limited to western Canada, rarely extending east of Alberta. Females belonging to Xanthosarus, have the 5-dentate mandible flattened, the outer tooth reflexed and expanded and the cutting side elongated and rotated perpendicular to the mandibular condyles. In the flattening process, the inner and outer cutting edges (best seen with the mandible opened) are brought closer together with the result that the inner cutting edge fuses with the third denticle and becomes obliterated in its outward extension to the base of the 2nd denticle. The reflexed, outer tooth is aligned with the four preceding denticles to form a nearly straight line; the tooth is expanded and elongated, resulting in an increase in the length of the cutting side (distance between the apices of the inner and outer teeth). Finally, the rotation of the cutting side from a parallel, scoop-like position (e.g. M. montivaga) to a blade-like position perpendicular to the mandibular condyles, approaches a scissor-like mandibular operation, with the condyles serving as the pivot and the cutting side of the mandible as the blade.

Females belonging to Xanthosarus can be recognized by the deep oblique emargination (which is deeper than wide) between the 3rd and 4th denticles and the parallel-sided 4th mandibular tooth, which is longer than wide at base. The obliqueness of the emargination (mostly occupied by the inner cutting edge) and the angulation of the parallel-sided 4th tooth, define the cutting path of the two mandibles as they slide past each other when they close.

BIOLOGY. The flattened mandible with the reflexed and broadly expanded outer denticles precludes females in this subgenus from being able to chisel nesting tunnels in wood. Older females usually bear a shortened mandible with the denticles (particularly the outer tooth) strongly abraded from biting, grinding and excavating nesting burrows in the soil. Abraded mandibles with rounded apices would evidently be incapable of piercing and chiselling holes in wood. Thus, females which excavate nesting burrows in the soil could not alternately chisel holes in wood. Hence, three distinctive groups become apparent; those that nest in the ground (to which Xanthosarus belongs); those that chisel holes in wood, and those that seek out and nest in ready-made holes, sometimes cleaning out or enlarging small holes, or filling enlarged holes with extra sections of leaf.

Key to species of the Subgenus Xanthosarus

Females

1. White, apical fasciae on terga II–V dense and white, usually not interrupted medially on the anterior terga. Mesoscutum, terga I and II with copious, elongate, white pubescence. Present only in Alberta.......................M. dentitarsus (p. 290)

   White, apical fasciae on terga II–V less dense and wide, usually interrupted medially on the anterior terga. Pubescence on mesoscutum and terga I and II more yellowish, often partially or entirely black on mesoscutum medially and tergum II. Present across Canada..2

2. Black pubescence usually occupying the posterior half of mesoscutum and often extending on to the scutellum. Usually occurring west of the 100th Meridian, but occasionally present as far east as Ontario.......... ....*M. perihirta* (p. 279)

Black pubescence on mesoscutum absent or usually occupying less than the apical half of mesoscutum, rarely extending on to the scutellum. Usually occurring east of the 100th Meridian, but occasionally present as far west as Alberta.............*M. latimanus* (p. 268)

Males

1. Posterior side of mesosternum with a sharp spur, just in front of mid-coxa................*M. dentitarsus* (p. 290)

Mesosternum without a spur.............................2

2. Ventral side of mid-basitarsus with a broad, glabrous and polished protruberance which is about half as wide as long.............................*M. latimanus* (p. 268)

Ventral side of mid-basitarsus with a narrow, keel-shaped, glabrous and polished protruberance which is less than .25 as wide as long...........*M. perihirta* (p. 286)

Opposite p. 268

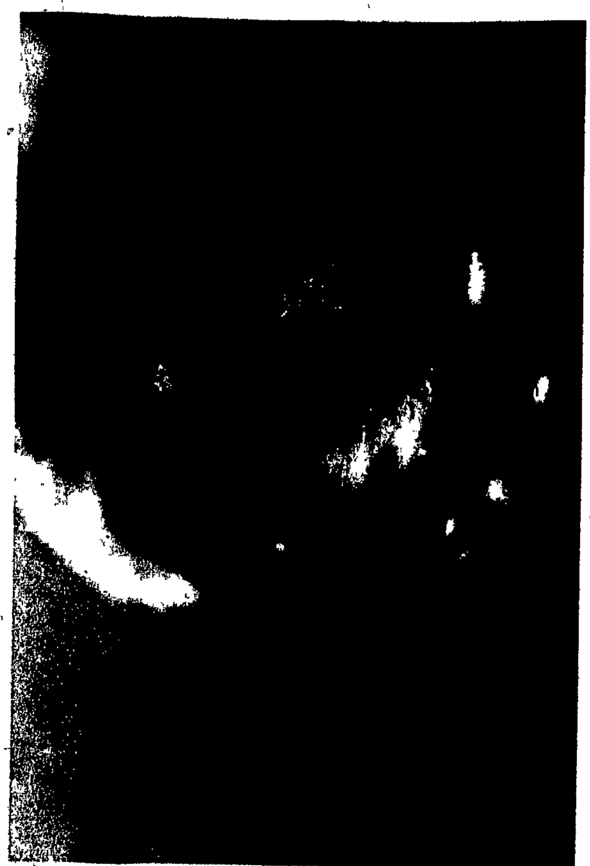


Fig. 30. M. latimanus, M. Face view.

Face 31. M. fortis, F. Mandible with the outer tooth reflexed and rounded, indicating that it probably excavates nesting burrows in the soil.

MEGACHILE (XANTHOSARUS) LATIMANUS SAY

Figures 30, 48, 50; cf. 67; 82; Map 21

Megachile latimanus Say, 1823:81 (new species)

Megachile (Xanthosarus) latimanus; Pengelly, 1955:199; Mitchell, 1962:157.

FEMALE. In addition to the characters described for females in the subgenus Xanthosarus, to which M. latimanus belongs, the following characters are usually distinctive in this species: Clypeus usually uniformly punctate throughout, without a median, longitudinal, impunctate and polished band. Pubescence on vertex and mesonotum medially, ranging from entirely yellowish-white to black; the black pubescence, when present, rarely extending into scutellum. Pubescence on body yellowish-white. Apical fasciae on terga II-V moderately narrow and usually interrupted medially on anterior terga. Lateral ocellus a little closer to vertex than to eye.

MALE. Large, glabrous and polished protruberance on ventral side of mid basitarsus, broad and rectangular, about half as wide as long. Posterior side of the broad and subpolished mesosternum without a sharp spine just in front of the mid-coxa. See "MALES" under Xanthosarus for a more detailed description.

COMMENT. The female can be recognized by the 5-dentate mandible with the parallel sided 4th mandibular tooth and the deep oblique emargination between the 3rd and 4th denticles which is deeper than wide (Fig. 67); the predominantly yellowish-white pubescence on head, thorax, terga I and II; the uniformly punctate clypeus which is usually without polished and impunctate median longitudinal band; and their distribution which is primarily restricted to Eastern Canada, but occasionally extends as far west as Alberta.

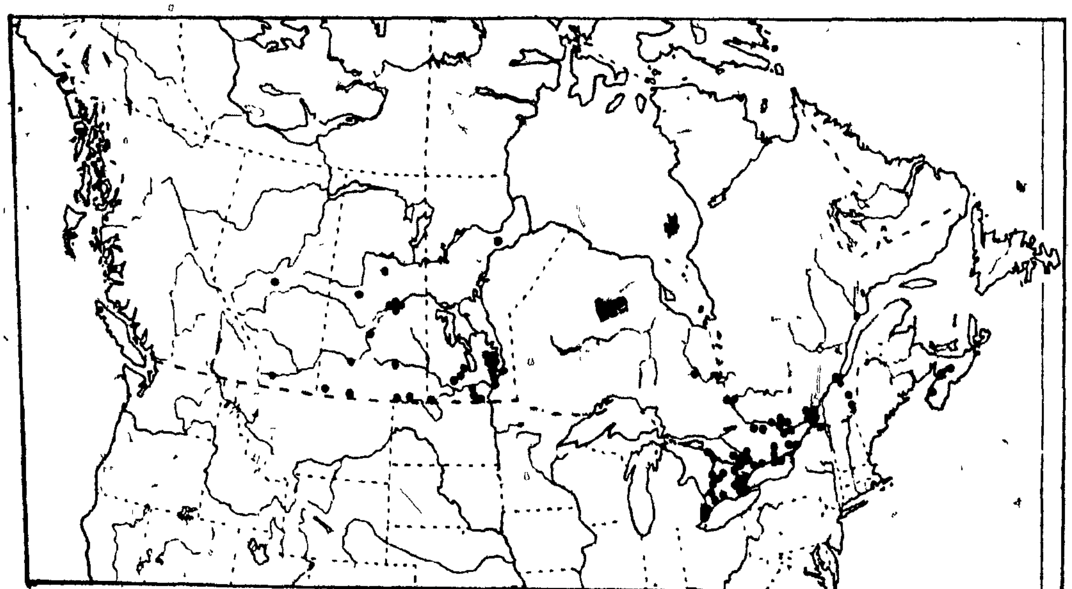
The male can be recognized easily by the large, polished, rectangular protruberance on the ventral side of mid-basitarsus, which is about half as broad as long. The sharp spur in the posterior side of mesosternum, just in front of mid-coxa is absent.

DISTRIBUTION. Occurs as far west as Alberta, south to Kansas and Georgia, and east to Nova Scotia. Localities from which M. latimanus was collected in Canada are as follows (Map 21): Nova Scotia: Annapolis County, 1 Aug. 1931, 1F, Lathyrus. Blomidon, 31 July 1952, 1F, 1M. King's County, 29 Aug. 1920, 1 M; 16 July 1929, 1M; 10 July 1930, 1 F, Convolvulus; 15 July 1930; 16 July 1930; 18 July 1930, 1F, 1M, Trilolium; 18 July 1930, 1F, Rosa; 23 July 1930, 1 M; 25 July 1930, 2F, 1M, Centaurea; 25 July 1930, 1F, Epilobium; 29 July 1930, 4 M;

31 July 1930, 1F, Solidago; 25 July 1930, 1F, Epilobium; 8 July 1931, 2F, Raphanus; 8 July 1931, 1M, Trifolium; 9 July 1931, Milkweed; 13 July 1931, 1F, Trifolium; 13 July 1931, 1F, Rosa; 15 July 1931, 1F, Centaurea; 16 July 1931, 1F; 18 July 1931, 1F, Trifolium; 18 July 1931, 1F; 20 July 1931, 1M; 30 July 1931, 3M; 11 Aug. 1931, 1F, Achillea; 21 Aug. 1931, 1M, Solidago; 23 Aug. 1931, 1F, Solidago; 11 Sept. 1931, 1M; 1 Aug. 1932, 1F, 1M, Solidago. Lun County, 3 July 1931, 1M. Smiths County, 15 July 1914, 2F, 1M; 15 July 1914, 1M. Truro, 2 Sept. 1923, 1F. New Brunswick: Fredericton, 7 Aug. 1914, 1F. Shediac, 4 Sept. 1926, 1F. Prince Edward Island: Dalvay House, Canadian National Park, 19 Aug. 1940. Quebec: Abbotsford, 6 July 1933, 1M; 1 Sept. 1933, 1F. Aylmer, 21 Sept. 1923, 1F. Covey Hill, July 1921, 2F. Cort Coulonge, 20 Aug. 1917, 1F. Hemmingford, 27 June 1923, 1F. Hull, 25 Aug. 1884, 1M; 16 Aug. 1894, 1F. Ile de Montreal, 5 Aug. 1906, 1F. Lachine, 18 Aug. 1966. Lanoraie, 11 June 1915, 1F; 13 July 1930. Lowe, 2 Aug. 1948, 1F, 1M., Burdock. Montreal, 10 Aug. 1924, 1F. Quebec City, 10 Aug. 1914, 1F. Rupert House, 8 Aug. 1949, 1F. St.Anne de la Pocatiere, 7 July 1914, 1F; 8 Aug. 1914, 1F. St. Anne's, 30 June 1921; 13 Sept. 1939; 14 July 1941. Ste. Foy, 8 Aug. 1971, 1M; 9 Aug. 1971, 1M. St.Hilaire, 15 Aug. 1926; 16 Aug. 1931, 1F, 2M; 16 Aug. 1971. St.Isidore, July 1936, 1F. St.Martin, 11 Sept. 1926. Ste.Anne de Bellevue, 29 July 1929, 1F; 12 Aug. 1962, 1M; 7 Aug. 1964, 1F; 18 June

1965; 22 June 1965; 11 July 1965, 1F, 1M; 30 July 1965; 4 Aug. 1965; 15 Aug. 1965, 1F; 17 Aug. 1965, 2F, 1M; 3 Sept. 1965, 3F, 4M; 14 Aug. 1966; 10 July 1967, 1F. Shawbridge, 7 July 1926; 19 July 1927, 1F. Terrebonne, 29 July 1931, 1F. Wakefield, 1 Sept. 1950, 1F. Ontario: Acton, 3 Aug. 1951, 9F, Elecampane; 18 Aug. 1951, 1M, Elecampane; 8 July 1955, 1F. Ancaster, 18 June 1955, 1M; 26 July 1955, 1F. Angus, 8 Aug. 1965, 1M. Arkell, 18 July 1951, 1F, Alfalfa; 20 July 1951, 1F, 1M, Scotch Thistle; 24 July 1951, 1F, Scotch Thistle; 26 July 1951, 1F, Blueweed; Aug. 1964; 20 June 1958, 1F. Atwood, 21 July 1952, 1F, Sow Thistle. Bell's Corners, 28 July 1939, 1M. Belwood, 6 July 1965, 1F. Brighton, 24 July 1956, 2F. Byron, 2 July 1956, 1F. Cameron, 27 July 1962, 1F. Carp, 7 Aug. 1953, 1F. Cayuga, 22 Aug. 1951, 1F, Red Clover; 6 Aug. 1952, 1F, Sow Thistle. Camp Borden, 22 July 1952, 1F, Alfalfa; 22 July 1952, 1M, Sweet Clover. Chatham, 24 Aug. 1913, 2F, 1sl. Cochrane, 8 Aug. 1917, 2F; 8 Aug. 1917, 1F. Coldwater, 10 July 1958, 1M. Dunedin, 21 July 1952, 1F, Elacampane; 22 July 1952, 1F, Elacampane. Dyer's Bay, 4 Sept. 1951, 1F, Alfalfa; 8 July 1952, 1F, Sweet Clover; 29 July 1952, 1F, Red Clover; 8 July 1953, 1F; 3 July 1954, 1M. Eastern Ontario, no date, 1F. Elmira, 7 July 1959, 2F, 1M; 20 Sept. 1970, 1F. Goderich, 28 June 1955, 1M. Golden Lake, 10 Sept. 1965, 1F. Grimsby, 22 July 1894, 1F. Guelph, July 1922, 1F; 10 July 1951, 1F, Alfalfa; 26 July 1951, 1F; 30 July 1951, 2F, Sunflower; 31 July 1951, 1M, Sunflower; 6 Aug. 1951, 1F, Wild Lettuce; 6 Aug. 1951, Blueweed; 13 Aug. 1951, 1F, 1M, Sunflower; 18 Aug. 1951, 1F, Sunflower; 13 June 1959, 1F; 23 Aug. 1961, 1F; 11 Aug. 1962, 1F, 1M; Aug. 1964, 1M; 12 July 1965, 1M; 25 July 1974, 1M. Hastings, 31 July. Hepworth, 15 July 1974, 1M; 16 July 1974, 1F, 1M; 26 June 1975, 1M. Hillcrest, 28 Aug. 1954, 1F, Scotch Thistle; 28 Aug. 1954, _Echium vulgare_. Horning, 12 July 1952, 1F. Kendal, 29 July 1951, 1M; 29 July 1961, 2F; 29 Aug. 1963, 1F, 1M. Kinburn, 18 July 1957, 1M. Kitchener, 19 Aug. 1959, Golden Rod, 1F. Kleinburg, 23 July 1952, 1F, 2M, Elacampane. Koney, 30 June 1975, 1M. Leaside, 4 Aug. 1961, 1F. London, 19 July 1967, 1M. Marmora, 6 July 1939, 1s1; 6 July 1939, 4F; 10 July 1939, 2F, 1M; 11 Sept. 1952, 2F, Viper's Bugloss. Midland, 14 July 1974, 1F. Minesing, 11 July 1954, 1F; 17 Aug. 1954, 1F. Muskoka, no date, 1F. Orangeville, 19 Aug. 1954, 1F, 1M. Orillia, 25 June 1924, 1F. Ottawa, 27 July 1911, 1M; 22 July 1913, 1F; 23 July 1913; 25 July 1913, 1F; 11 Aug. 1913, 2F; 11 Aug. 1913, 1F; 11 Aug. 1913, 1F; 12 Aug. 1913, 1F; 15 Aug. 1913, 1F; 15 Aug. 1913; 9 July 1914, 1F; 13 Aug. 1914, 1F; 13 July 1946, 5F, Alfalfa; 18 July 1946, 3F, Alfalfa; 16 July 1952, 1M; 16 July 1952, 1F; 1 Aug. 1957, 1M; 22 July 1963, 1M; 23 July 1963, 1F; 2 July 1968, 1M; 9 July 1968, 1M; 9 July 1968, 1F; 10 July 1968, 1F; 1 July 1970, 2M; 6 July 1970, 1F, 1F, 1M. Paris, 29 June 1955, 1F, 1M. Point Pelee, 9 Sept. 1954, 1F. Porte Hope, 28 July 1895, 1F; 30 Aug. 1963, 1F. Primrose, 22 July 1952, 3F, Chicory; 22 July 1952, 2F, Burdock; 17 July 1956, 1M. Puslinch, 8 Aug. 1951, 2F, Alfalfa; 8 Aug. 1951, 1F, Blueweed; 8 Aug. 1951, 2M, Knapp Weed; 11 July 1952, 2F, Scotch Thistle. Rockwood, 1 Aug. 1951, 1F, Scotch Thistle; 3 Aug. 1951, 1F, Canadian Thistle; 10 Aug. 1951, 1F, Alfalfa. Seaforth, 12 Aug. 1955, 1F. Southampton, 9 Aug. 1945, 1F. Speyside, 6 Sept. 1965, 2F; 30 July 1965, 1F; 20 Aug. 1965, 1M. Spencerville, 12 July 1939, 1F; 31 Aug. 1939, 1F. St.John's West, 1 Sept. 1954, 3F, Scotch Thistle. St.Thomas, 27 July 1924, 1F. Strathroy, 2 July 1925, 1F. Stittsville, 12 July 1939, 1M. Thornloe, 8 Aug. 1917, 1F. Toronto, 28 July 1888, 1F; 2 Sept. 1888, 1M; 11 July 1897, 1F; 9 Aug. 1957, 1M; 30 Aug. 1963, 1F; no date, 1F. Trenton, 3 Sept. 1905, 1F. Tweed, 17 July 1944, 1M. Vineland, 28 Aug. 1930, 1F. Vineland Station, 25 Aug. 1936, 1F; 7 Sept. 1936, 1F. Wellington, 28 Aug. 1954, 11F, Cichorium intybus; 28 Aug. 1954, 3F, 1M, Goldenrod; 28 Aug. 1954, 5F, 2M, Viper's Bugloss; 28 Aug. 1954, 1F, Scotch Thistle; 28 Aug. 1954, 1F, 1M. White Lake, 22 Aug. 1970, 1F. Manitoba: Altona, 19 Aug. 1953, 1F, Sunflower. Aweme, 14 July, 1M; 20 Aug. 1914, 1M; July 1920, 1M; 25 July 1922, 1M; 25 July 1924, 1M; 17 July 1924, 1F; 1 Aug. 1925, 2M; 6 Aug. 1925, 1F; 14 Aug. 1925, 1F; 25 Aug. 1925, 2F; 27 Aug. 1925, 1M; 3 Sept. 1925, 1F; 11 July 1926, 1M; 31 July 1925, 1F.

Balmoral, 26 Aug. 1924, 1F. Brandon, 4 April 1948, 1sl; 4 April 1948, 1M; 20 Aug. 1948, 1F; 18 Aug. 1964, 4F, 3M, Sunflower. Carberry, 30 July 1953, 1F. Carman, 10 Sept. 1954, 1F, Sunflower. Cherhill, 5 Aug. 1952, 1F. Fisher Branch, 22 July 1955, 1M; 19 July 1956, 1F. Gull Lake, 9 Aug. 1965, 2M. Lyleton, 9 Aug. 1939, 2F, Clover. Meleb, 13 July 1948, 2F. Morden, 2 Sept. 1954, 1F; 11 Sept. 1954, 1F, Sunflower. Oberon, 16 Aug. 1954, 4F, Sunflower; 24 Aug. 1954, 2F, Sunflower. Onah, 12 Aug. 1926, 1F. Pikwitone, 4 Aug. 1949, 2M. Riverton, 13 July 1948, 1M. Roblin, 8 July 1931, 1M. Stead, 7 Aug. 1965, 2M. Stony Mountain, 9 Aug. 1910, 1F. Teulon, 1 June 1923, 1M. Treesbank, 11 Aug. 1924, 1F. Winnipeg, 8 Aug. 1935, 4F, 1sl; 11 Aug. 1960, 1F. Saskatchewan: Atton's Lake, 11 July 1940, 1F. Estevan, 16 Aug. 1955, 1F. Love, 27 July 1944, 2F, Alfalfa; 29 July 1944, 1F, Alfalfa; 3 Aug. 1944, 2F, Alfalfa; 2 Aug. 1948, 1F, Burdock. Nipawin, 20 July 1944, 2F, Alfalfa; 1 Aug. 1944, 1F, Alfalfa. Regina, 15 Aug. 1905, 1F. Robsart, 17 July 1939, 1F, Sweet Clover. Rutland, 26 July 1940, 1F. Saskatoon, 20 Aug. 1942, 1M. Smeaton, 2 Aug. 1944, 1F, Alfalfa. Snowden, 28 July 1944, 1F, Alfalfa. Swift Current, 20 Aug. 1916, 4F; 29 Aug. 1916, 1F. Torquay, 14 Aug. 1955, 5M. Val Marie, 10 Aug. 1955, 1F. White Fox, 21 July 1944, 5F, Alfalfa. Alberta: Lacombe, 27 July 1959, 1F, Alfalfa. Lamont, 2 Aug. 1972, 5F, 1M.



Map 21. Canadian distribution of Megachile latimanus.

FLOWERS VISITED. Abutilon (Indian Mallow), (M); Achillea (Yarrow), (L); Agastache (Giant Hyssop), (M); Althaea (Marsh-mallow, Hollyhock), (M); Amorpha (Leadplant), (M); Arabis (Rock-Cress), (M); Arctium (Burdock), (L); Asclepias (Milk-weed), (L, M); Aster (Aster), (M); Baptisia (False Indigo, etc.), (M); Bidens (Bur-Marigold), (M); Blephilia (Wood-Mint), (M); Boltonia, (M); Campanula (Bellflower), (M); Carduus (Plumeless Thistle), (M); Cassia (Senna), (M); Centaurea (Star-Thistle), (L); Cephalanthus (Buttonbush), (M); Chamaemerion, (M); Chrysopsis (Golden Aster), (M); Cichorium (Chicory), (L); C. intybus (Chicory), (L); Cirsium (Thistle), (M); Cleome (Stinking-Clover), (M); Convolvulus (Bindweed), (L, M); Coreopsis (Tickweed), (M); Echium (Viper's Bugloss), (L); E. vulgare (Blueweed), (L); Eupatorium (Thoroughwort), (M); Gaillardia (Blanket-Flower), (M); Gerardia, (M); Grindelia (Gumweed), (M); Helenium (Sneezeweed), (M); Helianthus (Sunflower), (L, M); Hieraceum (Hawkweed), (M); Hydrophyllum (Waterleaf), (M); Inula (Elacampane), (L); Kuhnistera (Prairie-Clover), (M); Lactuca (Lettuce), (M); Lactuca canadensis (Wild Lettuce), (L); Lathyrus (Wild Pea), (L); Lepachys (Prairie-Coneflower), (M); Lespedeza (Bush-Clover), (M); Liatris (Button-Snakeroot), (M); Medicago (Alfalfa), (L, M, PB, P); Melilotus (Sweet Clover), (M); Mentzelia (Stickleaf), (M); Monarda (Horsemint), (M); Onopordum (Scotch Pine), (L); Pentstemon (Beard-Tongue), (M); Petalostemum (Prairie-Clover), (M); Physostegia (False Dragonhead), (M); Potentilla (Cinquefoil), (M); Psoralea (Scurf-Pea), (M); Pycnanthemum (Mountain-Mint), (M); Raphanus (Radish), (L); Rosa (Rose), (L, M); Rudbeckia (Coneflower), (M); Ruellia, (M); Solidago (Goldenrod), (L, M); Sonchus (Sow Thistle), (L); Stachys (Hedge-Nettle), (M); Strophostyles (Wild Bean), (M); Taraxacum (Dandelion, etc.), (M); Teucrium (Germander), (M); Trifolium (Clover), (L, M); T. pratense (Red Clover), (L); Verbena (Vervain), (M); Verbesina (Crown-Beard), (M); Veronica (Ironweed), (M); Vicia (Vetch), (M).

BIOLOGY. Females excavate nesting burrows in mounds, under roots of low growing plants or under stones, in moderately well drained locations. It is probable that soil which is not subject to flooding or excess moisture is selected since the larvae construct netted cocoons which are not impermeable to water (Fig. 6). Elevated nesting sites enable the female to excavate approximately horizontal tunnels 5-13 cm. in length and about 2-4 cm. below the surface. The soil is loosened with the disc-shaped mandible, then raked with the teeth at the apices of front and middle tibiae, and pushed posteriorly out of the burrow between the hind legs and ventral side of abdomen. Cell construction commences by inserting about 3 circular leaves at the base of the tunnel, followed by 5 to 16 oblong sections approximately 10 x 18 mm. to form the cell wall or cup. The outer leaf sections are merely pushed against the soil wall, while only the inner leaves are cemented with saliva along the margins to form the cup. The cell is provisioned with 9-16 loads of pollen collected over a period from 5-12 hours (Pengelly, 1955). After the female lays the egg the cell is sealed with up to 14 circular leaf sections approximately 8 mm. in diameter. The circular leaves are sometimes alternated with soil to form a plug. Additional, independent cells may be inserted into the tunnel when ample blossoms are available to the female. Insertion of an additional cell is facilitated by excavating a short branch off from the main tunnel, thereby permitting exit of the bee emerging from the preceding cell. Usually, not more than three cells are provisioned within a single burrow.

Pengelly (1955) noted that the leaves used for cell construction were taken from: *Acer negundo* (Manitoba maple); *Acer nigrum* (Sugar maple); *Lonicera tartarica* (Honeysuckle); *Polygonum scandens* (Climbing False buckwheat); *Prunus americana* (Chokecherry); *Prunus serotina* (Blackcherry); *Solanum dulcamara* (Nightshade); *Syringa vulgaris* (Lilac); *Vitis sp*. (Wild grape).

PARASITES. In his studies of their life history Pengelly (1955), observed that about 40% of the cells completed by *M. latimanus* were parasitized by *Coelioxys* spp. He succeeded in rearing 4 males and 2 females of *C. rufitarsus*; however, he also observed other species which he did not obtain from reared material. Ants and crickets were observed to raid the cells and devour the provisions, causing the female to abandon the nest.

ALFALFA POLLINATING POTENTIAL. Pengelly (1955) reported *M. latimanus* to be the most common pollinator in southern

Ontario, visiting 19-28 florets per minute and tripping most of the flowers visited.

Since M. latimanus nest in the soil, they do not lend themselves to the shifting of nesting sites desirable for pollination of large open fields of alfalfa. It is easier to move bees which nest in wood above ground than bees which nest in the soil. However, as indicated for M. melanophaea, they may be suitable for alfalfa fields adjacent to road allowances, hedges, river banks or strips of uncultivated land. To ensure perpetuity of large populations, an annual supply of blossoming alfalfa would have to be available nearby, particularly during periods when new stands of alfalfa are being established. It is unknown whether M. latimanus can construct cells out of alfalfa or whether a second plant would be required to provide the leaves for constructing cells.

MEGACHILE (XANTHOSARUS) PERIHIRTA COCKERELL

Figures 28, 29, 67, 82; Map 22

Megachile perihirta Cockerell, 1898:126 (new species)

Megachile (Xanthosarus) perihirta; Hobbs and Lilly, 1954: 455 (ecology); Hobbs, 1956:625 (ecology in relation to production of alfalfa seed); Mitchell, 1962:159 (description, distribution and flower records)

Opposite p. 280

Fig. 28. M. perihirta, F. Disc-shaped mandible, with outer tooth reflexed, flattened and rounded.

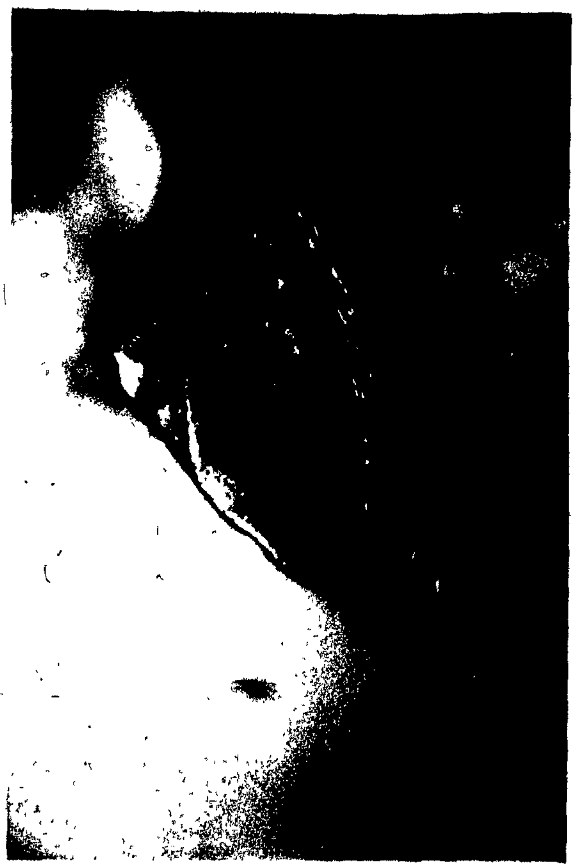


Fig.29. M. perihirta, F. Mandible worn down from digging nesting burrows in the ground.

FEMALE. In addition to the characters described in "FEMALES" of Xanthosarus, the following are usually distinctive of M. perihirta: a polished and impunctate median longitudinal band extending throughout the length of the clypeus; black pubescence on vertex and mesoscutum extending into scutellum; pubescence on body, yellowish-white laterally; apical fasciae on terga II-V, narrow, inconspicuous and interrupted medially on anterior terga. Lateral ocellus nearer to vertex than to eye.

MALE. Robust, glabrous and polished, keel-shaped protruberance on ventral side of mid-coxa; protruberance extending from base to near middle of basitarsus and becoming progressively deeper toward the apex; the keel about six times as long as wide. Posterior side of the broad and subpolished mesosternum without a sharp spine just in front of mid-coxa.

COMMENT. The female can be distinguished by the 5-dentate mandible with a parallel-sided 4th mandibular tooth and a deep oblique emargination between the 3rd and 4th denticles, which is deeper than wide (Figs. 24, 76); the black pubescence on mesoscutum often extending into the scutellum; the narrow and inconspicuous white apical fasciae on terga II-V, which are usually interrupted medially, particularly on the more anterior terga; the polished and impunctate median, longitudinal band usually extending throughout the length of the clypeus; and its distribution, which is primarily restricted to western Canada, although it has been collected as far east as Ontario.

The male can be recognized easily by the robust, glabrous and polished keel-shaped protruberance on the ventral side of mid-tibia; and the absence of sharp spurs on the posterior side mesosternum, just in front of mid-coxa.

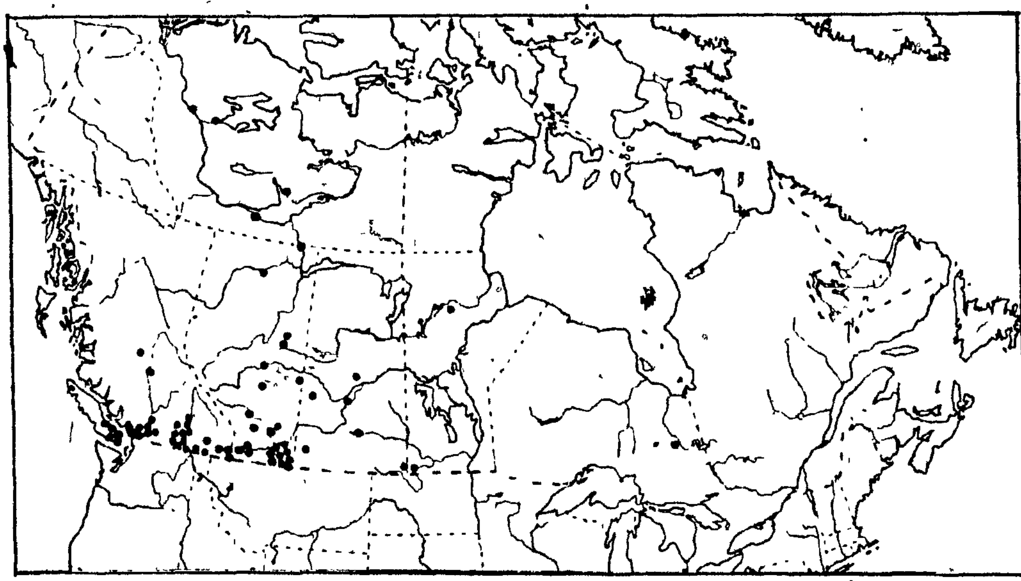
DISTRIBUTION. Highest concentrations in western North America, extending from the Mackenzie River to Mexico, occasionally found as far east as Ontario and Michigan. Localities from which M. perihirta was collected are as follows (Map 22): Ontario: Cochrane, 8 Aug. 1917, 2M. Thornloe, 9 Aug. 1917, 1F, 1M. Manitoba: Pikwitonei, 29 July 1949, 3F. Trees-Bank, 18 July 1910, 1M. Saskatchewan: Earl Gray, 10 Aug. 1924. Saskatoon, 28 July 1923, 1M. Shipman, 23 Aug. 1939, 1M. Swift Current, 23 Aug. 1916, 1M. Unity, Aug. 1925, 1M. Waskesiu, 26 July 1939. Alberta: Abee, 10 Aug. 1972, 1M. Aden, 1M. Athabaska, 12 Aug. 1915, 1M. Auburndale, 5 Aug. 1965. Bow R. Scandia, 2M. Brant, 5 Aug. 1926, 1F. Brooks, 23 July 1926, 2M, 1F. Brocket, 5 Aug. 1957, 1M, 1F; 5 Aug. 1957, 1M, 1F, sl; 5 Aug. 1957, 1F. Calgary, 5 Aug. 1926, 1M. Cypress Hills, 15 Aug. 1925, 1M. Edgerton, 11 Aug. 1925, 1M.

Edmonton, 2 July 1919, 1M; 1925, 1M; 5 Sept. 1950, 1M; 28 Aug. 1950, 1M. Ft.Vermillion, 28 July 1920, 1F. Golden Spide, 11 July 1957, 1M. Key R, 5 Aug. 1959, 1M, 1F. Lacombe, 27 July 1959, 1M, 1F; Lethbridge, 28 June 1913, 1M; 28 June 1914, 1F; 27 Aug. 1914, 1M; 16 July 1916, 1F; 27 July 1916, 1F;28 July 1916, 1F; 29 July 1916, 1M; 22 Aug. 1916, 1M; 6 July 1921, 1F; 14 July 1921, 1M; 18 July 1917, 4M; 28 July 1921, 1M; 15 Sept. 1921, 1M; 18 Aug. 1922, 1M; 6 Aug. 1923, 1M; 11 Aug. 1925, 1M; 10 July 1926, 1M; 23 July 1926, 1M; 4 July 1930, 1M; 16 July 1930; 18 July 1930; 18 July 1930, 1M; 20 July 1930, 1F; 14 Aug. 1940, 1M; 21 Aug. 1940, 1M; 22 Aug. 1940, 1F; 1 July 1941, 1F; 24 Aug. 1950, 1M; 25 Aug. 1950, 1M; 20 Aug. 1951, 1M; 7 July 1952, 1M; 25 July 1952, 1M; 25 July 1952, 2M; 30 July 1952, 3M; 31 July 1925, 1M; 8 Aug. 1952, 2M, 1F; 1952, 1M; 31 Aug. 1962, 1F; 16 June 1960, 1F, 1M; 27 Aug. 1962, 1M; 18 June 1963, 1F, 1M; 6 Aug. 1963, 1F; 30 Aug. 1963, 1M; 21 Sept. 1963, 1F, 1M. MacLeod, 21 July 1950, 1M. Manyberries, 11 Aug. 1932, 1F. McMurray, 27 July 1953, 1F. Medicine Hat, 20 Aug. 1911, 1M; 17 Aug. 1917, 1M; 20 Aug. 1960, 2M; 15 July 1917, 1M; 17 July 1917, 1M, 2F; 1 Aug. 1917, 1M, 1F; 15 July 1956, 4M. Milk River, 8 Sept. 1950, 3M. Rolling Hills, 31 July 1951, 2M, 1F; 31 July 1951, 1M; 31 July 1951, 2M; 29 July 1952, 2M; 29 July 1952, 1M, 1F, sl; 26 July 1958, 1M, 1F. Scandia, 16 June 1946, 1M; 29 June 1948, 1F; 27 June 1948, 4M; 7 July 1950, 1M; 18 July 1950, 1M;

21 July 1950, 1M; 11 July 1951, 1M, 3F; 11 July 1951, 1F; 26 July 1951, 1M; 26 July 1951, 11M, 3F; 17 July 1951, 1F; 17 July 1951, 4M, 2F; 23 July 1951, 1M, 2F; 6 Aug. 1951, 1M, 2F; 6 Aug. 1951, 1M, 1F; 13 Aug. 1951, 1M; Aug. 1951, 1F. Nr. Prunus, Aug. 1951, 1M, 3F. Scandia, 16 Aug. 1951, 1M, 1F; 17 Aug. 1951, 1M, 1F, sl; 21 Aug. 1951, 1M, 1F; 8 July 1952; 14 July 1952, 1F; 29 July 1952, 2M; 23 July 1954; 9 July 1956, 1F; 21 July 1958, 1M, 1F; 15 July 1960, 1M, 1F; 15 Aug. 1960, 1M, 1F. Stirling, 7 July 1941, 2F. The Gap, 8 Aug. 1959. Vauxhall, 18 July 1950, 1M, 3F; 23 July 1951, 11M, 4F. Wardlow, 9 Aug. 1947, 1M; 19 Aug. 1947, 1M. Welland, 3 Aug. 1915, 1F; 10 Sept. 1939, 1M. White Horse, 10 Aug. 1927, 2M; 15 July 1931, 3M; 4 Aug. 1952, 2M. British Columbia: Agassiz, 8 July 1914, 1M; 24 July 1922, 1M; 21 July 1926, 1M; 22 July 1926, 1M; 22 July 1926, 1M. Bowser, 21 June 1955, 1M. Chilcotin, 1 July 1929, 2F; 12 July 1920, 1F; 20 July 1930, 1F; 29 July 1930, 4M. Courtenary, 11 July 1930, 1F. Cranbrook, 21 June 1926, 1F; July 1953, 1M, 1F. Crescent, 14 Aug. 1916, 1F. Dog Creek, 28 Aug. 1967. Duncan, 26 July 1920, 1M. Fairview, 7 Aug. 1919, 9M. Fitzgerald, 7, 14, 21 Aug. 1921, 3M. Goldstream, 27 July 1902, 1M; 10 Aug. 1902, 1M. Hat Creek, 26 Aug. 1922, 1M. Hedley, 26 June 1953, 1M. Invermer, Aug. 1914, 2F; 30 June 1914, 1M. Kamloops, 26 June 1938, 1F; 25 July 1943, 2F; 8 Aug. 1943, 1F; 16 June 1950, 1M. Kaslo, 10 July 1906, 1M. Keremeo, 21 July 1917, 1M, 3F; 17 July, 1918,

1M; 9 July 1953. Lillooet, 5 July 1919, 1M; 9 June 1921, 2F; 28 June 1926, 1F. Lytton, 28 June 1931, 1M; 5 July 1931, 1F. MacGillivary, 14 July 1953, 1M. Manning Park, 7 Aug. 1953, 1M, 2F. Merritt, 20 July 1918, 1F. Minnie, 12 Aug. 1924, 1M. Mission City, 24 July 1943, 1F. Nelson, 29 July 1897; July 1897; Aug. 1897, 1M; 19 Aug. 1897, 1M; 25 June 1905, 1M; 28 June 1921, 1M; 26 July 1925, 1M, 1F. Okanaga, 16 July 1911, 1F; 21 July 1917, 2M, 2F; 16 June 1919, 1M; Aug., 2M. Oliver, 3 June 1923, 1F; 9 Aug. 1943, 1M; 24 July 1953, 1F; 21 Aug. 1953, 2M, 1F; 29 Aug. 1953, 2M. Osoyoos, 10 June 1919, 3F; 21 July 1953, 1M, 1F; 25 Aug. 1953, 1M. Peachland, 2 Aug. 1909, 1M. Penticton, 22 July 1909, 1M; 7 Aug. 1916, 2M, 1F; 22 June 1919, 3F; 7 June 1919, 1M; July 1919, 1M, 1F; 3 Sept. 1919, 3F; 7 Sept. 1919, 4M, 3F. Quesnel, 12 Aug. 1946, 1M; 19 Aug. 1946, 1F. Robson, 10 Sept. 1948, 1F. Royal Oak, 2 Aug. 1917, 1F. Ruskin, 17 July 1953, 1F. Salmon Arm, 4 July 1914, 1M; 4 Aug. 1914, 1M; 28 July 1925, 1M; July 1928, 1M. Shuswap, 6 July 1952, 1M. Sidney, 6 July 1914, 1F, sl; 7 July 1914, 1F; 15 Aug. 1916, 1M, 1F; 22 July 1925, 9M, 1F. Summerland, 9 Aug. 1916, 2F; 10 Aug. 1916, 5M; 20 July 1917, 8M, 2F; July 1917, 5M, 1F; 1917, 1F; 31 Aug. 1953, 1M, 5F; 30 July 1957, 1M; 15 Sept. 1957, 1F; 4 Aug. 1958, 5M; 4 Aug. 1958, 2M; 4 Aug. 1958, 2M; 11 July 1969, 1M. Trout Creek, 22 Aug. 1914, 1F. Vancouver, 15 Aug. 1916, 1F. Vaseaux, 13 June 1919, 1M; 12 June 1919, 1M. Vernon, 8 Aug. 1004, 8M; 24 Aug. 1904, 1M; 24 July

1917, 1M, 4F; 25 July 1917, 3M, 2F; 13 Aug. 1918, 1M; 25 Aug. 1919, 2F; 20 July 1920, 1M, 1F; 5 Aug. 1920, 1M; 6 Aug. 1920, 1M; 19 July 1921, 3M; 7 July 1920, 1M; 23 July 1921, 4M; 24 July 1920, 1F. Vernon, 26 July 1920, 6M, 2F; 27 July 1920, 16M, 3F; 28 July 1920, 2M, 4F; 28 July 1920, 1F; 28 July 1920, 1M, 1F; 2 Aug. 1920, 1M; 5 Aug. 1920, 1F; 6 Aug. 1920, 1M; 8 Aug. 1920, 1M; 9 Aug. 1920, 8M, 1F; 26 July 1923, 4M; 13 Aug. 1923, 1M; 14 Aug. 1923, 1M; 21 Aug. 1923, 1M; 29 Aug. 1923, 1M; 6 Aug. 1926, 1M, 1F; 28 Aug. 1926, 1F; 10 Sept. 1926, 1F; 11 July 1929, 1M. Victoria, 17 July 1909, 1M; 13 Aug. 1916, 5M, 3F; 16 Sept. 1917, 3M, 2F; 20 Sept. 1917, 1F; 30 Sept. 1917, 1M; 3 Aug. 1938, 1F; 25 July 1965. Walhachin, 27 June 1918, 2F. Wasa, 30 Aug. 1959; 3 Aug. 1960, 1F; 3 Aug. 1960, 3M; 5 Aug. 1960, 4M; 5 Aug. 1960. Northwest Territories: 14 July 1946, 1M; 15 July 1950, 2M; 22 July 1950, 2M; 7 Aug. 1950. Fort Smith, 24 July 1950, 1M. Hay River, 4 Aug. 1951, 5M. Norman Well, 9 Aug. 1949, 1F. Yellowknife, 14 June 1949, 1M; 26 July 1949, 1M; 4 Aug. 1949, 1M; 10 Aug. 1949, 2M.



Map 22. Canadian distribution of Megachile perihirta.

FLOWERS VISITED. Aster (Aster), (M); Cirsium (Thistle), (M): Cleome (Stinking-Clover, Spider-Flower), (M); Epilobium (Willow-Herb), (M); Eriogonum (Umbrella-Plant), (M); Helianthus (Sunflower), (M); Melilotus (Sweet Clover), (M); Trifolium (Clover), (M).

BIOLOGY. In southern Alberta, Hobbs and Lilly (1954) noted that the distribution of M. perihirta is restricted to mixed prairie or fescue grassland regions. Nests were found in gravelly areas, at the bases of widely spaced clumps of grass or pasture sage (Artemesia frigida); or in areas with light, sandy loam, which were more thickly covered with clumps of spear grass (Stipa) and grama grass (Bouteloua). Occasionally, nests were also found between or under stones. At Cochrane, Ontario, Sladen (1918) found M. perihirta nesting gregariously in a nearly new and bare, gravel railway embankment. He also found a similar nesting site in a nearly new gravel road at Invermere, B.C.

Burrows are usually excavated down into the soil at an angle of approximately 60°, then curved to a horizontal position at about 5 cm. underground. Generally, three cells are constructed and provisioned within the tunnel, but the number of cells varies from 1 to 9 (Hobbs, 1956).

Sections of leaves used for cell construction are cut from the following plants: Rosa (Rose), Prunus (Cherry), Salix (Willow), Convolvulus (Bindweed), Rumex (Curlydock) and Elaeagnus (Oleaster) (Hobbs and Lilly, 1954).

Construction of the cell base (made with about three circular sections of leaf, and walls (approximately 15 oblong sections) takes about 1-1/2 hours. The cell is provisioned with approximately 15 loads of pollen, requiring a period of about 3 hours. An egg is laid on the semi-fluid pollen-nectar matrix within about 15 minutes. The cell is then capped with 3-7 circular sections of leaf, with the last cell in the burrow capped with extra leaf sections alternated with soil to form a plug. Under optimal conditions, a female can complete a cell per day. Since a female lives for about 30 days, Hobbs (1959) estimated that a female completes about 15 cells during her lifetime.

PARASITES AND PREDATORS. In Alberta, Hobbs (1956) reared the following parasites from the cells of M. perihirta: Coelioxys rufitarsus Sm., Nemognatha lutea Lec. and Dasymutilla fulvohirta (Cress). Solenopsis molesta (Say) (Thief Ant) chewed a tiny hole in the cell, shredded the larva and removed the pieces through its tiny hole which was too small to permit the bee larva to pass through.

ALFALFA POLLINATING POTENTIAL. From an assessment of the 14 species of Megachile present in southern Alberta, Hobbs and Lilly (1954) judged M. perihirta and M. dentitarsus to be the principal pollinators of alfalfa. Additional preference was given to M. perihirta since the adults have an earlier emergence period (mean emergence date June 24), which coincides more closely with the flowering period of alfalfa. In Alberta, alfalfa flowers tripped after August 5-10 are subject to being frozen before they can mature. In Utah, Bohart (1957) observed that alfalfa is preferred by M. perihirta and that it actively trips 19-24 flowers per minute with 98% efficiency. In estimating the usefulness of a female in production of alfalfa seed, Hobbs (1956) calculated as follows:

5 seeds per pod produced by the flower tripped by the bee

x 372 flowers tripped to accumulate 1 load of pollen

x 15 loads of pollen to provision 1 cell

x 15 cells provisioned during her lifetime

= 418,500 seeds or about 2 pounds of alfalfa seed.

As the number of untripped flowers diminishes, the bee has to spend more time to seek out the untripped flowers, thereby reducing the rate at which the bee can pollinate the flowers.

Sladen (1918) proposed that M. perihirta "...might be encouraged to breed in the vicinity of alfalfa fields by spreading gravel and making it firm by rolling". On the other hand, Bohart (1957) found females nesting above the soil, between bales of hay. Since hay bales are more adaptable to being transferred to alfalfa fields, requiring cross fertilization, a population with the capacity of nesting between layers of hay could be adapted to large scale alfalfa production. An additional limitation to the use of M. perihirta is its apparent requirement for a secondary plant for cell construction. By the Bone River near Scandia, Alberta, Hobbs (1956) noted that lack of plants from which leaves could be used for cell construction "...compelled M. perihirta to use an isolated chokecherry bush, Prunus virginiana L. ...".

MEGACHILE (XANTHOSARUS) DENTITARSUS SLADEN

Figures cf. 67, 82; Map 23

Megachile diligens Sladen, 1918:125 (new species)

Megachile diligens Sladen, 1918:301 (biology, taxonomy)

Megachile dentitarsus Sladen, 1919:1925 (new name).

Megachile (Xanthosarus) dentitarsus; Mitchell, 1936:127 (description, distribution and flowers visited); Hobbs and Lilly 1954:455 (ecology); Hobbs, 1956:625 (biology)

FEMALE. See characters described for females in the subgenus Xanthosarus. Pubescence on head and first two abdominal segments dense, elongate and white; occasionally, brown hairs interspersed across mesoscutum and vertex; black hairs not extending into scutellum. Broad, dense and conspicuous white, apical fasciae on terga II-V; fasciae on the more anterior terga, usually not interrupted medially. Scattered, erect hairs on tergum VI white to golden; dense, subappressed short hairs, silvery white to brown, becoming more dense apicomedially. Scopa pale basally, becoming more reddish apically. Lateral ocellus usually subequally distant between eye, alternate ocellus and edge of vertex; sometimes, a little more distant to vertex.

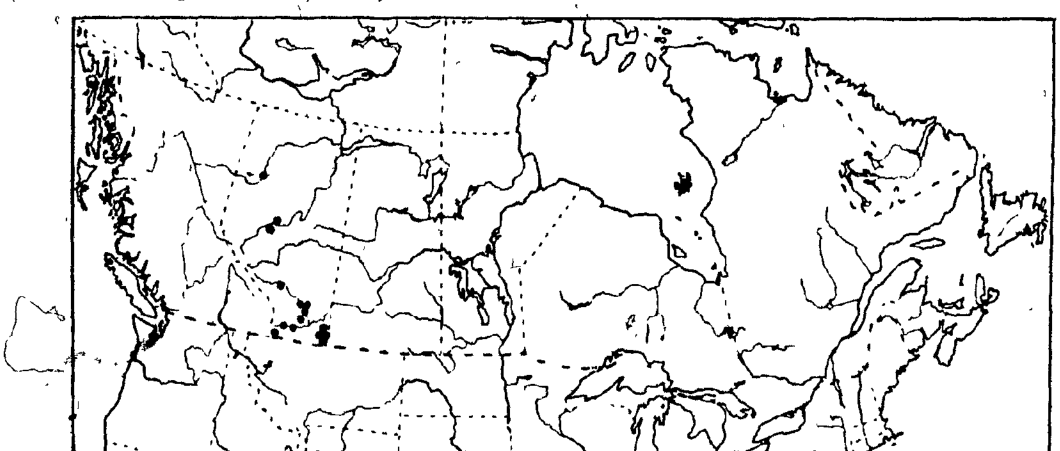
MALE. Prominent, pointed spur on posterior side of mesosternum, just in front of mid-coxa. Club-shaped, glabrous and polished protruberance on ventral side of mid-basitarsus, extending fully three-quarters of the length of mid-basitarsus, width of protruberance subequal to one-third of its length. A more extensive description of males is given in Xanthosarus.

COMMENT. The female can be recognized by the 5-dentate mandible with the parallel-sided 4th mandibular tooth and the deep oblique emargination between the 3rd and 4th denticles, which is deeper than wide (Figs. 48, 67); the broad and conspicuous white, apical fasciae on terga II-V, which are usually not interrupted medially on the more anterior terga; copious white pubescence on head, thorax and first two abdominal segments and its distribution confined to Alberta.

The male can be recognized easily by the prominent pointed spur on the posterior side of mesosternum just in front of mix-coxa. A spur on the mesosternum is also present in the male of *M. wheeleri*, however, the spur is on the anterior side of mesosternum, just behind front coxa. *M. dentitarsus* can also be distinguished by the polished, clavate protruberance on mid-basitarsus; the enlarged mid-femur which is distinctly thicker than either front or hind femora; the absence of mid-tibial spurs, and the conspicuous, white basitarsus which is narrower at apex than at base.

DISTRIBUTION. Extends from Alberta south to New Mexico. In Canada, it occurs only in Alberta in the following localities (Map 23): Alberta: Brooks, 12 Aug. 1924, 2F; 14 Aug. 1924, 2F; 17 Aug. 1924, 1M; 22 July 1926, 1F, Alfalfa; 22 July 1926, 2F, Alfalfa; 23 July 1926, 2F; 16 Aug. 1927, 2M, 1F; 21 July 1941, 1F. Heydlauff, 4 Aug. 1952, 5M, 5F. Irvine, 12 Aug. 1951, 1M. Legend, 23 Aug. 1955, 2F, Helianthus. Labrador I, 10 May 1954, 1F. Lethbridge, 28 June 1914, 3F; 27 July 1916, 2M, 1F; 22 Aug. 1916, 3M, Alfalfa; 18 July 1917, 2M; 27 July 1917, 1M; 14 July 1921, 1M; 15 Sept. 1921, 1F; 7 July 1923, 1M; 31 Aug. 1939, 1M, Alfalfa; 13 Sept. 1939, 1M, Anthophora cell; 4 July 1940, 1M, Alfalfa; 13 Aug. 1940, 1M; 22 Aug. 1940, 2M; 25 Aug. 1940, 1M; 31 July 1941, 2M; 15 Aug. 1941, 6M; 15 Aug. 1948, 1M, Gumweed; 21 July 1949, 3M, Helianthus; 22 July 1949, 1M, 1F, Helianthus; 7 Aug. 1951, 1M, Prairie Clover; 9 Aug. 1951, 1M; 15 Aug. 1951, 5M; 16 Aug. 1951, 3M, Alfalfa; 17 Aug. 1951, 2M; 20 Aug. 1951, 4M; 23 July 1952, 1M; 4 Aug. 1953, 3M, Petalostemon. Magrath, 14 Sept. 1951, 1M, Gumweed. Manyberries, 14 July 1949, 2M, Sweet Clover. Medicine Hat, 20 Aug. 1916, 11M; 15 July 1917, 1M. Prairie Bluff, 4 July 1970, 1M; 4 July 1970, 1F; 7 July 1970, 1M; 19 July 1970, 1M, 2F, Campanula rotundifolia; 31 July 1970, 1M, Epilobium angustifolium; 14 July 1971, 1M, sl; 23 July 1971, 1F; 25 July 1971, 1M; 26 July 1971, 1M; 27 July 1975, 1M, 3F. Redcliffe, 1 Aug.

1917, 1M. Red Deer, 22 July 1926, 1M. Sangudo, 12 July 1939. Scandia, 20 July 1946, 3M, Firewood; 16 May 1949, 1F; 18 May 1949, 3M, 1F; 19 May 1949, 1M; 20 May 1949, 2M; 21 May 1949, 3M; 23 May 1949, 2M; 24 May 1949, 3M; 26 May 1949, 3M; 28 May 1949, 1M; 21 June 1949, 1M; 18 July 1950, 2M; 6 Aug. 1951, 1M; 26 July 1951, 3M; 26 July 1951, 1M; 19 June 1952, 1F; 20 June 1952, 1F; 14 July 1952, 1M; 14 July 1952, 1M; 7 July 1953, 1F; 1949, 1F; 1949, 1M. Seven Persons, 8 July 1952, 1F. Vauxhall, 20 July 1951, 1M; 8 Aug. 1950, 1M. Wabamun, 7 July 1931, 3F; 28 June 1936, 2F, (Natm) egg; 21 July 1926, 2F. Waterton, 8 July 1923, 1M; 14 Aug. 1921, 1F. White Mud R., Peace River District, 15 July 1932, 1F. Judah-Peace River Dist., 9 July 1932, 1F. Lake Newell, 10 July 1974, 1F, 2M; 24 July 1974, 1F, 1M; 12 Aug. 1974, 1F, 1M.



Map 23. Canadian distribution of Megachile dentitarsus.

FLOWERS VISITED. Aster (Aster), (H); Cirsium arvense (Canada Thistle), (H); Cleome serrula (Stinking Clover), (M); Epilobium angustifolium (Fireweed), (H); Grindelia (Gumweed), (H); Helianthus (Sunflower), (M); Medicago sativa (Alfalfa), (H); Melilotus alba (Sweet Clover), (M); Petalostemum purpureum (Prairie-Clover), (H); Solidago rigida (Goldenrod), (M); Trifolium pratense (Red Clover), (M); Verbena (Vervain), (M).

BIOLOGY. Hobbs and Lilly (1954) have observed M. dentitarsus to nest in the ground and Bohart (1957) noted that it nests in soil with light vegetation. On July 21, 1950, N.D. Holmes found it nesting in a crack in the soil in a potato hill. The nest was approximately 7 cm. beneath the surface of the soil. Leaves used for the construction of cells are derived from Salix (Willow), Prunus (Cherry), and Rosa (Rose) (Hobbs and Lilly, 1954); Thermopsis (False Lupine), data on label - Haig. Foraging females have a tendency to make a loud buzzing sound when their foraging activity is interrupted, however, they are not known to sting.

ALFALFA POLLINATING POTENTIAL. At Medicine Hat and Lethbridge, Alberta, Sladen (1918) observed large numbers of M. dentitarsus actively tripping alfalfa at an average rate of 17 florets per minute. In Utah, Bohart (1957) reported that alfalfa was a preferred host and that it trips 18-26 flowers per minute with about 95% efficiency. In Alberta, Hobbs (1956) found that alfalfa flowers pollinated by M. dentitarsus produced an average of 6.3 seeds per pod, while flowers that were pollinated by other species of Megachile produced an average of 5 alfalfa seeds per pod.

There appear to be three major limitations to population increase and engagement of M. dentitarsus in large scale alfalfa production:

(1) Delayed adult emergence. Hobbs and Lilly (1954) report that in 1951 the first females to trip alfalfa were seen about July 20, while peak numbers did not arise until August 10. The authors also found that alfalfa flowers tripped after August 5-15 were subject to being frozen before the seed could mature. It is possible that a population with potencies for earlier flight might be selected and expanded. In accord with this, a female with early maturing potencies was collected from alfalfa on June 24, 1926 at Taber, Alberta; additionally, three males were collected on June 28, 1914, at Lethbridge, Alberta. The alfalfa flowering period could also be synchronized with the flight period of the pollinator "...by retarding alfalfa growth by clipping so that blooming would begin about July 1..." (Hobbs, 1956).

(2) Soil nesting behaviour. Provision of nesting sites in undisturbed, well drained sandy soil is incompatible with large scale alfalfa seed production. In some cases nesting sites consisting of packed gravel along road grades, as proposed by Sladen (1918) might prove feasible.

It may also be that since this species is closely related to *M. perihirta*, and since Bohart (1957) reported this species to nest between bales of hay, it might be found that a similar transportable nesting material might be improvised for *M. dentitarsus*.

(3) Secondary plant for cell construction. A suitable secondary plant from which sections of leaf could be cut for cell construction and a continuing annual access to flowering alfalfa fields would have to be available to promote continuing population increase.

MEGACHILE (PHAENOSARUS) FORTIS CRESSON

Figures 31, 71; Map 24

Megachile fortis Cresson, 1872:262 (new species).

Megachile fortis; Fischer, 1956:673 (morphology).

Megachile (Phaenosarus) fortis; Mitchell, 1962:156 (description, distribution and flowers visited).

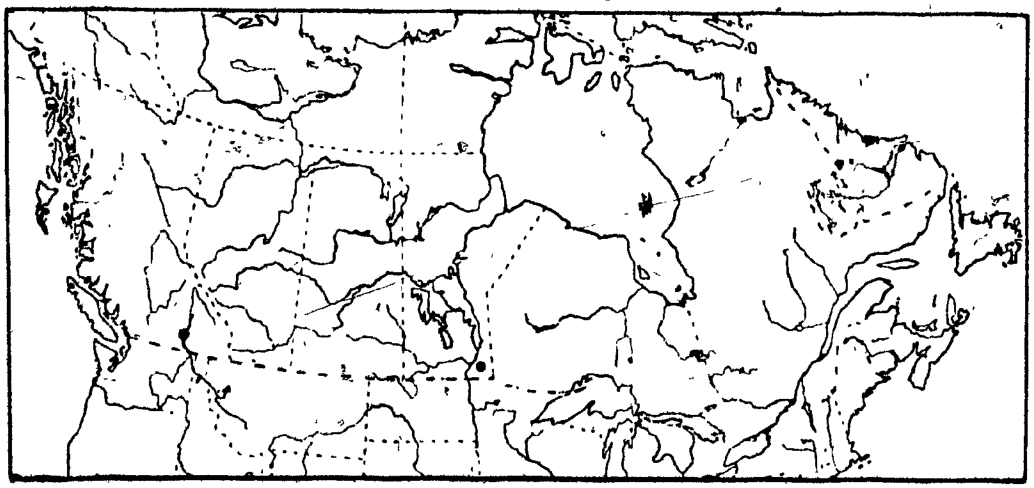
FEMALE. Length 17-19 mm. Mandible 5-dentate; outer tooth reflexed along the ventral side and greatly expanded, with the cutting side elongated and spade-like, not suitable for chiselling into wood (Fig.31). Outer cutting edge defining the 4th tooth and the emargination between the 3rd and 4th denticles approximately parallel-sided. Inner cutting edge occupying the emargination between the 3rd and 4th denticles forming approximately an isosceles triangle, with the distances from the apex of the 4th denticle to the base of the emargination (formed by the outer cutting edge) and the distal side of the inner cutting edge (approaching the 3rd denticle) subequal. Bevelled cutting edge on 3rd denticle, projecting toward the 2nd denticle, occupying nearly half the emargination between the two denticles. Inner cutting edge (best seen with the mandible opened) extending as a distinct carina along the base of the 3rd denticle and fusing near the base of the second tooth; the edge strongly elevated, occupying most of the two emarginations (formed by the outer cutting edge) between the 3rd and 5th denticles. Median half of apical border of clypeus weakly concave and with an impunctate, coriaceous band. Lateral ocellus, a little nearer to eye than to vertex. Mesoscutum densely punctured, without any polished or subpolished area between punctures; pubescence pale orange without black hairs medially. Apical fasciae on terga II-V dense and complete, not interrupted medially. Tergum VI nearly straight in profile; more distinctly concave laterally; pubescence intermixed ranging from suberect, plumose hairs to short, appressed hairs, mostly obscuring the integument medially toward the apex. Apical fringe of setae on sternum VI terminating before apex, exposing a glabrous, thickened and slightly upcurved apical rim.

MALE. Length 15-16 mm. Front tarsus and parts of femur and tibia yellowish-red, conspicuously contrasting with the black integument on the rest of the body and appendages. Front basitarsus longer than wide and approximately parallel-sided; shallow, polished, longitudinal band along the anterior side, bordered by dense setae, with the border on the dorsal side terminating a little beyond the middle of basitarsus. Robust front coxal spine terminating in a dense pointed cluster of short setae; large patch of stout, reddish-orange bristles just above the coxal spine. Hypostomal tubercle weakly developed; represented by a rounded elevation surmounted by dense setae. Median side of hypostomal concavity glabrous and subpolished, with the hypostomal carina entirely absent. Narrow, glabrous band extending diagonally from near ventral margin of eye to posterior border of cheek. Mandible 3-dentate. Ventral mandibular tooth broadly truncate apically; inner side of tooth brushing against the hypostomal concavity with a dense brush of plumose hairs directed outwardly. Apical segment of flagellum flattened, obliquely rounded; anterior side with dense short hairs, posterior side glabrous and polished. White apical bands on terga II-V progressively more strongly depressed on posterior terga, with depth of depression subequal to length of band. Preapical transverse carina on tergum VI rounded apically and curved ventrally; tergum weakly convex in profile, with an elevated median ridge rising above the lateral concavity. Tergum VII with a tapered median tubercle. Preapical margin of sternum IV with an acute median tubercle.

COMMENT. The female can be recognized by the 5-dentate mandible in which both the 4th tooth and the emargination between the 3rd and 4th denticles are approximately parallel sided (Fig. 31). The oblique parallel lines formed by the outer cutting edge define the cutting path as the two mandibles slide past each other when closing. In addition to this, the fringe of hairs on sternum VI terminates before the apex, with the apical rim glabrous, thickened, slightly elevated and extending a little beyond the apex of tergum VI. This is the largest species of leaf-cutter bees, ranging from 17-19 mm. in length. The mandibular conformation of species in the subgenus Xanthosarus resembles that in M. (Phaenosarus) fortis; however, the two groups can be separated by the narrower emargination in the outer cutting edge between the 3rd and 4th denticles (Figs. 28, 31), the absence of the glabrous and thickened apical rim on sternum VI, and the position of the lateral ocellus, which is nearer to the vertex than to the eye in the species of Xanthosarus, and closer to the eye than to the vertex in M. fortis.

The male can be readily recognized by its distinctive, apically truncate, ventral mandibular tooth (Fig. 71); or the postmedian transverse carina on tergum VI which is rounded apically, combined with the sharp preapical median tooth in sternum IV.

DISTRIBUTION. The species is fairly widely distributed, although it is rarely collected, extending from Manitoba south to New Mexico, east to Wisconsin and possibly to British Columbia. A specimen supplied by Simon Fraser University, suspected to have been collected at Summerland, B.C., did not have a locality label. In Canada, a specimen was collected at Aweme, Manitoba (Map 24).



Map 24. Canadian distribution of Megachile fortis.

FLOWERS VISITED. Dichrophyllum (Snow-on-the-Mountain), (M); Helianthus (Sunflower), (M); Silphium (Rosinweed), (M); Solidago (Goldenrod), (M); Vernonia (Ironweed), (M).

BIOLOGY. There is no published information on the biology of M. fortis; however, the flattened and disc-shaped mandible, with the outer tooth reflexed and rounded apically, indicate that it is probably incapable of chiselling tunnels in wood, but appears to be adapted to excavating nesting burrows in the soil.

ALFALFA POLLINATING POTENTIAL. Since the species probably nests in the soil, it does not lend itself to being readily transportable to alfalfa fields requiring pollination. Available records of flowers visited do not indicate that the species has ever been collected on alfalfa. The lack of evidence showing that it can be engaged as an alfalfa pollinator, along with the factor or factors which currently restrict its population densities, suggest that the possibilities of using *M. fortis* as an alfalfa pollinator appear remote at this time.

Subgenus ARGYROPILE Mitchell

Argyropile Mitchell, 1934:302 (new species)

This subgenus is represented by one species in Canada. The female and male characteristics are described under its species M. parallela.

MEGACHILE (ARGYROPILE) PARALLELA SMITH

Figures 32, 33, 66, 81; Map 25

Megachile parallela Smith, 1853:191 (new species)

Megachile (Argyropile) parallela: Fischer, 1951:49 (biology); Hobbs and Lilly, 1954:460 (ecology); Mitchell, 1962:159 (description, distribution, flower records).

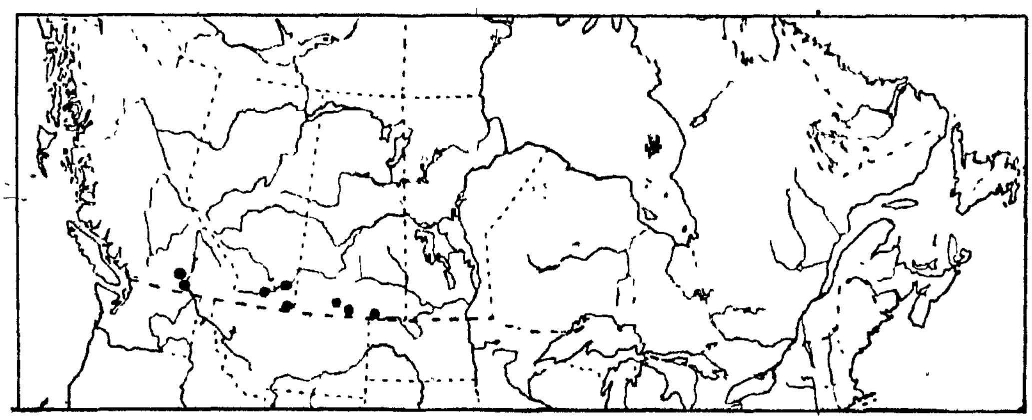
FEMALE. Length 13-15 mm. Pubescence on head, thorax and first two abdominal terga white; apical fasciae on terga II-V usually distinct and complete; scopa uniformly white. Mandible 4-dentate and flattened (Fig. 66); outer mandibular tooth expanded, reflexed and aligned with the three preceding denticles; cutting side, between the apices of the inner and outer denticles, elongated. Inner cutting edge elevated, occupying the evenly arcuate and elongate emargination formed by the outer cutting edge between the 3rd and 4th denticles; distance between the apices of the 3rd and 4th denticles nearly twice as great as the distance between the 2nd and 3rd denticles; inner cutting edge fusing distally with 3rd denticle. Bevelled edge on outer side of 3rd denticle extended approximately .8 of the distance to the 2nd denticle and occupying most of the emargination formed by the outer cutting edge, between the two denticles. Apical border of clypeus polished and impunctate, with blunt median tubercle. Abdominal tergum VI nearly straight in profile, with short appressed and plumose silvery hairs, largely obscuring the integument beneath; no scattered, elongate, suberect hairs apicomedially. Sternum I with a postmedian carinate rim extending obliquely, laterally to the apicolateral margin of sternum; triangle formed, bordered by the carina anteriorly, with minute, short pubescence contrasting conspicuously with the bordering elongate pubescence. Sternum VII with reduced scopal hairs not extending to apical margin but terminating in a short, dense preapical fringe; apex of sternum VI glabrous, subpolished and distinctly upcurved, extending a little beyond and above the apically truncate border of tergum VI.

MALE. Length 13-15 mm. Pubescence on head and thorax uniformly white. Mandible 4-dentate (Fig. 32); cutting side between the apices of the outer and inner denticles greatly elongated; inner mandibular tooth strongly expanded, with the distances from the apex of the 3rd tooth to either the inner or outer denticles subequal. Ventral mandibular tooth obliquely tapered apically. Hypostomal tubercle absent; hypostomal carina not extending to base of mandible; hypostomal concavity weakly defined, with only a small patch of shortened pubescence lateral to the small outwardly curved brush of hairs at the apex of the ventral mandibular tooth. Front coxal spine not greatly elongated, with a dense cluster of short setae at apex; area just in front of coxal spine occupied by elongate, whitish pubescence, without any stout reddish bristles. Front basitarsus dark and simple, without any trace of an excavation along the anteroventral side, or even a row of shortened bristles. Apical fasciae on terga II-IV distinct, usually not interrupted medially. Preapical margin of tergum V strongly elevated, recurved posteriorly and carinate. Postmedian, transverse carina on tergum VI, strongly flared laterally, semicircularly and deeply emarginate medially; area above the carina with dense, appressed plumose pubescence concealing the integument beneath; area beneath the carina with sparse suberect pubescence not concealing the integument. Apical margin of tergum VI with a pair of prominently protruding carinate denticles. Sternum IV with a broad and deep apical groove delineating a parallel-sided, sclerotized apical band, followed by a translucent membranous flap.

COMMENT. The female can be recognized by the abruptly upcurved glabrous and polished apical rim of sternum VI, which extends beyond and slightly above the truncate apex of tergum VI. A thickened, upcurved and glabrous apical rim on sternum VI is also present in M. fortis, which can be separated by the 5-dentate mandible. The mandibular configuration of M. parallela approaches that present in M. texana, which also has a 4-dentate mandible; an acute inner mandibular tooth and an evenly arcuate emargination of the outer cutting edge between the 3rd and 4th denticles, occupied by the elevated inner cutting edge (Figs. 56, 66). They can be separated however by the reflexed and expanded outer mandibular tooth in M. parallela, which has the cutting side, between the apices of the inner and outer denticles, longer than the distance between the apex of the inner tooth and the mandibular acetabulum; in M. texana cutting side is shorter than the distance between the apex of the inner tooth and the mandibular acetabulum.

The male can be recognized by the 4-dentate mandible combined with the dark and simple front basitarsus, and the absence of reddish bristles just anterior to the coxal spine.

DISTRIBUTION. British Columbia south to Mexico and east to Saskatchewan. Localities from which M. parallela was collected in Canada are as follows (Map 25): Saskatchewan: Lisieux, 4 Aug. 1955, 1F. Rock Glen, 2 Aug. 1955, 1F. Torquay, 14 Aug. 1955, 1F. Alberta: Lethbridge, 28 June 1914, 1M; 22 Aug. 1916, 1F; 7 Aug. 1939, 2M; 12 Aug. 1948, 1F, Gumweed; 13 Aug. 1948, 1F, Gumweed; 15 Aug. 1948, 1F; 17 July 1950, 1F, Gumweed. Medicine Hat, 17 July 1917, 1M; 23 Aug. 1919, 1F, 2M; 16 Aug. 1924, 2M. Wild Horse, 10 Aug. 1927, 1F. British Columbia: Kamloops, 27 July 1937, 1M. Summerland, 10 Aug. 1916, 1F, 1M. Thompson River, 8 Aug. 1914, 1F. Walhachin, 16 Aug. 1942, 3M.



Map 25. Canadian distribution of Megachile parallela.

FLOWERS VISITED. Boltonia (Boltonia), (M); Ceanothus (Redroot), (M); Cephalanthus (Buttonbush), (M); Cirsium (Thistle), (M); Coreopsis (Tickseed), (M); Gaillardia (Blanket-Flower), (M); Gilia (Standing-Cypress), (M); Grindelia squarrosa (Gumweed), (L); Helianthus (Sunflower), (M); Heliopsis (Ox-Eye), (M);

Heterotheca (Camphorweed), (M); *Hypericum* (St.John's-Wort), (M); *Lepachys* (Prairie-Coneflower), (M); *Medicago* (Alfalfa), (M); *Melilotus* (Sweet Clover), (M); *Petalostemum* (Prairie Clover), (M); *Phaseolus* (Kidney-Bean), (M); *Rudbeckia* (Coneflower), (M); *Silphium* (Rosinweed), (M); *Verbena* (Vervain), (M); *Verbesina* (Crown-Beard), (M).

BIOLOGY. The reflexed and expanded outer mandibular tooth with the elongated cutting edge precludes this species from being able to chisel into and excavate nesting sites in wood. The flattened and disc-shaped mandible, with the denticles becoming worn down in older females, suggests excavation of nesting burrows in the soil. In Kansas, Fisher (1951) observed a female to enter a burrow in a fallow field on July 16, 1949. The burrow was excavated at an angle of about 45° to a depth of about 5 cm. A cell, laid horizontally at the bottom of the burrow, was constructed of 15 entire leaves (not sectioned) of *Spirea vanhoutteii* (Spirea, common ornamental shrub) intermixed with 5 leaflets of *Trifolium repens* (White Clover). In southern Alberta, Hobbs and Lilly (1954) reported *M. parallela* to be restricted to the mixed prairie region; however, even there it is rarely found.

ALFALFA POLLINATING POTENTIAL. There appear to be five impediments to the implementation of *M. parallela* as an alfalfa pollinator:

(1) The species is seldom collected and rare (Hobbs and Lilly, 1954), indicating critical, unknown survival conditions suppressing its population size.

(2) Soil nesting habit, which restricts feasibility of population transfer to alfalfa fields requiring pollination.

(3) Late adult emergence, beginning in the last week in July and ending early in September, severely restricts the blossoming period during which the flower can be fertilized to permit the seed to develop to maturity before autumn frost (August 5-15) (Hobbs and Lilly, 1954). *M. parallela* appears to have coevolved with such Compositae as *Helianthus* spp. and *Grindelia squarrosa*, and the adult flight period of this bee coincides with the blossoming period of these plants.

(4) There is no record of *M. parallela* exhibiting a positive affinity to foraging upon alfalfa. In Alberta, Hobbs and Lilly (1954) noted its preference for composite flowers; however, 8 specimens were taken on an alfalfa field when competing flowers were reduced to a minimum by 2, 4-D spraying.

(5) A secondary plant such as *Spirea vanhouttei* (Spirea) might be required for cell construction, although the use of the leaves of *Trifolium repens* (White Clover) indicates that

it will utilize leaves which are fairly closely related to alfalfa.

Subgenus SAYAPIS Titus

Figures 34-37, 64, 70, 83

Sayapis, Titus, 1905:154 (new name); Mitchell 1934:301 (subgeneric classification)

FEMALES. Length 11-19 mm. Apical area of clypeus with elaborate and conspicuous excisions and protruberances. Mandibular inner cutting edge absent, or weakly developed as a rounded or small carinate ridge, far below the apices of the denticles, which can only be seen with the mandible opened; ridge of the inner cutting edge extending from inner tooth to the base of the second tooth. Secondary, bevelled cutting edge, extending from the outer side of the 3rd tooth, occupying about half the semicircular emargination between the 2nd and 3rd denticles. Abdomen approximately parallel-sided; gradular carinae on terga III and IV developed and narrowly overhanging the gradular grooves; white apical fasciae present and moderately dense on terga II-V, sometimes interrupted medially on the more anterior terga. Tergum VI strongly constricted apically; in lateral view, convexly rounded on basal two-thirds, then strongly curved to become flattened and horizontally aligned on apical third. Pilosity on tergum

VI highly variable in structure and colour, ranging from the primitive condition in which the pilosity closely resembles the slender black to brown hairs on the discs of anterior terga III-V (with the integument only slightly obscured beneath), to almost entirely clothed in dense, elongate and appressed white plumose hairs (which conceal most of the integument beneath).

MALES. Length 11-14 mm. Apex of front tibia and tarsi stramineous to white, conspicuously contrasting with the dark brown to black integument on the rest of the body; basitarsus elaborate, with a polished longitudinal boat-shaped excavation along the anterior side extending beyond the apex of the segment. Front coxa with 1-5 distinctive, elongated, robust, reddish bristles, just in front of the long, rounded front coxal spine. Mandible 3-dentate with the apex of the middle tooth about equidistant between the inner and outer teeth. Ventral mandibular tooth forked apically with a semicircular emargination separating the two prongs; the emargination occupied with a dense elongate brush of setae which coincides with the hypostomal concavity. Glabrous and polished hypostomal concavity narrowed by a long overlapping hypostomal tubercle on the posterior side; outer side of concavity lateral to the tubercle greatly expanded and extended posteriorly; posterior side of tubercle with elongate pubescence which is shorter and more dense toward the apex. White apical fasciae present on terga II-V, sometimes interrupted medially on the more anterior terga; translucent membranous band beneath the apical fasciae on terga II-IV usually extending a little beyond the apex of the apical fasciae. Gradular groove on tergum IV with a dense, wide band of short plumose hairs along the base, resembling an apical fascia. Pilosity on tergum VI deviating from the pilosity on terga III-V by a greatly increased proportion of short subappressed hairs and a much reduced proportion of elongate erect hairs which arise from conspicuously enlarged, polished and probably sensitized sunken craters. Apical margin of tergum VI with the lateral tubercle undeveloped, median tubercle represented by a reflexed submedian carina.

COMMENT. Females belonging to Sayapis can be distinguished by the elaborated emarginations and protruberances on clypeus (Figs. 34, 37); and the weakly developed inner cutting edge on the mandible which is situated below the denticles and can be seen only with the mandible opened.

Males can be recognized by the elongate and robust, 1-5 reddish bristles just anterior to the long, round, coxal spine; or the apically forked ventral mandibular tooth.

BIOLOGY. Species within the subgenus Sayapis appear to have developed from a Chelostomoides prototype with the inner mandibular cutting edge undeveloped or weakly developed as a ridge far below the denticles. The parallel-sided abdomen which is strongly constricted apically, also indicates their structural similarities.

The undeveloped or weakly developed inner cutting edge of the mandible does not facilitate the specialized leaf-cutting practises unique to leaf-cutter bees. Thus, within these groups there is evidence of experimentation and progressive specialization in the leaf-cutting and cell construction process. In Chelostomoides, which is probably an ancient group, that is widely distributed around the world, resin instead of leaves is used in cell construction (Hicks, 1927). In Sayapis a somewhat similar cell construction process is followed. Cells are made within the pithy core of plant stems such as sumac (Medler, 1964). The principal matrix consists of chewed leaves, soil and leaf pieces, with some approximately circular sections of leaves incorporated into the partitions between the cells and opening to the outside.

In more primitive groups, such as M. montivaga sections of petals which are easier to cut but make less substantial partitions and walls due to drying and warping are sometimes used in cell construction. Precise sections of oblong leaves for construction of the cup, and circular leaves which firmly fit in to seal the cup, are cut from firm leaves by more highly evolved leaf-cutter bees with well developed inner and outer cutting edges (Fig. 5).

Key to Species of the Subgenus Sayapis

Females

1. Robust hypostomal tubercle projecting from the postero-ventral side of head (Fig. 35).......*M. pugnata* (p. 316)
   Hypostomal tubercle absent..................................2

2. Clypeus laterally, with a prominent, parallel-sided, spatulate protruberance. Legs uniformly ferruginous (Fig. 37)...........................*M. fidelis* (p. 325)
   Clypeus laterally, with a short, tapered protruberance. Apices of tibiae and tarsi ferruginous, conspicuously contrasting with the dark, basal sections of their tibiae............................*M. mellitarsis* (p. 328)

Males

1. White apical fascia on fifth tergum absent. Boat-shaped dilation on front basitarsus extending to base of fourth tarsal segment............*M. mellitarsis* (p. 329)

   White apical fascia on fifth tergum present. Boat-shaped dilation not extending to base of fourth tarsal segment...2

2. Brush of dark bristles on ventral rim of boat-shaped excavation on front basitarsus, present only on the basal third of rim. Dorsal side of boat-shaped dilation covered with dense appressed pubescence apically.............................*M. pugnata* (p. 317)

   Brush of dark bristles on ventral rim of boat-shaped excavation extending throughout the entire length of front basitarsus. Dorsal side of boat-shaped dilation, mostly glabrous and polished apically..... ....*M. fidelis* (p. 326)

Opposite p. 316

Fig. 34. M. pugnata, F. Face view.

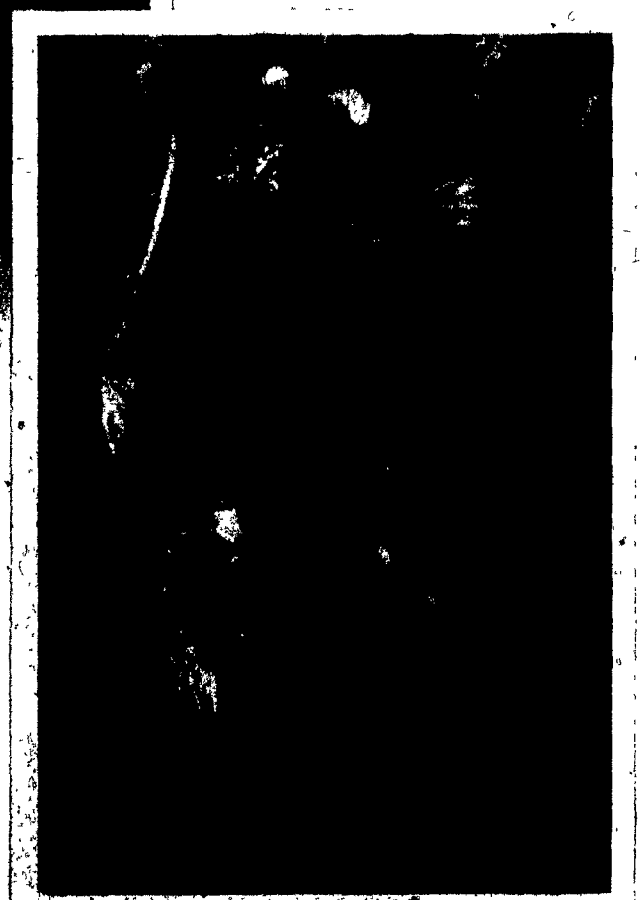


Fig. 35. M. pugnata, F. Lateral view of head.

MEGACHILE (SAYAPIS) PUGNATA SAY

Figures 34, 35, 36, 69, 83; Map 26

Megachile pugnatus Say, 1837:407 (new species)

Megachile (Sayapis) pugnata pugnata; Mitchell, 1962: 179 (description, distribution and flower records); Medler, 1964:918 (biology).

FEMALE. Length 11-19 mm. Head approximately cubical in lateral view; vertex and cheeks greatly extended posteriorly; distance between the lateral ocellus and edge of vertex about twice as great as the distance between the lateral ocelli. Conspicuous robust hypostomal tubercle, distantly separated from lower mandibular condyle by an expanded, subpolished and thinly pubescent hypostomal concavity. Mandible greatly elongated; its length from lower mandibular condyle to apex, greater than the maximum length of eye; cutting side of mandible. 4-dentate, sometimes with a weakly developed 5th tooth between the inner and 3rd denticles. Clypeus short and strongly protruding anteriorly, with a truncate median tubercle, bordered on each side by a rounded emargination and a blunt, subpolished lateral tubercle (Fig. 34); clypeal field below the submedian transverse protruberances, subpolished with sparsely scattered hairs; area above the protruberance strongly punctate with white or brown hairs

Opposite p. 317

Fig. 36. M. pugnata, M. Face view.

Fig. 37. M. fidelis, F. Face view.

arising from the punctures. Labrum elongated, nearly twice as long as wide at base; apical border concave medially. Abdomen elongate and approximately parallel-sided in dorsal view. Terga II-V usually with short brown to black pilosity on discs; white apical fasciae usually distinct. Pilosity on tergum VI highly variable in structure and colour; ranging from the primitive condition in which it closely resembles the black to brown pilosity on II-V with the integument only slightly obscured beneath (except along the apical rim) to mostly clothed with white, subappressed plumose hairs which largely conceal the integument. Scopa pale orange on sterna II-V; variously infuscated to black on sternum VI, terminating in a dense fringe of brown setae along the apical rim. Apex of sternum VI usually with a small median emargination.

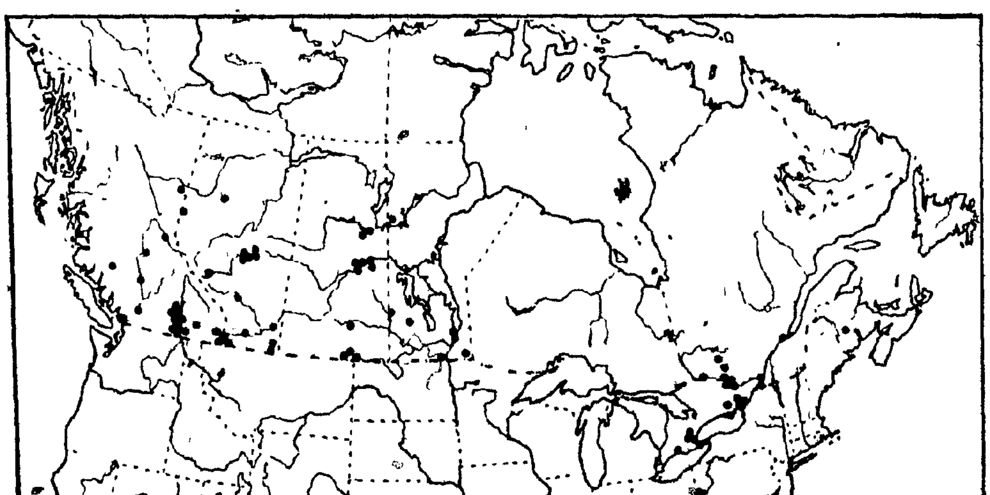
MALE. Length 11-14 mm. Elaborate, boat-shaped excavation on the anteroventral side of front basitarsus extending to near the base of the 4th tarsal segment; dorsal side of extension clothed with dense appressed pubescence; ventral rim bordering the excavation with a dense fringe of brown setae extending for only a third of the proximal length of basitarsus; distal section of ventral rim narrowly inflexed to overlie the excavation. Dense, elongate, fringe of pubescence along posterior rim on front tarsal segments 1-4 not clubbed apically. Apical white fascia on tergum V present. Apical segment of flagellum weakly flattened and dilated.

COMMENT. Females of M. pugnata can be readily recognized by the robust hypostomal tubercle on the postero-ventral side of the head; or the unusually elongate mandible which is longer than the maximum diameter of eye; or the broad polished and thinly pubescent hypostomal cavity between the mandible and hypostomal tubercle.

Males can be distinguished by the elaborate front basitarsus with a prominent fringe of brown setae on the basal third of the ventral rim surrounding the boat-shaped concavity.

Genotypically and phenotypically, this is a highly variable species, exhibiting both spatial and populational variations. Length of female varies from nearly 11 to 19 mm. indicating that some females may be nearly twice as large as others. These females do not build cells in which ovate sections of leaves of predetermined length are brought in to construct the cup-shaped cell, which is later provisioned approximately two-thirds full with pollen and nectar and then capped with circular leaves cemented around the rim. Instead, they merely use partitions between the cells in the tunnels. It may be that availability of suitable flowers and fluctuating weather conditions may affect the depth of pollen and nectar provisioned in the tunnel with the accompanying genetic plasticity for viable larvae and females to develop upon greatly reduced supplies of nutrient, resulting in remarkable phenotypic variation within a population. A continuum of spatial variations are also evident with predominant melanistic pubescence (particularly noticeable on the sixth tergum present on specimens developing in cool, damp regions, and xanthic pubescence in hot dry regions.

DISTRIBUTION. Widely distributed in North America, extending as far north as the Northwest Territories and as far south as Texas; in Canada it occurs from the east to the west coast. Localities from which it was collected in Canada are as follows (Map 26):



Map 26. Canadian distribution of *Megachile pugnata*.

Nova Scotia: Kings County, 15 July 1931, Centaurea; 29 July 1931, 1F, Cirsium. New Brunswick: Fredericton, 20 Sept. 1948, 1F. Quebec: Aylmer, 21 June 1915, 2M. Forestville, 11 Aug. 1950, 1M. Fort Coulonge, 18 July 1919, 1F; 23 July 1919, 1M. Gatineau Park, 11 Aug. 1948, 1F. Hemmingford, 19 July 1925, 1F. Ile de Montreal, 19 Aug. 1906, 1F. Kazabazua, 3 July 1913, 1F; 8 July 1913, 1M. Lowe, 2 Aug. 1945, 2F, 1M, Burdock. Quebec City, 8 Aug. 1914, 1F. Terrebonne, Aug. 1926. Ontario: Arkell, 3 Aug. 1951, 1F; 22 July 1974, 1F. Avonmore, 14 July 1939, 2M. Carp, 8 Aug. 1950, 1F. Constance Bay, 23 July 1969, 1M. Eramosa, 29 July 1959, 1F. Guelph, 31 July 1951, 1F, Sunflower; 12 June 1967, 3F, 2M, Ex soda straw; 17 June 1969, 1F. Marmora, 10 July 1952, 3M; 13 July 1952, 1M; 20 July 1957, 1M. Ottawa, 13 Aug. 1902, 1F; 1 July 1913, 1F, 2M; 1 July 1913, 1M; 8 July 1913, 1M; 11 July 1913, 1F, 2M; 15 July 1913, 1F; 15 July 1913, 1sl; 15 July 1913, 1F; 22 July 1913, 1F; 26 July 1913, 1F, 1M; 27 July 1913, 1M; 21 July 1954, 1F, Chicory. Perth, 15 Aug. 1950, 1F. Puslinch, 30 July 1953, 1M. Rockwood, 3 Aug. 1951, 1M, Sow Thistle. Spencerville, 14 Aug. 1939, 1F. St.Thomas, 23 Aug. 1924, 1F. Sudbury, 1888, 1F; 25 Aug. 1889, 1F; 1890, 1F. Trenton, 12 Aug. 1906, 1F. Thornloe, 9 Aug. 1917, 1F. Toronto, 25 July 1891, 1M; (no date), 1F, 1M. Manitoba: Altona, 17 July 1953, 1M, Gaillardia. Aweme, 20 July 1914, 1F;

13 July 1916, 1F; 15 July 1916, 1F, 1M; 9 July 1917, 1F; 20 June 1925, 1M; 23 July 1925, 1F; 1 Aug. 1925, 1F. Bogey Creek, 5 July 1962, 1F. Erickson, 29 July 1976, 1F; 2 Aug. 1976, 1F. Sprague, 9 July 1948, 1M. Teulon, 24 July 1922; 17 July 1923. Wanless, 20 July 1953, 1M, Nest in poplar log. Winnipeg, 6 Aug. 1936, 1F. Winnipeg Beach, 16 July 1916. Saskatchewan: Love, 3 July 1943, 2M, Hydrophyllum; 27 July 1944, 1F, Sow Thistle; 29 July 1944, 3F, Sow Thistle in Alfalfa field. Lisieux, 4 Aug. 1955, 1F. Nipawin, 7 Aug. 1952, 1F. Radisson, 29 July 1907, 1M. Rock Glenn, 2 Aug. 1955, 1F; 2 Aug. 1955, 1F. Snowden, 28 July 1944, 1F, 1M, Sow Thistle; 28 July 1944, 1F, Agoseris. Torquay, 14 Aug. 1955, 1F. White Fox, 4 July 1941, 1M, Dandelion, pub T5-golden; 27 June 1944, 1M; 4 July 1944, 2F, Dandelion; 21 July 1944, 1M, Sweet Clover. Alberta: Beaverlodge, 25 June 1931, 1F; 31 July 1931. Cypress Hills, 10 Aug. 1939, 1F; 13 July 1949, 1F, Sweet Clover. Delburne, 17 Aug. 1962, 1M. Edmonton, 11 Aug. 1916, 1M; 21 Aug. 1916, 1M; 21 Aug. 1916, 1F; 26 Aug. 1950, 1F. High Prairie, 10 July 1931, 1F. Lamont, 2 Aug. 1972, 1F; 3 Aug. 1972, 1F; 7 Aug. 1972, 1F; 15 Aug. 1972, 1M. Lethbridge, 28 June 1914, 1M; 22 Aug. 1916, 1F; 6 July 1921, 1M; 9 Aug. 1921, 1F; 2 Sept. 1948, 1F, Gumweed; 12 Aug. 1948, 1F, Gumweed; 15 Aug. 1948, 1F, Gumweed; 8 July 1956, 1F. Medicine Hat, 17 June 1917, 1M; 23 Aug. 1919, 1F, 2M; 16 Aug. 1924, 2M. McMurray, 17 July 1953, 1M. Nordegg, 5 Aug. 1921,

1F. Opal, 9 Aug. 1955, 1F. Orkney Dist, 2 Aug. 1930, 1M. Prairie Bluff, 7 July 1970, 1M; 19 July 1970, 1F, _Erigeron speciosus_; 24 July 1970, 1F; 24 July 1970, 1M, _Erigeron speciosus_; 5 Aug. 1971, 1M; 27 July 1972, 1F; 27 July 1975, 1F. Shaghnessy, 2 May 1967, 1F, emerged in laboratory. Wabamun, 23 June 1936, 1M. Waterton, 9 Aug. 1927, 1F. Wild Horse, 10 Aug. 1927, 1F. _British Columbia_: Armstrong, 8 July 1931, 1F. Crows Nest, 23 July 1926, 1F. Fitzgerald, 21 Aug. 1921, 1F. Fort Steele, 22 July 1915, 1F. Invermere, 30 June 1914, 1M; 14 Aug. 1915, 2F. Kamloops, 27 July 1937, 1M; 25 July 1943, 1F; 24 Aug. 1943, 1F. Kaslo, 11 June 1905, 1F; 23 June 1906, 1F; 10 July 1906, 2F; 4 July 1916, 1M; 3 Aug. 1916, 1F. Kinistino, 10 July, 1F. Lillooet, 9 June 1921, 1F; 30 June 1926, 1F (SetonLake). Naramata, 21 June 1919, 2M. Okanagan Falls, 15 June 1953, 1M. Peachland, 21 July 1909, 1F, 1M; 6 Aug. 1909, 1F, 1M. Penticton, 21 June 1919, 1F, 1M; 7 Sept. 1919, 1F. Quesnel, 12 Aug. 1946, 3F. Robson, 30 Aug. 1948, 1F. Rolla, 21 July 1927, 2F. Salmon Arm, 4 July 1914, 2M; 4 July 1914, 1F. Saratoga Beach, Oyster River, Vancouver Island, 7 July 1933, 1F. Smithers, 4 Aug. 1944, 1F, 1M, det. Mitch. Summerland, 9 Aug. 1916, 2F; 10 Aug. 1916, 1F; 10 Aug. 1916, 1F, 1M; 10 Aug. 1916, 1F; 20 July 1917, 1F. Thompson, 8 Aug. 1914, 1F. Vancouver, 25 Aug. 1902, 1F. Vernon, 25 July 1917, 1F, 1M; 23 July 1920, 2F; 26 July 1920, 3F; 27 July 1920, 5F; 28 July 1920, 1F; 3 Aug.

1920, 1F, 1M; 6 Aug. 1920, 1E; 9 Aug. 1920, 1sl; 26 July 1923, 1F. Walhachin, 27 June 1918, 1F; 27 June, 1F; 16 Aug. 1942, 3F. Wasa Lake, 2 July 1960, 2F; 2 July 1960, 1M. Williams Lake, 11 July 1938, 1F. Northwest Territories: Fort Smith, 14 July 1950, Thistle; 15 July 1950, 2F; 23 July 1950, 1F.

FLOWERS VISITED. Agoseris (L); Arctium (Burdock), (L, M); Asclepias (Milkweed), (M); Aster (Aster), (M); Blephilia (Wood-Mint), (M); Brauneria (Purple Coneflower) (M); Carduus (Plumeless Thistle), (M); Centaurea (Star Thistle), (L); Chrysanthemum (Chrysanthemum), (M); Cicuta (Water-Hemlock), (M); Circium (Thistle), (L, M); Coreopsis (Tickseed), (M); Dianthera (Water-Willow), (M); Erigeron speciosus (Showy Daisy), (L); Gaillardia (Blanket-Flower), (L); Grindelia (Gumweed), (L); Helianthus (Sunflower), (L, M); Hydrophyllum (Waterleaf), (L); Lepachys (Prairie-Coneflower), (M); Melilotus (Sweet Clover), (L, M); Monarda (Horsemint), (ML); Nepeta (Catmint), (M); Rudbeckia (Coneflower), (M); R. Serotina (Black-eyed Susan), (M ML); Silphium (Rosinweed), (M); Sonchus (Sow Thistle), (L); Taraxacum (Dandelion), (L, M); Trifolium (Clover), (M); Verbena (Vervain), (M); Verbesina (Crown-Beard), (M); Vernonia (Ironweed), (M); Veronica (Speedwell), (ML); Veronicastrum (Culver's Physic), (ML).

BIOLOGY. In Manitoba, Cole (1953) found a nest of *M. pugnata* in a poplar log. Medler (1964) in Wisconsin, succeeded in getting females to nest in trap nests made from bundles of sumac twigs. The female that inhabited the pithy core of the twigs did not construct cup-shaped cells (Fig. 4) as most other species of *Megachile*. Instead, only partitions, 2-3 cm. thick, made from circular leaf sections, chewed leaf and soil were constructed. Provisions of pollen and nectar were placed against the partition and enclosed within the sumac walls in cells about 15 mm. in length. A vestibule consisting of an empty elongate cell was generally fortified with several layers of leaf sections alternated with chewed leaf fibre and soil, to form a plug 3-6 mm. thick. Usually, 3-4 cells were provisioned within each twig. The mature larva constructed a semi-parchment-like cocoon in which it overwintered. During the following summer, 17-19 days at 21° were required for the adult to emerge.

PARASITES. From the specimens attracted to the sumac trap nests, Medler (1964), reared the following: Host: *M. pugnata* - 25; Parasites: *Coelioxys alternata* (Say) - 3; *Leucospis affinis* (Say) - 2; *Melittobia chalybii* Ashm. - 209 (small chalcid parasites produced from 1 bee).

ALFALFA POLLINATING POTENTIAL. Although the flight period of M. pugnata is relatively early, with adults collected from mid-June extending to September, there are no published records of it being collected on alfalfa.

In their study of alfalfa pollinators, Hobbs and Lilly (1954) in Alberta and Pengelly (1955) in Ontario, stated that it was seldom observed and that none were found pollinating alfalfa.

MEGACHILE (SAYAPIS) FIDELIS CRESSON

Figures 37, 70; Map 27

Megachile fidelis Cresson, 1878:120 (new species)

Megachile (Sayapis) fidelis; Mitchell, 1937:180 (description, distribution and flower records).

FEMALE. Length 11-13 mm. Mandible 4-dentate with the semicircular emargination between the 3rd and 4th denticles narrower and deeper than the emargination between the 2nd and 3rd denticles (Fig. 70). Apex of clypeus with a polished beak-like median protruberance, accentuated by a deep emargination on each side; a distinctive dorsoventrally flattened and laterally parallel-sided protruberance borders the emargination laterally; the lateral protruberance extends anteriorly then curves ventro-medially. Labrum sub-parallel laterally and truncate apically; more than half as wide as long. Gradular carina on tergum V weakly developed or obliterated medially. Legs uniformly ferruginous, contrasting with the dark brown to black integument on the rest of the body.

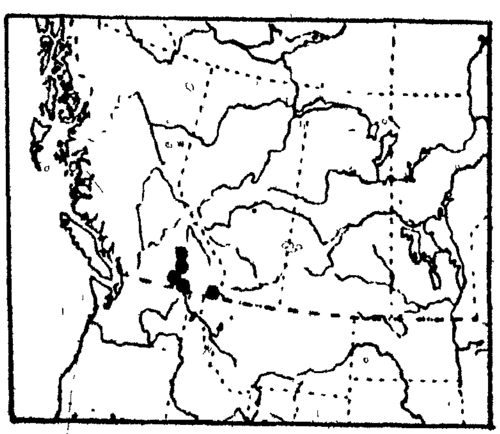
MALE. Elaborated boat-shaped excavation on the antero-ventral side of front basitarsus extending to just a little beyond the base of the 3rd tarsal segment; apical section of dorsal side of extension mostly glabrous and subpolished; ventral rim bordering the excavation with a dense fringe of brown setae extending throughout the entire length of basitarsus; apical border of extension emarginate just in front of 2nd tarsal segment. Dense, elongate fringe of pubescence along posterior rim of front tarsal segments 1-4 clubbed apically. White apical fascia on tergum V present. Apical segment of flagellum not flattened or dilated.

COMMENT. The female can be recognized by the distinctive protruberances and emarginations at the apex of clypeus with the beak-like median and the parallel-sided lateral protruberance; or, the uniformly ferruginous legs contrasting with the dark integument on the rest of the body; or, the 4-dentate mandible, with a narrower and deeper semicircular emargination (without an inner cutting edge) between the 3rd and 4th denticles, than the emargination between the 2nd and 3rd denticles.

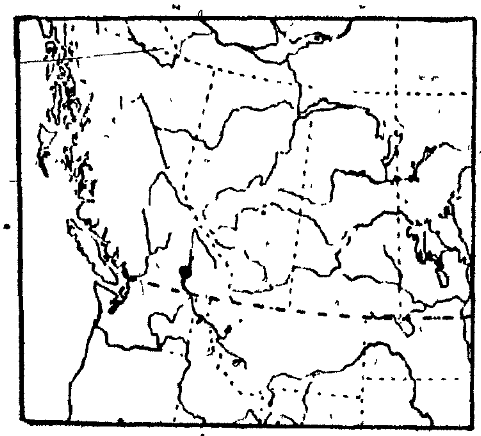
The males can be distinguished by the elaborated boat-shaped structure on front basitarsus with a row of dense brown bristles extending throughout the length of the ventral rim bordering the excavation; or, the presence of 1-5 robust reddish bristles anterior to front coxal spine, combined with the glabrous and subpolished dorsal side of the apical extension on front basitarsus.

DISTRIBUTION. British Columbia: Creston, 14 Aug. 1916, 1M. Okanagan Falls, 21 July 1917, 1F. Sicamous (Shuswap Narrows), 31 Aug. 1943, 1F. Summerland, 9 Aug. 1916, 1F. Vernon, 13 Aug. 1904, 1M; 23 July 1920, 1M; 27 July 1920, 2F; 3 Aug. 1920, 1F; 2 Sept. 1926, 1F; 24 July 1947, 1F. (Map 27).

27.



28.



Map 27. Canadian distribution of Megachile fidelis.
Map 28. Canadian distribution of Megachile mellitarsis.

FLOWERS VISITED. Aster (M); Cleome serrulata (Stinking-Clover), (M); Cosmos (M); Daucus carota (Carrot), (M); Verbena (Vervain), (M).

ALFALFA POLLINATING POTENTIAL. There is no published record of M. fidelis pollinating alfalfa. The species is rarely collected; data labels on specimens show that it has a late flight period extending from July 26 to Aug. 31, indicating that even if the species were more abundant and preferred foraging on alfalfa, its delayed flight period would curtail its usefulness as a pollinator of alfalfa.

MEGACHILE (SAYAPIS) MELLITARSIS CRESSON

Figure 68; Map 28

Megachile mellitarsis Cresson, 1878:121 (new species)
Megachile (Sayapis) mellitarsis; Mitchell, 1937:194 (description, distribution and flower records).

FEMALE. Length 13-16 mm. Mandible 4-dentate, with subequally deep semicircular emarginations on each side of the 3rd tooth; emargination between the 3rd and 4th denticles not occupied by an inner cutting edge; emargination between the 2nd and 3rd denticles with a bevelled edge extending from the outer side of the 3rd tooth, to occupy approximately half the excision (Fig. 68). Apex of clypeus viewed ventrally with a posterior and anterior ridge; anterior ridge arcuate on each side of the middle, forming a subpolished, semiovate field with a couple of enlarged punctures out of which arises a dense cluster of setae; clypeus in face view, with the anterior rim forming a rounded median, and a more arcuate lateral protruberance. Labrum subparallel, relatively short, 1.5 times as long as wide. Apices of tibiae and tarsi ferruginous, contrasting with the dark color on the more basal part of the legs. Gradular carina on tergum V well developed, overhanging the gradular groove along its base.

MALE. Length 11-12 mm. Elaborate boat-shaped structure on antero-ventral side of front basitarsus extending to 4th tarsal segment; ventral rim bordering the excavation inflexed and expanded apically to overlie the lower part of the concavity. Apical segment of flagellum flattened and dilated. Apices of the middle and hind tibiae and tarsi ferruginous, conspicuously contrasting with the dark colour on the more basal part of their legs. White apical fasciae present on terga II-IV, absent in tergum V.

COMMENT. The female can be distinguished by the ferruginous apices of the tibia and tarsi; or, the posterior and anterior ridge on the ventral side at the apex of the clypeus, with the anterior ridge separated on each side of the middle to form a conspicuous, polished, semiovate field; in face view, the anterior ridge forms a broadly rounded median and a more acute lateral protruberance.

The male can be separated by the ferruginous tibial apices and tarsi of middle and hind legs; or, by the 3 or 4 elongate robust reddish bristles just in front of the long, rounded front coxal spine, combined with the absence of a white apical fascia on tergum V.

DISTRIBUTION. British Columbia south to California and east to Colorado. In Canada, one female was collected at Westbank, B.C. 20 July 1919 (Map 28).

FLOWERS VISITED. Aster (Aster), (M).

ALFALFA POLLINATING POTENTIAL. Even if M. mellitarsis were more abundant, its foraging preference would probably correspond with that of the other species in the subgenus Sayapis, which exhibit a positive preference for flowers in the family Compositae.

V. PARASITES AND PREDATORS OF MEGACHILE

Figures 84 - 103

Over thirty parasites and predators have been reported to destroy up to nearly 80% of the potential population of leaf-cutter bees. Higher levels of parasitism and predation are likely with increased host populations of alfalfa pollinators. The following keys are designed to differentiate most of the notorious enemies of these bees (Fig. 84). Following the keys, brief notes are provided on the biology of the parasites and predators.

1. Mandibles absent, mouthparts coiled (Fig. 103)(Lepidoptera--Moths).............................<u>Vitula</u> <u>edmundsii</u> Pack

   Mandibles present, mouthparts not coiled.................2

2. Thorax and abdomen separated by 2 or 3 strong constrictions, with 1 or 2 elevated nodes between the constrictions (Fig. 95)(Ants)................Formicidae

   Thorax and abdomen not separated by a constriction, or separated by one constriction, without any elevated nodes between thorax and abdomen......................3

3. Anterior pair of wings membranous and translucent. Thorax and abdomen separated by a constriction (Figs.85-94) (Hymenoptera)....................................4

Anterior pair of wings not transparent, but thickened and modified to form protective covers. Thorax and abdomen not separated by a constriction (Figs.96-102)...........7

4. Front wing with veins and cross-veins enclosing cells (Figs. 94-96)..5

Front wing with at most, one short vein projecting from the anterior margin of the wing (Figs.88-94)............. ....Chalcidoidea (p.339)

5. Eyes clothed with erect hairs, which are much longer than the distance which separates them. Integument on abdomen uniformly black, usually with white apical fasciae (Fig.85).........................Coelioxys (p.333)

Eyes bare or with sparsely spaced, scarcely perceptible hairs. Abdomen maculated or coloured and irredescent (Figs. 86,87)..6

6. Ventral aspect of abdomen strongly concave beneath. Body strikingly irredescent (Fig.87)...............Chrysididae

Ventral aspect of abdomen convex beneath. Body masculated (Fig. 86)..........................Sapyga pumila Cress.

7. Apex of abdomen with a pair of prominently protruding forcep-like appendages. Antenna long and filiform (Dermaptera, Earwigs)..............Forficula auricularia

Apex of abdomen without a pair of promenently protruding forcep-like appendages (Figs. 96-102) (Beetles)...Coleoptera(p.341)

Key to Species of Coelioxys

Sixth tergum tapered and pointed apically. Antenna 12 segmented...................................Females(p.333)

Apex of sixth tergum emarginate medially, usually with 3 pairs of prominent tubercles projecting posteriorly. Antenna 13 segmented.........................Males(p.336)

Females

1. Clypeus inflexed apically....................C. sayi Robt.

Apex of clypeus flat and truncate or convex apically......2

2. Lateral margin of sixth sternum incurved preapically and notched, or uniting with an approximately parallel sided and longitudinally striated ventral projection, which extends a little beyond the incurved junction..........3

Lateral margin of sixth sternum with an evenly convex curve extending to the extreme apex; ventral aspect of sixth sternum not longitudinally striated apically......10

3. Gradular groove on second tergum entirely effaced medially. Sixth tergum without a distinctly depressed postmedian lateral sulcus.............. C. funeraria Smith

Gradular groove on 2nd tergum, distinctly depressed across the entire tergum. Sixth tergum with a distinctly depressed, postmedian lateral sulcus...........4

4. Sixth tergum abruptly narrowed near the middle, forming a prominent overhanging carinate angulation laterally...5

Sixth tergum gradually tapered apically, without a distinctly overlapping angulate lateral carina.............6

5. Tarsi ferruginous, distinctly brighter than the piceous basal leg segments................... C. rufitarsus Smith

Legs uniformly ferruginous............. C. atlantica Mitch.

6. Legs beyond the coxae ferruginous. Mesopleurum not obscured by pubescence medially, hairs usually shorter than the diameter of the puncture...... C. octodentata Say

Legs mostly piceous to black. Mesopleurum usually obscured by pubescence medially, hairs longer than the diameter of the puncture...............................7

7. Sixth tergum with a sharp carina running parallel with the lateral margin to near the apex of the lateral sulcus..8

Sixth tergum without a carina just above the lateral margin, or with a weakly rounded basal ridge...........9

8. Basal two-thirds of fifth sternum polished and rufous. Front coxal spine projecting as a prominent tubercle..C. grindeliae Ckll.

Basal two-thirds of fifth sternum black and opaque. Front coxal spine weakly projecting as a carinate ridge....................................C. sodalis Cress.

9. Apical margin of clypeus straight. Sixth tergum with a densely punctate and opaque concave area between the lateral margin and the dorso-lateral ridge...C. porterae Ckll.

Apical margin of clypeus convex. Sixth tergum without a dorso-lateral ridge at midlength, and without an opaque concavity between the ridge and the lateral margin....................................C. moesta Cress.

10. Apical half of sixth tergum strongly depressed and opaque laterally, with the depression bearing dense, short, silver hairs and scattered, erect, long, golden hairs; tip of sixth tergum usually abruptly upcurved...C. moesta Cress.

Apical half of sixth tergum weakly depressed near the apex and uniformly polished throughout the entire tergum; a few erect golden hairs present only along the lateral margin; tip of sixth tergum not abruptly upcurved. Posterior margin of scutellum with an upturned carina...11

11. Legs and tegulae piceous to blackish........................
....C. alternata alternata Say

Legs and tegulae pale ferruginous.........................
.................................C. alternata wisconensis Ckll.

Males

1. Lateral fovea on disc of second tergum (situated between gradular groove and apical rim), present as a small pit, or shallow depression, or deep elongate slit.......2

Disc of second tergum without a distinct lateral pit, depression or slit (between the gradular groove and apical rim)..8

2. Fovea on second tergum long and deep, its length greater than the distance from the anterior border of the fovea, to the apex of the tergum; fovea bordered by an impunctate subpolished rim..................C. rufitarsus Smith

Fovea on second tergum much shorter than the distance from the anterior border of the fovea to the apex of the tergum; fovea usually not completely surrounded by an impunctate subpolished rim...........................3

3. Fovea on second tergum weakly to strongly depressed; a narrow, impunctate slope separates the depressed fovea (with minute slender hairs) from the elevated posterior disc (with more robust hairs)........................4

Fovea on second tergum represented by an elongate to small ovate pit, not depressed below the disc............5

4. Transverse gradular groove on second tergum deeply depressed across the entire width of the tergum; fovea shallowly depressed and inconspicuous..*C. porterae* Ckll.

Transverse gradular groove on second tergum obliterated medially; fovea more distinctly depressed and conspicuous................................*C. funeraria* Smith

5. Transverse gradular groove on second tergum nearly obliterated medially; when present the shallow transverse groove is much closer to the posterior than to the anterior edge of the tergum, with the elevated area just posterior to the groove polished and impunctate..*C. sayi* Robt.

Gradular groove on second tergum deeply depressed and distinct across the entire width of the tergum; punctures on elevated area just posterior to the groove not separated by more than the diameter of puncture...6

6. Fovea on second tergum elongate; its length subequal to the distance from the gradular groove to the apex of the tergum, medially.................. C. octodentata Say

Fovea on second tergum reduced and short (sometimes absent and may be keyed through couplet 8); length of fovea much shorter than the distance from the gradular groove to the apex of the tergum, medially..............7

7. Legs and tegulae dark brown to black........C. moesta Cress

Legs and tegulae ferruginous............C. atlantica Mitch.

8. Transverse gradular groove on second tergum completely obliterated medially....................................9

Gradular groove on second tergum depressed across the entire width of the tergum..............................11

9. Anterior concavity of first tergum bordered by an elevated, subcarinate rim................C. modesta Smith

Concavity of first tergum not bordered by an elevated rim...10

10. Legs and tegulae piceous to black..........................
...............................C. alternata alternata Say

Legs and tegulae mostly ferruginous.......................
.......................C. alternata wisconsinensis Ckll.

11. Crowded punctures on dorso-lateral area of second tergum, just posterior to the gradular groove, much more dense than on a corresponding area on the second tergum........ ....C. sodalis Cress.

Punctures on dorso-lateral area of second tergum, just posterior to the gradular groove, subequally distant to punctures on a corresponding area on the third tergum...12

12. Transverse gradular depression on second tergum much closer to base than to apex. Apical fascia on fifth tergum, not interrupted medially. Fovea absent.......... ....C. grindeliae Ckll.

Gradular depression on second tergum closer to apex than to base. Apical fascia on fifth tergum broadly interrupted medially. Reduced fovea sometimes present....... ....C. moesta Cress.

Key to Species of Chalcidoidea

1. Minute, non-metallic brownish species, scarcely 2 mm long. Male with abbreviated wings, incapable of flight (Fig. 100); scape greatly dilated apically. Female, with antenna inserted low on face; distance from base of scape to apical margin of clypeus, subequal to the diameter of the antennal socket; scutellum with a pair

of distinct parallel longitudinal furrows (Figs. 90, 91)..............................<u>Melittobia</u> <u>chalybii</u> Ashm.

Slightly larger, maculated or metallic species, usually more than 3 mm long. Front wing extending to near the apex of abdomen in both males and females. Scape in male, not greatly dilated apically. Female, with antenna inserted at or a little below the middle of face; distance from base of scape to apex of clypeus several times as great as the diameter of antennal socket. Scutellum without a pair of parallel longitudinal furrows..2

2. Body maculated, black with yellow bands. Hind femur in both males and females greatly enlarged with prominent teeth along the ventral border (Figs. 88, 89)............ ....<u>Leucospis</u> <u>affinis</u> Say

Body metallic, blue or green on head and thorax, and either blue or green or maroon on abdomen. Hind femur not greatly enlarged and without prominent teeth, or with at most one tooth along the ventral border (Figs. 92-94)... 3

3. Body and hind femur with greenish reflections. Hind femur with a distinct preapical tooth on the ventral side. Hind tibia with two apical spurs. Ovipositor in female extending beyond apex of abdomen by a distance

subequal to the length of abdomen (Figs. 92,93)..........
.............................Monodontomerus obscurus Westw.

Head and thorax with bluish reflections; abdomen and hind femur maroon to reddish. Hind femur without a preapical ventral tooth. Hind tibia with one apical spur. Ovipositor when normally retracted not extending beyond apex of abdomen (Fig. 94)....................4

4. Distal margin of front wing bordered by a fringe of hairs (sections of the fringe of hairs sometimes rubbed off). Postmarginal vein subequal to the length of marginal vein..............................Pteromalus venustus Walker

Distal margin of front wing not bordered by a fringe of hairs. Marginal vein about twice as long as postmarginal vein (Fig. 94).....Dibrachys maculipennis (Szel)

Key to Genera and Species of Coleoptera

1. Hind tarsus 5 segmented....................................2

Hind tarsus 4 segmented....................................6

2. Prothorax strongly expanded posteriorly and approximately as wide at apex as elytra at base, forming an even convex curve at junction of prothorax and elytra (Figs.96-99) (Dermestidae-Dermestids).............................3

Prothorax tapered posteriorly, with apex of prothorax much narrower than base of elytra (Fig.100) (Cleridae-Checkered Beetle)...................Trichodes ornatus Say

3. Basal segment of hind tarsus much shorter than 2nd segment (Fig. 99)............................Attagenus sp.
   Basal segment of hind tarsus subequal to or longer than 2nd segment..4

4. Basal segment of hind tarsus much longer than 2nd segment (Fig. 98)..................Megatoma variegata Horn.
   Basal segment of hind tarsus subequal to 2nd segment.......5

5. Body uniformly covered with appressed, short, ovate scales (Fig. 97)..............Anthrenus pimpinellae Fab.
   Body with slender decumbent hairs of variable lengths and colour (Fig. 96)..........Trogoderma glabrum (Hbst.)

6. Maxillae modified to form a long sucking tube (Meloidae-Blister-Beetles)...................Nemognatha lurida Lec.
   Maxillae not modified to form a long sucking tube (Tenebrionidae-Darkling Beetles)........................7

7. Body dark brown, conspicuously contrasting with the red legs (Fig. 102).............Tribolium madans audax Hals.
   Body and legs uniformly red (Fig. 101)..Tribolium castaneum Hbst.

Biology of Parasites and Predators

Coelioxys (Cuckoo bee) (Megachilidae: Hymenoptera) (Fig.85) - The genus Coelioxys is closely related to Megachile. However, the females have lost the scopa and do not collect pollen grains. It is believed they are attracted by odour, to nests of leaf-cutter bees, where they deposit an egg while the cell is provisioned. The 2nd instar has elongated sickle-shaped mandibles, which are specially structured to kill the leaf-cutter bee larva. Following instars have mandibles that closely resemble those of leaf-cutter bee larvae, which they use to eat the provisions in the nest. Michener (1953) reported 29% of the larvae of M. brevis Say destroyed by C. octodentata Say.

Dermestid Beetles (Dermastidae: Coleoptera) (Fig. 96-99) - Dermestid beetles such as Trogoderma glabrum (Herbst.), Attagenus sp., Anthrenus pimpinellae Fab., Megatoma variegata Horn. which are present in Canada, have been found to infest up to 41% of the tunnels of leaf-cutter bees. Both larvae and the adults tunnel through bee nests, devour the provisions of pollen and nectar and kill both immature and mature larva.

Trichodes ornatus Say (Cleridae: Coleoptera) (Fig. 100) - The adult clerid beetles Trichodes ornatus Say feed and deposit their eggs on flowers of Mayweed (Anthemus cotula) and Yarrow

(Achillea Millefolium) (Eves and Johansen 1974). Leaf-cutter bees are attracted to these plants for pollen and leaf material. Thus, the first instar beetle larvae attach to the female bee and are transported into the bees nest, where they devour the provisions and destroy any instar of the Leaf-cutter Bee. Up to 46% of bee cells have been destroyed by the larvae of this beetle in eastern Washington (Eves and Johansen 1974).

Leucospis affinis (Say) (Leucospidae: Hymenoptera) (Figs. 88, 89) - The ovipositor of the female Leucospis affinis (Say), (which is curled over the abdomen) is able to penetrate through 4 to 7 mm of wood to reach its host within a cocoon and deposit an egg upon it. The parasitic larva does not feed upon the pollen and nectar provisions, but commences development after the Leaf-cutter Bee larva matures and spins its cocoon. The parasite then devours the host larva and pupates within its cocoon. Up to 20% parasitism was reported by Eves and Johansen (1974).

Melittobia chalybii Ashm. (Eulophidae: Hymenoptera) (Figs. 90, 91) - The minute females which are scarcely 2 mm long are probably attracted by odours to a bee cell being provisioned with pollen and nectar. Due to their small size, the females remain undisturbed by the bee on the inside wall of the cell. They remain inside the cell while it is capped by the bee and during the development of the bee larva. After the bee larva spins a cocoon, the parasite makes a hole in it and crawls inside with the prepupa. The parasite then pierces the integument of the host to immobilize it and feeds upon the blood that oozes out of the puncture. The egg which the parasite lays flows like a droplet of water and adheres to the integument of the host (Hobbs and Krunic 1971). Eggs are probably polyembryonic and up to 245 larvae may develop upon one host. The larvae are hyperparasitic and devour the larvae of other parasites which may be feeding upon the host. The prepupae of M. chalybii can tolerate freezing temperatures and have been found on wild Leaf-cutter Bees as far north as Wanless, Manitoba. This is by far the smallest parasite; however, its numerical superiority makes it one of the most lethal parasites of Leaf-cutter Bees.

Monodontomerus obscurus Westw. (Torymidae: Hymenoptera) (Figs. 92, 93) - This parasite enters the cell before the bee caps and cements the egg and provisions inside. After the bee larva develops and pupates the female parasite inserts her ovipositor through the cocoon into the host to immobilize it. The ovipositor is then partly withdrawn and eggs are deposited between the host and the cocoon (Hobbs and Krunic 1971). Six to ten parasite larvae may develop from the one bee larva. Eves and Johansen (1974) reported up to 50% parasitism on the alfalfa Leaf-cutter Bee in eastern Washington.

Sapyga pumila Cress. (Sapygidae: Hymenoptera) (Fig. 86) - The adult injects its ovipositor through the circular cap which seals off the provisions and egg deposited by the bee (Fig. 4), and inserts one or several eggs of its own upon the nectar and honey. Motile first instar larvae are cannibalistic and devour each other until only one larva survives, which devours the bee egg, as well as the provisions supplied by the bee. The mature larva spins a cocoon in the leaf-cell, overwinters, and emerges the following year. This parasite normally parasitizes species of Megachile. It was first observed in the nests of the Domesticated Leaf-cutter Bee (M. rotundata) in 1959, by 1971 its rate of parasitism in Utah had increased to 78.5% (Torchio 1972).

VI. CONCLUSIONS

In this study of Leaf-cutter Bees, consideration has been given to the importance of Leaf-cutter Bees in the production of Alfalfa hay, which is not only essential for sustaining our large livestock populations, but also determines the essential supply of daily human nutritional requirements. Practical and scientific evidence reveal that the principal limiting factor in the production of alfalfa seed is inadequate pollination. Endeavours by such eminent entomologists as Peck and Bolton (1946) Hobbs and Lilly (1954-1973), Pengelly (1953-58), Bohart (1957-1972), Stephen (1955-1961), Torchio and Parker (1963-1977) and others, disclose that Alfalfa requires to be cross-pollinated to produce seed and that honey bees will not pollinate Alfalfa.

Extensive observations have shown that Leaf-cutter Bees are the most efficient pollinators of alfalfa. Unfortunately, however, as alfalfa fields increase in size to produce more, populations of pollinators decrease, resulting in less Alfalfa seed produced. It is proposed that the principal reason for population decline is the destruction of nesting sites, and that this problem can be resolved by fabricating and supplying appropriate habitats.

The taxonomy, biology, distribution, enemies and the alfalfa pollinating potential of the 28 species of Leaf-cutter Bees occurring in Canada have been examined.

While many species of Canadian Leaf-cutter Bees are efficient pollinators of alfalfa, it is unlikely that they have coevolved with alfalfa, and are therefore not specifically adapted to its pollination. Generally, adult emergence is a little behind the commencement of the flowering period of alfalfa, thereby bypassing earlier blossoming alfalfa where early seed set is important in seed yields, as in northern regions, with a more limited frost-free period. American Leaf-cutter Bees usually also require a second plant to be grown along with Alfalfa, from which leaves can be obtained for constructing the cell. Additionally, southern species from drier and warmer regions are progressively less active and effective in more humid and cooler northern regions.

Cross-pollination and production of Alfalfa is a global problem. Accordingly, a global assessment and evaluation of alfalfa pollinators should be undertaken, with particular consideration of the pollinators in regions where alfalfa and its pollinators coevolved.

Demand for at least the current supply or an increase in the present production of human food is too important an issue to be hazarded upon the wellbeing of a single accidentally introduced species, or upon the coincidental transfer of effective cross-pollinators into regions where alfalfa is, or can be, planted and harvested for seed.

Development of appropriate nesting habitats, intensification of research into the selection, breeding and importance of effective pollinators might serve to stem the current tide of diminishing harvests of alfalfa seed.

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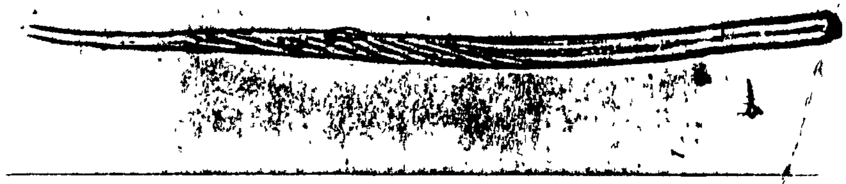


Fig. 38

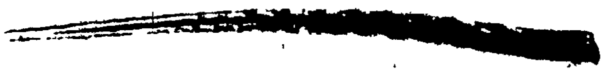


Fig. 39

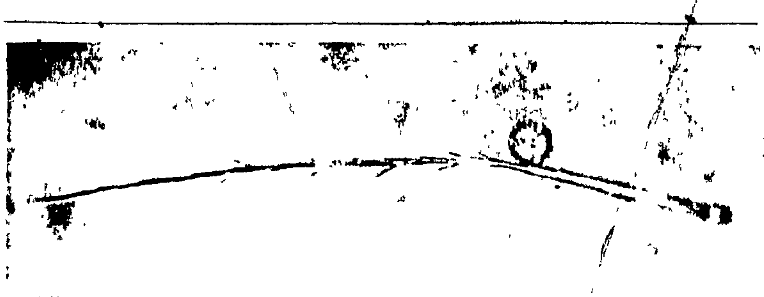


Fig. 40

Fig. 41

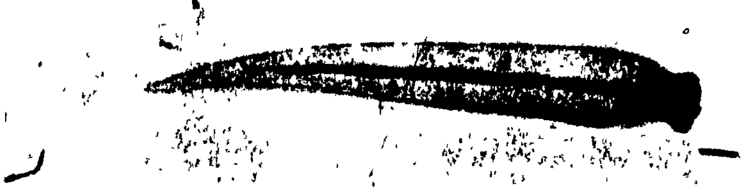


Fig. 42

Figs. 38-42. Hairs on various parts of the body of Megachile. 38, M. relativa, F, scopal hair x 516; 39, M. melanophaea, F, inner face of hind basitarsus x 258; 40, M. texana, M, hair on front coxa, pollen grain x 258; 41, M. brevis, M, bristle, bordering band of short hairs x 430; 42, M. texana, M, bristle, anterior to front coxal spine x 516.

Fig. 43

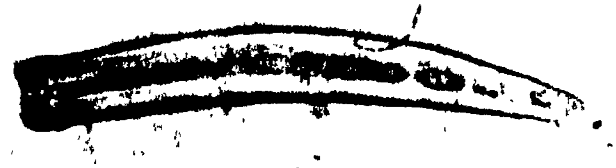


Fig. 44

Fig. 45

Fig. 46

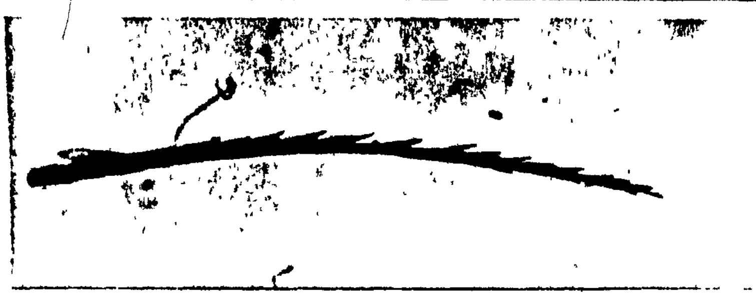


Fig. 47

Figs. 43-47. Hairs on various parts of the body of *Megachile*. 43, *M. brevis*, M, bristle at apex of 3rd front tarsal segment x 258; 44, *M. frigida*, M, hair on retracted sternum V x 516; 45, *M. centuncularis*, M, hair on retracted sternum V x 516; 46, *M. centuncularis*, F, barbed, erect hair on tergum VI x 240; 47, *M. relativa*, F, short, appressed hair on tergum VI x 516.

Megachile latimanus Say

Female

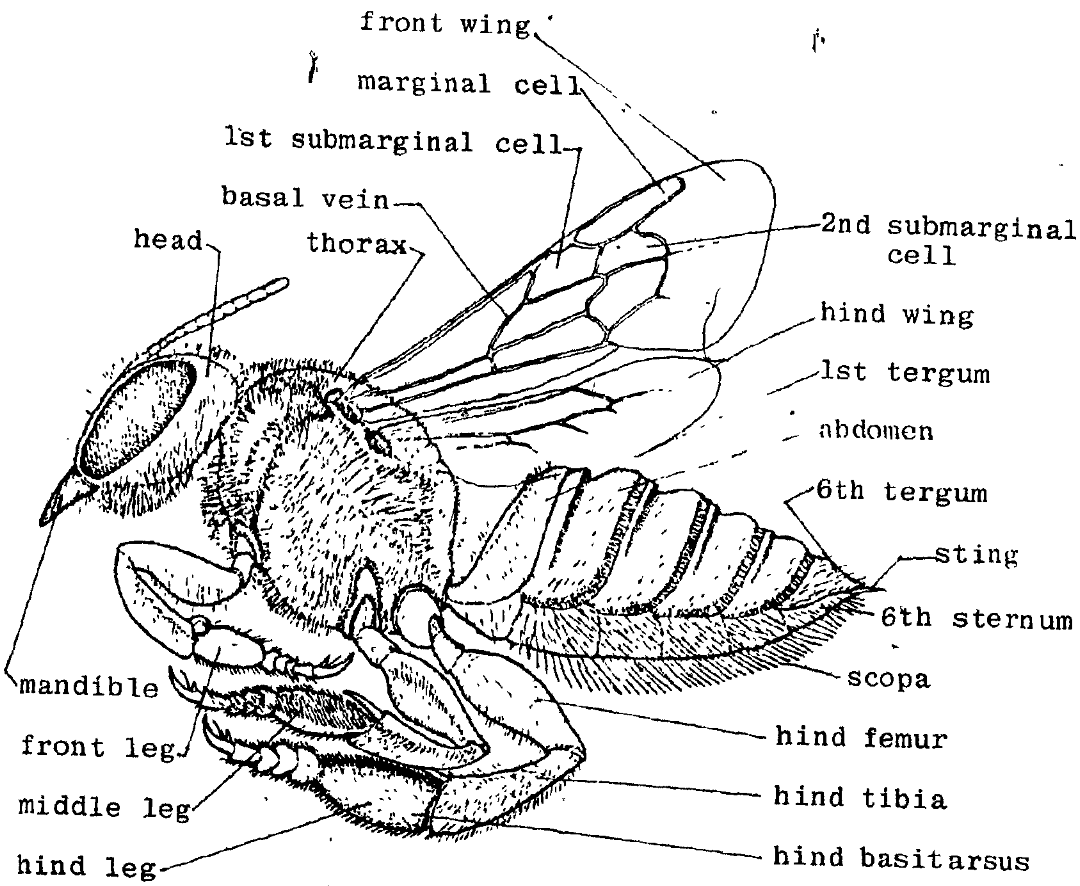


Figure 48. Female, lateral view.

Megachile rotundata (Fabricius)

Male, wings excluded

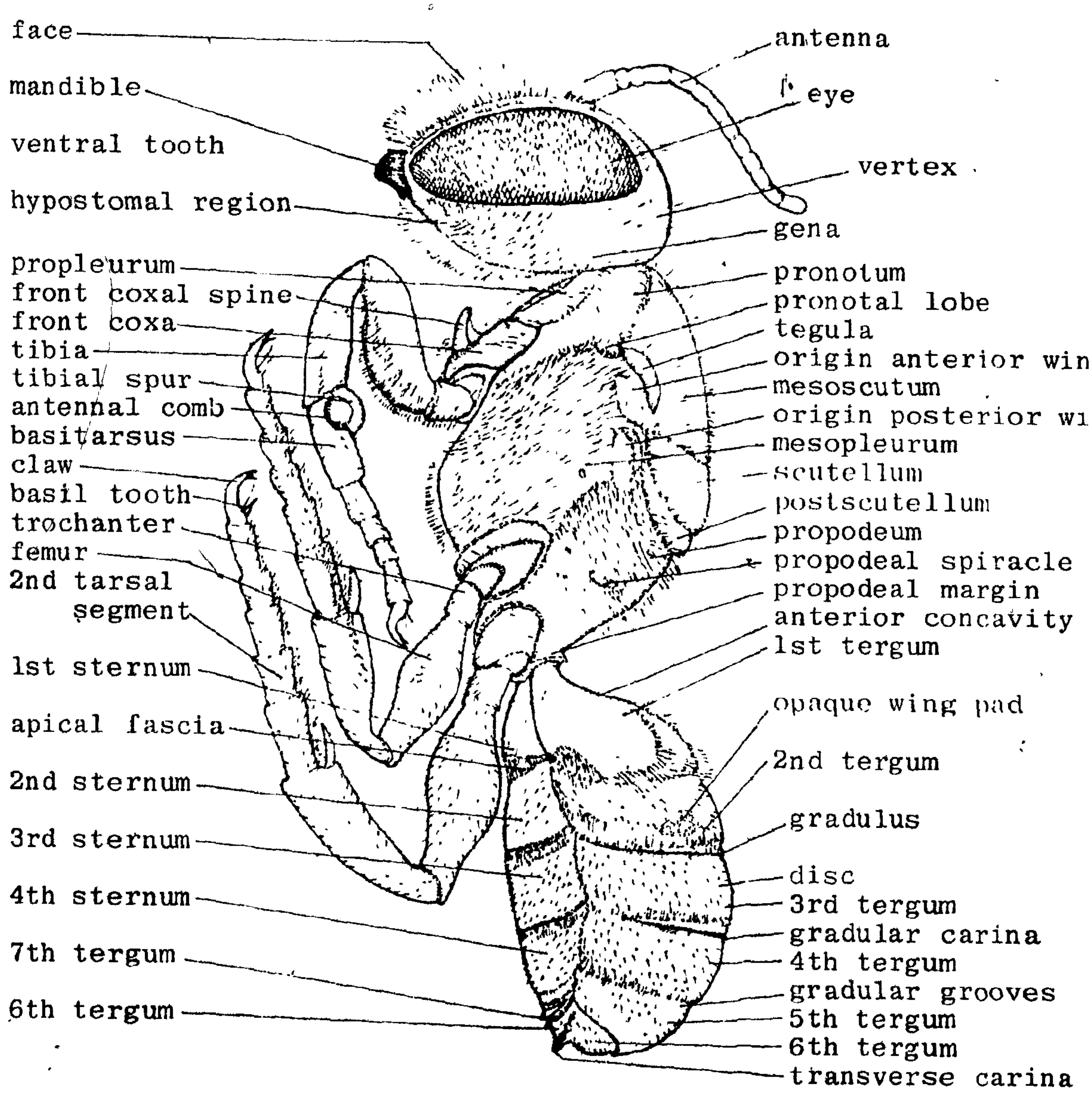


Figure 49. Lateral view.

Face view.

Fig. 50. Female

Fig. 51. Male

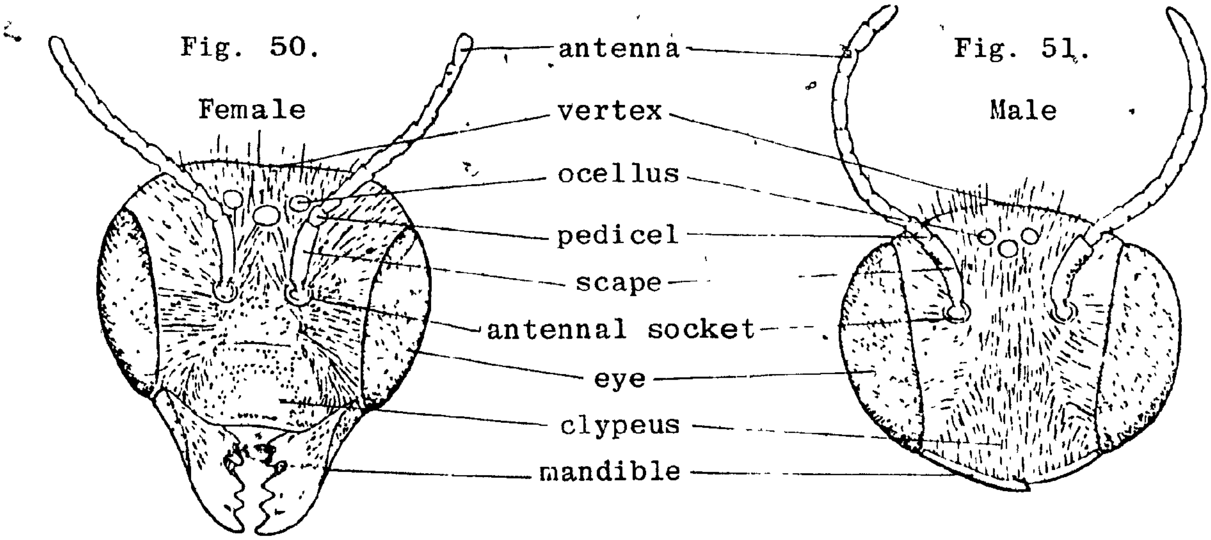
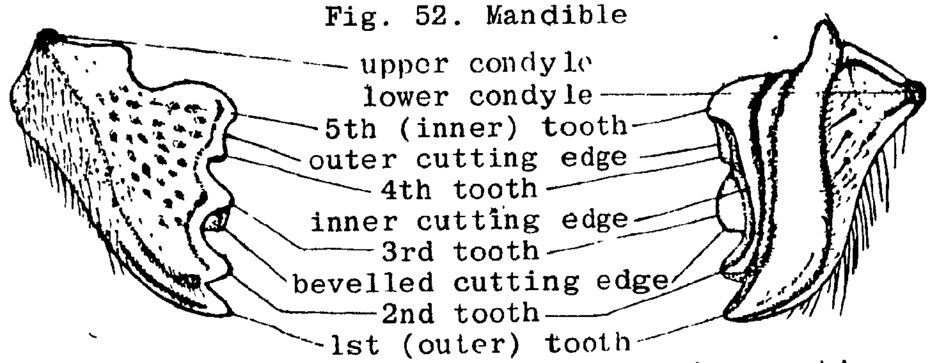


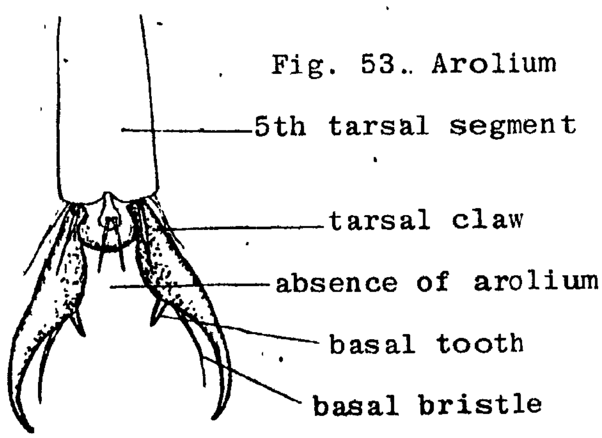
Fig. 52. Mandible

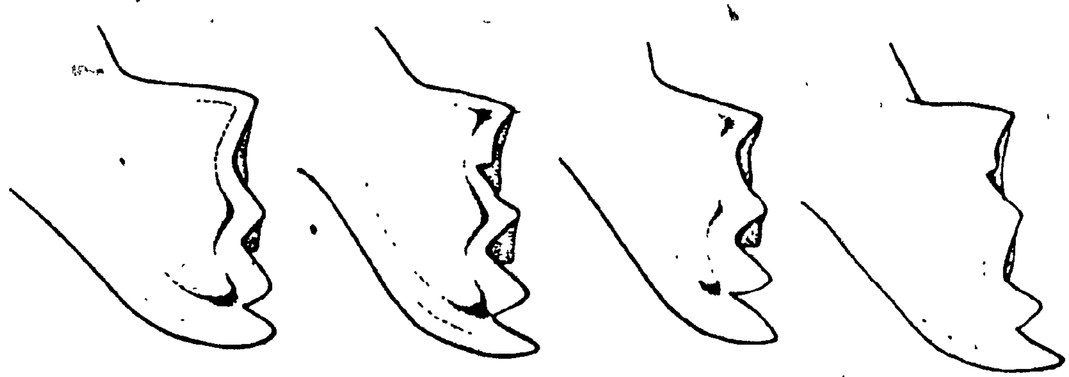


outer side

inner side

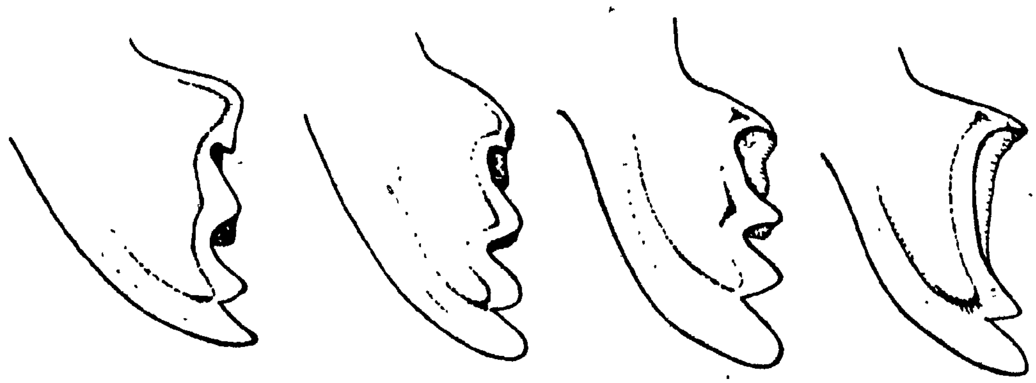
Fig. 53. Arolium





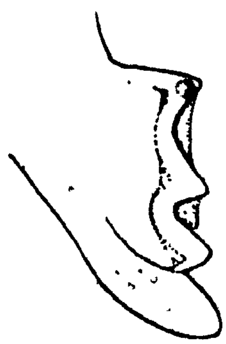
54. M. brevis 55. M. mendica 56. M. texana 57. M. rotundata

58. M. relativa 59. M. montivaga 60. M. inermis 61. M. addenda



62. M. frigida 63. M. melanophaea 64. M. wheeleri 65. M. anograe

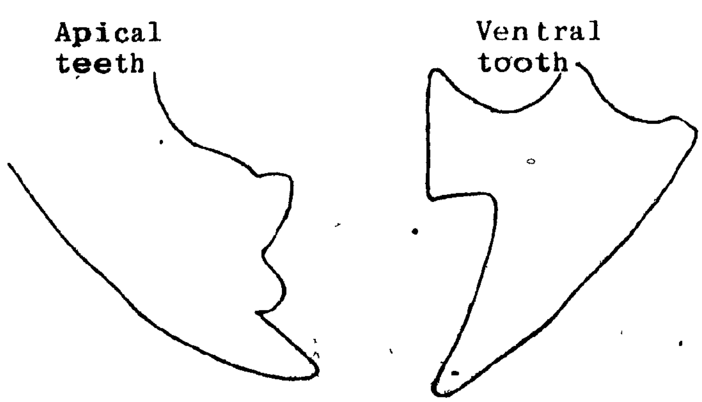
Figs. 54-65. Mandibles of Females.




66. <u>M. paraliela</u> 67. <u>M. perihirta</u>



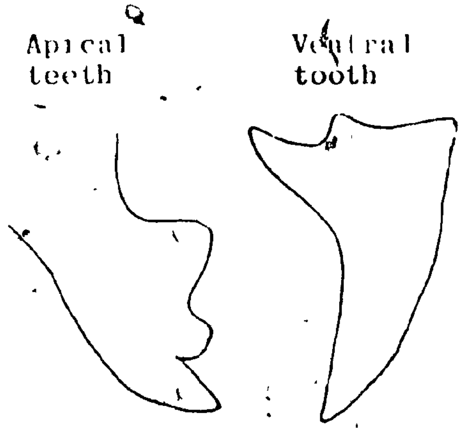
68. <u>M. mellitarsis</u> 69. <u>M. pugnata</u> 70. <u>M. fidelis</u>



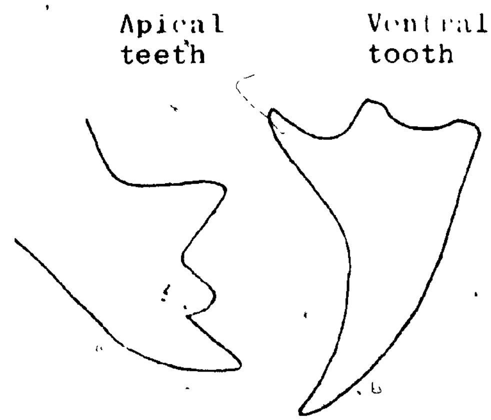
71. <u>M. fortis</u>

Figs. 66-70. Mandibles of Females

Fig. 71. Apical teeth and ventral tooth of Male.

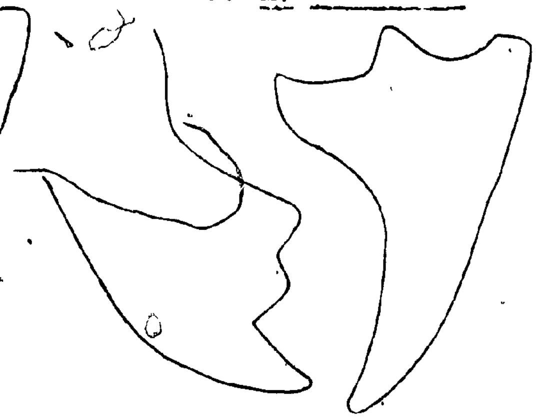


72. M. brevis



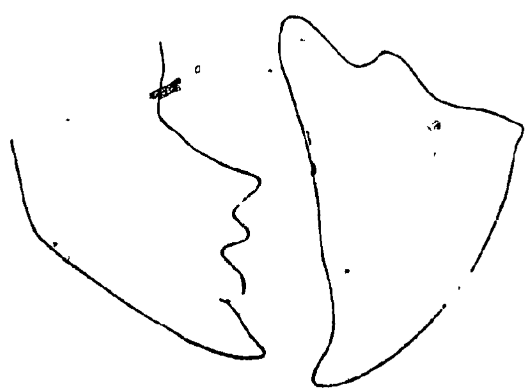
73. M. rotundata

74. M. relativa



75. M. montivaga

76. M. inermis

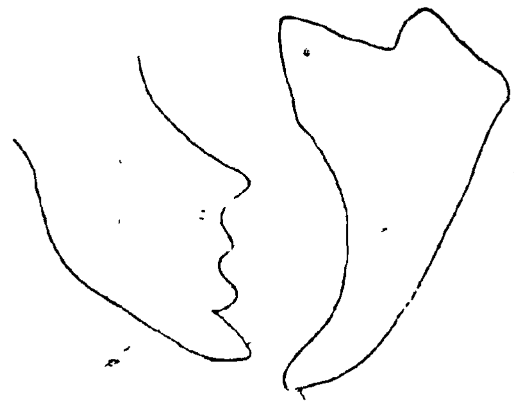


77. M. frigida

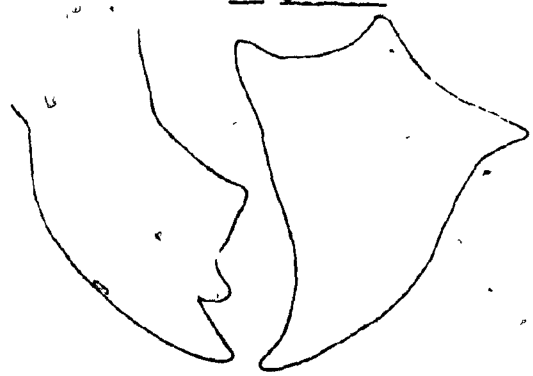
Figs. 72-77. Apical teeth and ventral tooth of Males.

Apical teeth | Ventral tooth | Apical teeth | Ventral tooth

78. M. giliae

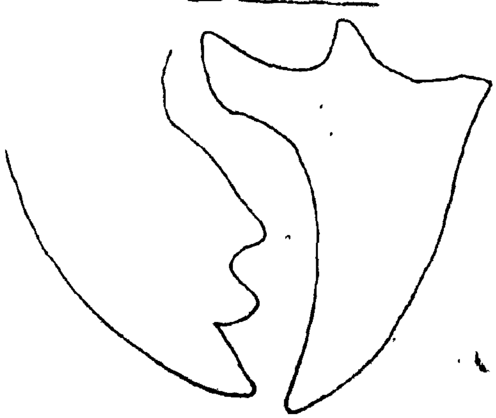


79. M. melanophaea

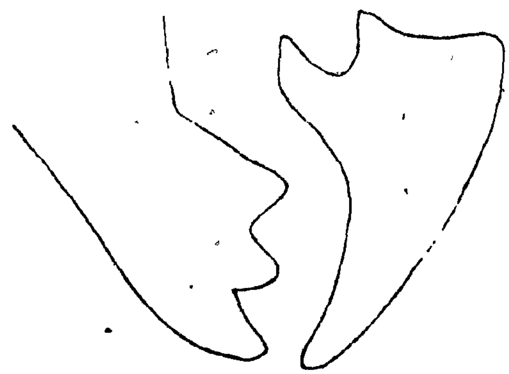


80. M. wheeleri

81. M. parallela



82. M. perihirta



83. M. pugnata

Figs. 78-83. Apical teeth and ventral tooth of Males.

PARASITES AND PREDATORS OF LEAF-CUTTER BEES

Fig. 84. Series of cells of *Megachile* riddled and destroyed by larvae of Cleridae (probably *Trichodes*).

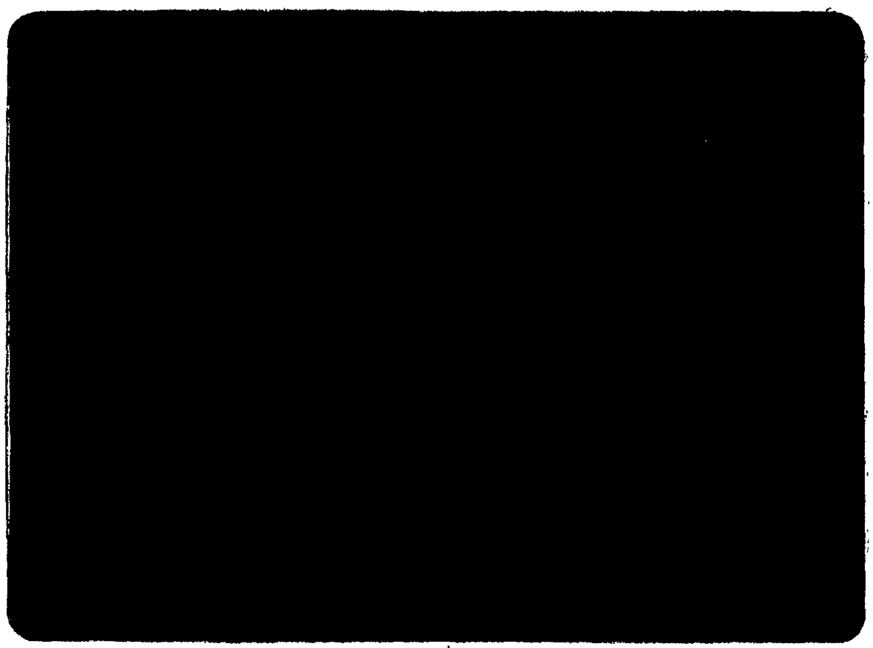


Fig. 85. *Coelioxys* - one of the most common parasites of Leaf-cutter Bees.

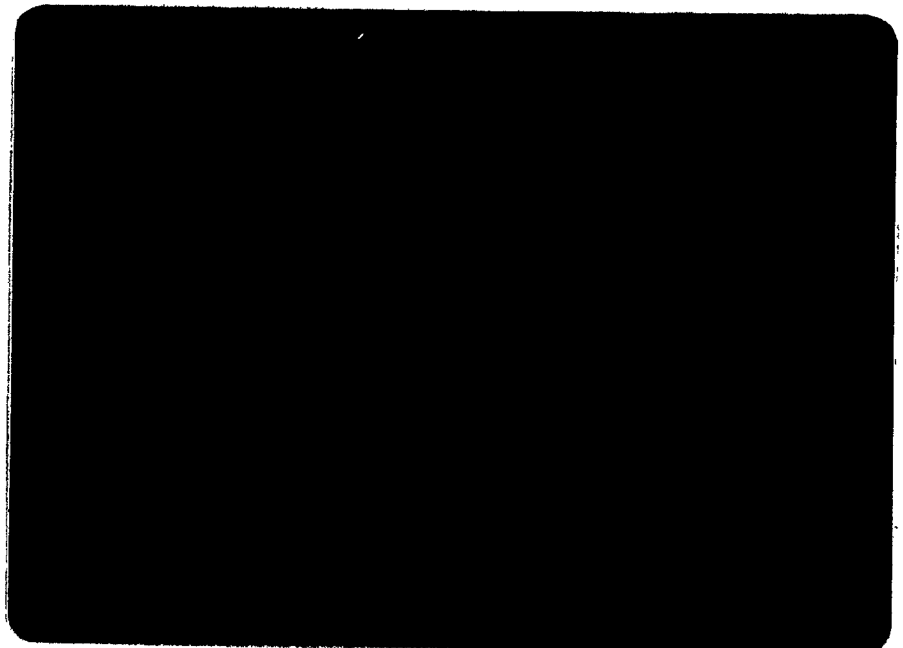


Fig. 86. Sapyga pumila - has been known to destroy up to 78.5% of Domesticated Leaf-cutter Bees (M. rotundata).

Fig. 87. Chrysididae, common parasite on solitary bees including Megachile (Peck & Bolton 1964).

Fig. 88. Leucospis affinis Say.. Female. One of the most common chalcid wasps on Leaf-cutter Bees.

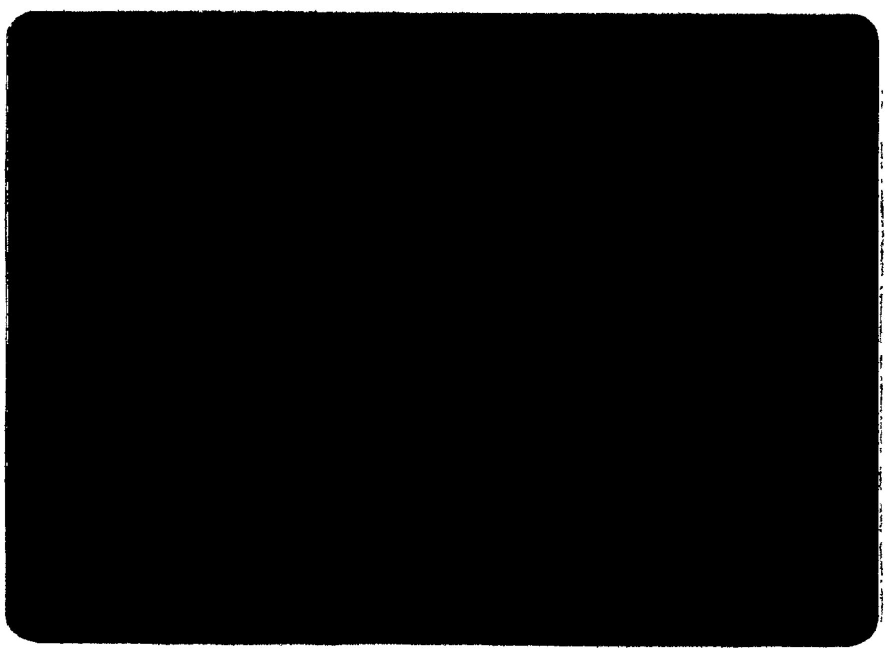


Fig. 89. Leucospis affinis Say.. Male.

Fig. 90. Melittobia chalybii Ashm. Female. Extremely minute parasite, widely distributed. A potential threat to Leaf-cutter Bees; probably polyembryonic, with up to 245 parasites developing upon one host (Megachile).

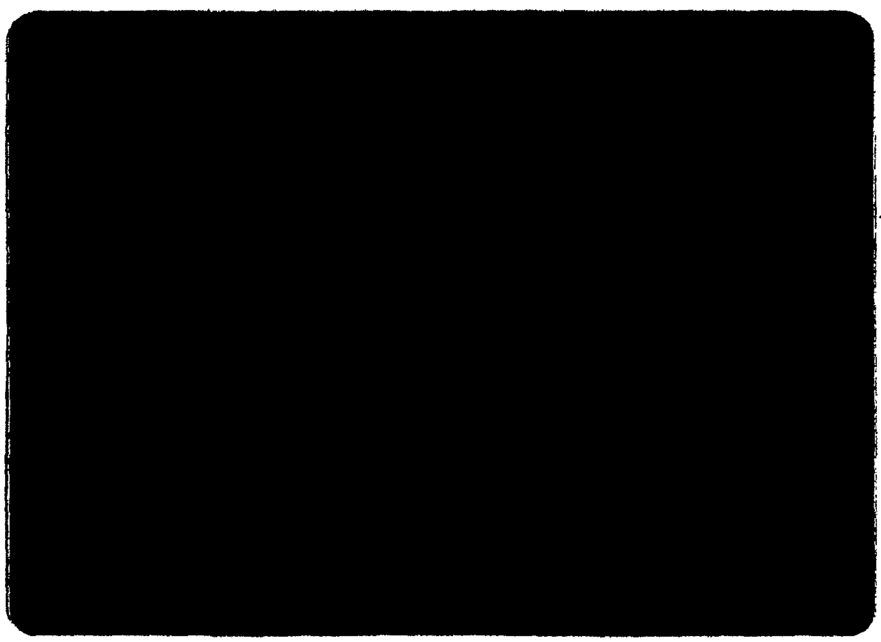


Fig. 91. Melittobia chalybii Ashm. Male.

Fig. 92. Monodontomerus obscurus (Westw.). Female. Six to ten parasites can develop upon one host larva; may parasitize up to 50% of the Leaf-cutter Bees.

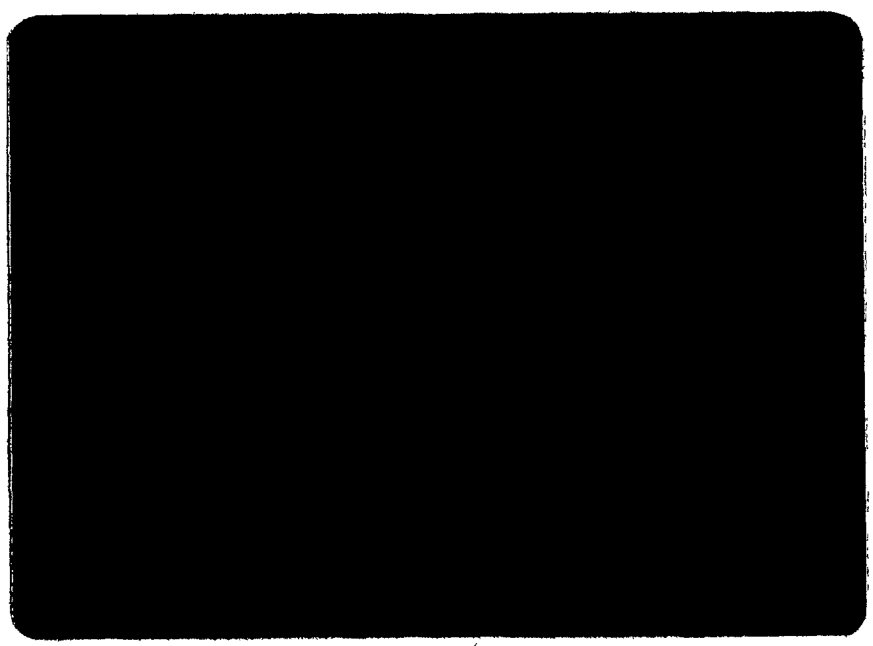


Fig. 93. Monodontomerus obscurus (Westw.) Male.

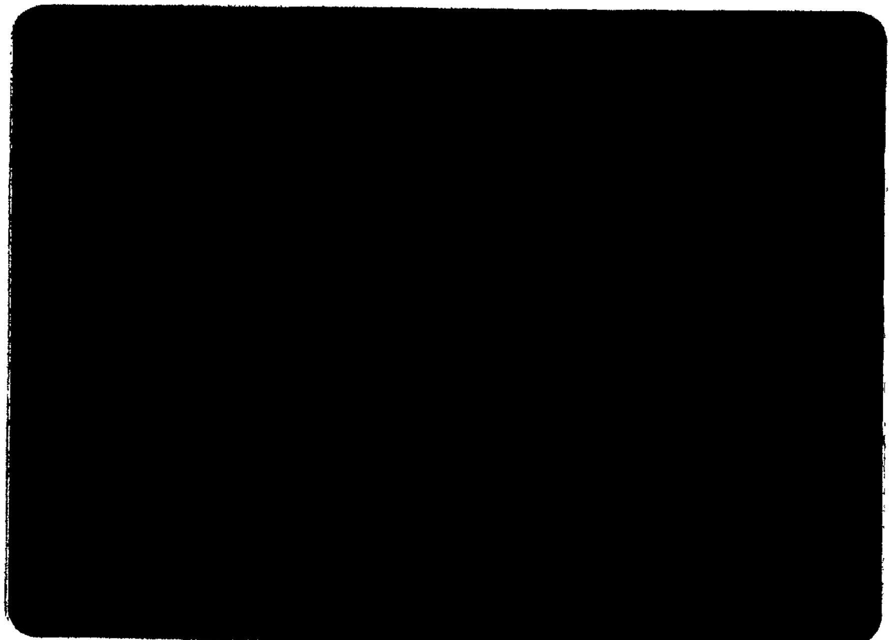


Fig. 94. Dibrachys maculipennis (Szel.). Female. Widespread in Canada, may prove to be a serious pest of Megachile.

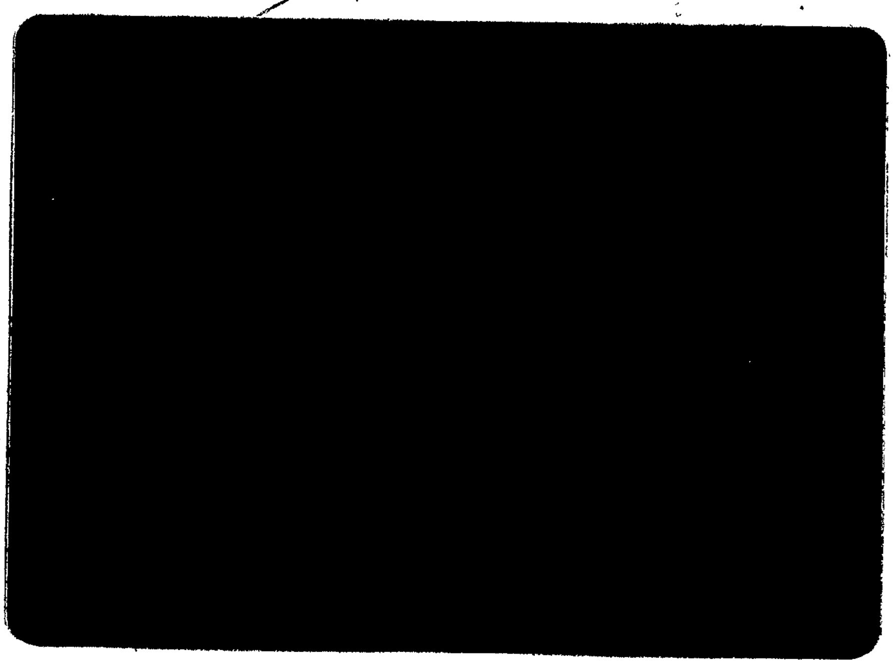


Fig. 95. Formica fusca L. Worker. One of the most common Ants which may destroy nests of Leaf-cutter Bees.

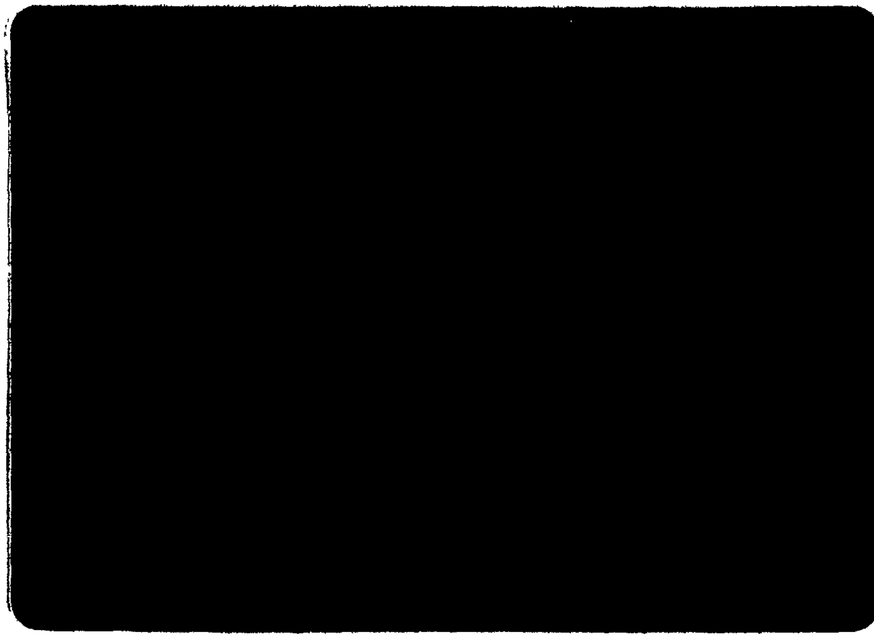


Fig. 96. Trogoderma glabrum (Hbst.) (Dermestid Beetle). Adults and larvae bore through bee cells in search of pollen and kill bee larvae. Up to 41% of M. rotundata tunnels have been observed to be infested with these beetles (Eves and Johansen, 1974).

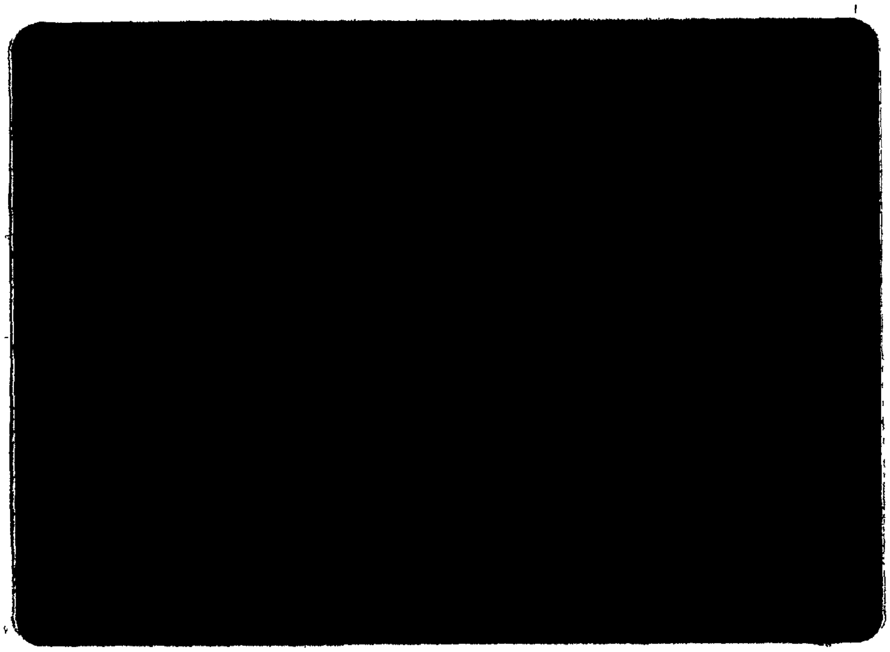


Fig. 97. Anthrenus pimpinellae (Fab.)(Dermestid Beetle).

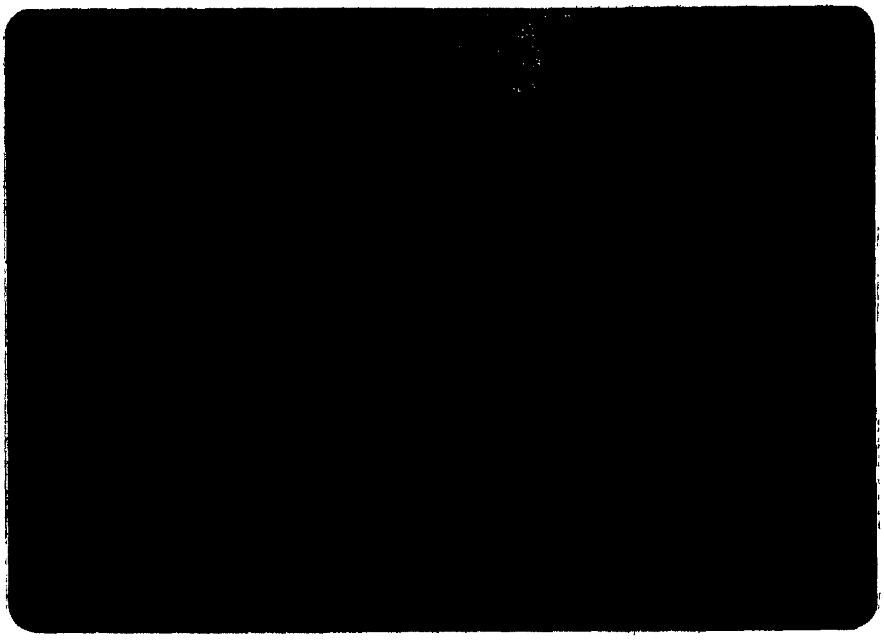


Fig. 98. Megatoma variegata Horn. (Dermestid Beetle).

Fig. 99. Attagenus sp. (Dermestid Beetle). This beetle has not yet been observed to occur in damaging numbers (Eves and Johansen, 1974).

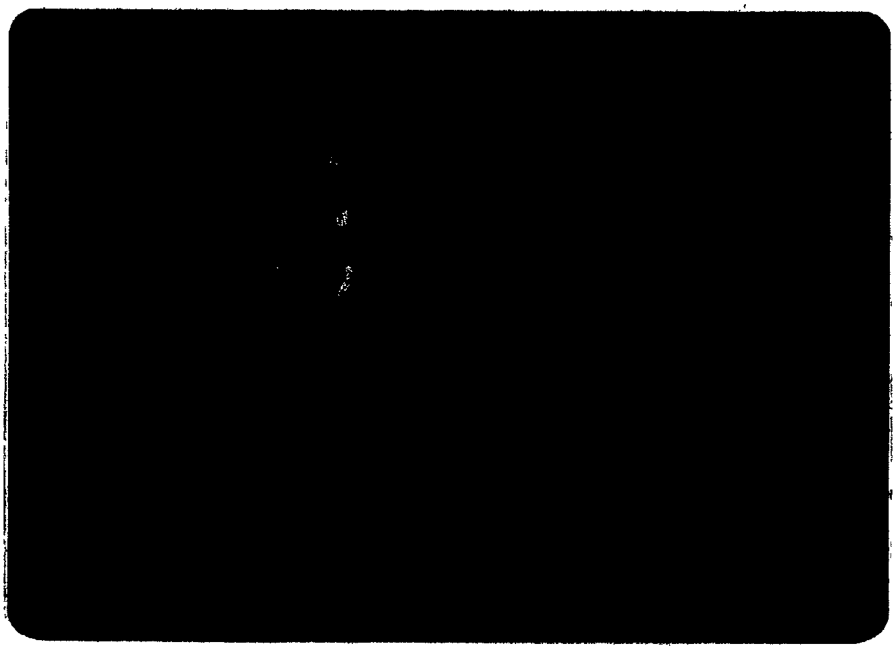


Fig. 100. Trichodes ornatus Say (Clerid Beetle). Beetle larvae transported from flower to bees nest by the female bee. Up to 46% of M. rotundata have been observed to be destroyed by this beetle (Eves and Johansen, 1974).

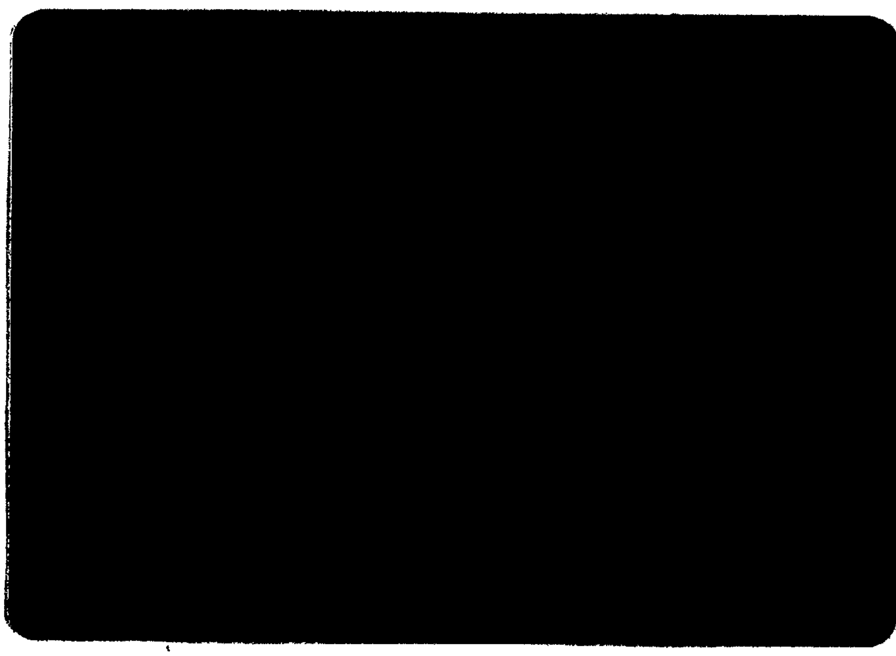


Fig. 101. Tribolium castaneum (Hbst.) (Red Flour Beetle), penetrates and destroys bee cells by devouring pollen and nectar provisions.

Fig. 102. Tribolium madens audax (Halst.) (Black Flour Beetle). Feeds on pollen and nectar provisions in the bees cells.

Fig. 103. Vitula edmundsii Pack. Larvae feed upon debris and destroy the cells of M. rotundata (Hobbs, 1968).