The genus *Chorthippus* (Orthoptera: Acrididae) in North America.

by

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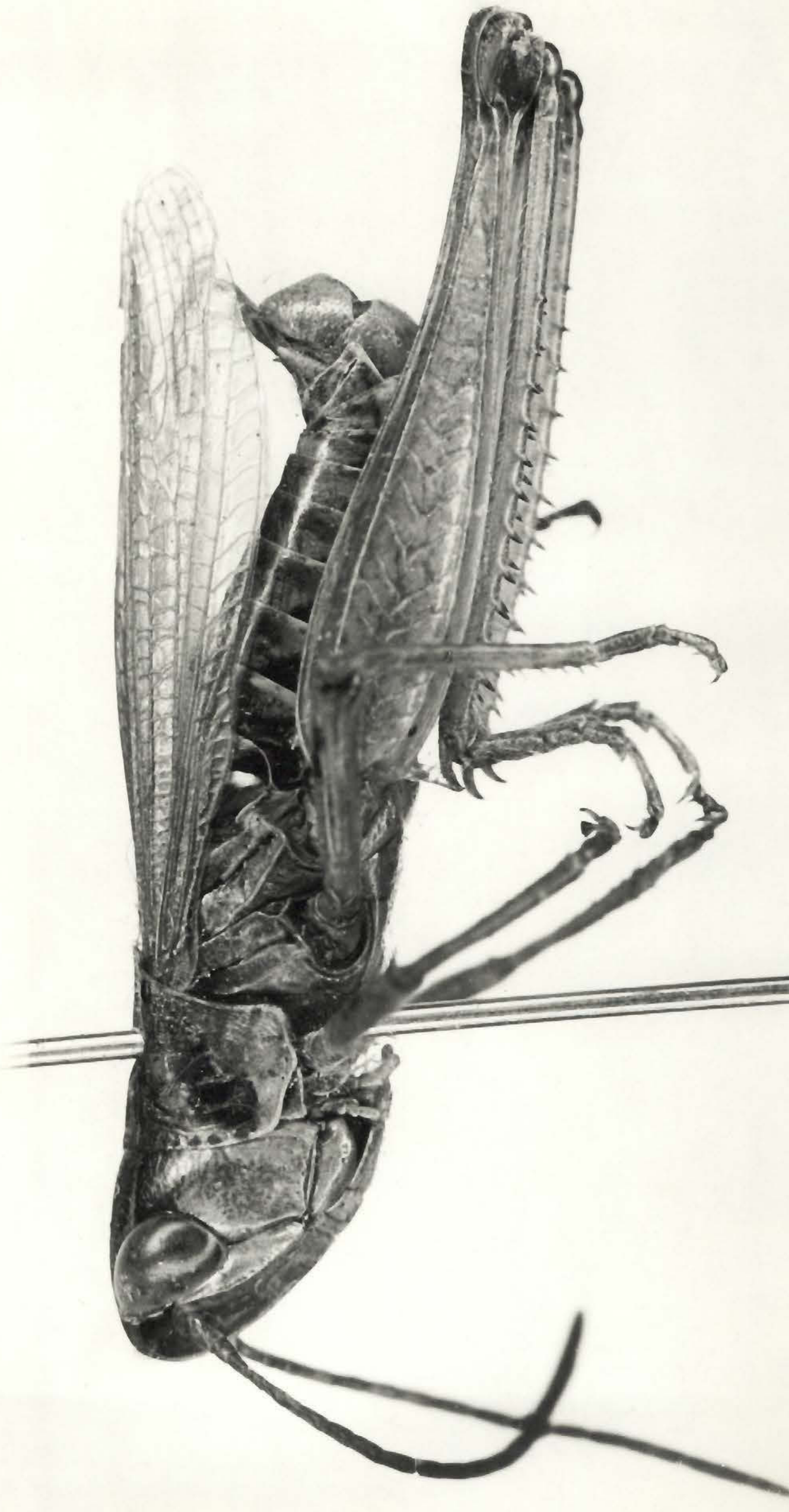
FRONTISPIECE

Chorthippus curtipennis (Harris)

Neotype



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I. INTRODUCTION

The genus *Chorthippus* in North America has been in a confused state for much of the past seventy years. The genus is typically Palaearctic, with many Old World species, and is represented in the Nearctic Region by what has, in more recent times, been listed as a single species. Hebard (1936) synonymized all specific names which had been applied within this genus in North America, under the name of an European species. Subsequently this name was shown to be a *nomen dubium*, as the original description would not differentiate between two well known European species to which it could almost equally well be applied (see p.22). This created the necessity of establishing whether North American *Chorthippus* is conspecific with either of these European species, and if so, with which. If North American specimens are not the same as either of the Old World species, what name should be applied to these Nearctic populations? Since *Chorthippus* is distributed over about three-quarters of the North American continent, the following questions naturally arise: (1) is there but a single species or are there more than one species?; (2) if only a single species is involved, does any segment of the population deserve subspecific status?; (3) what is the complete range of distribution?

The present study seeks to learn the answers to these questions.

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III. METHODS

Measurements of external characters were made with a linear scale placed in one ocular of a binocular dissecting microscope, all measurements ultimately being converted into millimeters. Earlier measurements of body length, femur length, etc., made with a vernier caliper, were discarded as it was found that better accuracy was obtained using the ocular measuring device mentioned. Eight male characters and seven female characters were measured or counted.

Samples of twenty-five specimens of each sex were taken at random from series from localities distributed over the North American continent (see map, Fig. 2).

The localities chosen were of necessity determined to some extent by the numbers of specimens available. Since such selection left gaps in the distributional pattern, smaller samples, usually the total of specimens on hand, from localities filling in these gaps were also measured in order to present a more complete picture.

The characters measured were not always the same for both sexes since this was not always appropriate. Measurements were taken of body length of males but not of females, since the total length of females is extremely variable depending upon whether the female is newly emerged, gravid (in which case the abdomen may be considerably extended), or spent following oviposition. Tegminal length and length of the hind femur were measured for both sexes (see Fig. 4). Other measurements taken, common to both sexes, were vertical depth of the eye and length of the subocular sulcus (see Fig. 5).

In addition to the above, the hind femora (the left one, where possible) of males were removed for further examination. The length of the row of stridulatory pegs on the inner face of the femur was measured, as was the distance from the proximal end of the femur to the beginning of the row of pegs. Similar measurements were made by Lux (1957) on samples of Chorthippus montanus (Charp.)

and C. longicornis (Latr.) (= parallelus (Zett.)) in Europe. The pegs in the stridulatory apparatus were counted. This was done by placing the femur, with the inner face upward on a microscope slide, dry, without a cover slip, and using a high powered binocular microscope with both direct and substage lighting. An ocular insert marked off in squares was used as reference as it was necessary to transport the femur across the visible field by means of a moveable stage, while counting. Femora were secured in place on the specimens following measurement by means of a drop of cement.

In addition to the four characters previously mentioned, measurements were made on females of the vertical depth of the pronotum (see Fig. 6), the narrowest (dorsal) width of the vertex between the eyes (see Fig. 7), and the length of the proximal segment of the hind tarsus (see Fig. 8).

Means, standard deviations, and standard errors of means were calculated for each character for each group of specimens (sample), and are recorded in the Tables III - XIX (see Appendix).

Drawings of external features, dorsal, lateral and frontal aspects of head and pronotum were made using a squared ocular insert in one ocular of a binocular dissecting microscope and squared paper. Such drawings were found to be more accurate than those done with a 'camera lucida'. All external drawings (Figs. 9 to 86) were made to the same scale.

Concealed genitalia, both male and female, were dissected out and were drawn. Basic preparation was the same for both sexes: immersion of the tip of the abdomen in cool water (at room temperature) for ninety minutes. This method produced less discoloration than immersion in warm or hot water as described by Roberts (1941). A very few specimens were found to require longer immersion but the great majority were quite pliable after the ninety-minute period.

Males were set in position by pushing the pin downward into the side of a large cork so that the abdomen rested on the dorsal face of the cork. Support pins were set beside the abdomen, and the cork was pinned to a moveable stage to facilitate examination of removal of the phallic structures by means of a dissecting microscope. The pallium was displaced posteriorly using an insect pin, exposing the aedeagal valves. Then the pin was inserted anteriorly into the dorsal part of the cavity thus exposed, then tipped downward and pulled posteriorly, tipping the entire phallus out of its normal position so that it remained attached to the abdomen only by the membrane connected with the pallium.

This was severed by means of oculist's dissecting scissors. The pallium was then pushed back into place, leaving the specimen with the same outward appearance as previous to removing the phallus.

Each phallus was soaked in cold ten-percent potassium hydroxide solution until all muscles could be removed easily. The epiphalli were dissected away from the remaining structures using dissecting scissors, since in its normal position the epiphallus obscures much of the dorsal aspect of the endophallus. After removal from the potassium hydroxide, the genitalia were washed in water and stored in glycerine in microvials, with the pin of the specimen inserted through the cork of the microvial.

The subgenital plates of females were removed, after soaking, by dissection, first along the sides then at the bases, with dissecting scissors. It was then necessary to sever the vagina in order to remove the plate from a specimen. Following removal, each subgenital plate was soaked in cold potassium hydroxide, washed, and was stored in glycerine in a microvial with the specimen from which it was removed.

Removal of the complete genital complex of females required removal of the distal end of the abdomen, since the spermatheca lies cephalad the remainder of the genitalia and was left inside the specimen in all attempts to remove the complex without removing the distal portion of the abdomen. Following potassium hydroxide treatment, muscles were teased loose, the genitalia washed in water and stored in glycerin in microvials.

All drawings of genitalic structures, both male and female, were made by the same method and to the same scale (see Figs. 98 to 262), using direct projection of the structure mounted in glycerin in a well slide with a cover slip, with a "Ken-a-Vision" projector*. Drawing by this method involved tracing the structures as projected. All tracings were checked by examining the structure using a conventional microscope.

Photographs were taken with a Leica, M-3, 35 mm. camera on a Leitz mount, using Adox KB 14 film, with film speed rating of 20 ASA. The distance from lens to subject was 3 3/4 inches, and all exposures were made at f-11 at shutter-speed of 1/50th second with the aid of a close-up ring flash†.

*Model Tech-A; Ken-a-vision Mfg. Co. Ltd., Raytown 33, Missouri, U.S.A.

†Manufactured by Speedlight Center, New York.

IV. REVIEW OF LITERATURE

North American specimens of the genus *Chorthippus* were first named *Locusta curtipennis* by Harris (1835, 1835a) but he did not describe the insect until some years later (Harris, 1841) when he used the name *Locusta* (*Chlöealtis*) *curtipennis*. Subsequently, the name *curtipennis* appeared in several publications in which it was attributed to Scudder, some of these citations being by Scudder himself (see Scudder, 1868a; Smith, S.I., 1869; Scudder, 1874), although Scudder (1862a) had previously credited Harris with authorship of the species.

Scudder (1862a) described the macropterous form as *Stenobothrus longipennis*, with the type locality Massachusetts, the same as that of *curtipennis* Harris. Scudder (*in* Packard 1869) afterward synonymized *longipennis* under *Stenobothrus curtipennis*, but the name persisted in the literature as a separate species, or as a subspecies of *curtipennis* for more than twenty years (Glover, 1872; Thomas, 1873, *in* Packard, 1873, 1876a, 1878; Provancher, 1876, 1877, 1883; Morse, 1894a, 1894b).

McNeill (1896) described *coloradensis* (also in *Stenobothrus*) from Fort Collins, Colorado, based on a single female sent to him by Gillette. This specimen is discussed further in Section VI. Three years later, however, Scudder (1899) placed *coloradensis* in synonymy under *Stenobothrus curtipennis*, but in the same paper, he described *Stenobothrus oregonensis*, based upon a large series of specimens from several localities in western Oregon. Subsequently, Rehn and Hebard (1912) designated a type specimen for *oregonensis*, and fixed Divide, Oregon, as the type locality. Rehn (1902b) pointed out that North American species, previously referred to *Stenobothrus*, should be placed in the genus *Chorthippus* Fieber, 1852. The change was not immediately accepted and some authors continued to use *Stenobothrus* for the following fifteen years (Caudell, 1903, 1908; Morse, 1903, 1904; Allard, 1910, 1911, 1912; Walker, 1906, 1906a, 1909, 1910; and others - see synonymy).

Rehn and Hebard (1906) in a footnote stated that the name *Stauroderus* should replace *Stenobothrus* if the divisions of Bolivar, 1898, were accepted as genera. Burr (1904) had accepted these names as such. Rehn and Hebard (*op. cit.*) further stated that *Chorthippus* would be the valid name if Bolivar's "divisions" were recognized as having only subgeneric rank. Hebard (1909) used *Stauroderus* as the generic name in place of *Stenobothrus* and *Chorthippus*, but reverted to *Chorthippus*, without explanation, in his next publication in which this genus was considered (Hebard, 1910).

Rehn (in Buckell, 1922) reduced oregonensis to subspecific rank under Chorthippus curtipennis (Harris), and it was so considered until Hebard (1936) placed all previously existing North American names referable to Chorthippus in synonymy under the Palaearctic species Chorthippus longicornis (Latreille, 1804).

Morse (1903) described acutus (also in the genus Stenobothrus) from Ormsby County, Nevada, based on five male specimens, in which the vertex was more produced anteriorly and more acute than in curtipennis. A type specimen for acutus Morse was designated by Morse and Hebard (1915). Hebard (1931) synonymized acutus under Chorthippus curtipennis and then (Hebard, 1936) further synonymized the name with Chorthippus longicornis (see above).

Hebard's treatment served to complicate the situation since Latreille's name longicornis is a nomen dubium, the original description being insufficient to determine whether parallelus (Zetterstedt, 1821) or montanus (Charpentier, 1825) should be placed in synonymy with it. Uvarov in Clark (1942) and more recently Kevan (1960), Ander (1960) and Vickery (1961), have questioned the synonymy of the North American species with either of the European species.

In order to understand the confused state of the taxonomy of the European species under which the North American names were synonymized, it is necessary to check the original descriptions of the three European species involved, and to review the most pertinent European literature.

Latreille's (1804) description of Acrydium longicorne is as follows: "Cette espèce est très-voisine de celle que Linnaeus nomme apricarius, et DeGéer criquet à étuis, à extrémité noire, ou c'est peut-être le même insecte. Petit, jaunâtre ou brun clair, avec la tête, le corselet, le dessus des cuisses verds. Les antennes sont plus longues que la moitié du corps, et comprimées. Le corselet a trois lignes longitudinales, élevées, dont les latérales un peu arquées en dedans et souvent sur un espace brun. Les élytres ne sont guères plus longues que l'abdomen, d'un gris brun ou jaunâtre pâle. Les genoux des cuisses postérieures sont noirâtres.

"Très-commun aux environs de Paris."

Zetterstedt (1821) described Gryllus parallelus as follows "6. G. parallelus thorace tricarinato, carinis lateralibus subrectis; supra lateribusque viridis, subtus flavicans, geniculus pedum posticorum nigris; hemelytris in mare paullo, in femina abdomine duplo, breviora, in utroque sexu pallescentia, unicolora."

The "habitat" was listed as Gottland, Olandia, Ostrogotha, and Scania. Then Zetterstedt further described the species: "Descr. I. v. Mas.& Fem. Statura prioris magnitudine minori, imprimis maris, qui femina duplo minor; differt praecipue a praecedente capite thoraceque totis virescentibus, hemelytris brevioribus, unicoloribus, & pedum posteriorum geniculus nigris. Caput cum antennis & oculis omnino ut in precedente constructum, colore viridi. Thorax etiam ut in illo, totus virescens. Hemelytra in mare abdomina paullo (circiter linea) breviora, pallida, immaculata; in femina dimidiam abdominis partem vix attingunt, tota virida, unicolora. Abdomen dorso aut viridi fuscum, aut brunneum, lateribus saepe nigro-maculatum ventre dilutiori. Differentia sexus ut in prioribus. Pedes glabri, testacei, posticorum femoribus supra viridibus, subtus flavis, geniculis nigris, saltem fuscus. Pulvilli perspicui.

"Variat ♂ . Antennis totis testaceis; variat etiam femina tota obscura vel pallida."

Charpentier (1825) gave the following description for his new species, Gryllus montanus: "Gr. thorace tricarinato, carinis lateralibus nonnihil curvatis: viridis, subtus flavidus, geniculis posticis nigris: elytris in mare abdominis longitudine, in foemina tertia parte thorace capiteque longioribus: alis dimidia elytrorum parte paullo majoribus.

"Habitat in Saxoniae et Silesiae regionibus montosis.

"Simillimus Gryllo parallelo: tamen differre videtur his notis: 1. capite latiore; 2. maris elytris multo latioribus, nervorumque alia forma; 3. praecipue alis dimidiam elytri longitudinem fere superantibus, superficiei igitur ambiti duplo majore quam in Gr. parall.

"Variat interdum vitta nigerrima ad thoracis dorsi, latera, a carina laterali ispa dissecta, qualem picturam in Gr. parallelo nunquam vidi. Foeminam habes vitta haud tenui, laete flava ad marginem anticum elytri insignem."

Comparison of these three descriptions reveals a remarkable similarily. Zetterstedt states for parallelus that the lateral carinae are almost straight while Charpentier describes the lateral carinae of montanus as no more than slightly curved. Latreille indicates that the carinae are a little curved in longicornis. The main points of difference between parallelus and montanus are provided by Charpentier, who was evidently familiar with Zetterstedt's species, montanus differing from parallelus in the following characters: 1. head broader; 2. male tegmina broader; 3. wings and tegmina longer; and 4. principal pronotal sulcus located behind the middle.

The prior description of longicornis by Latreille is not sufficient to determine which species, *parallelus* Zetterstedt, or *montanus* Charpentier, should be synonymized with it, but seven years after describing *parallelus*, Zetterstedt (1828) synonymized this name under *longicorne* (Latreille, 1804).

Fieber (1852) established the generic name *Chorthippus* to include the European species at present under discussion, naming a new species *Ch. pratorum* and listing as synonymous with it, *Gr(yllus) parallelus* Zetterstedt, *Gr. longicornis* Hagenbach, *Gr. blandus* Eversman, *Gr. montanus* Charpentier, and *Gr. variegatus* Fischer. This was unwarranted, but was accepted by some subsequent authors. Singer (1869) listed *Stenobothrus pratorum* Fieber with two varieties: *alpha*, *parallelus* Zetterstedt, with tegmina and wings shorter (wings one-third of abdomen); and *beta*, *montanus* Charpentier, with tegmina and wings longer (wings one-half of abdomen). Schoch (1876) placed the group under *Stenobothrus* Fischer with *Chorthippus* Fieber having subgeneric rank. He also recognized *pratorum* Fieber as valid and listed as synonyms, *parallelus* Zetterstedt, *longicorne* Latreille, and *montanus* Charpentier.

Finot (1883) considered that *montanus* Charpentier represented only a long-winged form or variety of *Stenobothrus parallelus* Zetterstedt. He made no mention of *longicornis* Latreille.

Sélys de Longchamps (1888) also considered montanus to be a variety of parallelus, having the wings of the male a little longer than the abdomen, and those of the female passing the middle of the abdomen. He proposed the name explicatus for the macropterous form with wings completely developed. The name explicatus is seldom found in subsequent literature, but the use of montanus as a varietal name of parallelus persisted for many years. Azam and Finot (1888) so considered it, yet Finot (1890) appears to have changed his opinion. In a discussion of the identity of the species named by Latreille as longicornis (a controversial subject from that time until 1962), Finot (op. cit.) decided that parallelus Zetterstedt was distinct from longicornis Latreille and that montanus Charpentier was synonymous with the latter. As reported by Finot (op. cit.) Charpentier concurred in this synonymy.

The characters used to separate longicornis from parallelus in Finot's key are: pronotal sulcus typically at the middle; axillary vein of the elytra of the male confluent with the middle of the anal vein, and the extruding valves of the ovipositor twice as long as wide (supported by his Fig. 93) for Stenobothrus longicornis Latreille; and, pronotal sulcus usually behind the middle, axillary vein of the elytra of the male free to the apex of the elytra, not confluent, and the extruding valves of the ovipositor with about equal length to width (supported by his Fig. 94) for <u>Stenobothrus</u> <u>parallelus</u> Zetterstedt.

Burr (1897) stated that <u>longicorne</u> Latreille was usually regarded as being synonymous with <u>parallelus</u> Zetterstedt, despite the views of Finot (<u>op.</u> <u>cit.</u>) but Burr (1910) following Finot, recognized both <u>parallelus</u> Zett. and <u>longicornis</u> Latr., stating, however, that the synonymy was confused, and further that the variety <u>explicatus</u> de Selys (of <u>parallelus</u>) is really <u>longicornis</u>. Burr (1913) considered <u>montanus</u> to be the macropterous condition of <u>parallelus</u>. with <u>longicornis</u> a distinct species but had some doubts about this latter point because of the variability of the characters used to separate <u>parallelus</u> from <u>longicornis</u>.

Azam (1913a) also used <u>montanus</u> Charpentier to refer to macropterous specimens of <u>parallelus</u>. He also misspelled the generic name, using <u>Chorthypus</u> for <u>Chorthippus</u> (subgeneric to <u>Stenobothrus</u>). Azam (1913b) again misspelled <u>Chorthippus</u>, the name this time appearing as <u>Chortippus</u>.

Zacher (1917) agreed with Finot and Burr in the separation of <u>parallelus</u> and <u>longicornis</u> but considered <u>montanus</u> (Charpentier) to be a synonym of <u>longicornis</u> rather than a form of <u>parallelus</u>. In a resumé of distribution of *C. parallelus*, he also listed this species as being introduced into North America.

Chopard (1922), following Finot and Burr, used *montana* Charpentier as a variety of *parallelus*, and considered *longicornis* (Latreille) as a distinct species. He stated that males were difficult to separate, but *longicornis* had longer antennae. He considered the females easy to separate on the basis of the ovipositor valves. Strohm (1924) followed the same line in the synonymy of these species, as did Tarbinsky (1925), mainly on the basis of the position of the pronotal sulcus, and on the ovipositor valves. Killington (1927) in reporting a rare macropterous individual of *parallelus* from Britain (Hampshire) applied *montanus* Charpentier as a varietal name.

Faber (1929) reviewed the earlier literature, including the original descriptions, and concluded that the names were misapplied, *parallelus* Zetterstedt being synonymous with *longicornis* Latreille, *montanus* Charpentier being a distinct species and the same as that referred to as *longicornis* Latreille by Finot. Faber's work was not universally accepted. Miram (1933) followed Faber's synonymy, but Weidner (1941) used *parallelus* Zetterstedt as a valid name, regarding *montanus* Charpentier as a synonym of *longicornis* Latreille.

Ander (1943) discussed the nomenclature concerning these species. He disagreed with Faber's interpretation, pointing out that Latreille's type was lost and that Latreille's description was inadequate to provide acceptable evidence for such an interpretation. He further stated that there existed in the Zetterstedt collection a pair of specimens of *montanus* Charpentier which were included in a collection of Charpentier material. Ander designated these specimens as "neotypes" and marked them as such. Since these specimens agreed with Charpentier's description of *montanus*, and Zetterstedt's type series of *parallelus* existed in the same collection, Ander had no further doubts about the identities of the two species. He was, however, unable to determine the position of *longicornis* Latreille and expressed the opinion that this name should be suppressed. Ultimately, (see later) *longicornis* was suppressed.

During the interim period the situation became no clearer. Various authors used various applications of the names, but three main conflicting views became apparent. One group, following Finot (1890) and Burr (1910), considered *longicornis* and *parallelus* as valid names with *montanus* representing the macropterous form of *parallelus*. Another group agreed with Faber (1929) in accepting *parallelus* as synonymous with *longicornis*, and with *montanus* distinct.

Still others agreed with Ander (1942) and ignored the name longicornis.

Sellier (1946), and Nagy (1948, 1949-1950) used parallelus and longicornis as distinct species while Bazyluk (1949) called the species parallelus (including variety montana Charpentier) and longicornis (with a new varietal name macroptera for the macropterous condition). He consistently misspelled the generic name, using Chortippus.

Carpentier (1951) followed the synonymy of Faber (loc. cit.). Ramme (1951) recognized parallelus and montanus, both macropterous and brachypterous forms occurring as in other species in the genus, with brachypterism as the normal state.

Chopard (1951) altered his previous view (Chopard, 1922) and, following Faber (1929), listed parallelus, sensu Finot, as a synonym of longicornis Latrèille and used "form macroptere" for macropterous individuals. Under montanus, he placed longicornis, sensu Finot, but Weidner (1952) adhered to the views of Finot. Zacher (1956) also held the latter view, and Vasiliu and Agapi (1958) considered parallelus (Zetterstedt) as synonymous with montanus (Charpentier). Harz (1960) recognized longicornis (Latreille), and held parallelus (Zetterstedt) to be synonymous with it, while montanus (Charpentier) was also considered a good species, thus accepting the views of Faber.

Ragge (1959) selected as lectotype for Chorthippus parallelus (Zetterstedt, 1821) a male from the type material, which consisted of two males and two females, at Universitetets Zoologiska Institution, Lund, Sweden. None of the four specimens has locality data.

Lux (1957, 1961) showed, by morphometric analysis and a study of the genitalia, that longicornis (Latreille), of which she considered parallelus (Zetterstedt) to be a synonym after Faber (1929), and montanus (Charpentier) are distinct species.

Kevan (1960) proposed that the plenary powers of the International Commission of Zoological Nomenclature be used to suppress the specific name longicorne Latreille, 1804, as published in the binomen Acridium longicorne. The basis for this proposal was that it was impossible to be certain of the correct taxonomic entity which should bear the name. Accordingly, the name longicorne Latreille 1804, (Acridium) was placed on the Official List of Rejected and Invalid Names in Zoology as No. 670 by Opinion 609 of the International Commission on Zoological Nomenclature (1961). Opinion 609 also resulted in the following action being taken: it (1) placed Chorthippus Fieber, 1852, on the Official List of Generic Names in Zoology as No. 1439;

(2) with type species, albomarginatum DeGeer, 1773 (Acridium), Name No. 1756 on the Official List of Specific Names in Zoology; and (3) placed parallelus Zetterstedt, 1821 (Gryllus) as Name No. 1757, and montanus Charpentier, 1825 (Gryllus) as Name No. 1758 on the same list.

As noted above, Ander (1943) considered two specimens of Charpentier's original series of montanus in the Zetterstedt collection as "neotypes" and marked them as such. This designation, however, appears to be improper. If the specimens are, in fact, part of the original series from which montanus was described, one of the two, preferably the male, should be designated as lectotype and the female would then be a paralectotype. If, however, there is some doubt, a neotype designation for one, but not both, of the two specimens would be proper. Ander (op. cit.) had little doubt that the specimens were formerly in the possession of Charpentier, so the present author has no hesitation in designating the male specimen lectotype and the female as paralectotype of Gryllus montanus Charpentier, 1825.

Hebard (1936) not only placed parallelus directly, and montanus by implication, in synonymy under longicornis, but included all of the North American names as well: curtipennis Harris, 1841; longipennis Scudder, 1862; coloradensis

McNeill, 1897; _oregonensis_ Scudder, 1899; and _acutus_ Morse, 1903. He stated, "By comparing our American series with those from the Old World we find that there is no feature warranting even racial recognition of the former."

It is possible that Hebard was motivated to compare European and North American specimens of _Chorthippus_ by the statement of Zacher (1917) that _parallelus_ occurs in North America as an introduced species. It is known that Hebard was familiar with Zacher's work, since he (Hebard, 1936) referred to the strong belief held by Zacher that _longicornis_ should not be considered as distinct from _parallelus_.

Many specimens in Hebard's collection, both of _parallelus_ and of _montanus_ from Europe and Asia, many of which are before the present author, were determined by various workers as _longicornis_. The Old World material considered by Hebard has been examined during the present study and it is apparent that the bulk of this is _montanus_, a species of wide distribution (all of northern Europe and Asia to the Kamchatka Peninsula), and the species which most closely resembles North American specimens of _Chorthippus_.

It is interesting to note that Hebard (1935a) stated, "we have recently placed _curtipennis_ Harris as a synonym" of _longicornis_ Latreille, although the paper in which this was done did not appear until the following year (Hebard, 1936).

During the short intervening period, the North American species was referred to at least once by other authors (Knutson and Jaques, 1935) as C. longicornis. Subsequently the majority of authors have also used this name for North American material although many uncritically continued to use curtipennis (see Synonymy, p.50). As already noted, however, Kevan (1960) and Ander (1960) and the present author (Vickery, 1961) expressed doubts about the synonymy of the North American and Old World species.

V. COMPARISON OF NORTH AMERICAN WITH RELATED OLD WORLD SPECIES

Hebard (1936) listed characters which had been employed previously to separate longicornis and parallelus, but he did not mention any specific character when placing all of the New World names in synonymy under longicornis.

The present study has included characters which were not used by Hebard: accurate measurements of specific characters in adequate samples of specimens; counts of the numbers of pegs present in the male stridulatory apparatus; genitalic comparisons, including complete phalli of males, with more detailed studies of the epiphalli, as well as the ovipositor valves, spermathecae and copulatory armature of the subgenital plates of females.

The genitalic differences between parallelus and montanus, as well as morphometric analyses of internal and external characters of these two species, have been studied by Lux (1957, 1961). Comparison of specimens of North American *Chorthippus* with her results and with specimens from Europe and Asia show that all American material stands much closer to *montanus* than to *parallelus*, but is distinct from both. The name *curtipennis* (Harris) must therefore be restored.

A. EXTERNAL MORPHOLOGY

Of the characters that have previously been used to distinguish between species of *Chorthippus*, tegminal venation was found to be so variable that it was not considered further in this study. The relative position of the principal transverse pronotal sulcus, likewise, was not considered after a preliminary survey, as it proved to be inconsistent (see Table I). Measurements of specimens of *montanus*, *parallelus* and *curtipennis* show that the sulcus in all three species may cross before the middle, at the mid-point, or behind the middle of the pronotum. The male abdominal terminalia do not serve to differentiate species of *Chorthippus*. The female ovipositor, however, provides a good character as follows: the dorsal and ventral ovipositor valves of *C. parallelus* (Fig. 131) are considerably shorter than in either *C. montanus* (Fig. 132) or *C. curtipennis* (Fig.134).

The dorsal valves of C. curtipennis are intermediate in size between those of C. montanus and C. parallelus, both in length and breadth. In some curtipennis specimens the length approaches that found in montanus, but the breadth in the latter is always greater than in curtipennis (see Table XX).

Two further external characters, in addition to the form of the ovipositor, which may be employed to separate montanus and curtipennis have also been revealed by the present study. The subocular sulcus is relatively straight in montanus (see Figs. 9a, 10a, 12a and 13a), at least in all of the specimens on hand, while, in curtipennis, the subocular sulcus is sinuous (see Fig. 15a). This sulcus is also sinuous in parallelus (see Figs. 11a and 14a). The lateral carinae of the pronotum of montanus, in lateral aspect, are nearly straight, or at most, only slightly arched in the anterior third (see Figs. 9b and 13b), while the carinae of curtipennis are always arched or humped in this region (Fig. 15b). In this character, parallelus resembles curtipennis for it also exhibits arching of the lateral pronotal carinae (see Figs. 11b and 14b).

B. MORPHOMETRIC DIFFERENCES AND SIMILARITIES

The figures obtained in the morphometric study of the three species show that there are several characters separating *montanus* and *curtipennis*, as well as others which exhibit the close relationship between these two species. Characters which are not significantly different are: length of body, tegmina and hind femur of males; and tegminal length, hind femur length, width of the vertex, length of the proximal segment of the hind tarsus and pronotal depth in females (Tables III - V & XII - XVI).

The mean number of stridulatory pegs in *montanus* is greater than in *curtipennis*, most *curtipennis* samples having means well below the lowest mean for *montanus*. The figures for *montanus* agree with those of Lux (1957, 1961).

Measurement of the row of stridulatory pegs and of the distance from the pegs to the proximal end of the femur will also distinguish *montanus* from *curtipennis*. Mean lengths of rows of pegs for two *montanus* samples agree with those of Lux (1957, 1961) and are greater than similar means for *curtipennis* (Table VII). The distance from the pegs to the proximal end of the femur is also different, smaller in *montanus* than in *curtipennis* (Table VIII).

The dorsoventral depth of the eye (see Figs. 5, 190, 191) as a measure of the overall size of the eye, differs between montanus and curtipennis, averaging smaller in both males and females of the former (see Tables II, IX, & XVII). Eyes in specimens of curtipennis from far northern localities actually average smaller than those of montanus but the specimens are much smaller than those from more southerly regions and are also smaller than montanus. Length of the subocular sulcus (Figs. 192, 193) shows less difference than that shown by the eye, curtipennis averaging longer than montanus in this character. The ratio of eye-depth to length of the subocular sulcus (see Tables XI & XIX) is smaller in montanus, both males and females, than in curtipennis over most of the range of the latter. Northern specimens of curtipennis, however, have smaller ratios than montanus. Specimens of parallelus have relatively larger eyes and shorter subocular sulci than montanus or curtipennis, giving a greater ratio than for either (Table II).

C. CONCEALED GENITALIA

i Males

Male internal genitalia of Chorthippus species are illustrated in Figures 46 to 130. As might be expected, the differences between the species, *parallelus*, *montanus* and *curtipennis* are not great. Variation within *curtipennis*, while relatively limited, is great enough, considering the phallus as a whole, to make practically impossible the separation of this species from *montanus* on this basis alone. In both *curtipennis* and *montanus* the phallus is larger than in *parallelus*.

The terminology used for the phallic structures in the present work (see Figs. 49a, b and 82a, b) is largely that of Roberts (1941), with some modification. Dirsh (1956), in referring to the epiphallus, also largely used the terminology of Roberts, adding only the terms anterior and posterior projections for the antero-lateral and postero-lateral areas of the lateral plate, stating that he used the term 'lateral plate' after Roberts. Comparison of Fig. 8, Plate 3 of Dirsh (*op. cit.*) with Fig. 80, page 226 of Roberts reveals that the two authors differed in their concepts of the lateral plate. In fact, Roberts labelled as lateral plates the structures called the anterior projections by Dirsh. The posterior projections of Dirsh are merely the postero-lateral parts of these lateral plates. The anterior projections of Dirsh (anterior parts of lateral plates of Roberts) are thickened, much like secondary or accessory lateral ancorae, and are extensions of the bridge, which pass beneath the ancorae, bend abruptly dorsally and anteriorly, coming to lie laterally to the ancorae. The anterior edges of the lateral plates are attached to these structures, which, to avoid confusion, I prefer to call the "anterior processes". In _Chorthippus_ they are clearly defined and noticably differentiated from the lateral plates (see Figs. 63 - 130).

One other departure from the terminology of Roberts (_op. cit._) is in the use of the terms "aedeagal sclerite" and the "endophallic apodeme", as proposed by Eades (1962).

In general form, the phallic structures of _Chorthippus curtipennis_ and of the other species of this genus that were studied, agree with the description by Roberts (1941) of the generalized phallic structures in the subfamilies Acridinae and Oedipodinae. There are two pairs of aedeagal valves, the proximal ends of the dorsal pair (D-v) being fused to form an arch, the arch of the dorsal valves (A-d-v), which articulates with, and is joined to (this is not shown in figures) the zygoma (Zyg) of the cingulum. The ventral aedeagal valves (V-v) each bear laterally a sclerite, the aedeagal sclerite (A-s), which is connected to the endophallic plates (Enph-pl) by a thin sigmoid flexure (flx). Anteriorly, each endophallic plate bears an endophallic apodeme (Enph-Apd). The ejaculatory sac (Ej-s) is small, opening anteriorly via the ejaculatory duct (Ej-d). The spermatophore sac (Sph-s) is relatively large and the gonopore processes (G-pr) are relatively long.

The cingulum (Cng) is borne dorsally, with the zygoma of the cingulum (Zyg) directly above the arch of the dorsal aedeagal valves (A-d-v). The apodemes of the cingulum (Apd-Cng) are long, rod-like, rather heavy processes directed anteriorly. The rami of the cingulum (Rm-Cng), which form a collar around the base of the aedeagal valves were found to be quite variable in shape. The suprarami, as described by Eades (1962) are small, and are not visible dorsally.

The epiphallus is characteristic for Acridinae, Roberts (1941), or Acridinae and Truxalinae, Dirsh (1956), in that it has a definite bridge (Br), which is distinctly arched. The epiphallus is located on the dorsum of the anterior end of the endophallus (with the latter in normal position). It functions as depressor of the female subgenital plate during the initial stages of copulation. The actual contact areas are the lophi (Lph), which are at the posterior ends of the epiphallus and borne on the postero-lateral branches of the bridge. Much of the surface of the lophi in the species examined were tuberculate, the tubercles possibly functioning as tactile sensillae.

An aperture (Aper) is always found on each side, between the arms of the bridge which bear the lophi. The ancorae (Anc) are separate sclerites, closely attached anterodorsally on the bridge.

In _C. curtipennis_ the ancorae are large, blunt, and slightly incurved. The lateral plates (L-pl) are broad, with the posterior projections (P-pr) well defined. The anterior processes (A-pr) are extensions of the bridge, lying laterad the ancorae. The lateral plates are attached anteriorly to the anterior processes. Specific differences are clearly shown in the male genitalia only by the epiphallus. As mentioned previously, the epiphallus of _montanus_, like that of _curtipennis_, is larger than that of _parallelus_ (see Figs. 69 and 67). Both have acute, incurved ancorae, a feature which separates these two Old World species from _curtipennis_, in which the ancorae are usually but little incurved and are rather blunt (compare Figs. 65 - 70 and 71 - 130).

ii Females

a. Subgenital Plate

Agarwala (1952, 1952a, 1953) was among the first to describe the internal structures of the female subgenital plate in any detail. Earlier observations were made by Jannone, but this paper has not been seen by the present author. Among other Acridoids, Agarwala described the subgenital plate of Omocestus viridulus (Linnaeus), a species not too far removed from Chorthippus. The subgenital plates in the species of Chorthippus herein studied clearly are of the same basic structure as in O. viridulus. The posterior edge of the plate is serrated and fusion of the plate with the floor of the genital chamber is apparent, though slight (F-e of Fig. 168). The egg-guide (E-g) is long and prominent, the tunic (t), so designated by Randell (1963) (the floor-pouches of Agarwala) is distinct, and the vagina (V) of Randell (op. cit.) (mesial pouch and common oviduct of Agarwala) is also evident. In some of the figures given here (Figs. 166, 167, 170, 176) the vagina is not illustrated because of damage to this structure during removal of the subgenital plate. The groove between the halves of the tunic (the two floor-pouches) is distinct and is carried on to the egg-guide. On either side of the base of the egg-guide in an antero-lateral position, a pair of small structures (c) join the floor of the genital chamber and the outer surface of the sub-genital plate. These structures, or pillars, were named "columellae" by Randell (op. cit.). In Chorthippus, the columellae are paired on each side. They are situated in a heavily sclerotized pigmented area which Randell called the contact areas and which are termed "Jannone's Organs" by Agarwala. The term contact area (C-a) is used here as it is more descriptive of function, these structures being the strengthened areas which come into contact with the lophi of the male epiphallus in the process of depression of the subgenital plate at the beginning of copulation.

Lux (1957, 1961) illustrated the subgenital plates of both C. parallelus and C. montanus. The egg-guide was labelled as 'mittlerer Fortsatz', the contact areas as 'Chitinbrücke', the tunic or floor pouches as 'Drusentasche'. The vagina or common oviduct was mentioned in her text but not shown or labelled in her diagrams. The subgenital plates of these two species are also figured in this paper, Fig. 166, illustrating that of C. montanus and Fig. 165 that of C. parallelus. A series of subgenital plates from females selected from points which represent the entire range of C. curtipennis are shown in Figures 167 to 183. The basic structure of the internal armature is the same in all of the specimens examined.

The subgenital plate of C. montanus is larger than that of C. parallelus. A comparison of these with subgenital plates of C. curtipennis shows that most of them are approximately the same as C. montanus, although specimens from California have smaller structures, more like those of _C. parallelus_. There is no feature of the subgenital plate which distinguishes _C. curtipennis_ from _C. montanus_, but measurement of the distance between the inner columellae shows that the columellae of _parallelus_ are set closer together than those of _curtipennis_ and _montanus_.

_b_. Spermatheca

Examination of the spermatheca reveals variation but no features that will separate the New and Old World species (Figs. 151 to 164).

_c_. Ovipositor Valves

Examination of the valves of the ovipositor reveals a striking difference between _parallelus_ (Fig. 131) and _montanus_ (Fig. 132), the valves in _montanus_ being nearly fifty percent longer, and with a ratio of breadth to length of the dorsal valve greater than that of _parallelus_. In most _curtipennis_ females the ovipositors are longer than those of _parallelus_ and shorter than those of _montanus_ (see Figs. 133 - 150). An exception was found in a female from Flagstaff, Arizona, (Fig. 143) whose ovipositor was approximately the same length as that of _montanus_. Breadth to length ratios in _curtipennis_ emphasize the fact that in _curtipennis_ the dorsal valve averages narrower than in either *montanus* or *parallelus*. Smaller ratios in *curtipennis*, nearer those of *montanus*, occur in the northwest (Alaska) and in the west (British Columbia, Oregon, Nevada and California), but specimens from these regions have ovipositors which are considerably shorter than in *montanus* and are broader in comparison to length than in specimens from the remainder of the continent.

D. COLOUR FORMS

Chorthippus curtipennis also differs from *C. montanus* and *C. parallelus* in its colour forms. Rubtzov (1935) reported six homologous colour forms in *Chorthippus* species in Siberia. The names applied to these forms were said to have been first used by Vorontsovsky in 1927. They are: (1) *viridis* (green dorsally and laterally); (2) *hyalosuperficies* (green dorsally, brown laterally); (3) *hyalolateralis* (brown dorsally, green laterally); (4) *rubiginosa* (entirely brown, with black markings near pronotal carinae and on abdomen); (5) *purpurea* (purple dorsally, green laterally); (6) *fuliginosa* (blackish-brown dorsally and upper parts of head and pronotal lobes, lower parts yellowish white). (For more complete descriptions see Table XXI).

Rubtzov recorded all six colour forms for *C. parallelus*, while *longicornis* [= *montanus*] occurred, in the specimens before him, in four forms only: *viridis*, *hyalolateralis*, rubiginosa and purpurea. He stated, however, that the two remaining forms would probably also be found upon examination of more specimens. He did not indicate the proportion of the various colour forms in his samples of either species.

Chorthippus curtipennis was found in the present study to occur almost exclusively in the three forms hyalolateralis, rubiginosa and purpurea. Only single specimens representing the fuliginosa and hyalosuperficies colour forms were found. Rubtzov (op. cit.) recorded the colour form viridis for all thirteen species of Chorthippus that he studied, but this form either does not occur in curtipennis, or is of extreme rarity, as it was not found during examination of approximately seven thousand specimens (see Table XXII).

E. RESUMÉ OF DIFFERENCES BETWEEN NORTH AMERICAN AND RELATED OLD WORLD SPECIES

The Nearctic species Chorthippus curtipennis (Harris) may be distinguished from its nearest relative, the Palearctic C. montanus (Charpentier), by the following features (see Table II):

1. there are fewer stridulatory pegs in males;
2. the row of stridulatory pegs is shorter;

3. the length from the proximal end of the row of stridulatory pegs to the base of the hind femur is greater;
4. the eyes of both males and females average larger, except for the small, far northern specimens in which they average smaller;
5. the average length of the subocular sulcus is greater in both males and females, except for far northern specimens, in which the overall size is smaller;
6. the ratio, eye-depth by length of the subocular sulcus, is greater in males, except for the small northern specimens (the ratio in _montanus_ females slightly exceeds that of _curtipennis_ females);
7. the subocular sulcus is sinuous, not straight as in _montanus_;
8. the lateral carinae of the pronotum, in lateral view, are arched or humped in the anterior third, not relatively straight as in _montanus_;
9. the ancorae of the male epiphallus are blunt and only slightly incurved, not acute and definitely incurved at the apices as in _montanus_;
10. the ovipositor valves are shorter and narrower, and have a greater ratio of length to breadth (in the only areas in which the ratios are nearly the same in the

two species, namely, in the west and northwest regions of North America, the ovipositor valves are much shorter than in montanus);

11. the colour form viridis is unknown, whereas it is common in montanus, constituting 55 per cent of the population (form viridis is also predominant in C. parallelus);

12. the predominating colour form is rubiginosa, 60 per cent of all specimens examined belonging to this form, whereas in montanus, only 11 per cent are form rubiginosa.

VI. SYNONYMY, DESCRIPTION, TYPE DESIGNATION AND DISTRIBUTION OF CHORTHIPPUS IN NORTH AMERICA

A. SYNONYMY AND LITERATURE REFERENCES TO C. CURTIPENNIS (HARRIS)

curtipennis Harris

Locusta curtipennis

Harris,	1835.	Hitchc. Rpt. geol. Mass., 2ed., p. 566, - nomen nudum.
	1835a.	Cat. Ins. Mass., p. 56, - nomen nudum.
Glover,	1872-74	Ill. N. Amer. Ent. Pl. VII, fig. 10; Pl. X, fig. 4; Pl. XII, fig. 18.

<u>Locusta</u> (<u>Chlöealtis</u>) <u>curtipennis</u>

Harris,	1841.	Rpt. Ins. Mass. inj. Veg., p. 149. /Privately reprinted, same pagination, 1842./
	1852.	Ibid. ed. 2, p. 160.
Rathvon,	1862.	U.S.D.A. Rpt. <u>1862</u>, pp. 386-387; fig. 28.
Harris,	1862.	Treat. Ins. inj. Veg., p. 184; pl. 3, fig. 1.

<u>Chlöealtis</u> <u>curtipennis</u>

Packard,	1861.	Rpt. nat. Hist. Me., <u>1861</u>, p. 376.
Glover,	1872-74.	Ill. N. Amer. Ent. Pl. VI, fig. 15; Pl. VII, fig. 10; Pl. X, fig. 4; Pl. XII, fig. 18.
Bruner, <u>in</u> Smith, J.B.,	1890.	N.J. Geol. Surv., p. 412.
Blatchley,	1891.	Can. Ent. <u>23</u>:76.
Osborne,	1892.	Proc. Iowa Acad. Sci. <u>1</u>(2):118.
Bruner,	1893.	Nebr. Acad. Sci. Publ. <u>3</u>:19-33.
Blatchley,	1894.	Can. Ent. <u>26</u>:222.

<u>Stenobothrus</u> <u>curtipennis</u>

Scudder,	1862.	Canad. Nat. & Geol. & Proc. nat. Hist. Soc. Montreal <u>7</u>(4):286.
	1862a.	Jour. Bost. Soc. nat. Hist. <u>7</u>:456.
	1868.	Amer. Nat. <u>2</u>:118.
	1868a.	Smithson. Misc. Coll. <u>8</u>(189):77.
Smith, S.,	1869.	Proc. Port. Soc. nat. Hist. <u>1</u>:147.
Scudder, <u>in</u> Packard,	1869.	Rec. amer. Ent. <u>1868</u>, p. 41.

Packard,	1869.	Guide Ins., p. 569. (and subsequent editions).
Walker, F.,	1870.	Cat. Derm. Salt. Brit. Mus. 4:754.
	1872.	Can. Ent. 4:31.
Glover,	1872.	Ill. N.A. Ent. Orth.: Pl. VI, fig. 15; Pl. VII, fig. 10; Pl. X, fig. 4; Pl. XII, fig. 18.
Smith, S.,	1872.	Conn. Bd. agr. Rpt. 1872; pp. 376, 382.
Thomas,	1873.	U.S. geol. Surv. Terr. Rpt. 5:91.
Thomas, in Packard,	1873.	Rec. amer. Ent. 1872, p. 32.
Scudder,	1874.	Hitchc. Rpt. geol. N.H. 1:373, fig. 57.
Scudder in Packard,	1874.	Rec. amer. Ent. 1873, pp. 39-41.
Thomas,	1875 (?).	Key Ill. Orth., p. 3.
	1875a.	Rpt. U.S. geol. Surv. w. 100 mer. Rpt. 5:872.
	1876.	Ill. State Lab. nat. Hist. Bull. 1:61-62.
	1876a	Proc. Dav. Acad. Sci. 1:251.
Provancher,	1876.	Nat. Can. 8:134.
	1877.	Ibid 9:300.
Uhler,	1877.	U.S. geol. geog. Surv. Terr. Bull. 4, Vol. 3:793.
Bessey,	1877.	Iowa agr. Coll. bienn. Rpt. 7:207.
Bruner,	1877.	Can. Ent. 9:144.
Thomas,	1878.	U.S. geol. Surv. Terr. Bull. 4:482.
	1878a.	Ann. Rpt. chief Eng., 1878, p. 1844.

Scudder,	1880.	Rpt. U.S. ent. Comm. 2:25.
Bruner in Riley,	1880.	Ibid. 2:55.
Thomas,	1880.	Rpt. Ill. State ent. 9:88, 93, 104.
Provancher,	1883.	Petite Faune Ent. Canad., p. 43.
Anon.	1883.	Label list insects Dom. Canada, p., 67.
Riley,	1884.	Stand. nat. Hist. 2:202.
Lintner,	1885.	Rpt. Ins. N.Y. 2:196-197.
Bruner,	1885.	Can. Ent. 17:10.
	1886.	U.S. ent. Rpt. 1885, p. 307.
Caulfield,	1886.	Can. Ent. 18:212.
	1887.	Can. rec. Sci. 2:400. /Reprinted 1887, with changed pagination, pp. 12-13./
	1888.	Ent. Soc. Ont. ann. Rpt. 18:70.
Comstock,	1888.	Intro. Ent., p. 102.
Fernald,	1888.	Mass. agr. Coll. ann. Rpt. 25 (1887):457.
	1888a.	Orth. New Eng., p. 37.
Davis,	1889.	Ent. Amer. 5:81.
McNeill,	1891.	Psyche 6:65.
Smith, J.,	1892.	N.J. exp. Sta. Bull. 90:31.
	1892a.	N.J. Ent. Rpt. 1892:436.
Scudder,	1893.	Ent. Soc. Ont. ann. Rpt. 23:76, fig. 52.

Morse,	1893.	Psyche 6:406.
Cockerell,	1893.	Trans. Amer. ent. Soc. 20:337.
Morse,	1894.	Psyche 7(1):14.
	1894a.	Ibid 7:104, 108.
	1894b.	Ibid 7:179.
Beutenmüller,	1894.	Amer. Mus. nat. Hist. Bull. 6:294-295.
Piers,	1896.	Trans. N.S. Inst. Sci. 9:213.
Morse,	1896.	Psyche 7:327, 420; pl. 7, fig. 12.
McNeill,	1896.	Proc. Dav. Acad. nat. Sci. 6:260-262.
Harvey and Knight,	1897.	Psyche 8:78.
Scudder,	1897.	Psyche 8:99-100.
Lugger,	1897.	Univ. Minn. agr. exp. Sta. Bull. 55:218, fig. 44.
Ball,	1897.	Proc. Iowa Acad. Sci. 4:239.
Bruner,	1897.	Nebr. Bd. Agr. ann. Rpt. 1896, p. 129.
Blatchley,	1898.	Can. Ent. 30:63.
Scudder,	1898.	Appalachia 8:303, 305-6.
	1898a.	Alp. Orth. N.A., pp. 6-7.
Walker, E.	1898.	Can. Ent. 30:126.
Scudder,	1899.	Proc. Amer. Acad. Arts Sci. 35:50.
	1900.	Psyche 9:101, 105.
	1900a.	Proc. Dav. Acad. nat. Sci. 8:26.
Fogg,	1900.	Manch. Inst. Arts. Sci. 1:43.

Smith,	1900.	N.J. State Bd. Agr. ann. Rpt. 27:155.
Scudder,	1901.	Occ. Pap. Bost. Soc. nat. Hist. 6:302-303.
Scudder & Cockerell,	1902.	Proc. Dav. Acad. Sci. 9:26.
Rehn, in Skinner,	1902.	Trans. Amer. ent. Soc. 29:41.
Rehn,	1902.	Ent. News 13:311.
Walker,	1902.	Can. Ent. 34:254.
Caudell,	1903.	Proc. U.S. nat. Mus. 26:783.
Blatchley,	1903.	Ill. Dept. geol. & nat. Res. ann. Rpt. 26(1901):246.
Mead,	1904.	Ohio Nat. 4:111.
Morse,	1904.	Carneg. Inst. Publ. 18:18, 23, 32.
Gillette,	1904.	Colo. Agr. exp. Sta. Bull. 94:27.
Bruner,	1904-08.	Biol. Cent.-Amer. Orth. 2:91.
Rehn,	1905.	Ent. News 16:23.
Walker,	1906.	Can. Ent. 38:55.
	1906a.	Ent. Soc. Ont. ann. Rpt. 36(1905):66.
Blatchley,	1908.	Proc. Ind. Acad. Sci. 1908:187.
Caudell,	1908.	Proc. U.S. nat. Mus. 34:73.
Walker,	1909.	Can. Ent. 41:139-140, 176.
Morse,	1909.	Ecol. Surv. I. Roy., L. Super., Mich. 1908, p. 300.
Allard,	1910.	Ent. News 21:352-353.
Walker,	1910.	Can. Ent. 42:274.
Kirby,	1910.	Brit. Mus. Publ. 3(2):188.

Allard,	1911.	Ent. News 22:28, 34.
Woodward,	1911.	Rpt. Mich. Acad. Sci. 13:156-157.
Walden,	1911.	Conn. St. geol. & nat. Hist. Surv. Bull. 16:83-84; pl. 8, fig. 4.
Allard,	1912.	Ent. News 23:462.
Washburn,	1912.	Minn. St. Ent. 14th Rpt. (1911-12): 12, 13; pl. 1, fig. 6.
Vestal,	1914.	Ent. News 25:105.
Fox,	1914.	Proc. Acad. nat. Sci. Phila. 1914: 445-447, 449-450, 456-457, 466, 468, 472-473, 477-478, 493-494.
Somes,	1914.	Univ. Minn. agr. exp. Sta. tech. Bull. 141:28; pl. 1, fig. 6.
Kellogg,	1914.	Amer. ins., Ed. 3, rev., p. 140, 142; Fig. 174.
Fox,	1915.	Proc. Ind. Acad. Sci. 1914:294-295, 298.
DuPorte & Vanderleck,	1917.	Ent. Soc. Ont. ann. Rpt. 47(1916): 92.
	1917a.	Ann. ent. Soc. Amer. 10:51, 54, 58.
Fox,	1917.	Proc. U.S. nat. Mus. 52:212.
Pettit & McDaniel,	1918.	Mich. agr. Coll. exp. Sta. Bull. 83:10, 11.
Britton,	1920.	Conn. St. geol. nat. Hist. Surv. Bull. 31:39.
Henderson,	1924.	Utah agr. Exp. Sta. Tech. Bull. 191:128.
Comstock,	1924.	Intro. Ent., pp. 82-83; figs. 92, 93.

Chorthippus curtipennis

Rehn,	1902.	Can. Ent. 34:317.
	1903.	Ent. News 13:307.
	1904.	Ibid. 15:235.
	1904a.	Ibid. 15:327.
Rehn and Hebard,	1909.	Proc. Acad. nat. Sci. Phila. 61:143.
Rehn,	1910.	Ent. News 21:24.
Hebard,	1910.	Ibid. 21:184.
Rehn and Hebard,	1910.	Proc. Acad. nat. Sci. Phila. 1910:628-629.
Smith, J.,	1910.	N.J. St. Mus. ann. Rpt. 1909:180.
Kirby,	1910.	Brit. Mus. Publ. 3(2):188.
Rehn and Hebard,	1911.	Ent. News 22:6.
Caudell,	1911.	Ibid. 22:162.
Sherman and Brimley,	1911.	Ibid. 22:388.
Walker, in Faull,	1913.	Canad. Inst. Toronto, p. 300.
Walker,	1915.	Can. Ent. 47:340.
Hebard,	1915.	Ent. News 26:306.
Walker, in Gibson,	1915.	45th ann. Rpt. Ent. Soc. Ont. 1914:147.
Walker,	1916.	Can. Ent. 48:221.
Rehn and Hebard,	1916.	Proc. Acad. nat. Sci. Phila. 1916:96, 106.

Gooderham,	1917.	Proc. ent. Soc. N.S. 1916:25.
Fox,	1917.	Proc. U.S. nat. Mus. 52:212.
Piers,	1918.	Trans. N.S. Inst. Sci. 14:266-269.
Lutz,	1918.	Field book insects, p. 69.
Morse,	1919.	Psyche 26:32-33.
Walker,	1920.	Rpt. Can. Arc. Exped. (1913-18); Rpt. 3(J):4.
Blatchley,	1920.	Orth. N.E. Amer., p. 234-236.
Buckell,	1920.	50th ann. Rpt. Ent. Soc. B.C., 1919:54, 56.
Morse,	1921.	Maine agr. exp. Sta. Bull. 296: 9, 12, 14-15, 26, 34; figs. 8 & 9.
Rehn, in Buckell,	1922.	Proc. ent. Soc. B.C. 20:20-21.
Hubbell,	1922.	Occ. Pap. Mus. Zool. Univ. Mich. 113:16-17.
	1922a.	Ibid. 116:38-39.
Hebard,	1925.	Proc. Acad. nat. Sci. Phila. 77:61.
	1925a.	Trans. Amer. ent. Soc. 51:42.
Criddle,	1926.	Trans. Roy. Soc. Can. 20:509; Pl. I, fig. 2.
Davis, in Leonard,	1926.	Cornell Univ. agr. exp. Sta. Mem. 101:30.
Johnson,	1927.	Wistar Inst. anat. Biol. Phila., p. 22.
Hebard,	1928.	Proc. Acad. nat. Sci. Phila. 80:228.
Fox,	1928.	N.J. Dept. Agr. Circ. 138:45.

Buckell,	1929.	Proc. ent. Soc. B.C. (1928) 25:11-12.
Hubbell,	1929.	Jour. N.Y. ent. Soc. 37:34.
Hebard,	1929.	Proc. Acad. nat. Sci. Phila. 81:330.
Fulton,	1930.	Ann. ent. Soc. Amer. 23:639.
Buckell,	1930.	Proc. ent. Soc. B.C. (1930), 27:20.
Hebard,	1931.	Proc. Acad. nat. Sci. Phila. 82:384.
	1931a.	Ibid. 83:143.
Knowlton and Janes,	1931.	Utah Acad. Sci. 9:105.
Henderson,	1931.	Utah Agr. exp. Sta. Circ. 96: 24-25; Fig. 8.
Hebard,	1932.	Univ. Minn. agr. exp. Sta. tech. Bull. 85:25.
	1933.	Ent. News 44:63.
Criddle,	1933.	Proc. World Grain Exh. & Conf. pp. 476, 480, 489-490.
Hebard,	1934.	Ent. News 45:104.
	1934a.	Ill. nat. Hist. Surv. Bull. 20(3):177-178.
	1935.	Proc. Acad. nat. Sci. Phila. 87:52.
	1935a.	Trans. Amer. ent. Soc. 61:283.
Gurney,	1935.	Can. Ent. 67:187.
Shotwell,	1936.	Ins. pest. Surv. Bull. 16(supp. to 5):219 (Mimeo).
Hebard,	1936.	N. Dak. agr. exp. Sta. tech. Bull. 284:31-33.
Gilbert & Thompson,	1937.	Ent. Soc. Ont. ann. Rpt. 67(1936):65.
Knowlton & Sorenson,	1938.	Utah Acad. Sci. Arts Lett. 15:87.

Brimley,	1938.	N. Car. Dept. Agr. Div. Ent. Bull. p. 24.
Mills & Pepper,	1938.	Mont. St. Coll. agr. exp. Sta. Mimeo Circ. 9:9.
Semans,	1939.	Ohio Jour. Sci. 39:163, 164.
Urquhart,	1941.	Contrib. Roy. Ont. Mus. Zool. 20:4, 25.
Semans,	1941.	Ohio Jour. Sci. 41(6):459.
Clark,	1942.	Ent. mo. Mag. 78:162.
Semans,	1943.	Ohio Jour. Sci. 43:228.
Chagnon,	1944.	Nat. Canad. 71:62, 145.
	1944a.	Contrib. Inst. Biol. Univ. Montreal 14:34.
Procter,	1946.	Wistar. Inst. Anat. Biol. Phila. p. 38.
Judd,	1948.	Can. jour. Res. D. 26:120.
Pierce,	1948.	Harv. Univ. Pr. pp. 46, 47, 240-245; Figs. 45, 46, 181-183.
Mills & Pepper,	1949.	Mont. St. Coll. agr. exp. Sta. Mimeo Circ. 9(Rev.):9; figs. 3 & 4.
Benoit, P.,	1958.	Laval Univ. Quebec, M.Sc. Thesis, pp. 45, 46; Fig. 75.
Robert,	1959.	Ann. Soc. ent. Quebec 5:45, 46, 47.
Kevan,	1960.	Bull. Zool. Nomencl. 17:203-204.
Ander,	1960.	Opusc. Ent. 25:226-228.

<u>Chortippus</u> (<u>sic!</u>) <u>curtipennis</u>

Tinkham,	1939.	Can. Ent. <u>71</u>:123.

<u>Stenobothrus</u> (no species included)

Comstock,	1920.	Intro. Ent. Ed. 2, p. 82; figs. 92, 93.
	1924.	Intro. Ent. Rev. Ed. p. 82, 83; figs. 92, 93. (Subsequent editions also use <u>Stenobothrus</u>.)

<u>Stauroderus</u> <u>curtipennis</u>

Rehn and Hebard,	1906.	Proc. Acad. nat. Sci. Phila. <u>58</u>:369.
Hebard,	1909.	Ent. News <u>20</u>:155.

<u>Stauroderus</u> (<u>Stenobothrus</u>) <u>curtipennis</u>

Fox,	1915.	Proc. Ind. Acad. Sci. <u>1914</u>: 294, 303-304.

<u>Sturoderus</u> (<u>sic!</u>) (<u>Stenobothrus</u>) <u>curtipennis</u>

Fox,	1915.	Proc. Ind. Acad. Sci. <u>1914</u>: 295, 309.

<u>longipennis</u> Scudder.

<u>Stenobothrus</u> <u>longipennis</u>

Scudder,	1862a.	Bost. Jour. nat. Hist. <u>7</u>:457.
	1868a.	Smiths. misc. Coll. <u>8</u>:77.
Smith, S.I.,	1869.	Proc. Portl. Soc. nat. Hist. <u>1</u>:147.
Scudder, <u>in</u> Packard,	1869.	Rec. Amer. Ent. <u>1868</u>, p. 41.
Walker,	1870.	Cat. Derm. Salt. Brit. Mus. <u>4</u>:754.

Glover,	1872-74.	Ill. N. Amer. Ent., Pl. V, fig. 15.
Thomas, *in* Packard,	1873.	Rec. amer. Ent. 1872, p. 32.
Scudder, *in* Packard,	1874.	Ibid. 1873, p. 41.
Thomas,	1875.	U.S. geol. geog. Surv. w. 100 m. Rpt. Zool. 5:872.
Provancher,	1876.	Nat. Can. 8:134.
	1877.	Ibid. 9:300.
Thomas,	1878.	U.S. geol. Surv. Terr. Bull. 4:482.
Provancher,	1883.	Petite Faune Ent. Canad., p. 43.
Anonymous,	1883.	Label list ins. Dom. Canad., p. 67.
Morse,	1894.	Psyche 7:14.
	1894a.	Ibid. 7:104, 108.
Scudder,	1900a.	Proc. Dav. Acad. nat. Sci. 8:26.
	1901.	Occ. Pap. Bost. Soc. nat. Hist. 6:303.
Bruner,	1904-08.	Biol. Cent.-Amer. Orthop. 2:91.
Kirby,	1910.	Brit. Mus. Publ. 3:188.
Blatchley,	1920.	Orth. N.E. Amer., p. 236.
Hebard,	1925.	Proc. Acad. nat. Sci. Phila. 77:61.
	1936.	N. Dak. agr. exp. Sta. tech. Bull. 284:31-33.

curtipennis longipennis Scudder.

Stenobothrus curtipennis longipennis

Thomas,	1873.	U.S. geol. Surv. Terr. Rpt. 5:91.

Morse,	1894.	Psyche 7:104.
	1896.	Ibid. 7:420.
Harvey & Knight,	1897.	Ibid 8:78.
Smith,	1900.	Ins. N.J., p. 155.
Scudder,	1901.	Occ. Pap. Bost. Soc. nat. Hist. 6:303.
Walker,	1902.	Can. Ent. 34:252.

coloradensis McNeill.

Stenobothrus coloradensis

McNeill,	1897.	Proc. Dav. Acad. nat. Sci. 6:260, 262-263; pl. 5, figs. 25, 25a, 25b.
Bruner,	1897.	Nebr. Bd. agr. ann. Rpt. 1896:129.
Scudder,	1899.	Proc. Amer. Acad. Arts Sci. 35:50.
	1900a.	Proc. Dav. Acad. nat. Sci. 8:26.
	1901.	Occ. Pap. Bost. Soc. nat. Hist. 6:302.
Bruner,	1904-08.	Biol. Cent.-Amer. Orthop. 2:91.
Caudell,	1911.	Ent. News 22:162.
Blatchley,	1920.	Orth. N.E. Amer., p. 236.
Hebard,	1925.	Proc. Acad. nat. Sci. Phila. 77:61.
	1936.	N. Dak. agr. Exp. Sta. tech. Bull. 284:31-33.

Chorthippus coloradensis

Kirby,	1910.	Brit. Mus. Publ. 3(2):188.

<u>oregonensis</u> Scudder.

<u>Stenobothrus</u> <u>oregonensis</u>

Scudder,	1899.	Proc. Amer. Acad. Arts Sci. <u>35</u>: 50-51.
	1900a.	Proc. Dav. Acad. nat. Sci. <u>8</u>:26.
	1901.	Occ. Pap. Bost. Soc. nat. Hist. <u>6</u>:303.
Rehn and Hebard,	1912.	Proc. Acad. nat. Sci. Phila. <u>1912</u>:91.

<u>Chorthippus</u> <u>oregonensis</u>

Kirby,	1910.	Brit. Mus. Publ. <u>3</u>(2):188.
Buckell <u>in</u> Criddle & Curran,	1923.	52nd ann. Rpt. Ent. Soc. Ont., <u>1922</u>:89.
Hebard,	1936.	N. Dak. agr. exp. Sta. tech. Bull. 284:31-33.

<u>curtipennis</u> <u>oregonensis</u> Scudder.

<u>Chorthippus</u> <u>curtipennis</u> <u>oregonensis</u>

Rehn, <u>in</u> Buckell,	1922.	Proc. ent. Soc. B.C. <u>20</u>:20-21.
Buckell,	1929.	Ibid. <u>25</u>:11-12.
Fulton,	1930.	Ann. ent. Soc. Amer. <u>23</u>:612, 634.

<u>acutus</u> Morse.

<u>Stenobothrus</u> <u>acutus</u>

Morse,	1903.	Psyche <u>10</u>:115.
Baker,	1903.	Pomona Coll. Publ. <u>1</u>:13.

Walker, *in* Fletcher,	1906.	36th ann. Rpt. Ent. Soc. Ont. 1905:103.
Walker,	1910.	Can. Ent. 42:257.
Morse and Hebard,	1915.	Proc. Acad. nat. Sci. Phila. 66:100.
Hebard,	1931.	Proc. Acad. nat. Sci. Phila. 82:384.

Chorthippus acutus

Kirby,	1910.	Brit. Mus. Publ. 3(2):187.
Hebard,	1936.	N. Dak. exp. Sta. tech. Bull. 284:31-33.

longicornis, *nec* Latreille, 1804. (Hist. nat. Crust. Ins. 12:159. (*Acrydium*).)

Chorthippus longicornis

Hebard,	1935.	Trans. Amer. ent. Soc. 61:283.
Knutson & Jaques,	1935.	Proc. Iowa Acad. Sci. 42:181.
Hebard,	1936.	N. Dak. agr. exp. Sta. tech. Bull. 284:8, 31-33, 60.
	1936a.	Ent. News 47:15.
Slifer & King,	1936.	Jour. N.Y. ent. Soc. 44:345.
Knutson,	1937.	Field & Lab. 5:41.
Hebard,	1937.	Ent. News 48:225.
Shotwell,	1938.	Jour. econ. Ent. 31:604.
Slifer,	1939.	J. Morph. 65:pl. 1, fig. 17.
Rehn, J.W.H.,	1939.	Can. Ent. 71:176.

Rehn, J.W.H., 1939a. Fragm. Faun. Mus. Zool. Polon. 4:261.

Urquhart, 1941. Univ. Toronto Biol. Ser. 48:119.

1941a. Ibid. 50:31, 34; pl. 27, fig. 71.

1941b. Contrib. Roy. Ont. Mus. Zool. 20:4, 25.

Alexamder, 1941. Univ. Colorado Stud. D, 1:146.

Creighton and Robertson, 1941. Jour. Heredity 32:339-341.

Creighton, 1941. Jour. exp. Zool. 87:347-369.

Clark, 1942. Ent. mo. Mag. 78:162.

Ball, et al., 1942. Univ. Ariz. agr. exp. Sta. tech. Bull. 93:293.

Cantrall, 1943. Univ. Mich. Mus. Zool. Misc. Publ. 54:52, 55, 62, 94.

Hebard, 1945. Trans. Amer. ent. Soc. 71:85.

White and Rock, 1945. Sci. Agr. 25:583.

Coleman, 1947. Genetics 32:435-447.

LaRivers, 1948. Amer. midl. Nat. 39:666.

Smith, inHandford, 1948. Res. Grassh. Inves. 1947, pt. 3, p. 9. (parasites of).

Weber, 1949. Ent. News 60:121.

Alexander, 1951. Ecol. 32:108.

Rehn, J.A.G., 1952. Ent. News 63:30-31.

Romanow, W., 1952. Orth.Man. Univ. Man. M.Sc. Thesis, pp. 37-38.

Knowlton, 1952. Utah agr. exp. Sta. Mimeo. 386:2.

Slifer, 1953. Trans. Amer. ent. Soc. 79:58, 64; pl. 3, fig. 17.

Hauke, 1953. Bull. Univ. Nebr. St. Mus 3:

Washburn, 1953. Jour. econ. Ent. 46:898.

Pepper, et al., 1953. Mont. agr. exp. Sta. Bull. 484:5.

Froeschner, 1954. Iowa St. Coll. Jour. Sci. 29:215.

Barnum, 1954. Gr. Basin Nat. 14:39-60.

Newton & Gurney, 1956-57. U.S.D.A. Coop. econ. Ins. Rpt. 6:839 (Map 22).

Brooks, 1958. Can. Ent. Supp. 9:55.

Rehn, in Hubbs, 1958. Zoogeog. 12, p. 273.

Gangwere, 1958. Pap. Mich. Acad. Arts Sci. Lett. 43:127.

Kreasky, 1960. Ann. ent. Soc. Amer. 53:436-437.

Gangwere, 1960. Ent. News 71:8.

1960a. Ibid. 71:197.

1960b. Can. Ent. 92:911-913.

Vickery, 1961. Proc. N.S. Inst. Sci. 25:56-57.

Gangwere, 1961. Trans. Amer. ent. Soc. 87:90-91.

Mulkern, 1962. N. Dak. Research Rpt. 7:14, 16, 17, 23.

Onsager and Mulkern, 1963. N. Dak. agr. exp. Sta. tech. Bull. 446:22, pl. 3, fig. 9.

Helfer, 1963. Brown & Co., Dubuque, Iowa, pp. 168, 231.

Chortippus (sic!) longicornis

Tinkham, 1939. Can. Ent. 71:123.

Miscellaneous.

Chorthippus, (no specific name) Hebard, 1926. Trans. Amer. ent. Soc. 52:56.

Chorthippi (Tribal name only) Lutz, 1918. Field book insects, p. 69.

Lutz, 1935. Field book of insects, p. 62.

B. REDESCRIPTION AND SELECTION OF NEOTYPE FOR C. CURTIPENNIS (HARRIS, 1841)

Harris' original description of Locusta (Chlöealtis) curtipennis, 1841, is as follows: "Olive-gray above, variegated with dark gray and black; legs and body beneath yellow; a broad black line extends from behind each eye on the sides of the thorax; wing-covers, in the male, as long as the abdomen, in the female, covering two-thirds of the abdomen; wings rather shorter than the wing-covers, transparent, and faintly tinged with yellow; hinder knees black; spines on the hind shanks tipped with black. Length from 1/2 to more than 8/10 inch; exp. from 7/10 inch to nearly 1 inch.

"The flight of the short-winged locust is noiseless and short, but it leaps well. Great numbers of these insects are found in our low meadows, in the perfect state, from the first of August till the middle of October. They are easily distinguished from other locusts by their short and narrow wings, by the yellow color of the body beneath, and by the yellow legs and black knees."

Harris added a footnote, as follows: "This species closely resembles a Swedish insect which I have received under the name of parallelus Zetterstedt; but is evidently distinct from it."

The same description is given in Harris (1862) but the footnote is not repeated.

Harris' specimens are no longer in existence, which makes necessary the designation of a neotype for curtipennis. Considerable difficulty was encountered in selecting a specimen from those available, as most of the specimens from Massachusetts, in the districts from which Harris' original material originated, are in very poor condition. Legs and antennae are missing from many of them and others have been damaged by Dermestid beetles. However, the following specimen (Fig. 15) was eventually selected as neotype of the species: Male, Waltham [Mass., U.S.A.], Sept. 9, '91. Museum of Zoology, University of Michigan.

A redescription of the species, based on this specimen is as follows:

Head: rounded in anterior view; face slanted, frontal angle acute, 60 degrees; frontal fastigium relatively broad, 0.5 mm., narrowing slightly at frontal ocellus, expanding ventrally to 0.8 mm.; lateral foveolae distinct, face depressed behind fastigium and beneath foveolae, partially covering antennal socket; antero-lateral area of face with H-shaped suture; prominent arcuate ridges extending from beneath lateral ocelli to epistomal sulcus; subocular sulci deep and minutely sinuous, 1.05 mm. in length; eyes rounded, prominent, dorso-ventral length, 1.80 mm.; antennae long, 10.1 mm., 22 segments, slightly dorso-ventrally compressed.

Thorax: pronotum longitudinally tricarinate, median carina distinct, slightly and evenly elevated, cut behind the middle by principal transverse sulcus; lateral carinae incurving slightly at the anterior third then diverging to posterior edge; pronotum wider posteriorly than anteriorly; lateral carinae cut by three sulci, two anterior to the principal sulcus; in lateral aspect, lateral carinae humped at anterior third and depressed at principal transverse sulcus.

Tegmina and wings: fully developed, tegmina 11.52 mm. long, slightly surpassing the abdomen; hyaline, with pale brown veins (tip of right tegmen slightly torn).

Legs: typical for the genus, pale brown, darker on the tarsi, knees of posterior legs black; hind femur length, 10.88 mm.

Abdomen: indented at base of subgenital plate, apex of plate acute, 42 degrees; furculae triangular, cerci subcylindrical, rather blunt, 0.68 mm. in length.

Colouration: general colour dark brown above, lighter brown to gray laterally and ventrally; head dark brown dorsally, with pale median longitudinal line, broad brown longitudinal stripe dorsolaterally, separated from dorsal colour by pale greenish-brown line; genal area gray; fastigium dark brown above fading to gray-brown below; mouthparts gray to gray-brown; pronotum with dark stripes dorsally and dorsolaterally; lateral lobes gray below, series of six small spots along the anterior margins of the lateral lobes and a large patch on the ventral half near the anterior edge, black; abdomen black above, greenish brown laterally and on the underside with triangular black patches on the anterior edges of the notal plates laterally; tegmina hyaline, veins pale brown, legs pale brown, darker on tarsi; posterior knees black.
General measurements: length of body - 15.28 mm.; tegmina - 11.52 mm.; hind femora - 10.88 mm.; stridulatory pegs - 127; length of row of pegs - 3.99 mm.; cercus - 0.68 mm.

The colouration of this specimen is not typical of the major colour forms found in the species. These are discussed later in Section VII, subsection E.

C. THE TYPE SPECIMENS OF NORTH AMERICAN CHORTHIPPUS

curtipennis (Harris, 1841)

As previously noted, Harris' specimens are lost. The male selected by the present author as neotype is deposited in the insect collection of The Museum of Zoology, University of Michigan, Ann Arbor, Michigan, U.S.A. This specimen bears a white handwritten label "Waltham, Sept. 9, '91" (referring to Waltham, Massachusetts, U.S.A.), collector unknown. A second label bears the determination "Chorthippus longicornis (Latreille), Det. T.H. Hubbell, 1950" (see Fig. 15 and Fig. 219).

longipennis (Scudder, 1862)

The holotype of Scudder's longipennis is Type Number 15238 of the Museum of Comparative Zoölogy, Harvard University, Cambridge, Massachusetts. It is a male and bears the following: a faded, red, circular label; a second, white label in Scudder's handwriting, "S. longipennis Scudd. Cambridge"; a third, smaller label "longipennis" in pencil; a fourth label, handwritten "Stenobothrus longipennis Scudd." on white, type-set in red as follows "Cab. S.H. Scudder", with a thin red border line; a fifth red label printed "Type 15238"; and a sixth, small label "Museum of Comparative Zoology". The left tegmen and wing of this specimen are spread, but the wing remains folded. The right posterior leg is missing and the tarsus is missing from the left posterior leg (see Fig. 16 and Fig. 221).

coloradensis (McNeill, 1897)

All efforts to trace McNeill's type have been unsuccessful. McNeill described the species from a single female collected by C. P. Gillette, Fort Collins, Colorado. The specimen was labelled "Colo., 1936". The habitat was given as "the eastern slopes of the Rocky Mountains, south to Utah and Colorado, and west to the Sierra Nevada Mountains." Should it become necessary to designate a neotype for coloradensis, there is, in the collection of the Museum of Comparative Zoology, Harvard University, a male specimen, labelled Fort Collins, Colorado, Baker, and determined as S. coloradensis by Scudder. This specimen bears a label "Colo., 1921", indicating that it was probably at one time in the same series as the specimen sent from Fort Collins to McNeill by Gillette, probably before McNeill described the species. The right antenna is missing from this specimen, otherwise it is intact and in good condition (see Fig. 19 and Fig. 224).

oregonensis (Scudder, 1899)

Scudder described this species in the same paper as that in which he synonymized McNeill's coloradensis with curtipennis Harris. Scudder's description was based upon a large series of specimens from western Oregon. A type specimen was desiginated by Rehn and Hebard (1912) as follows: "male, Divide, Oregon, Sept. 12 [1897]; A.P. Morse; Scudder collection". A footnote regarding the selection of the type locality is as follows: "A specimen from this locality was chosen as the single type owing to the fact that Divide, Oregon is about the middle of the northward and southward range of this species."

This specimen is in the collection of the Museum of Comparative Zoology, Harvard University, and has been seen during the present study. It bears labels as follows: first, a printed white label "Divide, Or. (Cottage Grove) Sept 12, 1897", a second, white, printed label "A.P. Morse Coll."; a third, white label, partly in type and partly handwritten by Scudder, "Stenob. oregonensis Scudder Type, 1899"; a fourth, red label, "Type 15239"; a fifth, large, label, white with a red border, hand-printed, "Stenobothrus oregonensis Scudd. Det. Scudd. 1899"; and a sixth, small, white, type-set label "Museum of Comparative Zoology" (see Fig. 18, and Fig. 222).

<u>acutus</u> (Morse, 1903)

Morse described <u>acutus</u> from five male specimens from Nevada. Morse and Hebard (1915) designated as type one of these males from Ormsby Co., Nevada, July 6, C.F. Baker. This type is in the collection of the Museum of Comparative Zoology, Harvard University. Morse and Hebard (<u>op. cit.</u>) further designated the type locality, although this does not appear on the specimen label, as follows: "lower edge of pine zone, 1,770- 2,000 metres west of Carson City."

The type was not examined by the author during the present study, but a paratypic male, bearing the same data, together with a label "Stenobothrus acutus Morse, Type 1903", was loaned by the Academy of Natural Sciences of Philadelphia (see Fig. 17 and Fig. 223).

D. DISTRIBUTION

In general, Chorthippus is found in North America from east coast to west coast (excepting the British Columbia wet-belt) and from the edge of the tree-line in the north southward to 40° North Latitude. It extends far to the south of this in mountainous areas, above 3,200 feet altitude in the eastern Appalachian mountain chain into Virginia, North Carolina and Tennessee; and above 6,000 feet in the western mountains, extending into Colorado, New Mexico, Arizona, Utah, Nevada and California. It is not found in the western desert areas of Nevada, Utah, and parts of Wyoming. It does not occur south of Nebraska, and Wisconsin, and occupies only the northern halves of Illinois, Indiana and Ohio. An isolated colony was found in Louisiana. Chorthippus is thus found in all ten provinces of Canada, as well as from the Yukon and Northwest Territories, and in thirty-six of the forty-nine continental United States.

A list of all the localities from which the genus has been reported would be very unwieldy, but all these localities are listed on file cards in the Lyman Entomological Museum, Macdonald College, and may be referred to at this source. Only those localities in areas on the periphery of distribution are listed here, but all localities are plotted on the map (Fig. 1).

United States of America

Maine: Common throughout, although no specimens have been seen from northwestern Maine; this is probably due to inadequate collecting in this area.

New Hampshire: Common throughout.

Vermont: Common throughout.

Massachusetts: Common throughout.

Connecticut: Common throughout.

Rhode Island: Common throughout.

New York: Common throughout.

New Jersey: Common throughout.

Pennsylvania: Common throughout.

Delaware: Sussex County - Lewes. One female from this locality is the only known specimen from Delaware. This locality marks the southern limit of Atlantic coastal distribution.

Maryland: Garret County - New Germany (5m. SSE Grantsville), and 5m. S. Keyser (2,850 feet). Apparently confined to the mountains in the northwestern part of the state.

Virginia: Bath County - Fossifern, Jackson River; Giles County - Mountain Lake Bio. Station; Grayson County - Whitetop Mountain (5,000 - 5,400 feet); Highland County - Monterey and Sounding Knob (4,200 feet); Shenandoah Nat. Park - Big Meadows near Fisher Gap.

West Virginia: Tucker County - Canaan Valley (3,300 feet), and Thomas; Preston County - Aurora and Craneville (1m. SSE, 2,600 feet); Randolph County - Comer, top of Cheat Mountain, 9m. SE of Huttonsville (3,798 feet).

North Carolina: Avery County - Cranberry, Grandfather Mountain and Linville; Jackson County - Balsam (4,500 - 5,700 feet); Mitchell County - Roan Mountain (6,200 feet) and Roan Valley; Transylvania County - Mount Pisgah (summit, 5,740 feet); Yancey County - Pinnacle Mountain (5,000 feet); and Blue Ridge County - Mahogany Rock (3,425 feet). Chorthippus is confined to the mountains in North Carolina, the above localities representing the known southern limits in the Appalachians.

Tennessee: Carter County - Roan Mountain (6,300 feet), is the only known locality in which Chorthippus occurs in Tennessee. This locality is in the mountains, close to the North Carolina boundary.

Ohio: Lucas County - Toledo, Maumee, and Dorr and Crissy Roads; Hardin County; Williams County; Champaign

County - Urbana (4m. S.) and Cedar Swamp. The Champaign County localities mark the southern limit of distribution.

Michigan: Common throughout.

Indiana: Elkhart County - Millersburg; Marshall County - Lake Maxneucke; Porter County; Lake County; Fulton County; Boone County; Warren County - Pine; Vigo County; Putnam County; Marion County. Marion, Putnam and Vigo Counties mark the southern limit in this area.

Illinois: Cook County - Chicago, Kenilworth, North Evanston, Riverside and Winnetka; Lake County - Beach, Cedar Lake, Channel Lake, Deep Lake, Lake Forest, Sun Lake, and Waukegan; McHenry County - Algonquin; Champaign County - Urbana. Urbana marks the southern limit of *Chorthippus* distribution in Illinois.

Wisconsin: Scattered throughout the state.

Iowa: Winnebago County - Forest City; Emmet County; Dickinson County - W. Okilboji Lake; Cherokee County - Larabee (1.5m. NW.); Plymouth County - Westfield (7m. SE.); Woodbury County - Sioux City; Johnson County - Iowa City; Story County - Ames; Davis County - Bloomfield; Union County - Afton Junction. The last named localities mark the southern limit of *Chorthippus* as it has not been reported from Missouri.

North Dakota: Found throughout the state.

South Dakota: Found throughout the state.

Nebraska: Cuming County - West Point; Thomas County - Halsey; Sioux County - Glen; Deuel County - Chappell (12m. E., 3,500 feet); Keith County - between Korty and Roscoe (8,000 feet); Lincoln County - North Platte (2,800 feet); Furnas County - Cambridge. The southern localities in Nebraska mark the southern limits of the species, as it has not been reported from Kansas.

Montana: Glacier County - Browning; Toole County - Shelby; Missoula County - Lolo, Paradise (2,500 feet), Missoula; Lewis and Clark, and Powell Counties - McDonald Pass (Continental Divide, 6,325 feet); Powell County - Garrison (4,300 to 4,400 feet); Judith Basin County - Hobson; Fergus County - Lewistown, and Lewistown (8m. WSW, 4,000 feet); Dawson County - Glendive; Beaverhead County - Continental Divide, Lakeview area; Gallatin County - Sappington, Bozeman, Bozeman Mountain (West Side, 6,000 - 6,500 feet), Gallatin Valley, Gallatin Canyon,Mystic Lake (6,400 - 7,000 feet); Park County - Livingston; Yellowstone County - Billings.

The gaps in distribution in northeastern, central and southeastern Montana are possibly due to lack of collecting in these areas. Hebard (1928) listed Wagner, Phillips County, in the northeast, Columbus, Stillwater County, and Sixteenmile Canyon, Meagher County, in the south, localities which are not represented in the collection under study. However, Hebard (1932), after studying a large collection from northeastern Montana, did not add new localities for this species. If the map, Fig. 1, is a true distribution for the species in Montana, it is notable that it occurs widely in the mountains but is scarce in the lowlands.

Wyoming: Crook County - Warren Peaks; Campbell County - Gillette (4m. E., 4,525 feet); Niobara County - Lusk and Manville; Converse County - Douglas; Sheridan County - Ft. McKinney; Natrona County - Casper; Platte County - Gurnsey; Laramie County - Pine Bluffs, Cheyenne, Veedauwo Park (8,200 feet); Albany County - Esterbrook, Snowy Range, Centennial, Laramie and Tie Siding; Carbon County - Medecine Bow Peak (summit); Yellowstone National Park - Camp Cowen, Firehole River (7,100 feet), Dragon's Mouth Spring (7,600 feet), Canon Camp (7,700 feet), Emerald Spring, Grand Canyon (8,000 feet), Mammoth Hot Springs (summit hill, head of springs, 7,000 feet), Shoshone Canyon, between Tower and Yellowstone Falls, Upper Geyser Basin (7,830 feet), Swan Lake, Madison River, Lone Star Geyser and

Yellowstone Lake (7,960 feet); Teton County - Jackson, Lake Solitude (9,500 feet), Cascade Canyon (9,000 feet), Moran, Menor's Ferry, Jackson's Hole (6,600 feet), Snake River (6,950 feet), West Teton Pass and Togwatee Pass; Sublette County - The Rim, Gros Ventre Range (between Bondurant and Pinedale, 7,916 feet); Lincoln County - Smoot and Afton; Uinta County - Evanston and Lonetree. Other specimens have been seen from Pole Mountain, but the geographical location of this place has not been determined.

It is interesting to note that the recorded distribution in Wyoming is split into two distinct sections, with no specimens recorded in a band running north and south throughout the state. This may not be the true pattern of distribution, but due to lack of collecting in this region, since the general area differs little from those from which the species is known.

Colorado: Sedgewick County - Julesburg (3,460 - 3,550 feet); Weld County - Greeley; Larimer County - Estes Park (8,000 feet), Laporte, Livermore, Owl Canyon; Boulder County - Allen's Park Boulder (foothills, w. of, 6,800 - 7,500 feet), Hygiene (5,500 feet), Nederland (8,200 feet), Ward B. Pk.; Jefferson County - Evergreen; Park County - Top of Crow Hill Pass (betw.

Bailey and Scheffers Crossing, (8,753 feet); Eagle County - Tenessee Pass (10,240 feet); Grand County - Valley of upper Muddy Creek (below Muddy Pass, Park Range, 8,300 feet), Rabbit Ears Pass (summit, 9,680 feet); Adams County - Denver, Westminster; El Paso County - Colorado Springs, Manitou (6,400 - 6,700 feet), same (7,700 feet), Pike's Peak; Teller County - Florissant; Chaffee County - Garfield; Gunnison County - Cochetopa Creek, Gothic (9,500 feet); Custer County - Westcliffe; Saguache County - Marshall Pass (10,250 feet); Huerfano County - East Spanish Peak; Las Animas County - Fisher's Peak; Costilla County - Garland (8,000 feet); Alamosa County - Alamosa (7,546 feet); Conejos County - Cumbres (peak north of, 10,200 - 11,200 feet), Los Pinos (9,625 - 10,200 feet); Rio Grande County - Monte Vista; Mineral County - Wolf Creek Pass (summit, 10,850 feet); San Juan County - Silverton (9,302 feet); Mesa County - Grand Junction; San Miguel County - Cushman Lake (9,700 feet); La Plata County - Cima (8,500 feet). Other specimens have been seen from Colorado, labelled Brainerd Park, Pingree Park, and N. Park, but the exact geographical location of these localities has not been established. N. Park probably refers to Rocky Mountain National Park.

New Mexico: Colfax County - Therma; Rio Arriba County - Chama (7,863 - 8,000 feet); San Miguel County - Rociada, Beulah (7,250 feet); SantaFe County - Head of Nambes Creek (Sangre del Cristo Range, 10,700 feet), Lake Peak (west slope of Sangre del Cristo Mountains, 10,000 - 11,000 feet); Otero County - Cloudcroft (8,600 - 8,700 feet), Mescalero (2.5m. N.E., 7,100 feet), Sierra Blanca (11,000 feet). It is not known whether Chorthippus occurs in the relatively large area between the northern and southern populations in New Mexico. It is probable that further collecting would reveal more colonies. It is also probable that Chorthippus exists in these mountainous areas as isolated colonies, confined to peaks or to ranges of peaks.

Arizona: Apache County - Greer (8,400 feet), Alpine (8,000 feet), Eagar (8,100 feet), Springerville (White Mountains, 25m. N. of, 10,000 feet); Coconino County - Flagstaff (9,400 - 10,500 feet); San Francisco Peaks (10,500 feet); Cochise County - Barfoot (Chiricahua Mountains, 8,200 feet), Portal. It is probable that Chorthippus occurs in other areas in Arizona as isolated colonies.

Utah: Cache County - Logan, Cache Junction, Providence;

Box Elder County - Mantua (3m. N., 5,800 feet); Summit County - Henefer; Salt Lake County - Salt Lake Valley (4,300 feet); Tooele County - Vernon; Beaver County - Tushar Mountains (Merchant Valley, East Fork, 9,000 feet), Tushar Mountains (Puffer Lake, 8,250 - 8,400 feet); Iron County - Cedar Breaks (10,400 feet). The locality Spring Lake is represented in the specimens seen by the author, but the geographical location has not been established. Cedar Breaks is the most southerly locality for Chorthippus in Utah.

Idaho: Bonner County - Priest Lake; Latah County; Washington County - Goose Creek Canyon (Payette Mountains, 4,500 feet), Rock Flat (Payette Mountains, 5,300 feet), Evergreen, 3,600 feet; Valley County - McCall (Big Payette Lake, 5,000 to 5,050 feet); Custer County - Stanley (6,250 feet); Gem County - Emmett; Canyon County - Nampa (2,482 feet); Blaine County - Bellevue and Soldier; Bannock County - Pocatello (4,000 feet); Franklin County - Preston; Caribou County - Soda Springs; Teton County - Driggs (6,108 feet) Fremont County - St. Anthony (4,965 feet), Ashton, Red Rock Pass, Boot Jack Fal. The localities, Rea and Willow Flats, Cub River Canyon have not been located geographically and are not plotted on the map (Fig. 1).

Nevada: Elko County - Carlin, Tuscarora (4m. S.E.), Secret Valley (W. of Ruby Mountains, 5,000 feet), Clover Valley (5,700 feet); White Pine County - Steptoe Valley; Washoe County - Sparks (4,400 feet); Ormsby County. The distribution of *Chorthippus* is divided in Nevada, confined to the northeast corner and to a small area in the west near the California border. It is not known if this is true distribution or due to lack of collecting in the intervening area. This area is crossed by several highways and, if *Chorthippus* occurs there, it is likely that it would have been represented in the collections seen by the author during the present study.

California: *Chorthippus* is relatively common over the northern part of California and only the southernmost points of distribution are given here. San Bernadino County - Big Bear Valley; Tulare County - Tulare (282 feet); Fresno County - Shaver Lake; Inyo County - Mammoth Lake; Mono County - Topaz, Tioga Pass (10,000 feet, nr. Mono Pass 12,000 feet), below Saddle Bag Lake (9,800 feet); Tuolumne County - Tuolumne Meadows; Alameda County - Berkeley; Alpine County - Coleville; San Mateo County - Crystal Lake, Daly City, Kings Mountain, Moss Beach, San Mateo Mountains, San Bruno

Mountain. The Big Bear Valley specimens, one male and one female were collected by Timberlake, Aug. 7 and 13, 1933. The altitude of this area is approximately 8,000 feet above sea level. This colony appears to be isolated, as it occurs south of the Mojave Desert, much further south than any other recorded locality in California. The Tulare specimens, one male and five females, probably also represent an isolated colony. In no other place south of the 40^{th} parallel of Latitude does Chorthippus occur at such a low altitude (282 feet at Tulare; it is usually confined to altitudes above 6,000 feet).

Louisiana: Natchitoches, an isolated colony.

Oregon: Widely reported from all parts of the state.

Washington: Ferry County - Republic; Stevens County - Springdale, Loon Lake (Colville V.); Spokane County - Little Baldy Hill; Whitman County - Pullman, Dry creek between Colfax and Steptoe; Columbia County - Waitsburg (15m. SE, Blue Mountains); Yakima County - North Yakima, Yakima River (La Chapples); Gray Harbor County - Copalis. Chorthippus is confined to the eastern and southern margins of Washington with the exception of the locality of Copalis, which marks the northern limit of Chorthippus on the Pacific coast.

Alaska: Unalakleet; Old John Lake (south slope of the Brooks Range), Canning River, Fort Yukon, Circle, Eagle, Fairbanks, Anchor River (sphagnum bog, 5 m. S. Kenai Peninsula). All of these localities are south of the northern limit of wooded country.

Canada

Yukon: White Horse, Canyon Creek, Dry Creek and Marsh Lake. *Chorthippus* has been found only in south and southwestern Yukon, well below the northern limit of woodlands.

Northwest Territories (Mackenzie): Fort Simpson and Hay River. Although recorded from two southern localities, *Chorthippus* could exist farther north in the western part of the Mackenzie Territory, as the northern limit of trees extends far to the north along the Mackenzie River. It would not be surprising to find *Chorthippus* in the basin of the Mackenzie River. East of Great Slave Lake the "tree line" is much farther south, approaching the northern boundaries of Saskatchewan and Manitoba.

British Columbia: Upper Peace River district - (halfway between Brad's and Pink Mountain (2,500 to 2,850 feet)); Peace River district - Pouce Coupe, Taylor, Rolla; Western districts - Anahim Lake, Quesnel, Jesmond, Big Bar Creek, Chilcotin,Barkerville, Tranquille, Rock Creek, Nicola and Nicola Lake, Merritt, Pass Lake, and Kamloops; Northeastern district - Field, Beaver Mouth and Downie Creek. In the southeastern corner of British Columbia, _Chorthippus_ has been found in numerous localities, which are not listed here, but which are shown on the distribution map, Fig. 1.

This insect is mainly confined to the southeastern half of the province and its western limits are at Quesnel, Anahim Lake, Big Bar Creek, Merritt and Penticton. These localities are all in the so called 'dry belt', and in this dry belt, _Chorthippus_ is found only on grasslands, with the exception of Anahim Lake. Buckell (1930) reported that it did not occur on Vancouver Island. No specimens from Vancouver Island were seen during the present study or from any of the offshore islands or from the mainland 'wet belt', which extends, on the coast, along the whole length of the province.

Alberta: Peace River District - Fairview, Dunvegan, Peace River, Beaverlodge, Goodwin, Halcourt, McLennan; North and far North-east - Slave Lake, McMurray, Waterways; Northeast - Cold Lake, Flat Lake, Fort Kent, Beaver Dam; Jasper District - Jasper, Henry

House, Pyramid Lake (Jasper National Park), Marlboro, Rosevear. Numerous other localities in southern Alberta are shown on the map (Fig. 1), and are not listed here. Further collections in the north and north west areas of the province would probably increase the known distribution of Chorthippus in Alberta, as it occurs in Northwest Territories, north of the Alberta boundary.

Saskatchewan: Northern limits of distribution are: Waterhen Lake, Harlan, Lloydminster, Atten Lake, Waskesiu, Alticane, Leask, Parkside, Holbein, Prince Albert, Shipman, Smeaton, White Fox, and Hudson Bay. Chorthippus appears to be common throughout the remaining southern two-thirds of the province, and will probably be found farther north when collections are made in that area.

Manitoba: Northern records of Chorthippus are: Churchill (west coast, Hudson's Bay), Gillam, Mile 500 and Mile 505 (Hudson's Bay Railway), The Pas, Swan River (Bonito), Ethelbert, Sifton, Gilbert Plains, Victoria Beach. Common in southern Manitoba. At Churchill, the distribution of Chorthippus stops short abruptly at the 'tree line'.

Ontario: Favourable Lake, Rainy River, Port Arthur, Fort William, Nipigon, Black Sturgeon Lake, Rossport, Attawapiskat, Onakawana, White River, Smoky Falls (near Kapuskasing), Goulais River, Sault Ste. Marie, Thessalon, Sowerby, Missisagi River (Iron Bridge), Whitefish, Sudbury, Searchmont, Kirkland Lake, Sesekinika, Stonecliffe and Chalk River mark the known northern limits of Chorthippus in Ontario. The species is known from many southern localities.

Quebec: Chorthippus is known from the following northern localities: Lac Mistassini, Laniel, La Verendrye Park, Laurentides Park, Riviere au Tonnerre and Bradore Bay. It is common south of the St. Lawrence River, in the Gaspe peninsula, and on Iles de la Madeleine. It has not been recorded from Anticosti Island, or other islands in the Lower St. Lawrence River.

New Brunswick: Common throughout, except in heavily forested areas.

Nova Scotia: Common throughout, including Cape Breton Island. It has not been recorded from Sable Island.

Prince Edward Island: Common throughout.

Newfoundland: Labrador - Cartwright, Northwest River and Hopedale; Island - Salmonier, Colinet, Turks Water, St. John's, Bay Bulls, Port-aux- Basques, St. Anthony. Ander (1960) recorded the following localities which were not represented in the present collection: Cow Head, Port au Choix, Rencontre West

(Big Bay), Grand Bank, Norris Arm, Lewisporte, Twillingate, Glenwood, Gambo, Kitty's Brook (East Sandy Lake) and Millertown Junction.

St. Pierre and Miquelon

Chorthippus was not reported by Rehn, J.W.H. (1939a), the only author who has reported on the Orthoptera of these French islands.

VII. VARIATION IN NORTH AMERICAN CHORTHIPPUS

A. GENERAL CONFORMATION

The group of Holarctic Chorthippus species under study, those which in recent years have been called longicornis (Latreille), are typically small and slender, more so than many Old World species of the genus.

The face is distinctly slanted and the vertex rounded, but the angle between them is acute, when viewed laterally. Lateral foveolae are present at the upper lateral margins of the frontal fastigium and are visible dorsally.

The antennae are long (8-11 mm. in males) and the segments are somewhat flattened, particularly near the distal ends.

The lateral pronotal carinae are arcuate, incurved slightly behind the middle, and are cut by three sulci.

The median carina is always low, slightly but uniformly elevated, never arched above the lateral areas. It is cut by the posterior sulcus only. Laterally, the lateral carinae appears humped on the anterior third of the pronotum. **in North American <u>Chorthippus</u>.**

The legs are long and slender, the hind femora exceeding the abdomen by one-third of their length in males, or by somewhat less than one-quarter in females.

The tegmina exhibit considerable variation in length and in venation. Brachypterism appears to be normal, with the tegmina extending nearly to the end of the abdomen in males, or covering one-half to three-quarters of the abdomen in females. Macropterous individuals occur in which the tegmina may be nearly twice as long as the abdomen in males, or one and a half times as long in females. In many population samples, specimens have been found with tegmina of intermediate lengths.

The male abdomen is slender and is curved upward at the distal end. The female abdomen is much deeper, tapering more or less gradually to the distal end. The female ovipositor valves in preserved specimens are variable in positon, being greatly retracted to greatly extruded. Accurate assessment of variation in the ovipositor is difficult unless the entire female terminalia are removed from the specimen, although breadth of the dorsal valve can be measured in many intact specimens.

B. MANDIBLES

Isely (1944) discussed and figured the types of mandibles found in "American grasshoppers", including the Acrididae and Tettigoniidae. Twenty-one, of the twenty-four species of Acridinae studied, were of the gramnivorous type, shown by fusion in the cutting edges of the incisor lobes and in shallow furrows and flattened ridges in the molar areas. The Acrididae possessing gramnivorous type mandibles are said by Isely (op. cit.) to be adapted to feed upon the leaves of mature grasses. Isely did not include *Chorthippus* species in his study, but the mandibles of *Chorthippus* species are clearly of the gramnivorous type.

Williams (1954) figured the mandibles of several species of Acrididae from Britain, including four species of *Chorthippus*, namely, *parallelus* (Zetterstedt), *vagans* (Fieber), *bicolor* (Charpentier) [= *brunneus* Thunberg], and *albomarginatus* (DeGeer), and noted that the considerable differences between the mandibles of these species were "interesting from the systematic point of view". Therefore, a preliminary study was made of the mandibles of eleven specimens of *Chorthippus*: a male of each of C. *montanus* and *C. parallelus* from Germany, and seven males and two females from various localities in North America (Figs. 35-45). The differences found between the mandibles of the two European species were not great, less in fact, than between mandibles of specimens from different areas in North America. The incisor teeth of both mandibles were longer and more regular in the *parallelus* than in the *montanus* specimen. In *parallelus* the mandibles were angulate, while in *montanus* they were rounded (Figs. 35, 36).

In general, the mandibles of North American *Chorthippus* males were found to be larger than in either of the European species, exceptions being found in the small specimens from Churchill, Manitoba, and from Mendocino, California. In form, the mandibles were found to be basically similar in specimens from Ste. Anne de Bellevue, Quebec (Fig. 37), and Churchill, Manitoba, (Fig. 38), each having length and breadth of about the same dimensions and each possessing similar molar and incisor surfaces. A specimen from Ann Arbor, Michigan, had considerably larger mandibles, the outer surface of the left mandible differing in structure from the Quebec and Manitoba specimens. In the Ann Arbor specimen the outer surface was found to extend much closer to the inner face, becoming interposed between the incisor and molar surfaces. A similar condition was found on inner surface of the right mandible (Fig. 40). Mandibles from a specimen from Mountain Lake, Giles County, Virginia (Fig. 39), were longer than broad, longer than those from Michigan, and much larger than those from Quebec. In the Virginia specimen, however, apart from over-all size and their greater elongation, the mandibles were very similar to those of Quebec material.

The mandibles of a specimen from Flagstaff, Arizona, (Fig. 41) were found to be broader than long, rather than elongate, due to the greater length of the incisor teeth which were longer than in any other specimen examined. The condition was more accentuated in the left than in the right mandible. Mandibles from a Divide, Oregon, specimen (Fig. 42) were distinctly longer than broad, particularly in the case of the left mandible, resembling neither those from the Arizona sample or the much smaller mandibles of a specimen from Medocino, California (Fig. 43). The latter were similar in size to those from Churchill, Manitoba material, the length being approximately equal to the breadth. The California specimens, male and female, (Figs. 43, 45) have very shallow incisor surfaces compared with other North American specimens examined.

The two females, in which the mandibles were studied were from Ste. Anne de Bellevue, Quebec, (Fig. 44) and Mendocino, California (Fig. 45). Mandibles of the Quebec female corresponded to those of the male from the same locality, except that in the female the mandibles were larger and the left one more nearly square in outline with somewhat longer incisor teeth. Comparison of the mandibles of the California male and female showed a similar size differential, those of the female being much larger, slightly longer than broad, and more angulate than those of the male.

C. MORPHOMETRICS

i. Morphometrical Comparisons

a. Body length (Table III, Fig. 184).

In North America, the general trend is toward small individuals in northern areas, with a progressive increase in size of specimens sampled from the north toward the southern limits of distribution; 12.51 mm. being the mean length of males at Churchill, Manitoba, and 16.28 mm. at Ann Arbor, Michigan.

Body length does not vary greatly over the east-central part of the continent, but specimens from the Atlantic coast, in Nova Scotia are smaller (14.36 mm. for males) than specimens from inland areas. Increase in size continues toward the southwest, but changes in the prairie region where specimens are small, comparable in size with those from Nova Scotia. Males of the southern Manitoba and Saskatchewan samples have means for body length of 14.08 to 14.88 mm.

Specimens from the western mountains are larger than average, with the samples from Colorado Springs, Colorado - 16.16 mm., Flagstaff, Arizona - 16.03 mm., and Divide, Oregon - 15.38 mm. in mean length of body. In contrast, male specimens from McCall, Idaho - 13.90 mm., and Mendocino, California - 14.88 mm., are much smaller than males from other western areas.

Body length of females is variable, as mentioned previously, and was not measured. In general however, the variation is size of females in North America roughly parallels that of the males, the females being appreciably larger than the males. In California the size differential between males and females is greater than anywhere else in North America.

The mean length of males of *C. parallelus* from Germany (15.18 mm.) and of *C. montanus* from Germany (14.73 mm.) and eastern Siberia (14.74 mm.) are intermediate within the range of variation found in *C. curtipennis* in North America.

b. Tegminal length (Tables IV and XII, Figs. 188, 189)

The tegminal length is variable, with the means of population samples for this character directly affected by the relative proportion of macropterous to brachypterous individuals in the sample. The most variable samples can be detected in the tables, by the high standard deviations from the mean values.

In general, this insect, in both sexes, tends to be brachypterous in the northern and coastal areas of North America, with a greater proportion of macropterous individuals occurring toward the centre of its range. This agrees with the opinion of Hebard (1935b): "Tegminal reduction is often found the most pronounced in material from the most rigorous portions of the range of a species of grasshopper."

Occasionally, a population sample, such as that from McMurray, northern Alberta, was found to contain nearly all macropterous forms. The appearance of macropterous forms in Orthoptera is not understood (although a considerable amount has been written about it), but it has been found that, in certain localities, during certain seasons, macropterous specimens may predominate, while during other seasons, in the same localities, macropterous forms may be rare. This was the case at Ste. Anne de Bellevue, Quebec, where, in 1960, nearly all of the specimens captured were macropterous, whereas during the seasons 1961, 1962, and 1963, macropterous forms were rarely seen, even though collections during these seasons exceeded those of 1960. It is interesting to note that *Chorthippus* was among the Orthoptera of several species (mostly *Melanoplus bivittatus* (Say)), that migrated into the centre of the city of Montreal during the same summer when macropterism in Chorthippus was remarkably prevalent (July 18, 1960). Grasshoppers "invaded the city" in such numbers that the event was widely reported in the press all over eastern Canada (Anonymous, 1960).

The introduced tettigoniid, Metrioptera roeseli (Hagenbach), was also among the invaders; in this species also, the macropterous form was extraordinarily prevalent (Kevan, 1961).

It may also be noted that the mean body length of the macropterous Chorthippus individuals from Ste. Anne de Bellevue (14.26 mm.) is somewhat shorter than the mean length of 14.72 mm. for the brachypterous individuals from the same locality. This might indicate further adaptation for dispersal through smaller body size in the macropterous specimens, but this not borne out by the body length of the macropterous individuals from McMurray, Alberta. In the latter sample,and also in the sample from Ann Arbor, Michigan, the smallest specimens tend to be brachypterous.

c. Hind Femur length (Tables V & XIII, Figs. 186, 187).

Lux (1957, 1961) recorded the following measurements for two species of Chorthippus in Europe: montanus, males 9.72 mm. ± 0.066, standard deviation, 0.410, range of variation 8.8 - 10.9 mm.; females, 11.85 mm. ± 0.088, standard deviation, 0.623, range of variation 10.4 - 13.25 mm.; parallelus, males, 9.28 mm. ± 0.077, standard deviation 0.422, range of variation 8.5 - 10.1 mm.; females, 11.38 mm. ± 0.95, standard deviation 0.501, range of variation 10.5 - 12.9 mm.

In North America, the general mean for length of the hind femur of curtipennis is 10.38 mm. for males, sample means varying from 8.80 to 11.79 mm.; in the females the general mean is 12.08 mm., with sample means varying from 10.56 to 13.54 mm.

The length of the hind femora of curtipennis appears to be directly correlated with over-all body length, and for the purpose of studying variation in females, is a more precise measurement than body length. The variation in hind femur length is shown graphically by Fig. 186 (males) and by Fig. 187 (females) and follows closely the outline already given for total body length. With few exceptions, the femur length of males corresponds to that of females from the same localities throughout the range in North America. Male femora, however, were found to be somewhat longer in proportion to those of the females in material from Flagstaff, Arizona. Conversely, in material from Idaho (McCall), Oregon (Divide) and California

(Mendocino), the femora of males were found to be proportionally shorter than those of the females. As previously pointed out male specimens from these last three locations are noticeably smaller in relation to the size of the females than in any other part of the continent.

d. Eye Depth (Tables IX & XVII, Figs. 190, 191).

Eye depth, measured as in Fig. 5, varies considerably, being somewhat smaller in the northern material and somewhat larger than average in specimens from areas in which the specimens are large: Michigan (Ann Arbor), Virginia (Mountain Lake). It does not, however, appear to be closely correlated with body size. The relative size of the eye in males and females from the same locations is very close in specimen samples from northern areas and across the eastern part of the continent as far west as Minnesota, except at Mer Bleue, Ontario, where the eyes of the males are disproportionately smaller than those of the females. This is also true of the samples from the prairies, although this conclusion may be erroneous, due to the small size of the samples from the prairie areas. Samples from southwestern Quebec, New York, Michigan and

Minnesota were consistent in that the eye size of males was only slightly smaller than that of females from the same localities. The relative eye-sizes in this region were, in fact closer in the two sexes than anywhere else on the continent. In the west, the curves for eye size in males and in females are noticeably less similar than in the east. In Idaho, the eyes of both sexes are smaller; in Oregon, the eyes of females are larger than in any other area, excepting Ann Arbor, Michigan, but the eyes of males from Oregon are very close to the mean size for the continent; in California, the eyes of females average smaller, and the eyes of males average larger than those from Oregon.

e. Subocular Sulcus Length (Tables X & XVIII, Figs. 192, 193).

The length of the subocular sulcus is less variable than the eye depth, tending to be somewhat shorter than average in northern specimens, particularly in males from Churchill, Manitoba, and in both sexes in the far west. The greatest sulcus length occurs in specimens from Ontario (Mer Bleue), Michigan (Ann Arbor), Virginia, Colorado and Arizona. Specimens from Idaho (McCall), Oregon (Divide) and California (Mendocino) have the sulcus very short, and the means for sulcus length in the Divide and Mendocino samples are considered to be significantly different, the mean for the Mendocino sample being much smaller. The means of the male samples from Arizona and Colorado are much greater than those of the Oregon and California male samples. In the case of the females, means from Oregon, Colorado and Arizona are similar, and are much greater than in the California sample.

The northern Alberta (McMurray) sample has a relatively short mean sulcus length for both sexes, similar to the length of this character found in the samples from northern Manitoba.

The subocular sulcus length of the male specimen from Natchitoches, Louisiana, is only slightly greater than the general mean but that of the female is not only far greater than the mean of any other sample, but beyond the range of any sample except those from Michigan (Ann Arbor) and Virginia (Mountain Lake).

f. Ratio of Eye Size to Subocular Sulcus Length (Tables XI, & XIX, Fig. 194).

The ratio of eye depth to length of the subocular sulcus varies from region to region: in general, below average in the northwest; average or slightly above average in the north-east and east to the prairies; below average on the prairies; average in males and above average in females from northern Alberta; slightly below average in the southern Appalachians and Wyoming, Colorado and Arizona; above average in Oregon and Idaho; and far greater than average in California; - so much so, that this ratio will distinguish the California specimens from all others.

The ratios for the two sexes parallel each other in nearly all localities, exceptions being found only in northern Manitoba and in the small sample from Idaho.

g. Number of Male Stridulatory Pegs (Table VI, Fig. 185).

The number of stridulatory pegs on the inner face of the hind femora is used quite extensively in Europe in separating various species of the genus Chorthippus (Perdeck, 1957; Lux, 1961; Faber, 1929). In the North American samples in which peg numbers were counted during the present study, the standard deviations of sample means, standard errors of these means and actual range of variation within the samples were large, but were within the same order of difference as comparable values reported by Lux (1957, 1961) for Chorthippus montanus and parallelus [as longicornis] in Europe. Ander (1960) reported the number of pegs in C. curtipennis as a little lower than in montanus, with a mean for curtipennis of 137 pegs. The mean number for all North American samples, in the present study is 122.7 pegs.

In general, in North America, northern specimens have fewer pegs while those from more southerly localities have a greater number. In the eastern and central part of the continent, males have greater than the mean number of pegs. The mean numbers of pegs in southern Manitoba and southern Saskatchewan are below the general mean, but this may be due to inadequate numbers of specimens in these samples. Specimens from Colorado have above the average numbers of pegs, but the samples from California, Oregon, Idaho and Arizona are all close to the general mean, but California specimens having the lowest mean number of pegs of any sample from the western part of the continent.

_h_. Length of Row of Stridulatory Pegs (Table VII).

Lux (1957, 1961) reported the length of the row of stridulatory pegs in males of _C. montanus_ to be 4.76 mm. ± 0.058 (S.D., 0.365; range of variation 4.0 to 5.85 mm.) and of _C. parallelus_ to be 4.02 mm. ± 0.058 (S.D., 0.315; range of variation 3.3 to 4.4 mm.). The general mean of the row of pegs in North American _Chorthippus_ samples is 3.85 mm., less than either of the species reported by Lux (_op. cit._). No specimens were found with a longer stridulatory apparatus than the mean given by Lux for _C. montanus_.

Variation of this character in samples from North America is rather great, the northern and prairie specimens averaging shorter, and all others averaging longer than the mean value. A striking difference is found between two samples from Ste. Anne de Bellevue, Quebec, a brachypterous sample having a mean of 3.77 mm.(0.08 mm. less than the general mean), while the other sample in which all specimens are macropterous, has a mean of 4.15 mm. (0.30 mm. greater than the general mean). This suggests a correlation between the two characters, tegminal length and length of the row of stridulatory pegs. This suggestion is strengthed somewhat by the fact that in the east and north the graph lines plotted for the means of these two characters are approximately parallel. However, this is not borne out by the sample from McMurray in northern Alberta; where the mean tegminal length is greater than for any other sample, while the mean for the length of the row of pegs is not correspondingly great. The reverse of this is shown by the samples from Idaho and California, which have short tegmina but a longer than average stridulatory apparatus.

i. Length of Proximal End of Femur (Table VIII).

Lux (1957, 1961) measured the distance from the base of the femur of males to the beginning of the row of stridulatory pegs, and listed the following values: *C. montanus*, 1.21 mm. ± 0.019 (S.D., 0.120; range of variation 1.0 - 1.5 mm.); *C. parallelus*, 1.18 mm. ± 0.021 (S.D., 0.114; range of variation, 0.9 - 1.5 mm.). The general mean for this character in North American *Chorthippus* is 1.37 mm., greater than for either of the European species measured by Lux.

Variation over the North American continent is not great, smaller mean measurements for this character occurring in the north, mid-west and far southwest, larger mean measurements being found in the western mountains and also in the mountains in Virginia. The means vary but little from the general mean over most of eastern North America.

j. Width of Vertex of Females (Table XIV, Fig. 7).

The width of the vertex, the narrowest distance between the eyes, is a fairly constant value in females, having a general mean of 1.05 mm., sample means varying between 0.93 mm. and 1.20 mm., actual specimen measurements varying between 0.80 and 1.29 mm.

The general trend is towards a narrower vertex in the east and north, all the means being below the general mean, except for Ann Arbor, Michigan (1.13 mm.) and Mountain Lake, Virginia (1.18 mm.), which are greater, and

Mer Bleue, Ontario (1.08 mm.) and Ithaca, New York (1.09 mm.), which are only slightly greater than the general mean. In the far west all means are above the general mean, excepting the sample from Mendocino, California (1.02 mm.), with the broadest vertex being found in the sample from Divide, Oregon (1.20 mm.). It is interesting to note that female specimens from these two localities can be separated by this character, as those from Mendocino range in size from 0.95 to 1.10 mm., while the Divide specimens range from 1.10 to 1.29 mm. Specimens from McCall, Idaho, are more similar to those from California with a mean width of vertex of 1.06 mm. The specimens from McMurray, Alberta, average 0.97 mm. across the vertex, the narrowest of any western sample.

k. Pronotal Depth of Females (Table XV, Fig. 195).

The pronotal depth of females has a general mean of 2.92 mm., sample means varying from 2.74 to 3.14 mm., individual specimens varying from 2.40 to 3.40 mm.

The general trend is practically the same as that indicated by the width of the vertex. The sample from Divide, Oregon has a mean pronotal depth of 3.12 mm., while that from Mendocino, California is considerably smaller, with a mean of 2.85 mm. The mean pronotal depth of females from Ann Arbor, Michigan (3.08 mm.) is noticeably greater than the means of the two samples which are geographically nearest to Ann Arbor, 2.79 mm. at Keweenaw Pt., Michigan, and 2.78 mm. at Republic, Minnesota. Specimens from Mountain Lake, Virginia, with a mean pronotal depth of 3.14 mm., are the largest to be found in the east. Prairie specimens from southern Manitoba and Saskatchewan exhibit greatest pronotal depth, but this may be erroneous due to the small samples from these localities.

l. Length of Proximal Segment of Hind Tarsus of Females (Table XVI).

The length of the proximal segment of the hind tarsus of females has a general mean of 1.78 mm., sample means varying from 1.52 to 1.98 mm., and individual specimens varying from 1.43 to 2.23 mm.

This character varies in much the same way as the width of the vertex and the pronotal depth, with the following exceptions: Alaska specimens have the same mean pronotal depth as specimens from the Yukon, but the mean tarsal length is much less in the Alaska specimens. Tarsal length is not as great in specimens from Mer Bleue, Ontario, as might be expected considering their other measurements; tarsi of New York specimens, on the other hand, are longer than would be expected.

ii. Resumé of Morphometric Variation in North American <u>Chorthippus</u>.

In order that this section should not become unwieldy and involved, it seems best, in view of the rather confused picture presented by the analysis of characters, to deal with each geographical group as a unit, rather than to treat individual samples separately.

<u>a</u>. Labrador

Specimens are characterized by small size, reflected not only in total length but in all other characters which are affected by general size. Males have fewer stridulatory pegs than specimens from more southerly areas.

<u>b</u>. Northern Quebec

Larger than from Labrador, as might be expected of specimens from a more southerly locality, but smaller than average in all characters. The number of stridulatory pegs is also smaller than average.

<u>c</u>. Northern Manitoba

The three localities represented are, from south to north, The Pas, Gillam and Churchill. The differences between the three samples are slight. General size does not decrease from south to north, as the specimens from Gillam are larger in some respects than those from The Pas.

Specimens from Churchill are approximately of the same size and conformation as those from Hopedale, Labrador.

d. Yukon and Alaska

In the Yukon, _Chorthippus_ is considerably larger than in any of the northern areas so far considered, and also larger than in Alaska. The size of the samples from these areas is rather small, however, and therefore less accurate than samples from most other areas.

_e_. Nova Scotia, New Hampshire and Quebec.

The samples from these areas are very similar morphometrically, and measurements are near the general mean values. In general appearance they are also similar in nearly all characters. A comparison of macropterous and brachypterous samples from Ste. Anne de Bellevue, Quebec, indicates that, except for the difference in length of tegmina and wings, the two samples are very similar. The sample from Nova Scotia, which is considered typical of eastern _Chorthippus_, is compared with samples from Virginia, Arizona, Oregon and California in Figs. 196 - 211.

_f_. Ontario, New York, northern Michigan and Minnesota.

Chorthippus specimens from these areas are very similar to those from Nova Scotia, New Hampshire and Quebec, but are slightly larger. A greater proportion of macropterous individuals is noticeable, although the sample from Mer Bleue, Ontario consists entirely of brachypterous specimens.

There is a general trend toward macropterism in the interior of the continent, east of the western mountains. Hebard (1935b) expressed the opinion that in species exhibiting macropterism and brachypterism, the latter state is usually predominant in the more rigorous parts of the distribution. Creighton and Robertson (1941) associated long tegmina of C. longicornis [= curtipennis] in Iowa with high temperature and consequent short developmental period. This appears to be substantiated by distribution of the macropterous individuals at hand, since the great majority are from locations which have higher mean temperatures than those found over the remainder of the continent where C. curtipennis is found.

Specimens from Keweenaw Point, Michigan, are smaller than those from Ann Arbor, Michigan (see below). It could be argued that the former are affected by proximity to Lake Superior, but no such influence affects the populations from New York (Ithaca) and Minnesota (Republic), which are similar in most respects to the specimens from Keweenaw Point.

g. Ann Arbor, Michigan.

The specimens from Ann Arbor are characterized by large size, considerably larger than the previous group in most respects. The proportion of macropterous individuals is relatively high, but less than in New York or Minnesota. The number of stridulatory pegs on the femora of the males is less than in the previous group.

h. Southern Manitoba, Southern Saskatchewan and Wyoming

In the prairie areas, specimens are smaller in size than other western specimens. Tegminal length is below the mean, except at Aweme, Manitoba, where macropterism appears to be more common than in the other prairie locations. Male stridulatory pegs are relatively constant in this area, with sample means near the general mean. The depth of the pronotum of females is greater than average, similar to specimens from Ann Arbor, Michigan, and from the western mountains. Eye size is smaller than the general mean for this character, while the length of the subocular sulcus is proportionally greater, giving a low ratio of eye depth to subocular sulcus length in both sexes in Manitoba and Saskatchewan (1.42 - 1.51 in males and 1.20 - 1.25 in females). The ratio is smaller than in most of northern Manitoba (where the range of mean ratios is 1.47 - 1.48 in males and 1.34 - 1.36 in females at The Pas and Gillam), and is about equal to that of the Churchill sample (1.52 in males and 1.23 in females). The ratios for the sample from Wyoming are higher (in males, 1.56, and about the same in females, 1.32).

_i_. McMurray, Alberta

This northern population has characters in common with more southerly as well as with other northern samples. Both sexes are about the same size as prairie specimens, somewhat larger than those from northern Manitoba. Seventy per cent of the individuals in the sample are macropterous. Macropterism may not be the normal condition, but if not, the general structure should not differ greatly from that of the present sample, judging by the general conformity of macropterous and brachypterous samples from Ste. Anne de Bellevue, Quebec. In length of the hind femur of both sexes the McMurray sample is very similar to the samples from southern Manitoba and Alberta. This is also true of eye depth. The length of the subocular sulcus is short in females and about average in males. The ratio, eye depth to subocular sulcus, is relatively high in females, whereas, in the males, it is near average. The width of the vertex in females is narrow, comparable to those of the samples from northern Manitoba. The pronotal depth is shorter than any other western group, similar to the samples from the far north and from the eastern part of the continent. The length of the proximal segment of the hind tarsus of females is also short, less than in any except the northern samples.

j. Mountain Lake, Virginia

Specimens from this area are larger than average, similar in size to specimens from New York and Keweenaw Point, Michigan, but slightly smaller than those from Ann Arbor, Michigan. The hind femora are larger than expected in both sexes as the length is greater than in any eastern sample, except in that from Ann Arbor. The number of stridulatory pegs is in the same range as for the samples from New York, northern Michigan and Minnesota, being greater than the mean for this character at Ann Arbor, Michigan. Eye size of both sexes is similar to that of samples from Ann Arbor, Michigan, and is larger than in all other specimens at hand. The length of the subocular sulcus is greater than in any eastern sample. The ratio of eye depth to subocular sulcus is much lower than for any other eastern sample, being comparable with samples from the prairies and from northern Manitoba in this respect. The width of the vertex and depth of the pronotum of females are greater than in all other eastern samples. Figs. 196 - 211 compare this sample with samples from Nova Scotia, Arizona, Oregon and California.

_k_. Colorado and Arizona

The Colorado sample is slightly more variable than that from Arizona. In general, specimens are larger than average, nearly as large as at Ann Arbor, Michigan, and larger than other western specimens. The hind femora of males and females from Colorado are large, larger than in the Virginia sample, while in Arizona both sexes have shorter femora, similar in length to those of eastern specimens in Nova Scotia, New York, and northern Michigan. Males in the Colorado sample have a greater number of stridulatory pegs; the mean peg number for the Arizona sample is precisely at the general mean. Tegminal length in Colorado is slightly variable, due to the presence in the sample of a small number of macropterous individuals; the Arizona specimens are all brachypterous and average shorter than the general mean for tegminal length. In both samples the depth of the pronotum of the females is greater than the mean, the Arizona sample having the greatest measurement for this character of any sample (except for Virginia in which it is the same). The width of the vertex in females is virtually the same in the two samples and is relatively great, the same as in Virginia and only slightly exceeded by specimens from Oregon and

Louisiana. The mean length of the proximal segment of the hind tarsus is greater than average, the sample from Colorado having a greater mean than that from Arizona in this respect. Eye size is larger than average. Females have about the same eye size in each sample, but the eyes of Arizona males are larger than those of males from Colorado. The subocular sulcus is relatively long, but is much longer in males from Arizona than in those from Colorado. In this character measurement, the samples from Virginia and Arizona have the greatest mean length. The length of this sulcus, in females, shows a reversed situation, with females from Colorado having longer sulci than females from Arizona. The ratios of eye depth to subocular sulcus length are similar for males in both samples, and are lower than average, being about the same as for Virginia. Similar ratios in the females show Colorado specimens to be at the general mean and Arizona females slightly above the mean.

In general comparison, the samples from Arizona and from Virginia are very similar (see Figs. 192 - 210), indicating either parallel lines of development of the two groups in their mountain habitats, or confluence of distribution in relatively recent times.

1. Idaho and Oregon

The Idaho sample is small, and the measurements may not present a true reflection of Chorthippus as it occurs in that area. The means for several characters are rather different from the similar means for the Oregon sample. The Idaho specimens are smaller, similar to specimens from the eastern part of the continent and from the prairies of southern Manitoba, whereas specimens from Oregon are larger than average, although smaller than those from Colorado and Arizona.

The length of the hind femora in the Idaho sample is similar in both sexes to that of southern Manitoba material. The hind femora of males from Oregon are about the same as those from Idaho, but in females, the mean is greater, about the same as in Colorado specimens and larger than in those from Manitoba.

The tegmina of both sexes are shorter in the Oregon sample, very short in the females, comparable with those of specimens from the far north. The Idaho sample shows a reversal of this, with the males having very short tegmina, like northern specimens, and the females having longer tegmina, similar to the brachypterous sample from Quebec.

The mean number of male stridulatory pegs occur in both samples as in the general mean for North America.

Pronotal depth in females is above average, about the same as the females in Colorado and Arizona. The vertex width is the greatest of all samples in the general range of Chorthippus in North America. In the females from Idaho, however, the vertex is much narrower, like the specimens from southern Manitoba. The length of the proximal segment of the hind tarsus is greater than average in both Idaho and Oregon, similar to the means of specimens in Colorado and Arizona.

The mean of measurement of eye depth in males from Oregon is slightly above the general mean but much less than the means of eye depth of the Colorado and Arizona samples. The females have large eyes, exceeded in size only by those of females from Ann Arbor, Michigan. The eye depth of Idaho males is less, more like the specimens from southern Manitoba and Yukon. The eye depth of females from Idaho is also much less than in the Oregon female sample, more closely resembling this character in samples from the prairies and the eastern part of the continent.

The length of the subocular sulcus in males of both samples is less than the general mean, much smaller than in Colorado and Arizona, the Idaho males having very short sulci, comparable in this character with males from

Churchill, Manitoba. The mean sulcus length of females in the Oregon sample is above average and similar to the Arizona sample (see Figs. 205, 207), whereas in Idaho, this length is less than average and nearly the same as in eastern Canada, Wyoming, southern Manitoba and Saskatchewan.

The ratio of eye depth to subocular sulcus length in males and females in Oregon is much greater than the ratios expressed for samples in Arizona and Colorado. The Idaho sample has a ratio greater than that of the Oregon sample, in the case of males, while in the females the ratio is the same as for females in Arizona and less than that of Oregon females.

m. California (Figs. 196 - 211)

The length of specimens is slightly above the average, but slightly smaller than from Oregon. The hind femora of males are very short, comparable in length with specimens from the far north, while in females, the femur length is only slightly below average, smaller than in females from Oregon, and of similar length to eastern Canadian specimens.

Tegminal length is also very short, shorter than from any other area on the continent in males, and similar to the tegminal length of far northern specimens in females.

The number of stridulatory pegs is below the general mean, less than in males from Oregon, and only slightly greater than in northern specimens.

Pronotal depth averages less, the vertex is narrower, and the proximal segment of the hind tarsus is shorter in females from California than in all western and most eastern samples, but not than in specimens from the northern areas of the distribution.

The mean for eye-depth measurement in males is similar to the means found in eastern populations, larger than in Oregon, but smaller than in Colorado or Arizona. In females, this proportion is reversed, as mean eye depth in California is less than in Oregon but greater than in Colorado or Arizona.

The subocular sulcus is very short in California specimens, shorter in males from California than in males from Oregon or any other North American locality except Idaho. In females the sulcus is shorter in California specimens than in any other population sample. Only in females from McMurray, Alberta, and the far north (not including Yukon and Alaska), is this sulcus found to be nearly as short as in the females from California.

The ratio of eye depth to subocular sulcus in both sexes is far greater in California than elsewhere , and easily distinguishes this population from all others in North America (Fig. 194).

n. Louisiana

Although the sample from this area, from Natchitoches, consists of a single male and a single female, plus an immature specimen of each sex, the measurements are included for comparison with the sample populations from other areas.

The body length of the male is slightly greater than the general mean, comparable with specimens from New York or New Hampshire. It is smaller than specimens from Virginia or from the southwest (Colorado and Arizona).

The hind femur of the male is short, slightly below the general mean value, similar in size to specimens from Nova Scotia. The hind femur of the female is proportionally longer, greater than the general mean, and comparable in size with the femora or females from Virginia or Arizona.

Both specimens are brachypterous; the tegmina are shorter in both sexes than the general means, very similar in length to the brachypterous sample from Ste. Anne de Bellevue, Quebec.

The number of stridulatory pegs on the inner face of the hind femur of the male is greater than the mean number of pegs in any other sample, but falls within the upper range of variation of a great many samples.

The pronotal depth of the female is greater than the means for this character of any population sample. It is exceeded by specimens in the upper variation range from Ann Arbor, Michigan, Virginia, Colorado and Oregon.

The width of the vertex of the female is very great, equalled only by the mean of the sample from Oregon.

The proximal segment of the hind tarsus is long, similar in measurement to the means for samples from Virginia, Michigan (Ann Arbor) Arizona and Colorado.

The eye of the male is large, similar to the eyes of males from Virginia, Michigan (Ann Arbor) and Oregon. The eye of the female is also large, but smaller than in material from the above-mentioned localities, with the exception of that from Michigan (Ann Arbor) which it equals in size.

The male subocular sulcus is long, but somewhat shorter than the means for the Virginia, Arizona, and Michigan (Ann Arbor) population samples. The sulcus, in the female is very long, much longer than in any other sample.

The resultant ratio of eye depth to subocular sulcus length of the male is at the mean for North American Chorthippus; the ratio for the female, however, is lower than for any other sample, with the mean ratio of the sample from Virginia showing the closest relationship.

D. CONCEALED GENITALIA

1. Males

The epiphallus of Chorthippus curtipennis appears to be quite variable, much more variable than one might be led to believe, since so many recent papers have figured genitalia of a species from a single specimen. Dirsh (1956) points out that the phallic complex is subject to intraspecific variability, particularly in the epiphallus, and in any species a series, rather than single examples, should be studied. This was found to be very true in C. curtipennis.

It would not be difficult, upon examination of the epiphalli of many specimens to consider some of them sufficiently different to warrant specific definition (see Figs. 63 to 130). However, this variation is not necessarily geographical, since specimens collected from a single location (three-quarters of an acre) at South Ohio, Yarmouth County, Nova Scotia, 16-VIII-1961, show considerable variation (see Figs. 73 and 74). Comparisons of epiphalli from other areas also show variation. Epiphalli from four specimens from Ste. Anne de Bellevue, Quebec (see Figs. 77 to 80), two brachypterous and two macropterous individuals, exhibit differences in the shape of the bridge and distance between the lophi, which appear to correlate with tegminal length, the brachypterous individuals having the bridges more rounded and the lophi closer together. That these indications are not valid specific differences can be seen by comparison with Fig. 87, which shows the epiphallus of a specimen from Ann Arbor, Michigan. This specimen is macropterous, although its epiphallus more closely resembles those of the brachypterous individuals from Quebec.

The only feature of the epiphallus which appears to correlate with geography is a general compression, producing a structure which is wider in comparison with its length, in the western part of the continent, particularly in Oregon and California, and also to some extent in Nevada and British Columbia. However, specimens with comparable epiphalli are known from other such widely scattered points as Ann Arbor, Michigan (Fig. 87) and Churchill, Manitoba (Fig. 95). The specimens from Quesnel (Fig. 124) and Rock Creek (Fig. 127), British Columbia, and McCall, Idaho (Fig. 115) do not conform to the pattern. The endophallus of a specimen from Chama, New Mexico, shows differences from the others figured (see Fig. 58), yet the epiphallus of this specimen (Fig. 112) is not distinguishable from others from the general region. Epiphalli from Arizona are found to be larger than the average (Fig. 111).

On the basis of the epiphallus alone, or considering the whole phallic structure, there may be some justification for splitting *curtipennis* into more than one species or subspecies, although the degree of variation that occurs at single localities and some inconsistencies make this rather difficult.

ii. Females

a. The Subgenital Plate (Figs. 167 - 183)

The subgenital plates of females from various regions in North America are basically similar, but variation occurs in each of the component parts. The egg-guide is shortest in a specimen from Alberta (Czar), and longest in specimens from Nova Scotia (South Ohio, Yarmouth County) and Nebraska (Glen, Sioux County). Depth and width of the tunic (or floor pouches) is different in each specimen examined. The extent of the pigmented areas varies, as does the shape, size and position of the columellae. For the most part, there is no discernible pattern to the variation. However, the specimens from Oregon, and, in particular, California (Fig. 180), have subgenital plates which are smaller than the others, nearly the same size as that of *C. parallelus*, while all of the others are approximately the same size as that of *C. montanus*. The most notable difference is found in the subgenital plate of the female from Louisiana (Fig. 183), where accessory armature surrounding the columellae is quite apparent.

b. Spermatheca (Figs. 153 - 164)

Within the range of Chorthippus in North America, there appears to be a tendency toward larger spermathecal sacs in the interior and smaller sacs in the coastal regions of the East and West and in the North.

c. Ovipositor Valves (Figs. 133 - 150)

The dorsal and ventral ovipositor valves are more variable than the "intervalvulae" or "mesal valves", so that reference to the latter is omitted here. The variation is greatest in the dorsal valve, mainly in length and in the ratio of length to greatest breadth. The ratios of the valves studied are presented in Table XX. In general, the females from northern areas, which are smaller overall, have smaller ovipositor valves. This is not reflected in a smaller length to breadth ratio, since the reduction in size does not discriminate against either dimension. The exception to this is found in a female from Alaska (north slope of the Brooks Range), in which the dorsal valve is decidedly broader in comparison with its length (Fig. 150). This is also noticeable in the specimens from Oregon and California, which also have short, broad ovipositors (Figs. 146 to 148), and has been found in a specimen from Chilcotin, British Columbia (Fig. 149). A specimen from Flagstaff, Arizona, has ovipositor valves which are larger than those of specimens from any other part of North America (Fig. 143). Reference to Figs. 177 and 111 shows that the female subgenital plate and the male epiphallus of specimens from Arizona are also larger than others on the continent.

E. COLOUR FORMS (TABLE XXII)

The predominating colour forms of *Chorthippus* in North America are *hyalolateralis* and *rubiginosa* as described by Rubtzov (1935). Form *hyalolateralis* is green laterally and ochreous-brown dorsally. This type of colouration appears to predominate in northeastern areas - in Labrador, 77 per cent, and in northern Quebec, 82 per cent of the total population - but this does not hold true for northern Manitoba, where it is represented in only 32 per cent of the specimens examined. Form *rubiginosa*, characteristically all brown, but varying from light brown, reddish-brown to blackish-brown, is the predominant form in most areas, varying from 52 per cent in Virginia to 84 per cent in Michigan (Ann Arbor). The form *purpurea*, which is green laterally and purple to red dorsally, is not common and does not occur in many of the localities represented in the collection at hand, the highest percentage, 8 per cent, occurring at South Ohio, Nova Scotia. Specimens of this type were also found to occur in Virginia, Minnesota, southern Manitoba and Saskatchewan, Oregon and California.

Creighton and Robertson (1941) designated these forms by means of symbols: S+, corresponding to from *rubiginosa* (the most common type); SL, corresponding to *hyalolateralis*; and SR, representing form *purpurea*. A fourth symbol, SV, was used to designate specimens which are variegated laterally on the head and pronotum. Specimens with light and dark variegation of the lateral areas of the head and pronotum occur in the collection at hand, but this pattern has been ignored here, since it occurs in conjunction with all of the previously mentioned forms.

Two colour types which are exceedingly rare in North American *Chorthippus* are: *hyalosuperficies*, green on the head, pronotum and tegmina, which is known only from a single specimen from Colorado (Colorado Springs); and *fuliginosa*, blackish-brown, with sides of face and lower halves of pronotal lobes yellowish white, which is known only from a single specimen from California (Mendocino). Neither of these last two colour forms were reported to occur in C. montanus by Rubtzov (1935).

Clark (1943) proposed a system of symbols which would provide for very accurate description of colour variation in the Acrididae. This system of symbols describes even slight variation, and for this reason tends to become rather unwieldy.

VIII. DISCUSSION

The present study indicates the differences between C. montanus and the North American species, for which the name Chorthippus curtipennis (Harris) is reinstated.

Specimens of C. montanus were, in fact included among the material examined by Hebard (1936), when he synonymized curtipennis (Harris) and its synonyms with "C. longicornis (Latreille)" [= montanus (Charpentier)], as were specimens of C. parallelus (Zetterstedt) from Britain and other parts of Europe.

Examination of male and female genitalia, as well as external characters reveals that North American Chorthippus is very similar to the two Palaearctic species, C. montanus and C. parallelus. Of these two, the very widely distributed C. montanus is more nearly like the North American form.

The significance of the very close relationship between the two species cannot be ignored, and leaves no doubt that curtipennis is derived from montanus, or that both have evolved from a common ancestral stock. Since montanus is known as a single specific entity over the vast area of northern Eurasia, from France to the Kamchatka Peninsula, the former path of evolution seems the most reasonable. Bey-Bienko and Mishchenko (1951) state that approximately eighty species of Chorthippus are found in Europe, North Africa, Asia and North America. Chorthippus in North America, however, has been considered, for many years, to comprise but a single, rather variable species. Thus it seems reasonable to suppose that the genus is much younger in North America than in Europe and Asia.

Rehn (1958) states that the genus Chorthippus is a "relatively recent Palaearctic "intrusive in North America, "so recent that the single species we have is also widely distributed in Eurasia. Chorthippus has a large number of Old World species, and it is possible that we received C. longicornis in an interglacial period." Other genera of Acridinae, presumably reached North America by way of a land bridge linking Alaska and Siberia, notably Aeropedellus, Chlöealtis, Chrysochraon, Napaia and Stethophyma (Rehn, op. cit.). The primarily Nearctic genus Melanoplus, however, apparently migrated in the opposite direction and established itself in the Old World, where it seems to be represented by a single, rather atypical species.

It will be noted that Rehn (op. cit.) follows Hebard (1936) in considering North American Chorthippus to be conspecific with the Old World species C. longicornis [= montanus]. Nevertheless, although it has been shown that C. curtipennis of North America is not conspecific with C. montanus, the ancestral stock from which it arose must undoubtedly have been montanus. However, it may have arrived in North America considerably earlier than Rehn believed since there is evidence of relict populations in far southern locations, indicating that the Wisconsin glaciation had affected the distribution. Subsequent loss of the land bridge cut off the colony of Chorthippus, which had begun to migrate south and east, preventing gene interchange with the parent population.

Migration of Chorthippus from the point of entry on the North American continent was probably slow at the beginning, but was finally forced by glaciation, causing it to reach the most southerly areas of the continent. As the ice receded, Chorthippus must have migrated northward again. Climatic changes occurred, which made the southern areas less suitable for occupation by the species, but some segments probably remained in the more favourable locations. This would explain the small colony found by Hubbell at Natchitoches, Louisiana, in 1935. Hubbell (in litt.) is of the opinion that other isolated colonies of Chorthippus may also remain in the Ozark Mountains. A parallel to this condition is found in Ceuthophilus, as Hubbell (1936) reported disjunct distribution of three species, two of which he considered to be relict populations following recession of the polar ice following the Wisconsin Ice Age.

Apart from the colony in Louisiana and another at Tulare, southern California, Chorthippus is confined to mountainous regions in the southern areas of its distribution. In the Appalachian chain in the eastern United States, in Virginia, West Virginia, North Carolina and Tennessee, it appears to be confined to suitable areas which are higher than 3,200 feet above sea level. In the western mountains, in Colorado, Arizona, and New Mexico, Chorthippus is apparently confined to altitudes above 6,000 feet. This is also true to some extent in Utah, Nevada, Idaho, Oregon and California, although the range is extended relatively far southward in California in lowland areas. Since the species is confined to peaks and ranges, the distribution has become disjunct at a number of points, creating isolated colonies, which are cut off from the common gene pool.

Chorthippus, in North America, is normally brachypterous, nearly always so in the northern and coastal areas of distribution, with increasing proportions of macropterous individuals occurring in inland regions, which supports the opinion of Creighton and Robertson (1941) that long tegmina in *C. longicornis* [= *curtipennis*] appear to be associated with high temperature and short developmental period. In general, however, *Chorthippus* is relatively non-dispersive, so that gene flow from one area to another would be a slow process. Genetic changes in one area might not appear for a long period of time in other areas which were relatively close geographically. Certainly, in areas where distribution is no longer confluent, genetic change could produce divergent lines of development.

It is this author's thesis that slight genetic changes have occurred in many places within the range of *Chorthippus* in North America, and, further, that the gene flow has been so slow (or interrupted) that many segments have begun to diverge. In some cases, notably in Virginia and in Arizona, the changes have either been parallel or else occurred long ago at a time when confluence of distribution between the two areas was much more direct than at present.

The same can be said for populations in Labrador and at Churchill, Manitoba.

It seems obvious that *Chorthippus* is undergoing speciation in North America. It also seems obvious that population centres in some locations have diverged to a sufficient degree that they might deserve subspecific or specific rank. The colony at Natchitoches, Louisiana, has probably been isolated from the main area of distribution for a very long time, and appears to have diverged considerably in certain respects from the line of stock known by the specific name *curtipennis*. It is unfortunate that more specimens could not be obtained from this colony for the present study, since the present author considers this population to be sufficiently divergent to warrant specific designation. This opinion is based on the armature of the female subgenital plate, the male epiphallus, and the following external features: large eye size; greater length of the subocular sulcus; greater pronotal depth of the female; and greater number of male stridulatory pegs.

Some other populations are probably worthy of subspecific definition, although it is far from easy to establish the areas of interbreeding occupied by intermediate forms on account of the relatively small changes in characters and the difficulty with which these changes must be measured.

The population at Mendocino, California, is different from all of the others which were sampled, and can be separated by relatively easily measured morphological characters. In some respects the population at Divide, Oregon (the type locality of _oregonensis_ Scudder), has inherent characteristics, and in other respects it seems to be intermediate between the Mendocino form and other populations from McCall, Idaho, Colorado Springs, Colorado, and specimens from various localities in British Columbia. Rehn _in_ Buckell (1922) considered most of the specimens which he examined from British Columbia to be intermediates between _Chorthippus_ _curtipennis_ _curtipennis_ (Harris) and _C._ _c._ _oregonensis_ (Scudder): those from Anahim Lake (in the extreme west) as nearly typical _curtipennis_; those at Vernon (in the south) as nearer _oregonensis_; and those from Chilcotin (between the previous two localities) as ranging from nearly typical _curtipennis_ to distinctly intermediate forms, the majority being intermediates. The specimens from British Columbia examined during the present study show this relationship, but, as previously pointed out, the specimens from the type locality of _oregonensis_ (Scudder) also appear to be intermediate forms.

The population at Flagstaff, Arizona, differs in a number of characters from others, and the specimens from

Colorado Springs, Colorado, appear to be intermediate between it and typical _curtipennis_, and also between it and another form found in the prairie regions of southern Saskatchewan and Manitoba and extending into North Dakota, and parts of Montana and Wyoming.

Alexander (1951) indicated that _Chorthippus_ _longicornis_ [= _curtipennis_] might prove to be a resident alpine species in the mountains in Colorado, since it appeared to be confined to higher altitudes (up to 10,500 to 11,500 feet, and well above timber line in some cases). Kreasky (1960) reported that most of the eggs of _C._ _longicornis_ [= _curtipennis_] required a 3-year developmental period at an altitude of 8,500 feet, in the Big Horn Mountains, Wyoming. This is probably also the case in other mountainous areas. (_C._ _curtipennis_ eggs, from Ste. Anne de Bellevue, Quebec, were hatched only after five months, when incubated for the whole period at 80 degrees Fahrenheit.)

If _C._ _curtipennis_ is in fact a resident alpine species, it would undoubtedly occur in a series of more or less isolated populations in the western mountains, and in such situations would tend, eventually, to become sufficiently divergent so that other isolating mechanisms could maintain identity even if the geographical barrier ceased to exist. A three year egg cycle could be due to climatic factors or could have a genetic basis. If the latter be true, such a population would seem already to have diverged to a great extent from the typical *curtipennis*, as found in lowland areas.

The sample from Ann Arbor, Michigan, differs somewhat from the neighbouring populations at Keweenaw Point, Michigan, and Republic, Minnesota, and these latter samples are typical *curtipennis*.

There is also evidence that the species is undergoing change in the Appalachian Mountains, as exhibited by the population from Mountain Lake, Virginia. It is also possible, even probable, that other groups, isolated in the mountains in the east and in the west, have also diverged from the common stem to a sufficient degree to warrant recognition.

The very small specimens from northern Canada could probably also be recognized as subspecific.

The present author, however, is in agreement with the precepts of Hubbell (1954, 1956) that "graphic presentation, description and use of non-technical names is preferable when describing infraspecific variation." Hubbell (1954) states "nothing should ever be named for the sake of naming it, but only in order that something may be said about it." Therefore, I do not propose to apply names to most of the variants herein described until such time that biological study, in conjunction with the present analysis, has shown this to be desireable.

It is probably significant that the known distribution of C. montanus is nearly twice as large as the range occupied by C. curtipennis; further, C. montanus is a much older entity, probably ancestral to C. curtipennis; and yet no subspecies of C. montanus have been described. This indicates a fairly high degree of stability, and this has probably been a factor in the taxonomic confusion within this group of Chorthippus during the past hundred years.

However, specimens from two areas in North America appear to be sufficiently different from typical C. curtipennis to warrant application of names; it is proposed to call the Louisiana specimens hubbelli, new species, and those from California, californicus, new subspecies of C. curtipennis.

Little more can be done on the basis of dead, dried, pinned specimens. Further names could be applied, but this would be premature. Thus the conclusion is really the beginning, since according to Mayr, Linsley and Usinger (1953): "A careful study of the phenomena of individual variation .... is an indispensible prerequisite of all sound taxonomic work." This is interpreted by Bigelow (1958) as inferring that "biological study should come first; .... taxonomic work that is not based on a careful study of individual variation (i.e., on a biological study) is not sound."

The present author agrees in principle with this quotation, although it could be argued that museum taxonomy, in the accepted sense, can point the way for the biological study. The present study does just this.

Mayr, Linsley, and Usinger (*op. cit.*) further state, "the most practical diagnostic characters are those that relate to some easily visible character with but slight variability", and "a single character is not as reliable as a character complex", and still further "the study of variation is one of the foremost tasks of the taxonomist." The present project has considered all of these features as applied to 'museum taxonomy'. It has also pointed out the geographical areas in which biological differences should most likely occur. The next essential step would be a study of the biology of the populations in the indicated areas, including habits, food preferences, and, above all, mating behaviour and stridulation, which, as is now well known, provides a reliable method of distinguishing between closely related Palaearctic species of *Chorthippus*.

Jacobs (1953) has shown that females of *Chorthippus montanus* reacted to the stridulation of *montanus* males, but not to the stridulation of the males of the closely related *C. parallelus*. Perdeck (1957) found song to be the specific isolating mechanism between the sympatric species, <u>Chorthippus</u> <u>brunneus</u> (Thunberg) and <u>C.</u> <u>biguttulus</u> (L.). In nature, very few hybrids of these two species have been found, although hybrids were produced in the laboratory by stimulating a female of one species to copulate with a male of the other in the presence of stridulation by a male which was conspecific with the female.

A comparative study of stridulation and mating behaviour of <u>Chorthippus</u> throughout its North American distribution was not possible during the present study, but such a study should facilitate the further elucidation of this genus in North America.

IX. SUMMARY

The specific name <u>curtipennis</u> (Harris) is reinstated for North American <u>Chorthippus</u>, which is not (as erroneously supposed) conspecific with an Old World species. Characters differentiating the species are discussed. A neotype is designated and described for <u>C.</u> <u>curtipennis</u> (Harris), and complete synonymy is included.

A study of variation, including genitalia and morphometrics, portrays the great variability within the genus in North America. It is proposed later to describe as new to science one new species as well as a new subspecies of <u>C.</u> <u>curtipennis</u>. Several additional,

geographically variant populations are discussed, but cannot be assigned subspecific status on the basis of museum specimens alone.

The present study, based on dried museum specimens, indicates precise geographical areas in which the species should be studied further, and the nature of the biological investigations which should be carried out in order to complete the evaluation of this genus in North America.

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FIGURES

1 - 238

Fig. 1. Map - Chorthippus distribution in North America.

Filled circles - Localities from which specimens were seen during present study.

Filled triangles - Localities from literature, not represented in collection at hand.

Montana - Hebard (1928).

Newfoundland - Ander (1960).

FIG. I.

CHORTHIPPUS DISTRIBUTION IN NORTH AMERICA

Fig. 2. Map - Locations of sample populations.

1. Labrador (Hopedale)
2. Quebec (Lac Mistassini)
3. Manitoba (The Pas)
4. Manitoba (Gillam)
5. Manitoba (Churchill)
6. Yukon (various localities)
7. Alaska (various localities)
8. Nova Scotia (South Ohio, Yarmouth County)
9. New Hampshire (Star I., Isles of Shoals, Rockingham County)
10. Quebec (Ste. Anne de Bellevue - brachypterous)
11. Quebec (Ste. Anne de Bellevue - macropterous)
12. Ontario (Mer Bleue, near Ottawa)
13. New York (MacLean Bog, Ithaca)
14. Michigan (Keweenaw Point)
15. Michigan (Ann Arbor)
16. Minnesota (Republic)
17. Manitoba (Senkiw)
18. Manitoba (Aweme)
19. Saskatchewan (Fort Qu'Appelle)
20. Albetta (McMurray)
21. Wyoming (various localities)
22. Virginia (Mountain Lake, Giles County)
23. Colorado (Colorado Springs)
24. Arizona (Flagstaff)
25. Idaho (McCall, Boise County)
26. Oregon (Divide)
27. California (Mendocino)
28. Louisiana (Natchitoches)

FIG. 2.

CHORTHIPPUS SAMPLE LOCATIONS

Fig. 3. _Chorthippus_ _curtipennis_ (Harris), male, Ste. Anne de Bellevue, Quebec, Canada, 12-X-1961, V.R. Vickery. Drawn by Miss D. Johnstone.

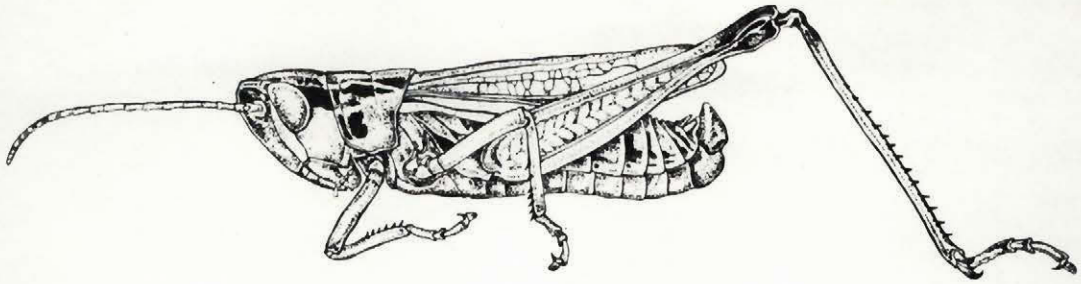
Fig. 4. _C._ _curtipennis_; hind femur, inner face, showing position of measured characters.

Fig. 5. _C._ _curtipennis_; head, lateral aspect, showing positon of measured characters.

Fig. 6. _C._ _curtipennis_, female; pronotum, lateral aspect, showing measurement points for depth of pronotum.

Fig. 7. _C._ _curtipennis_, female; head dorsal aspect, indicating points of measurement of width of vertex.

Fig. 8. _C._ _curtipennis_, female; hind tarsus, location of measurement.



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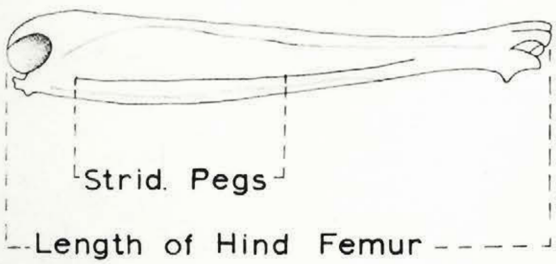
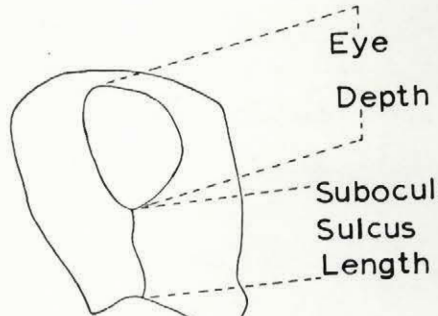
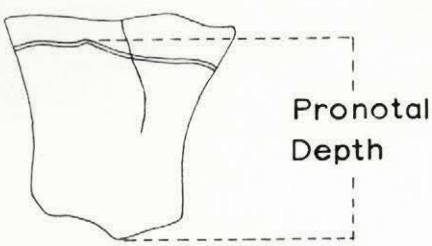

Strid. Pegs
Length of Hind Femur

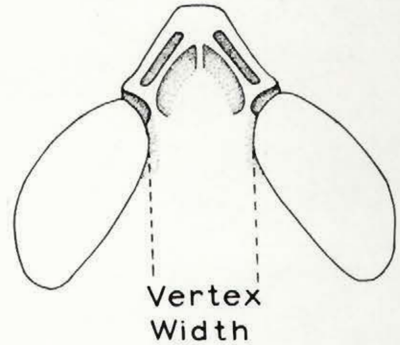
4


Eye
Depth
Subocular
Sulcus
Length

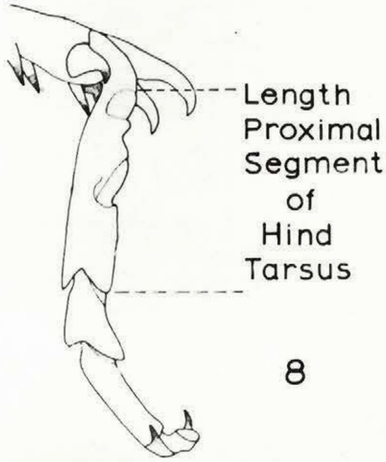
5


Pronotal
Depth

6


Vertex
Width

7


Length
Proximal
Segment
of
Hind
Tarsus

8

A. Head and pronotum, lateral aspect.

B. Head and pronotum dorsal aspect.

C. Head, frontal aspect.

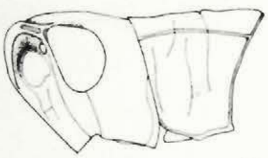
Fig. 9. *C. montanus* (Charp.), male; Karlsrhue, Germany, 6-IX-1959, H. Knipper.

Fig. 10. *C. montanus*, male; Zaibakal, Siberia.

Fig. 11. *C. parallelus* (Zett.), male; Rastatt, Germany, 19-VII-1959, H. Knipper. (L.E.M.)

Fig. 12. *C. montanus*, female; Oz Sachdal, der. ershi, 7-VIII-1920, A.M. Diakonov. Olonetsk Eksp. Coll. (A.N.S.P.)

Fig. 13. *C. montanus*, female; Karlsrhue, Germany, 6-IX-1959, H. Knipper. (L.E.M.)



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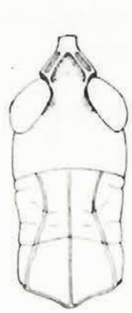
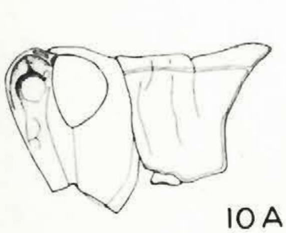
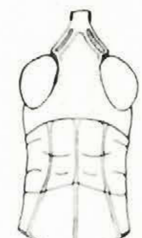


9B

9C

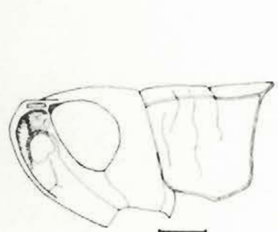


10A



10B

10C

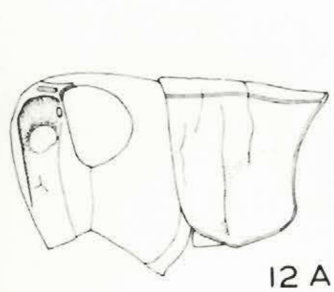


1.0 mm.

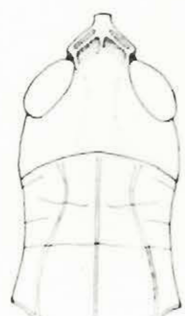
11A

11B

11C



12A



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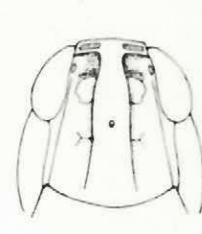

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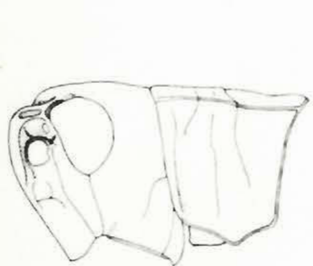
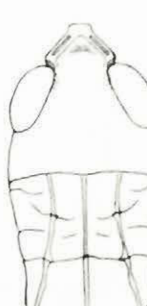


13A



13B

13C

A. Head and pronotum, lateral aspect.

B. Head and pronotum, dorsal aspect.

C. Head, frontal aspect.

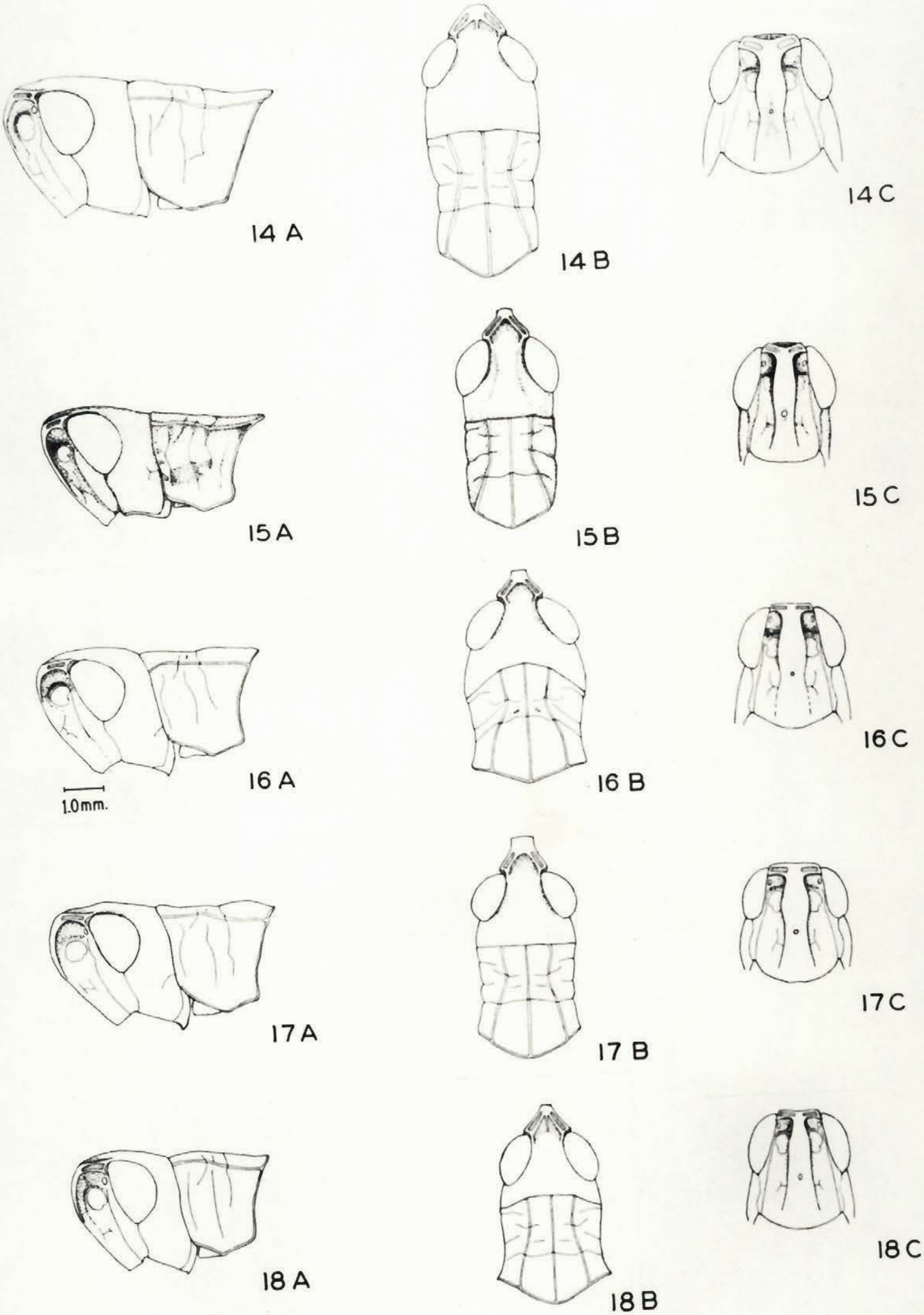
Fig. 14. *C. parallelus*, female; Rastatt, Germany, 19-VII-1959, H. Knipper. (L.E.M.)

Fig. 15. *C. curtipennis* (Harris), male neotype; Waltham, [Mass., U.S.A.], 9-IX-1891. (U. Mich.)

Fig. 16. Type, *longipennis* Scudder, male; Cambridge [Mass., U.S.A.], n.d. (M.C.Z. type no. 15238).

Fig. 17. Paratype, *acutus* Morse, male; Ormsby County, Nevada, July, Baker. (A.N.S.P.)

Fig. 18. Type, *oregonensis* Scudder, male; Divide, Oregon, 12-IX-1897. (M.C.Z. type no. 15239).


14 A
14 B
14 C
15 A
15 B
15 C
16 A
16 B
16 C
1.0mm.
17 A
17 B
17 C
18 A
18 B
18 C

A. Head and pronotum, lateral aspect.

B. Head and pronotum, dorsal aspect.

C. Head, frontal aspect.

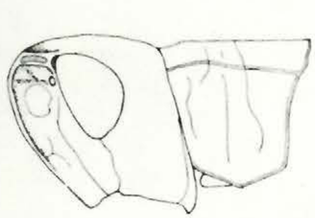
Fig. 19. Male, supposedly of series from which *coloradensis* McNeill, was named; Ft. Collins, Colorado, Baker. (M.C.Z.)

Fig. 20. *C. curtipennis*, male; Hopedale, Labrador, 13-IX-1931, W.W. Perrett. (C.N.C.)

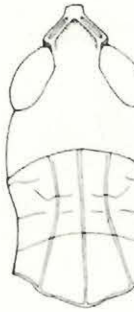
Fig. 21. Male; Churchill, Manitoba, 10-VIII-1937. W.J. Brown. (C.N.C.)

Fig. 22. Male; Ste. Anne de Bellevue, Quebec, 24-IX-1960, V.R. Vickery. (L.E.M.)

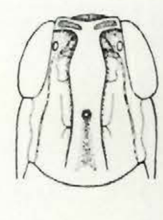
Fig. 23. Male; Flagstaff, Coconino County, Coconino Nat'l Forest, Arizona, 1-IX-1935, T.H. and G.G. Hubbell. (U. Mich.)



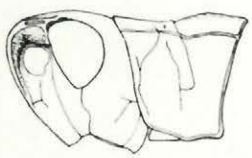
19 A



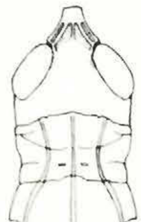
19 B



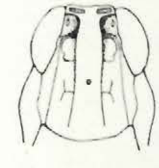
19 C



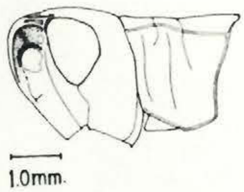
20 A



20 B

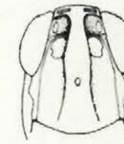


20 C



21 A

21 B



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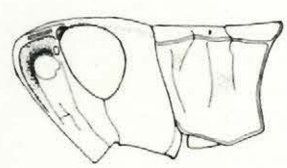
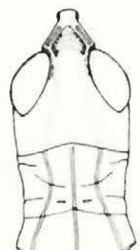
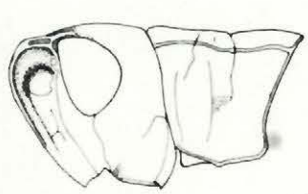


22 A



22 B

22 C



23 A

23 B

23 C

A. Head and pronotum, lateral aspect.

B. Head and pronotum, dorsal aspect.

C. Head, frontal aspect.

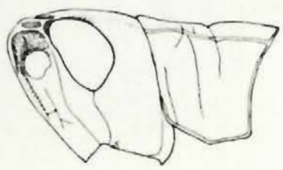
Fig. 24. Male; Flagstaff, Coconino County, Coconino Nat'l Forest, Arizona, 1-IX-1935, T.H. and G.G. Hubbell (U. Mich.) (Same data as Fig. 23)

Fig. 25. Male, Mendocino, California, 7-XI-1960, J. Helfer. (L.E.M.)

Fig. 26. Female, paratype S. acutus Morse, Ormsby County, Nevada, July 6, Baker. (A.N.S.P.)

Fig. 27. C. curtipennis, female; Hopedale, Labrador, 13-IX-1931, W.W. Perrett. (C.N.C.)

Fig. 28. Female, Churchill, Manitoba, 7-VIII-1937, W.J. Brown. (C.N.C.)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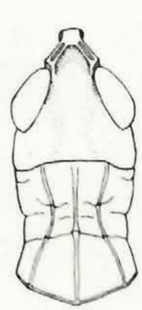
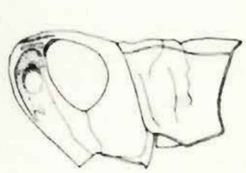
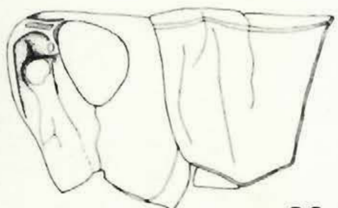

24 B


24 C

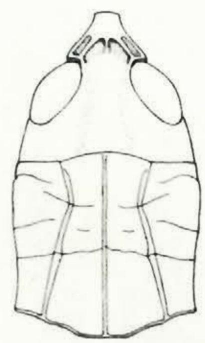

25 A


25 B


25 C


1.0mm.

26 A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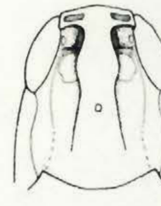
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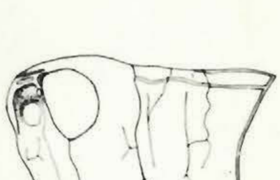
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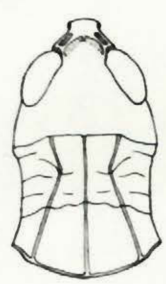
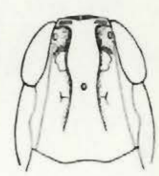

27 B


27 C


28 A


28 B


28 C

A. Head and pronotum, lateral aspect.

B. Head and pronotum, dorsal aspect.

C. Head, frontal aspect.

Fig. 29. Female, Faneuil Station, Massachusetts, 26-VII-1892. (M.C.Z.)

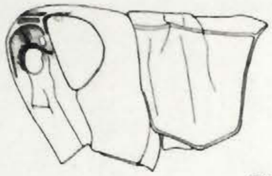
Fig. 30. Female, Ste. Anne de Bellevue, Quebec, 19-X-1961, V.R. Vickery. (L.E.M.)

Fig. 31. Female; Flagstaff, Coconino County, Coconino Nat'l Forest, 1-IX-1935, T.H. and G.G. Hubbell. (U. Mich.)

Fig. 32. Female, Mendocino, Mendocino County, California, 23-VI-1958, J.R. Helfer. (J.R.H.)

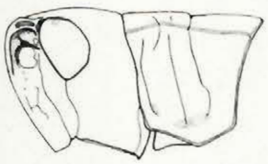
Fig. 33. Male, Natchitoches, Natchitoches County, Louisiana, 17-IX-1935, T.H. and G.G. Hubbell. (U. Mich.)

Fig. 34. Female, same data as Fig. 33.


29 A


29 B


29 C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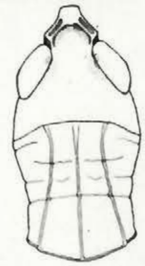
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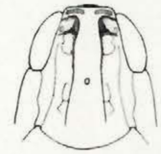
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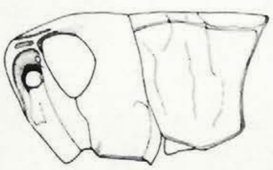
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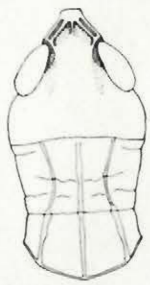
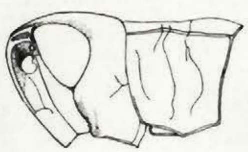

31 B


31 C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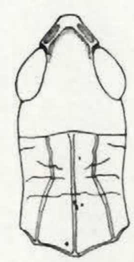
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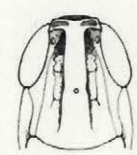
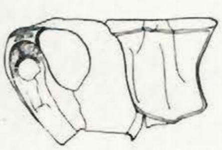
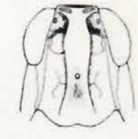
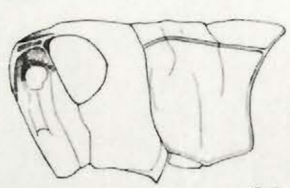
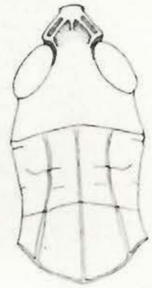

32 C

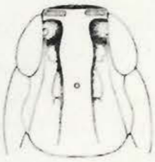

33 A


33 B


33 C


1.0 mm.
34 A


34 B


34 C

A. Outer face left mandible.

B. Outer face right mandible.

C. Inner face left mandible.

D. Inner face right mandible.

Fig. 35. *C. montanus*, male Karlsrhue, Germany, 6-IX-1959, H. Knipper. (L.E.M.)

Fig. 36. *C. parallelus*, male, Rastatt, Germany, 19-VII-1959, H. Knipper. (L.E.M.)

Fig. 37. *C. curtipennis*, male Ste. Anne de Bellevue, Quebec, 12-X-1961, V.R.Vickery. (L.E.M.)

Fig. 38. Male; Churchill, Manitoba.

Fig. 39. Male; Mountain Lake, Giles County, Virginia, 26-VIII-1946, T.H. Hubbell, (U. Mich.)

Fig. 40. Male Ann Arbor, Washtenaw County, Michigan, 24-IX-1933, I.J. Cantrall. (U. Mich.)

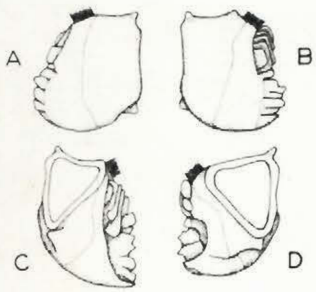
Fig. 41. Male, Flagstaff, Coconino County, Arizona. (9,600 - 9,800 feet)

Fig. 42. Male, Divide, Douglas County, Oregon. (800 - 1,000 feet)

Fig. 43. Male, Mendocino, California.

Fig. 44. Female, Ste. Anne de Bellevue, Quebec.

Fig. 45. Female, Mendocino, California.



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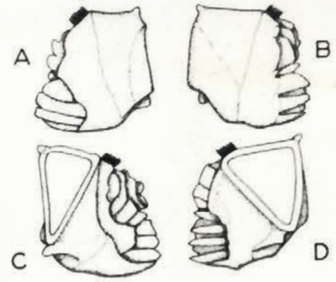

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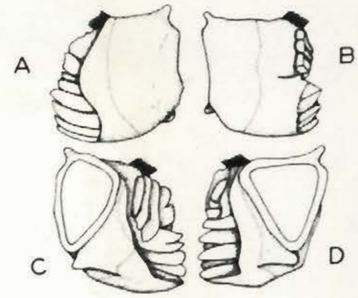

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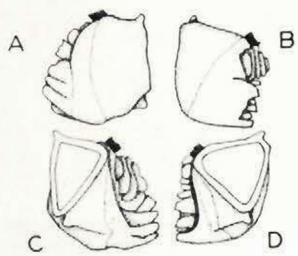

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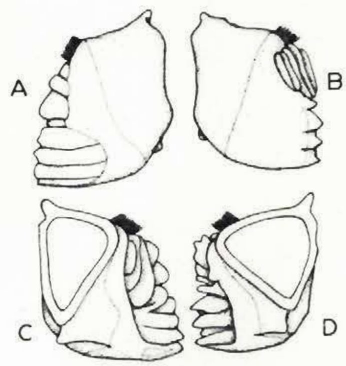
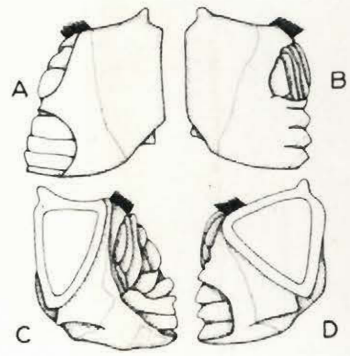
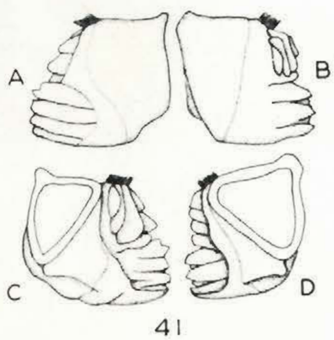


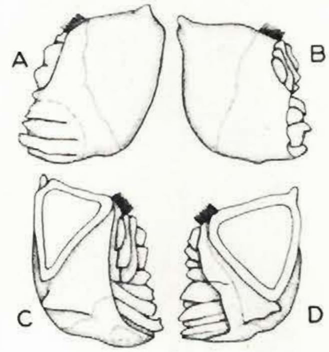
39



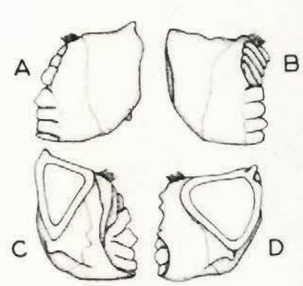
40



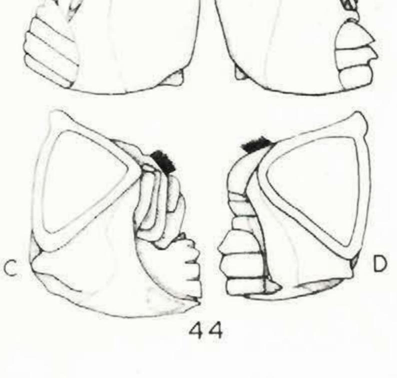
41



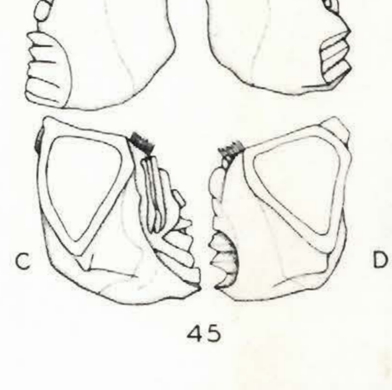
42



43



44



45

A. Male phallus (epiphallus removed), lateral aspect.

B. Dorsal aspect.

Fig. 46. *C. montanus*, Karlsrhue, Germany.

Fig. 47. *C. parallelus*, Rastatt, Germany.

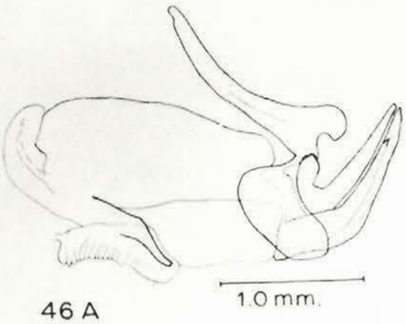
Fig. 48. *C. curtipennis*, Hopedale, Labrador.

Fig. 49. Nantucket, Massachusetts, 29-VIII-1911, Fox. (A.N.S.P.)

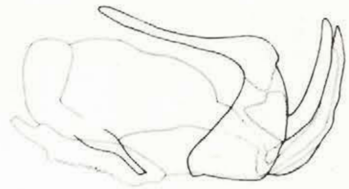
D-v	dorsal valve
A-d-v	arch of dorsal valves
V-v	ventral valve
A-s	aedeagal sclerite
Cng	cingulum
Zyg	zygoma of cingulum
Apd-Cng	apodeme of cingulum
Rm-Cng	ramus of cingulum
flx	sigmoid flexure
Sph-s	spermatophore sac
G-pr	gonopore
Ej-s	ejaculatory sac
Ej-d	ejaculatory duct
Enph-pl	endophallic plates
Enph-Apd	endophallic apodeme

Fig. 50. Mountain Lake, Giles County, Virginia.

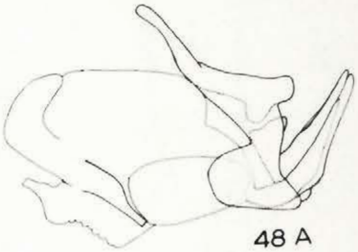
Fig. 51. Marmora, Ontario, 9-X-1941, G.H. Hammond (C.N.C.)



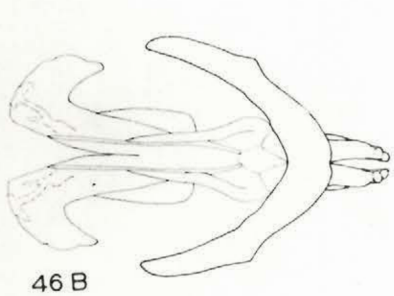
46 A



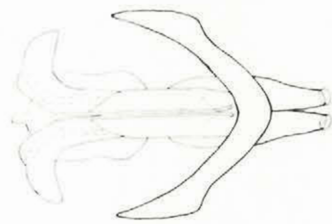
47 A



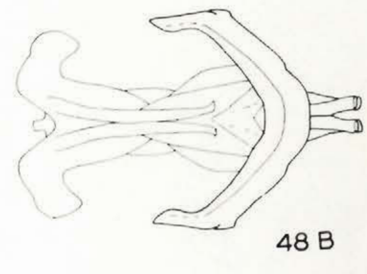
48 A



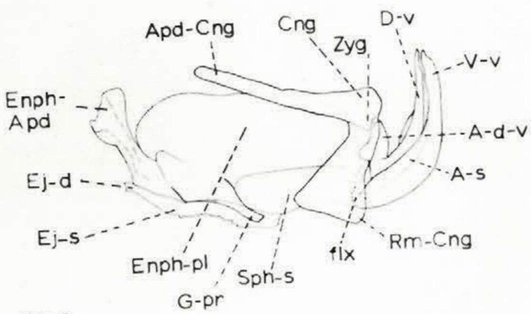
46 B



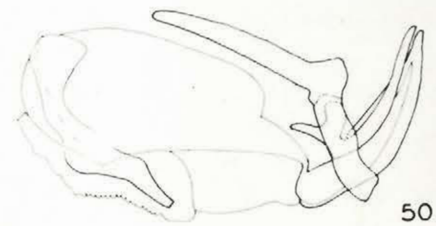
47 B



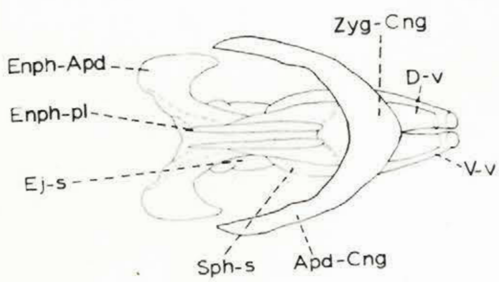
48 B



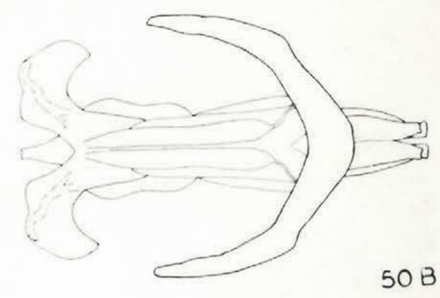
49 A



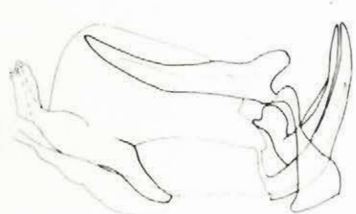
50 A



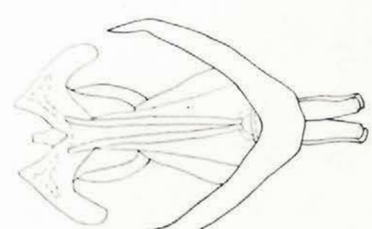
49 B



50 B



51 A



51 B

A. Male phallus (epiphallus removed), lateral aspect.

B. Dorsal aspect.

Fig. 52. Churchill, Manitoba.

Fig. 53. Plummer, Minnesota.

Fig. 54. Missoula, Montana.

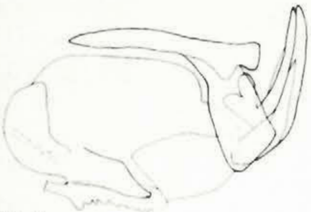
Fig. 55. McMurray, Alberta.

Fig. 56. Colorado Springs, El Paso County, Colorado.

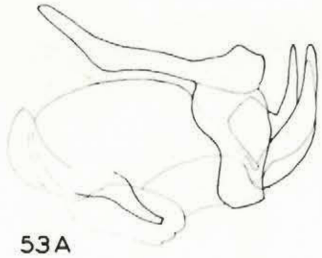
Fig. 57. Flagstaff, Coconino County, Arizona.

Fig. 58. Chama, New Mexico.

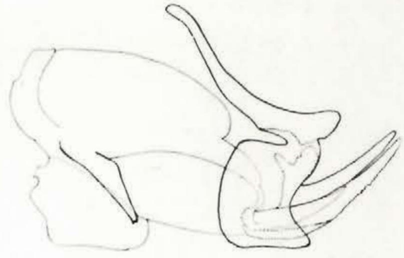
Fig. 59. Divide, Oregon.



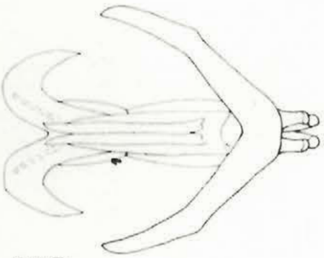
52 A



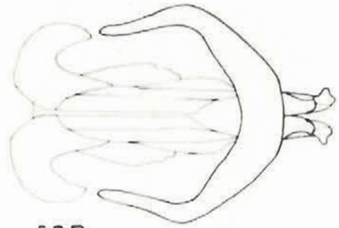
53 A



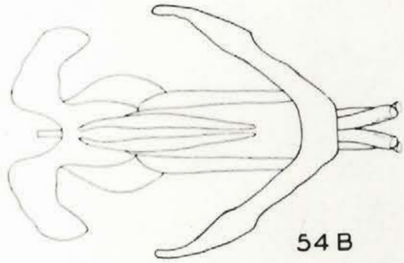
54 A



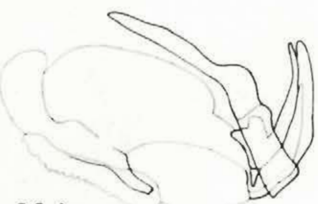
52 B



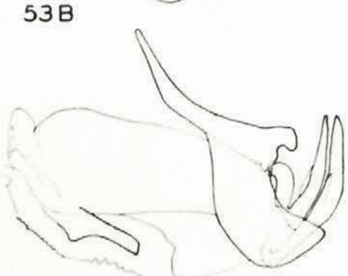
53 B



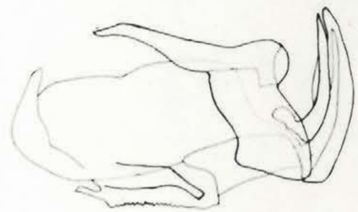
54 B



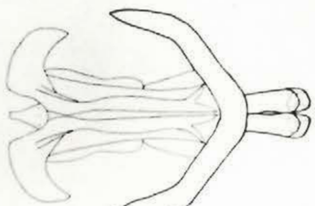
55 A



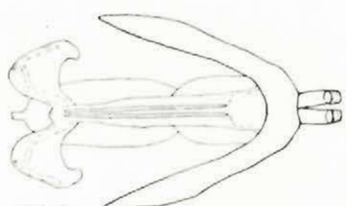
56 A



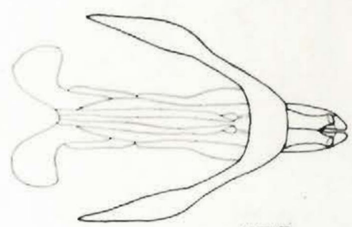
57 A



55 B

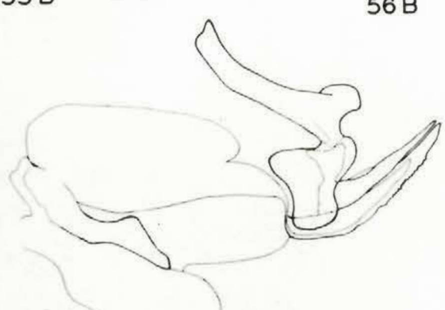


56 B



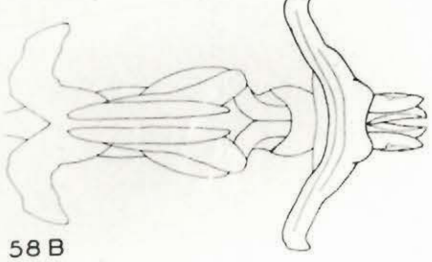
57 B

1.0 mm.

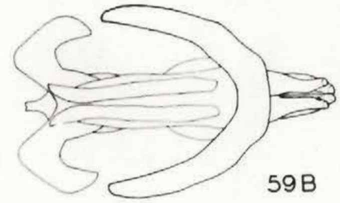


58 A

59 A



58 B



59 B

A. Male phallus (epiphallus removed), lateral aspect.

B. Dorsal aspect.

Fig. 60. Mendocino, California.

Fig. 61. Marsh Lake, Yukon.

Fig. 62. Natchitoches, Louisiana.

Male epiphallus:

A. Dorsal aspect.

B. Lateral aspect.

Fig. 63. *Euchorthippus albolineatus*, Rabat, Morocco.

Fig. 64. *C. dorsatus loratus* F.W.

Fig. 65. *C. parallelus*, Brighton, Sussex, England.

Fig. 66. *C. parallelus*, Rastatt, Germany.

Fig. 67. *C. parallelus*, Rastatt, Germany.

Fig. 68. *C. montanus*, Karlsrhue, Germany.

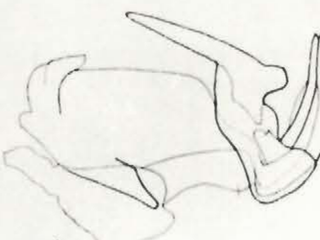
Fig. 69. *C. montanus*, Karlsrhue, Germany.

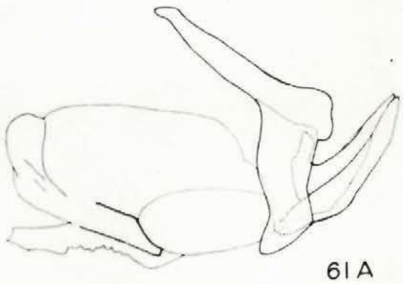
Fig. 70. *C. montanus*, Zaibakal.

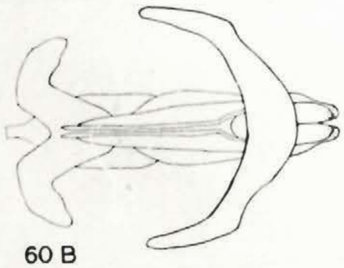
Fig. 71. *C. curtipennis*, Cartwright, Labrador.

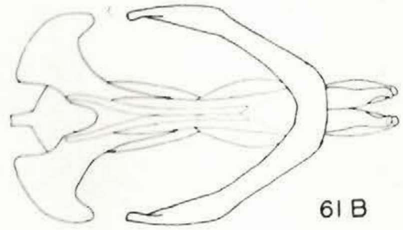
Fig. 72. Hopedale, Labrador.

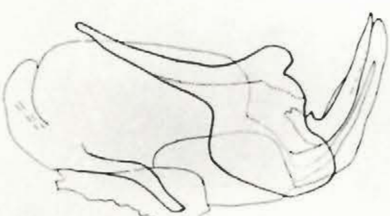
Fig. 73. South Ohio, Yarmouth County, Nova Scotia.

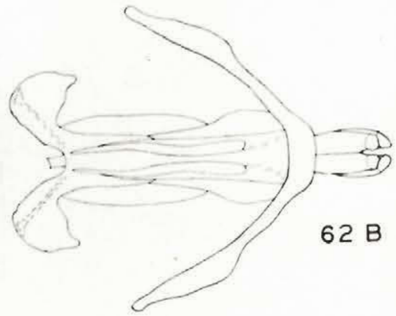

60 A

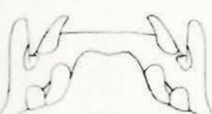

61 A


60 B


61 B


62 A


62 B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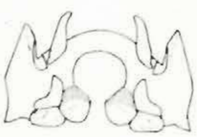
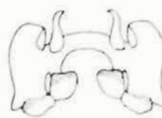
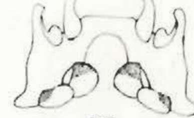

64

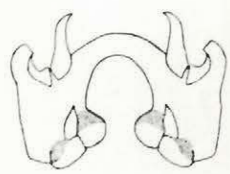

65


66


67 A


67 B

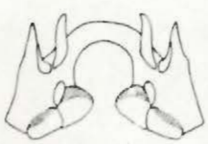

68

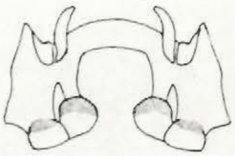

1.0 mm.

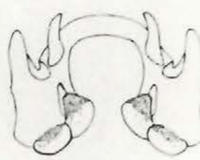
69 A


69 B


70


71

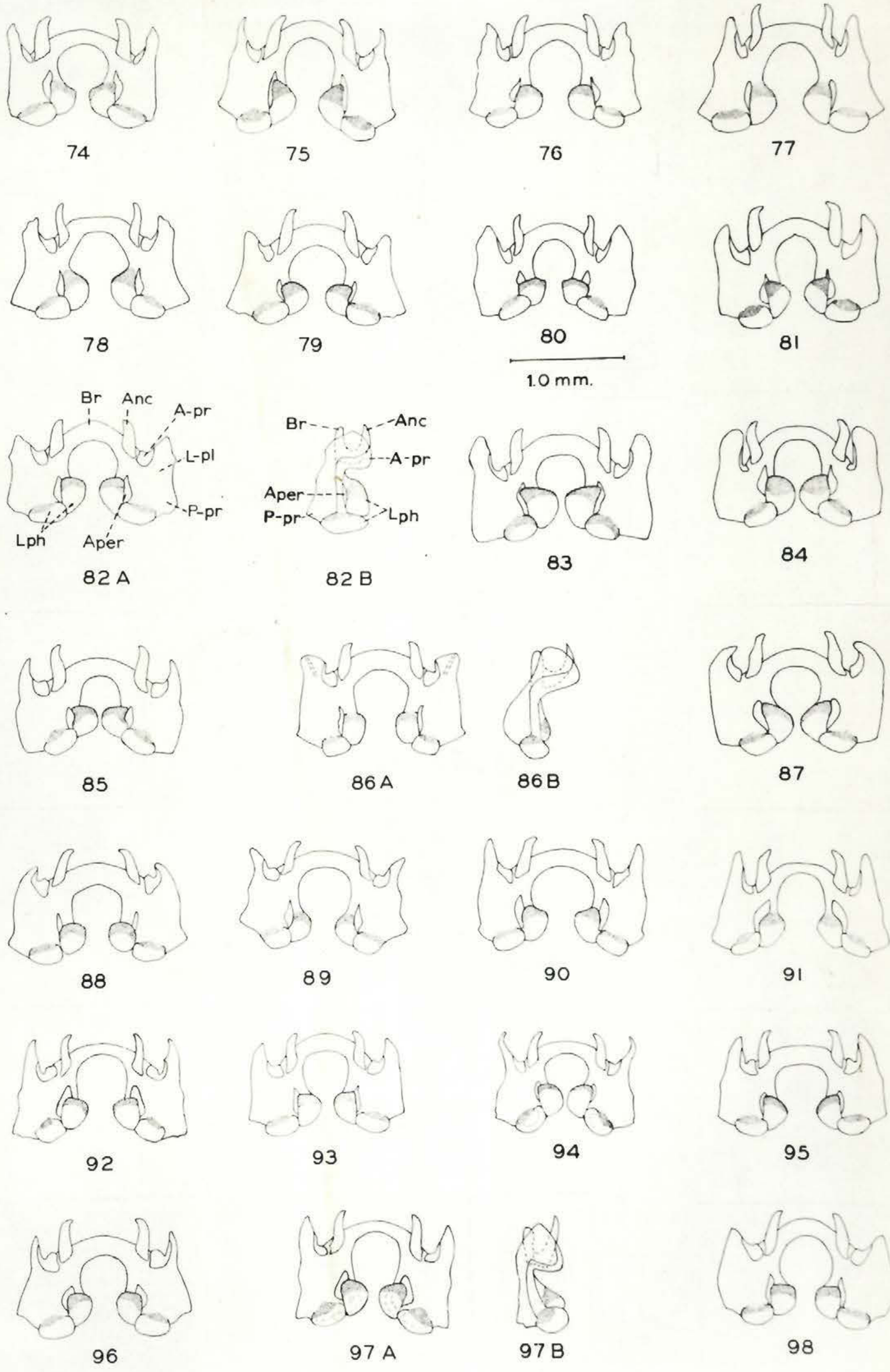

72


73

Male epiphallus: A. <u>Dorsal aspect</u>.

B. <u>Lateral aspect</u>.

Fig. 74. South Ohio, Yarmouth County, Nova Scotia. (Same data as Fig. 73).
Fig. 75. Lac Mistassini, Quebec.
Fig. 76. Isles of Shoals, Star I., Rockingham County, New Hampshire.
Fig. 77. Ste. Anne de Bellevue, Quebec. (macropterous)
Fig. 78. Same data as Fig. 77. (macropterous)
Fig. 79. Same locality as Fig. 77. (brachypterous)
Fig. 80. Same locality as Fig. 77. (brachypterous)
Fig. 81. Ithaca, New York.
Fig. 82. Nantucket, Massachusetts.
<u>Anc</u>, ancora; <u>Aper</u>, aperture; <u>A-pr</u>, anterior process; <u>Br</u>, bridge; <u>Lph</u>, lophi; <u>L-pl</u>, lateral plate; P-pr, posterior process.
Fig. 83. Mountain Lake, Virginia.
Fig. 84. Canaan Valley, Tucker County, West Virginia.
Fig. 85. Mer Bleue, Ontario.
Fig. 86. Marmora, Ontario.
Fig. 87. Ann Arbor, Michigan.
Fig. 88. Keweenaw Point, Michigan.
Fig. 89. Glen, Sioux County, Nebraska.
Fig. 90. Port Arthur, Ontario.
Fig. 91. Devil's Lake, North Dakota.
Fig. 92. Aweme, Manitoba.
Fig. 93. The Pas, Manitoba.
Fig. 94. Gillam, Manitoba.
Fig. 95. Churchill, Manitoba.
Fig. 96. Same data as Fig. 95.
Fig. 97. Missoula, Montana.
Fig. 98. Plummer, Minnesota.


74
75
76
77
78
79
80
81
1.0 mm.
Br
Anc
A-pr
L-pl
P-pr
Lph
Aper
82 A
Br
Anc
A-pr
Aper
P-pr
Lph
82 B
83
84
85
86 A
86 B
87
88
89
90
91
92
93
94
95
96
97 A
97 B
98

Male epiphallus: A. _Dorsal aspect_.

B. _Lateral aspect_.

Fig. 99. Esterbrook, Wyoming.

Fig. 100. Hobson, Montana.

Fig. 101. Ft. Qu'Appelle, Saskatchewan.

Fig. 102. Czar, Alberta.

Fig. 103. McLeod, Alberta.

Fig. 104. Banff, Alberta.

Fig. 105. McMurray, Alberta.

Fig. 106. Puffer Lake, Utah.

Fig. 107. Henefer, Utah.

Fig. 108. Colorado Springs, Colorado.

Fig. 109. Cushman Lake, Colorado.

Fig. 110. Chiricahua Mountains, Arizona.

Fig. 111. Flagstaff, Arizona.

Fig. 112. Chama, New Mexico.

Fig. 113. Nambes Creek, New Mexico.

Fig. 114. Carlin, Nevada.

Fig. 115. McCall, Idaho.

Fig. 116. Pocatello, Idaho.

Fig. 117. Summit, Baker-Grant Counties, Oregon.

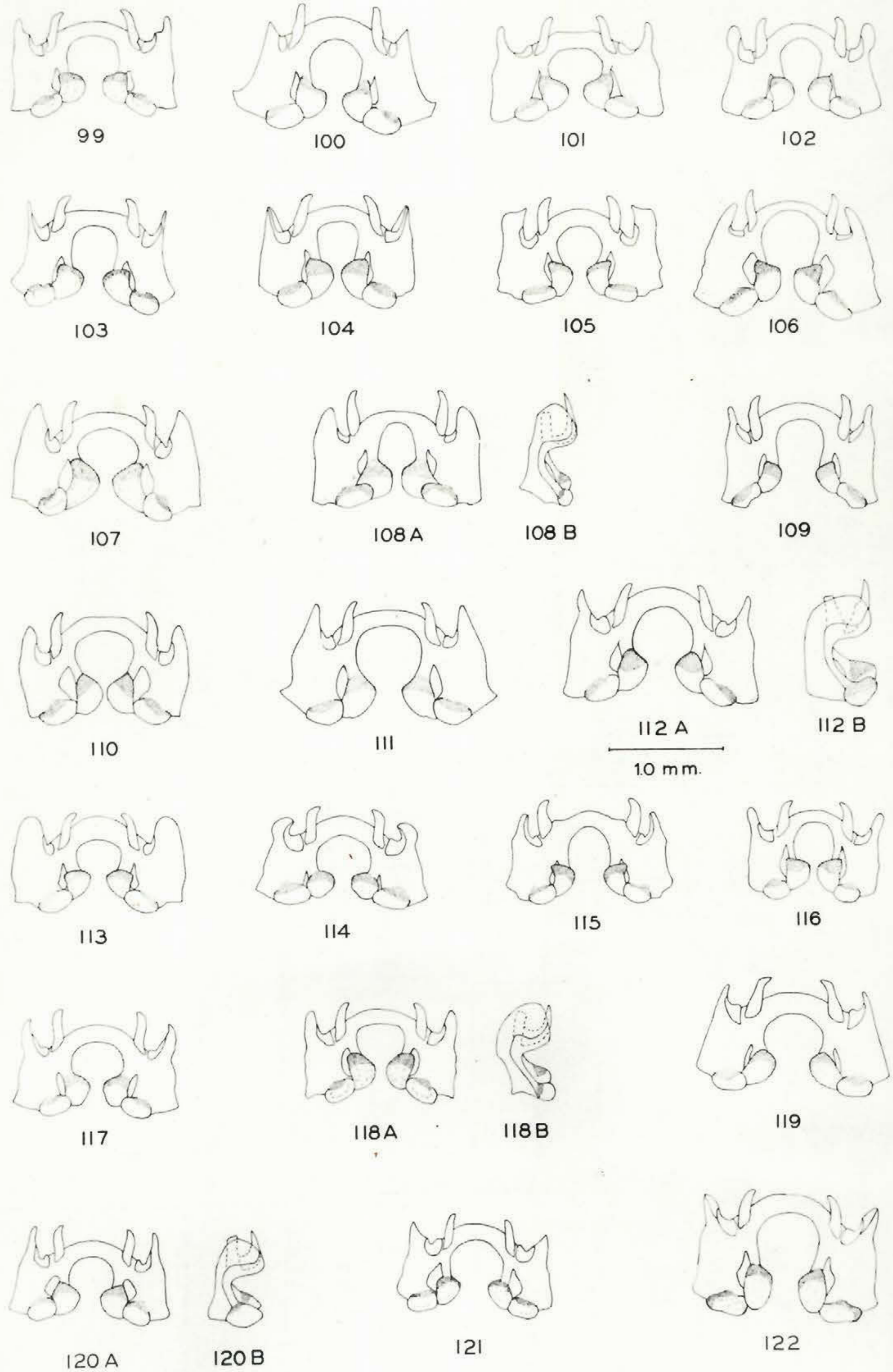
Fig. 118. Divide, Oregon.

Fig. 119. Mendocino, California.

Fig. 120. Mendocino, California.

Fig. 121. Mendocino, California.

Fig. 122. Creston, British Columbia.


99
100
101
102
103
104
105
106
107
108 A
108 B
109
110
111
112 A
112 B
1.0 mm.
113
114
115
116
117
118 A
118 B
119
120 A
120 B
121
122

Male epiphallus: A. Dorsal aspect.

B. Lateral aspect.

Fig. 123. Kamloops, British Columbia.

Fig. 124. Quesnel, British Columbia.

Fig. 125. Chilcotin, B.C.

Fig. 126. Chilcotin, B.C.

Fig. 127. Rock Creek, B.C.

Fig. 128. Marsh Lake, Yukon.

Fig. 129. Old John Lake, Alaska.

Fig. 130. Natchitoches, Louisiana.

Female ovipositor valves, lateral aspect.

Fig. 131. *C. parallelus*, Rastatt, Germany.

Fig. 132. *C. montanus*, Karlsrhue, Germany.

Fig. 133. C. curtipennis, Hopedale, Labrador.

Fig. 134. Nantucket, Massachusetts.

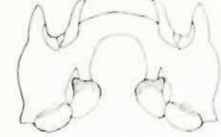
Fig. 135. Ithaca, New York.

Fig. 136. Canaan Valley, West Virginia.

Fig. 137. Mountain Lake, Virginia.

Fig. 138. Mer Bleue, Ontario.

123



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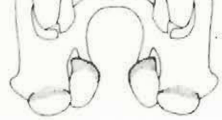

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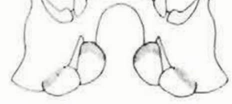

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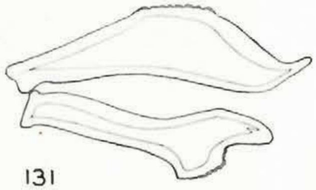
130 A

130 B



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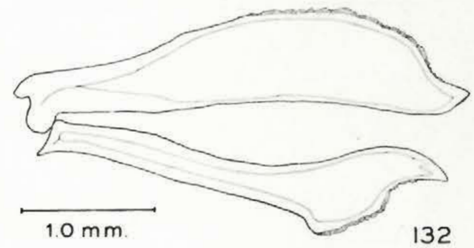
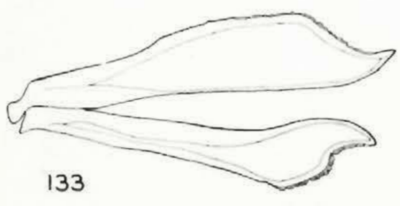


1.0 mm.

132



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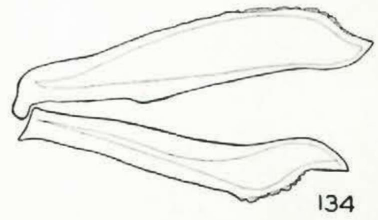

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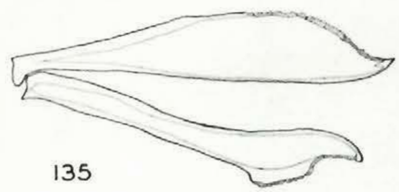

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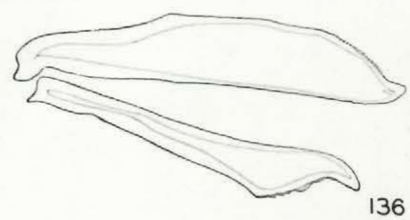

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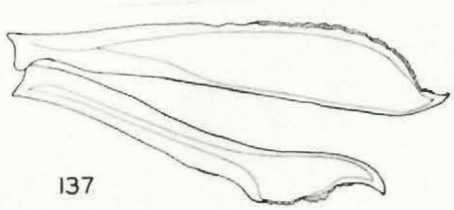

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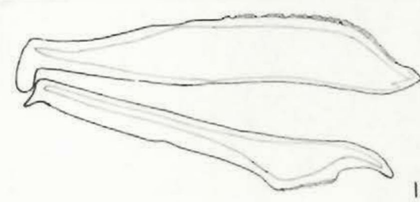


138

Female ovipositor valves, lateral aspect.

Fig. 139. *C. curtipennis*, Ste. Anne de Bellevue, Quebec.

Fig. 140. Churchill, Manitoba.

Fig. 141. Republic, Minnesota.

Fig. 142. Esterbrook, Wyoming.

Fig. 143. Flagstaff, Arizona.

Fig. 144. McMurray, Alberta.

Fig. 145. Carlin, Nevada.

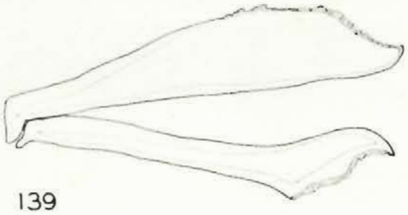
Fig. 146. Divide, Oregon.

Fig. 147. nr. Mono Pass, Mono County, California.

Fig. 148. Mendocino, California.

Fig. 149. Chilcotin, British Columbia.

Fig. 150. North Slope, Brooks Range, Alaska.



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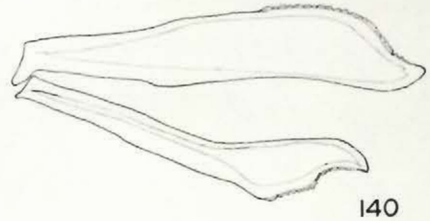

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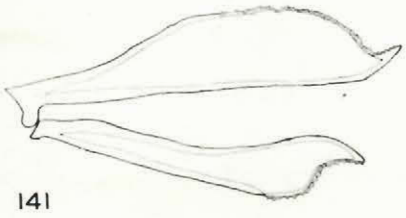

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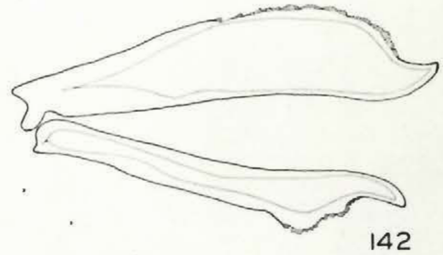

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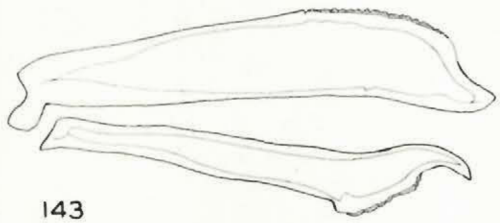

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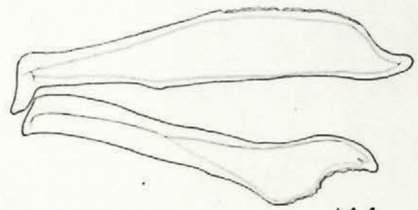

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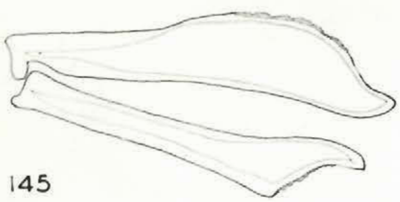

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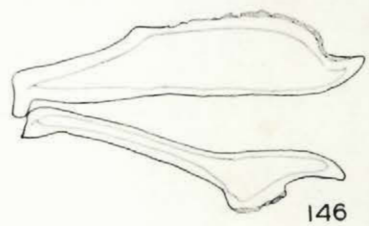

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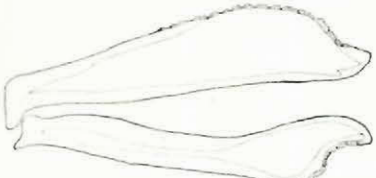

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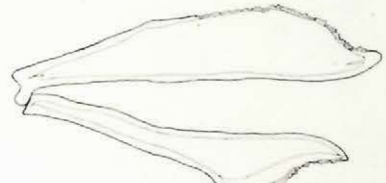

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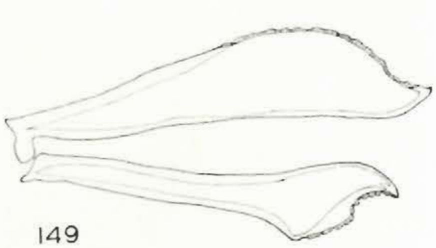

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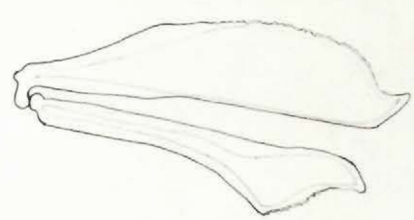


150

Female spermatheca

Fig. 151. *C. montanus*, Karlsrhue, Germany.

Fig. 152. *C. parallelus*, Rastatt, Germany.

Fig. 153. *C. curtipennis*, Hopedale, Labrador.

Fig. 154. Nantucket, Massachusetts.

Fig. 155. Mountain Lake, Virginia.

Fig. 156. Canaan Valley, West Virginia.

Fig. 157. Mer Bleue, Ontario.

Fig. 158. Churchill, Manitoba.

Fig. 159. McMurray, Alberta.

Fig. 160. Esterbrook, Wyoming.

Fig. 161. Carlin, Nevada.

Fig. 162. Flagstaff, Arizona.

Fig. 163. Divide, Oregon.

Fig. 164. Mendocino, California.

Female subgenital plate, cleared, dorsal aspect.

Fig. 165. *C. parallelus*, Rastatt, Germany.

Fig. 166. *C. montanus*, Karlsrhue, Germany.

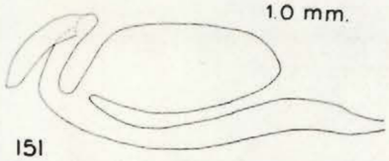
Fig. 167. *C. curtipennis*, Hopedale, Labrador.

Fig. 168. South Ohio, Yarmouth County, Nova Scotia. *E-g*, egg guide; *C-a*, contact area; *F-e*, fusion edge; *c*, columellae; *t*, tunic; *V*, vagina.

Fig. 169. Nantucket, Massachusetts.

Fig. 170. Ste. Anne de Bellevue, Quebec.

1.0 mm.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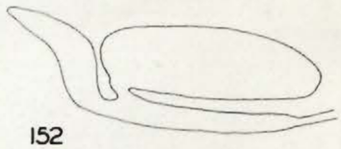
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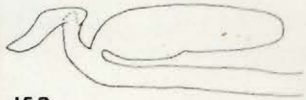
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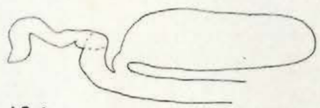
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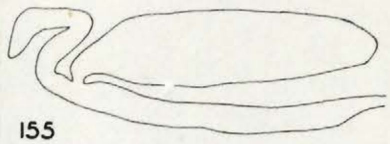
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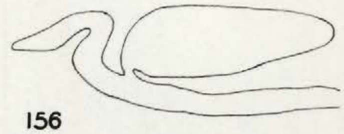
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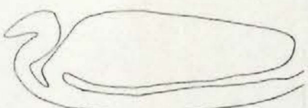
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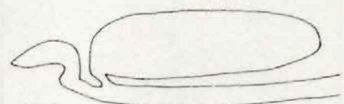
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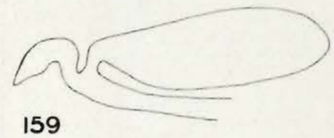
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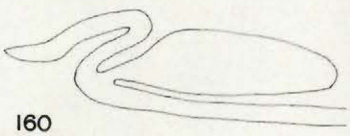
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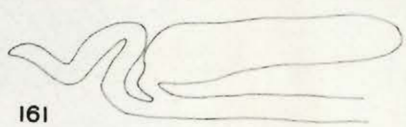
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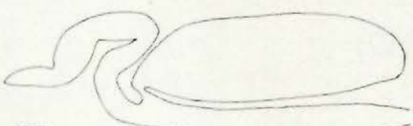
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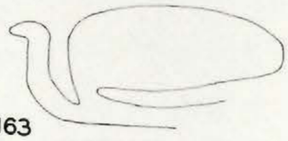
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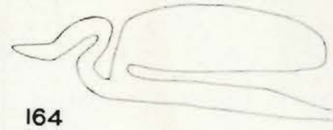
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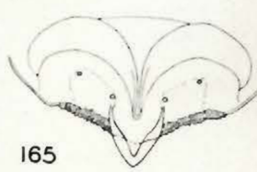
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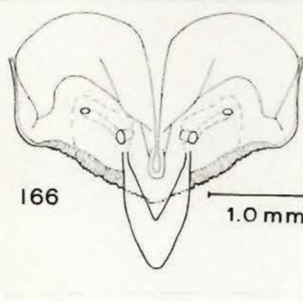
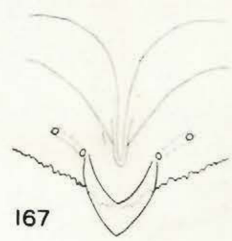

166

1.0 mm.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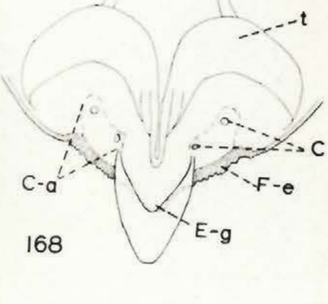

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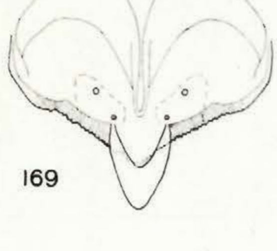
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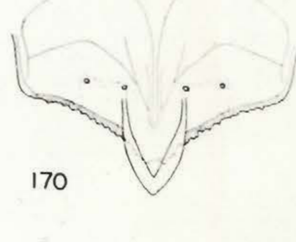

170

Female subgenital plate, cleared, dorsal aspect.

Fig. 171. Churchill, Manitoba.

Fig. 172. Glen, Sioux County, Nebraska.

Fig. 173. Lewiston, Montana.

Fig. 174. Czar, Alberta.

Fig. 175. Esterbrook, Wyoming.

Fig. 176. Colorado Springs, Colorado.

Fig. 177. Flagstaff, Arizona.

Fig. 178. Chama, New Mexico.

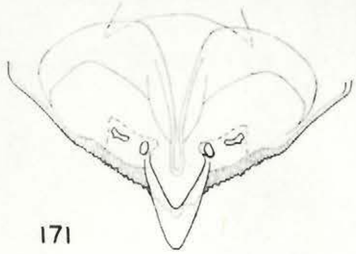
Fig. 179. Divide, Oregon.

Fig. 180. Mendocino, California.

Fig. 181. Chilcotin, British Columbia.

Fig. 182. north slope, Brooks Range, Alaska.

Fig. 183. Natchitoches, Louisiana.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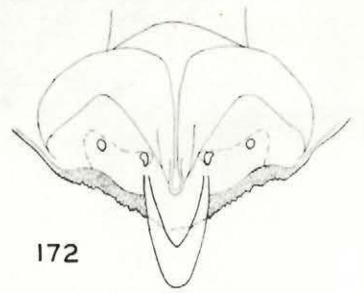
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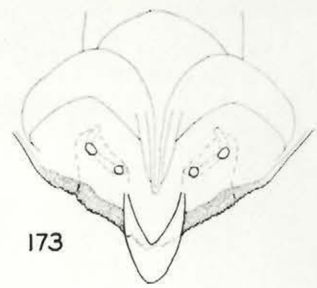
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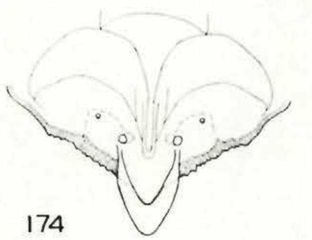
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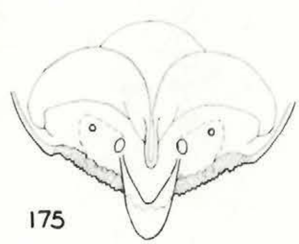
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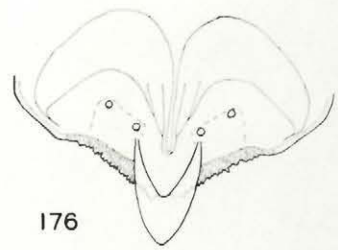
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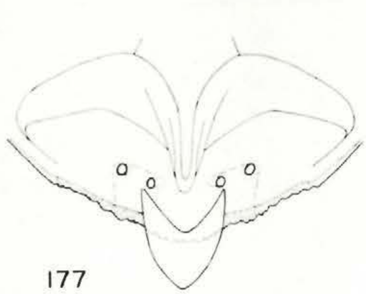
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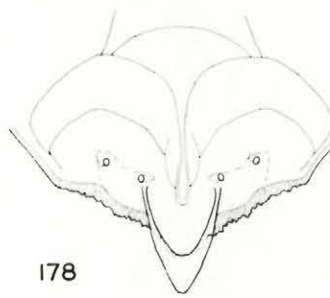
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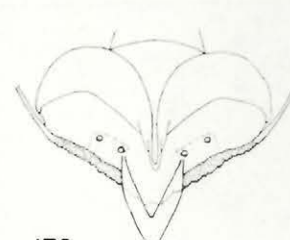
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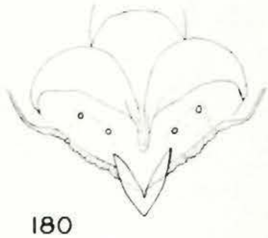
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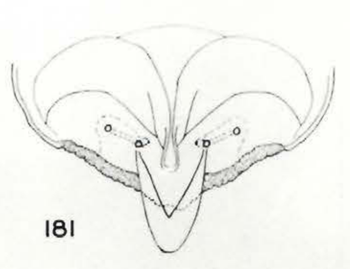
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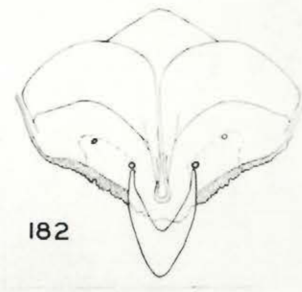

182

1.0 mm.

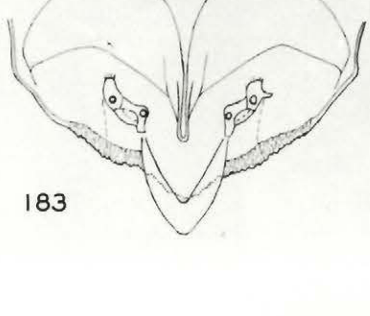
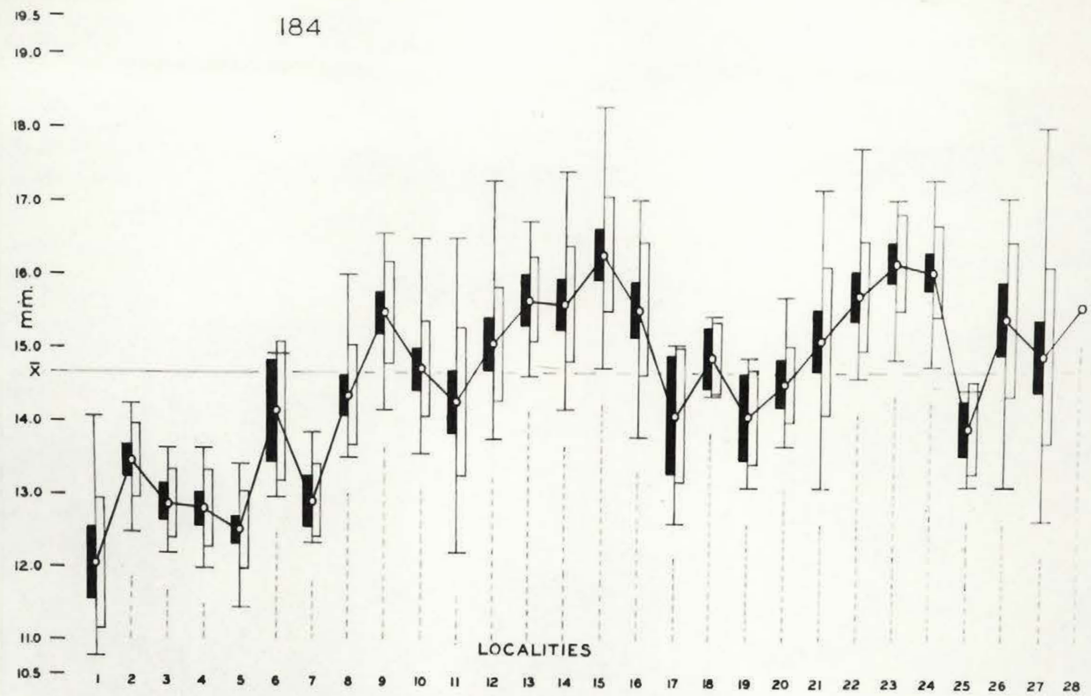

183

Fig. 184. Variation, body length, males, various localities:

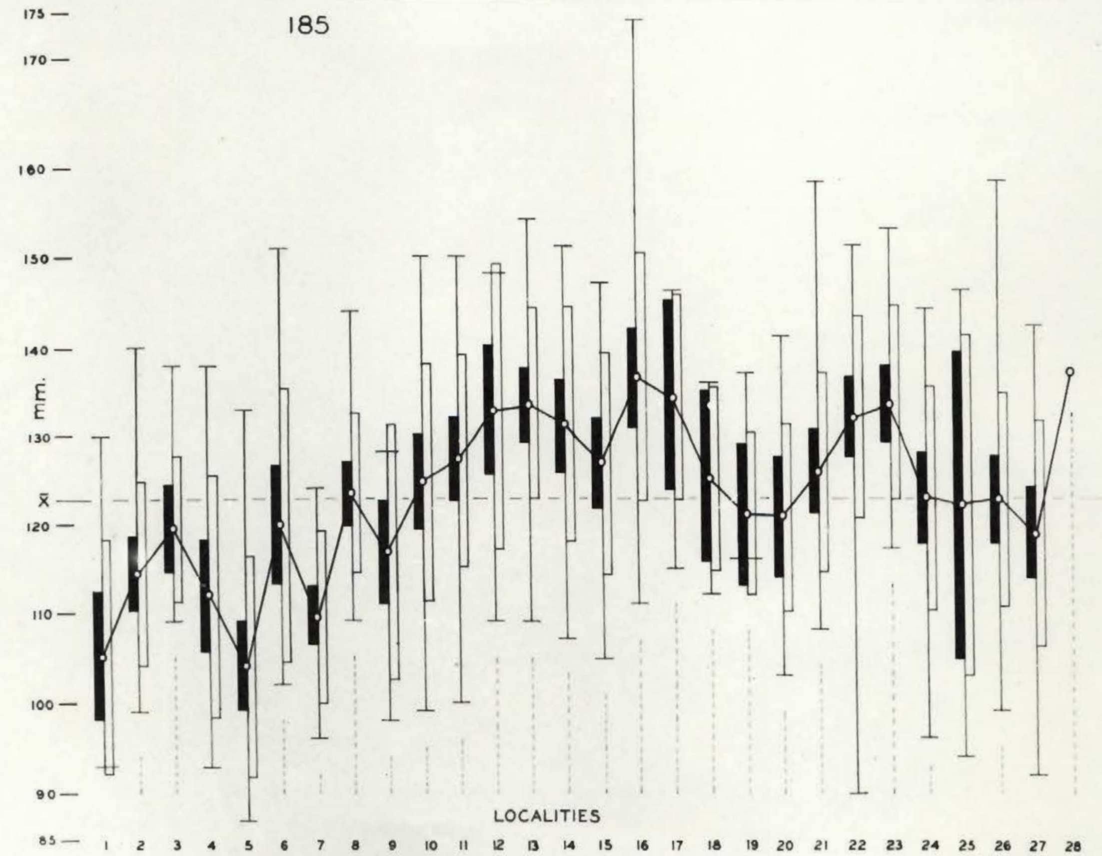
Circle indicates the mean value;
open rectangle indicates plus or minus the standard deviation;
dark rectangle indicates plus or minus twice the standard error of the mean.
Horizontal numbers indicate sample localities, as follows:

1. Labrador (Hopedale)
2. Quebec (Lac Mistassini)
3. Manitoba (The Pas)
4. Manitoba (Gillam)
5. Manitoba (Churchill)
6. Yukon (various localities)
7. Alaska (various localities)
8. Nova Scotia (South Ohio, Yarmouth County)
9. New Hampshire (Star I., Isles of Shoals, Rockingham County)
10. Quebec (Ste. Anne de Bellevue - brachypterous)
11. Quebec (Ste. Anne de Bellevue - macropterous)
12. Ontario (Mer Bleue, near Ottawa)
13. New York (MacLean Bog, Ithaca)
14. Michigan (Keweenaw Point)
15. Michigan (Ann Arbor)
16. Minnesota (Republic)
17. Manitoba (Senkiw)
18. Manitoba (Aweme)
19. Saskatchewan (Fort Qu'Appelle)
20. Alberta (McMurray)
21. Wyoming (various localities)
22. Virginia (Mountain Lake, Giles County)
23. Colorado (Colorado Springs)
24. Arizona (Flagstaff)
25. Idaho (McCall, Boise County)
26. Oregon (Divide)
27. California (Mendocino)
28. Louisiana (Natchitoches)

Fig. 185. Variation, numbers of stridulatory pegs on the inner face of the hind femora, males. Legend and localities as in Fig. 184.



BODY LENGTH, MALES



NO. STRIDULATORY PEGS, MALES

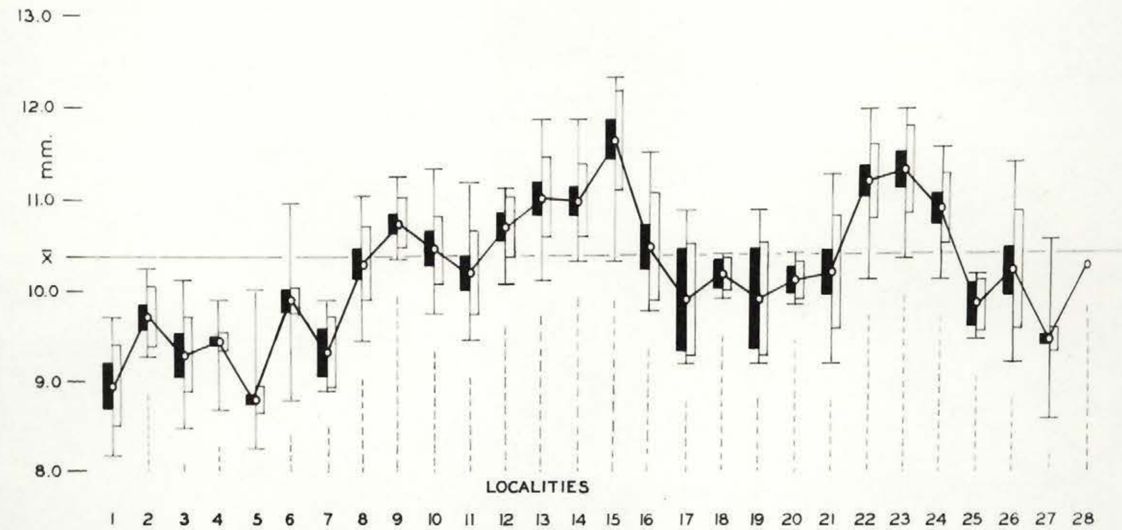
Fig. 186. Variation, hind femur length, males.

Circle indicates the mean value;
open rectangle indicates plus or minus the standard deviation;
dark rectangle indicates plus or minus twice the standard error of the mean.
Horizontal numbers indicate sample localities, as follows:

1. Labrador (Hopedale)
2. Quebec (Lac Mistassini)
3. Manitoba (The Pas)
4. Manitoba (Gillam)
5. Manitoba (Churchill)
6. Yukon (various localities)
7. Alaska (various localities)
8. Nova Scotia (South Ohio, Yarmouth County)
9. New Hampshire (Star I., Isles of Shoals, Rockingham County)
10. Quebec (Ste. Anne de Bellevue - brachypterous)
11. Quebec (Ste. Anne de Bellevue - macropterous)
12. Ontario (Mer Bleue, near Ottawa)
13. New York (MacLean Bog, Ithaca)
14. Michigan (Keweenaw Point)
15. Michigan (Ann Arbor)
16. Minnesota (Republic)
17. Manitoba (Senkiw)
18. Manitoba (Aweme)
19. Saskatchewan (Fort Qu'Appelle)
20. Alberta (McMurray)
21. Wyoming (various localities)
22. Virginia (Mountain Lake, Giles County)
23. Colorado (Colorado Springs)
24. Arizona (Flagstaff)
25. Idaho (McCall, Boise County)
26. Oregon (Divide)
27. California (Mendocino)
28. Louisiana (Natchitoches)

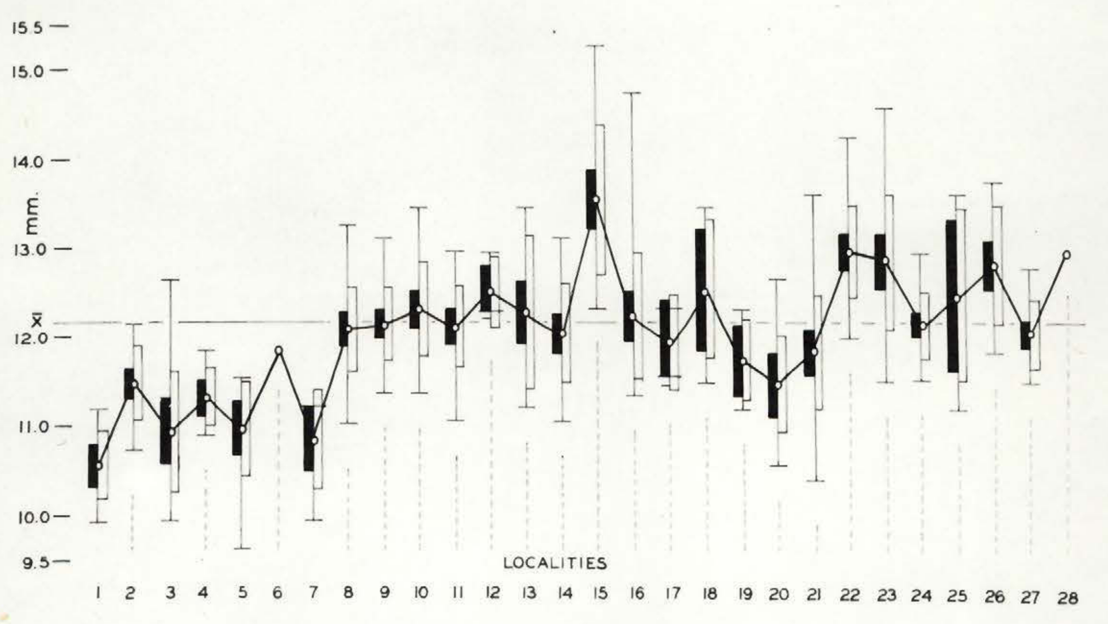
Fig. 187. Same, females. Legend and localities as in Fig. 186.

186



HIND FEMUR LENGTH, MALES

187



HIND FEMUR LENGTH, FEMALES

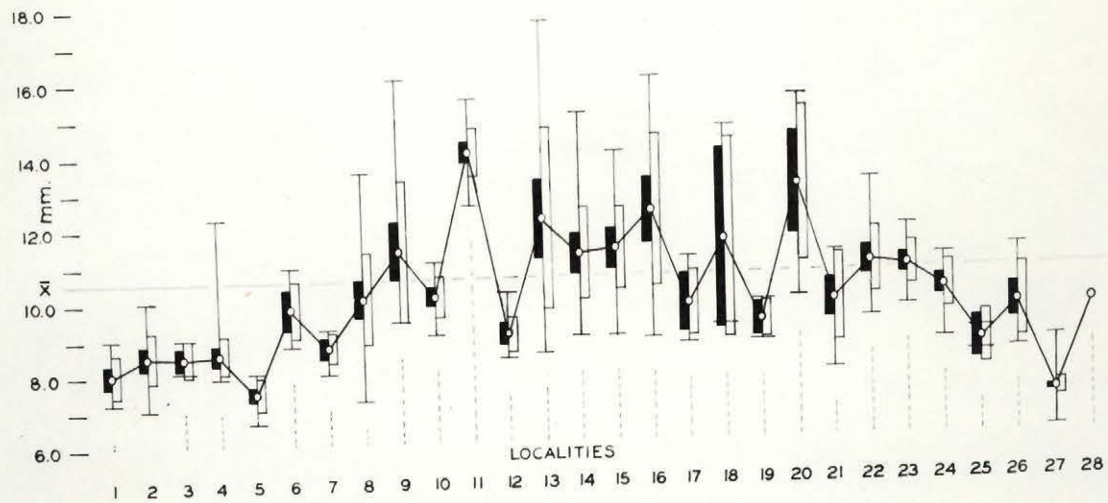
Fig. 188. Variation, tegminal length, males.

Circle indicates the mean value;
open rectangle indicates plus or minus the standard deviation;
dark rectangle indicates plus or minus twice the standard error of the mean.
Horizontal numbers indicate sample localities, as follows:

1. Labrador (Hopedale)
2. Quebec (Lac Mistassini)
3. Manitoba (The Pas)
4. Manitoba (Gillam)
5. Manitoba (Churchill)
6. Yukon (various localities)
7. Alaska (various localities)
8. Nova Scotia (South Ohio, Yarmouth County)
9. New Hampshire (Star I., Isles of Shoals, Rockingham County)
10. Quebec (Ste. Anne de Bellevue - brachypterous)
11. Quebec (Ste. Anne de Bellevue - macropterous)
12. Ontario (Mer Bleue, near Ottawa)
13. New York (MacLean Bog, Ithaca)
14. Michigan (Keweenaw Point)
15. Michigan (Ann Arbor)
16. Minnesota (Republic)
17. Manitoba (Senkiw)
18. Manitoba (Aweme)
19. Saskatchewan (Fort Qu'Appelle)
20. Alberta (McMurray)
21. Wyoming (various localities)
22. Virginia (Mountain Lake, Giles County)
23. Colorado (Colorado Springs)
24. Arizona (Flagstaff)
25. Idaho (McCall, Boise County)
26. Oregon (Divide)
27. California (Mendocino)
28. Louisiana (Natchitoches)

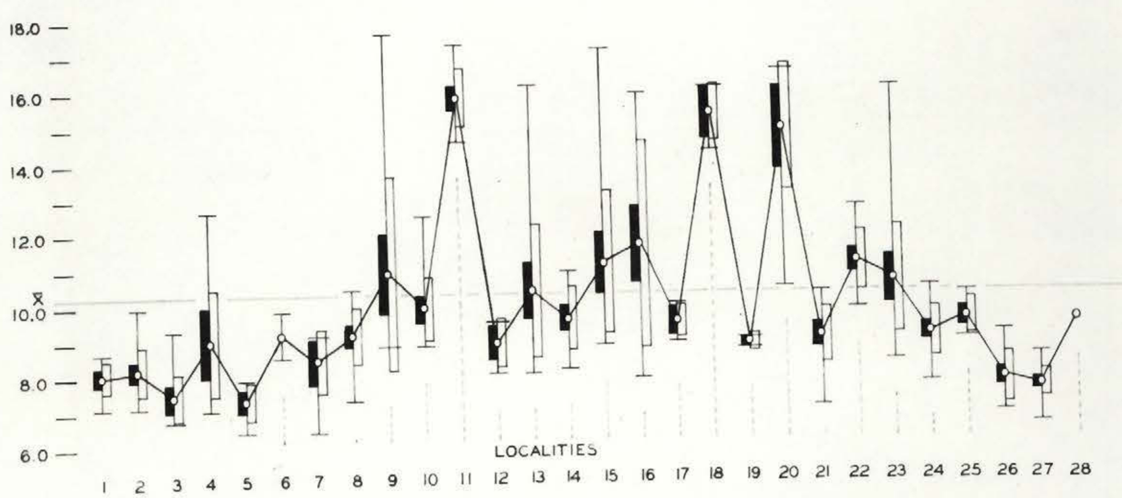
Fig. 189. Same, females. Legend and localities as in Fig. 188.

188



TEGMINA LENGTH, MALES

189



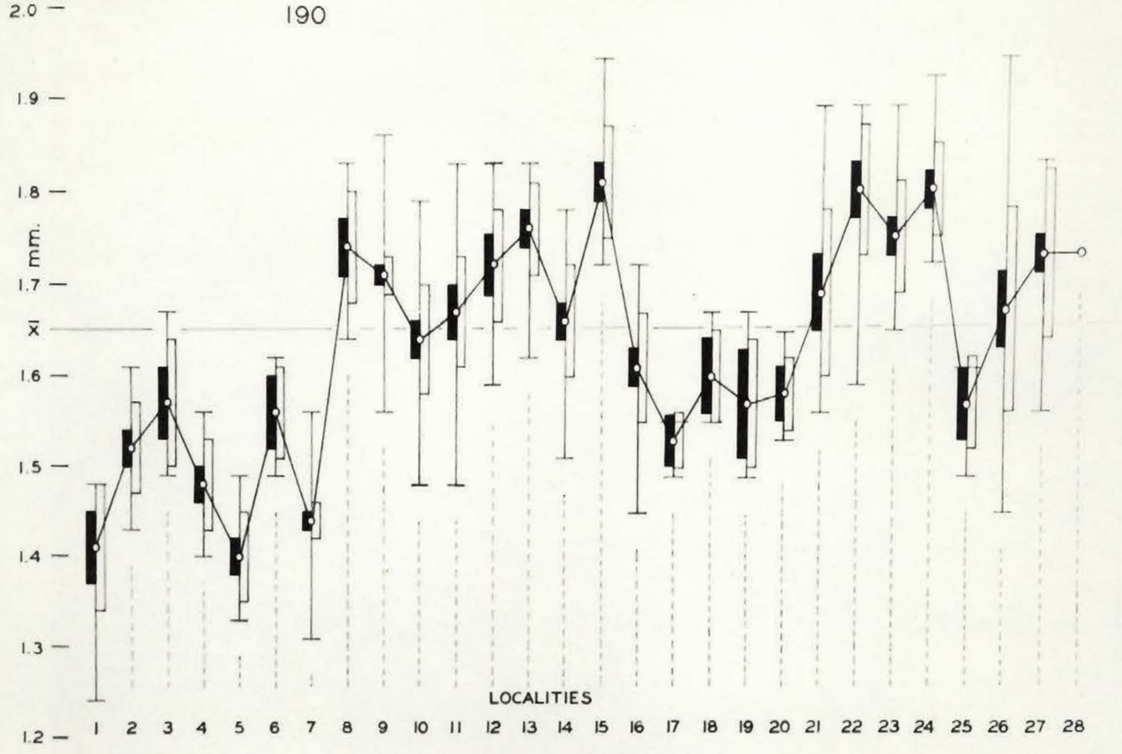
TEGMINA LENGTH, FEMALES

Fig. 190. Variation, <u>eye depth, males</u>.

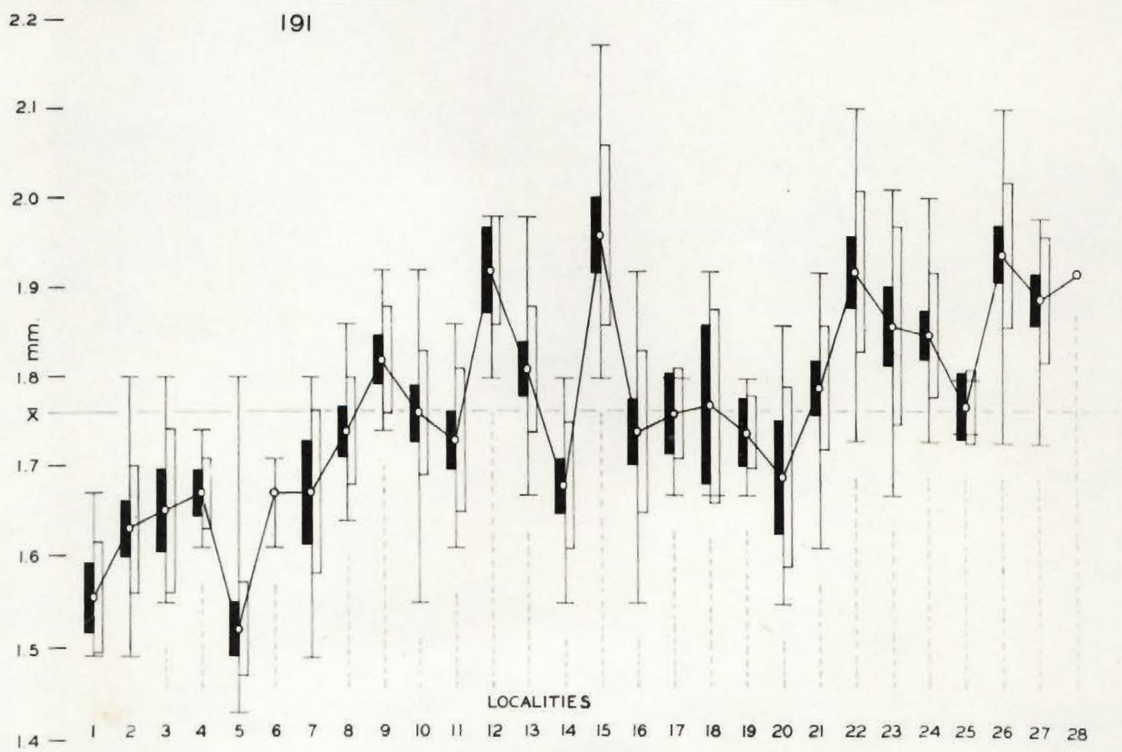
<u>Circle</u> indicates the mean value;
<u>open rectangle</u> indicates plus or minus the standard deviation;
<u>dark rectangle</u> indicates plus or minus twice the standard error of the mean.
Horizontal numbers indicate sample localities, as follows:

1. Labrador (Hopedale)
2. Quebec (Lac Mistassini)
3. Manitoba (The Pas)
4. Manitoba (Gillam)
5. Manitoba (Churchill)
6. Yukon (various localities)
7. Alaska (various localities)
8. Nova Scotia (South Ohio, Yarmouth County)
9. New Hampshire (Star I. Isles of Shoals, Rockingham County)
10. Quebec (Ste. Anne de Bellevue - brachypterous)
11. Quebec (Ste. Anne de Bellevue - macropterous)
12. Ontario (Mer Bleue, near Ottawa)
13. New York (MacLean Bog, Ithaca)
14. Michigan (Keweenaw Point)
15. Michigan (Ann Arbor)
16. Minnesota (Republic)
17. Manitoba (Senkiw)
18. Manitoba (Aweme)
19. Saskatchewan (Fort Qu'Appelle)
20. Alberta (McMurray)
21. Wyoming (various localities)
22. Virginia (Mountain Lake, Giles County)
23. Colorado (Colorado Springs)
24. Arizona (Flagstaff)
25. Idaho (McCall, Boise County)
26. Oregon (Divide)
27. California (Mendocino)
28. Louisiana (Natchitoches)

Fig. 191. Same, <u>females</u>. Legend and localities as in <u>Fig. 190</u>.



EYE DEPTH, MALES



EYE DEPTH, FEMALES

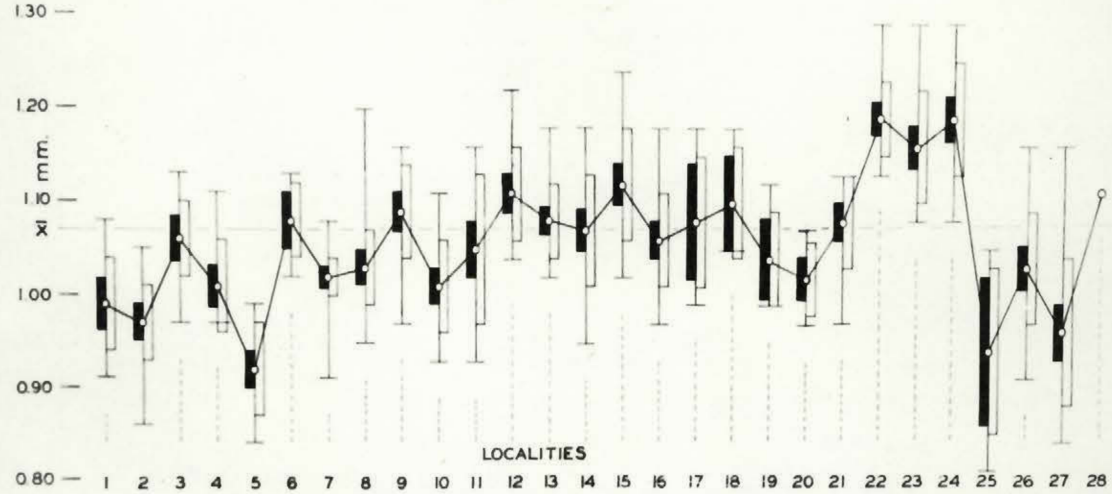
Fig. 192. Variation, subocular sulcus length, males.

Circle indicates the mean value;
open rectangle indicates plus or minus the standard deviation;
dark rectangle indicates plus or minus twice the standard error of the mean.
Horizontal numbers indicate sample localities, as follows:

1. Labrador (Hopedale)
2. Quebec (Lac Mistassini)
3. Manitoba (The Pas)
4. Manitoba (Gillam)
5. Manitoba (Churchill)
6. Yukon (various localities)
7. Alaska (various localities)
8. Nova Scotia (South Ohio, Yarmouth County)
9. New Hampshire (Star I. Isles of Shoals, Rockingham County)
10. Quebec (Ste. Anne de Bellevue - brachypterous)
11. Quebec (Ste. Anne de Bellevue - macropterous)
12. Ontario (Mer Bleue, near Ottawa)
13. New York (Mac Lean Bog, Ithaca)
14. Michigan (Keweenaw Point)
15. Michigan (Ann Arbor)
16. Minnesota (Republic)
17. Manitoba (Senkiw)
18. Manitoba (Aweme)
19. Saskatchewan (Fort Qu'Appelle)
20. Alberta (McMurray)
21. Wyoming (various localities)
22. Virginia (Mountain Lake, Giles County)
23. Colorado (Colorado Springs)
24. Arizona (Flagstaff)
25. Idaho (McCall, Boise County)
26. Oregon (Divide)
27. California (Mendocino)
28. Louisiana (Natchitoches)

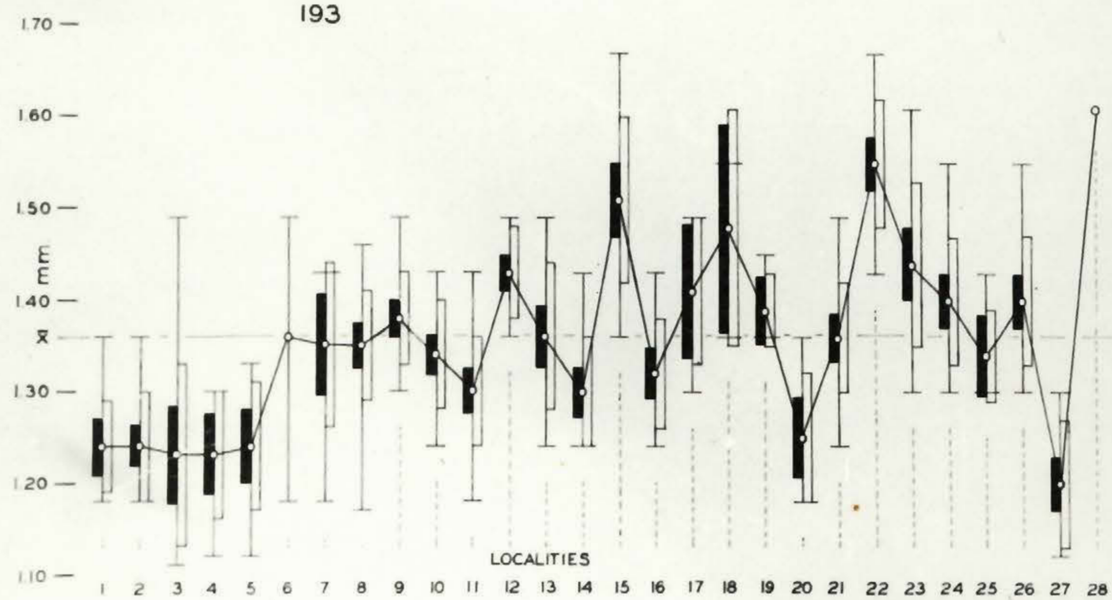
Fig. 193. Same, females. Legend and localities as in Fig. 192.

192



SUBOCULAR SULCUS LENGTH, MALES

193



SUBOCULAR SULCUS LENGTH, FEMALES

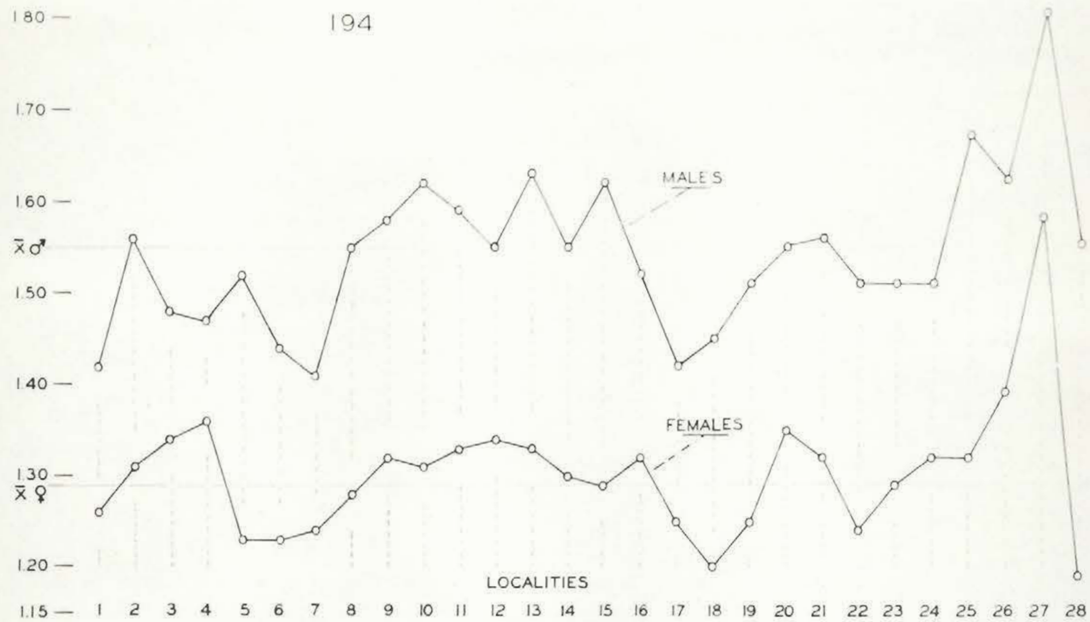
Fig. 194. Variation, ratio of eye depth to subocular sulcus length, males and females.

Horizontal numbers indicate sample localities, as follows:

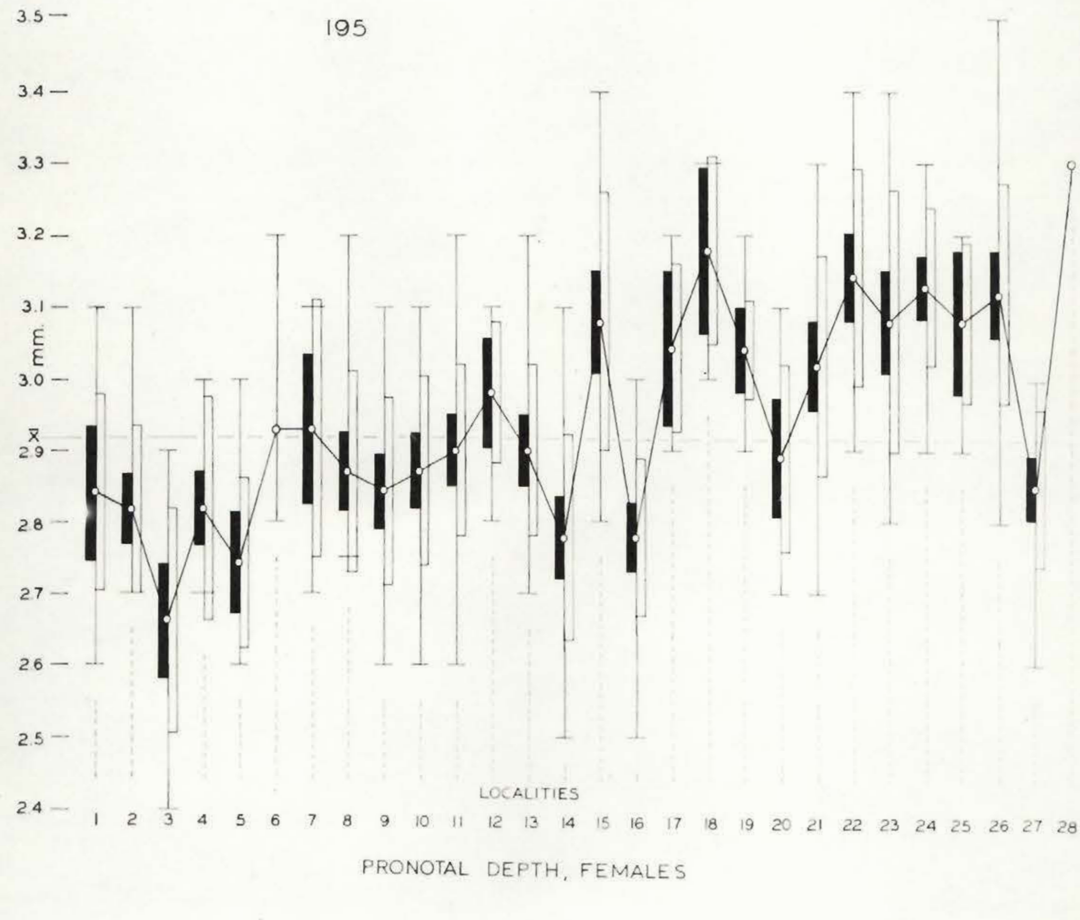
1. Labrador (Hopedale)
2. Quebec (Lac Mistassini)
3. Manitoba (The Pas)
4. Manitoba (Gillam)
5. Manitoba (Churchill)
6. Yukon (various localities)
7. Alaska (various localities)
8. Nova Scotia (South Ohio, Yarmouth County)
9. New Hampshire (Star I., Isles of Shoals, Rockingham County)
10. Quebec (Ste. Anne de Bellevue - brachypterous)
11. Quebec (Ste. Anne de Bellevue - macropterous)
12. Ontario (Mer Bleue, near Ottawa)
13. New York (MacLean Bog, Ithaca)
14. Michigan (Keweenaw Point)
15. Michigan (Ann Arbor)
16. Minnesota (Republic)
17. Manitoba (Senkiw)
18. Manitoba (Aweme)
19. Saskatchewan (Fort Qu'Appelle)
20. Alberta (McMurray)
21. Wyoming (various localities)
22. Virginia (Mountain Lake, Giles County)
23. Colorado (Colorado Springs)
24. Arizona (Flagstaff)
25. Idaho (McCall, Boise County)
26. Oregon (Divide)
27. California (Mendocino)
28. Louisiana (Natchitoches)

Fig. 195. Variation, pronotal depth, females.

Localities as in Fig. 194.
Circle indicates the mean value;
open rectangle indicates plus or minus the standard deviation;
dark rectangle indicates plus or minus twice the standard error of the mean.



RATIO, EYE DEPTH BY SUBOCULAR SULCUS



PRONOTAL DEPTH, FEMALES

Scatterdiagrams, eye depth and subocular sulcus length.
Regression lines x on y - solid line,
y on x - broken line
crossing at means.
Ellipses represent twice the standard deviations of the means:

solid line - California
dotted line - Arizona
dashed line - Nova Scotia
dash and single dot - Oregon
dash and two dots - Virginia

Symbols represent measurements of individuals:

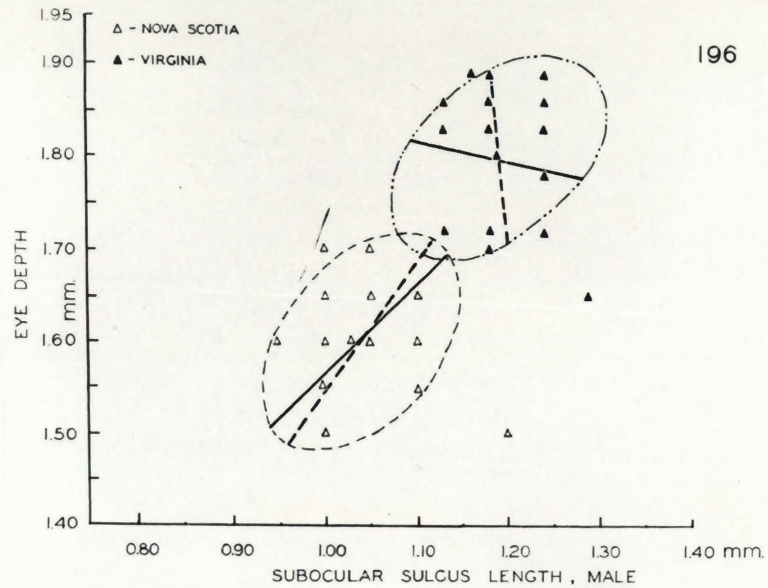
open triangles - Nova Scotia
filled triangles - Virginia
open circles - Oregon
filled circles - Arizona
open squares - California

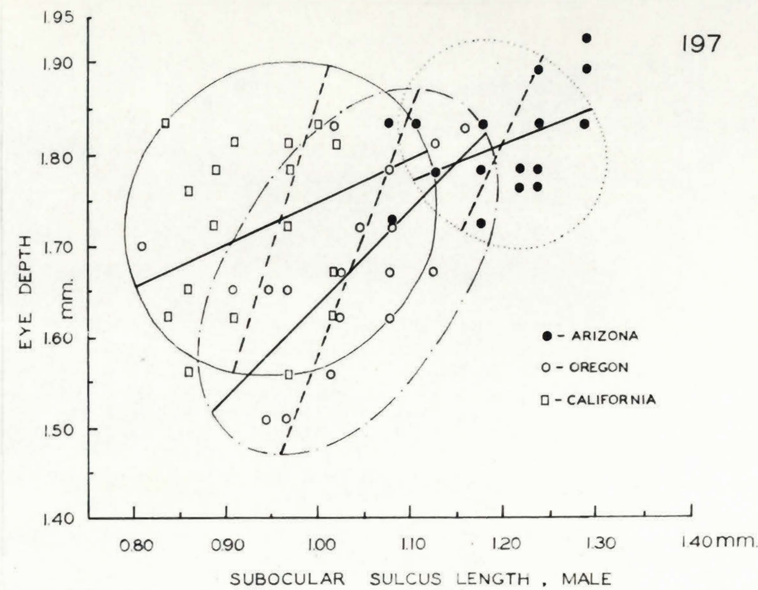
Fig. 196. Males, Nova Scotia (South Ohio) and Virginia (Mountain Lake).

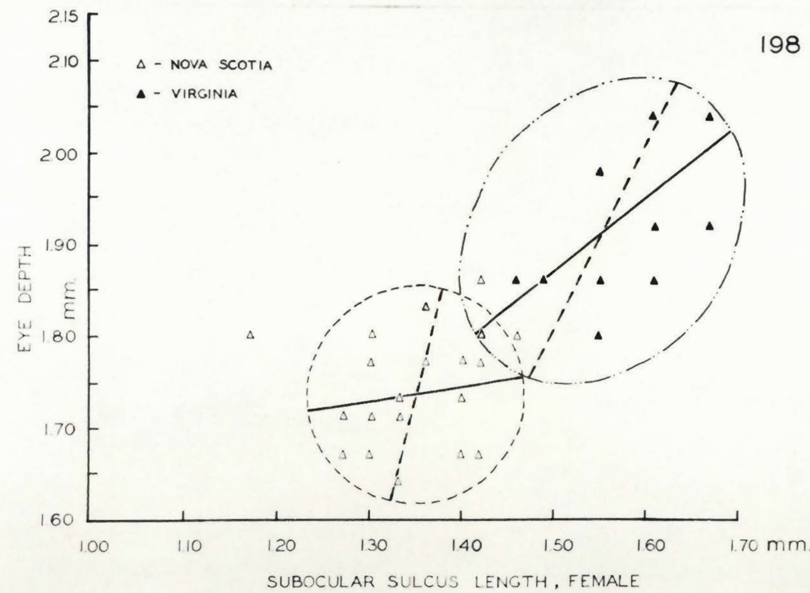
Fig. 197. Males, Arizona (Flagstaff); Oregon (Divide); and California (Mendocino).

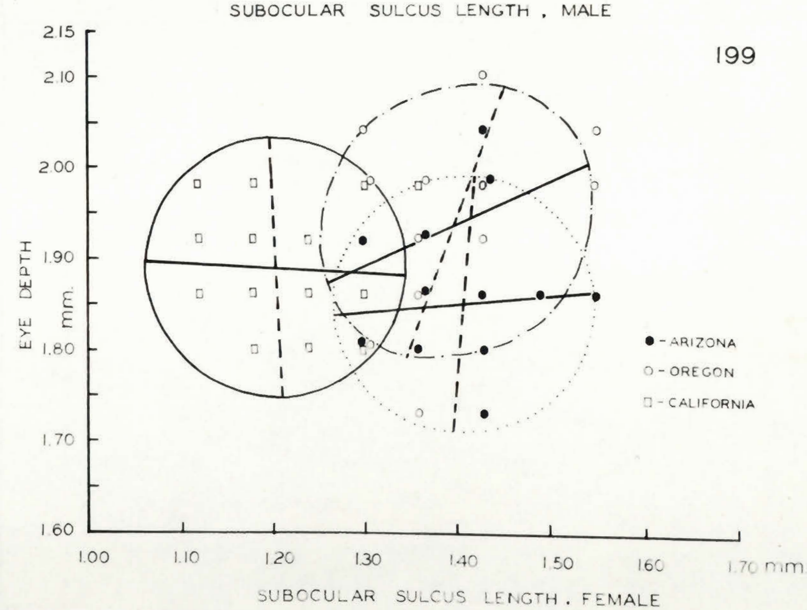
Fig. 198. Females, Nova Scotia and Virginia.

Fig. 199. Females, Arizona, Oregon and California.


196
Δ - NOVA SCOTIA
▲ - VIRGINIA
EYE DEPTH mm.
SUBOCULAR SULCUS LENGTH, MALE
1.40 mm.


197
● - ARIZONA
O - OREGON
□ - CALIFORNIA
EYE DEPTH mm.
SUBOCULAR SULCUS LENGTH, MALE
1.40 mm.


198
Δ - NOVA SCOTIA
▲ - VIRGINIA
EYE DEPTH mm.
SUBOCULAR SULCUS LENGTH, FEMALE
1.70 mm.


199
● - ARIZONA
O - OREGON
□ - CALIFORNIA
EYE DEPTH mm.
SUBOCULAR SULCUS LENGTH, FEMALE
1.70 mm.

Scatterdiagrams, eye depth and hind femur length.

Regression lines $\quad$ x on y - solid line
y on x - broken line
crossing at means.

Ellipses represent twice the standard deviations of the means:

solid line - California
dotted line - Arizona
dashed line - Nova Scotia
dash and single dot - Oregon
dash and two dots - Virginia

Symbols represent measurements of individuals:

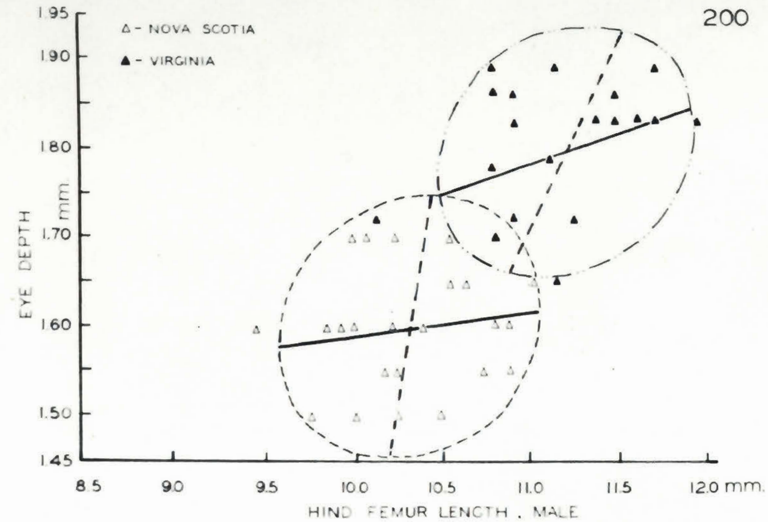
open triangles - Nova Scotia
filled triangles - Virginia
open circles - Oregon
filled circles - Arizona
open squares - California

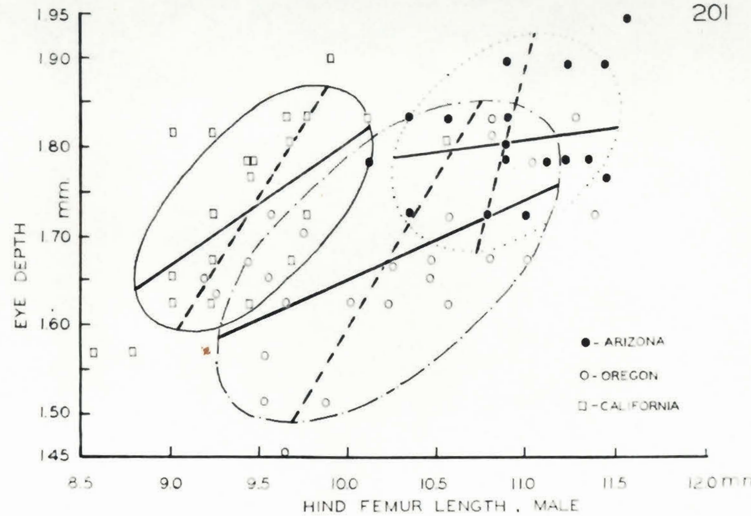
Fig. 200. Males, Nova Scotia and Virginia.

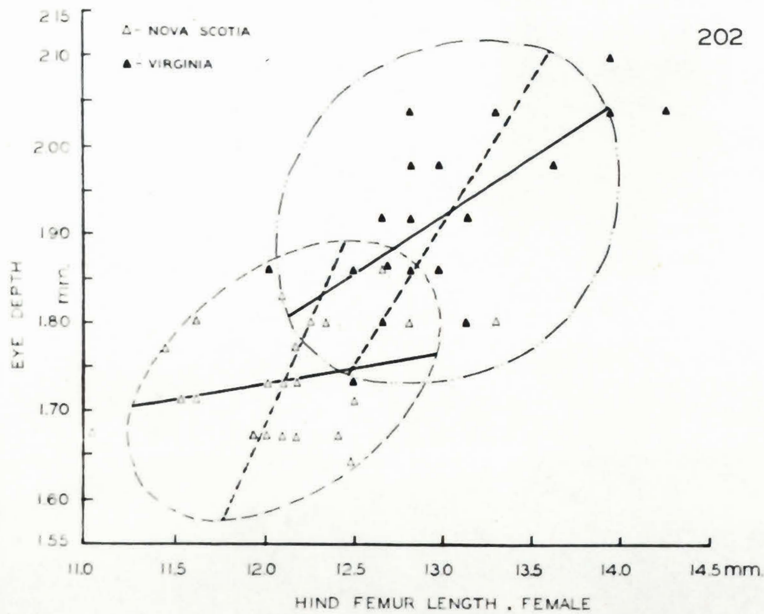
Fig. 201. Males, Arizona, Oregon and California.

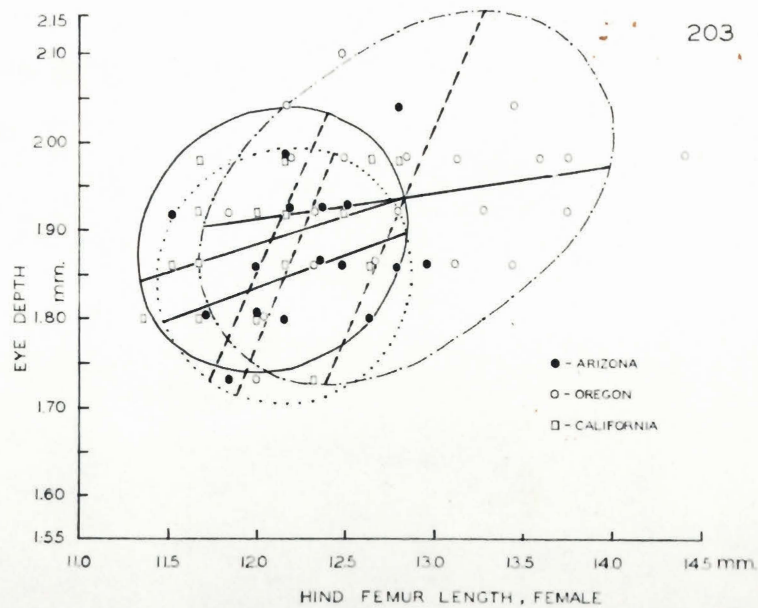
Fig. 202. Females, Nova Scotia and Oregon.

Fig. 203. Females, Arizona, Oregon and California.


200
Δ - NOVA SCOTIA
▲ - VIRGINIA
EYE DEPTH mm.
1.95
1.90
1.80
1.70
1.60
1.50
1.45
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0 mm.
HIND FEMUR LENGTH, MALE


201
● - ARIZONA
O - OREGON
□ - CALIFORNIA
EYE DEPTH mm.
1.95
1.90
1.80
1.70
1.60
1.50
1.45
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0 mm.
HIND FEMUR LENGTH, MALE


202
Δ - NOVA SCOTIA
▲ - VIRGINIA
EYE DEPTH mm.
2.15
2.10
2.00
1.90
1.80
1.70
1.60
1.55
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5 mm.
HIND FEMUR LENGTH, FEMALE


203
● - ARIZONA
O - OREGON
□ - CALIFORNIA
EYE DEPTH mm.
2.15
2.10
2.00
1.90
1.80
1.70
1.60
1.55
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5 mm.
HIND FEMUR LENGTH, FEMALE

Scatterdiagrams, subocular sulcus length, femur
length.

Regression lines x on y - solid line
y on x - broken line
crossing at means.

Ellipses represent twice the standard deviations
of the means:

solid line - California
dotted line - Arizona
dashed line - Nova Scotia
dash and single dot - Oregon
dash and two dots - Virginia

Symbols represent measurements of individuals:

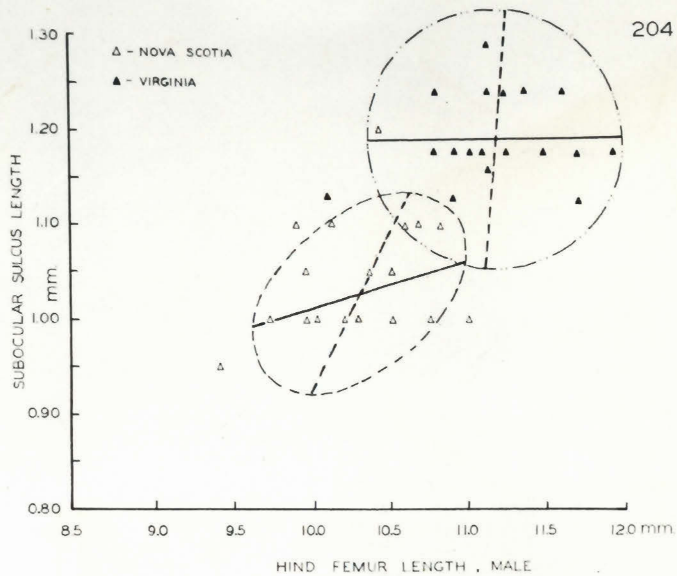
open triangles - Nova Scotia
filled triangles - Virginia
open circles - Oregon
filled circles - Arizona
open squares - California

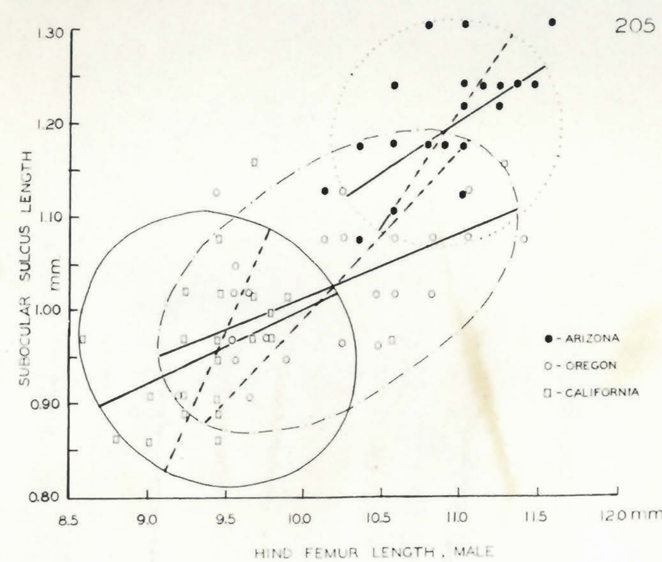
Fig. 204. Males, Nova Scotia and Virginia.

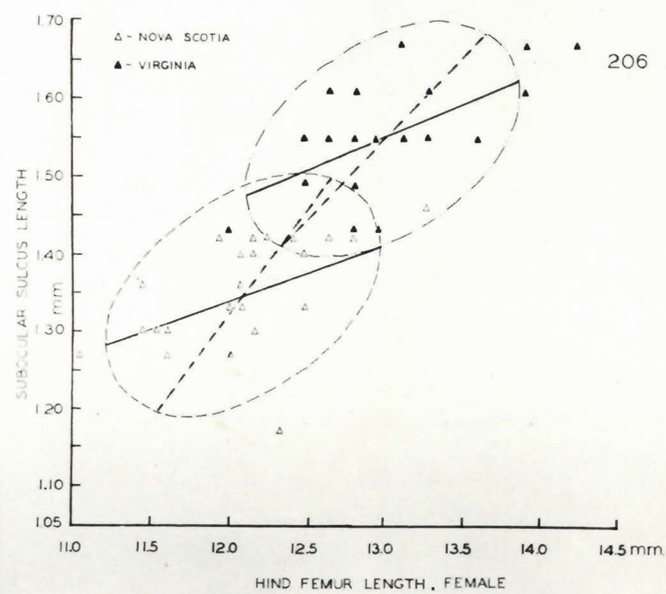
Fig. 205. Males, Arizona, Oregon and California.

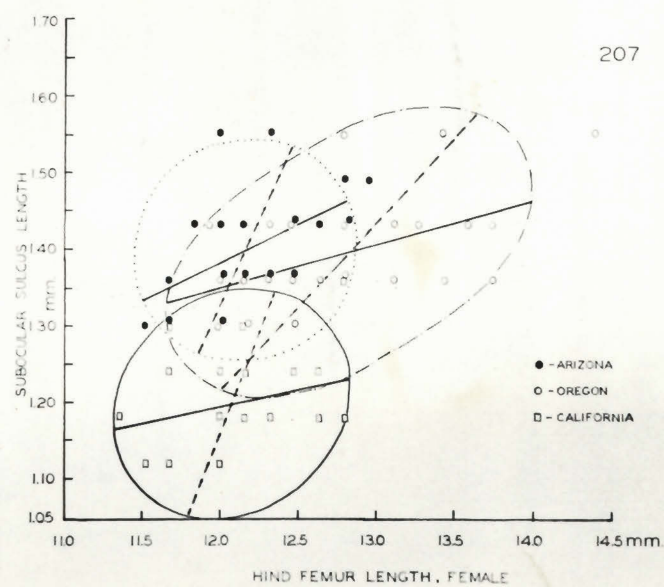
Fig. 206. Females, Nova Scotia and Virginia.

Fig. 207. Females, Arizona, Oregon and California.


204
Δ - NOVA SCOTIA
▲ - VIRGINIA
SUBOCULAR SULCUS LENGTH mm.
HIND FEMUR LENGTH, MALE
1.30
1.20
1.10
1.00
0.90
0.80
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0 mm.


205
● - ARIZONA
○ - OREGON
□ - CALIFORNIA
SUBOCULAR SULCUS LENGTH mm.
HIND FEMUR LENGTH, MALE
1.30
1.20
1.10
1.00
0.90
0.80
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0 mm.


206
Δ - NOVA SCOTIA
▲ - VIRGINIA
SUBOCULAR SULCUS LENGTH mm.
HIND FEMUR LENGTH, FEMALE
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.05
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5 mm.


207
● - ARIZONA
○ - OREGON
□ - CALIFORNIA
SUBOCULAR SULCUS LENGTH mm.
HIND FEMUR LENGTH, FEMALE
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.05
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5 mm.

Scatterdiagrams.

Regression lines x on y - solid line
y on x - broken line
crossing at means.

Ellipses represent twice the standard deviations of the means.

solid line - California
dotted line - Arizona
dashed line - Nova Scotia
dash and single dot - Oregon
dash and two dots - Virginia

Symbols represent measurements of individuals:

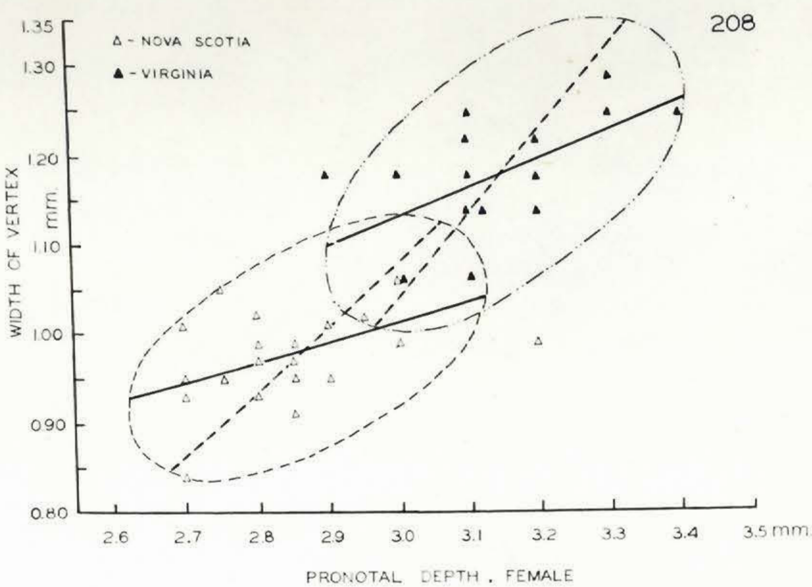
open triangles - Nova Scotia
filled triangles - Virginia
open circles - Oregon
filled circles - Arizona
open squares - California

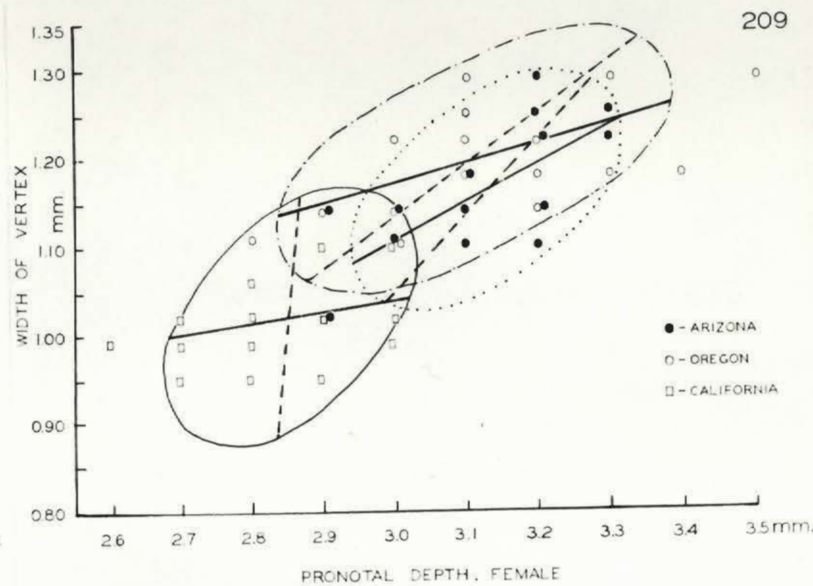
Fig. 208. Width of vertex and pronotal depth, females, Nova Scotia and Virginia.

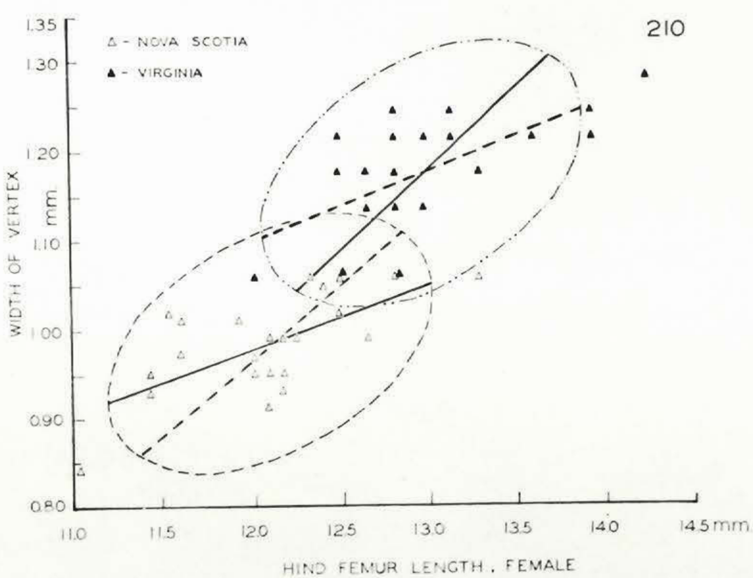
Fig. 209. Width of vertex and pronotal depth, females, Arizona, Oregon and California.

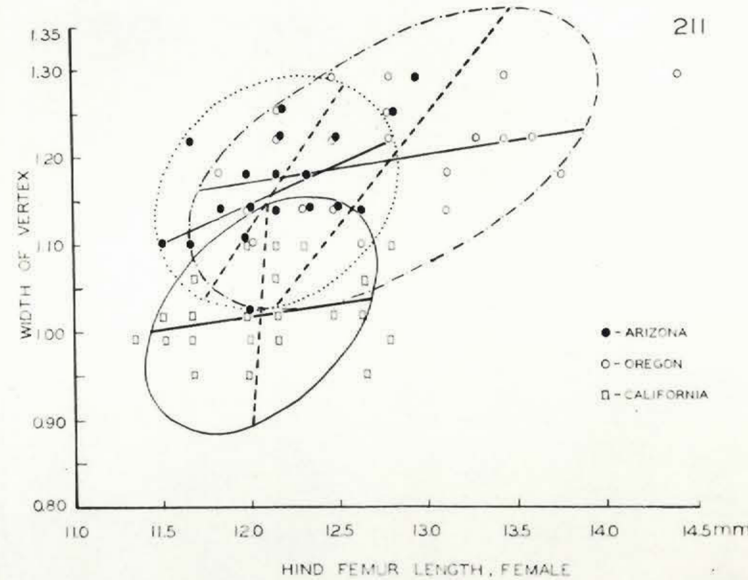
Fig. 210. Width of vertex and hind femur length, females, Nova Scotia and Virginia.

Fig. 211. Width of vertex and hind femur length, females, Arizona, Oregon and California.


208
Δ - NOVA SCOTIA
▲ - VIRGINIA
WIDTH OF VERTEX mm.
1.35
1.30
1.20
1.10
1.00
0.90
0.80
2.6
2.7
2.8
2.9
3.0
3.1
3.2
3.3
3.4
3.5 mm.
PRONOTAL DEPTH, FEMALE


209
● - ARIZONA
○ - OREGON
□ - CALIFORNIA
WIDTH OF VERTEX mm.
1.35
1.30
1.20
1.10
1.00
0.90
0.80
2.6
2.7
2.8
2.9
3.0
3.1
3.2
3.3
3.4
3.5 mm.
PRONOTAL DEPTH, FEMALE


210
Δ - NOVA SCOTIA
▲ - VIRGINIA
WIDTH OF VERTEX mm.
1.35
1.30
1.20
1.10
1.00
0.90
0.80
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5 mm.
HIND FEMUR LENGTH, FEMALE


211
● - ARIZONA
○ - OREGON
□ - CALIFORNIA
WIDTH OF VERTEX
1.35
1.30
1.20
1.10
1.00
0.90
0.80
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5 mm.
HIND FEMUR LENGTH, FEMALE

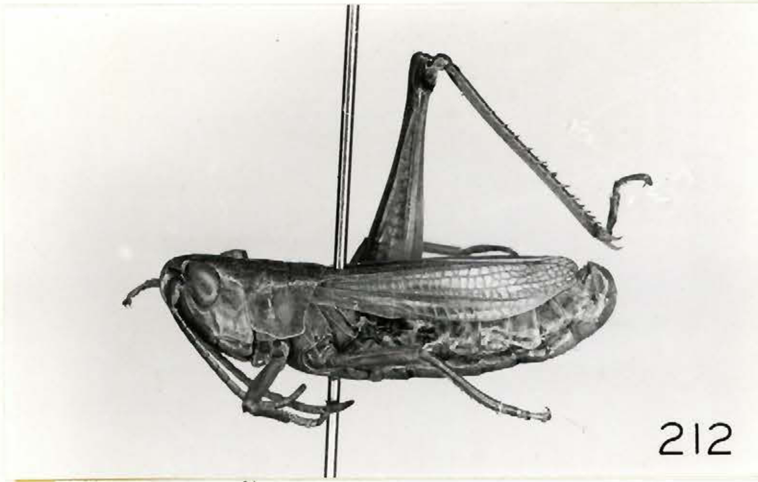
Photographs, approximately 4X

Fig. 212. Chorthippus parallelus, male, Rastatt, Germany, 19-VII-1959, H. Knipper. (L.E.M.) See also Fig. 11.

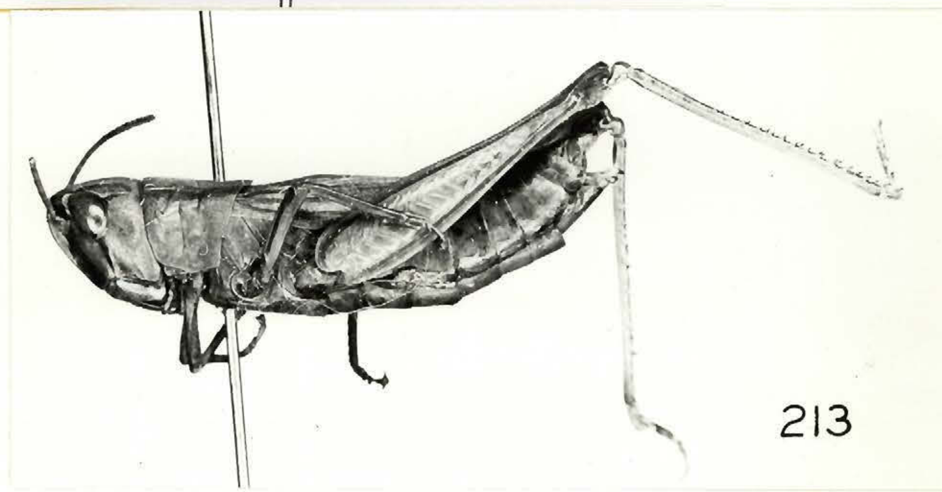
Fig. 213. C. parallelus , female, same data. See also Fig. 14.

Fig. 214. C. montanus, male Karlsrhue, Germany, 6-IX-1959. H. Knipper. (L.E.M.) See Also Fig. 9.

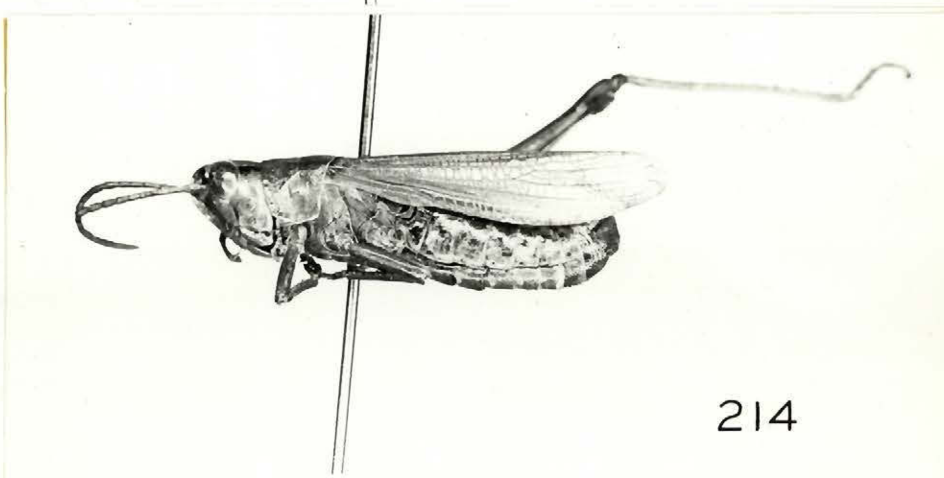
Fig. 215. C. montanus, female, same data. See also Fig. 13.



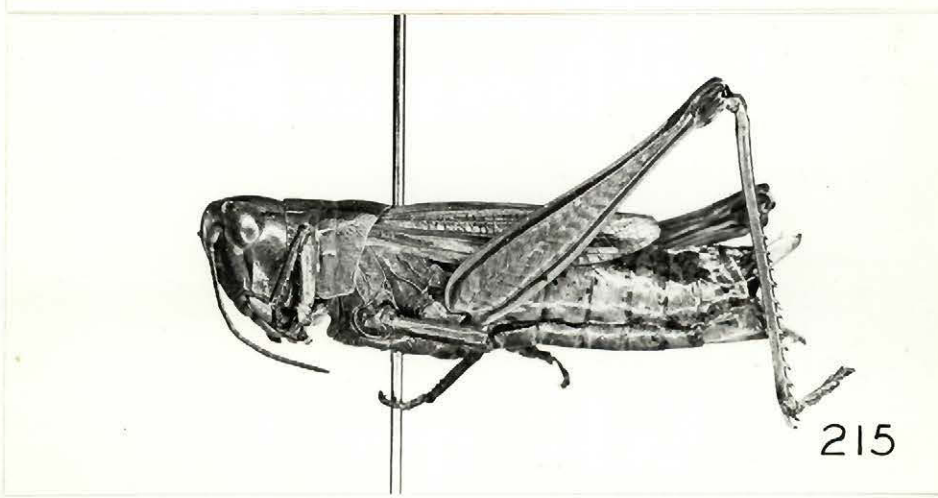
212



213



214



215

Photographs approximately 10X.

Female Abdominal Terminalia

Fig. 216. *C. parallelus*, same specimen as Fig. 213.

Fig. 217. *C. montanus*, same specimen as Fig. 215.

Fig. 218. *C. curtipennis*, same specimen as Fig. 220.

216

217

218

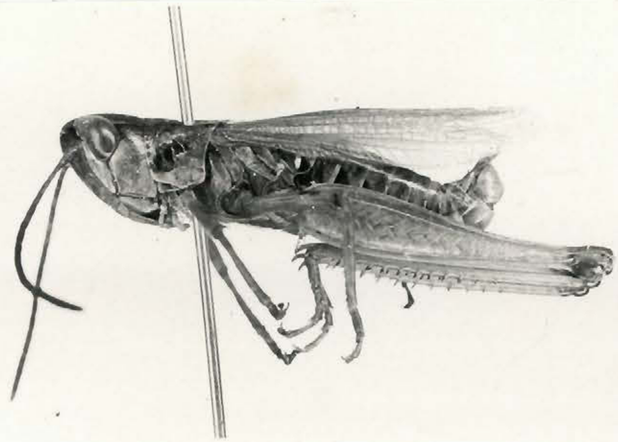
Photographs, approximately 4X.

Fig. 219. C. curtipennis, Neotype, male. See also Fig. 15.

A. Lateral aspect.

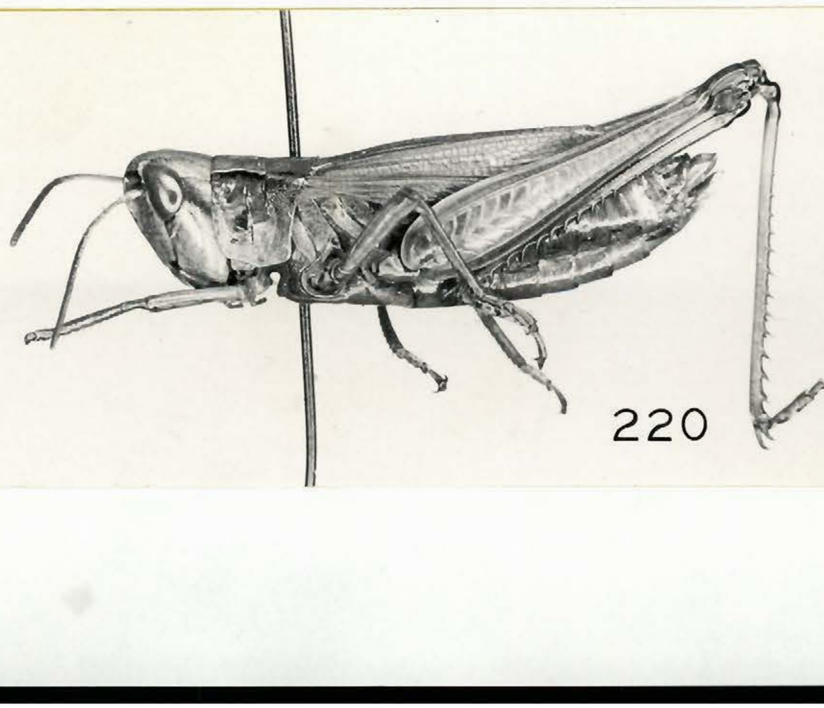
B. Dorsal aspect.

Fig. 220. C. curtipennis, female, Faneuil Sta., Mass., July 26, 1892. (M.C.Z.) See also Fig. 29.



219 A

219 B



220

Photographs, approximately 4X.

Fig. 221. Type, Stenobothrus longipennis Scudder, male.

See also Fig. 16.

A. Lateral aspect.

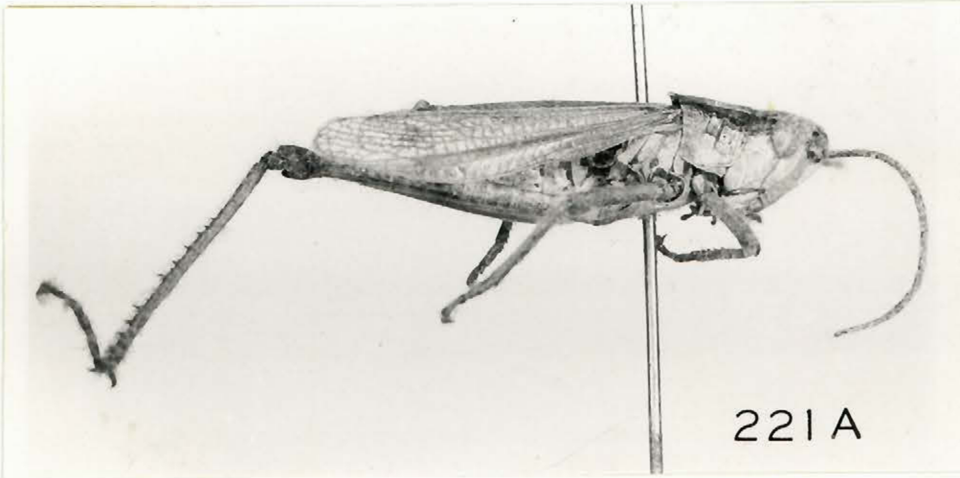
B. Dorsal aspect.

Fig. 222. Type, Stenobothrus oregonensis Scudder, male.

See also Fig. 18.

A. Lateral aspect.

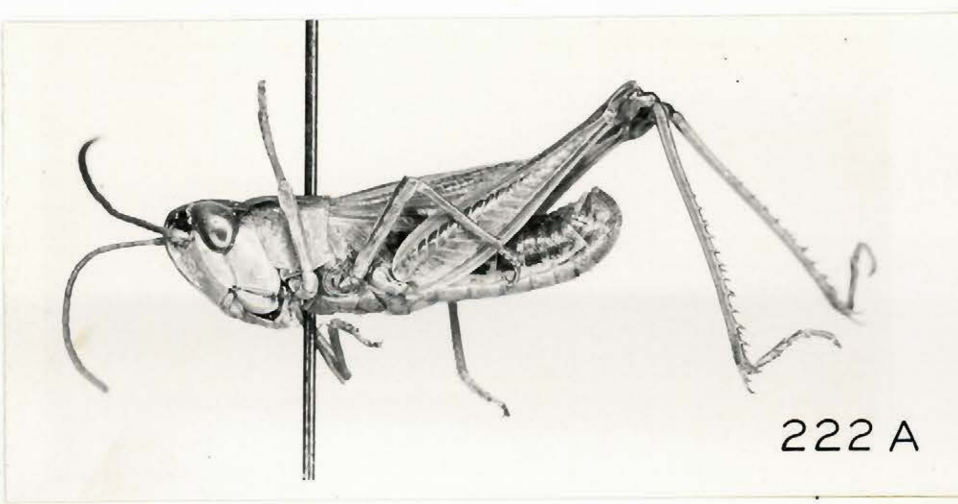
B. Dorsal aspect.



221 A

221 B

222 B



222 A

Photographs, approximately 4X.

Fig. 223. Paratype, _Stenobothrus_ _acutus_ Morse, male. See also Fig. 17.

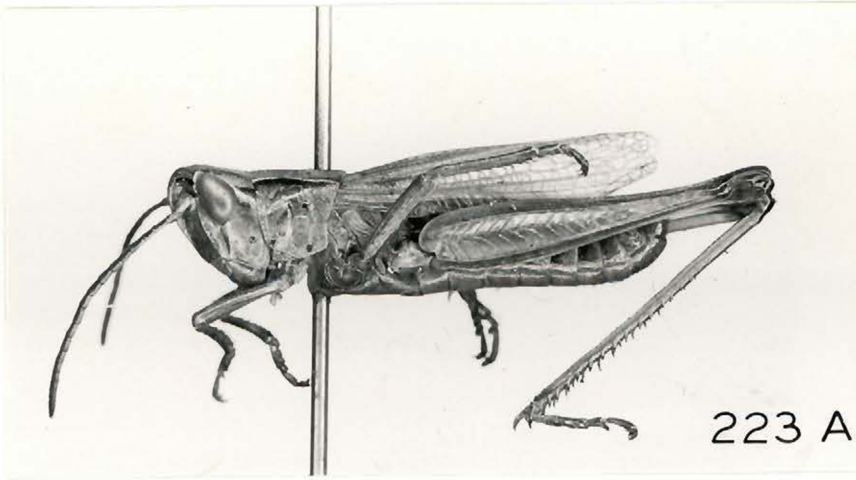
A. Lateral aspect.

B. Dorsal aspect.

Fig. 224. _Stenobothrus_ _coloradensis_ McNeill (det. Scudder), male. See also Fig. 19.

A. Lateral aspect.

B. Dorsal aspect.



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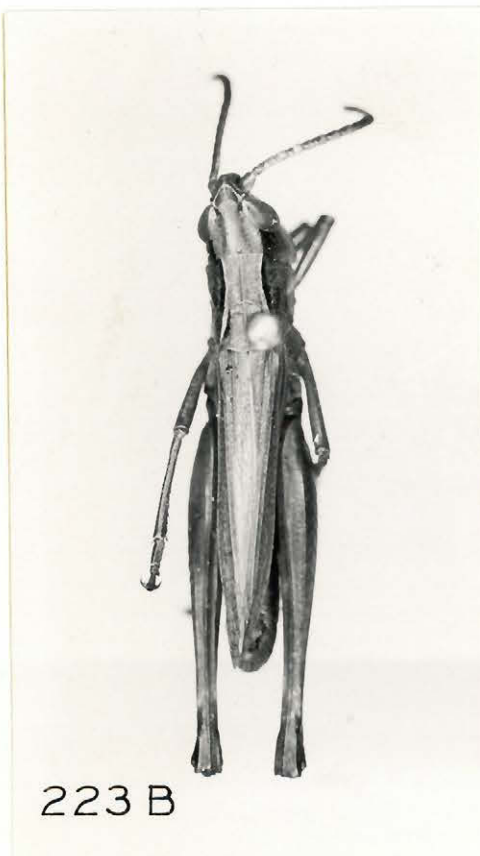
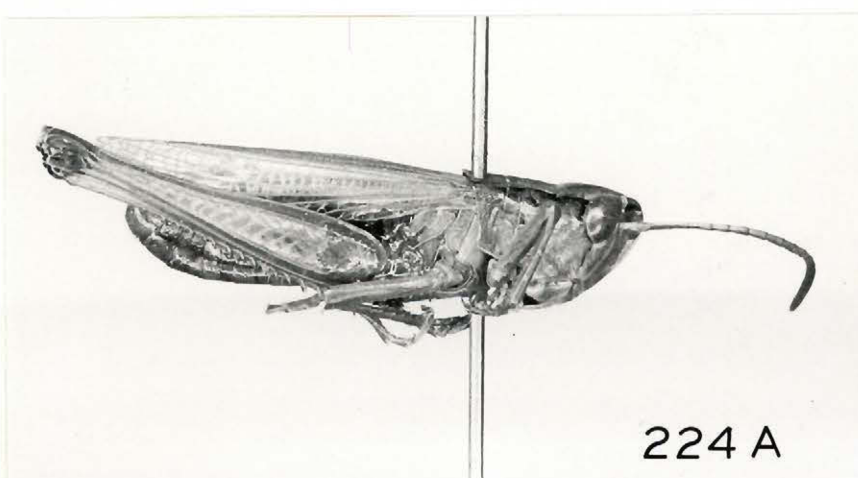


223 B

224 B



224 A

Photographs, approximately 4X.

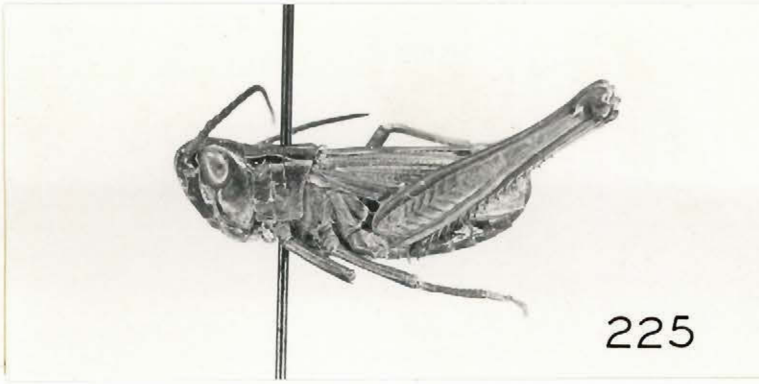
<u>C. curtipennis</u>

Fig. 225. Male. Hopedale, Labrador. See also Fig. 20.

Fig. 226. Female, Hopedale, Labrador. See also Fig. 27.

Fig. 227. Male, Churchill, Manitoba. See also Fig. 21.

Fig. 228. Female, Churchill, Manitoba. See also Fig. 28.



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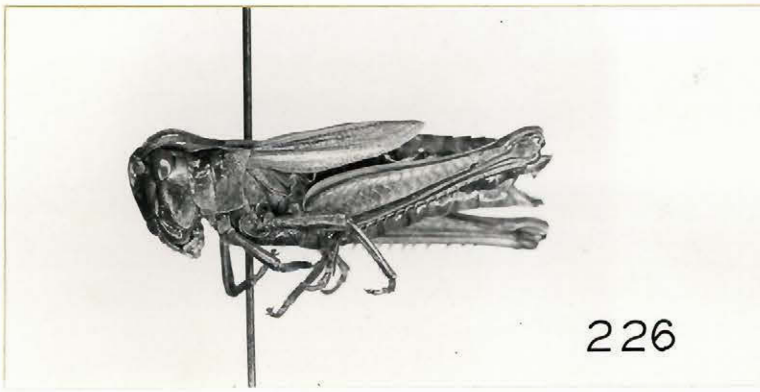

226

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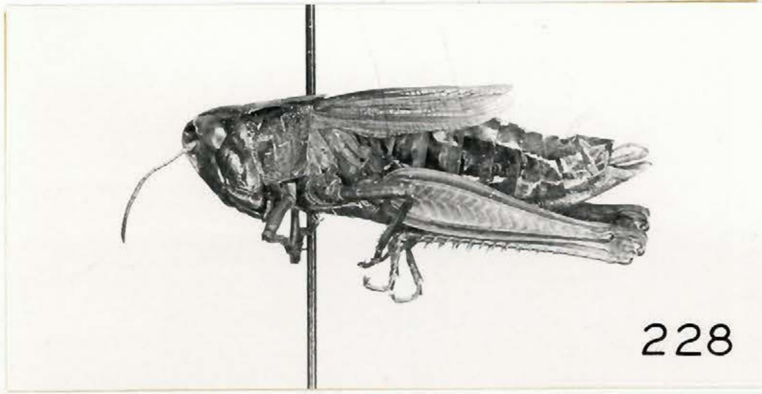


228

Photographs, approximately 4X.

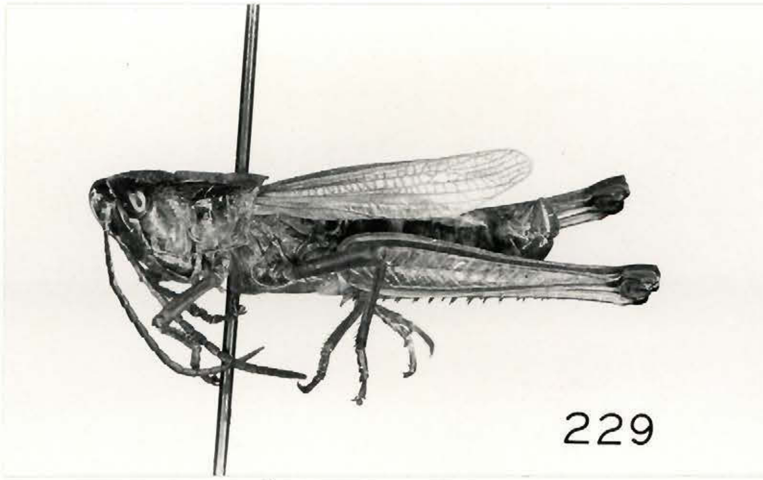
<u>C. curtipennis</u>

Fig. 229. Male, Mountain Lake, Giles County, Virginia, 26-VII-1946, T.H. Hubbell (83). (U. Mich.)

Fig. 230. Female, same data as Fig. 229.

Fig. 231. Male, Ann Arbor, Michigan, 28-VI-1920, T.H. Hubbell (261). (U. Mich.)

Fig. 232. Female, Ann Arbor, Michigan, 9-IX-1934, I.J. Cantrall (29). (U. Mich.)



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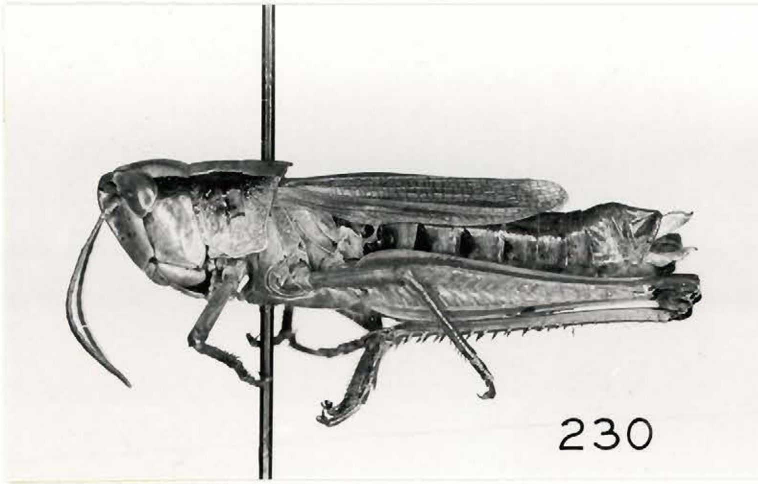

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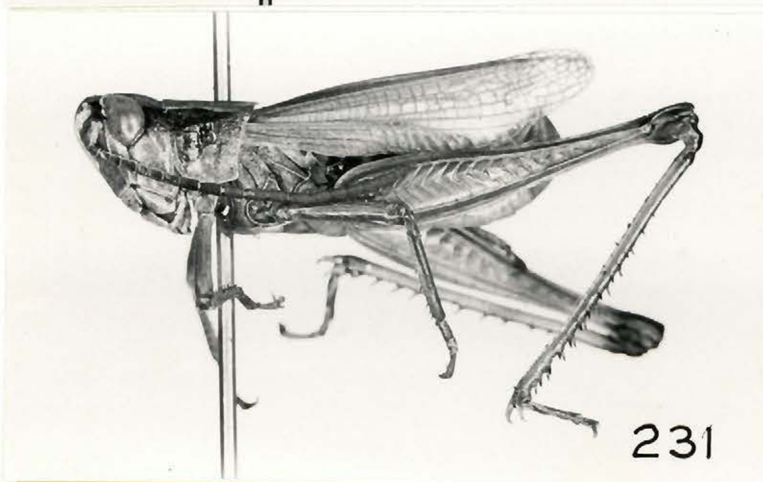

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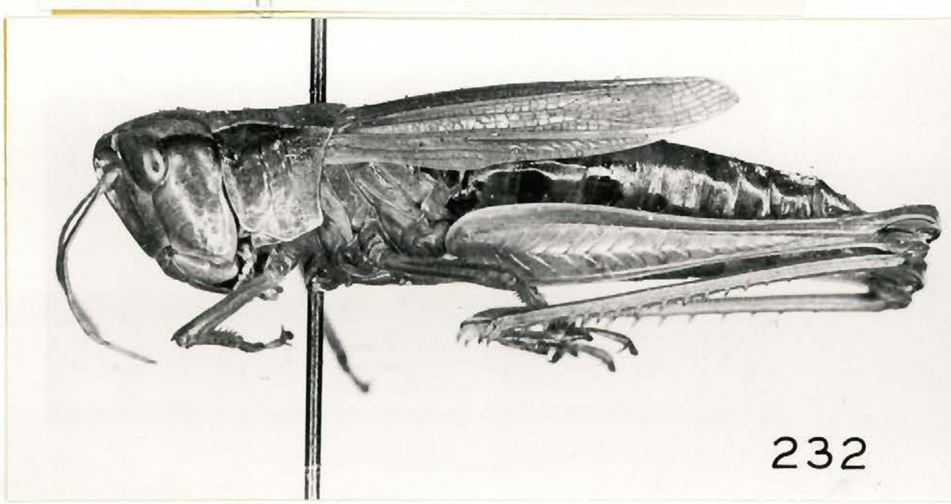


232

Photographs, approximately 4X.

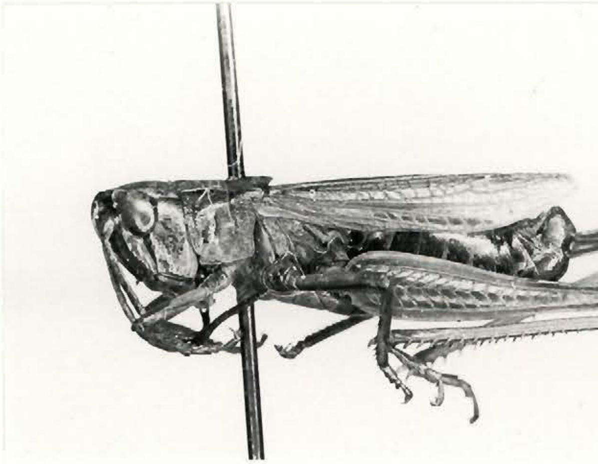
C. curtipennis

Fig. 233. Male, Flagstaff, Arizona. See also Fig. 24.

Fig. 234. Female, Flagstaff, Arizona. See also Fig. 31.

Fig. 235. Male, Mendocino, California. See also Fig. 25.

Fig. 236. Female, Mendocino, California. See also Fig. 32.



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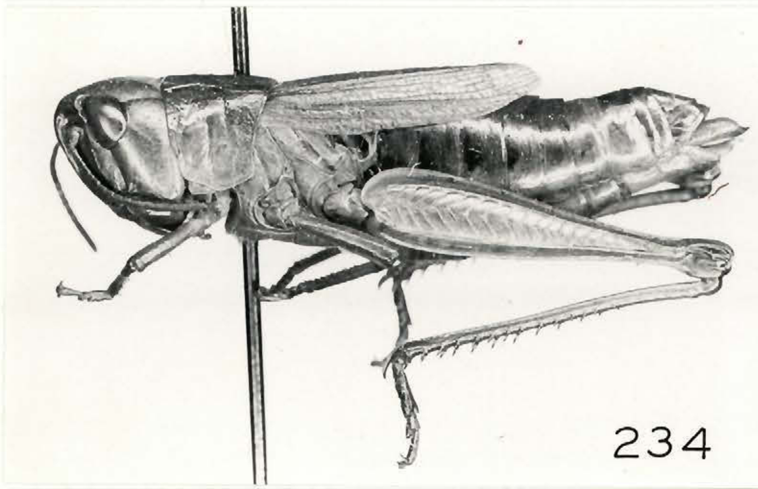

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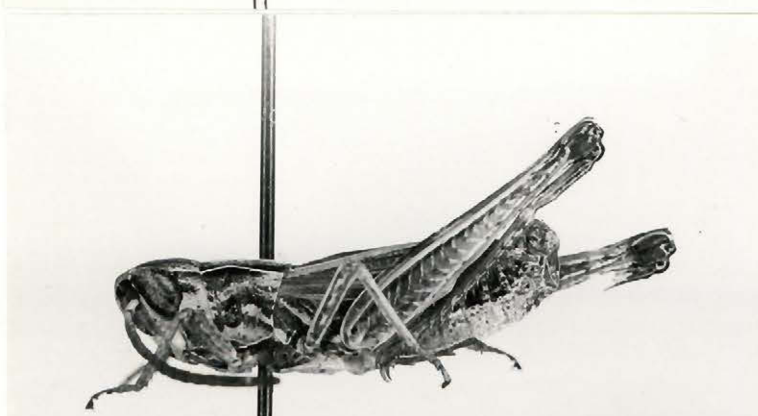

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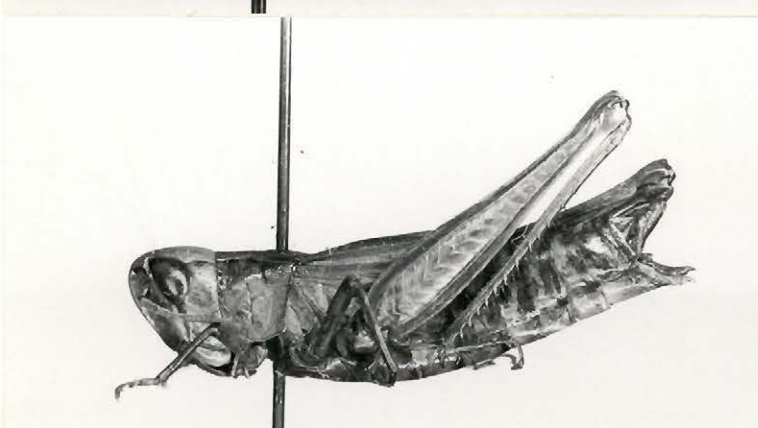


236

Photographs, approximately 4X.

<u>Chorthippus</u>, new species.

Fig. 237. Male, Natchitoches, Louisiana. See also Fig. 33.

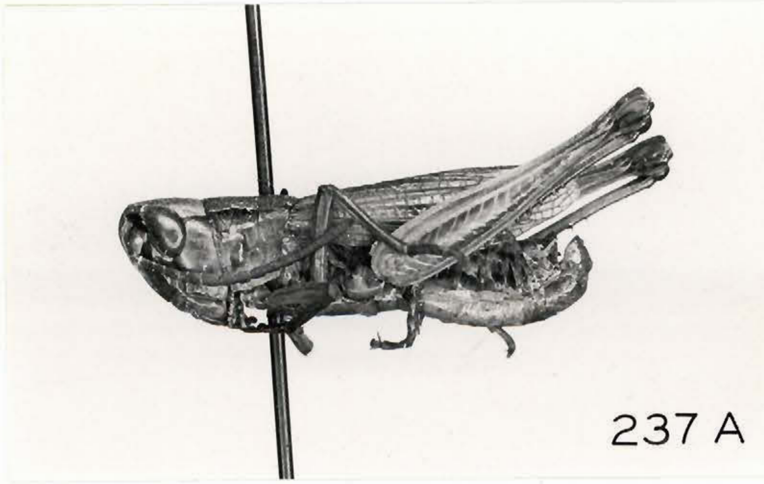
A. Lateral aspect.

B. Dorsal aspect.

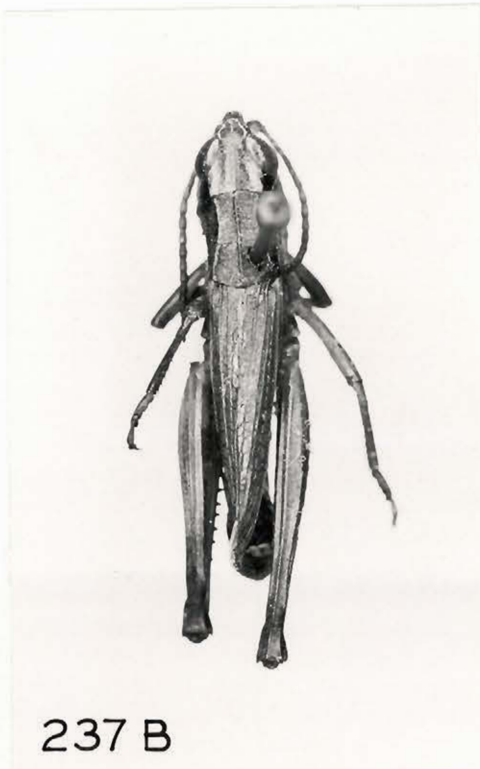
Fig. 238. Female, Natchitoches, Louisiana, See also Fig. 34.

A. Lateral aspect.

B. Dorsal aspect.

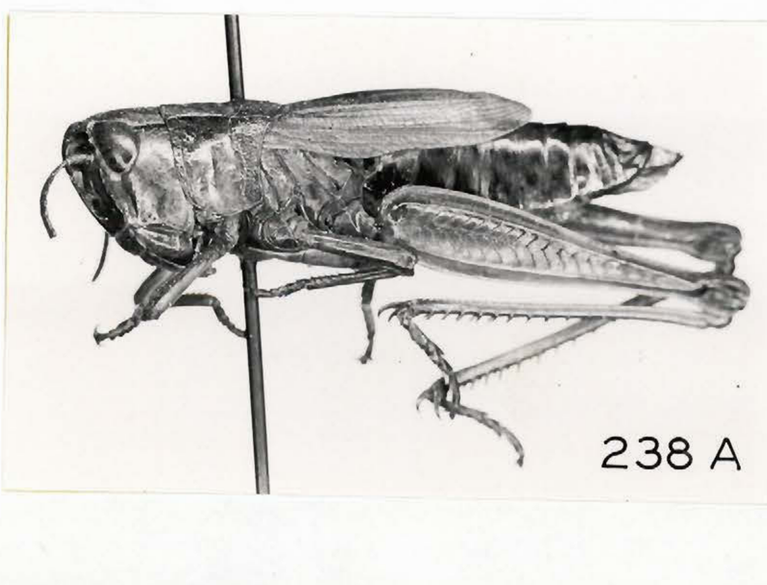


237 A



237 B

238 B



238 A

APPENDIX

Tables I - XXII

TABLE I

Position of Transverse Pronotal Sulcus, Males.

Species	Origin	No.	Sulcus before middle	Sulcus at middle	Sulcus behind middle	Range of variation
montanus	Germany	14	10	1	3	- .32 to + .21 mm.
parallelus	Germany	5	1	2	2	- .21 to + .05 mm.
curtipennis	Nova Scotia	29	25	0	4	- .21 to + .16 mm.
curtipennis	Quebec	22	17	5	0	- .21 to 0 mm.

TABLE II

Comparison of characters, montanus, parallelus and curtipennis.

	curtipennis male	curtipennis female	montanus male	montanus female	parallelus male	parallelus female
1. Male strid. pegs $\bar{x}$ no.	122.7		129.4		99.4	
2. Length of row of pegs $\bar{x}$ mm.	3.85		4.18		3.86	
3. Prox. end of femur to pegs $\bar{x}$ mm.	1.37		1.31		1.44	
4. Depth of Eye $\bar{x}$ mm.	1.73	1.92	1.53	1.69	1.68	1.80
5. Length of subocular sulcus $\bar{x}$ mm.	1.11	1.61	1.01	1.35	0.94	1.24
6. Ratio Eye / Sulcus $\bar{x}$	1.55	1.25	1.51	1.29	1.79	1.34
7. Subocular sulcus	slightly sinuous		straight		sinuous	
8. Lateral carinae of pronotum	humped ant. third		straight		humped ant. third	
9. Ancorae of epiphallus	blunt		acute, incurved		acute, incurved	
10. Ovipositor valves, length to breadth ratio	4.2 - 5.9		4.8		4.0	
11. Colour types (Table XXII)	2*, 3, 4, 5, 6*		1, 3, 4		1 - 6	
12. Predominant colour type	4 (60%)		1 (55%)		3 (42%)	

* Colour types 2 and 6 are very rare in curtipennis.

TABLE III

Body length, males (mm.)

Species Sample		n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	15.18	0.24	0.107		14.85-15.40
montanus	1	14	14.73	0.59	0.158		13.42-15.40
	2	17	14.74	0.79	0.192		13.34-15.87
curtipennis		512	14.68	1.97	0.098		
	1	13	12.04	0.88	0.244	-2.64	10.78-14.08
	2	25	13.45	0.50	0.100	-1.23	12.48-14.24
	3	11	12.86	0.47	0.142	-1.82	12.21-13.64
	4	19	12.81	0.51	0.116	-1.87	11.99-13.64
	5	25	12.51	0.53	0.106	-2.17	11.44-13.42
	6	7	14.15	0.95	0.359	-0.53	12.98-14.96
	7	9	12.90	0.52	0.173	-1.78	12.32-13.86
	8	25	14.36	0.65	0.131	-0.32	13.52-16.00
	9	25	15.49	0.70	0.140	+0.81	14.15-16.56
	10	25	14.72	0.65	0.130	+0.04	13.60-16.48
	11	25	14.26	1.05	0.209	-0.42	12.21-16.48
	12	20	15.09	0.77	0.174	+0.41	13.76-17.28
	13	25	15.69	0.58	0.116	+1.01	14.63-16.72
	14	25	15.61	0.78	0.156	+0.93	14.19-17.38
	15	25	16.28	0.76	0.152	+1.60	14.74-18.26
	16	25	15.55	0.90	0.180	+0.87	13.80-17.02
	17	5	14.11	0.92	0.411	-0.57	12.64-15.04
	18	5	14.88	0.47	0.210	+0.20	14.40-15.44
	19	5	14.08	0.69	0.309	-0.60	13.12-14.88
	20	10	14.52	0.51	0.161	-0.16	13.68-15.44
	21	25	15.13	1.00	0.200	+0.45	13.11-17.14
	22	25	15.71	0.73	0.146	+1.03	14.61-17.71
	23	25	16.16	0.68	0.136	+1.48	14.84-17.02
	24	25	16.03	0.62	0.124	+1.35	14.75-17.27
	25	5	13.90	0.62	0.277	-0.78	13.12-14.40
	26	25	15.38	1.05	0.210	+0.70	13.11-17.02
	27	25	14.88	1.21	0.242	+0.20	12.65-17.94
	28	1	15.52			+0.84	

TABLE IV

Tegmina Length, males (mm.)

Species	Sample	n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	9.30	0.21	0.094		9.09-9.66
montanus	1	14	10.64	0.64	0.171		9.66-11.50
	2	17	12.09	0.95	0.230		10.35-13.57
curtipennis		512	10.54	2.77	0.138		
	1	13	8.03	0.55	0.153	-2.51	7.26-9.02
	2	25	8.52	0.70	0.141	-2.02	7.12-10.08
	3	11	8.50	0.47	0.142	-2.04	8.14-9.02
	4	19	8.59	0.51	0.116	-1.95	7.92-12.32
	5	25	7.50	0.44	0.086	-3.04	6.71-8.14
	6	7	9.86	0.75	0.284	-0.68	8.80-10.96
	7	9	8.75	0.42	0.140	-1.79	8.03-9.24
	8	25	10.12	1.24	0.248	-0.42	7.36-13.54
	9	25	11.37	1.93	0.386	+0.83	9.43-16.10
	10	25	10.17	0.57	0.114	-0.37	9.12-11.20
	11	25	14.15	0.66	0.132	+3.61	12.65-15.52
	12	20	9.10	0.47	0.106	-1.44	8.48-10.24
	13	25	12.24	2.47	0.494	+1.70	8.58-17.60
	14	25	11.28	1.25	0.250	+0.74	9.02-15.18
	15	25	11.44	1.14	0.227	+0.90	9.02-14.08
	16	25	12.45	2.07	0.414	+1.91	8.97-16.79
	17	5	9.82	0.83	0.371	-0.72	8.80-11.20
	18	5	11.62	2.71	1.212	+1.08	9.28-14.72
	19	5	9.44	0.43	0.192	-1.10	8.80-9.92
	20	10	13.15	2.12	0.671	+2.61	10.08-15.52
	21	25	9.98	1.19	0.238	-0.56	8.05-11.27
	22	25	10.98	0.88	0.176	+0.44	9.43-13.23
	23	25	10.81	0.56	0.112	+0.27	9.76-11.96
	24	25	10.23	0.66	0.132	-0.31	8.80-11.11
	25	5	8.77	0.62	0.277	-1.77	8.48-9.12
	26	25	9.76	0.97	0.194	-0.78	8.51-11.39
	27	25	7.39	0.19	0.039	-3.15	6.38-8.80
	28	1	9.76			-0.78	

TABLE V

Hind Femur, length, males (mm.)

Species Sample		n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	9.61	0.51	0.228		8.80-10.12
montanus	1	14	9.42	0.65	0.174		8.80-10.12
	2	7	9.78	0.52	0.197		8.97-10.70
curtipennis		512	10.38	1.21	0.060		
	1	13	8.93	0.46	0.128	-1.45	8.14-9.68
	2	25	9.71	0.32	0.065	-0.67	9.28-10.24
	3	11	9.29	0.42	0.127	-1.09	8.47-10.12
	4	19	9.45	0.10	0.022	-0.93	8.69-9.90
	5	25	8.80	0.15	0.031	-1.58	8.25-10.01
	6	7	9.90	0.14	0.063	-0.48	8.80-10.96
	7	9	9.34	0.39	0.130	-1.04	8.91-9.90
	8	25	10.31	0.40	0.074	-0.07	9.44-11.04
	9	25	10.75	0.28	0.056	+0.37	10.35-11.27
	10	25	10.46	0.37	0.090	+0.08	9.76-11.36
	11	25	10.20	0.45	0.090	-0.18	9.46-11.20
	12	20	10.66	0.31	0.069	+0.28	10.08-11.12
	13	25	11.03	0.44	0.088	+0.65	10.12-11.88
	14	25	10.99	0.39	0.078	+0.61	10.34-11.88
	15	25	11.64	0.53	0.106	+1.26	10.34-12.32
	16	25	10.48	0.59	0.118	+0.10	9.78-11.50
	17	5	9.90	0.63	0.282	-0.48	9.20-10.88
	18	5	10.18	0.18	0.081	-0.20	9.92-10.40
	19	5	9.90	0.63	0.282	-0.48	9.20-10.88
	20	10	10.10	0.20	0.062	-0.28	9.84-10.40
	21	25	10.20	0.62	0.124	-0.18	9.20-11.27
	22	25	11.19	0.41	0.082	+0.81	10.12-11.96
	23	25	11.31	0.48	0.096	+0.93	10.35-11.96
	24	25	10.89	0.38	0.076	+0.51	10.12-11.55
	25	5	9.84	0.27	0.121	-0.54	9.44-10.16
	26	25	10.21	0.64	0.128	-0.17	9.20-11.39
	27	25	9.45	0.13	0.026	-0.93	8.58-10.56
	28	1	10.24			-0.14	

TABLE VI

Nos. of stridulatory pegs, males.

Species	Sample	n	$\bar{x}$	S.D.	S$\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	99.4	13.0	5.81		90-121
montanus	1	14	129.4	13.0	3.48		102-144
	2	7	144.0	9.0	3.40		130-154
curtipennis		512	122.7	19.2	0.91		
	1	13	105.3	13.0	3.61	-17.4	93-130
	2	25	114.5	10.3	2.05	-8.2	99-140
	3	11	119.5	8.2	2.47	-3.2	109-138
	4	19	112.0	13.6	3.12	-10.7	93-138
	5	25	104.1	12.3	2.46	-18.6	87-133
	6	7	120.0	15.5	5.86	-2.7	110-151
	7	9	109.5	9.7	3.23	-13.2	96-124
	8	25	123.5	9.0	1.80	+0.8	109-144
	9	25	116.8	14.4	2.88	-5.9	98-128
	10	25	124.8	13.3	2.65	+2.1	99-150
	11	25	127.3	12.0	2.39	+4.6	100-150
	12	20	132.9	16.1	3.60	+10.2	109-148
	13	25	133.5	10.6	2.12	+10.8	109-154
	14	25	131.1	13.1	2.62	+8.4	107-151
	15	25	126.8	12.5	2.50	+4.1	105-147
	16	25	136.3	13.9	2.78	+13.6	111-174
	17	5	134.2	11.5	5.14	+11.5	115-146
	18	5	125.0	10.4	4.65	+2.3	112-136
	19	5	121.0	9.1	4.07	-1.7	116-137
	20	10	120.7	10.7	3.38	-2.0	103-141
	21	25	125.8	11.4	2.28	+3.1	108-159
	22	25	131.9	11.4	2.28	+9.2	90-151
	23	25	133.5	10.8	2.16	+10.8	117-153
	24	25	122.8	12.7	2.54	+0.1	96-144
	25	5	122.0	19.2	8.59	-0.7	94-146
	26	25	122.7	12.2	2.44		99-158
	27	25	118.9	12.8	2.55	-3.8	92-142
	28	1	137			+14.3	

TABLE VII

Length of row of stridulatory pegs, males (mm.)

Species	Sample	n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	3.86	0.11	0.049		3.50-4.46
montanus	1	14	4.18	0.30	0.080		3.74-4.77
	2	7	4.47	0.27	0.102		4.03-4.73
curtipennis		512	3.85	0.51	0.024		
	1	13	3.30	0.22	0.061	-0.55	2.94-3.66
	2	25	3.66	0.25	0.049	-0.19	3.25-4.22
	3	11	3.72	0.23	0.069	-0.13	3.50-4.10
	4	19	3.50	0.24	0.055	-0.35	3.01-3.92
	5	25	3.13	0.18	0.037	-0.72	2.79-3.55
	6	7	3.79	0.11	0.042	-0.06	3.45-4.13
	7	9	3.47	0.31	0.103	-0.38	3.08-4.10
	8	25	3.93	0.21	0.042	+0.08	3.54-4.49
	9	25	3.80	0.26	0.051	-0.05	3.39-4.28
	10	25	3.77	0.24	0.047	-0.08	3.36-4.26
	11	25	4.15	0.28	0.055	+0.30	3.68-4.64
	12	20	3.91	0.29	0.065	+0.06	3.45-4.50
	13	25	4.10	0.38	0.076	+0.25	3.63-4.48
	14	25	4.02	0.19	0.039	+0.17	3.63-4.48
	15	25	4.13	0.30	0.060	+0.28	3.68-4.75
	16	25	4.15	0.28	0.056	+0.30	3.56-4.63
	17	5	3.84	0.47	0.210	-0.01	3.47-4.64
	18	5	3.76	0.19	0.085	-0.09	3.47-3.96
	19	5	3.51	0.44	0.197	-0.34	3.16-4.05
	20	10	3.98	0.27	0.085	+0.13	3.61-4.42
	21	25	3.97	0.35	0.070	+0.12	3.41-4.71
	22	25	4.19	o.23	0.046	+0.34	3.72-4.68
	23	25	4.26	0.34	0.069	+0.41	3.61-4.92
	24	25	3.93	0.24	0.048	+0.08	3.55-4.39
	25	5	3.99	0.31	0.138	+0.14	3.60-4.40
	26	25	3.95	0.32	0.064	+0.10	3.30-4.55
	27	25	3.93	0.24	0.048	+0.08	3.39-4.30
	28	1	4.39			+0.54	

TABLE VIII

Length proximal end hind femur to pegs, males (mm.)

Species	Sample	n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	1.44	0.07	0.031		1.34-1.54
montanus	1	14	1.31	0.07	0.019		1.22-1.45
	2	7	1.31	0.11	0.027		1.12-1.47
curtipennis		512	1.37	0.05	0.002		
	1	13	1.27	0.12	0.024	-0.10	1.09-1.49
	2	25	1.41	0.08	0.015	+0.04	1.29-1.60
	3	11	1.33	0.13	0.039	-0.04	1.14-1.47
	4	19	1.34	0.81	0.185	-0.03	1.22-1.51
	5	25	1.31	0.11	0.022	-0.06	1.09-1.49
	6	7	1.39	0.61	0.230	+0.02	1.16-1.67
	7	9	1.35	0.15	0.050	-0.02	1.12-1.61
	8	25	1.41	0.09	0.017	+0.04	1.30-1.61
	9	25	1.41	0.11	0.022	+0.04	1.18-1.67
	10	25	1.34	0.10	0.020	-0.03	1.18-1.58
	11	25	1.32	0.11	0.022	-0.05	1.09-1.49
	12	20	1.42	0.10	0.022	+0.05	1.27-1.61
	13	25	1.42	0.10	0.020	+0.05	1.27-1.65
	14	25	1.37	0.10	0.020		1.16-1.58
	15	25	1.40	0.10	0.020	+0.03	1.22-1.65
	16	25	1.31	0.38	0.076	-0.06	1.09-1.61
	17	5	1.31	0.10	0.048	-0.06	1.17-1.39
	18	5	1.31	0.10	0.048	-0.06	1.26-1.46
	19	5	1.31	0.10	0.048	-0.06	1.31-1.53
	20	10	1.44	0.08	0.025	+0.07	1.29-1.56
	21	25	1.39	0.09	0.018	+0.02	1.22-1.51
	22	25	1.48	0.08	0.016	+0.11	1.32-1.72
	23	25	1.39	0.11	0.022	+0.02	1.22-1.65
	24	25	1.49	0.09	0.018	+0.12	1.29-1.67
	25	5	1.38	0.03	0.012	+0.01	1.30-1.50
	26	25	1.35	0.09	0.018	-0.02	1.18-1.63
	27	25	1.31	0.12	0.024	-0.06	1.12-1.58
	28	1	1.33			-0.04	

TABLE IX

Depth of Eye, males (mm.)

Species	Sample	n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	1.68	0.08	0.036		1.56-1.78
montanus	1	14	1.53	0.09	0.024		1.38-1.65
	2	7	1.55	0.10	0.038		1.45-1.67
curtipennis		512	1.65	0.04	0.002		
	1	13	1.41	0.07	0.019	-0.24	1.24-1.48
	2	25	1.52	0.05	0.011	-0.13	1.42-1.61
	3	11	1.57	0.07	0.021	-0.08	1.49-1.65
	4	19	1.48	0.05	0.011	-0.17	1.40-1.56
	5	25	1.40	0.05	0.010	-0.25	1.30-1.49
	6	7	1.56	0.05	0.019	-0.09	1.49-1.62
	7	9	1.44	0.02	0.006	-0.21	1.29-1.56
	8	25	1.60	0.07	0.014	-0.05	1.50-1.70
	9	25	1.71	0.02	0.005	+0.06	1.56-1.83
	10	25	1.64	0.06	0.012	-0.01	1.48-1.73
	11	25	1.67	0.06	0.014	+0.02	1.48-1.83
	12	20	1.72	0.06	0.013	+0.07	1.59-1.83
	13	25	1.76	0.05	0.010	+0.11	1.62-1.83
	14	25	1.66	0.06	0.012	+0.01	1.51-1.78
	15	25	1.81	0.06	0.012	+0.16	1.72-1.94
	16	25	1.61	0.06	0.012	-0.04	1.45-1.72
	17	5	1.53	0.03	0.013	-0.12	1.49-1.55
	18	5	1.60	0.05	0.022	-0.05	1.55-1.67
	19	5	1.57	0.07	0.031	-0.08	1.49-1.67
	20	10	1.58	0.04	0.014	-0.07	1.53-1.65
	21	25	1.69	0.09	0.018	+0.04	1.56-1.89
	22	25	1.80	0.07	0.014	+0.15	1.65-1.89
	23	25	1.75	0.06	0.012	+0.10	1.59-1.89
	24	25	1.80	0.05	0.010	+0.15	1.72-1.92
	25	5	1.57	0.05	0.022	-0.08	1.49-1.61
	26	25	1.67	0.11	0.022	+0.02	1.45-1.94
	27	25	1.73	0.09	0.018	+0.08	1.56-1.89
	28	1	1.73			+0.08	

TABLE X

Subocular sulcus length, males (mm.)

Species	Sample	n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	0.94	0.03	0.013		0.92-0.97
montanus	1	14	1.01	0.04	0.011		0.92-1.05
	2	7	1.00	0.05	0.019		0.97-1.05
curtipennis		512	1.07	0.07	0.003		
	1	13	0.99	0.05	0.014	-0.08	0.91-1.08
	2	25	0.97	0.04	0.009	-0.10	0.86-1.05
	3	11	1.06	0.04	0.012	-0.01	0.97-1.13
	4	19	1.01	0.05	0.011	-0.06	0.97-1.11
	5	25	0.92	0.05	0.010	-0.15	0.84-0.99
	6	7	1.08	0.04	0.015	+0.01	1.02-1.13
	7	9	1.02	0.02	0.006	-0.05	0.91-1.08
	8	25	1.03	0.04	0.009	-0.04	0.95-1.20
	9	25	1.08	0.05	0.010	+0.01	0.97-1.16
	10	25	1.01	0.05	0.009	-0.06	0.93-1.11
	11	25	1.05	0.08	0.015	-0.02	0.93-1.16
	12	20	1.11	0.05	0.011	+0.04	1.04-1.22
	13	25	1.08	0.04	0.008	+0.01	1.02-1.18
	14	25	1.07	0.06	0.012		0.95-1.18
	15	25	1.12	0.06	0.012	+0.05	1.02-1.24
	16	25	1.06	0.05	0.010	-0.01	0.97-1.18
	17	5	1.08	0.07	0.031	+0.01	0.99-1.18
	18	5	1.10	0.06	0.027	+0.03	1.05-1.18
	19	5	1.04	0.05	0.022	-0.03	0.99-1.12
	20	10	1.02	0.04	0.011	-0.05	0.97-1.07
	21	25	1.08	0.05	0.010	+0.01	0.97-1.13
	22	25	1.19	0.04	0.008	+0.12	1.13-1.29
	23	25	1.16	0.06	0.012	+0.09	1.08-1.29
	24	25	1.19	0.06	0.012	+0.12	1.08-1.29
	25	5	0.94	0.09	0.040	-0.13	0.81-1.05
	26	25	1.03	0.06	0.012	-0.04	0.91-1.16
	27	25	0.96	0.08	0.015	-0.11	0.84-1.16
	28	1	1.11			+0.04	

TABLE XI

Variation, Ratio-Eye depth/Subocular sulcus, males

Species	Sample	n	Ratio E/S	Dev. from general Ratio
parallelus		5	1.79	
montanus	1	14	1.51	
	2	17	1.55	
curtipennis		512	1.55	
	1	13	1.42	-0.13
	2	25	1.56	+0.01
	3	11	1.48	-0.07
	4	19	1.47	-0.08
	5	25	1.52	-0.03
	6	7	1.44	-0.11
	7	9	1.41	-0.14
	8	25	1.55	
	9	25	1.58	+0.03
	10	25	1.62	+0.07
	11	25	1.59	+0.04
	12	20	1.55	
	13	25	1.63	+0.08
	14	25	1.55	
	15	25	1.62	+0.07
	16	25	1.52	-0.03
	17	5	1.42	-0.13
	18	5	1.45	-0.10
	19	5	1.51	-0.04
	20	10	1.55	
	21	25	1.56	+0.01
	22	25	1.51	-0.04
	23	25	1.51	-0.04
	24	25	1.51	-0.04
	25	5	1.67	+0.12
	26	25	1.62	+0.07
	27	25	1.80	+0.25
	28	1	1.55	

TABLE XII

Tegmina length, females (mm.)

Species Sample		n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	7.26	0.40	0.178		6.88-7.84
montanus		18	9.64	1.34	0.316		6.40-12.80
curtipennis		474	10.27	2.49	0.124		
	1	10	8.01	0.43	0.136	-2.26	7.20-8.64
	2	25	8.20	0.67	0.136	-2.07	7.20-9.92
	3	15	7.42	0.64	0.165	-2.85	6.72-9.28
	4	10	8.92	1.51	0.477	-1.35	7.04-12.64
	5	12	7.26	0.49	0.141	-3.01	6.40-7.84
	6	4	9.12			-1.15	8.48-9.76
	7	10	8.40	0.87	0.275	-1.87	6.40-9.12
	8	25	9.13	0.78	0.156	-1.14	7.28-10.40
	9	25	10.87	2.70	0.539	+0.60	8.80-17.60
	10	25	9.85	0.80	0.160	-0.42	8.80-12.48
	11	25	15.75	0.74	0.147	+5.48	14.56-17.28
	12	7	8.84	0.62	0.234	-1.43	8.00-9.44
	13	25	10.39	1.83	0.367	+0.12	8.00-16.16
	14	25	9.53	0.85	0.171	-0.74	8.16-10.88
	15	25	11.10	2.00	0.400	+0.83	8.80-17.12
	16	25	11.57	2.87	0.573	+1.30	7.84-15.84
	17	5	9.44	0.43	0.192	-0.83	8.80-9.92
	18	5	15.30	0.73	0.326	+5.03	14.24-16.00
	19	5	8.80	0.20	0.089	-1.47	8.64-8.96
	20	10	14.80	1.77	0.560	+4.53	10.40-16.48
	21	25	9.00	0.77	0.150	-1.27	7.04-10.24
	22	25	11.10	0.77	0.155	+0.83	9.76-12.64
	23	25	10.55	1.52	0.311	+0.28	8.32-16.00
	24	25	9.10	0.64	0.128	-1.17	7.68-10.40
	25	5	9.50	0.47	0.109	-0.77	8.96-10.24
	26	25	7.80	0.66	0.132	-2.47	6.88-9.12
	27	25	7.57	0.40	0.080	-2.70	6.56-8.48
	28	1	9.44			-0.83	

TABLE XIII

Hind femur length, females (mm.)

Species	Sample	n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	11.55	0.27	0.120		11.36-11.84
montanus		18	12.28	0.64	0.151		11.52-13.44
curtipennis		474	12.08	0.27	0.120		
	1	10	10.56	0.38	0.120	-1.52	9.92-11.20
	2	25	11.48	0.42	0.083	-0.60	10.72-12.16
	3	15	10.93	0.68	0.176	-1.15	9.92-12.64
	4	10	11.31	0.32	0.101	-0.77	10.88-11.84
	5	12	10.94	0.53	0.153	-1.14	9.60-11.52
	6	4	11.84			-0.24	11.36-12.16
	7	10	10.83	0.56	0.177	-1.25	9.92-11.20
	8	25	12.10	0.49	0.097	+0.02	11.04-13.28
	9	25	12.16	0.40	0.080	+0.08	11.36-13.12
	10	25	12.32	0.52	0.104	+0.24	11.36-13.44
	11	25	12.12	0.47	0.094	+0.04	11.04-12.96
	12	7	12.52	0.39	0.147	+0.44	11.84-12.96
	13	25	12.28	0.87	0.175	+0.20	11.20-13.44
	14	25	12.04	0.56	0.112	-0.04	11.04-13.12
	15	25	13.54	0.83	0.167	+1.46	12.32-15.20
	16	25	12.24	0.71	0.143	+0.16	11.20-14.72
	17	5	11.93	0.54	0.242	-0.15	11.36-12.64
	18	5	12.54	0.77	0.344	+0.46	11.68-13.44
	19	5	11.74	0.46	0.206	-0.34	11.20-12.32
	20	10	11.47	0.55	0.174	-0.61	10.56-12.64
	21	25	11.84	0.64	0.130	-0.24	10.40-13.60
	22	25	12.97	0.51	0.102	+0.89	12.00-14.24
	23	25	12.87	0.74	0.151	+0.79	11.52-14.56
	24	25	12.16	0.37	0.074	+0.08	11.52-12.96
	25	5	12.48	0.95	0.425	+0.40	11.20-13.60
	26	25	12.83	0.64	0.128	+0.75	11.84-13.76
	27	25	12.07	0.40	0.080	-0.01	11.36-12.80
	28	1	12.96			+0.88	

TABLE XIV

Vertex width, females (mm.)

Species	Sample	n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	1.08	0.03	0.013		1.03-1.10
montanus		18	1.06	0.06	0.014		1.01-1.22
curtipennis		474	1.05	0.09	0.004		
	1	10	1.00	0.05	0.016	-0.05	0.91-1.06
	2	25	1.00	0.05	0.010	-0.05	0.91-1.06
	3	15	0.93	0.07	0.018	-0.12	0.80-1.06
	4	10	0.98	0.05	0.016	-0.07	0.95-1.03
	5	12	0.94	0.05	0.014	-0.11	0.86-0.99
	6	4	1.05				1.03-1.06
	7	10	1.02	0.05	0.016	-0.03	0.95-1.10
	8	25	0.99	0.06	0.012	-0.06	0.84-1.06
	9	25	1.04	0.06	0.011	-0.01	0.95-1.14
	10	25	1.03	0.04	0.008	-0.02	0.95-1.10
	11	25	1.01	0.06	0.012	-0.04	0.91-1.10
	12	7	1.08	0.06	0.023	+0.03	0.95-1.14
	13	25	1.09	0.05	0.009	+0.04	0.99-1.18
	14	25	1.01	0.05	0.009	-0.04	0.87-1.10
	15	25	1.13	0.06	0.012	+0.08	1.03-1.22
	16	25	1.04	0.04	0.008	-0.01	0.99-1.14
	17	5	1.07	0.07	0.014	+0.02	1.03-1.18
	18	5	1.07	0.07	0.014	+0.02	1.03-1.14
	19	5	1.04	0.07	0.014	-0.01	0.99-1.10
	20	10	0.97	0.03	0.009	-0.08	0.95-1.03
	21	25	1.09	0.07	0.013	+0.04	0.91-1.22
	22	25	1.18	0.06	0.012	+0.13	1.06-1.29
	23	25	1.17	0.07	0.013	+0.12	1.06-1.29
	24	25	1.16	0.06	0.012	+0.11	1.02-1.29
	25	5	1.06	0.04	0.018	+0.01	1.03-1.10
	26	25	1.20	0.06	0.012	+0.15	1.10-1.29
	27	25	1.02	0.05	0.009	-0.03	0.95-1.10
	28	1	1.20			+0.15	

TABLE XV

Pronotal depth, females (mm.)

Species Sample		n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	2.80	0.07	0.031		2.70-2.90
montanus		18	2.91	0.16	0.038		2.60-3.30
curtipennis		474	2.92	0.19	0.009		
	1	10	2.84	0.15	0.047	-0.08	2.60-3.10
	2	25	2.82	0.12	0.025	-0.10	2.70-3.10
	3	15	2.63	0.16	0.041	-0.29	2.40-2.90
	4	10	2.82	0.16	0.051	-0.10	2.70-3.00
	5	12	2.74	0.12	0.035	-0.18	2.60-3.00
	6	4	2.93			+0.01	2.80-3.20
	7	10	2.93	0.18	0.057	+0.01	2.70-3.10
	8	25	2.87	0.14	0.027	-0.05	2.75-3.20
	9	25	2.84	0.13	0.026	-0.08	2.60-3.10
	10	25	2.87	0.13	0.026	-0.05	2.60-3.10
	11	25	2.90	0.12	0.025	-0.02	2.60-3.20
	12	7	2.98	0.10	0.038	+0.06	2.80-3.10
	13	25	2.90	0.12	0.025	-0.02	2.70-3.20
	14	25	2.79	0.14	0.029	-0.13	2.50-3.10
	15	25	3.08	0.18	0.035	+0.16	2.80-3.40
	16	25	2.78	0.11	0.023	-0.14	2.50-3.00
	17	5	3.04	0.12	0.054	+0.12	2.90-3.20
	18	5	3.18	0.13	0.058	+0.26	3.00-3.30
	19	5	3.04	0.07	0.031	+0.12	2.90-3.20
	20	10	2.89	0.13	0.041	-0.03	2.70-3.10
	21	25	3.02	0.15	0.031	+0.10	2.70-3.30
	22	25	3.14	0.15	0.030	+0.22	2.90-3.40
	23	25	3.08	0.18	0.035	+0.16	2.80-3.40
	24	25	3.13	0.11	0.021	+0.21	2.90-3.30
	25	5	3.08	0.11	0.049	+0.16	2.90-3.20
	26	25	3.12	0.15	0.030	+0.20	2.80-3.50
	27	25	2.85	0.11	0.022	-0.07	2.60-3.00
	28	1	3.30			+0.38	

TABLE XVI

Proximal segment, hind tarsus, females, length (mm.)

Species	Sample	n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	1.72	0.16	0.008		1.61-1.86
montanus		18	1.79	0.11	0.025		1.61-1.98
curtipennis		474	1.78	0.16	0.008		
	1	10	1.56	0.06	0.019	-0.22	1.49-1.67
	2	25	1.66	0.09	0.018	-0.12	1.49-1.80
	3	15	1.59	0.10	0.026	-0.19	1.43-1.74
	4	10	1.58	0.12	0.038	-0.20	1.43-1.74
	5	12	1.52	0.10	0.029	-0.26	1.43-1.80
	6	4	1.83			+0.05	1.74-1.92
	7	10	1.59	0.13	0.041	-0.19	1.49-1.74
	8	25	1.81	0.10	0.021	+0.03	1.65-1.98
	9	25	1.79	0.08	0.016	+0.01	1.67-1.92
	10	25	1.78	0.11	0.021		1.67-2.11
	11	25	1.80	0.08	0.017	+0.02	1.67-1.98
	12	7	1.83	0.10	0.038	+0.05	1.67-1.98
	13	25	1.92	0.09	0.018	+0.14	1.74-2.11
	14	25	1.71	0.07	0.014	-0.07	1.61-1.86
	15	25	1.98	0.12	0.024	+0.20	1.73-2.23
	16	25	1.81	0.11	0.023	+0.03	1.61-1.98
	17	5	1.76	0.05	0.022	-0.02	1.67-1.80
	18	5	1.90	0.10	0.045	+0.12	1.80-2.05
	19	5	1.76	0.05	0.022	-0.02	1.74-1.86
	20	10	1.66	0.07	0.027	-0.12	1.55-1.80
	21	25	1.68	0.13	0.026	-0.10	1.43-1.92
	22	25	1.97	0.08	0.016	+0.19	1.86-2.17
	23	25	1.94	0.10	0.020	+0.16	1.80-2.17
	24	25	1.83	0.09	0.017	+0.05	1.61-1.98
	25	5	1.84	0.07	0.031	+0.06	1.74-1.92
	26	25	1.92	0.10	0.020	+0.14	1.73-2.17
	27	25	1.77	0.10	0.020	-0.01	1.61-1.92
	28	1	1.86			+0.08	

TABLE XVII

Depth of Eye, females (mm.)

Species	Sample	n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	1.80	0.03	0.013		1.74-1.86
montanus		18	1.69	0.09	0.021		1.55-1.92
curtipennis		474	1.76	0.013	0.007		
	1	10	1.56	0.06	0.019	-0.20	1.49-1.67
	2	25	1.63	0.07	0.015	-0.13	1.49-1.80
	3	15	1.65	0.09	0.023	-0.11	1.55-1.80
	4	10	1.67	0.04	0.013	-0.09	1.61-1.74
	5	12	1.52	0.05	0.014	-0.24	1.43-1.80
	6	4	1.67			-0.09	1.61-1.71
	7	10	1.67	0.09	0.028	-0.09	1.49-1.80
	8	25	1.74	0.06	0.012	-0.02	1.64-1.86
	9	25	1.82	0.06	0.012	+0.06	1.74-1.92
	10	25	1.76	0.07	0.015		1.55-1.92
	11	25	1.73	0.08	0.016	-0.03	1.61-1.86
	12	7	1.92	0.06	0.023	+0.16	1.80-1.98
	13	25	1.81	0.07	0.015	+0.05	1.67-1.98
	14	25	1.68	0.07	0.015	-0.08	1.55-1.80
	15	25	1.96	0.10	0.021	+0.20	1.80-2.17
	16	25	1.74	0.09	0.018	-0.02	1.55-1.92
	17	5	1.76	0.05	0.022		1.67-1.80
	18	5	1.77	0.11	0.049	+0.01	1.67-1.92
	19	5	1.74	0.04	0.018	-0.02	1.67-1.80
	20	10	1.69	0.10	0.032	-0.07	1.55-1.86
	21	25	1.79	0.07	0.015	+0.03	1.61-1.92
	22	25	1.92	0.09	0.019	+0.16	1.73-2.10
	23	25	1.86	0.11	0.022	+0.10	1.67-2.11
	24	25	1.85	0.07	0.014	+0.09	1.73-2.04
	25	5	1.77	0.04	0.018	+0.01	1.74-1.80
	26	25	1.94	0.08	0.016	+0.18	1.73-2.10
	27	25	1.89	0.07	0.014	+0.13	1.73-1.98
	28	1	1.92			+0.16	

TABLE XVIII

Subocular sulcus, length, females (mm.)

Species	Sample	n	$\bar{x}$	S.D.	$S\bar{x}$	Dev. from general $\bar{x}$	Range
parallelus		5	1.24	0.07	0.031		1.18-1.30
montanus		18	1.35	0.09	0.021		1.24-1.55
curtipennis		474	1.36	0.11	0.006		
	1	10	1.24	0.05	0.016	-0.12	1.18-1.36
	2	25	1.24	0.06	0.012	-0.12	1.18-1.36
	3	15	1.23	0.10	0.026	-0.13	1.05-1.49
	4	10	1.23	0.07	0.022	-0.13	1.12-1.30
	5	12	1.24	0.07	0.020	-0.14	1.12-1.33
	6	4	1.36				1.18-1.49
	7	10	1.35	0.09	0.028	-0.01	1.18-1.43
	8	25	1.35	0.06	0.012	-0.01	1.17-1.46
	9	25	1.38	0.05	0.010	+0.02	1.30-1.49
	10	25	1.34	0.06	0.011	-0.02	1.24-1.43
	11	25	1.30	0.06	0.013	-0.06	1.18-1.43
	12	7	1.43	0.05	0.019	+0.07	1.36-1.49
	13	25	1.36	0.08	0.017		1.24-1.49
	14	25	1.30	0.06	0.013	-0.06	1.24-1.43
	15	25	1.51	0.09	0.020	+0.15	1.36-1.67
	16	25	1.32	0.06	0.013	-0.04	1.24-1.43
	17	5	1.41	0.08	0.036	+0.05	1.30-1.49
	18	5	1.48	0.13	0.058	+0.12	1.36-1.55
	19	5	1.39	0.04	0.018	+0.03	1.36-1.45
	20	10	1.25	0.07	0.022	-0.11	1.18-1.36
	21	25	1.36	0.06	0.013		1.24-1.49
	22	25	1.55	0.07	0.014	+0.19	1.43-1.67
	23	25	1.44	0.09	0.019	+0.08	1.30-1.61
	24	25	1.40	0.07	0.014	+0.04	1.30-1.55
	25	5	1.34	0.05	0.022	-0.02	1.30-1.43
	26	25	1.40	0.07	0.014	+0.04	1.30-1.55
	27	25	1.20	0.07	0.014	-0.16	1.12-1.30
	28	1	1.61			+0.25	

TABLE XIX

Variation, Ratio-Eye depth/Subocular sulcus, females

Species Sample		n	Ratio E/S	Dev. from general Ratio
parallelus		5	1.34	
montanus		18	1.25	
curtipennis		474	1.29	
	1	10	1.26	-0.03
	2	25	1.31	+0.02
	3	25	1.34	+0.05
	4	10	1.36	+0.07
	5	12	1.23	-0.06
	6	4	1.23	-0.06
	7	10	1.24	-0.05
	8	25	1.28	-0.01
	9	25	1.32	+0.03
	10	25	1.31	+0.02
	11	25	1.33	+0.04
	12	7	1.34	+0.05
	13	25	1.33	+0.04
	14	25	1.30	+0.01
	15	25	1.29	
	16	25	1.32	+0.03
	17	5	1.25	-0.04
	18	5	1.20	-0.09
	19	5	1.25	-0.04
	20	10	1.35	+0.06
	21	25	1.32	+0.03
	22	25	1.24	-0.05
	23	25	1.29	
	24	25	1.32	+0.03
	25	5	1.32	+0.03
	26	25	1.39	+0.10
	27	25	1.58	+0.29
	28	1	1.19	-0.10

TABLE XX

Dorsal ovipositor valves, females

Species Sample	length (mm.)	breadth (mm.)	length/breadth ratio
<u>parallelus</u>			
Germany - Rastatt	2.31	0.58	4.0
- (Lux, 1961)	2.31		
<u>montanus</u>			
Germany - Karlsrhue	3.40	0.71	4.8
- (Lux, 1961)	3.23		
<u>curtipennis</u>			
Labrâdor, Hopedale	2.95	0.57	5.2
Manitoba, Churchill	2.82	0.50	5.6
Quebec, Ste. Annes	2.84	0.56	5.1
Ontario, Mer Bleue	2.97	0.50	5.9
Mass., Nantucket	2.66	0.48	5.5
N.Y., Ithaca	2.86	0.53	5.4
Virginia, Mountain L.	3.31	0.60	5.5
W. Virginia, Canaan Val.	2.92	0.51	5.7
Minn., Republic	2.81	0.53	5.3
Wyo. Esterbrook	3.02	0.63	4.8
Alta., McMurray	2.80	0.48	5.8
Alaska, N. Slope Brooks Range	2.80	0.59	4.7
Calif., nr. Mono Pass	2.57	0.56	4.6
Calif., Mendocino	2.64	0.54	4.9
Oregon, Divide	2.50	0.59	4.2
Nevada, Carlin	2.78	0.58	4.8
Ariz., Flagstaff	3.40	0.60	5.6
B.C., Chilcotin	2.97	0.60	4.9
La., Natchitoches		0.80	

TABLE XXI

Colour Types in Chorthippus (adapted from Rubtzov, 1935)

1.	viridis	Green all over, except ventrally, more or less distinct ochreous or brownish-black shading on antennae, eyes, legs and abdomen.
2.	hyalosuperficies	Green on head, pronotum between carinae, tegmina behind first ulnar vein. Sides of body and legs vary from ochreous brown to brownish-black.
3.	hylolateralis	Green laterally on head, thorax, legs and abdomen (latter sometimes with brownish-black spots). Ochreous brown dorsally.
4.	rubiginosa	Brown all over, with more or less distinct black markings near pronotal carinae and on sides of abdomen. General colour varies from light brown through reddish-brown to blackish brown. Some specimens are, in addition, variegated with light gray and black across the sides of the head and lateral lobes of the pronotum. Others have a distinct buff to pale brown stripe dorsally on head and pronotum.
5.	purpurea	Purple above on head, pronotum between the carinae, and on tegmina; green laterally; abdomen and legs with ochreous brown spots.
6.	fuliginosa	Blackish-brown above, top and sides of head, disc of pronotum and upper halves of lateral lobes, abdomen above and on sides, and tegmina; sides of face and lower halves of pronotal lobes yellowish-white.

TABLE XXII

Colour types, <u>Chorthippus</u> per cent*

Species Sample	n	1	2	3	4	5	6
<u>parallelus</u>							
(Rubtzov, 1935)		x	x	x	x	x	x
Europe & Asia	11	34	0	42	24	0	0
<u>montanus</u>							
(Rubtzov, 1935)		x		x	x	x	
Europe & Asia	32	55		34	11	0	
<u>curtipennis</u>							
Labrador	23			77	23	0	
Nova Scotia	50			32	60	8	
Quebec	50			82	18	0	
New York	50			24	76	0	
Virginia	50			36	58	6	
Michigan	50			16	84	0	
Minnesota	50			18	70	2	
S. Man. & S. Sask.	50			44	52	4	
Man., Churchill	47			32	68	0	
Colorado	50		2	32	66	0	
Arizona	50			24	76	0	
Oregon	50			20	78	2	
California	50			14	82	2	2

x Colour type, Rubtzov, 1935; number or proportion not given.

* Colour types in percentage of total sample number.
Equal numbers, males and females, where possible.

(See TABLE XXI for descriptions of colour types.)