CYTOTAXONOMICAL STUDIES OF SOME SCHIZOPHOROUS DIPTERA

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A Thesis Submitted to the Faculty of

Graduate Studies and Research, McGill University,

in Partial Fulfillment of the Requirements

for the Degree of

Master of Science

-1966-

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I INTRODUCTION

The study of the biological sciences has led to four great generalizations:

(A) Darwin's and Wallace's (100 years ago) theory of evolution by natural selection, which tells us that higher organisms are derived by a continuous evolutionary progression from the first primitive organisms.

(B) The cell theory of Schleiden (1838) and Schwann (1839), which states that all organisms are composed of cells.

(C) The chromosomal theory of heredity (Sutton 1903), which involved the understanding that the function of chromosomes is to control heredity.

(D) The gene - enzyme relationship (Garrod 1909) asserting that genes control the synthesis of enzymes.

Recent biochemical - genetical studies have provided evidence that chromosomes synthesize messenger RNA which transmits its messages to ribosomes; the ribosomes then act as the sites for synthesizing enzymes, which in turn control the function of the cell. The fact that chromosomes are genetical material has been proved by Avery et al. (1944), Hershey and Chase (1952) and others. It is now generally agreed that, as far as the higher animals are concerned, most evolutionary transformations have had their origin in the chromosomes and that these bodies which constitute the physical basis of heredity also furnish the material source of evolutionary changes.

Since the chromosomes represent the physical basis of the evolutionary mechanism, any significant alteration in their structure or behavior represents not only an evolutionary change, but also a change in the apparatus upon which all future transformations will depend. In this sense, the studies of morphological and physiological characteristics of the chromosomes of an organism become important. The comparison of chromosomal DNA and its protein products at the molecular level will give the most satisfactory information of all evolution studies. Unfortunately, such work is by no means easy at this moment. However, the differences in chromosome number and shape which frequently distinguish one species from its relatives throw new light on the problems of taxonomy. In addition, the cytological characteristics of whole groups of organisms have a bearing on the differentiation of the higher categories of our classification and on the problem of their evolutionary patterns, plasticity and adaptiveness.

II. Review of Literature

1. The Karyotype and Speciation

The karyotype is defined as the basic chromosome set of an individual or species, and varies in form, size and number. It is a valuable morphological character, particularly because of its intimate association with the genetic make-up of the species. The karyotype was early recognized as a definite species character (Navashin 1915); the morphology of the chromosome among individuals of the same species being reasonably constant, with departures from

the species pattern being attributed largely to recognizable aberrations. Thus cytology became an accepted and exceedingly useful tool in the hand of the taxonomist who is interested in something more than simple morphological criteria for defining species relationships. In fact, relationships within natural groups of species can scarcely be considered complete in an evolutionary sense unless there is good cytotaxonomic data to reinforce conclusions based on morphological criteria. And the gross knowledge of the genome complement of an organism would also be necessary in any molecular genetical analysis.

In the early period of cytology it did not seem likely that chromosome numbers as such were of any particular evolutionary importance. Thus Morgan, Bridges and Sturtevant (1925) wrote to a geneticist, "Many of these comparisons between the karyotypes of different species will seem of little significance", because to them it was not the shapes and sizes of chromosomes which were important, but the genes contained in the chromosomes. Similarly, Wilson (1925) considered that both cytological and genetical evidence proved that the chromosomes were compound bodies, containing many different components. So long as the sum total of these remains the same, or nearly so, it seemed immaterial whether they be grouped to form few or many aggregates.

Such views are no longer tenable for various reasons. In the first place, it is now realized that the recombination index of a

species (Darlington 1937a) is one of the fundamental properties of its genetic system. This recombination index, which is simply the sum of the haploid number and the chiasma frequency, represents the mean number of blocks of genes segregating independently at meiosis. Thus the formal genetics of a species with many chromosome pairs and /or a higher chiasma frequency will be quite different from that of a species with a low recombination index. This difference is no doubt reflected in the population dynamics and in the evolutionary patterns of different groups of organisms. In the second place, we now regard the overwhelming majority of evolutionary changes in the karyotype as having been caused by structural changes involving both breakage and fusion, rather than being due to fusion or fragmentation alone. In organisms with localized centromeres which also do not lose their function or arise de novo, each chromosome is monocentric and an evolutionary increase in chromosome number must involve duplication of a centromere together with a region (large or small) around it. On the other hand, a decrease in chromosome number must mean the permanent loss from the karyotype of a region containing a centromere. This is the dislocation hypothesis of evolution of chromosome number (Navashin 1932), and although its applicability in groups such as the Homoptera, which seem to lack individualized centromeres, has been challenged (Troedsson 1944), there can be no doubt that it does apply in the great majority of animal groups. Thus, Wilson was in error in supposing that the sum total of hereditary components remains the same when an evolutionary change in

the karyotype also involve alterations in gene sequence, which may in many cases lead to position effects of one kind or another. The newer concept of the chromosome as an organized body whose parts stand in a definite functional relationship to one another has replaced the crude, atomistic idea of a row of entirely independent genes strung together like beads on a thread.

It is obvious that, in the majority of species, the lengths and shapes of the chromosomes which make up the karyotype are not at random, In many forms we have a symmetrical karyotype. Alternatively, there may be two size-classes of chromosome, each with definite characteristics. These conditions would not be encountered with such regularity if the structural changes which become established in phylogeny were of all possible types. It seems, rather, that in many groups chromosome after chromosome has undergone the same type of structural change, so that they have all retained a similar morphology (White 1954).

Chromosome modifications in either number or structure are often associated with the accumulation of morphological changes that culminate in speciation (Boyes 1965a). However, the fact that related species may have similar karyotypes indicated that aberrations are not a necessary accompaniment to speciation. Speciation may be due to gene mutation, with geographical space providing the barrier between them, preventing crossing. On the other hand, similar karyotypes, as seen in mitotically dividing cells, may mask a wealth of

hidden aberration.

Two classical examples of pairs of sibling species are Drosophila melanogaster Meigen and D. simulans Sturtevant, and D. pseudo-obscura Frolowa and D. persimilis Dobzhansky. They differ in paracentric inversions as demonstrated in their salivary chromosome, but their mitotic karyotypes are very similar. Burla et al. (1949) have noted a similar case in the willistoni group of D. tropicalis (Burla & da Cunha) and D. paulistorum (Dobzhansky & Pavan) which have very similar ($n = 3$) mitotic karyotypes but differ in their salivary gland chromosome structure. It is, therefore, easier to identify the species by their salivary chromosome rather than by mitotic chromosome morphology. In other cases, there are different descriptions of karyotypes provided by different authors for the same species. For example, Drosophila robusta Sturtevant has three metacentrics and a dot according to Carson and Stalker (1947); but Metz (1916) and Wharton (1943) found a rod, two metacentrics and a dot. Some of these differences may stem from inaccurate or incomplete observations, but some probably represent real variation, indicating the presence of sibling species. Boyes and van Brink (1964) reported two chromosome numbers ($n = 4$ and 5) in Syrphus ribesii L. and suggested that when differences in chromosome number occur within a species, the groups, involved are likely to be at least sibling species.

Boyes (1954) reported an intraspecific difference of karyotypes in a collection of Hylemya brassicae (Bouche) from different geographic locations. On the other hand, Robertson (1957) in analysing the karyotypes

in geographic isolate of carrot rusty fly (Chamaepsila rosae (F.)) found no chromosomal separation at subspecies levels. However, as will be discussed later, due to the limitations of the techniques, the variations of karyotype measurements may be large enough to conceal some existing karyotype separation. The value of cytotaxonomy is described by Boyes (1965); "Cytological research is helpful in the solution of taxonomic problems and its value in this context is obviously greater in those taxonomic groups in which karyotypic variations are the most abundant and frequent. Of course, no one would expect cytotaxonomy to provide solutions for all taxonomic problems and in fact in some cases it has revealed new ones or added to the complexity of old ones."

The general laws of Chromosomal changes of significance in evolution may be classified into four main categories: (A) Gene mutation, (B) sectional rearrangements of parts of chromosome, (C) loss or reduplication of whole chromosomes, (D) loss or reduplication sets of chromosomes. Gene mutations, important though they may be as caustive agents of evolutionary changes, may actually, be very minute sectional rearrangements, differing only quantitatively from the second category. Losses and reduplications of whole chromosomes have probably occurred only very rarely in animal evolution (White 1963). The occurrence of chromosome aberrations themselves are not alone responsible for the evolution of species; good evidence has been provided, however, as to the possible role they can play. It is perhaps best to consider their action within, rather than between, species.

The evolutionary changes within species is dependent in the long run upon a constantly produced series of randon gene mutations.

Gene mutations and chromosomal rearrangements are physical and chemical accidents which are non-adaptive in origin. Natural selection acts as a filter eliminating mutations and rearrangements which are non-adaptive, and conserving in the population, those which are adaptive. No doubt countless structural changes and gene mutations have failed to establish themselve in evolution, because they were genetically "deleterious", in the sense that they upset genic balance of the organism. But even if a chromosomal rearrangement is satisfactory from this point of view, it still has to be one which does not diminish the efficiency of the mitotic or meiotic mechanism in a purely mechanical way.

In sexually reproducing species, all populations may exhibit genetic polymorphism; the characteristics of the populations as a whole being determined by the gene frequencies in them. The species is, therefore, a dynamic, rather than a static, entity; flowing, as it were, through time and modified as mutation and selection pressures permit. Selection, however, acts not only on a single gene but on the whole organism; and it is, therefore, the genotype as a whole that is selected for or against by the environment in which it finds itself. A new species group usually evolves from one species. It is possible that much less frequently two or more species split off together and, by parallel evolution at the species level, form

a new species. All evolutionary patterns are the results of the responses of genetical systems to the variety of ecological niches in the environment. Every species may be regarded as possessing a genetic system which is theoretically unique in type. However, in practice, the nature of chromosomal modifications that accumulate in different genera and families has been found to be characteristic for the group concerned (White 1954).

2. Primary and Secondary Constrictions

The centromere, forming the primary constriction of metaphase chromosomes, in Diptera appears simply as a non-staining region with no morphological evidence of structure under a photomicroscope. It is one of the most important morphological characteristics of the chromosome. The centromere is believed to be the attaching point of the spindle during the poleward movement. Therefore, the position of centromere is best identified at anaphase. The properties of centromeres and telomeres do, to some extent, control the occurrence of chromosomes. As mentioned before, an increase in chromosome number needs duplication of a centromere, while a decreased chromosome number involves the loss of a centromere.

The secondary constriction is often related to nucleolar formation and involves the presence of a separate segment or satellite in a chromosome. Unfortunately, secondary constrictions are found to be infrequent and irregular in location (Boyes 1953; Robertson 1957). The value of secondary constrictions would be greatly increased if,

with the improving of technique it were possible to reveal the presence of the secondary constrictions as clearly and constantly as for the centromeres.

3. Somatic Pairing

Stevens (1907, 1908) first studied the chromosomes of Diptera and called attention to the fact that the chromosomes are associated in pairs in mitotic metaphase. This observation was then confirmed and greatly extended in a series studies by Metz (1914, 1916a, 1916b, 1922). It was found that in prophase the association of homologous is closer than in metaphase. Hinton (1946) explained that the pairing between homologous chromosomes is due to a specific attraction between the homologous parts of the chromosome and not to a gross or general attraction between the chromosome as whole or between the centromeres. Somatic pairing begins at a time when the chromosomes are separated by distances too great for short-distance chemical interactions to operate. The evidence indicates long range specific attractive forces as the underlying mechanism in somatic pairing of the chromosomes (Hinton op. cit.).

4. Sex Chromosomes

The sex chromosomes can be regarded as a rather highly modified pair of autosomes which mainly control sex determination. Therefore, most of the general laws of chromosome evolution appear to apply to

the sex chromosomes as well as to the autosomes. But the sex chromosomes seem to be, to some extent, isolated in their evolution from the rest of the chromosome set. Striking differences in sex chromosomes of related species have been demonstrated in a number of insects (Smith 1953, 1960; Bush 1962; Boyes 1965b; Schrader 1950; Manna 1958). In these cases, sex chromosomes alone provide valuable data for cytotaxonomical studies. The size of human sex chromosome, as noted in the karyotype, has been proved to be directly proportional to the size of sex chromatin body (Barr body) (Taft et al. 1965).

Henderson and Parsons (1963) reported that the sex chromosomes of eleven species of Tipulid (Tipulidae; Diptera) show more readily detectable variation than do the autosomes. Taylor (1960) and many others have shown that the sex chromosomes are late in duplication. All of these characteristics are believed to be related to the heterochromatin which will be treated in a later section.

The sex chromosome system in Diptera is mainly of the XY type, but the XO type has been reported in Dasyllis grossa (Fabricius) (Asilidae) and four species of Drosophila (Patterson and Stone 1952). Also the X_1X_2Y type has been found in Hylemy fugax (Mg.)(Boyes 1953), Anastrepha serpentina (Wied.) (Bush 1962) and Drosophila miranda (Dobzhansky 1935a).

The earlier work on the genetics of Drosophila suggested that in a species of this genus the Y-chromosome may be more or less completely inert (Wilson 1925). However, Krivshenko (1952) has demon-

strated that a primary non-disjunction of the sex chromosomes of D. busckii Coq. female results in the appearence of X X Y females but no XO male. The absence of XO male indicates, then, that the Y-chromosome of D. busckii Coq. contains at least one gene which is essential for the development of zyyotes, carrying in the Y-chromosome. Examination of the chromosomes in the salivary gland cells of male larvae has revealed the presence of an euchromatic element in the Y-chromosome.

5. Heteropycnosis

Chromosome, or parts of chromosomes, whose cycle of condensation differs from that of the majority of the chromosomes are said to exhibit heteropycnosis (Gutherz 1907). Heteropycnosis is said to be positive if the chromosomes are more condensened, and negative if they are less condensed, than the rest of the complement. A Barr body, therefore, is the result of positive heteropycnosis of a single X-chromosome during interphase. Chromosomes, or parts of chromosomes, exhibiting positive heteropycnosis are often said to consist of heterochromatin (Heitz 1928). It is probable that all chromosomes contain heteropycnotic regions which may be extensive or short, few or numerous, but constant in position for any one chromosomal element at various stages of the chromosomal cycle (White 1954). In certain cases, a chromosome or chromosome region which is positively heteropycnotic at one stage, may be negatively heteropycnotic at another

(White 1940a). On the other hand, some heterochromatic chromosomes do not naturally show a reversal of behavior. Therefore the characteristics of heteropyncnosis are helpful in identifying individual chromosomes, particularly sex chromosomes. However, they also give a lot of difficulties in the composing of karyotypes, as will be discussed later.

The inertness of heterochromatin was first suggested by Heitz (1934). If heteropycnosis can be regarded as a universal sign of genetical inertness, then we can predict the inertness of particular chromosome region in species of animals which have not yet been worked out genetically. In many cases, the X, as well as the Y, chromosome is largely heteropycnotic (White 1940a,b). It seems likely that the active sex-determining regions of the X-chromosome are relatively small, most of the chromosome being inert (White op. cit.)

Due to the genetical inertness of heterochromatin, the occurrence of centric fusions and other types of whole arm transposition is probably facilitated by the existence of the heterochromatic region around the centromeres (White 1954). One would not expect small deficiences and duplications of heterochromatin to affect the viability of the individual nearly as much as would a corresponding deficiency or duplication of euchromatin. By the same token, wherever the heterochromatin is found, alteration in form or size of the chromosome may be accomplished without the sacrifice of euchromatic portions. Therefore, a certain amount of heterochromatin is

evolutionary desirable as a safety factor, permitting a greater degree of karyotype variability than an inflexible system composed of euchromatin only. In Drosophila, gain or loss of heterochromatin has varied chromosome morphology considerably (Patterson and Stone 1952). Seven different types of Y-chromosomes, entirely heterochromatic, have been recognized in Drosophila pseudoobscura (Dobzhansky 1935). Patterson and Stone (1952) listed 28 examples of added heterochromatin in this genus. Smith (1965) reported that species of Chilocorus differ in chromosome number owing to centric fusion of metacentric chromosomes. The concomitant loss of arms is tolerated because in all unfused chromosomes, one arm is completely heterochromatic, the other euchromatic. All this indicates that the gain or loss of heterochromatin is not uncommon in karyotype evolution.

6. Supernumerary Chromosomes.

Wilson (1905) first discovered supernumerary or accessory chromosomes in addition to the normal chromosomes in the hemipteran insect Metapodius. Sup-chromosomes are generally of a smaller size than other members of the chromosome complements. As a group, they are relatively unstable. In wild populations of certain species of animals, sup-chromosomes are present in some individuals but not in others. In some cases the majority of the population may carry sup-elements, whereas, in other instances the proportion of individuals carrying them may be very low. Frequently a species which shows

sup-chromosomes in certain local populations may lack them in another geographic area.

The sup-chromosome appear to be genetically inert (Swanson 1957). Whether absent or whether present in large numbers, they produce little detectable phenotypic expression. This suggests that structurally they are largely heterochromatic, a hypothesis supported by the fact that they may also exhibit the differential staining characteristics of heterochromatin. It is of course, possible that the continued presence of supernumeraries in certain populations indicates that they perform some, as yet undetermined, function that guarantees their survival, but that is too subtle to detect genetically. However, the effect of sup-chromosomes seems very similar to that of extra heterochromatic regions present in the larger member of unequal pairs of autosomes (White 1954). Where a supernumerary element is present in a single dose, in a small fraction of the population, it is probable that individuals with one supernumerary element are adaptively superior to those with none, but those individuals with several sup-chromosomes are inferior. Under such circumstances, an equilibrium frequency would be established which would retain the sup-chromosomes in the population at a level which would not lead to the production of many individuals with a high number of sup-chromosomes.

In Drosophila putrida Sturtevant, the evolutionary dimunition of extra chromosomes (heterochromatin) which results in forms with a reduced number of chromosomes and the minimum of heterochromatin has been

suggested by Patterson and Stone (1952). The fixation of super-numerary chromosomes in the population causes the increase of chromosome number has also been demonstrated by Ward (1949), Patterson and Stone (1952). Supernumerary chromosomes were also found in Hylemya cilicrura H. (Boyes 1954) but their evolutionary value is unknown.

Apart from sup-chromosome (accessory or extra chromosomes) which are generally, although not necessarily, smaller than the usual chromosomes, microchromosomes are sometimes found throughout the plant and animal kingdom (Swanson 1957). They are minute in size and it is difficult to distinguish heterochromatic accessory chromosomes from euchromatic necessary ones. The "dot" chromosomes are found in many Drosophila species (Patterson and Stone 1952) and Syrphid species (Boyes and van Brink 1964). In some cases, these tiny chromosomes are confused with sex chromosomes; whether they are involved in a sex-determining mechanism or whether they are independent from sex chromosomes is not known in many cases. Presumably the most significant role of the sup-chromosomes and microchromosomes is to provide a direct way of varying the chromosome number. The terms supernumerary chromosome, extra chromosome, accessory chromosome, E-chromosome, S-chromosome, B-chromosome and microchromosome seem a little confusing. As Stern (1958) has pointed out "the terminology, which applies the word 'supernumerary' alike to all special chromosomes needs improvements." In the insect group, sup-chromosomes are so named, because they are

absent in the somatic tissues and, obviously, are not needed for somatic development. They are nevertheless essential components of the germ line (White 1950). E-chromosome was used by White (1950) to refer to a sup-chromosome in order to separate it from the normal chromosome complement (S-chromosome). B-chromosome is mainly used in maize for extra chromosomes. However, there are cases where extra chromosomes are found in the germ line but there is no information as to whether they are also found in somatic cells. In this case it would seem proper to use the term extra or accessory chromosome.

7. Changes in Chromosome Number.

In theory, the changes in chromosome number can arise through abnormal mitotic or meiotic division. However, most of the changes in chromosome number which have occurred in insects have almost certainly been the result of sectional rearrangements, while the abnormal nuclear divisions are rare or do not occur at all (White 1963). Patterson and Stone (1952) have suggested that centric fusions account for the reduction in chromosome number and the origin of metacentric in the genus Drosophila where the most primitive species have rod-shaped chromosomes and subterminal chromosomes. According to their analysis, the modifications of the primitive configurations which are detectable by an examination of the metaphase chromosomes have been: (A) centric fusions, (B) pericentric inversions, (C) changes in the amount of heterochromatin and (D) translocations. The number of centric fusions which have become established in phylogeny is at least ten times as

great as the number of ordinary translocations.

If most of a chromosome becomes translocated onto or into another chromosome, the minute region containing the spindle attachment, which is left behind, will usually be lost from the chromosome set after a few generations if it does not contain any essential genes (White 1940). This is probably the usual way in which the chromosome number becomes diminished. Chromosome elimination in Miastor spec. has been shown by Nicklas (1959).

Evolutionary increases in chromosome number probably come about through duplication of regions containing a spindle attachment (White 1940). One way in which this can occur is through the formation of small sup-chromosomes as has been previously discussed. Most of the sup-chromosomes which have been described have probably arisen through the deletion of a large part of a chromosome (White op. cit.); with the parts containing the spindle attachment and telomere subsequently joining up to form a chromosome. Such a sup-chromosome may easily become included in a gamete which also contains the normal unaltered chromosome. In this way, the "sup" may later become part of the regular chromosome set of the species, with the possibility of portions of the other chromosomes being translocated on to it during further development.

So far as can be determined, there is no direct connection between basic chromosome number and phylogenetic position (Swanson 1957). In other words, there are differences among phylogenic groups, but no

obvious trends can be correlated with the degree of phylogenetic development, or with specialization, unless such correlations are made within the narrower limits of family or genus. At this level a general tendency towards reduction in basic chromosome number parallels specialization (Swanson op. cit.). Changes in the basic chromosome number of Drosophila have been extensively investigated (Patterson and Stone 1952), and the pattern of change indicates that reductions in number are frequent (128 cases in 215 species investigated). On the other hand, increases are rare, the only one being recorded is in Drosophila trispine Loew which has been mentioned before. Therefore, increase in chromosome number must be difficult and has seldom been accomplished in Drosophila. However, it would seem relatively easier in a species with accessory and genetically inert elements to increase the basic number than to decrease it. One would expect that the transfer of euchromatin to these inert elements would, in one step, convert them from unessential to essential members of the complement.

8. Changes in Chromosomal Configuration.

The discovery that X-rays could induce mutation (Muller 1927) and the rediscovery of the salivary gland chromosome of the Diptera (Painter 1933; Heitz and Bauer 1933) led to a much more precise understanding of the nature of structural rearrangements in the chromosome and their consequences, on the cellular, organismal and population levels. It is now possible to make direct comparisons between the gene sequence of

different individuals and species in certain cases (White 1954). Due to homologous pairing, inversions and translocations in hybrids can be identified and the nature of the chromosome difference of the parents can be determined. It is very unfortunate that the salivary gland technique of cytological analysis can be applied only in some Diptera. In addition to the salivary gland, the polytene chromosomes of Diptera have been found in Malipighian tube, vesicular seminales (Pavan and Breuer 1952) as well as in the foot-pads (Whitten 1964) and intestine, testis and ovary. But their usefulness in the purpose of studying chromosomal rearrangements are unknown.

Theoretically, one might suppose that closely related species might differ genetically but their chromosome sets would be structurally identical, with the sequences of the genetic loci being exactly the same. In fact, this seems to occur rarely, if ever. The case, at least in the genera Drosophila, Chironomus and Sciara, shows the most closely related species almost always differ, if but slightly, in their gene sequence (White 1954).

Fusions, translocations and pericentric inversions will change the chromosomal configuration. Duplications and deletions may further alter form; but paracentric inversions may merely shift the gene order within an arm. With the exception of possible position effects which will be discussed later, reciprocal translocations and inversions are balanced changes and normally have no detectable phenotypic effect. On the other hand, duplication and deficiencies are unbalanced changes

and would usually have recognizable, and sometimes, severe phenotypic effects. The general tendency from the patterns of chromosome evolution in the genus Drosophila (Patterson and Stone 1952) show translocations are few, except in special cases involving hetero-chromatic material. Fusions are fairly common. Paracentric inversions are very frequent, and pericentric inversions have occurred a number of times. The addition, subtraction and shift of hetero-chromatic has accomplished some extensive changes in metaphase chromosome pattern without a correspondingly great shift of genes in the system.

Brown (1940) has made the most complete and pertinent analysis of the effect of translocation on crossing over and disjunction in Drosophila. In general, all heterozygous translocations cause reduction in number of functional gametes in both male and female. Therefore, heterozygous translocations are at a decided selection disadvantage and would be retained very rarely (Wright 1941). However, there are cases in which translocations involved in the evolution of Drosophila have been reported (Dobzhansky and Dreyfus 1943). Hiroyoshi (1964) reported that the translocation of a part of the Y chromosome to the second chromosome in Musca domestica L. results a sex-limited inheritance and an abnormal sex ratio. Lachance (1964) has demonstrated that a mutant of black R cell in wing Cochliomyia hominivorax (Coq.) was associated with a reciprocal translocation which showed preferential segregation in male flies.

Fusion involves a transverse breakage of the chromosome and reunion of the broken ends in a way that is different from the original one. Breakage without reunion does not give rise to stable alterations of the karyotype, and reunion without previous breakage does not occur at all (White 1954). Fusion may occur, not only in such a way as to yield a metacentric (centric fusion), but it also in such a way as to yield a longer acrocentric by tandem fusion. Tandem fusions may also yield larger subterminals from metacentrics and acrocentrics. The centric fusion may be considered as a special type of translocation involving the entire euchromatic arms of rod chromosomes. In Drosophila melanogaster $\overset{M.}{\wedge}$X-4 fusions have been studied by Stone (1934), Painter and Stone (1935), and Stone and Griffen (1940). Crossing over is not usually affected, although it was reduced slightly in the region of the fusion in some cases. The fusion is at no selective disadvantage either in the heterozygous or homozygous condition. In Drosophila, however, centric fusions, are possible, as well as more likely, than other kinds of translocations, because of the large blocks of centric heterochromatin. Loss of a centromere plus adjacent heterochromatin produces no marked effect on viability, and can, consequently, be more readily withstood than the loss of euchromatin. Furthermore, the more pronounced breakability of heterochromatin as contrasted to euchromatin would tend to favor centric fusions. Robertson (1916) proposed that the number of major chromosome arms in the complements of closely related groups of animals

tends to remain constant in the course of evolution. This has been referred to by some authors as "Robertson's law". Matthey (1945, 1949) used the term "nombre fondamental" (N.F.) to indicate the number of major chromosome arms in a species; counting each metacentric as two arms and each acrocentric as one. Smith (1962) has studied the chromosome reduction by centric fission between closely related species of Pissodes (Bark weevil) by hybridization tests. Thus fusions are commonly applied to explain the numerical changes of the chromosome complements of closely related species.

Many papers by Dobzhansky and others have demonstrated that each local race of Drosophila is likely to carry a distinct combination of inversions. The first case of pericentric inversion demonstrated by direct cytological observation in a natural population is the one reported by Miller (1939) in the B-chromosome (element E) of Drosophila algonquin Sturtevant & Dobzhansky. Sturtevant and Beadle (1936) have presented the basic genetic evidence and interpretation of the effects of inversions in Drosophila. Inversions do not increase the rate of nondisjunction when chromatid exchanges occur within the limits of heterozygous paracentric inversions, or involve the transposition of the centromere. Inversions produce so few aneupoid gametes that they are at only a slight selective disadvantage. Pericentric inversions produce relatively many aneupoid gametes, and, thus, are at a pronounced selective disadvantage. Homozygous inversions have neither selective advantage nor disadvantage. Furthermore, White (1963) explained

that Drosophila avoids "paying the penalty" for paracentric inversion heterozygosity because there is no crossing over in the male, and in the female the dicentric and acentric chromatids are shunted into the polar bodies. On the other hand, pericentric inversion heterozygosity in Drosophila leads to the production of a certain number of eggs carrying deficiencies and duplications, because there is no mechanism for shunting such monocentric, but abnormal, chromatids into the polar bodies. Thus pericentric inversions are a "prohibited" category of rearrangement in Drosophila whereas paracentric ones are "permitted". The cytological analysis of the salivary gland chromosomes in interspecific hybrids reported in Drosophilidae, Chironomidae, Simuliidae and Agromyzidae have been proved to be a valuable method in elucidating inversions (Patterson and Stone 1952; White 1954). Furthermore, the cytological evidence can also be compared with the genetic data.

9. The Measurement of Chromosome.

Cell size (Mirsky and Ris 1951), nutritional condition (Pierce 1937), degree of polyploidy (Manton 1952; Walker 1938) and genetic condition (Thomas 1936) can influence the size of the chromosome. Tobgy (1943) has shown that determination of chromosome size must reside within the chromosome itself rather than being of a more general nuclear origin. This gave the idea of using percentage of total chromosome length (TCL) to express the length of an individual chromosome. The relative chromosome size in the complement is considered to be reproducable.

For many years, cytologists have described specific genomes in terms of their measurements or relative lengths and arm ratios of the chromosome involved. In general, these lengths and arm ratios have been regarded as constants, subject only to the occasional deviations of spontaneous rearrangements. Nevertheless, it has been recognized in practice that the manipulation during preparation and other factors introduce errors, and that, in addition, chromosomes of a genome may differ in innate variability. Temperature effects on chromosome contraction have been described by Matsuura (1935, 1937), Straub (1937), Huskins and Wilson (1938), Wilson and Huskin (1939), Barber (1940), Warlington and Lacour (1940), Swanson (1942, 1943), Wilson and Boothroyd (1944), Jain (1957) and Rees (1958). Genotypic control of chromosome length has also been known for many years (Lesley and Frost 1927; Lamm 1936; Upcott 1937; Swanson 1942, 1943; Burnham 1946).

Longley (1941) first suggested that the contracting process may not take place simultaneously in all chromosomes of the genome, or even in all sections of the same chromosome. The need for, and the convenience of, an analysis of variance on cytological measurement data was discussed by Harte (1950). Ihm (1953) also pointed to the need for setting confidence limits in cytological studies involving size criteria. Hintzche (1955) reported on the necessity for adequate numbers of observations in experiments dealing with comparison of cytological data. A statistical procedure was designed by Lighty

and Plaisted (1960) to measure variation between homologues at various stages in the preparation of the karyotype. In assessing the sources of variation of the measurements of the chromosomes of Lilium candidum, it was found that the variation between different sources of the same clone, different plants within the sources and different date of collections within the plants do not contribute differentially to the mean ratio for all measurements of a given chromosome. However, the slides, cells, and homologues each introduced a differential contribution to the mean ratio, and had large components of variance. Therefore, the observed variation in the ratio measurement of a chromosome in a clone is largely attributable to the effect of cytological manipulation, rather than to variations existing in the living material. This leads Lighty and Plaisted (op. cit) to point out the usefulness of a statistical treatment in estimating the relative importance of the contribution to variability of various factors. Lighty and Plaisted (op. cit.) have also shown that the variance tends to increase as the mean ratio gets larger. Therefore, if the chromosomes are predominantly of the median type, fewer measurements need to be taken to give the same standard deviation than if the chromosomes are sub-median or sub-terminal.

Maguire (1962) analyzed the variability in length and arm ratio of the pachytene chromosome of corn and concluded that chromosomes with larger arm ratios seem to have inherently more variable arm

ratios. However, chromosomes with greater arm ratios do not appear to have greater inherent variabilities in absolute length. Maguire (op. cit.) also divided the chromosome variability into two kinds. One contributes approximately uniformly per unit length to variability throughout the genome. The other kind of variability is a characteristic property of each chromosome unrelated to length in any consistent way, although several of the shorter chromosomes would seem to be comparatively low in this kind of variability.

The differential chromosome condensation has been confirmed by comparing the chromosome lengths at two different stages, late prophase and metaphase of Petunia hybrida where the effect of colchicine appeared equivalent at each stage (Takehisa 1963). From this finding, it is evident that the differential chromosome condensation is manifestation of the different condensating abilities intrinsic to the chromosome itself and not a result of the modifications due to colchicine treatment. The differential chromosome condensation has been reported by Svardson (1945), Wickbom (1949). On the other hand, Bajer (1959) reported that in Haemanthus katharinas Bak. and Leucojum aestivum L. all the chromosomes shorten in a similar way in all the stages independently of their sizes. It seems that the differential chromosome condensation is a characteristic of a particular species.

In species where differences in condensation are normal occurrences, they are found associated with heterochromatic chromosomes or heterochromatic segments of chromosome (Rees 1958). The total

amount of heterochromatin per complement differs in different species, and the degree of chromosome contraction is different between the eu- and heterochromatic chromosomes or chromosome segment in meiosis (Eberle 1957). In Scilla (a plant genus) it was found that long chromosomes were more frequently retarded in contraction than short ones (Rees 1958). Heterochromatin intimately relates to the differential chromosome condensation in meiosis as confirmed by Eberle (1957) and Brown (1961), whose studies show that paired chromosomes equal in length, differ in their amount and distributions of heterochromatin. Furthermore, Miduno (1962) has found, using his differential staining technique that the heterochromatin may be responsible for the differential chromosome condensation. Therefore, the differential chromosome condensation has a certain relationship to heterochromatin.

The differences in chromosomes, as related to the total chromosome length, apparently involve heteropycnotic or heterochromatic chromosomes or parts of chromosomes (Boyes 1961). Boyes and Naylor (1962) analysed the allosome-autosome length relationships in Musca domestica L. and found that all chromosomes contract in smaller cells and expand in larger cells; and also, that the heterochromatic X-chromosomes are less active in this respect than the autosomes. Therefore, idiograms based on short somatic chromosome complements may differ from those based on long complements if certain chromosomes are heterochromatic. This leads them to suggest the necessity of total complement length accompanying the idiograms. However, an

assumption often made in preparing a karyotype is that there is no variation in the percentage of TCL and arm ratios between homologous chromosomes from different cells of the same tissue of the same organism within a given environment. The composition of an idiogram is based on the statistical results of a number of measurements. If the idiogram should go with total chromosome length, then it is necessary to give the same kind of statistical treatment for the TCL. This will, however, make it difficult to follow Boyes and Naylor's (1962) suggestion, because there is a large intrinsic variation in between each total chromosome length (Boyes 1960).

10. Cytological Data on the Schizophorous Flies

According to "A Catalogue of the Diptera of America North of Mexico" (Stone et al. 1965) the division of Schizophora includes 58 families, involving several thousand species of higher Diptera. However, cytological data found in literature cites only 353 species. These 353 species are distributed in 14 families; among them 108 species are in the section of Calyptratae, and 245 species are in the Acalyptratae.

Before the 1940's, cytological data on Diptera was only available on chromosome number and the relative length of individual chromosomes. After 1950, and due to the improvement of slide preparation and light microscopy, more detailed studies of the morphology of chromosome structure became possible. Sex-chromosomes, centromeres, secondary constrictions, heteropycnotic segments, and supernumerous chromosomes were then reported.

Family Psilidae

Robertson (1957), by comparing the somatic complements of the carrot rust fly, Chamaepsila rosae (F.), from different collections concluded that the relative lengths and arm ratios of chromosomes did not separate the carrot rust fly into geographical races.

Family Otitidae

Metz (1916) studied the chromosomal behavior in spermatogonial cells of Chaetopsis fulvifrons M. and Camptonoura picta Fabr. His illustrations of metaphase clearly showed 2n = 8 for Chaetopsis fulvifrons M. and 2n = 12 for Camptonoura picta Fabr. These illustrations have been measured by me and the relative length of individual chromosomes were calculated. These data are presented in Table 1. Unfortunately the centromeres are not clear in the illustrations.

Family Tephritidae

The spermatogenesis of Tephritis arnicae L. was first studied by Keuneke (1924). Several of his pictures showed 2n = 12 for this species. Emmart (1935) reported 2n = 10 in Anastrepha ludens L. Frissi and Springhetti (1953) found n = 6 in Dacus oleae Gmel. The same number (n = 6) has also been reported for six out of seven species of Queensland Dacinae by Davis (1955). One species, however, had n = 7. Unfortunately, the morphology of the chromosomes was not clear. Mendes (1958) found distinct morphological differences in the chromosomes of two species of Brazilian tephritids, Anastrepha fraterculus

(Wied.) and Ceratitis capitata (Wied.) both of which had n = 6. The karyotypes of six species of the Mexican fruit flies in the genus of Anastrepha were studied by Bush (1962). A number of telocentric autosomes were reported in his paper. The most interesting finding is the X_1 X_2 Y in A. serpentina (Wied.). Furthermore, 2n = 12 was found in A. ludens L. which was not in agreement with Emmart's (1935) reports. Krimbas (1963) presented a better picture of the somatic metaphase chromosomes of Dacus olae G.

Family Dryomyzidae

A mitotic metaphase and a metaphase I figure of spermatocyte of Neuroctena analis F. was illustrated by Metz (1916); 2n = 12 chromosomes are quite clear in his picture.

Family Sciomyzidae

The germ cells of Tetanocera sparsa were studied by Stevens early in 1908. Five pairs plus an XY pair are fairly clear in her five metaphase figures.

Family Lauxaniidae

A very good spermatogonial mitotic metaphase figure was presented by Metz (1916). Five pairs plus an XY pair are quite obvious in his illustration.

Family Drosophilidae

The karyotypes of 215 species in the genus of Drosophila have been used for the evolutionary study by Patterson and Stone (1952).

In this genus 26 species have $n = 3$, 50 species have $n = 4$, 52 species have $n = 5$, 86 species have $n = 6$, and one species has $n = 7$. Metz (1914, 1916a, b) reported $2n = 8$ in Chymomyza amoena, Ch. procnemis, Mycodrosophila dimidiata and Scaptomyza graminum, and $2n = 10$ in Scaptomyza adusta.

Family Anthomyiidae

Metaphase figures of Scatophaga pallida Walk. and Phorbia brassica were first described by Stevens (1908). Metz (1916) presented metaphase figures of Fucellia marina Macg. Spermatogenesis of Scatophaga stercoraria L. was then studied by Keuneke (1924). Frolowa (1929) presented metaphase figures of Pegomya geniculata (Bouche) in which five pairs plus an XY pair were also found. The karyotypes of nine species of the genus Hylemya were carefully analysed by Boyes (1954a, b). All species except H. fugax had 12 chromosomes. H. fugax (Mg.) males had 13 chromosomes and females had 14 chromosomes. One to three supernumerary chromosomes were found in a few larvae of H. cilicrura (Rond.). The most stimulating finding was that he was able to demonstrate small intraspecific differences between collections of H. brassicae (Bouche) from different geographical areas.

Family Muscidae

The earliest valuable chromosomal data was found in Stevens'

(1908) illustrations of Musca domestica L. where she showed 2n = 12 chromosomes. Metz (1916) also showed 2n = 12 in Homalomya sp., Ophyra leucostoma Wied. and M. domestica L. Valuable cytological data on M. domestica L. has been reported by Keuneke (1924), Perje (1948), Ramade (1961), Franco et al (1962), Boyes et al. (1962), Rubini (1964), Hiroyoski (1964),Milani (1964) and Boyes et al.(1964), among which the finding of XX, XY, YO, XXX, XXY and OY and the translocation of Y to the second chromosome are of particular interest. The number 2n = 12 was observed in Fannia glaucescens (Zett.) by Boyes (1954). A description of the karyotypes of nine species in this family was given by Boyes et al.(1964), in which Phaonia variegata Fabr., Muscina stabulans Fall. and Orthellia nudissima L. had 2n = 10. Lachance (1964) also reported 2n = 10 in Haematobia irritans (L.) and Stomoxys calicitrans (L.)

Family Calliphoridae

The cytological data of at least 28 species in this family are available in the literature. Again, the earliest data was found in Stevens' (1908) work. Six pairs of chromosome were clearly indicated in her metaphase illustrations of Calliphora vomitoria (L.) and Lucilia caesar L. Metz (1916) also reported 2n = 12 chromosomes in Phormia regina (Mg.), Calliphora viridescens Desr. and C. erythrocephala (Mg.). The karyotype of C. erythrocephala (Mg.) has been the subject of a number of studies (Metz, 1916; Keueneke 1924; Frolowa 1929; Naville 1932; Strasburger 1933; Bier 1960; Ullerich 1963; Melander 1963). The

metaphase chromosomes of the species L. caesar L. showed much more detailed in Keuneke's (1924) work than Stevens' (1908). Metaphase figures of Phormia terrae-novae (Naville 1932) and Callitroga hominivorax (Coq.) (Kaufman and Wasserman 1957) were also analysed by Boyes (1961). The mitotic chromosomes of Lucilia sericata (Mg.) were described by Fish (1950). Boyes (1961) has reported 2n = 12 chromosomes for 20 species of this family and Ullerich (1963) also found six pairs in 11 species. Recently Lachance et al. (1964) have presented a very nice spermatogonial mitotic metaphase figure of C. hominivorax (Coq.). By careful analysis, the relative length of individual chromosomes and their arm ratios coincided in most details with the results of Boyes (1961). However, a noticeable size difference on the Y-chromosome was found.

Family Sarcophagidae

Cytological data for at least 29 species in this family are available in the literature. Illustrations of mitotic metaphase figures of Sarcophaga sarraceniae are available in Stevens' work (1908). Cytological data of four species of this family (Sarcophaga tuberosa serraceniae Riley, Sarcophaga sp., Ravinia communis Park and R. peniculata Park) were reported by Metz (1916). Metaphase figures of Sarcophaga carnaria (L.) have been illustrated by Keuneke (1924). Boyes (1953) contributed karyotypes of nine species in this family, in which nine pairs plus one or two tiny chromosomes were found in Pseudosarcophaga affinis (Fall.) whereas the rest had 2n = 12.

The karyotypes of 12 more species were presented by Boyes (1963). All of these species had six pairs of chromosomes. So far, with the exception being P. affinis (Fall.) it seems that the chromosome number in this family is much more stable than in many other families.

Family Tachinidae

Cytological data on at least 18 species in this family are available in the literature. A very clear mitotic metaphase chromosome figure of Bessa selecta (Mg.) from Smith (1943) was measured; the data is summarized in Table 1. Smith (1944) has also seen 2n = 12 in Phorocera hamata (A. and W.). Boyes et al.(1957) has presented the karyotypes of 16 species all of which regularly contained 2n = 12 chromosomes in their somatic complements. Thus far there is no species in this family with a chromosome number other than 2n = 12.

Family Cuterebridae

Boyes (1964) reported six pairs of chromosome in Cuterebra emasculator Fitch in which Pair VI is conspicuously longer than the other autosomal pairs.

Family Oestridae

The karyotypes of Cephenemyia phobifer Clark, Oestrus ovis L., Hypoderma lineatum (de Villiers) and H. bovis L. have been described by Boyes (1964). All four species have six pairs of chromosomes. The most interesting point is that O. ovis L. and H. bovis L. both

have a very long, metacentric and heterochromatic X-chromosome. H. lineatum (de Villiers) also has a fairly long X-chromosome. The karyotype of H. lineatum (de Villiers) was also described by Lachance (1964). Unfortunately the positions of centromeres on the X-chromosome and the autosomes is not coincident with the report of Boyes (1964).

III MATERIAL AND METHODS

1. Materials used:

The following synopsis gives the 54 species of Schizophora flies, representing 40 genera and 14 families whose chromosomes were studied.

Acalyptratae

Diopsidae

Sphyracephala brevicornis (Say)

Otitidae

Ceroxys latiusculus (L.)

Melieria crassipennis F.

Myrmecothea myrmecoides L.

Seioptera vibrans (L.)

Euxesta notata Wied.

Platystomatidae

Rivellia prob. *viridulans* R.-D.

Tephritidae

Epochra canadensis L.

Dryomyzidae

Dryomyza anilis F.

Sciomyzidae

Atrichomelina pubera L.

Pherbellia grisescens M.

Pherbellia nana F.

Pherbellia new sp.

Antichaeta melanosoma M.

Dictya atlantica Steyskal

Dictya brimleyi Steyskal

Dictya sabroski Steyskal

Dictya texensis Curran

Sepedon armipes Loew

Sepedon fuscipennis Loew

Tetanocera loewi Steyskal

Tetanocera sp.

Pscadina zerni Mayer

Lauxaniidae

Minettia flaveola Coq.

Chamaemyiidae

Cremifania nigrocellulata Cz.

Leucopomyia obscura H.

Helemyzidae

Suillia nemorum (Mg.)

Suillia sp.

Calyptratae

Anthomyiidae

Cordilura ciliata

Cordilura ontario Cn.

Achaetella varipes (Walk.)

Orthochaeta hirtipes John.

Hylemya echinata (Segny)

Hylemya florilega Zett.

Hydrophoria conica Wied.

Pegomya betae (C.)

Pegomya bicolor (Wied.)

Muscidae

Fannia canicularis (L.)

Hydrotaea scambus Zett.

Calliphoridae

Chrysomyia albiceps (Wied.)

Chrysomyia chloropyga (Wied.)

Chrysomyia putoria (Wied.)

Phaenicia caeruleiviridis Macq.

Cynomyopsis cadaverina (R.-D.)

Pollenia rudis (Fab.)

Sarcophagidae

Sphenometopa tergata (Coq.)

Blaesoxipha hunteri (Hough)

Blaesoxipha opifera (Coq.)

Sarcophaga latisterna Park.

Ravinia querula (Walk.)

Tachinidae

Peleteria iterans (Walk.)

Archytas apicifera (Walk.)

Bessa selecta (Mg.)

Winthemia rufopicta (Big.)

The locations where the flies were collected, the tissues used, the number of cells analysed, and the number of individual flies involved are summarized in Table 1.

2. Preparation of Slides

Living flies were etherized until they stopped moving. The anaesthetized flies were then placed on their back in a depression on a dissecting slide and a few drops of distilled water were added. Under a dissecting microscope, the testes or ovaries of the flies were

pulled out from the lateral incisions on the fourth segment of the abdomen. In cases where the third instar larvae were used, the dissections were made by pulling the larval heads off and removing the larval brains. The brains, testes or ovaries were then transfered onto a (95% ethyl alcohol) clean glass slide, two drops of stain (2% solution mixture of orcein in lactic and acetic acids) were added for staining exactly three minutes. While staining the tissues the dissected flies were dried on a paper towel; their wings and legs, were spread and pinned up for species identification. After removing the excess stain, the tissues on be slides were covered with a cover slip and firmly squashed and pressed. The slides were then left for several hours to dry at the edges, after which the edges of the cover slips were sealed with a thin layer of colourless, transparent finger nail polish. These temporary slides can be stored for several weeks if they are stored in a plastic slide box with added moisture, and sealed with cellulose tape at the edges of the slide box.

3. Analyses of Chromosome Complements

The temporary slides were scanned for metaphase chromosome figures under a Zeiss Photomicroscope or Zeiss Ultra-Phot microscope. Structural details of chromosomes on faintly stained slides were found to be better resolved by using phase contrast whereas those on darkly stained slides were found to be better resolved by using ordinary light. Important characters of the chromosome were noted during the microscopic

observation. The good metaphase chromosome figures were then photographed under a combination of a 100 X oil immersion objective, 1.25 X Optovar and 3.2 X projective (this gave a film magnification of X 400), or drawn by camera lucida. After photographs were taken the slides were made permanent for further reference by quick freezing with dry ice and prying off the coverslips. Slides and coverslips were then transferred directly into 95% ethanol for about five minutes and mounted separately in Zeiss L D 25 phase contrast mounting medium. The chromosome figures were printed at a magnifying of X 2250 from the actual size of the chromosomes.

By choosing a central point on the centromere, both arms of each chromosome were measured by a compass. For the purpose of secondary arm ratio calculation, wherever a secondary constriction was encountered, the measurement of each segment of the arm was recorded separately. The pairs of chromosomes were then numbered I-VI in order of increasing size, on the basis of the average lengths of the homologous pairs with the exception that the X-chromosomes which are always Pair I regardless of their relative lengths. The percentage of the total chromosomes length (TCL) of each pair was calculated by considering the total length of Pairs I-VI as 100% (the X-chromosomes were doubled in males). The arm ratio of individual chromosomes was calculated by dividing the length of the long arm by that of the short arm. The statistical analysis was done by IBM programming. For this purpose, both long arms as well as both short arms of a pair of

chromosome were added up and ponched on the data cards. The program is shown as follows:

```
  0 $IBFTC MAIN
  1       DIMENSION P(100,20), SDT(20), SDU(20), DIV(100,20), TM(20),
         1  V(100), A(100,20), B(100,20), SAB(100), PER(20), T(20),
         2  U(20), SDAB(20), SARM(20), GARM(20)
  2     19 READ (5,2)NCONT,NCEL,NPAR,NSPC
  7      2 FORMAT (413)
 10        M = NCEL
 11        N = NPAR
 12        READ (5,1) (( A(1,J), J=1,N), I=1,M)
 23        READ (5,1) ((B(I,J), J=1,N), I=1,M)
 34      1 FORMAT(16F5.2)
 35        FLM = FLOAT(m)
 36        FLM1 = FLM - 1.
 37        FLN = FLOAT(n)
 40        FLN1 = FLN - 1.
 41        WRITE (6.3)NCEL,NPAR,NSPC
 42      3 FORMAT (1HO,// 1H , 30X, 13, 6H CELLS, 5X, 13, 6H PAIRS, 10X,
         1  3HSP., 13//1H, 5X, 3HNO., 7X, 3HPER, 9X, 3HSDU, 9X, 2HTM,
         2  10X, 3HSDT, 9X, 4HSARM, 8X, 4HGARM)
 43        DO 11 K=1,M
 44        SAB(K)=0.0
 45        DO 11 J=1,N
 46        SAB(K) = A(K,J) + B(K,J) + SAB(K)
 47     11 CONTINUE
 52        DO 10 J=1,N
 53        PER(J)=0.0
 54        SDAB(J)=0.0
 55        DO 10 K=1,M
 56        DIV(K,J)=A(K,J)/B(K,J)
 57        SDAB(J)=DIV(K,J) + SDAB(J)
 60        P(K,J) =    (A(K,J) + B(K,J)/SAB(K)
 61        PER(J) = P(K,J) + PER(J)
 62     10 CONTINUE
 65        DO 21 J=1,N
 66        U(J)=0.0
 67        T(J)=0.0
 70        DO 21 K=1,M
 71        T(J) = (SDAB(J)/FLM - DIV(K,J) )**2 + T(J)
 72        U(J) = ( PER(J)/FLM - P(K,J) )**2 + U(J)
 73     21 CONTINUE
 76        DO 9 J=1,N
 77        SDT(J) = SQRT(T(J)/FLM1)
100        SDU(J) = SQRT(U(J)/FLM1)*100.
101        TM(J) = SDAB(J)/FLM
102        PER(J) = 100.*PER(J)/FLM
103        NUM = J
104        SARM(J)= PER(J)/(TM(J)+1.)
105        GARM(J)= PER(J)-SARM(J)
106        WRITE (6,7)NUM, PER(J), SDU(J), TM(J), SDT(J), SARM(J),
         1  GARM(J)
```

```
107       7 FORMAT (1HO, 4X, 13, 6F12.4)
110       9 CONTINUE
112         SMEAN = 0.0
113         TMEAN = 0.0
114         DO 16 I = 1,M
115         V(I) = 0.0
116         DO 15 J = 2,N
117        15 V(I) = V(I) + DIV(I,J)
121         TMEAN = TMEAN + V(I)/FLN1
122        16 SMEAN = SMEAN + SAB(I)
124         TMEAN = TMEAN/FLM
125         SMEAN = SMEAN/FLM
126         SMEANM= SMEAN * 40./9.
127         SDIVS = 0.0
130         TDIVS = 0.0
131         DO 17 I=1,M
132         V5 = TMEAN - V(I)/FLN1
133         TDIVS = TDIVS + V5*V5
134         V6 = SMEAN - SAB(I)
135        17 SDIVS = SDIVS + V6*V6
137         TDIV = SQRT(TDIVS/FLM1)
140         SDIV = SQRT(SDIVS/FLM1)
141         SDIVM = SDIV * 40./9/
142         WRITE (6,18)N,TMEAN,TDIV,SMEAN,SDIV, SMEANM, SDIVM
143        18FORMAT (1HO,/IH , 10X, 12HMEAN OF 2 TO, 13, 10H AVERAGE
             1  ARM RATIO =, F8.4, 15X, 5HS.D.=, F8.4/ 1H , 20X,20HMEAN
             2  of T.C.L. IN CM,4X, 1H=, F8.4, 15X, 5HS.D=, F8.4/1H,20X,
             3  24HMEAN OF T.C.L. IN MICRON, 1H=, F8.4,15X, 5HS.D.=,
             4  F8.4)
144          IF(NCONT.EQ.1) GO TO 19
147          CONTINUE
150          END
```

A sample of the results printed out by the machine is shown as follows:

2 CELLS 6PAIRS SP. 54

NO.	PER (% of TCL.)	SDU (Standard deviation)	TM (Arm ratio)	SDT (Standard deviation)	SARM (Short arm)	LARM (Long arm)
1	7.8916	1.3016	0.0000	0.0000	7.8916	0.0000
2	16.3163	0.0423	1.7071	0.6754	6.0273	10.2890
3	16.6419	1.2816	1.5425	0.4529	6.5455	10.0963
4	17.7592	0.6363	1.1821	0.0253	8.1384	9.6208
5	18.5946	0.6301	1.5685	0.3471	7.2394	11.3552
6	22.7966	0.0285	1.7660	0.1895	8.2418	14.5548

MEAN OF 2 TO 6 AVERAGE ARM RATIO = 1.5532 S.D. = 0.1569

MEAN OF TCL. IN CM =14.6750 S.D. = 2.7789

MEAN OF TCL. IN MICRON=65.222 S.D. =12.3508

The percentage of TCL and the lengths of short arm were then used for composing the idiogram of each species. The secondary arm ratios were calculated manually using the proximal part over the distal part. The percentages of TCL of Y-chromosomes were also calculated manually from their relative ratio to the X-chromosomes. The percentages of TCL, the arm ratios of individual chromosomes, the average II-VI arm ratios, the average TCL in microns along with their standard deviations for the chromosomes of each species, are summarized in Table 1.

For karyotypic comparisons, the available chromosome data in the literature either results adopted directly, chromosomal illustrations

measured (except flies in Drosophilidae) or data summarized is all put in Table 1.

In arranging the position of each species of flies, the classification system from "A Catalog of the Diptera of America North of Mexico" by Stone et al. (Agricultural Handbook No. 276, United States Dept. of Agriculture) was used. Leven et al's (1964) nomenclature system for centromeric position on chromosome was used in this thesis.

IV DESCRIPTIONS OF KARYOTYPES

Sphyracephala brevicornis (Say)

Adults collected in Virginia in August of 1964 were used for cytological study. Eight metaphase I chromosome complements from two adult fly testes were analysed. The results are shown in Table 1, Idiogram 1, and a metaphase I chromosome picture is shown in Figure 1.

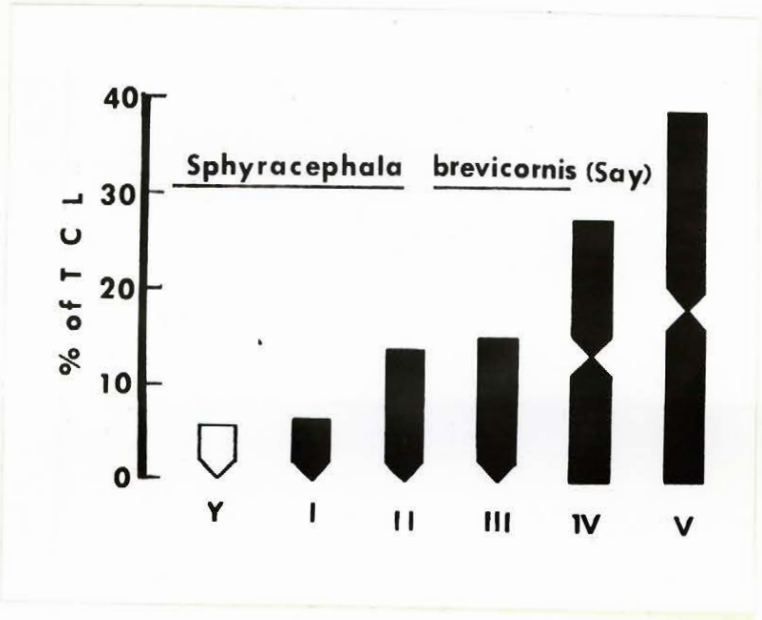
In every complement, four pairs of autosomes and an XY pair were found. The average TCL was 34.91 μ. Pairs II and III were very short compared to Pairs IV and V. The positions of the centromeres were not very clear in all the complement analysed. Presumably, Pairs II and III were telocentric; whereas the centromeres of Pairs IV and V were in the median regions.

The distinct differences in length between each individual chromosome makes the pairs of chromosomes easily identifiable, and the karyotype of this species is distinguishable from those other species studied.

The presumed X- and Y-chromosomes in this species were relatively small and always far apart. The positions of centromeres obtained in this study require confirmation.

Ceroxys latiusculus (L.)

A collection of adults in Pullman, Washington, U.S.A. in 1964 was used for this study. Eight mitotic metaphase figures from a single ovary were studied. These results are presented in Table 1, Idiogram 2, and a mitotic metaphase picture is given in Figure 2.



Idiogram 1

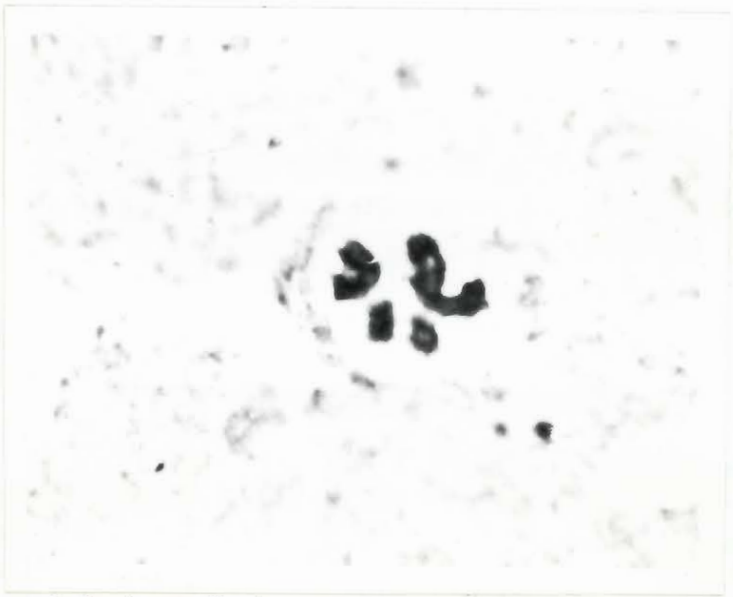
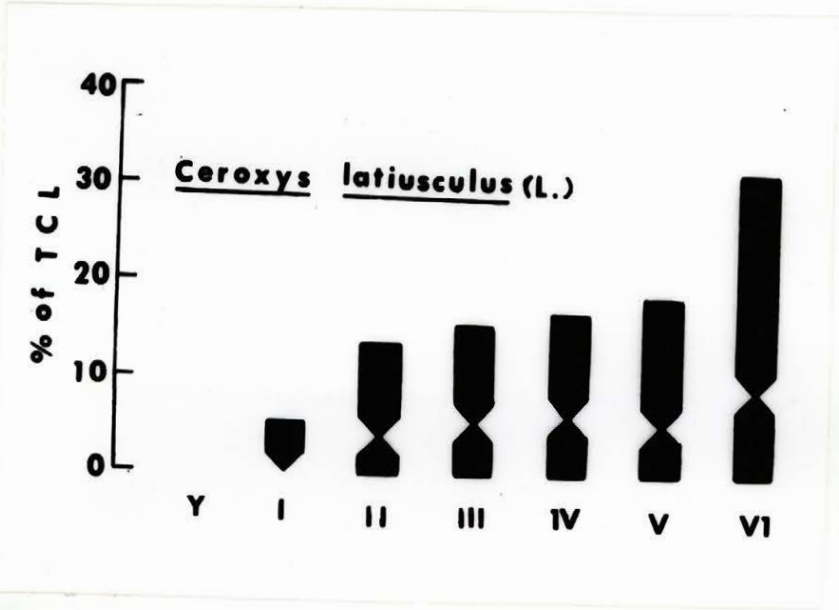


Figure 1. Metaphase I chromosome complement of Sphyracephala brevicornis Say. from the testis of an adult male, tiny XY on right bottom corner, X 2250.



Idiogram 2

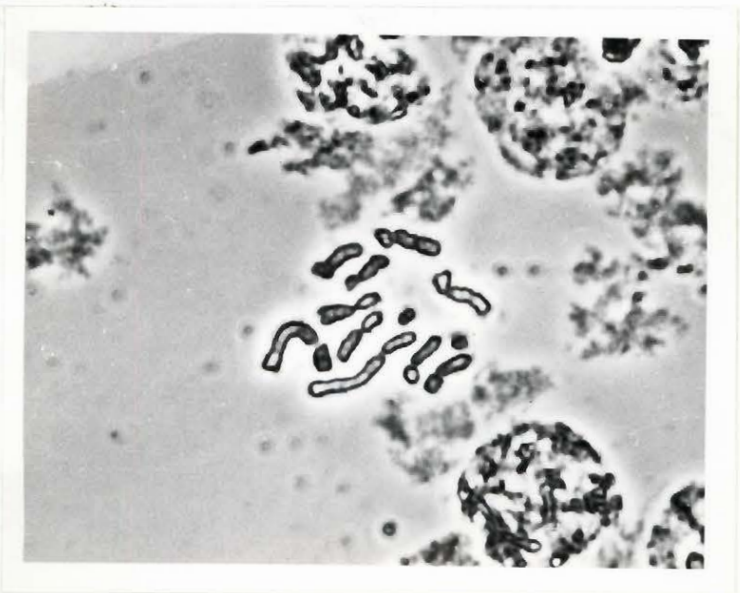


Figure 2. Mitotic metaphase chromosome complement of Ceroxys latiusculus (L.) from the ovary of an adult female, X 2250.

The chromatids and centromeres were fairly clear in most cases. Twelve chromosomes were present in each cell, with an average TCL of 44.56 μ. Pairs II, III, IV and V differed only slightly in length between each two adjacent pairs, while Pair VI was distinctly longer than Pair V. The centromeres of the autosomes were all found in the submedian regions. However, Pairs III and IV had a lower arm ratio when compared to the other autosomes. A secondary constriction was often found in the median region of the long arm of Pair V.

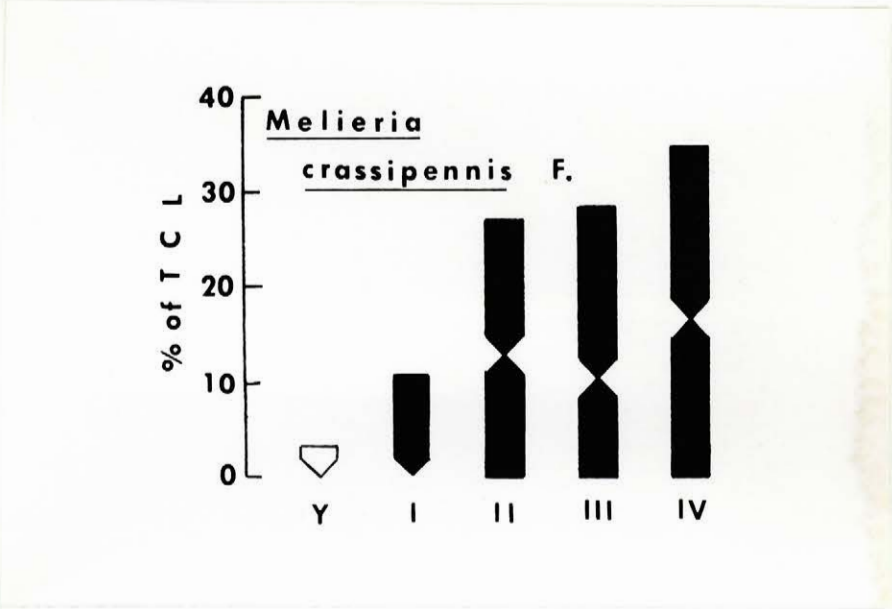
The X-chromosome appeared as a small dot and generally was not paired. The big Pair VI and the small X-chromosome make this karyotype easily identifiable.

Melieria crassipennis F.

Adults collected in the Netherlands in 1962 were subjects for this study. Ten mitotic metaphase figures from a single testis were analysed. The results are summarized in Table 1, Idiogram 3. A mitotic metaphase picture can be seen in Figure 3.

Four pairs of chromosomes were found in each of the ten figures analysed. The average TCL was 35.48 μ. Pair IV was 6.4% TCL longer than Pair III and Pair III was 2.2% TCL longer than Pair II. Pair II and Pair III could be separated more easily by their arm ratio. Pair II and Pair IV had their centromere in the median region, while the centromere of Pair III was in the submedian region.

The X-chromosome constituted 10.5% of the TCL and was telocentric. The Y-chromosome was small (about 3.2% of the TCL) and telocentric.



Idiogram 3

Figure 3. Mitotic metaphase chromosome complements of Melieria crassipennis F., from the testis of an adult male, X 2200.

Myrmecothea myrmecoides L.

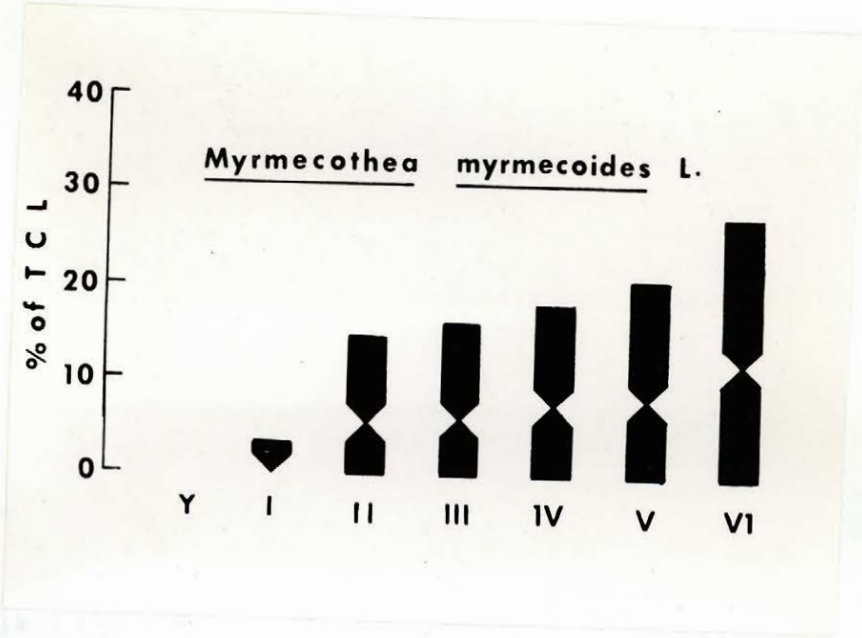
Adult specimens were collected in Virginia in the August of 1964. Four metaphase II figures from a testis were analysed. The results are shown in Table 1, Idiogram 4, and a metaphase II picture is shown in Figure 4.

The chromosome complement of this species contains five pairs of autosomes and most probably an XY. The average TCL was 54.82 μ. The centromeres of the autosomes were all found in the median region, while the centromere of the X-chromosome was probably at the terminal point. Since only metaphase II figures were available, the X-and Y-chromosomes in this species could not be distinguished one from the other with certainty.

Seioptera vibrans (L.)

Adults were collected in Pullman, Washington, U.S.A. in August of 1964. Five mitotic metaphase complements from an ovary were studied. The results are shown in Table 1, Idiogram 5, and a mitotic metaphase picture can be seen in Figure 5.

Six chromosomes were found in every figure studied. Unfortunately, the position of centromeres was not very distinct. The average TCL was very low (24.35 μ). The centromere of the smallest pair was probably in the terminal region; while the centromeres of Pairs II and III were in the median region. The smallest pair was presumed to be the two X-chromosomes because in some figures they were poorly paired. The simplicity of the karyotype of this species makes its chromosome



Idiogram 4

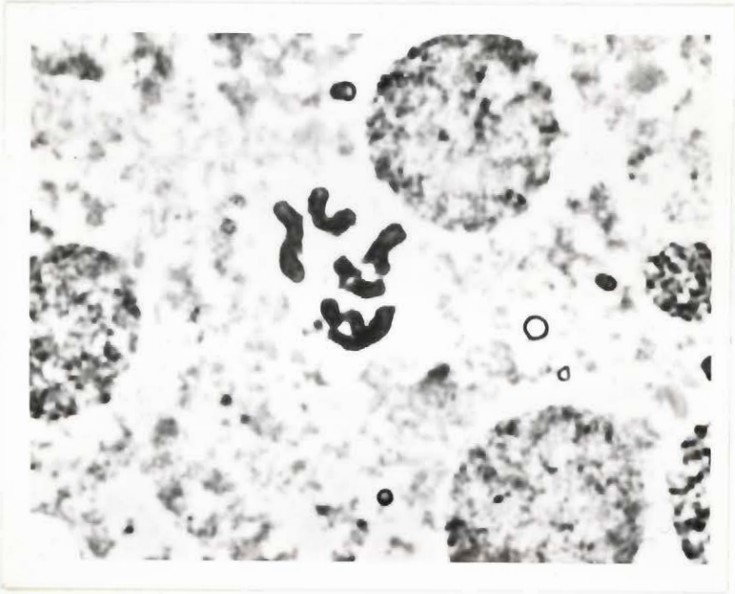
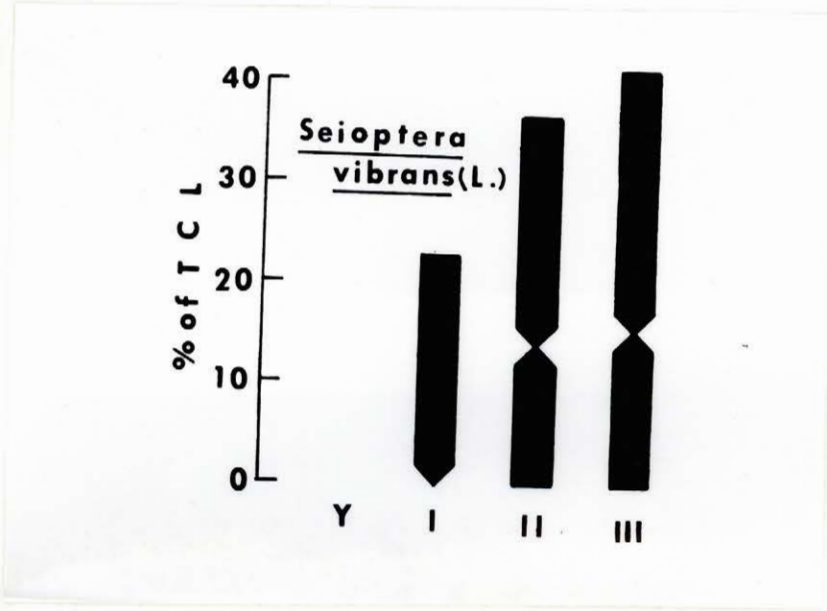


Figure 4. Metaphase II chromosome complement of Myrmecothea myrmecoides L. from the testis of an adult male, X 2250.



Idiogram 5

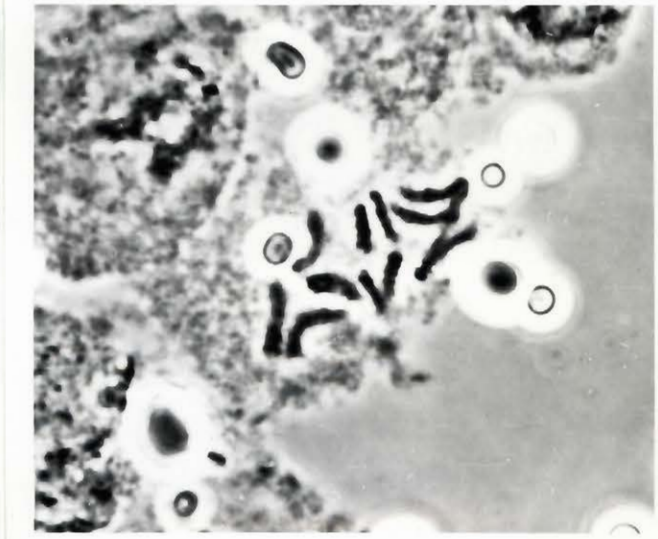


Figure 5. Mitotic metaphase chromosome complement of Seioptera vibrans (L.) from the ovary of an adult female, X 2250.

complement easily identifiable and the individual chromosomes are easily recognized.

Euxesta notata Wied.

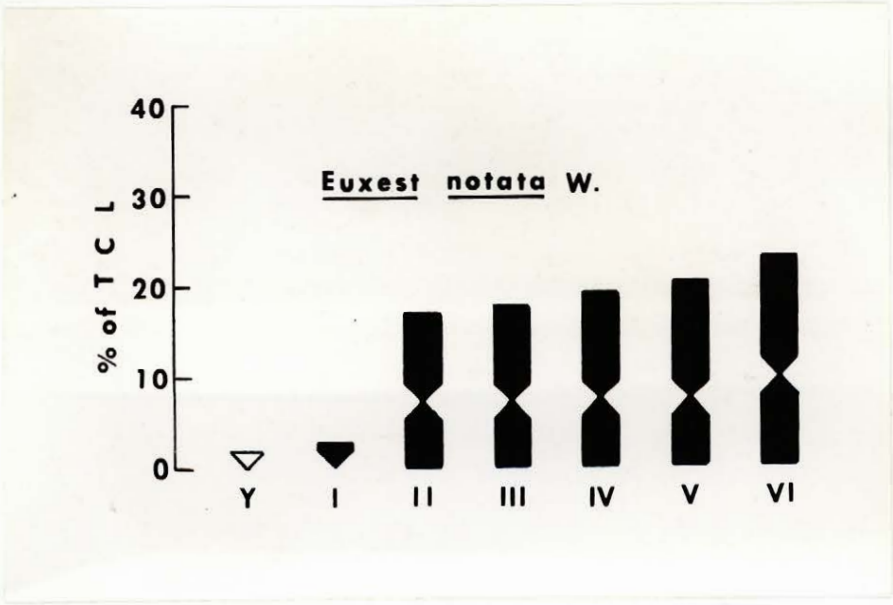
Larvae were obtained from the University of Western Ontario in February of 1964. Ten mitotic metaphase figures from a larval brain of a presumed male were analysed. The results of this analysis are summarized in Table 1, Idiogram 6, and a mitotic metaphase picture is given in Figure 6.

Five long pairs plus two small dot-like chromosomes were observed in each of the ten complements. The average TCL was 51.09 μ. Among the autosomes, the length difference between each two adjacent pairs, except between Pairs V and VI, was not obvious. Pair II constituted 16.8% of TCL, Pair III 17.8%, Pair IV 19.2%, Pair V 20.2% and Pair VI 23.3% of TCL. No distinct difference in the position of the centromeres was found, except that the centromere of Pair II was more nearly submedian, while the centromeres of the other autosomes were more nearly median.

The X- and Y-chromosomes in this species were obvious as two very small dots, but though small, in most cases they were fairly clear.

Rivellia prob. viridulans R.-D.

Adults collected in North Carolina in July of 1964 were used for the chromosome analysis of this species. All twenty-four mitotic metaphase figures from an ovarian tissue contained six chromosomes. The average TCL was 43.46 μ. The locations of centromeres of auto-



Idiogram 6

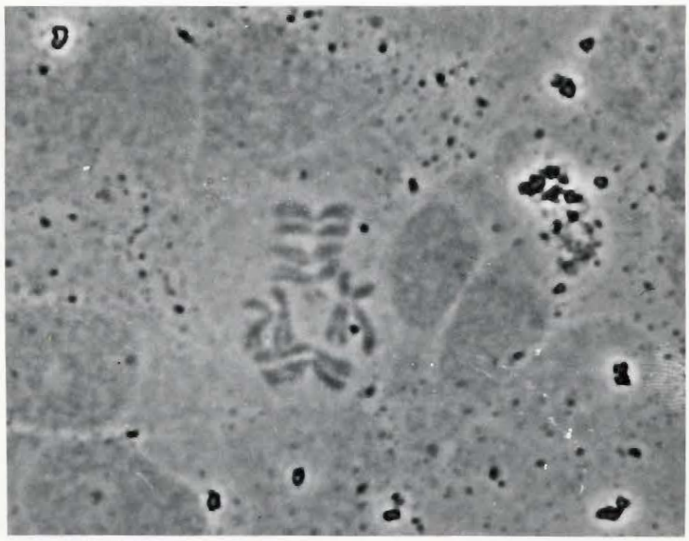
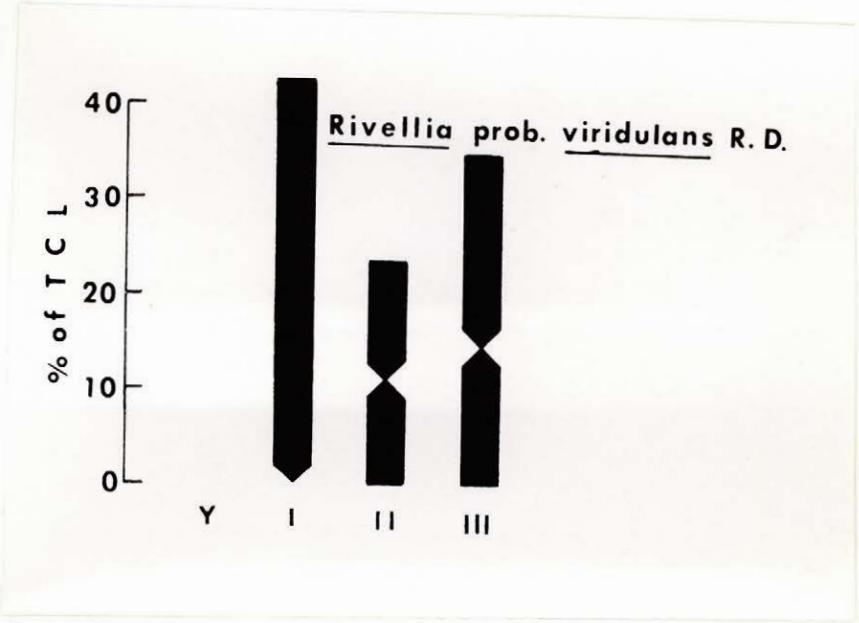


Figure 6. Mitotic metaphase chromosome complement of Euxesta notata Wied. from a larval brain, X 2250.



Idiogram 7

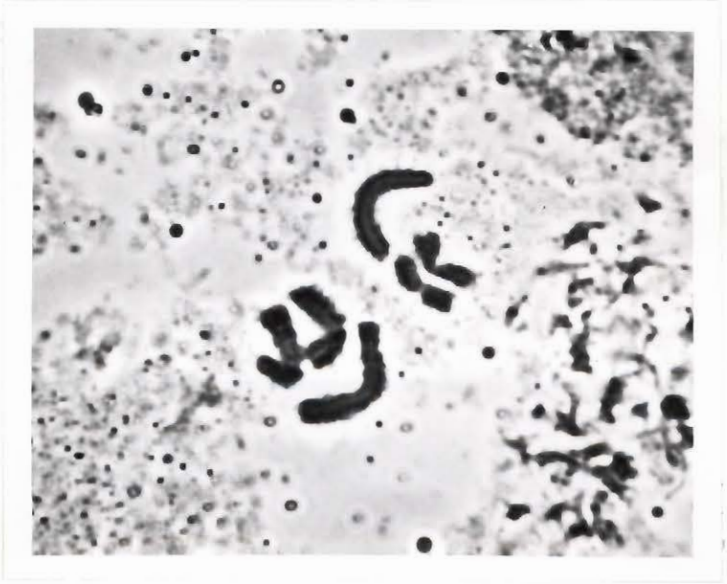


Figure 7. Mitotic metaphase chromosome complement of Rivellia prob. viridulans R.-D. from the ovary of an adult female, X 2250.

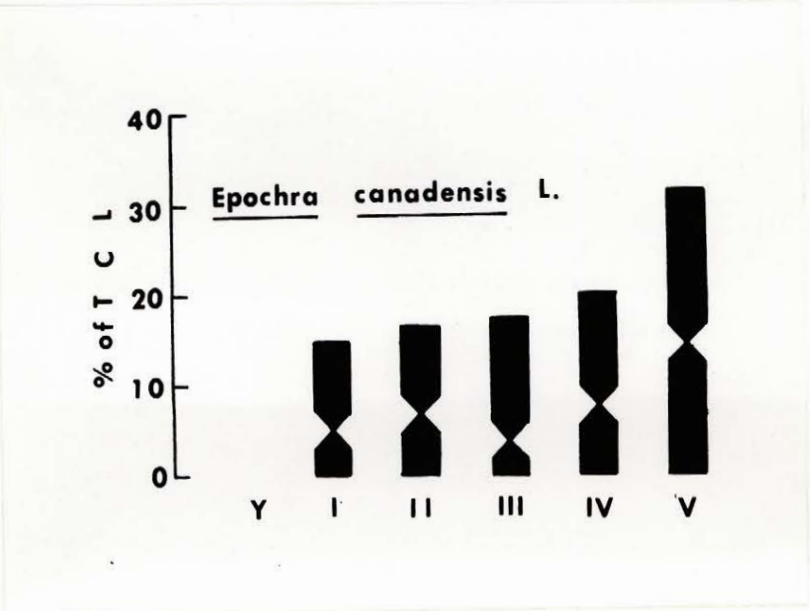
somes were all found in median region, but the length of Pairs II and III were distinctly different. The most distinguishing characteristic of this karyotype was the very long X-chromosome, which appeared as the longest chromosome in the complement. Even more surprising is the fact that in no case was any indication of a centromere found along the X-chromosome. The other reason supporting the X-chromosome's being telocentric is that in most cases one end of the X-chromosome was narrower. This deduction is further strengthened by the observation there was a hint from three poor anaphase figures. The X-chromosomes in most cases were not paired and in several cases were found to be heterochromatic.

The results of chromosome analysis are shown in Table 1, Idiogram 7, and a mitotic metaphase picture is given in Figure 7.

Epochra canadensis L.

Adults collected in British Columbia were used for cytological study. Eight mitotic metaphase figures from an ovary were analysed. The results of the analysis are shown in Table 1, Idiogram 8, and a mitotic metaphase picture can be seen in Figure 8.

$2n = 10$ was obtained in each of the eight figures analysed. The average TCL was 71.80 μ. The length differences between Pairs I, II and III were not obvious. However, Pair III differed from Pair IV by 2.8% of TCL. An even more distinct length difference (11.3% of TCL) was found between Pair IV and V. Pair I had its centromere in a subterminal region. The centromeres of other chromosomes in the



Idiogram 8

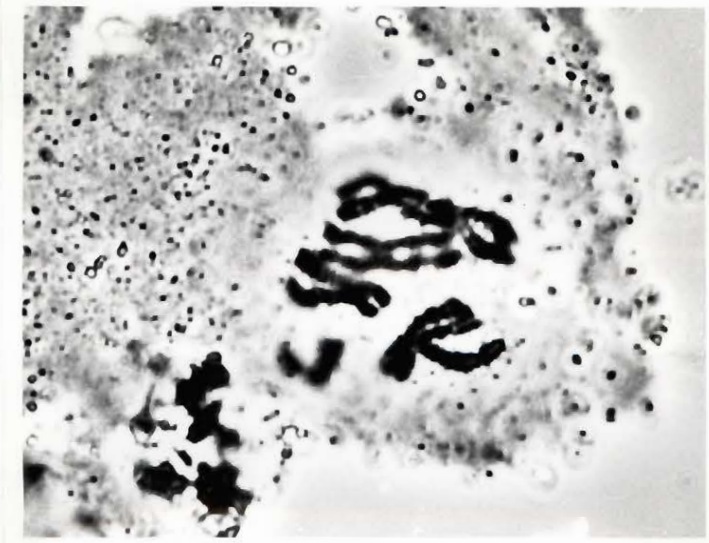


Figure 8. Mitotic metaphase chromosome complements of Epochra canadensis L. from the ovary of an adult female, X 2250.

complement were found in the median region. Pair I was not well paired in some cases.

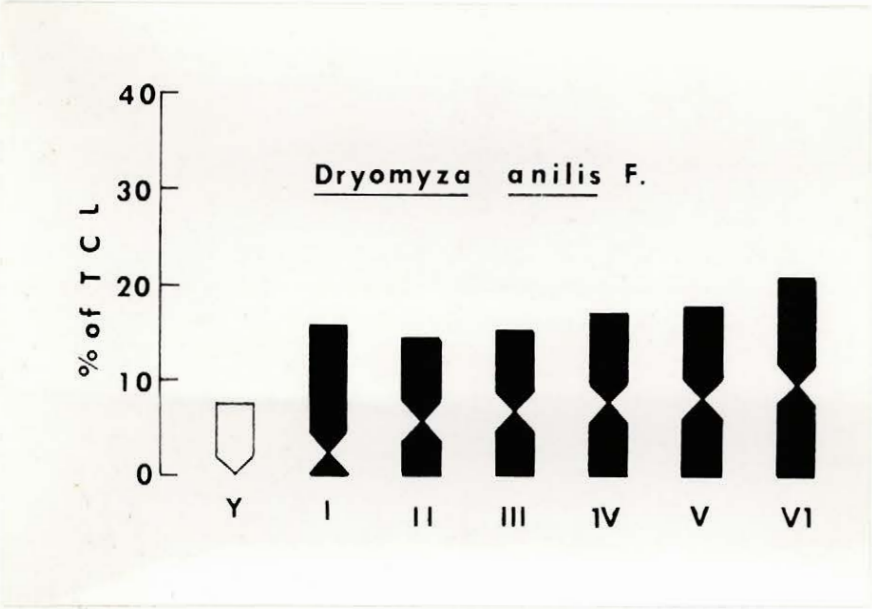
The karyotype of this species, as well as individual chromosomes in the complement, was peculiar and easily recognized.

Dryomyza anilis F.

Collections obtained from Czechoslovakia in August of 1965 were used for cytological study. Six mitotic metaphase figures from a testis were analyzed. The results of the analysis are shown in Table 1, Idiogram 9, and a mitotic metaphase picture is given in Figure 9.

The average TCL was 75.71 μ. $2n = 12$ was found in each of the six complements analysed. Four metaphase II figures were also obtained, in which one figure showed five autosomes plus one X-chromosome. The other three figures showed five autosomes plus a Y-chromosome. Pair II differed from Pair III by only 1.2% of TCL; Pair IV differed from Pair V by only 0.7% of TCL, while Pair III differed from Pair IV by about 1.6% of TCL. The difference between Pair V and Pair VI was 2.8% of TCL. All the centromeres of the autosomes were found in the median region; however, Pairs II and V had relatively higher arm ratios than the rest of the complement. Pair IV gave the lowest arm ratio.

The X-chromosome in this species was the only chromosome which had a centromere in the subterminal region. It was very easily recognised by this criterion alone. It was slightly longer than



Idiogram 9

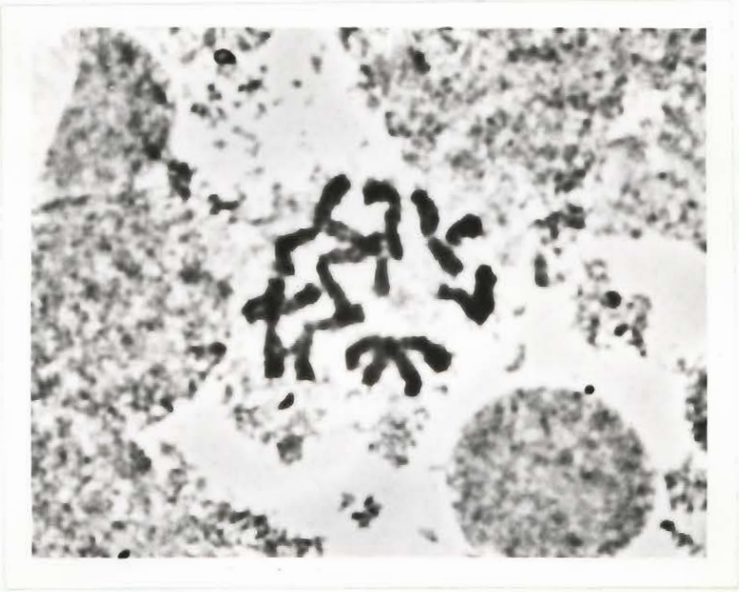


Figure 9. Mitotic metaphase chromosome complement of Dryomyza anilis F. from the testis of an adult male, X 2250.

Pair III. The Y-chromosome was the shortest in the complement and was presumably telocentric.

Atrichomelina pubera L.

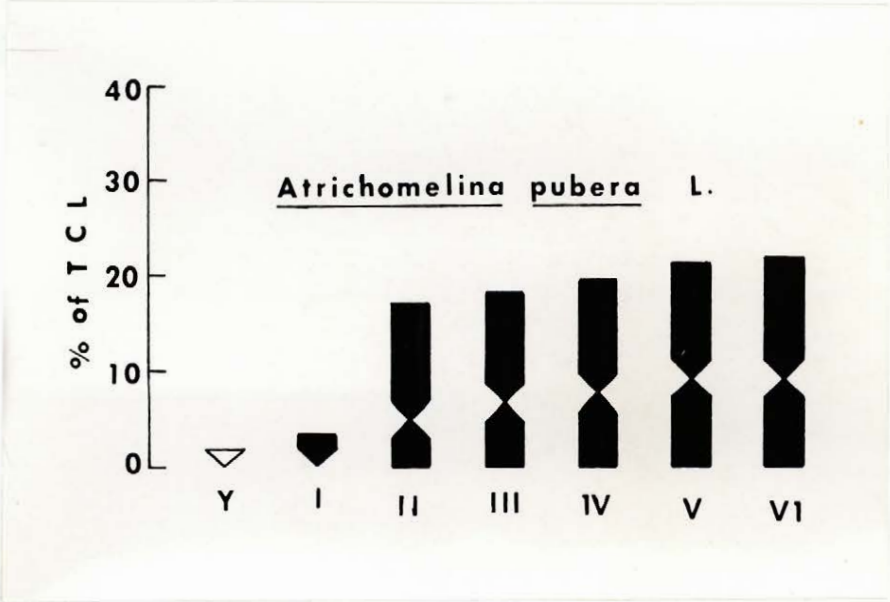
Collections from Ithaca, New York were used for cytological studies. Twelve chromosomes were found in each of the nineteen mitotic metaphase complements studied from four presumed female and one presumed male larval brain. The results are summarized in Table 1, Idiogram 10, and a mitotic metaphase picture is shown in Figure 10.

The average TCL was 58.93 μ. The autosomes did not show any distinct differences in length, but the location of centromeres of Pairs II and III was in the submedian region, while in Pairs IV, V and VI the centromeres were in the median region. The X-and Y-chromosomes appeared as tiny spots and were presumably telocentric.

Pherbellia grisescens M.

Collections from Kabul, Afghanistan were used for cytological study. Nine mitotic metaphase figures from two pupal brains were analaysed. The results of this analysis are summarized in Table 1, Idiogram 11, and a mitotic metaphase picture is given in Figure 11.

Five pairs of autosomes and an X-X pair were found in the three figures from one pupa; while only five pairs of autosomes and one X were found for the other six figures from the remaining pupa. The Y-chromosome was not observed. The average TCL was 55.67 μ. Pair VI in this species was distinctly longer than Pair V, but the



Idiogram 10

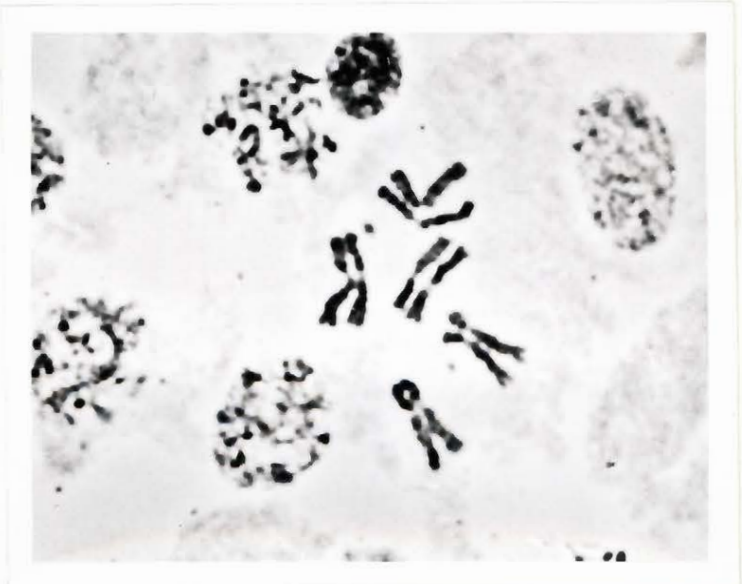
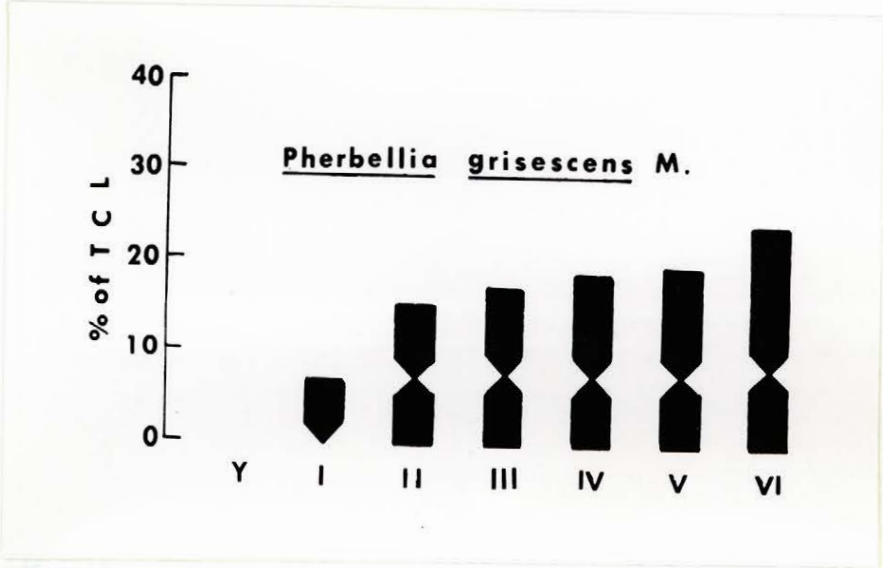


Figure 10. Mitotic metaphase chromosome complement of Atrichomelina pubera L. from a larval brain, X 2250.



Idiogram 11

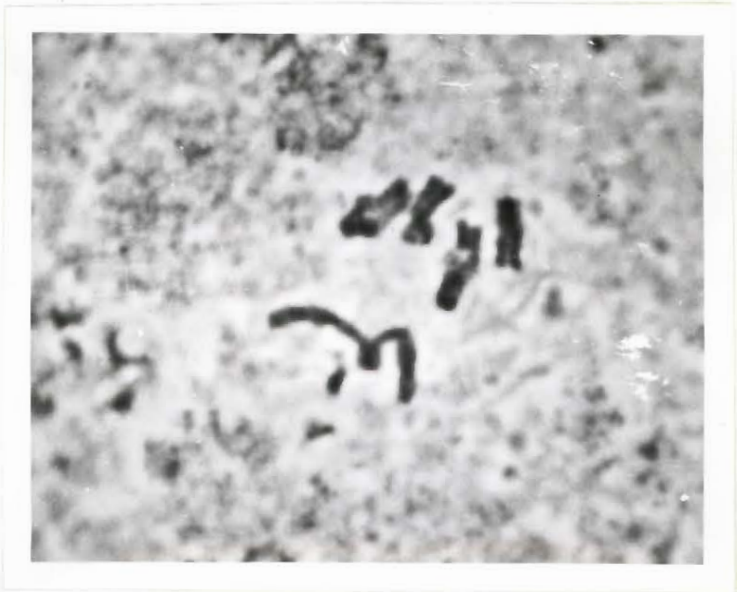


Figure 11. Mitotic metaphase chromosome complements of Pherbellia grisescens M. from a pupal brain, X 2250.

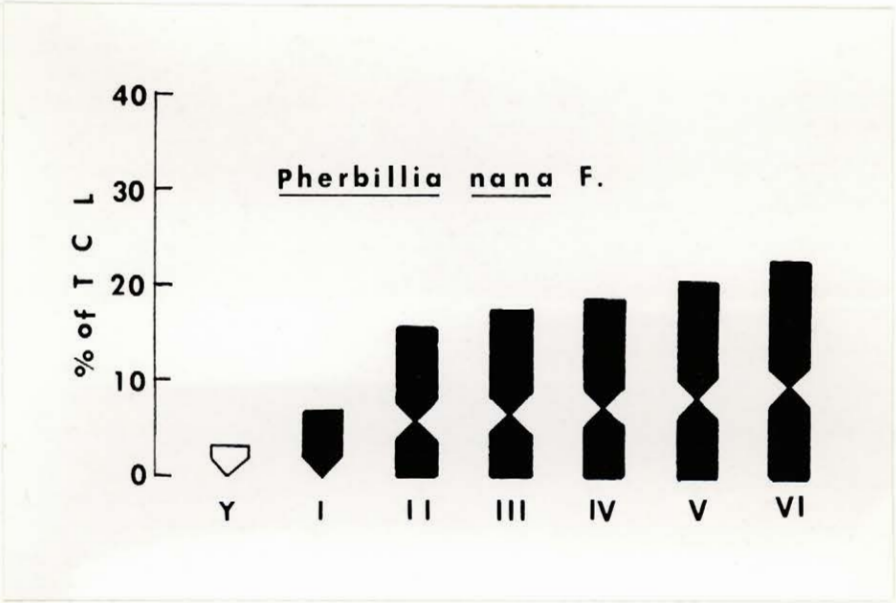
length difference between the other two adjacent pairs of autosomes was not obvious. Pair II and Pair IV had a very similar arm ratio of 1.19 and 1.17 respectively; also Pair IV and Pair V had similar arm ratios of 1.48 and 1.58 respectively. On the other hand, Pair VI had a higher arm ratio of 1.72, and its centromere was closer to the submedian region.

The X-chromosome was less than one half the length of Pair II. One end of this chromosome was narrow, indicating that perhaps this X-chromosome was telocentric. Occasionally a secondary constriction was observed near the narrow end of the chromosome.

Pherbellia nana F.

Collections from Ithaca, New York were used for this study. Nine mitotic metaphase figures from three presumed male larval brains were analysed and the results are summarized in Table 1, Idiogram 12, and a mitotic metaphase picture is given in Figure 12.

In all cells five pairs of autosomes plus an X-and Y-chromosome were found. The average TCL was 51.21 μ. The centromeres of the autosomes were all in the median region, and the difference in length between each two adjacent pairs was not distinct. Pair II differed from Pair III by only 1.5% of TCL, Pair III differed from Pair IV by 1.1% of TCL, Pair IV differed from Pair V by 1.9% of TCL and Pair V differed from Pair VI by 1.9% of TCL. The X-chromosome was much shorter than any of the autosomes and was presumably telocentric. The Y-chromosome in this species was observed as a small dot and did not stain very darkly at mitotic metaphase.



Idiogram 12

Figure 12. Mitotic metaphase chromosome complement of Pherbellia nana F. from a larval brain, X 2250.

Pherbellia new sp.

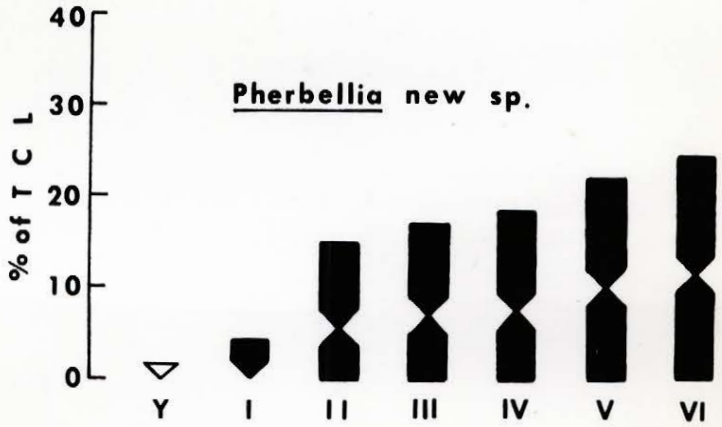
Thirteen mitotic metaphase figures from the pupal brain of two presumed males were analysed. The results are shown in Table 1, Idiogram 13, and a mitotic metaphase picutre is shown in Figure 13.

The average TCL was 48.27 μ. $2n$ = 12 was obtained in each of the thirteen complements. The length differences between Pairs II, III and IV were not obvious; while those differences between Pairs IV, V and VI were more conspicuous. Pair VI was 2.9% of TCL longer than Pair V; Pair V 3.6% of TCL longer than Pair IV; Pair IV 1.4% of TCL longer than Pair III; and Pair III 2.2% of TCL longer than Pair II. The locations of the centromeres of the autosomes of this species were in the median region. However, Pair II had a higher arm ratio than the other members of the complements, while Pair V had a lower arm ratio.

The X-chromosome in this species was very small. The narrowing at one end of it was presumed to indicate the position of the centromere. A secondary constriction was found close to this narrower end of the X-chromosome in two complements analysed. The Y-chromosome, though small, was recognizable in every complement analysed.

Antichaeta melanosoma M.

Cytological studies were performed on specimens from Ithaca, New York. Ten mitotic metaphase figures from a presumed female larval brain were analysed. The results are summarized in Table 1, Idiogram 14, and a mitotic metaphase picture is given in Figure 14.



Idiogram 13

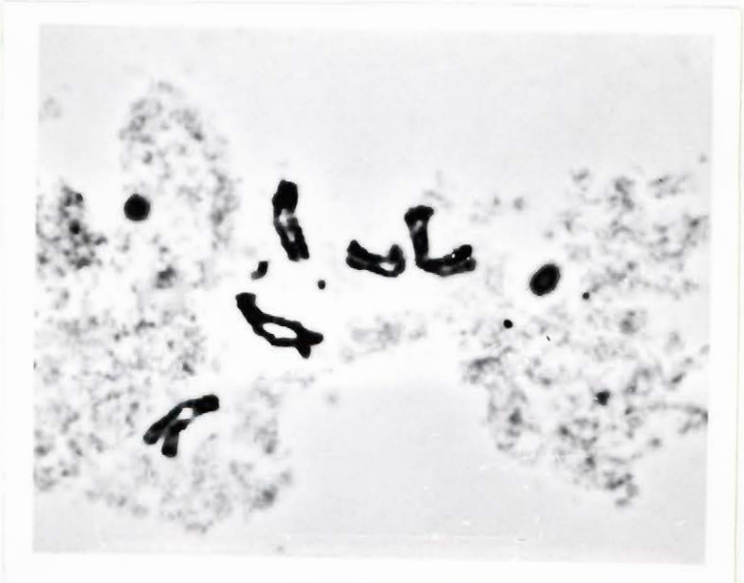
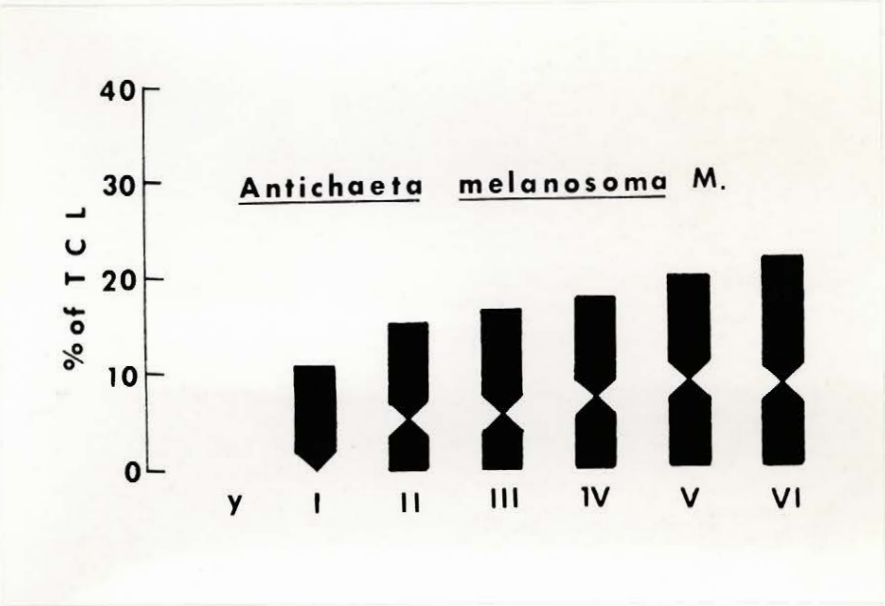


Figure 13. Mitotic metaphase chromosome complements of Pherbellia new sp. from a pupal brain, X 2250.



Idiogram 14

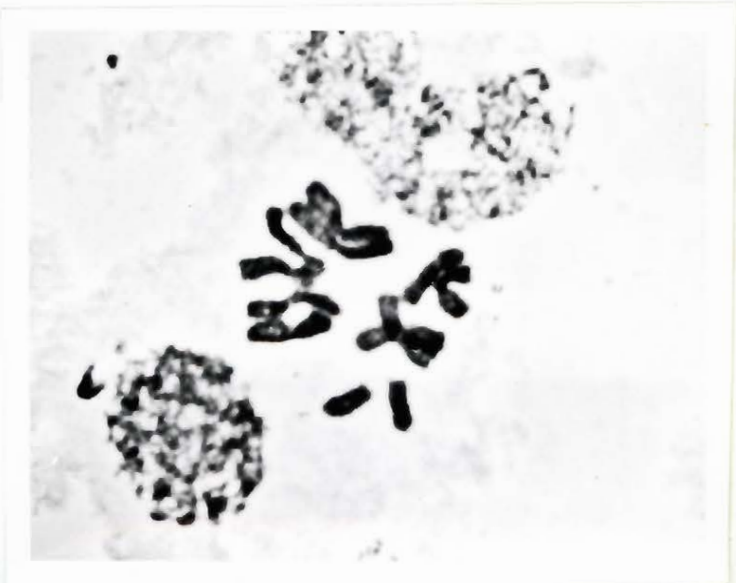


Figure 14. Mitotic metaphase chromosome complement of Antichaeta melanosoma M. from a larval brain, X 2250.

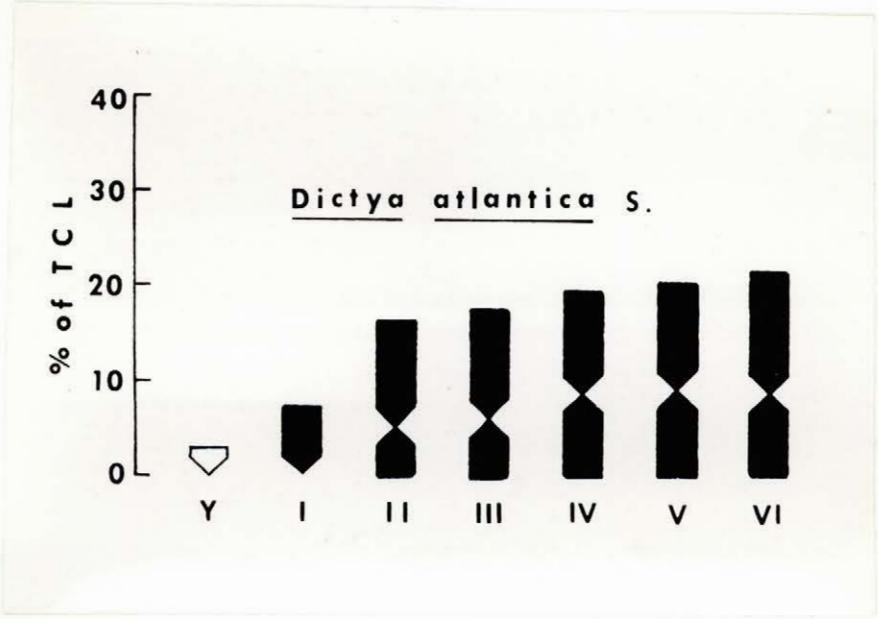
Twelve chromosomes were found in every figure studied. The average TCL was 74.19 μ. The centromeres of Pairs II and III were found in the median region. In pairing assignment, the pairs were found gradually increasing in length, but the length difference between the shortest pair and longest pair was considerable.

The X-chromosome was found to be about two-thirds the length of Pair II. This chromosome was presumed to be telocentric and in several cases, a secondary constriction was found in the median region. In a few cases this constriction was submedian, but in no case did the two constrictions occur together. Therefore, whether there is only one constriction or two independent constrictions is not known.

Dictya atlantica Steyskal

Collections from Scranton, Pennsylvania, U.S.A. were used for this study. The analysis was based on fourteen mitotic metaphase figures obtained from the larval brains of one presumed female, and four presumed males. The results of the analysis are summarized in Table 1, Idiogram 15, and a mitotic metaphase picture is given in Figure 15.

The average TCL was 61.01 μ. The differences in the length of autosomes were not obvious. Pair II constituted 16.0% of TCL, with similar measurements for Pairs III, IV, V, and VI being 17.2%, 19.0%, 20.1% and 21.1% of TCL respectively. The centromeres of Pairs IV, V and VI were in the median region, while the centromeres of Pairs II and III were in the submedian regions. Pair II had an arm ratio of



Idiogram 15

Figure 15. Mitotic metaphase chromosome complement of Dictya atlantica s. from a larval brain, X 2250.

2.02, Pair III 1.88, Pair IV 1.22, Pair V 1.29 and Pair VI 1.47.

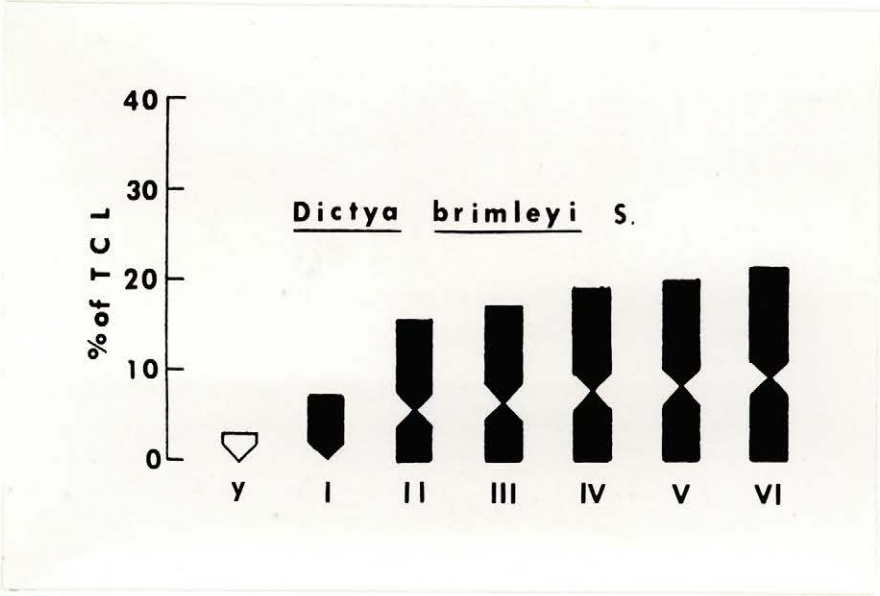
The X-chromosome constituted 6.7% of TCL. No sign of constriction was found along the entire length of the X-chromosome. However, in two cases, the X-chromosome was narrower at one end, presumably this end carried the centromere. The Y-chromosome appeared as a small dot corresponding to 3.1% of the TCL.

Dictya brimleyi Steyskal

Collections from Scranton, Pennsylvania, U.S.A. were used for analysis. The study was based on ten mitotic metaphase figures from the larval brains of two presumed males. The results of the analysis are summarized in Table 1, Idiogram 16, and a mitotic metaphase picture is shown in Figure 16.

All ten complements analyzed contained twelve chromosomes each, the average TCL measured 58.47 μ. The differences in length of the autosomes were not distinct. Pair II was only 1.2% of TCL shorter than Pair III; Pair III was 1.7% of TCL shorter than Pair IV; Pair IV was 1.3% of TCL shorter than Pair V; and Pair V was 1.4% of TCL shorter than Pair VI. The centromeres of Pairs IV, V and VI were in the median region, while the centromeres of Pairs II and III were in the submedian region. Furthermore, the arm ratio of Pair II was much higher than that of Pair III. Pair V had a higher arm ratio than Pair IV and similarly, Pair IV was higher than Pair VI.

The X-chromosome was less than one half the length of Pair II and constituted only 7.1% of TCL. It was presumed to be telocentric;



Idiogram 16

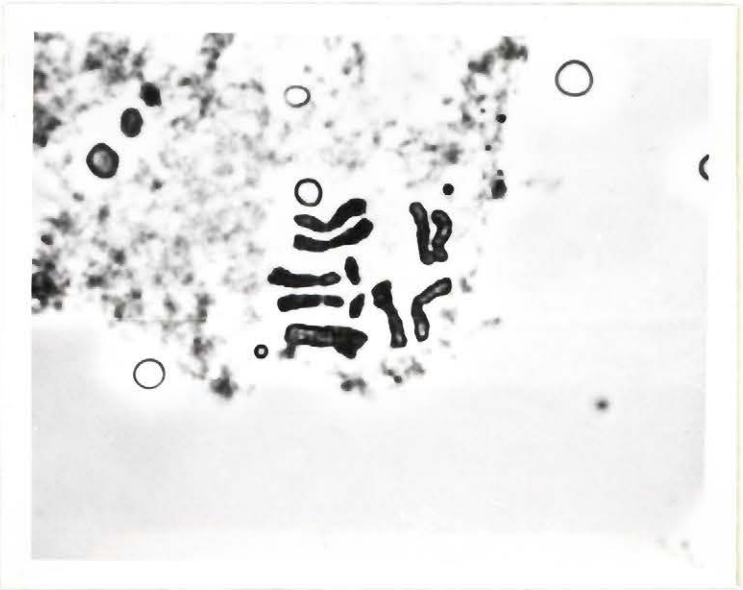


Figure 16. Mitotic metaphase chromosome complement of Dictya brimleyi S. from a larval brain, X 2250.

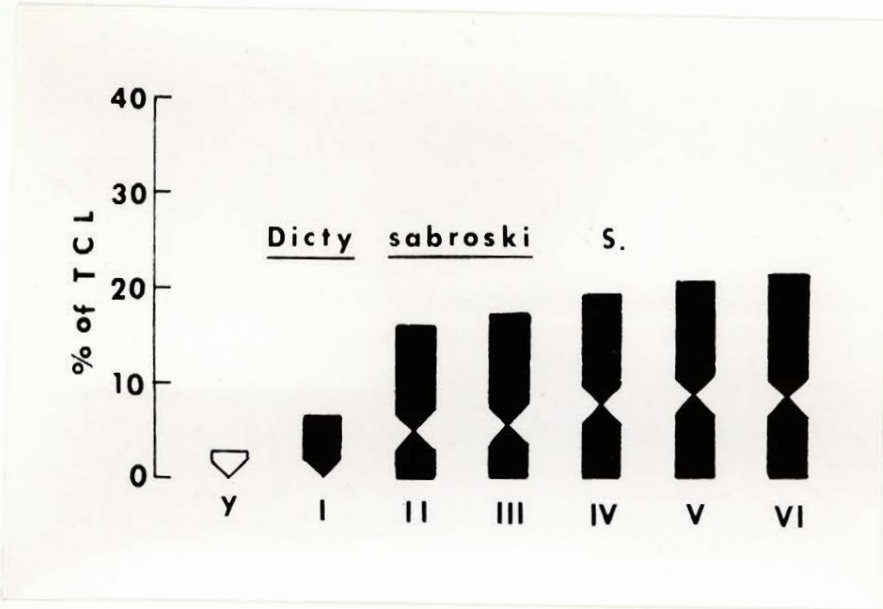
however, a constriction was observed in the submedian region in four of the ten cells analysed. The Y-chromosome showed as a very small dot, corresponding to 3.1% of TCL and was presumed to be telocentric.

Dictya sabroski Steyskal

Collections from Lebanon, Mo., and Collinsville, Illinois were used for the chromosome analysis of this species. Although more than forty clear mitotic metaphase figures were obtained from the larval brain preparation, only eleven figures from two presumed female larvae and three male larvae were used for detailed examination. The results are summarized in Table 1, Idiogram 17, and a mitotic metaphase picture is given in Figure 17.

$2n = 12$ was obtained in every figure. The average TCL was 60.78 μ. The length differences in the autosomes were not very obvious; Pair VI was only 1.2% of TCL longer than Pair V, Pair V 1.1% of TCL longer than Pair IV; Pair IV 1.9% of TCL longer than Pair III, and Pair III 1.2% of TCL longer than Pair II. The centromeres of Pairs IV, V and VI were in the median region, with those of Pairs II and III being in the submedian region. Pair II had a higher arm ratio than Pair III; while Pair VI had an arm ratio higher than Pairs IV and V. However, the arm ratios of Pairs IV and V were not appreciably different.

The X and Y chromosomes in this species were telocentric. This observation was confirmed by several mitotic anaphase figures, in which the daughter X-and Y-chromosomes were straight and with no



Idiogram 17

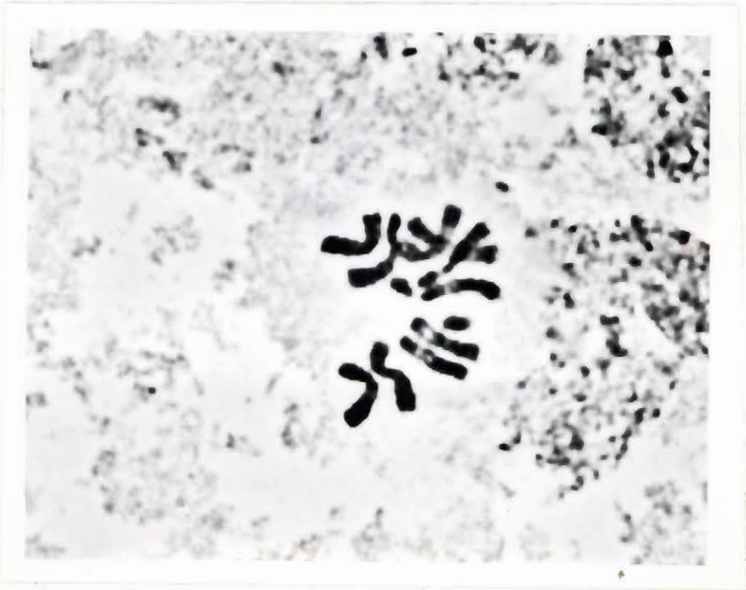


Figure 17. Mitotic metaphase chromosome complement of Dictya sabroski S. from a larval brain, X 2250.

bending at the pulling points. The X-chromosome was 9.7% of TCL shorter than Pair II. The Y-chromosome appeared as a very small dot and was quite often difficult to locate.

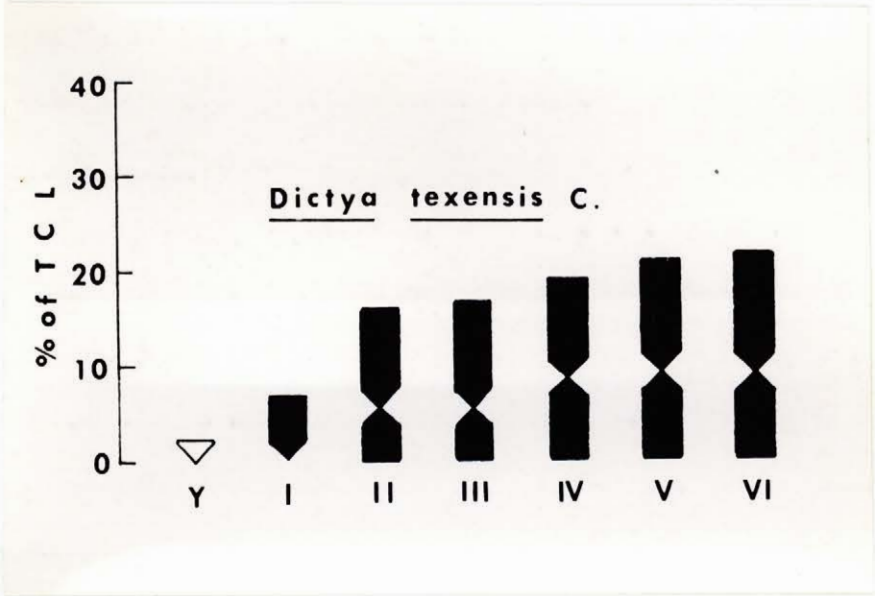
Dictya texensis Curran

Collections from Lubbock, Texas, U.S.A. were used for these studies. Thirteen mitotic metaphase figures from three presumed female and two presumed male larval brains were analysed. A diploid number of 12 was found for all complements. The figures were fairly clear in showing the locations of the centromeres but chromatids could not be seen. The average TCL was 74.01 μ. The results of the analysis of the chromosome complements are shown in Table 1, Idiogram 18, and a mitotic metaphase picture is given in Figure 18.

Pair II differed from Pair III by only 0.5% of TCL, and Pair III differed from Pair IV by 2.2% of TCL. The centromeres of Pairs II and III were in the submedian region, while those of Pairs IV, V and VI were in the median region. The X-chromosome in this species was telocentric, and was very short when compared with the autosome. The X-chromosome was 9.6% of TCL shorter than Pair II and in several cases had a submedian secondary constriction. The Y-chromosome in this species was evident as a small, pale staining dot.

Sepedon armipes Loew

Collections from Ithaca, New York were used for cytological analysis. Nine mitotic metaphase figures from larval brains were studied. The results are summarized in Table 1, Idiogram 19, and a mitotic metaphase picture is given in Figure 19.



Idiogram 18

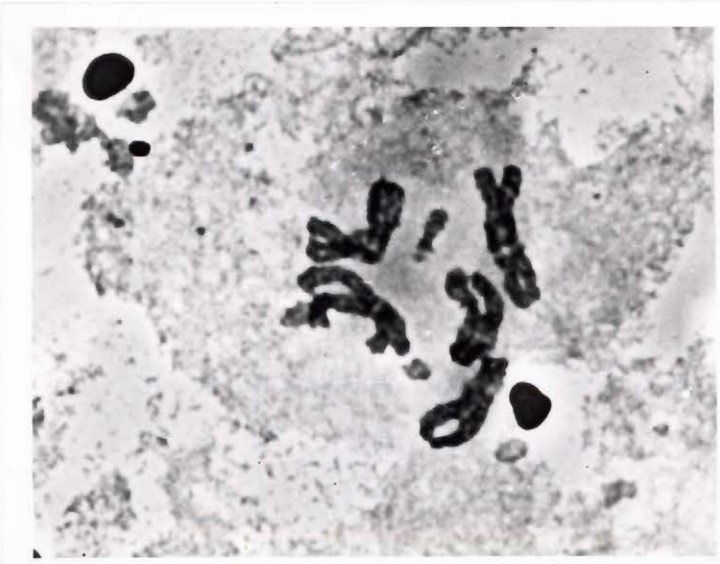
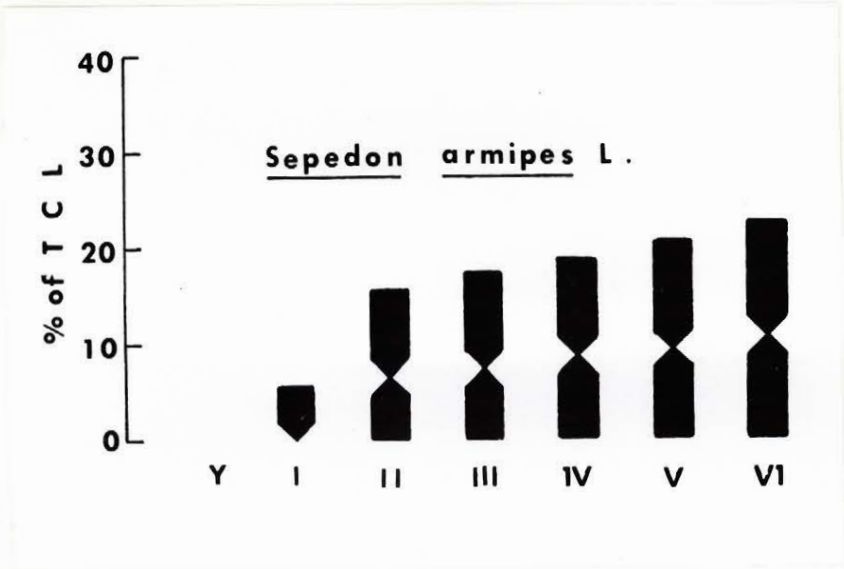


Figure 18. Mitotic metaphase chromosome complement of Dictya texensis C. from a larval brain, X 2250.



Idiogram 19

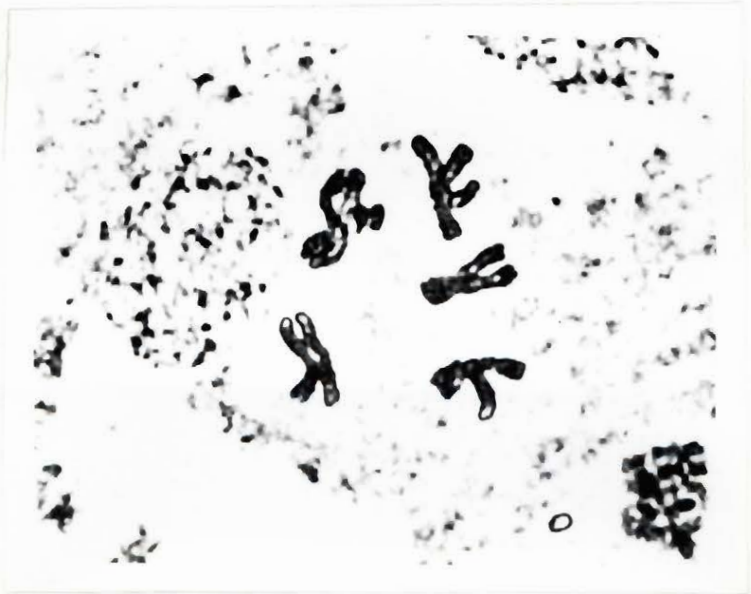


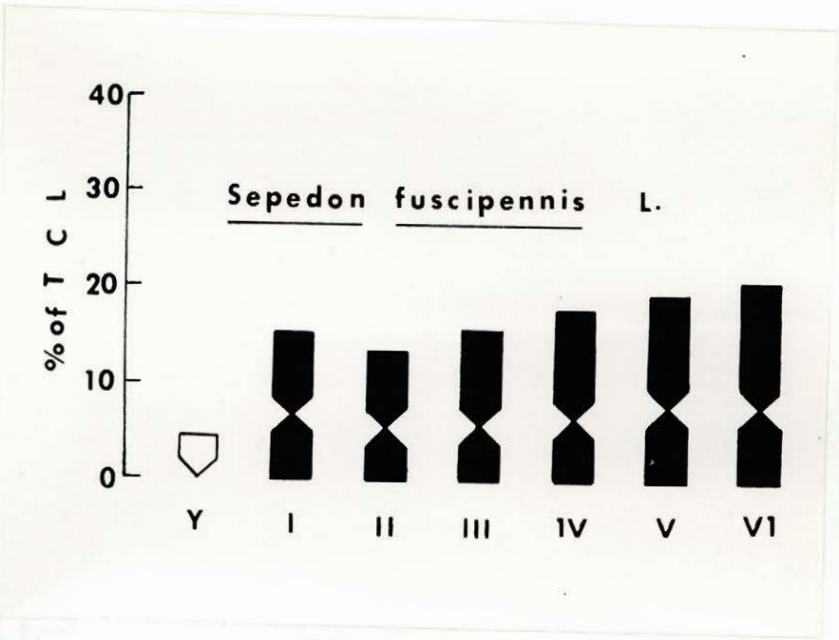
Figure 19. Mitotic metaphase chromosome complements of Sepedon armipes L. from a larval brain, X 2250.

Five pairs of autosomes were obtained in each of the complements analysed. Two X's were consistantly found in each of five figures from two larval brains; while in each of four other figures, also from larval brain, only one X was found. These latter figures did not suggest the presence of a Y-chromosome. The average TCL was 52.69 μ. The X-chromosome was telocentric and constituted only 5.7% of TCL. The arm ratios of the autosomes in this species were all very low; hence, all the centromeres of autosomes were found in the median region. Pair II differed from Pair III by 1.5% of TCL; Pair III differed from Pair IV by 1.2% of TCL; Pair IV differed from Pair V by 1.7% of TCL; and Pair V differed from Pair VI by 2.3% of TCL.

Sepedon fuscipennis Loew

Collections from Ithaca, New York were used for cytological analysis. Seven mitotic metaphase figures from larval brains of one presumed female and two presumed males were carefully studied. The results are summarized in Table 1, Idiogram 20, and a mitotic metaphase picture is given in Figure 20.

The average TCL was 83.92 μ. $2n = 12$ was found in each complement analysed. The length differences between each two adjacent autosome pairs was not large. However, it was not difficult to separate the largest pair from the shortest pair of autosomes. The X-chromosome constituted 15.0% of TCL and was about the same length as Pair III. Pair I had an arm ratio of 1.37, Pair II 1.48, Pair III 1.70, Pair IV



Idiogram 20

Figure 20. Mitotic metaphase chromosome complements of Sepedon fuscipennis L. from a larval brain, X 2250.

1.82, Pair V 1.54, and Pair VI 1.59. The Y-chromosome was about 4.2% of TCL and was presumed to be telocentric. The XX or XY chromosomes were not paired in most cases.

Tetanocera loewi Steyskal

Collections from Ithaca, New York were used for cytological study. Three mitotic metaphase figures from one testis, and two metaphase II figures from a second testis were pooled for analysis. The results are shown in Table 1, Idiogram 21, and a mitotic metaphase picture is given in Figure 21.

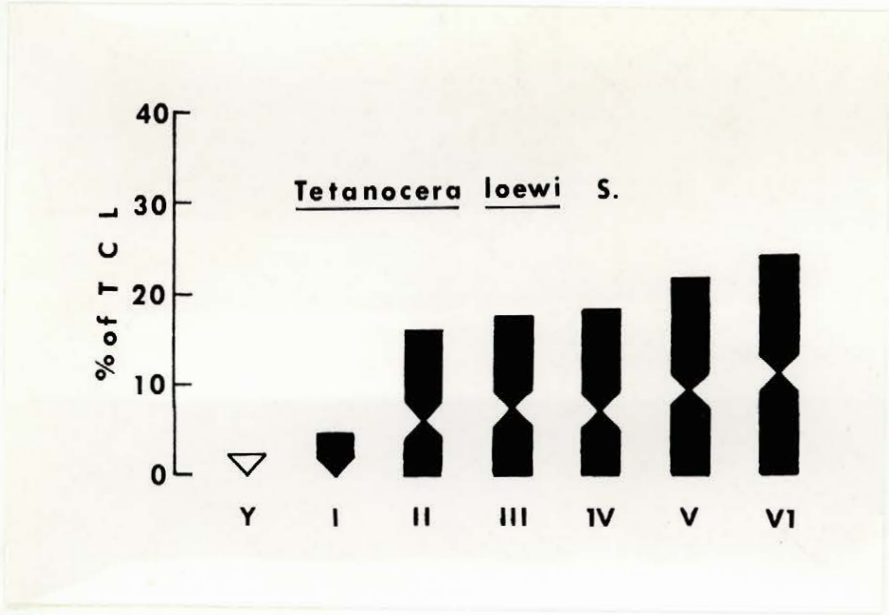
The average TCL was 79.43 μ. $2n$ = 12 was found in each of the five complements analysed. The length differences among Pairs II, III and IV were not obvious; while the difference between Pairs IV and V, and Pairs V and VI were appreciable. Pairs II, III and IV had higher arm ratios; whereas Pairs V and VI had lower arm ratios.

The X-chromosome in this species was very small compared to the autosomes, and was presumed to be telocentric. The Y-chromosome appeared as a very small dot and in some cases was difficult to locate.

Tetanocera sp.

Adults collected in British Columbia were subjects for this study. Five mitotic metaphase figures from an ovary were analysed. The results are shown in Table 1, Idiogram 22, and a mitotic metaphase picture is shown in Figure 22.

Six pairs of chromosomes were found in each of the five complements analysed. The average TCL was 107.98 μ. The length differences



Idiogram 21

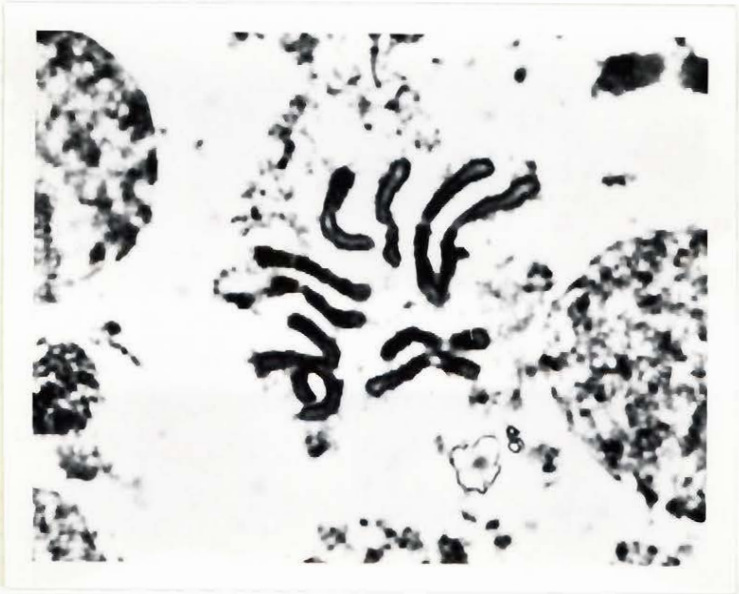
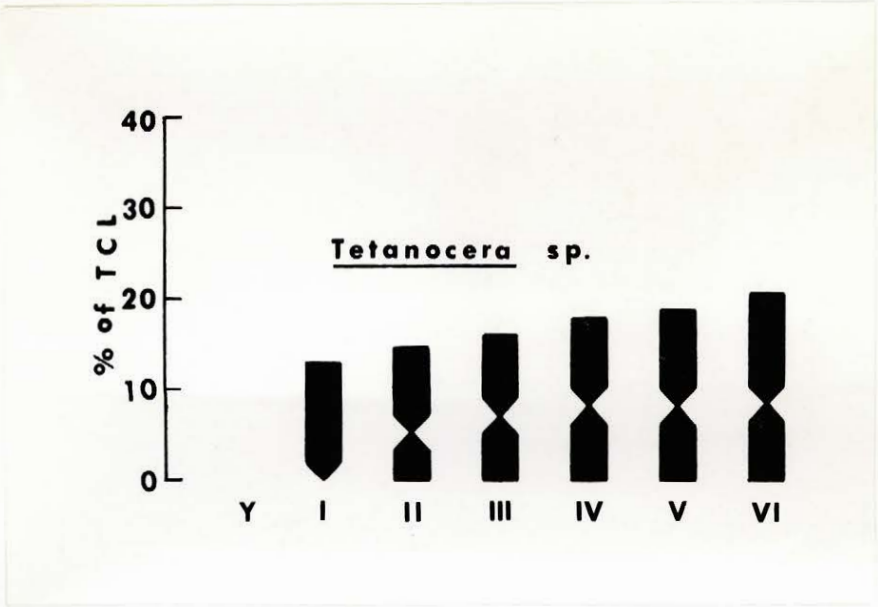


Figure 21. Mitotic metaphase chromosome complement of Tetanocera loewi S. from a larval brain, X 2250.



Idiogram 22

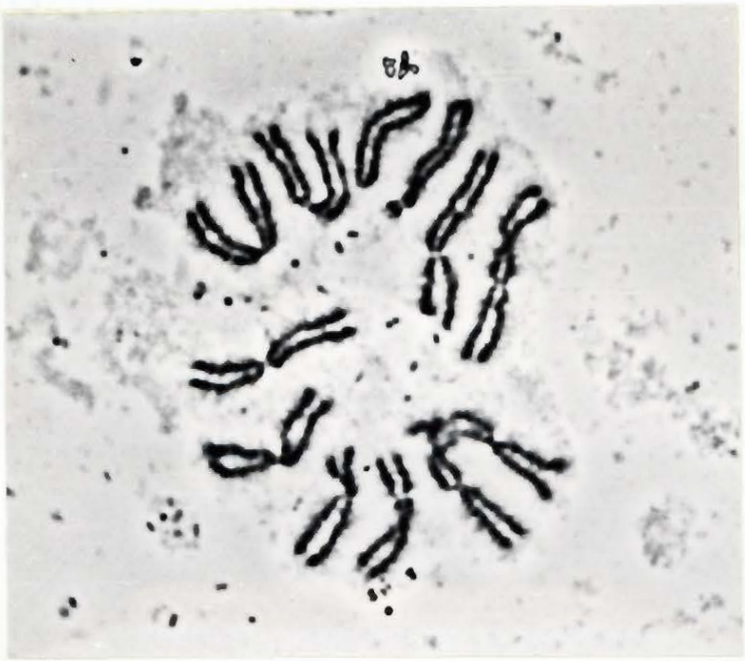


Figure 22. Mitotic metaphase chromosome complement of Tetanocera sp. from the ovary of an adult female, X 2250.

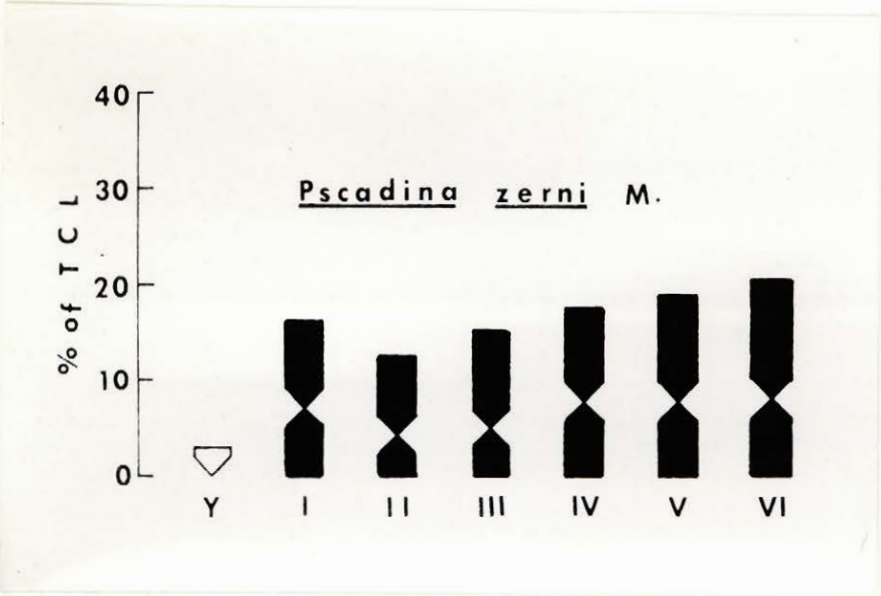
between two individual chromosomes were not obvious. Pair II constituted 14.5% of TCL, Pair III 15.9%, Pair IV 17.7%, Pair V 18.6%, and Pair VI 20.3% of TCL. Pair II had a higher arm ratio and its centromere was close to a submedian region, while the centromeres of the other autosomes were found in the median region.

The X-chromosome constituted 13.0% of TCL and slightly shorter than Pair II. Nevertheless, because it is telocentric, the X-chromosome was easily identified. A satellite was often observed in one of the X-chromosomes.

Psacadina zerni Mayer

Collections from Sor, Denmark were used for cytological analysis. Fiftenn mitotic metaphase figures from larval brains of four presumed females and one presumed male were analysed. The results of the analysis are shown in Table 1, Idiogram 23, and a mitotic metaphase picture is given in Figure 23.

The average TCL was 77.96 μ. The X-chromosome in this species was not the shortest pair in the complement. On the contrary, the length of the X-chromosome was found to lie between that of Pair III and Pair IV. The X-chromosome constituted 16.1% of TCL, Pair II 12.4%, Pair III 15.1%, Pair IV 17.4%, Pair V 18.7% and Pair VI 20.2%. The length difference between the adjacent pairs was not obvious in this species. The centromeres of Pairs IV, V and VI were in the median region; while the centromeres of Pairs II and III were in the submedian region. Furthermore, Pair VI had an arm ratio appreciably



Idiogram 23

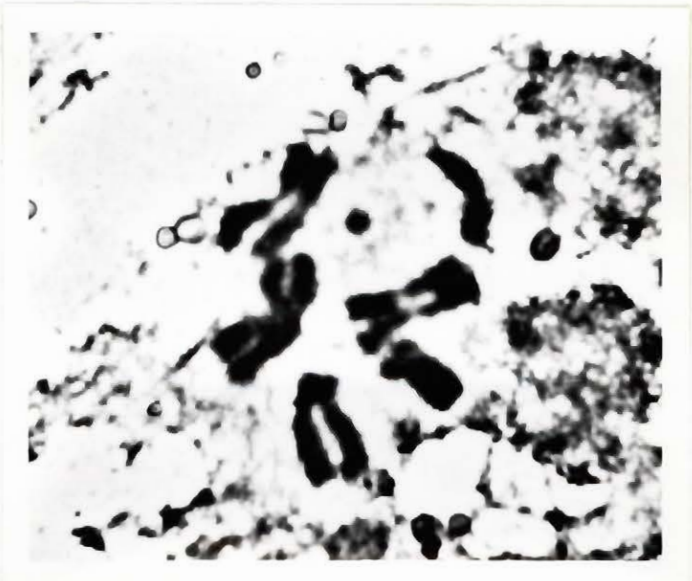


Figure 23. Mitotic metaphase chromosome complement of Pscadina zerni Mayer, from a larval brain, X 2250.

higher than Pairs IV and V. Pair III had an arm ratio higher than Pair II. The most interesting observation was that the X-chromosome had a centromere in the median region, although this was not obvious in some figures. In some very extended figures a satellite on the long arm of the X was observed. The Y-chromosome in this species appeared only as a small dot.

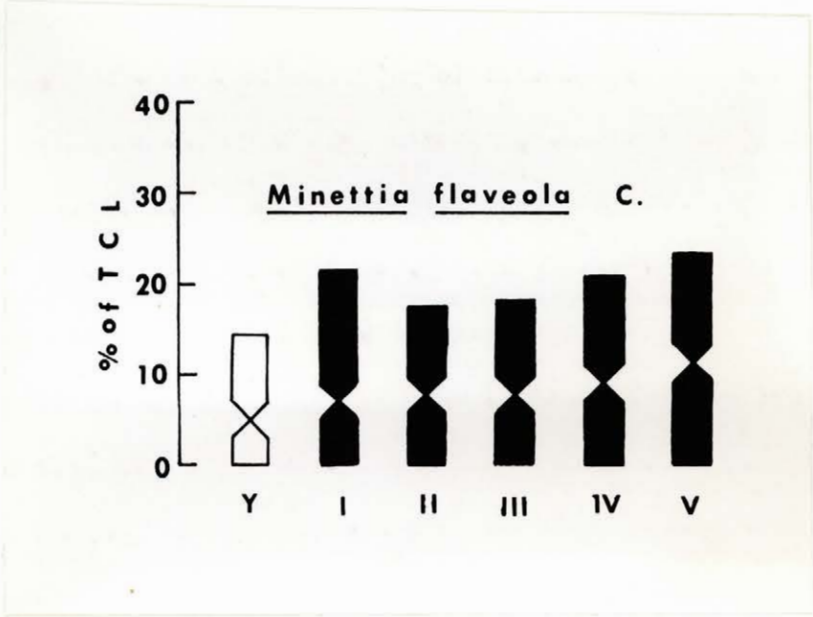
A secondary arm ratio of 1.16 based on measurements of seven chromosomes was obtained for the long arm of Pair V. The secondary constrictions in other chromosomes of this species were not recorded frequently.

Minettia flaveola Coq.

Adults were collected in Pullman, Washington, U.S.A. in 1964. Six mitotic metaphase chromosome complements from a testis were analysed. The results are shown in Table 1, Idiogram 24, and a mitotic metaphase picture is shown in Figure 24.

All figures analysed were neat and clear. In all cases the eight autosomes were well paired, while the X- and Y-chromosomes were not paired. The average TCL was 61.45 μ. The centromeres of the autosomes were all found in the median region, while the centromeres of the X- and Y-chromosome were found in the submedian regions. The locations of the centromeres were also confirmed by a very nice mitotic anaphase figure (Figure 25).

Pair II and Pair III were approximately in equal length. However, there were noticeable length differences between Pair III and Pair IV



Idiogram 24

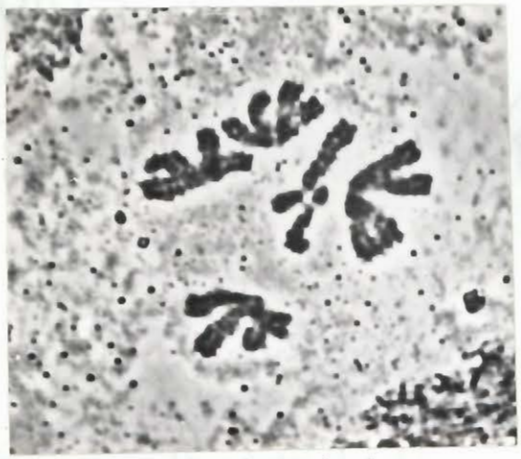


Figure 24. Mitotic metaphase chromosome complement of Minettia faveola Coq. from the testis of an adult male, X 2250.

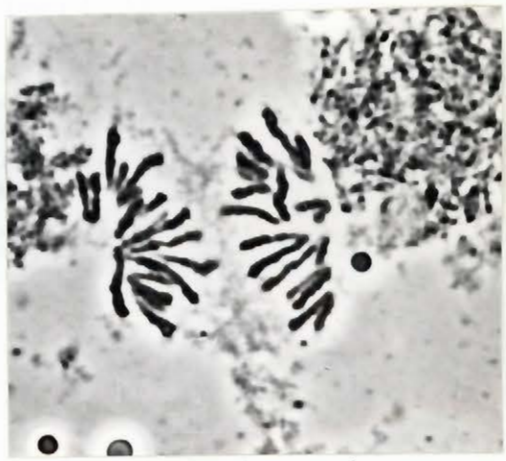


Figure 25. Mitotic anaphase chromosome complement of Minettia flaveola Coq. from the testis of an adult male, X 2250.

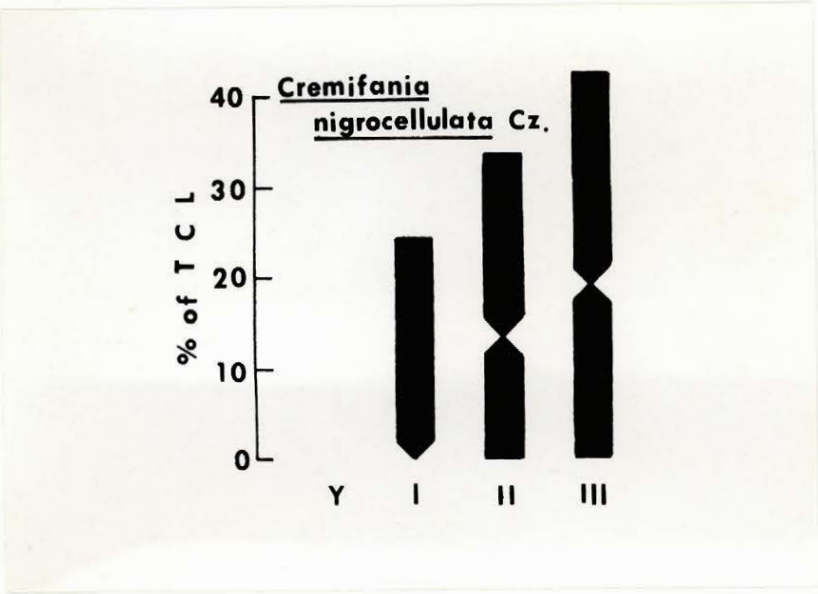
as well as Pair IV and Pair V. The X-chromosome was quite long in this species. It constituted 21.4% of TCL and was just 1.5% of TCL shorter than Pair V. The Y-chromosome was also long and corresponded to 14.3% of TCL.

Cremifania nigrocellulata Cz.

Larvae were obtained from Winterthur, Switzerland. Ten mitotic metaphase figures from six larval brains were drawn with a camera lucida and then analysed. The results of the analysis are shown in Table 1, Idiogram 25, and a mitotic metaphase picture is given in Figure 26.

Six chromosomes were obtained in each complement analysed. The average TCL was 27.19 μ. Pair II differed from Pair III by 8.8% of TCL. The centromeres of both Pair II and Pair III were found in the median region. Nevertheless, Pair II had a higher arm ratio (1.42) than Pair III (1.20).

The shortest pair in the complement was assumed to be the sex pair of chromosomes; they were characterized by their poor pairing in most of the cases. A mitotic anaphase figure was obtained which showed very clearly that the sex chromosomes were telocentric. One sex chromosome was 95% (averaged from ten figures) of the other in length. It is postulated that the Y-chromosome of this species is but 1.2% of TCL shorter than the X-chromosomes. Otherwise, both chromosomes in question in all the ten figures from six larvae were X-chromosomes. A secondary constriction was often observed in the sex chromosomes but its location was not consistent.



Idiogram 25

Figure 26. Mitotic metaphase chromosome complement of Cremifania nigrocellulata Cz. from a larval brain, X 3500.

Leucopmyia obscura H.

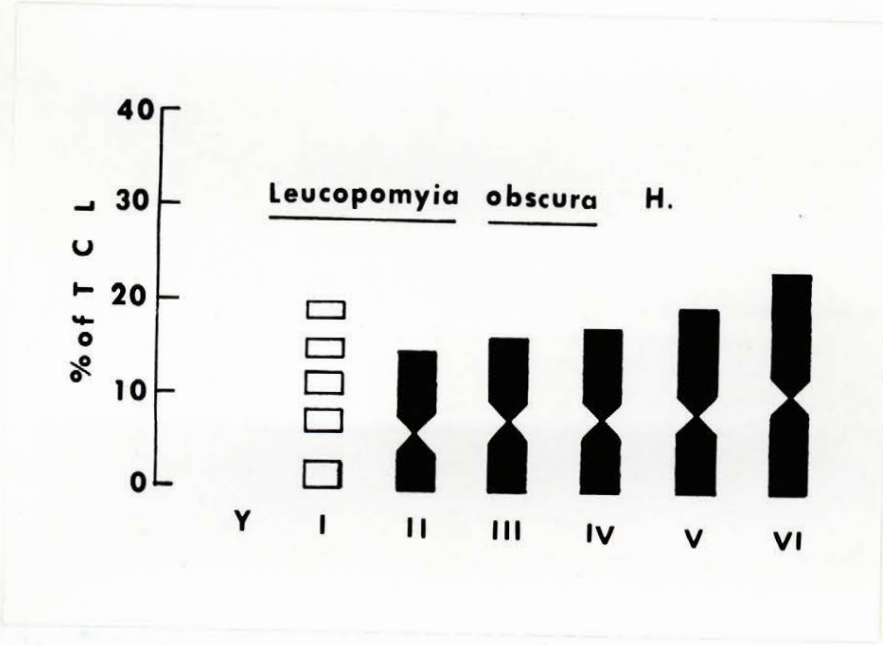
Six mitotic metaphase figures from three larval brains were drawn by camera lucida and were analysed. Five pairs of autosomes and five microchromosomes were found in each of the six figures analysed. In analysing the chromosome complement of this species, the five microchromosomes were put together as Pair I. The results of the analysis are summarized in Table 1, Idiogram 26, and a mitotic metaphase picture can be seen in Figure 27.

The average TCL was 46.86 μ. Pair VI was 3.8% of TCL longer than Pair V; Pair V was 2.1% of TCL longer than Pair IV; Pair IV was 1.0% of TCL longer than Pair III, and Pair III was 1.8% of TCL longer than Pair II. The centromeres of the autosomes were all found in the median regions. The average II-VI arm ratio was only 1.25.

The five microchromosomes constituted 3.0%, 2.2%, 2.1%, 1.9% and 1.7% of TCL respectively. In four of the six figures a constriction in the centre of each of the five microchromosomes was observed. These microchromosomes may possibly be involved in the sex determination. It would be interesting to see their behavior in the meiotic division.

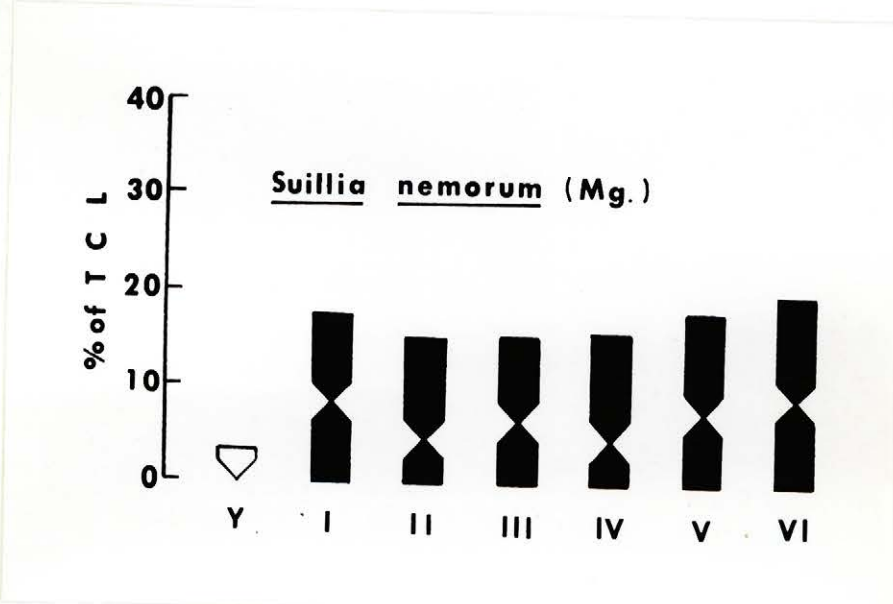
Suillia nemorum (Mg.)

Adults collected in British Columbia in 1964 were used for this study. Seven mitotic metaphase figures were obtained from the testis of an adult fly. Surprisingly enough, these seven figures can be divided into two cell populations. One population (three figures) showed a long X-chromosome with a centromere in its median region,



Idiogram 26

Figure 27. Mitotic metaphase chromosome complement of Leucopomyia obscura H. from a larval brain, X 3500.



Idiogram 27

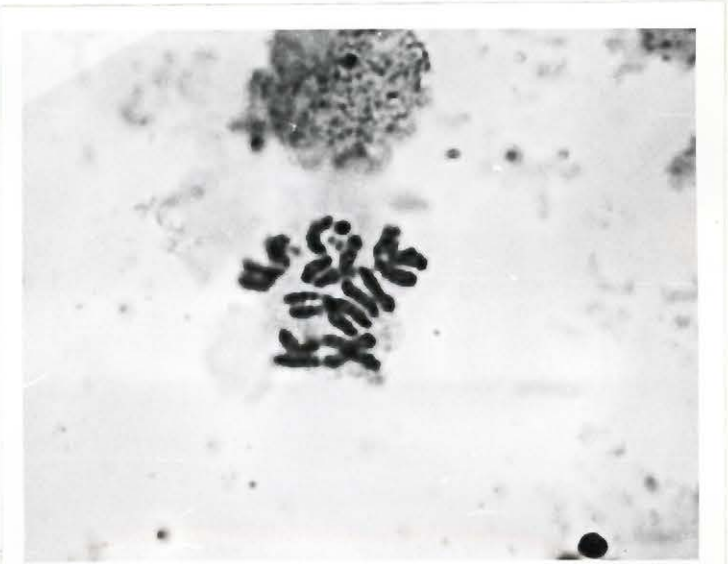
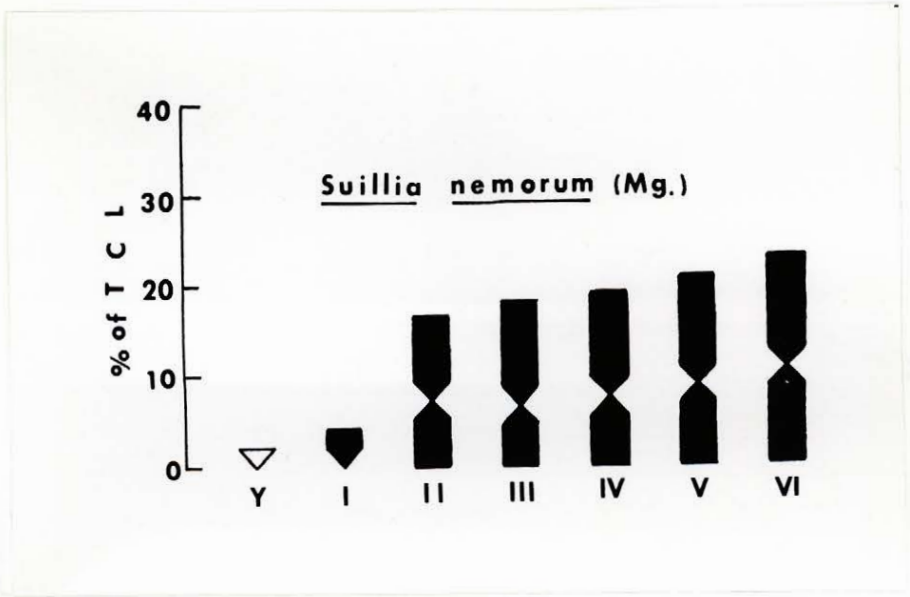


Figure 28. Mitotic metaphase chromosome complement of Suillia nemorum (Mg.) from the testis of an adult male, showing the long x-chromosome, X 2250.



Idiogram 28

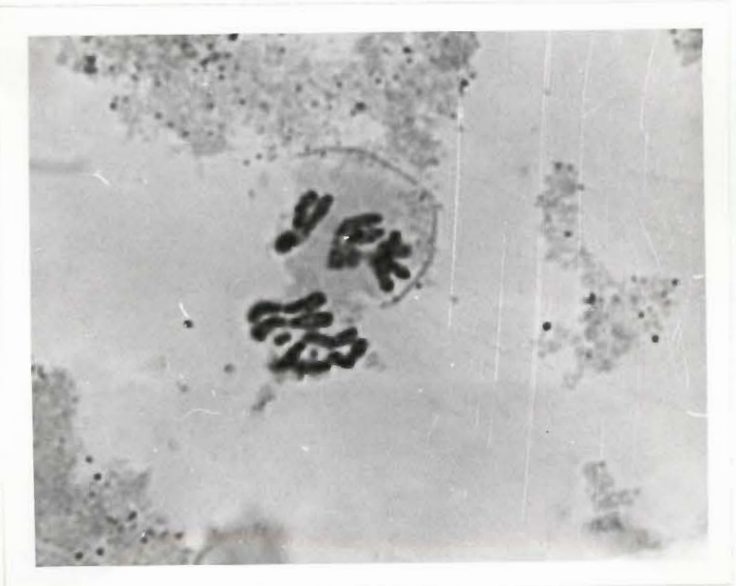


Figure 29. Mitotic metaphase chromosome complement of Suillia nemorum (Mg.) from the testis of an adult male, showing the short x-chromosome, X 2250.

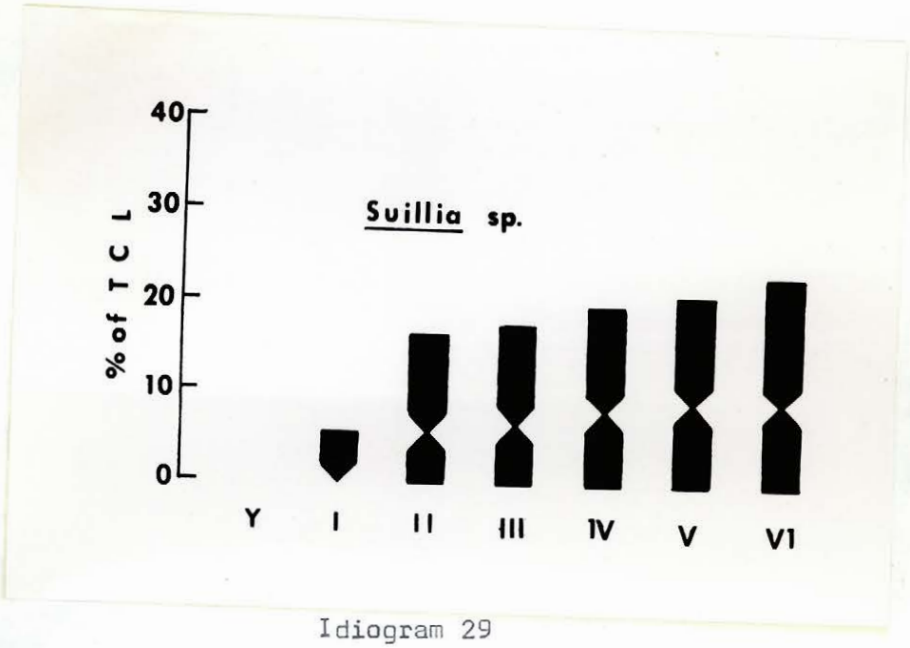
while the other (four figures) had a short, telocentric X-chromosome. The two cell populations were therefore analysed separately. After discarding two distorted figures, two figures from the long X-chromosome cell population and three figures from the short X-chromosome cell population were analysed. The results of this analysis are summarized in Table 1, Idiogram 27 and 28. Two mitotic metaphase pictures from the two cell populations are given in Figure 28 and 29.

Both cell populations agreed with $2n = 12$. However, the average TCL and average II-VI arm ratio were completely different in the two populations of cells. Since only a limited number of flies and cells were analysed, these observations require further confirmation. It would be very interesting if these observations proved to be true.

Suillia sp.

Adults were collected in British Columbia in 1964. Four mitotic metaphase figures from an ovary were analysed. The results are shown in Table 1, Idiogram 29, and a mitotic metaphase picture is given in Figure 30.

The average TCL was 52.88 μ. Twelve chromosomes were found in each complement analysed. Pair II differed from Pair III by only 0.9% of TCL; Pair III differed from Pair IV by 1.9% of TCL; Pair IV differed from Pair V by 1.4% of TCL; and Pair V differed from Pair VI by 2.5% of TCL. The centromere of Pair II was close to the submedian



Idiogram 29

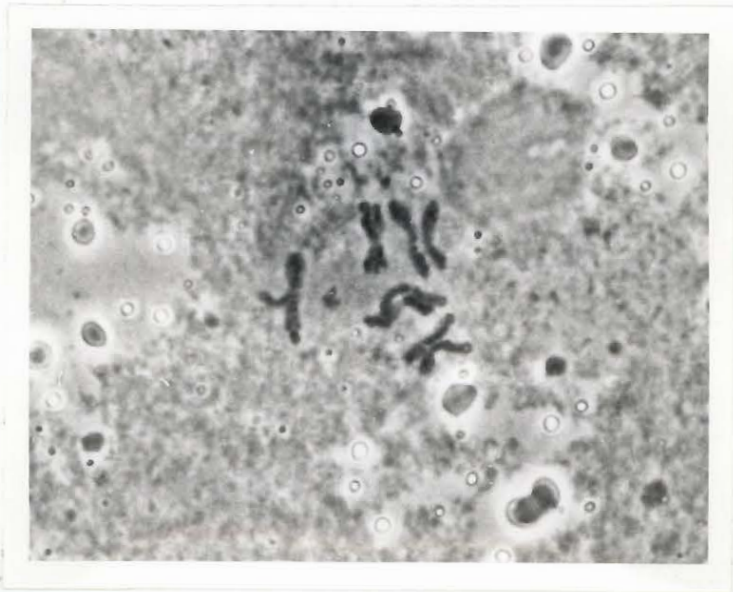


Figure 30. Mitotic metaphase chromosome complement of Suillia sp. from the ovary of a female adult, X 2250.

region; whereas, the centromeres of the other autosomes were in the median region. Furthermore, Pair III and Pair VI had higher arm ratios; while Pairs IV and V had lower arm ratios.

The X-chromosome was a small telocentric dot-like configuration.

Cordilura ciliata

Adult specimens were collected in Czechoslovakia in August of 1965. Five metaphase I figures from a testis were analysed, and the results are shown in Table 1, Idiogram 30. A metaphase I picture is shown in Figure 31.

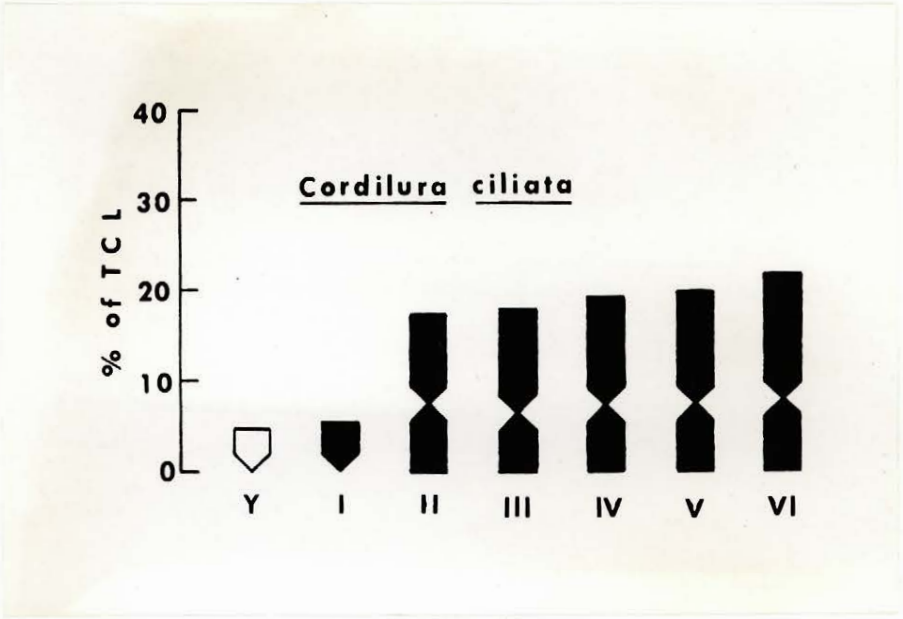
Six pairs of chromosomes were found in each complement analysed. The average TCL was 91.36 μ. The length difference between each two adjacent pairs of autosomes was not distinct. Except for Pair II with a low arm ratio (1.33), the other autosomes had fairly high arm ratios (e.g. the average II-VI arm ratio was 1.61).

The X and Y chromosomes were short (5.20% and 4.37% of TCL respectively) and appeared to be telocentric.

Cordilura ontario Cn.

Parasitic larvae were collected from their hosts in Virginia in 1964. Fifteen mitotic metaphase figures from four larval brains were analysed. In all fifteen figures, the centromeric constrictions and chromatids were very clear. The results of the analysis are summarized in Table 1, Idiogram 31, and a mitotic metaphase picture is shown in Figure 32.

A diploid number of twelve was found in every cell studied, and the average TCL was 81.60 μ. The autosomes differed only slightly



Idiogram 30

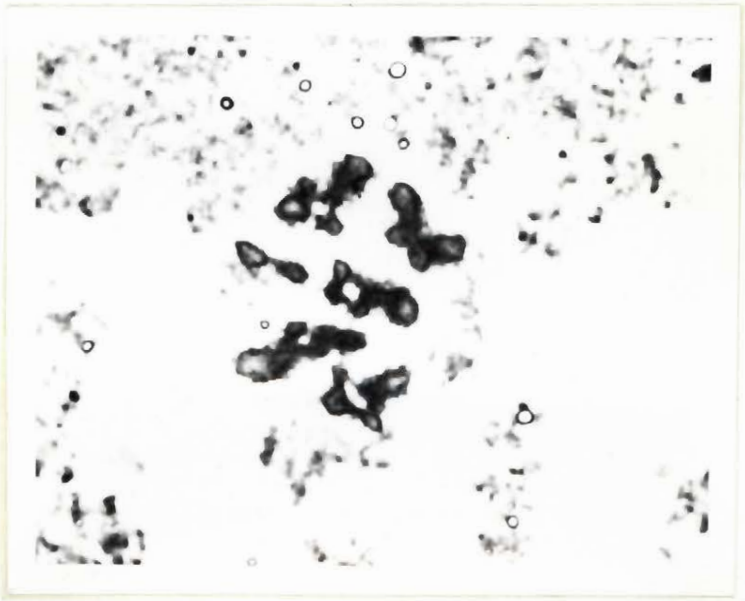
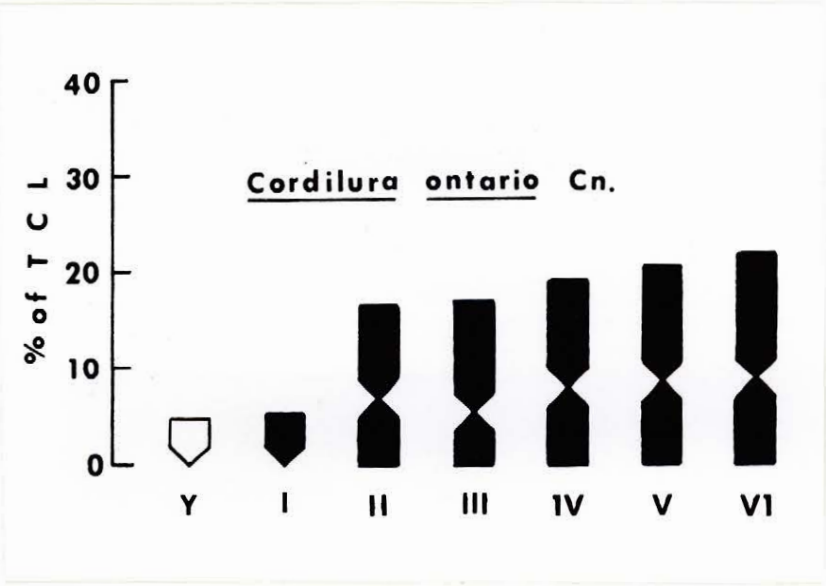


Figure 31. Metaphase I chromosome complement of Cordilura ciliata from the testis of an adult male, X 2250.



Idiogram 31

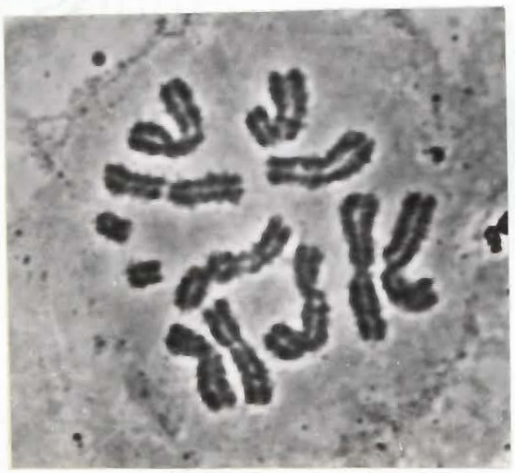


Figure 32. Mitotic metaphase chromosome complement of Cordilura ontario Cn. from a larval brain, X 2250.

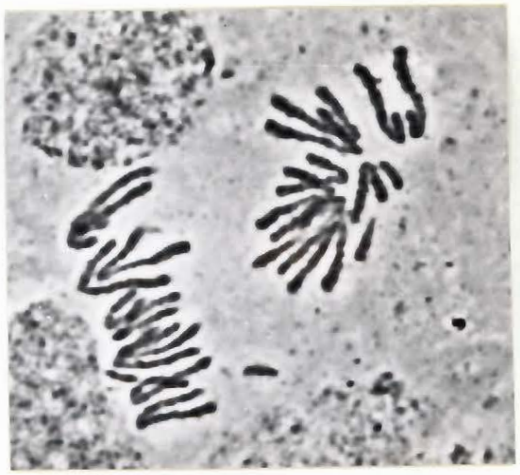


Figure 33. Mitotic anaphase chromosome complement of Codilura ontario Cn. from a larval brain, X 2250.

in length between each two adjacent pairs; with all the centromeres being located in the median region, except for Pair III where the centromere was observed in the submedian region. A secondary constriction was occasionally found in the median region of the long arm of Pair VI.

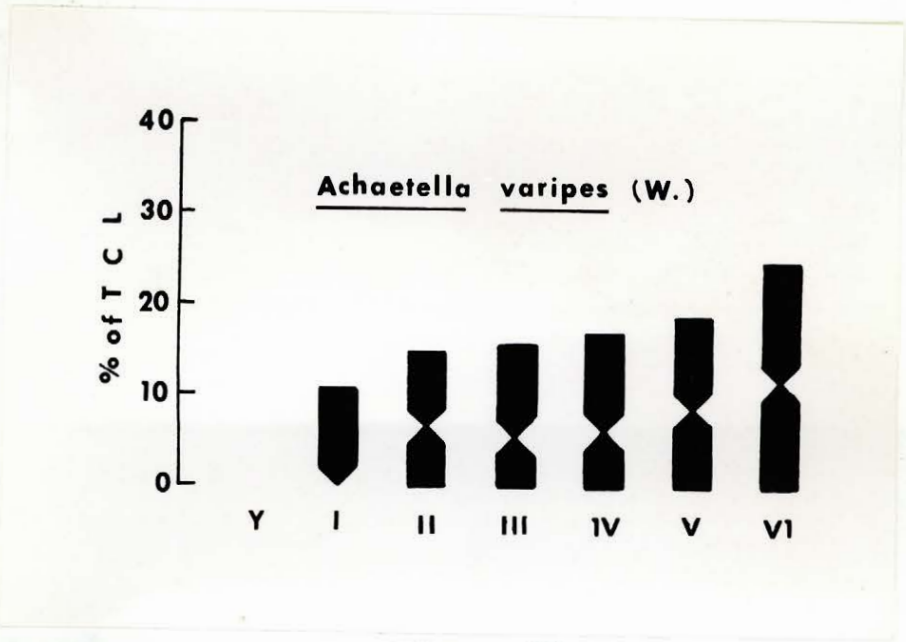
The X-chromosome was small in comparison to the autosomes and was telocentric. The presumed Y-chromosome was just 0.5% of TCL and shorter than the X-chromosome. However, because of the small difference in TCL (0.5%), it was difficult to be sure that it was in fact an XY pair being studied and not a XX pair. A mitotic anaphase picture showing the locations of centromeres is given in Figure 33.

Achaetella varipes (Walk.)

Larvae collected from Virginia in 1964 were used for cytological studies. Five mitotic metaphase complements from a larval brain were analysed. The results are shown in Table 1, Idiogram 32 and a mitotic metaphase picture is given in Figure 34.

All five figures analysed had clear centromeres and all agreed with $2n = 12$. The average TCL was 77.64 μ. From Pair II to V the length differences between each two adjacent pairs was slight. However, Pair VI was much longer than these four pairs. The centromeres of Pairs II, V and VI were in the median region, with those of Pairs III and IV in the submedian region. A secondary constriction in the median region of the long arm of Pair III was occasionally observed.

The X-chromosomes were 4.0% of TCL shorter than Pair II and were presumed to be telocentric. In most cases XX pairing was poor. In



Idiogram 32

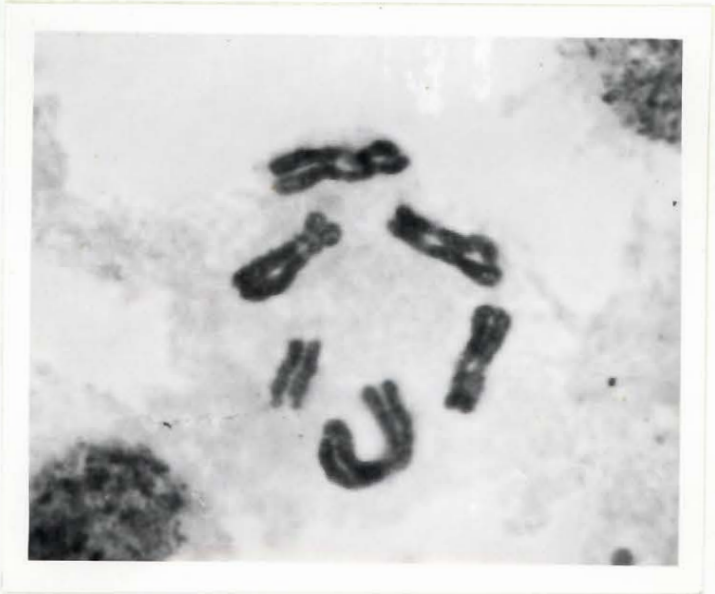


Figure 34. Mitotic metaphase chromosome complements of Achaetella varipes (Walk.) from a larval brain, X 2250.

one case, an achromatic centromere-like region was observed in the median region of one of the X's. In three of the five figures, a secondary constriction near the centromere end of the X-chromosome was observed. This then appeared as a satellite on the X-chromosome.

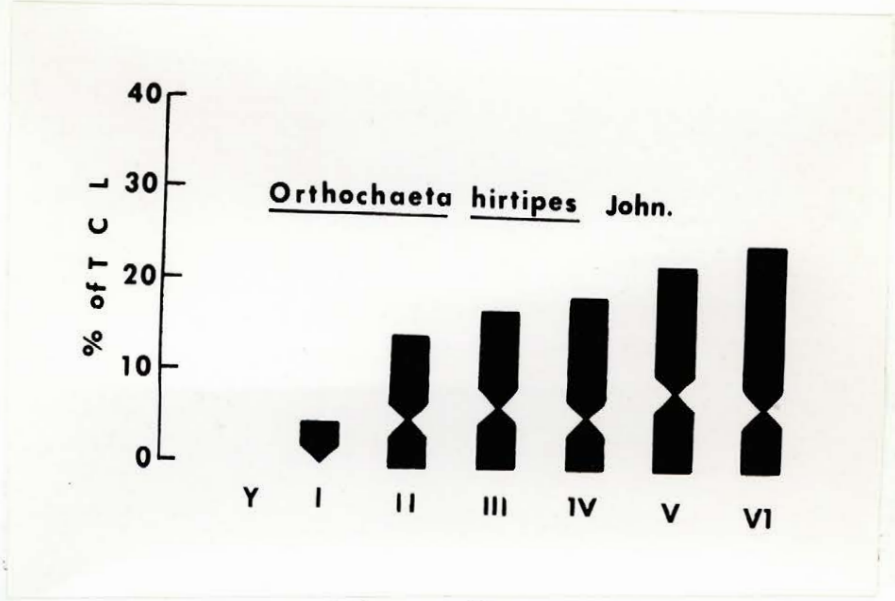
Orthochaeta hirtipes John.

Adults were collected in Port of Spain, Trinidad, in 1957. Six pairs of chromosomes were found in three late metaphase II figures from a female ovary. Although the chromosomes were slightly distorted, the pulling apart of the daughter chromosomes starting from the centromeric region was obvious. The average TCL was 64.44 μ. The results of analysis are shown in Table 1, and Idiogram 33. A late metaphase II picture is given in Figure 35.

The centromeres of Pairs II, III and V were at the median region, while the centromeres of Pairs IV and VI were at the submedian region. Pair II consisted of 13.9% of TCL, Pair III 16.8%, Pair IV 18.5%, Pair V 22.1% and Pair VI 24.5%. The length difference between each two adjacent pairs was appreciable. The X-chromosome was much shorter than Pair II (4.2% of TCL) and presumably was telocentric.

Hylemya echinata (Seguy)

Larvae provided by Dr. Mary Miles (Wye College, Kent, England) were studied cytologically. Ten mitotic metaphase figures from the larval brains of two presumed females and one presumed male were drawn by camera lucida and analysed. The results of the analysis are summarized in Table 1, Idiogram 34, and a mitotic metaphase drawing is shown in Figure 36.



Idiogram 33

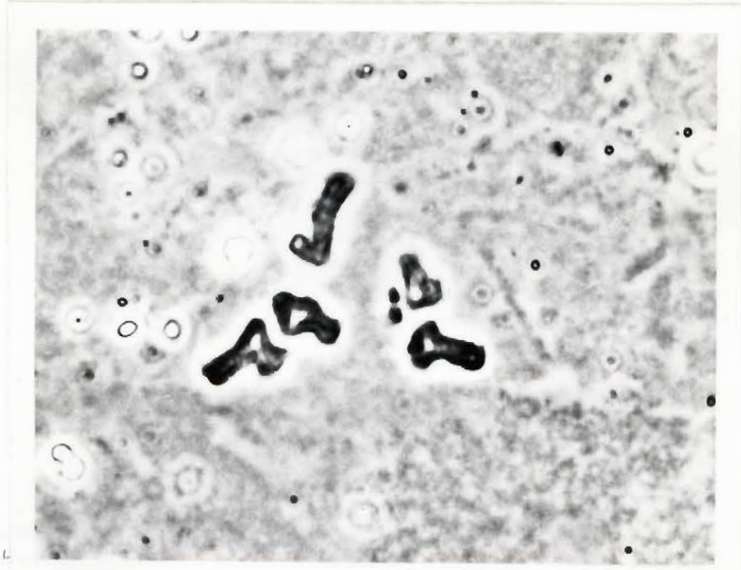
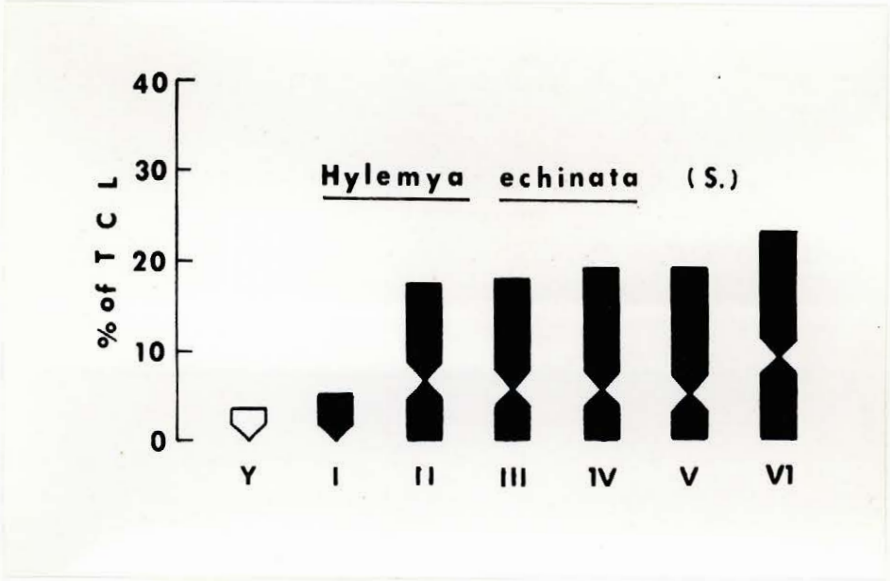


Figure 35. Late metaphase II chromosome complements of Orthochaeta hirtipes John. from the ovary of an adult female, X 2250.



Idiogram 34

Figure 36. Mitotic metaphase chromosome complements of Hylemya echinata (S.) from a larval brain, X 3500.

2n = 12 was obtained in each of the ten figures analysed. The average TCL was 91.04 μ. The length differences among Pairs II, III, IV and V were not obvious, while Pair VI was distinctly longer than Pair V. The II-VI average arm ratio was very high (2.06), but Pair VI's centromere was in the median region. The centromeres of the other autosomes were in the submedian region.

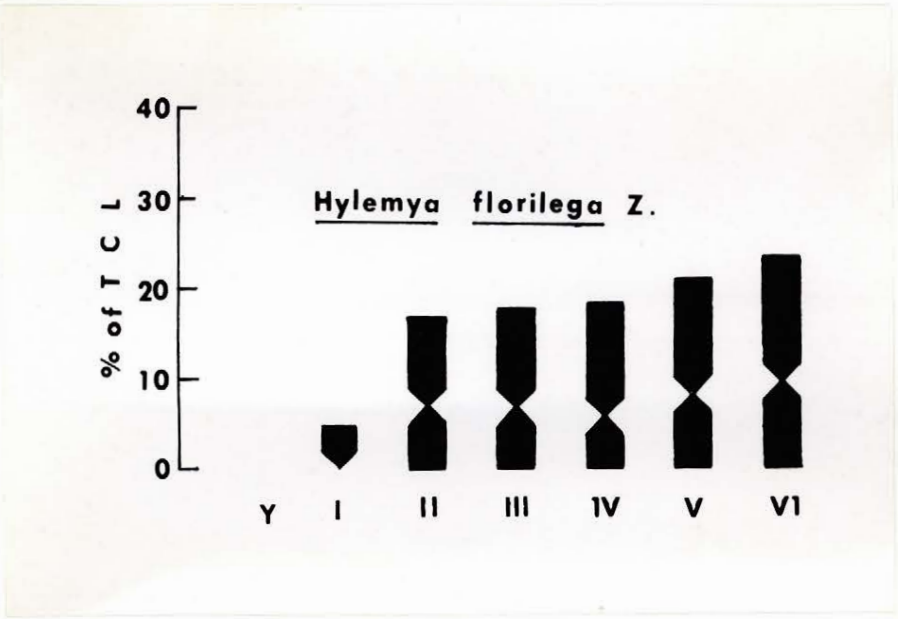
The X-chromosome was small, constituted 5.0% of TCL, and was presumably telocentric. A secondary constriction was often found on the X-chromosome. The Y-chromosome was slightly shorter than the X-chromosome, and corresponded to 3.9% of TCL. Presumably, it was also telocentric and with an occasional secondary constriction.

Hylemya florilegea Zett.

Adults collected in the Netherlands in 1962 were used for cytological study. Seven mitotic metaphase figures obtained from an ovary were analysed. The results of analysis are shown in Table 1, Idiogram 35, and a drawing of a mitotic metaphase is shown in Figure 37.

2n = 12 was found in every complement analysed. The average TCL was 60.77 μ. Pairs II, III and IV were approximately equal in length. Pair IV differed from Pair V by 2.7% of TCL and had a high arm ratio. Its centromere was found in the submedian region, while the centromeres of other autosomes were found in the median region but near the submedian regions.

The telocentric X-chromosome constituted 4.9% of TCL and was quite clear in every complement.



Idiogram 35

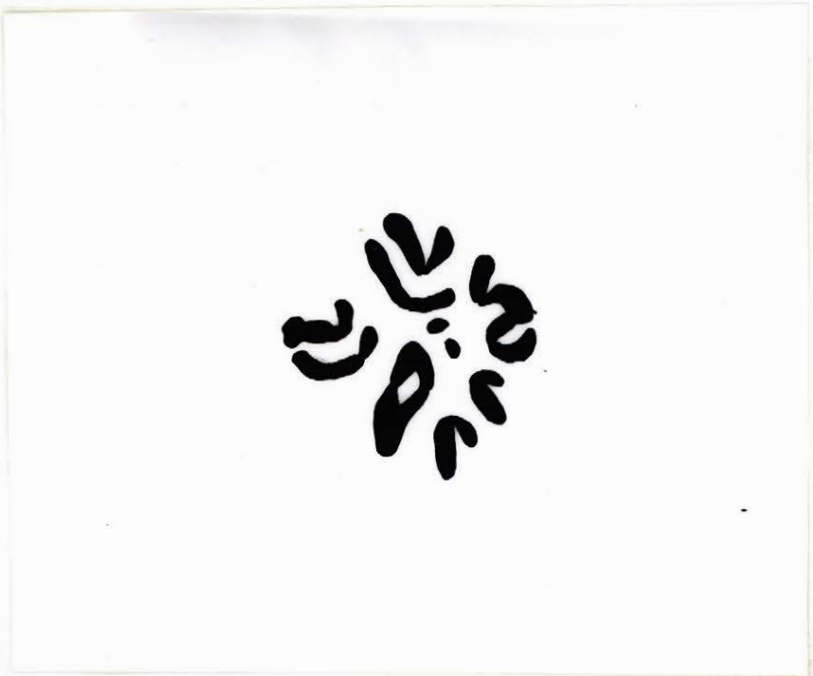


Figure 37. Mitotic metaphase chromosome complements of Hylemya florilegea Zett. from the ovary of an adult female, X 2250.

Hydrophoria conica Wied.

Adults were collected in St. George, Grenada, in July of 1957. Three mitotic metaphase figures from an ovary and two metaphase II figures from a testis were put together for analysis. The results of analysis are summarized in Table 1, Idiogram 36, and a mitotic metaphase picture can be seen in Figure 38.

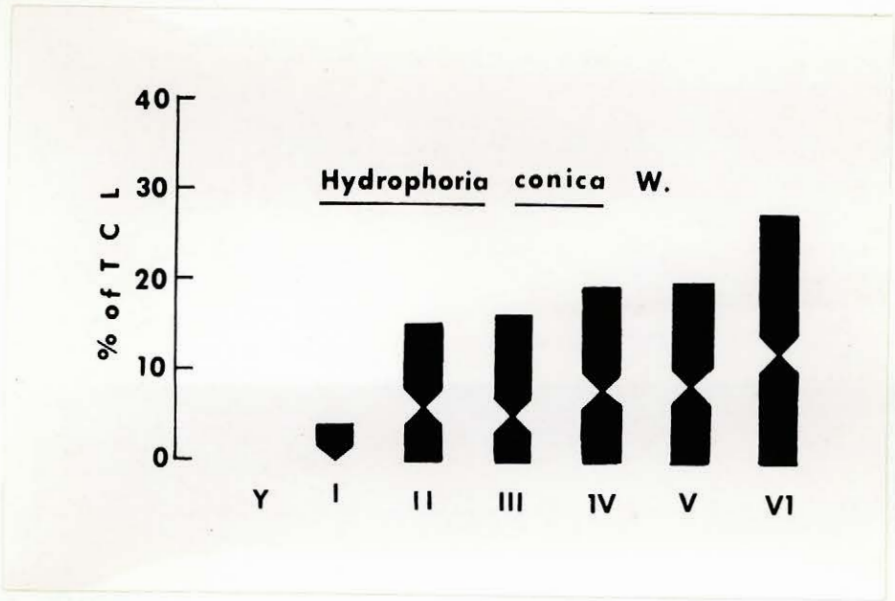
The chromosomes were very large in all five figures analysed. The average TCL was 103.33 μ. Six pairs were found in this species. Pairs II and III, Pairs IV and V were almost equal in length respectively; while the length difference between Pair III and IV was obvious. Furthermore, there was even more distinct difference in length between Pair V and Pair VI. The centromere of Pair III was in the submedian region, as opposed to the centromeres of other autosomes which were located in the median region.

The X-chromosome in this species was very small and was presumed to be telocentric.

Pegomya betae (C.)

Larvae were provided by Dr. Mary Miles (Wye College, Kent, England). Ten mitotic metaphase figures from the larval brains of three presumed females and three presumed males were drawn by camera lucida and were analysed. The results of the analysis are shown in Table 1, Idiogram 37, and a mitotic metaphase picture can be seen in Figure 39.

2n = 12 was found in each of the ten figures analysed. The average TCL was 112.54 μ. From Pair II to Pair V the length



Idiogram 36

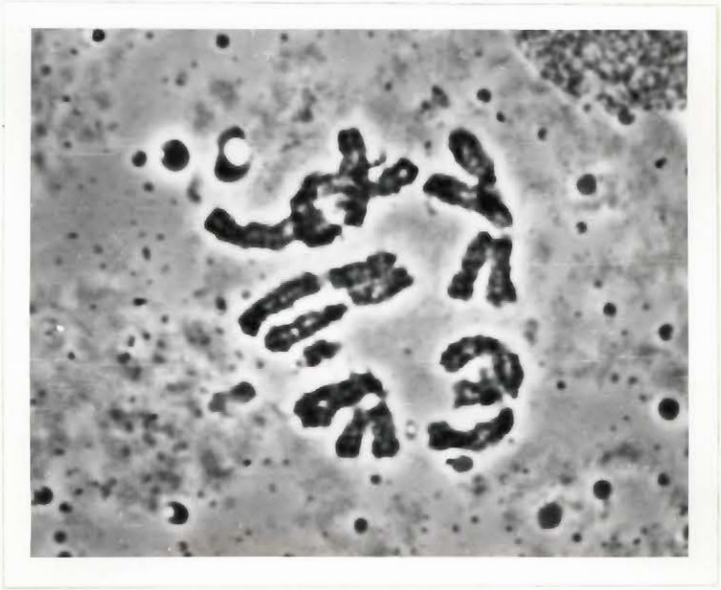
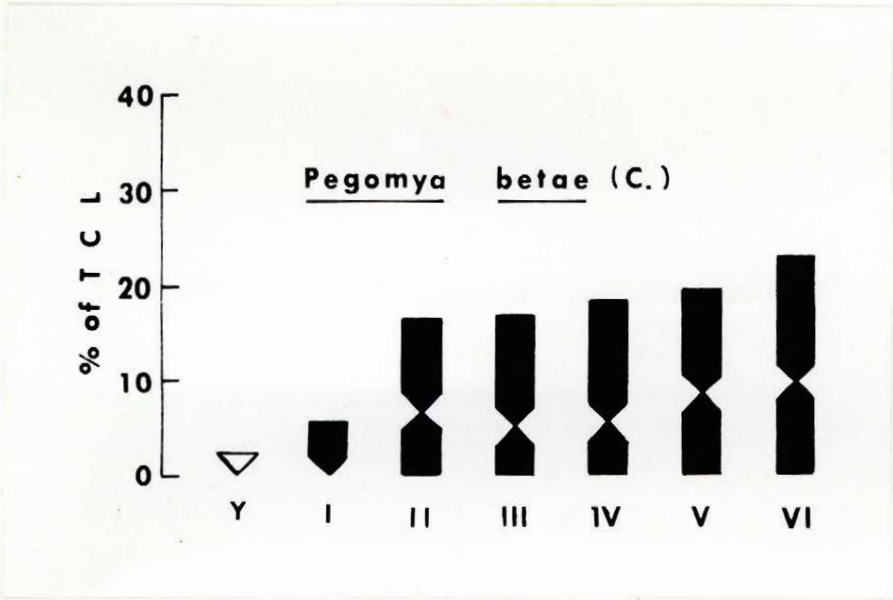


Figure 38. Mitotic metaphase chromosome complement of Hydrophoria conica Wied. from the ovary of an adult female, X 2250.



Idiogram 37

Figure 39. Mitotic metaphase chromosome complement of Pegomya betae (C.) from a larval brain, X 3500.

difference between each two adjacent pairs was not obvious, while Pair VI was distinctly longer than Pair V. Pairs III and IV had their centromeres in a submedian region, the centromeres of other autosomes were found in their median regions. The II-VI average arm ratio of this species was 1.74.

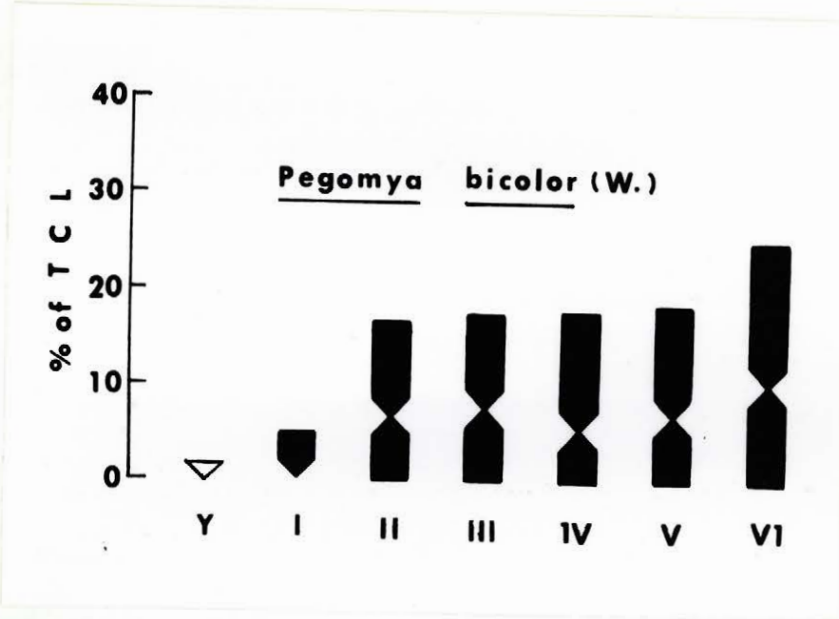
The telocentric X-chromosome constituted 5.8% of TCL. The Y-chromosome of this species was very small, corresponding only to 2.2% of TCL.

A secondary constriction was consistently found in the X-chromosome. An average secondary arm ratio of 3.8 from nine chromosomes was found in the long arm of Pair VI, an average secondary arm ratio of 1.63 from ten chromosomes was found in the short arm of Pair VI, and an average secondary arm ratio of 0.53 from seven chromosomes was found in the short arm of Pair IV. Inconsistently located secondary constrictions were also found in the other chromosomes.

Pegomya bicolor (Wied.)

Larvae provided by Dr. Mary Miles (Wye College, Kent, England) were used for cytological study. Eleven mitotic metaphase figures from the larval brains of seven presumed females and three presumed males were drawn by camera lucida and analysed. The results of the analysis are shown in Table 1, Idiogram 38. A mitotic metaphase picture can be seen in Figure 40.

The chromosome complement, $2n = 12$ was found in each of the eleven figures analysed. The average TCL was 99.87 μ. The length



Idiogram 38

Figure 40. Mitotic metaphase chromosome complements of Pegomya bicolor (Wied.) from the larval brain of a presumed male, X 3500.

difference among Pairs II, III, IV and V was slight. However, Pair VI was much longer than Pair V. The centromeres of Pairs IV and V were in the median regions, but Pair IV had a higher arm ratio than Pair V. The centromeres of Pairs II, III and VI were found in the median regions.

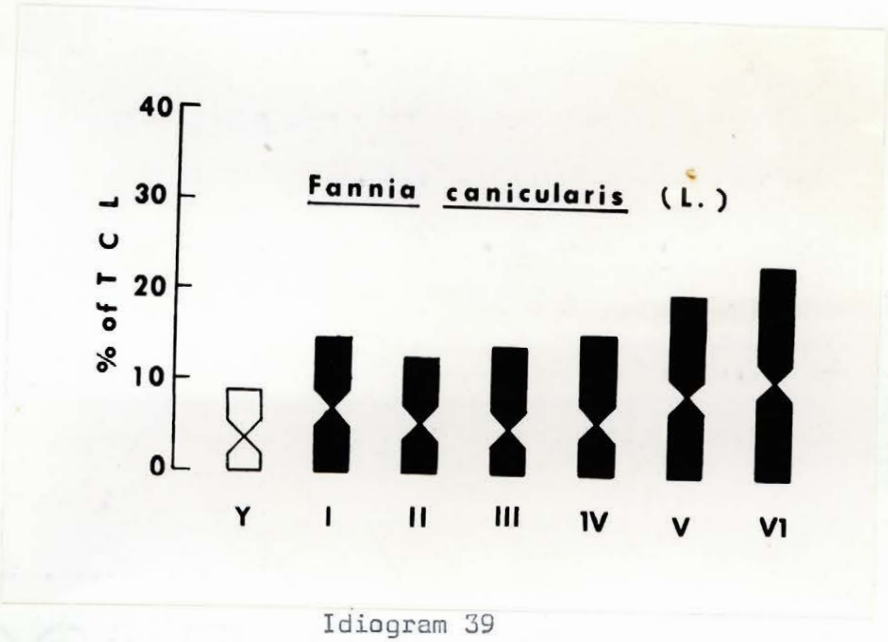
The X-chromosome constituted 5.04% of TCL. A very good mitotic anaphase figure showing the telocentric X was obtained. The Y-chromosome was very tiny, corresponding to only 1.74% of TCL.

Secondary constrictions were occasionally observed in the complements.

Fannia canicularis (L.)

An adult fly was caught in the Genetics Department of McGill University in late September 1959 and its larvae were reared on liver-Pard combination in a bottle with paper towel saturated with 11% sugar solution. Eleven mitotic figures from the larval brains of two presumed females and three presumed males were drawn by camera lucida and were analysed. The results of the analysis are shown in Table 1, Idiogram 39, and a mitotic metaphase drawing is shown in Figure 41.

The chromosome complement, $2n = 12$, was found in each of the eleven figures analysed. The average TCL was 103.54 μ. Pair II differed from Pair III by 1.3% of TCL, Pair III differed from Pair IV by 1.5% of TCL, Pair IV differed from Pair V by 4.4% of TCL, Pair V differed from Pair VI by 3.4% of TCL. The centromere of Pair III was found in a submedian region, while the centromeres of other chromosomes were found in the median region, but Pair IV had a higher arm ratio than the rest.



Idiogram 39

Figure 41. Mitotic metaphase chromosome complement of Fannia canicularis (L.) from a larval brain, X 3513.

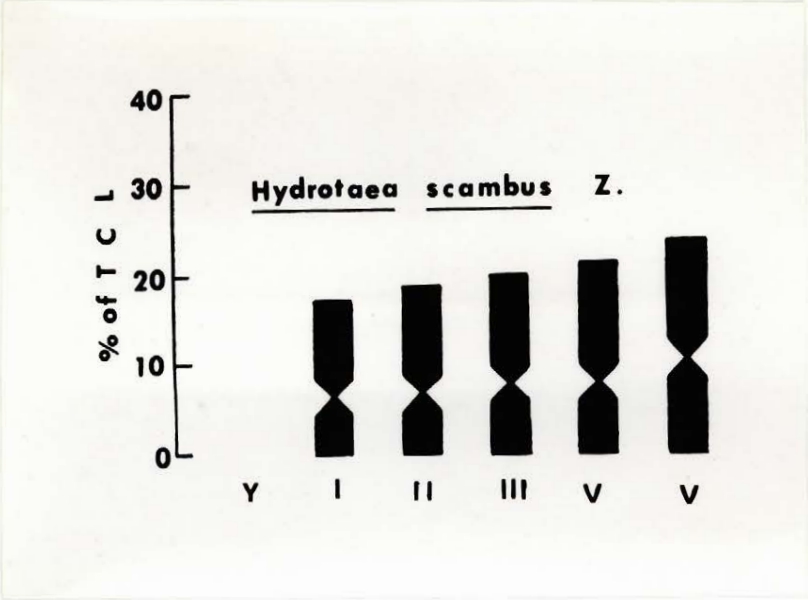
The X-chromosome constituted 14.6% of TCL, and its length was ranked between Pair III and Pair IV. The centromere was located in the median region. The Y-chromosome was the shortest chromosome in the complement, its length corresponded to 9.0% of TCL. The Y-chromosome had a centromere in its median region.

The secondary constrictions were found in the X- and Y-chromosome and every autosome, but they were not consistent in their positions and secondary arm ratios.

Hydrotaea scambus Zett.

A collection of adults from Pullman, Washington, U.S.A. (July 1964) were subjected to analysis. Seven metaphase II figures from a testis were analysed, and the results are shown in Table 1, Idiogram 40, and a metaphase II picture is given in Figure 42.

Five pairs of chromosomes were found in all seven complements analysed. The average TCL was 88.97 μ. The figures were all very clear and neat, with the daughter chromosomes and centromeres being obvious. The assignment of Pair I in this species was based only on its being the shortest in length in the complement. Therefore, whether Pair I is involved in sex determination is not known. The length differences between each two adjacent pairs of chromosomes in this species was not distinct except between Pairs V and VI. Nevertheless, the centromere of the longest pair was in the median region of the chromosomes; while the centromeres of Pairs I, II, III and IV were found to be closer to the submedian region. A very nice anaphase II figure indicating the position of all centromeres was also obtained.



Idiogram 40

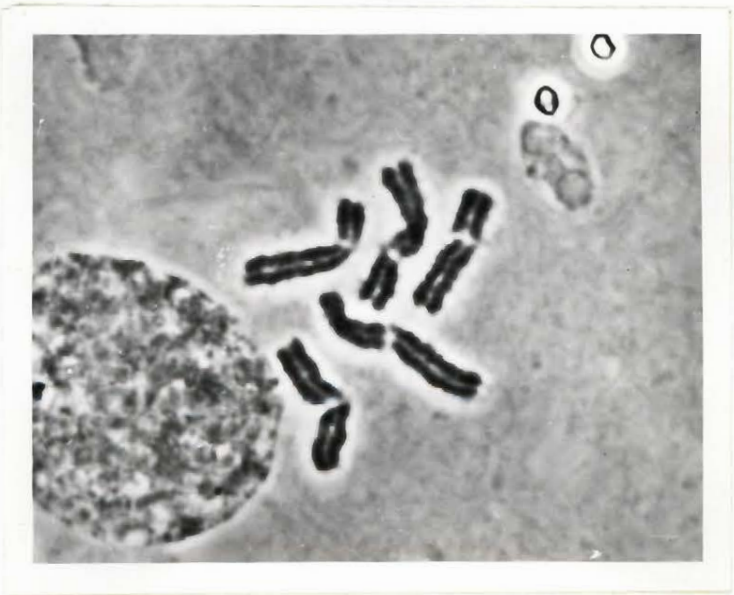


Figure 42. Metaphase II chromosome complement of Hydrotaea scambus Zett. from the testis of an adult male, X 2250.

This agreed well with the results from the metaphase II figures. No secondary constrictions were found in this species.

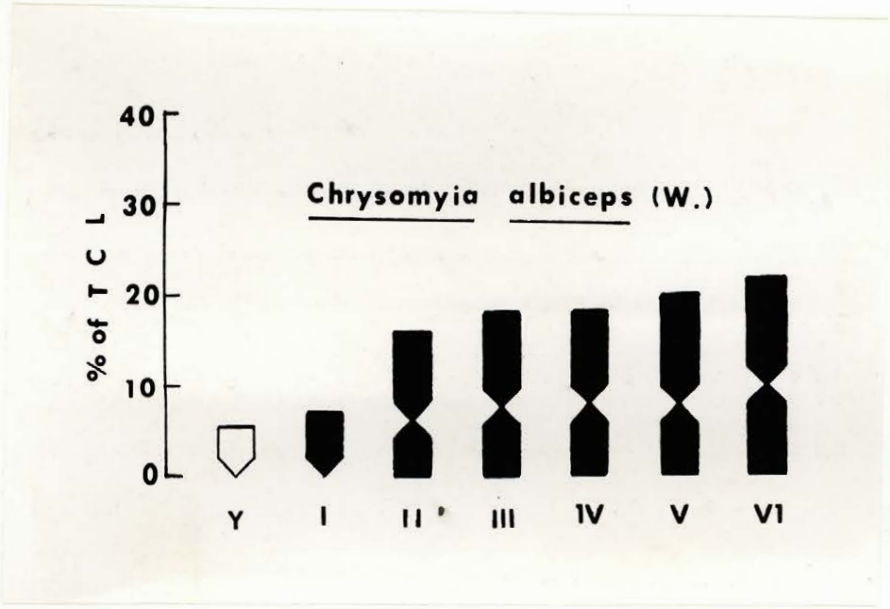
Chrysomyia albiceps (Wied.)

Larvae obtained from Dr. H. Paterson (Johannesburg, South Africa) in 1962 were used for cytological studies. Five mitotic metaphase figures from larval brains of two presumed males were drawn with a camera lucida and subsequently analysed. The results of analysis are summarized in Table 1, Idiogram 41, and a drawing of a mitotic metaphase picture is given in Figure 43.

Five pairs of autosomes plus an XY pair were found in each of the five figures studied. The average TCL was 43.88 μ. Pair II was 1.7% of TCL shorter than Pair III, while Pair III was only 0.7% of TCL shorter than Pair VI. All autosomal centromeres were found in the median region. Pair V had a higher arm ratio than the other autosomes, as opposed to Pair VI which had a lower arm ratio. The X-chromosome was telocentric and constituted 7.2% of TCL. The Y-chromosome was a little bit shorter than the X-chromosome and was also telocentric.

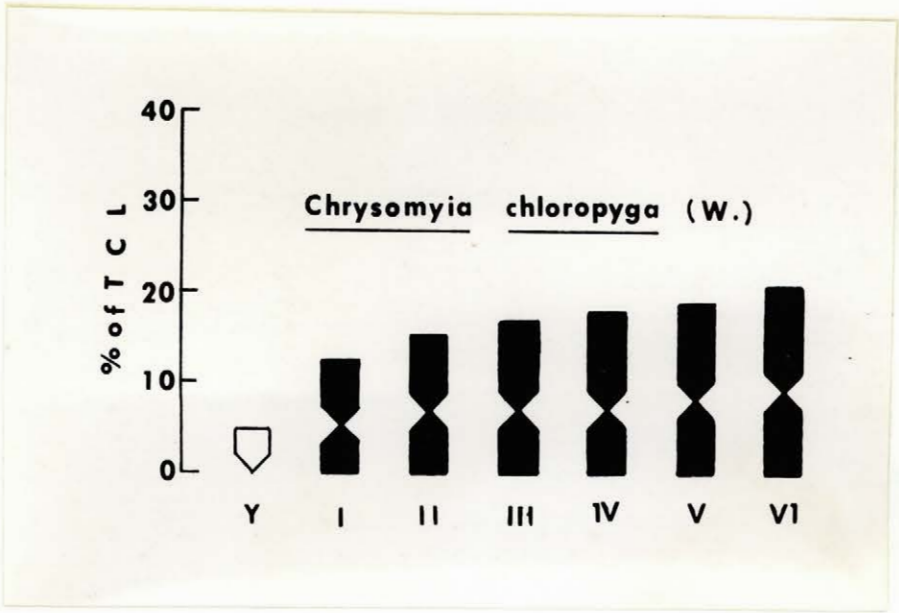
Chrysomyia chloropyga (Wied.)

The subjects of this study were also obtained from Dr. H. Paterson (Johannesburg, South Africa) in 1962. Fifteen mitotic metaphase figures from larval brains of three presumed females and four presumed males were drawn with a camera lucida and then analysed. The results of the analysis are shown in Table 1, Idiogram 42, and a drawing of a mitotic metaphase is shown in Figure 44.



Idiogram 41

Figure 43. Mitotic metaphase chromosome complement of Chrysomyia albiceps (Wied.) from a larval brain, X 3523.



Idiogram 42

Figure 44. Mitotic metaphase chromosome complement of Chrysomyia chloropyga (Wied.) from a larval brain, X 3523.

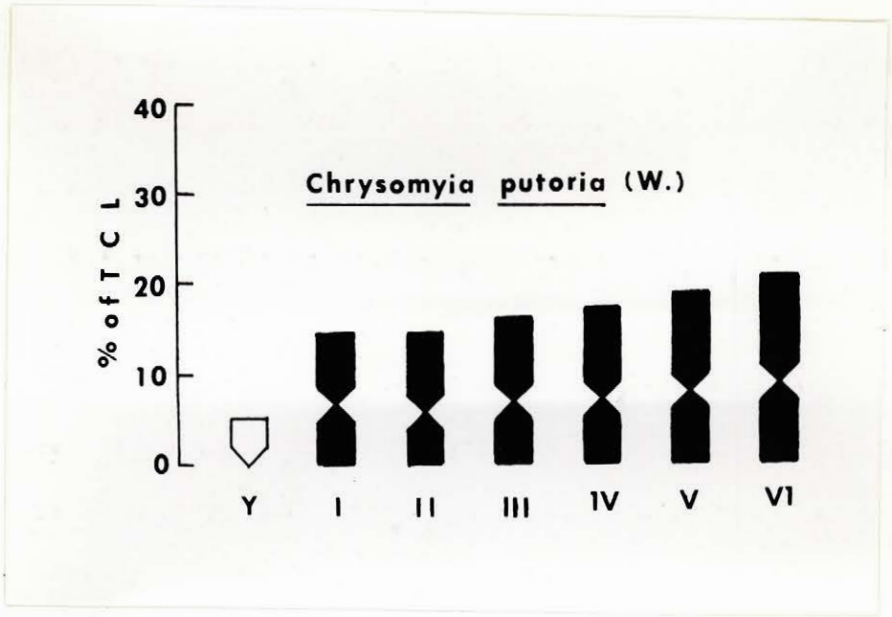
A diploid number of 12 was obtained in each cell analysed. The average TCL was 64.37 μ. No distinct length difference was found between any two adjacent pairs of autosomes. The centromeres of all the autosomes were found in the median region and all had very low arm ratios, Pair II 1.22, Pair III, 1.31, Pair IV 1.40, Pair V 1.30 and Pair VI 1.30.

The X-chromosome had an arm ratio of 1.39 and constituted 12.3% of TCL. The Y-chromosome was telocentric and corresponded to 4.8% of TCL. In some cases the X- and Y-chromosomes were heterochromatic.

Secondary constrictions were found in many chromosomes of this species. In the long arm of Pair I, a secondary arm ratio of 1.05 was obtained on four different measurements, while a similar ratio of 3.27 in the long arm of Pair II was obtained (six chromosomes measured). By measuring ten chromosomes of Pair II and eight of Pair VI, secondary arm ratios of 1.05 and 2.13 were obtained for the short arm of Pair II and the long arm of Pair VI, respectively. Other secondary constrictions were examined in the long arm of Pair V, the short arm of Pair IV and both arms of Pair III, but measurements showed their positions to be inconsistent.

Chrysomyia putoria (Wied.)

Larvae obtained from Dr. H. Paterson (Johannesberg, South Africa) in 1962 were used for cytological studies. Nineteen mitotic metaphase figures from larval brains of two presumed females and three presumed males were drawn with a camera lucida and subjected to analysis. The results are summarized in Table 1, Idiogram 43, and a mitotic metaphase drawing is given in Figure 45.



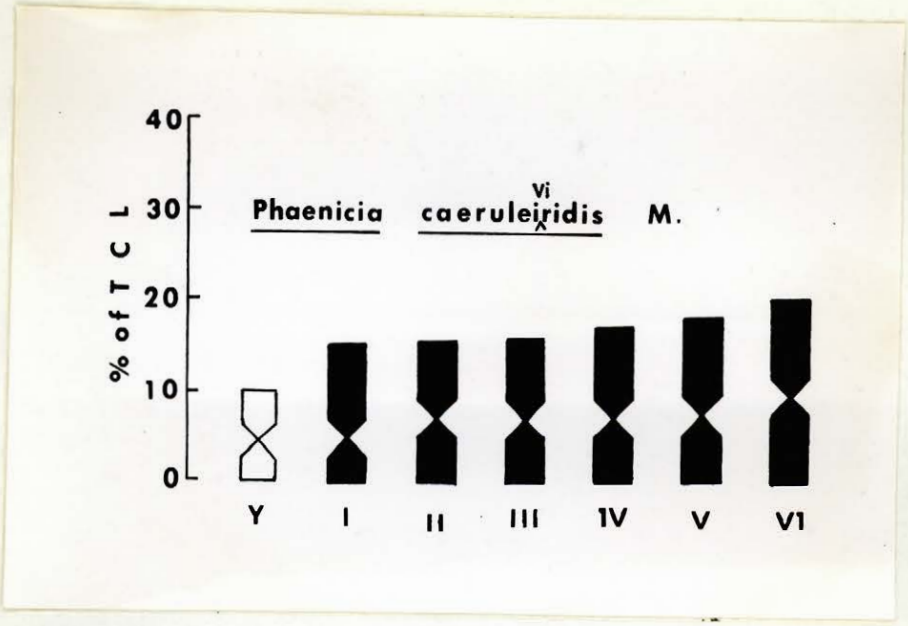
Idiogram 43

Figure 45. Mitotic metaphase chromosome complement of Chrysomyia putoria (Wied.) from a larval brain, X 3523.

2n = 12 was found in each of the nineteen figures analysed, with an average TCL of 64.29 μ. The X-chromosome was about the same length as Pair II and constituted 14.2% of TCL. Pair II constituted 14.3% of TCL, while similar measurements taken for Pairs III, IV, V and VI were 15.9%, 16.9%, 18.4%, and 20.2% of TCL respectively. The centromeres of all the chromosomes in the complements except the Y-chromosome were found to be in the median region. The Y-chromosome was telocentric and corresponded to 5.1% of TCL. A satellite was found at the end opposite to the centromere. In some cases the X- and Y-chromosomes were seen to be heterochromatic. Secondary constrictions were found in almost every X- and Y-chromosome; however, they yielded very inconsistent secondary arm ratios.

Phaenicia caeruleiviridis Macq.

These adult specimens were collected in Mississippi, U.S.A. in April 1964. Four mitotic metaphase figures from a testis were analysed. The results are summarized in Table 1, Idiogram 44, and a mitotic metaphase picture is given in Figure 46. The average TCL was 67.90 μ. Pairs II, III, IV and V differed only slightly in length. However, the difference in length between Pair II and VI was quite noticeable. All the centromeres of the X- and Y-chromosomes were found in the submedian region. The X-chromosome was about the same length as Pair II, whereas the Y-chromosome was about two thirds the length of the X-chromosome. No distinct secondary constrictions were observed in this species.



Idiogram 44

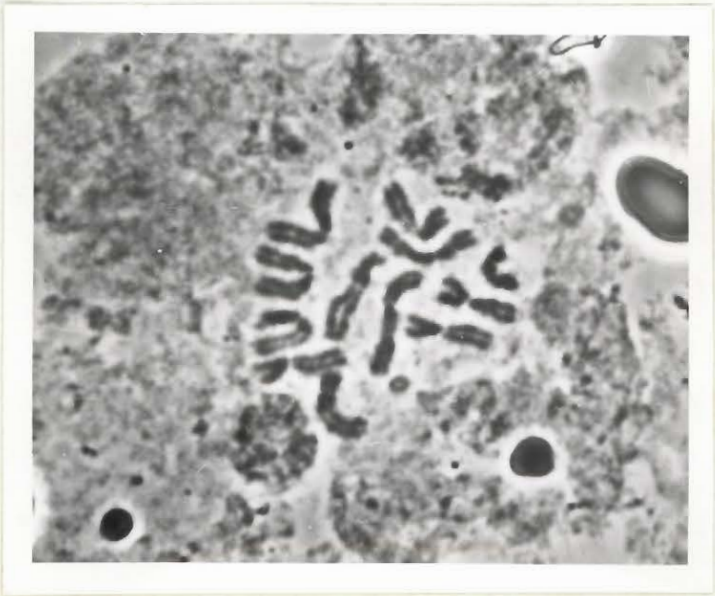


Figure 46. Mitotic metaphase chromosome complement of Phaenicia caeruleiviridis Macq. from the testis of an adult male, X 2250.

Cynomyopsis cadaverina (R.-D.)

Adults collected in Mississippi, U.S.A. were used for cytological study. A mitotic metaphase figure and a metaphase I figure were combined for analysis. The results are summarized in Table 1, Idiogram 45, and a drawing of a mitotic metaphase can be seen in Figure 47. Unfortunately, the two figures analysed were ambiguous in some parts. This would certainly affect the accuracy of the results and made the detailed comparison impossible.

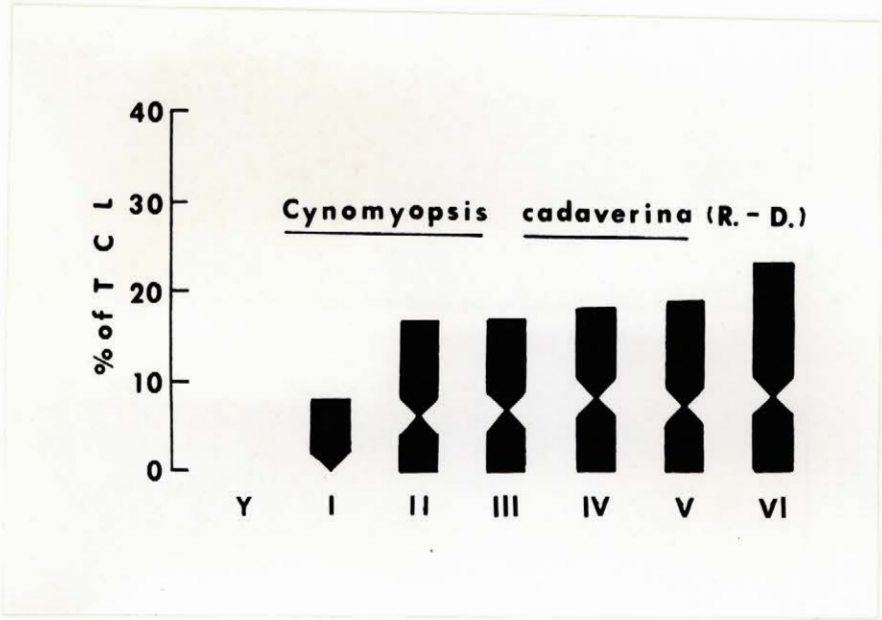
Pollenia rudis (Fab.)

Adults were collected at Mount Orford, Quebec in July of 1963. Eight metaphase I figures were obtained from a testis. Unfortunately, the centromeres could not be located with certainty. It was, therefore, considered futile to attempt to calculate the arm ratios. The relative chromosome length is shown in Table 1, and a metaphase I picture can be seen in Figure 48. The results appear in agreement with those of Boyes (1961). However, a higher percentage of TCL for the X-chromosome was obtained from this study. It could be that the X's were compacted with the Y's, thereby increasing the measurement.

Sphenometropa tergata (Coq.)

Adults were collected in Pullman, Washington, U.S.A. in July 1964. Four metaphase I figures from a testis were analysed. The results are summarized in Table 1, Idiogram 46, and a metaphase I picture is given in Figure 49.

Six pairs were found in each complement analysed. The average TCL was 63.22 μ. Pairs II and III, and Pairs IV and V were near



Idiogram 45

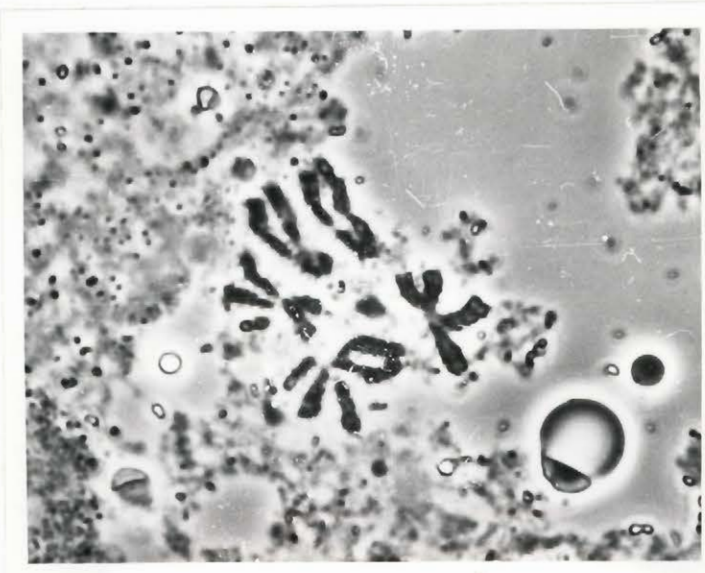


Figure 47. Mitotic metaphase chromosome complement of Cynomyopsis cadaverina (R.-D.) from the testis of an adult male, X 2250.

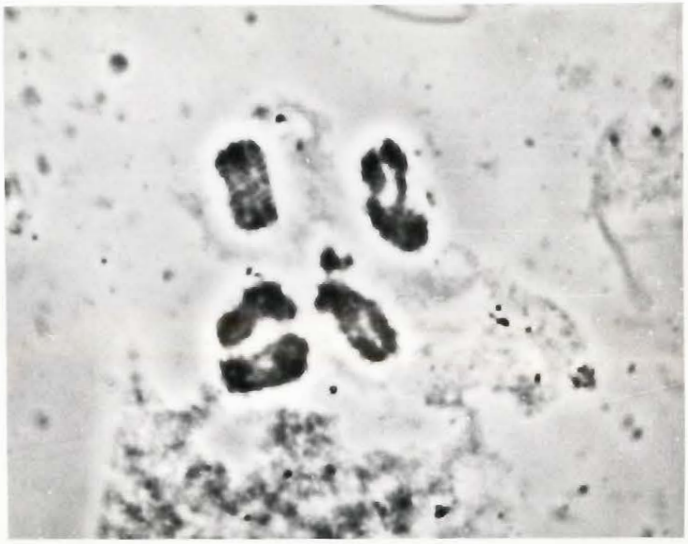
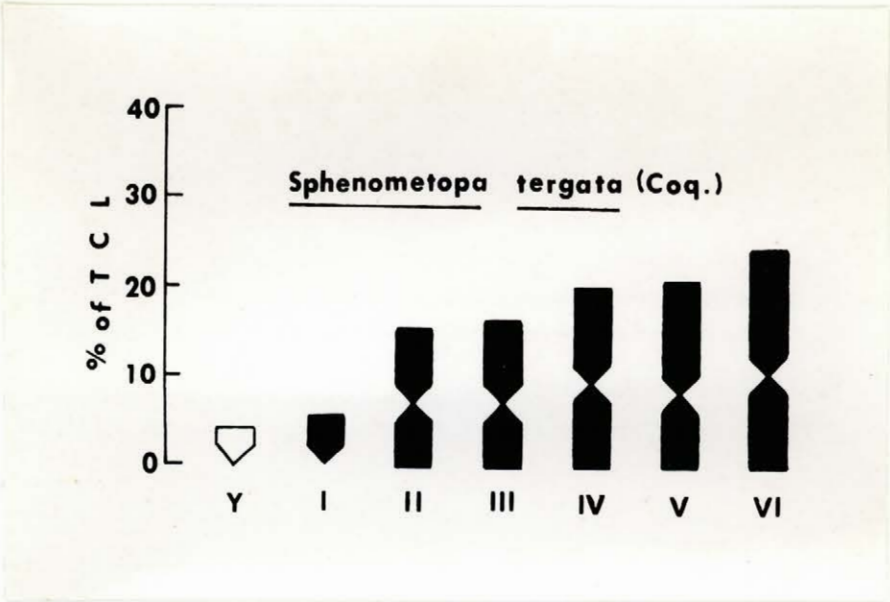


Figure 48. Metaphase I chromosome complement of Pollenia rudis (Fab.) from the testis of an adult male, X 2250.



Idiogram 46

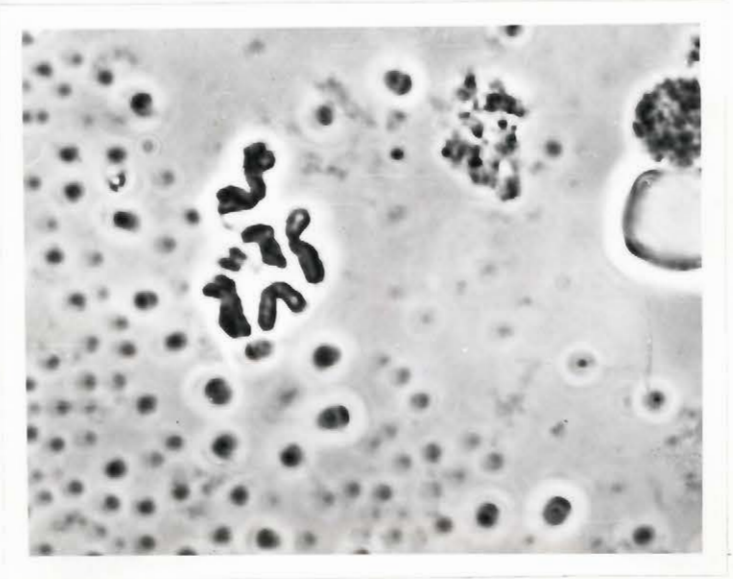


Figure 49. Metaphase I chromosome complement of Sphenometropa tergata (Coq.) from the testis of an adult male, X 2250.

each other in length. However, there was a noticeable difference in length between Pairs III and IV as well as Pairs V and VI. The centromeres of these autosomes were all found in the median regions.

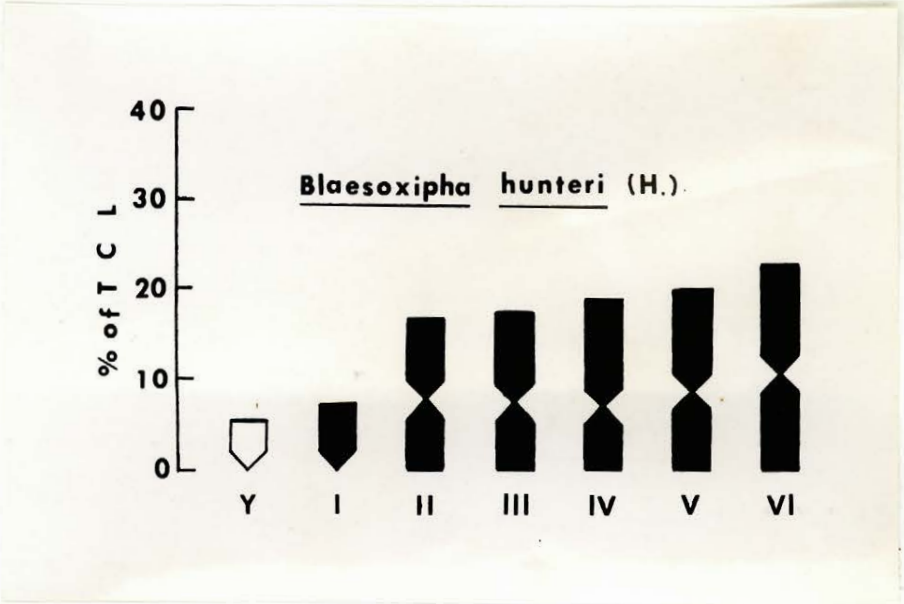
The X-chromosome was much shorter as compared to the autosomes (about one third of the length of Pair II) and was found to be telocentric. The Y-chromosome was dot-like in appearance, and was also presumed to be telocentric.

Blaesoxipha hunteri (Hough)

Adults were collected at Pullman, Washington, U.S.A. in July of 1964. Due to the limitation of available figures, one mitotic metaphase, one metaphase I and two metaphase II figures from two testes were pooled in the analysis. The results of analysis are summarized in Table 1, Idiogram 47, and a mitotic metaphase picture is given in Figure 50.

Six pairs of chromosomes were found in all four complements analysed. The average TCL for four complements was 76.8 μ. The length difference between each two adjacent pairs from Pair II to Pair V was slight, while Pair VI was appreciably longer than Pair V. All the centromeres of the autosomes were found in the median regions. However, Pair IV showed a higher arm ratio, while Pair II and Pair VI had a lower arm ratio.

The X-chromosome constituted 7.1% of TCL and was presumed to be telocentric. It could be noted that a median constriction was observed here in two cases, and a subterminal constriction in one case. In



Idiogram 47

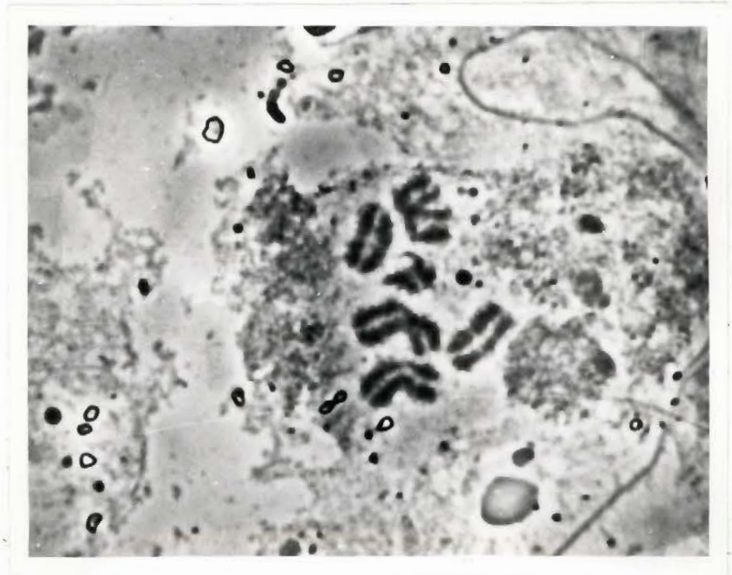


Figure 50. Mitotic metaphase chromosome complement of Blaesoxipha hunteri (Hough) from the testis of an adult male, X 2250

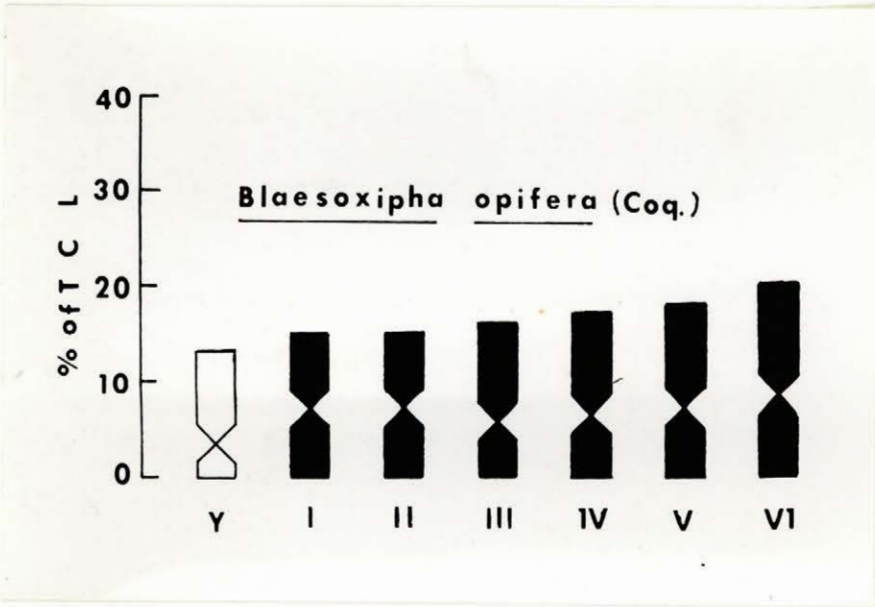
one case the X-chromosome was entirely heterochromatic. On the other hand, the Y-chromosome was about 73% of X-chromosome, corresponding to 5.2% of TCL and was presumed to be telocentric.

Blaesoxipha opifera (Coq.)

Specimens of adult flies obtained at Pullman, Washington, U.S.A. in July of 1964 were studied. Four mitotic metaphase figures from three testes were subjected to analysis. The results are shown in Table 1, Idiogram 48, and a mitotic metaphase picture is given in Figure 51.

A diploid count, $2n = 12$, was found in each complement analysed, with an average TCL of 75.73 μ. No obvious difference in length between any of the chromosome pairs was found in this species. Pair II differed from Pair III only by 0.9% of TCL, Pair III from Pair IV by only 1.0% of TCL, and Pair IV only 0.9% of TCL from Pair V. On the other hand Pair VI was 2.3% of TCL longer than Pair V. Pair II had an arm ratio of 1.19, while Pairs III, IV, V and VI had an arm ratio of 1.73, 1.64, 1.50 and 1.41 respectively. The large difference in arm ratio between Pairs II and III served as an easy criterion for distinguishing these chromosomes.

The X-chromosome was about equal in length with Pair II and had a very low arm ratio. The X- and Y-chromosomes were not well paired in all the complements studied. It was, therefore, difficult to differenciate the X-chromosome from Pair II. The Y-chromosome, corresponding to 13.1% of TCL was slightly shorter than the



Idiogram 48

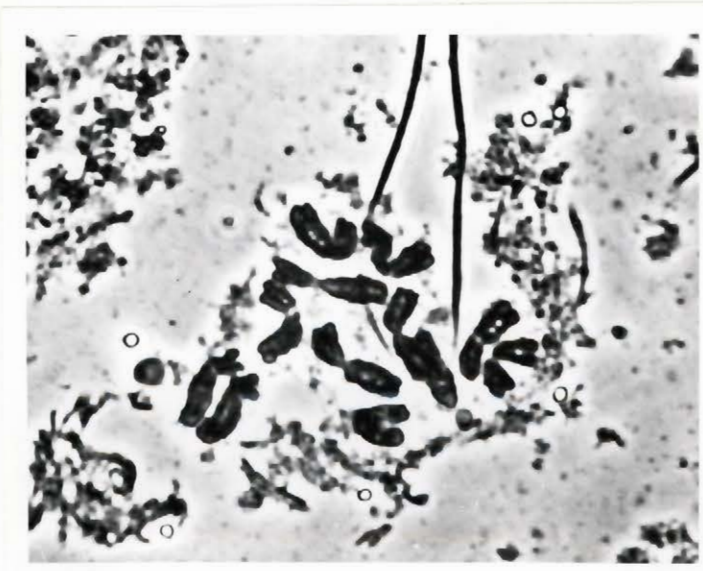


Figure 51. Mitotic metaphase chromosome complement of Blaesoxipha opifera (Coq.) from the testis of an adult male, X 2250.

X-chromosome and consistently carried a constriction near the subterminal region. This was presumed to be a centromere.

Sarcophaga latisterna Parker

Adults were collected in Mississippi, U.S.A. in April of 1964. Three metaphase II figures from a testis were studied. Five pairs plus one chromosome were found in each complement. The average TCL was 46.96 μ. The centromeres of Pairs II, III, V and VI were in the median region, while the centromere of Pair IV was in the submedian region.

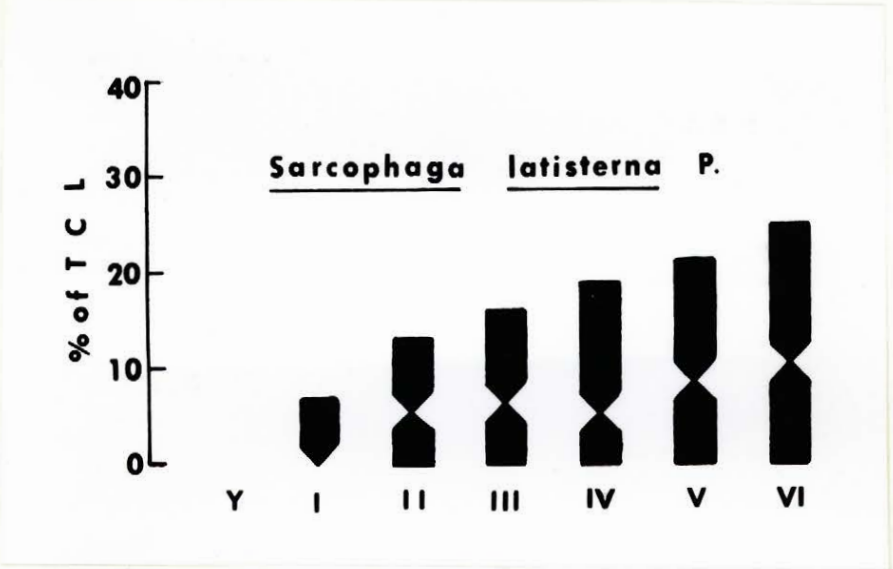
Since only metaphase II figures were available it is possible that the presumed X-chromosome was in fact a Y-chromosome, or a XY complex.

The results of chromosome analysis are summarized in Table 1, Idiogram 49, and a metaphase II picture of the chromosomes is shown in Figure 52.

Ravinia querula (Walk.)

Adults were collected in Pullman, Washington, U.S.A. in July of 1964. Five metaphase I figures from a testis were analysed, and the results are summarized in Table 1, Idiogram 50, and a metaphase I picture is shown in Figure 53.

The average TCL was 70.84 μ. The length differences between each two adjacent pairs was appreciable; Pair II differed 3.4% of TCL from Pair III; Pair III 1.9% of TCL from Pair IV, Pair IV 2.4% of TCL from Pair V and Pair V 2.2% of TCL from Pair VI. The arm ratios were



Idiogram 49

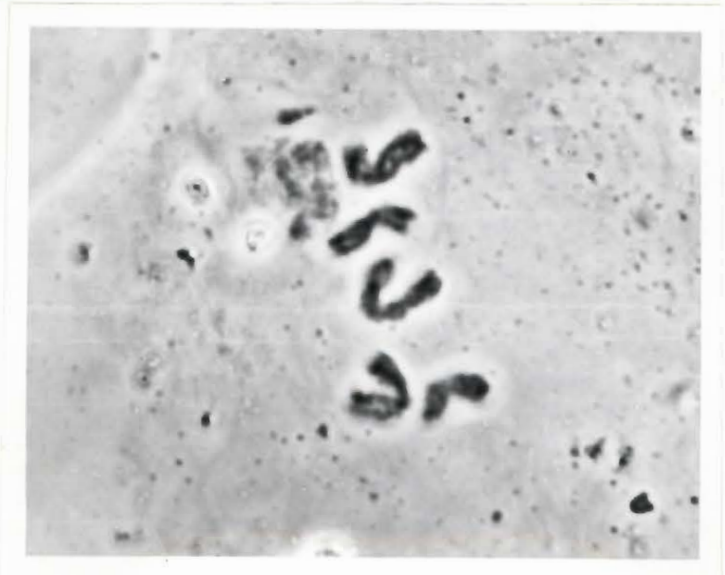
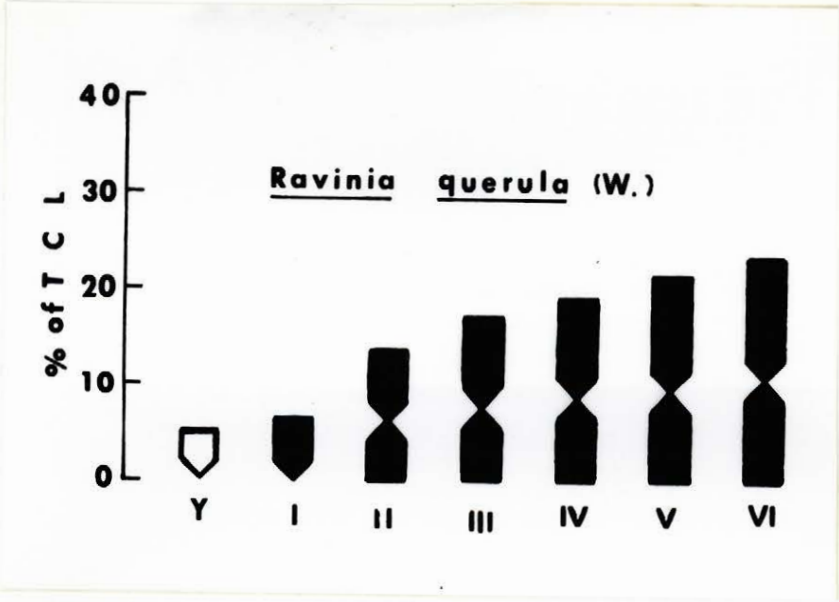


Figure 52. Metaphase II chromosome complement of Sarcophaga latisterna Parker from the testis of an adult male, X 2250.



Idiogram 50

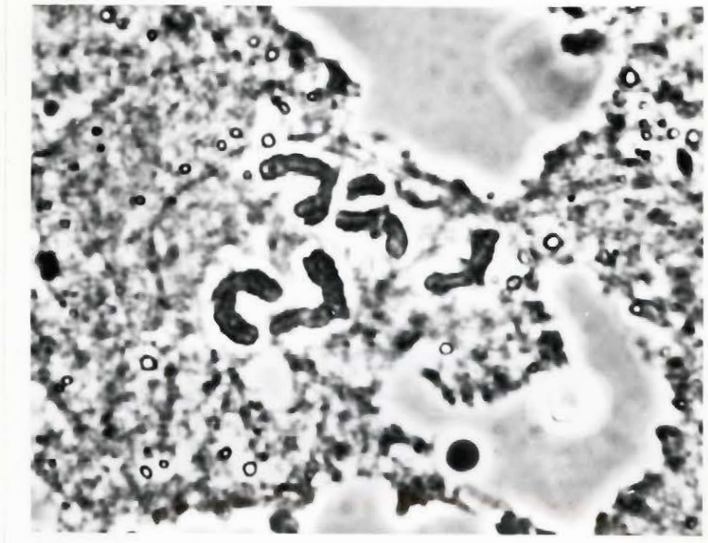


Figure 53. Metaphase I chromosome complements of Ravinia querula (Walk.) from the testis of an adult male, X 2250.

all very low in this species (II-VI average 1.22). All the centromeres of the complement were found in the median regions.

The X-chromosome was about half the length of Pair II and was telocentric. The telocentric Y-chromosome was about 80% of the X-chromosome, corresponding to 4.9% of TCL. The X-and Y-chromosomes were well paired in all five metaphase I figures analysed.

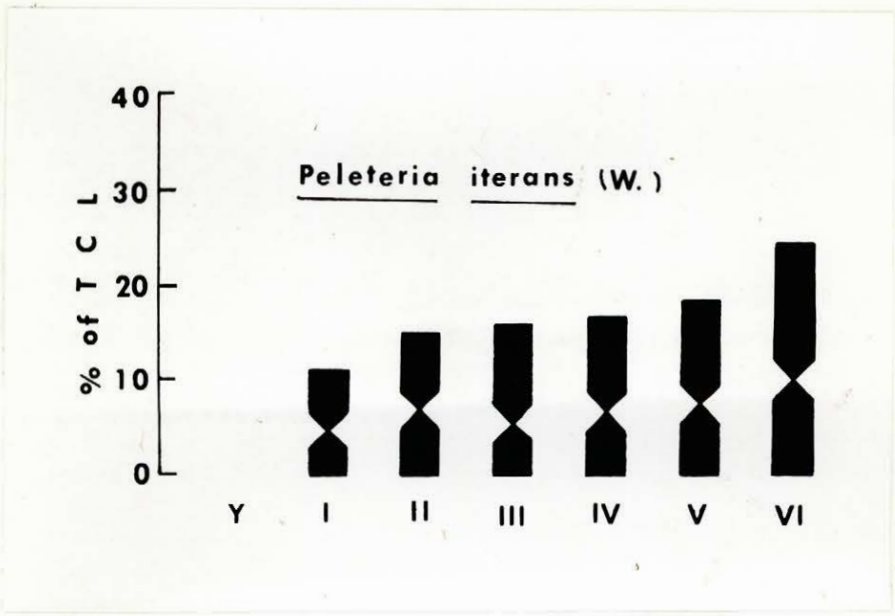
Peleteria iterans (Wlk.)

Adults were collected in British Columbia in August 1964. Four mitotic metaphase figures from one ovary were analysed. The results are summarized in Table 1, Idiogram 51, and a mitotic metaphase picture can be seen in Figure 54.

The average TCL was 40.56 μ. Twelve chromosomes were found in every case, but the centromeres in most cases were not very clear. Pairs II, III, IV and V did not show any distinct differences in length; however, Pair VI was appreciably longer than Pair V. Pair II was also much longer than the X-chromosome. The centromere of Pair III was found in the submedian region; while the centromeres of other chromosomes, including the X-chromosome, were found in the median region.

Archytas prob. apicifera (Walk.)

Adults were collected from North Carolina in the July of 1964. Five very good mitotic metaphase figures were obtained from ovarian tissue. Twelve chromosomes were found in each complement studied. The average TCL was 50.62 μ. Pairs II, III and IV were almost equal in length, while the length differences between Pairs IV and V, and



Idiogram 51

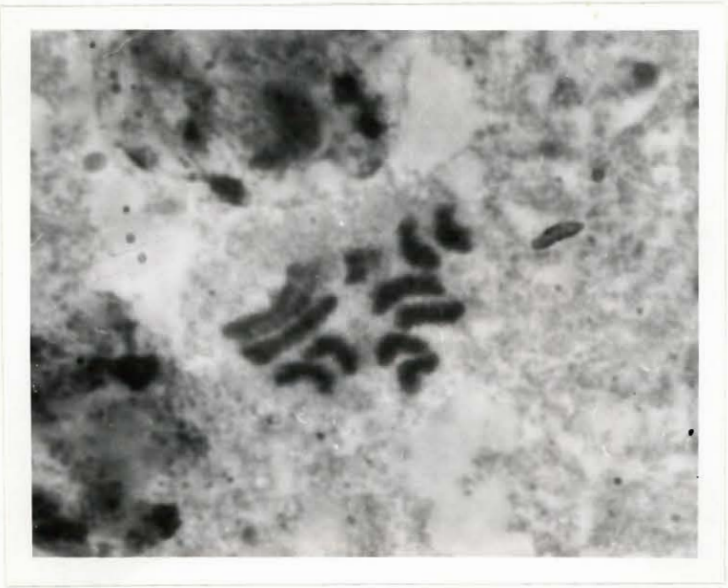
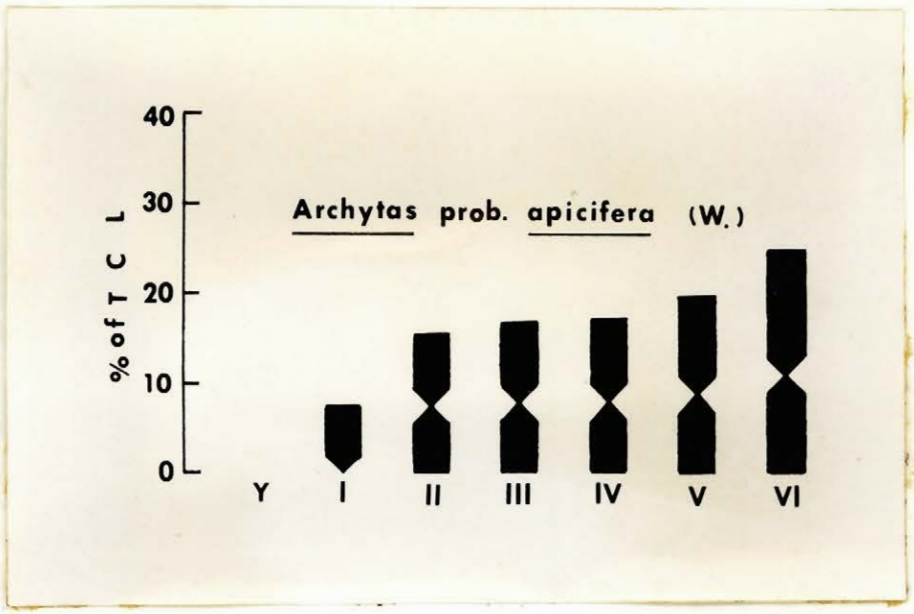


Figure 54. Mitotic metaphase chromosome complement of Peleteria iterans (Walk.) from the ovary of an adult female, X 2250.



Idiogram 52

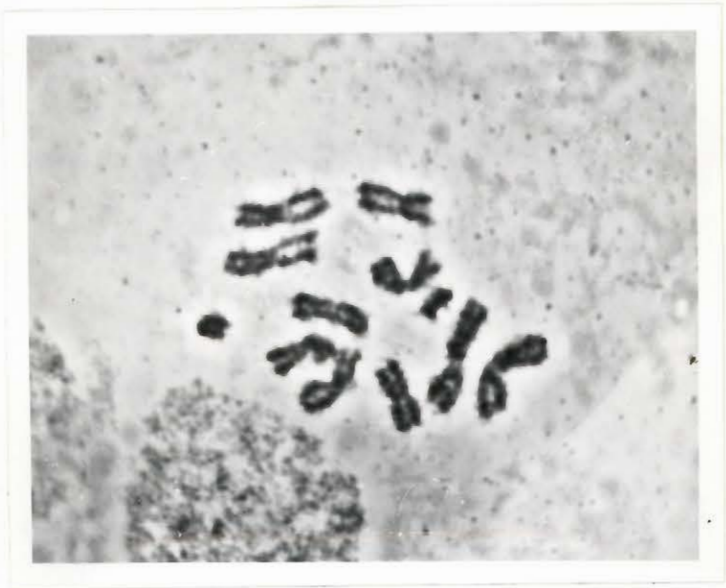


Figure 55. Mitotic metaphase chromosome complement of Archytas apicifera (Walk.) from the ovary of an adult female, X 2250.

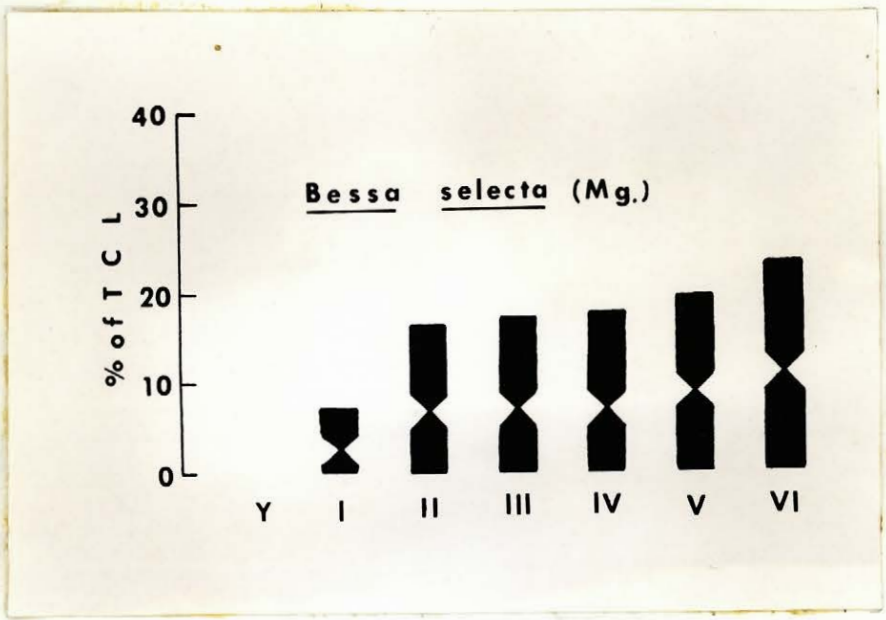
V and VI were obvious. The two X-chromosomes were distinct in this species; their length being about half that of Pair IV. . All the centromeres of the autosomes were found in the median region, while that of the X-chromosome was probably telocentric. However, in one case a subterminal constriction on the X-chromosome was observed. The results of chromosome analysis are shown in Table 1, Idiogram 52, and a mitotic metaphase picture is given in Figure 55.

Bessa selecta (Mg.)

Larvae for these studies were obtained from Winnipeg, Canada. Fifteen mitotic metaphase figures from three larval brains were drawn by camera lucida and subsequently analysed. The results are presented in Table 1, Idiogram 53, and a mitotic metaphase picture is shown in Figure 56.

Twelve chromosomes were observed in each complement analysed. The average TCL was 61.74 μ. The length difference between each two adjacent pairs, from Pair II to Pair V, was not distinct. However, Pair VI was appreciably longer than Pair V. The centromeres of the autosomes were all found in the median region. The average II-VI arm ratio was low (1.37) in this species.

The shortest pair in the complement constituted 6.9% of TCL. A centromere was found in its submedian region, while a secondary constriction was often observed in its long arm. The shortest pair was not well paired in several cases; hence they were assumed to be the sex chromosomes. By measuring the length it was found that one



Idiogram 53

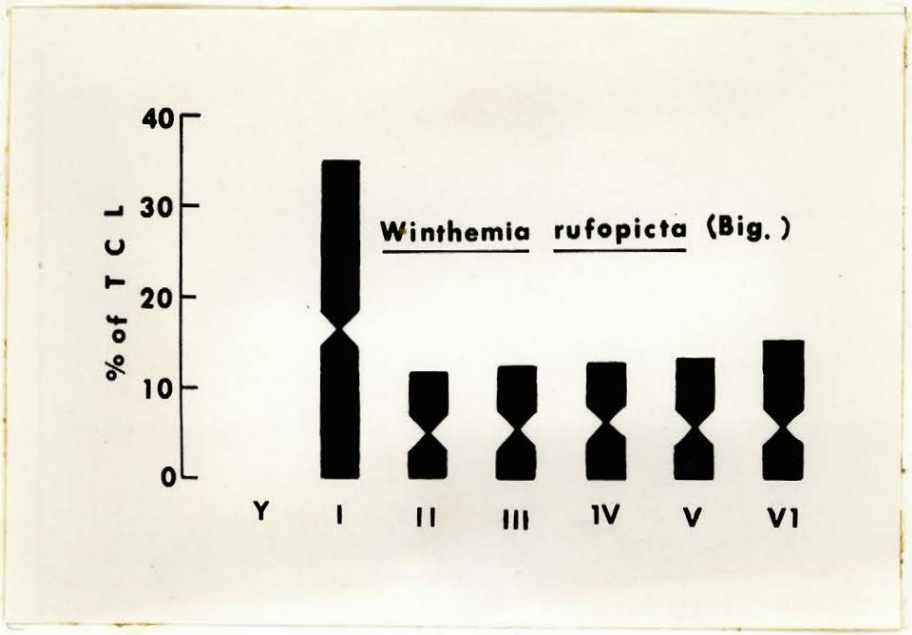
Figure 56. Mitotic metaphase chromosome complement of Bessa selecta (Mg.) from a larval brain, X 3510.

sex chromosome was about 80.7% of the other. Nevertheless, it could not be ascertained that the shorter one was the Y-chromosome and not the error observation of the X-chromosome.

Winthemia rufopicta (Big.)

Adults were collected in North Carolina in July of 1964. Two mitotic metaphase figures from an ovary were analysed, the results are summarized in Table 1, Idiogram 54, and a mitotic metaphase picture is given in Figure 57.

Six pairs of chromosomes were found in both figures analysed. The average TCL was 77.20 μ. The interesting observation in the karyotype of this species was its X-chromosome, which was more than twice as long as Pair VI, and had a centromere in its median region. Pairs II, III, IV and V differed only slightly in their length, while Pair VI was noticeably longer than Pair V. Also a higher arm ratio was only found in Pair VI, nevertheless, the centromeres of all the chromosome complements of this species were found in the median region.



Idiogram 54

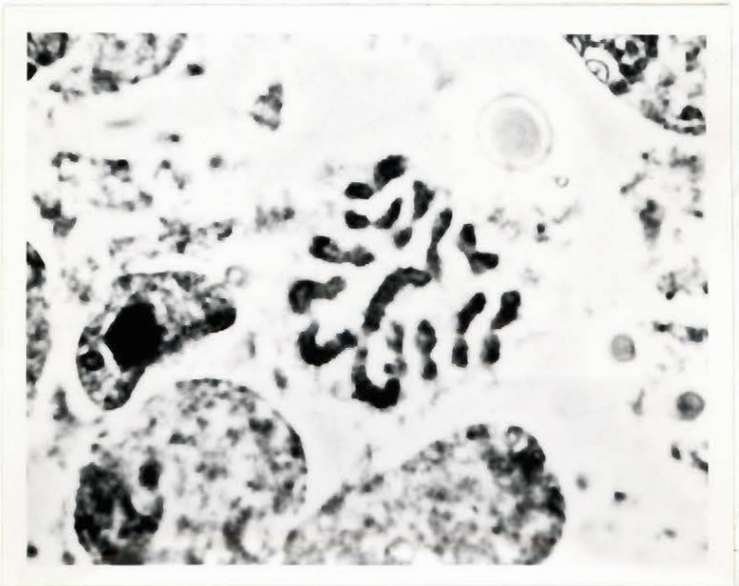


Figure 57. Mitotic metaphase chromosome complement of Winthemia rufopicta (Big.) from the ovary of an adult female, X 2250.

TABLE 1. CHROMOSOMES OF SCHIZOPHORA, DIPTERA

Classification	Percentage of TCL Y	I	II	III	IV	V	VI	TCL in μ	Arm Ratio Y	I	II	III	IV	V	VI	Average arm ratio II-VI	Authorities	Materials studied	No.of cells	No.of individuals	Sources of material
Family Diopsidae																					
Sphyracephala brevicornis (Say)	6 5.70 ± 1.64	6.19 ± 1.33	13.55 ± 2.10	14.89 ± 1.67	27.12 ± 3.14	38.26 2.94	-	34.91 ± 1.982	0	0	0	0	1.11 ± 0.17	1.12 ± 0.10	-	0.56 ± 0.04	Jan	Adult testis	8	2 ♂	Virginia
Family Psilidae																					
Chamaepsila rosae (F.)		36.6 ± 0.35	16.7 ± 0.25	22.3 ± 0.22	24.4 ± 0.21	-	-	50.9 ± 1.6	1.08 ± 0.03	1.33 ± 0.03	1.31 ± 0.04	1.22 ± 0.04	1.55 ± 0.02	-	-	1.36	Robertson 1957	larval brains	20		England
Chamaepsila rosae (F.)		36.2 ± 0.35	16.5 ± 0.24	22.5 ± 0.25	24.8 ± 0.25	-	-	53.5 ± 2.2	1.20 ± 0.05	1.34 ± 0.03	1.37 ± 0.05	1.27 ± 0.04	1.56 ± 0.04	-	-	1.40	Robertson 1957	larval brains	18		Prince Edward Island
Chamaepsila rosae (F.)		36.6 ± 0.43	16.3 ± 0.08	22.3 ± 0.23	24.9 ± 0.26	-	-	52.5 ± 1.5	1.12 ± 0.04	1.32 ± 0.02	1.33 ± 0.04	1.20 ± 0.03	1.61 ± 0.05	-	-	1.38	Robertson 1957	larval brains	20		Ontario
Chamaepsila rosae (F.)		36.5 ± 0.70	16.5 ± 0.27	22.1 ± 0.44	25.0 ± 0.09	-	-	50.8 ± 1.6	1.11 ± 0.04	1.38 ± 0.06	1.36 ± 0.06	1.16 ± 0.04	1.56 ± 0.09	-	-	1.36	Robertson 1957	larval brains	115		British Columbia
Family Otitidae																					
Subfamily Otitinae																					
Camptoneura picta Fabr.		3.8	16.9	18.0	19.6	19.8	21.8										Metz 1916				
Ceroxys latiusculus (L.)		4.25 ± 1.33	13.54 ± 0.90	15.47 ± 0.99	16.70 ± 0.98	18.13 ± 0.88	31.40 ± 1.23	44.56 ± 3.138		0	2.61 ± 1.00	1.90 ± 0.31	1.78 ± 0.41	2.51 ± 0.91	2.57 ± 0.34	2.27 ± 0.22	Jan	adult ovary	8	1 ♀	Pullman Washington
Melieria crassipennis F.	3.16 ± 2.00	10.47 ± 1.053	26.93 ± 1.436	28.08 ± 1.467	34.52 ± 1.491	-	-	35.48 ± 5.489	0	0	1.12 ± 0.108	1.79 ± 0.153	1.08 ± 0.079	-	-	1.33 ± 0.077	Jan	testis	10	1 ♂	Netherlands
Myrmecothea myrmecoides L.		3.42 ± 0.90	14.40 ± 0.27	15.97 ± 0.43	18.03 ± 0.52	20.56 ± 2.11	27.62 ± 2.98	54.82 ± 2.748	0	0	1.80 ± 0.74	1.67 ± 0.47	1.49 ± 0.22	1.60 ± 0.16	1.31 ± 0.48	1.58 ± 0.21	Jan	adult testis	4	1 ♂	Virginia
Seioptera vibrans (L.)		22.37 ± 0.56	36.39 ± 1.22	41.24 ± 1.51	-	-	-	24.35 ± 1.431		0	1.58 ± 0.24	1.65 ± 0.08	-	-	-	1.62 ± 0.15	Jan	adult	5	1 ♀	Pullman Washington

Note:
1. Standard deviations follow below the average and are separated by sign of ±.
2. Numbers on top of the percentages of TCL and arm ratios of the Y-chromosomes indicate the number of complements for the data of the Y-chromosomes.

TABLE 1 (continued)

Classification	Percentage of TCL Y	I	II	III	IV	V	VI	TCL in μ	Arm Ratio Y	I	II	III	IV	V	VI	Average arm ratio II-VI	Authorities	Materials studied	No.of cells	No. of individuals	Sources of material
Subfamily Ulidiinae																					
Chaetopsis fulvifrons M.	3	3.2	19.3	37.6	40.0	-	-										Metz 1916				
Euxesta notata Wied.	1.99 ± 0.18	2.69 ± 1.01	16.79 ± 0.99	17.77 ± 0.88	19.22 ± 0.96	20.20 ± 0.83	23.33 ± 0.98	51.09 ± 9.637	0	0	1.33 ± 0.31	1.53 ± 0.38	1.50 ± 0.35	1.73 ± 0.55	1.32 ± 0.12	1.48 ± 0.10	Jan	larval brains	10	1 ♂	Univ. of West Ont Ontario
Family Platystomatidae																					
Rivellia prob. viridulans R.-D.		42.17 ± 2.01	23.71 ± 2.78	34.12 ± 3.08	-	-	-	43.46 ± 9.132		0	1.20 ± 0.11	1.35 ± 0.13	-	-	-	1.27 ± 0.09	Jan	adult ovary	24	1 ♀	North Carolina
Family Tephritidae																					
Ceratitis capitata (Wied.)				n = 6													Mendes 1958				Brazil
Anastrepha apheloçentoma Stone	2.55	9.6	17.1	17.2	17.3	17.8	20.8			2.26	1.92	1.64	1.17	3.32	1.55	1.92	Bush 1962	larval brains	25	5	Tamazunchale, San Luis Potosi, Mexico
Anastrepha distincta Greene		Similar to Anastrepha fraterculus (Wiedemann)															Bush 1962	larval brains	40	7	Cocoyoc Morelos, Mexico
Anastrepha fraterculus (Wied.)				n = 6													Mendes 1958				Brazil
Anastrepha fraterculus (Wied.)	15.8	14.8	15.4	15.8	16.5	21.6			0	0	0	0	0	0	0	Bush 1962	larval brains	128	32	Monte Blanco, Verocruz Mexico	
Anastrepha ludens L.				2n = 10													Emmart 1935				
Anastrepha ludens (Loew)	6.40	15.5	15.5	15.6	15.6	15.8	21.6			0	0	0	0	0	0	0	Bush 1962	larval brains	47	16	Cuernovaca, Morelos, Mexico
Anastrepha mombinpraeoptans Sein.		Similar to Anastrepha fraterculus (Wiedemann)															Bush 1962	larval brains	46	14	Cocoyoc Morelos, Mexico
Anastrepha serpentina (Wied.)	23.62	12.2 16.7	14.7	16.4	17.8	22.1	-			0 0	1.41	1.46	1.00	1.50	-	1.34	Bush 1962	larval brains	39	13	Monte Blanco, Veracruz Mexico

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No. of cells	No. of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Anastrepha spatulata Stone	4.80	12.7	15.2	15.5	15.9	16.8	23.6		0	0	0	0	0	0	1.05	0.21	Bush 1962	adult testes		3 ♂	Canyon de Lobos Morelos, Mexico
Anastrepha striata Schiner	3.86	16.3	14.3	15.9	15.9	16.0	21.6		0	0	0	0	1.37	1.33	0.54		Bush 1962	larval brains	71	20	Tequila, Jalisco, Mexico
Anastrepha zuelaniae Stone	10.22	13.5	15.9	16.3	16.3	16.9	21.0		0	0	0	0	0	0	0	0	Bush 1962	larval brains	39	3	Tamazunchale, San Luis Potosi, Mexico
Dacus oleae Gmel.				n = 6													Frizzi & Springhetti 1953				Italy
Dacus oleae Gmel.		8.7	16.2	16.9	17.5	18.4	22.1		2.80	2.12	4.85	1.00	1.19	3.24	2.48		Krimbos 1963				
Afrodacus jarvisi (Tryon)		4.88 ± 1.808	12.36 ± 1.697	14.01 ± 1.052	15.16 ± 0.957	16.25 ± 1.083	17.58 ± 1.238	VII 19.75 ± 2.176									Davis 1955	larval brains	9	12	Queensland, Australia
Austrodacus cucumis (French)				6 pairs													Davis 1955	larval brains		12	Queensland, Australia
Diplodacus sienatiles (Tryon)				6 pairs													Davis 1955	pupal testis		6	Queensland, Australia
Epochra canadensis L.		15.09 ± 2.066	16.51 ± 1.451	17.16 ± 1.048	19.94 ± 2.047	31.30 ± 1.793	-	71.80 ± 13.602	2.05 ± 0.343	1.41 ± 0.220	3.54 ± 0.544	1.57 ± 0.343	1.14 ± 0.141	-	1.92 ± 0.196		Jan	adult ovary	8	1 ♀	British Columbia
Strumeta bryoniae (Tryon)	8.65 ± 1.199	12.70 ± 1.199	13.74 ± 1.182	15.37 ± 0.814	17.06 ± 0.941	18.91 ± 1.335	22.23 ± 1.475										Davis 1955	larval brains	9	6	Queensland, Australia
Strumeta cacuminata Hering				6 pairs													Davis 1955	larval brains		6	Queensland, Australia
Strumeta humeralis (Perk.)	10.20 ± 1.020	14.78 ± 4.486	13.65 ± 1.702	15.46 ± 0.730	16.92 ± 1.475	18.43 ± 0.745	20.76 ± 1.604										Davis 1955	larval brains	10	12	Queensland, Australia

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No.of cells	No.of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Strumeta tryoni (Frogg.)	11.00[6] ± 0.660	12.66 ± 1.635	13.75 ± 1.228	14.80 ± 1.384	16.94 ± 1.356	19.74 ± 1.596	22.10 ± 2.129										Davis 1955	larval	9	30	Queensland, Australia
Tephritis arnicae L.		7.1	15.5	15.5	18.1	18.7	25.2										Keuneke 1924	adult testes			
Family Dryomyzidae																					
Dryomyza anilis F.	7.56[6] ± 1.97	15.75[5] ± 1.86	14.18 ± 0.66	15.28 ± 0.95	16.87 ± 1.55	17.63 ± 1.21	20.37 ± 0.77	75.71 ± 5.6147		6.00 ± 0.49	1.47 ± 0.22	1.29 ± 0.13	1.17 ± 0.10	1.48 ± 0.27	1.21 ± 0.09	1.32 ± 0.08	Jan	adult testis	6	1 ♂	Czechoslovakia
Neuroctena analis F.		11.8	14.3	14.9	18.4	19.5	21.1										Metz 1916				
Family Sciomyzidae																					
Subfamily Sciomyzinae																					
Atrichomelina pubera L.	1.65[5] ± 0.49	3.24 ± 0.91	16.80 ± 0.73	18.02 ± 0.56	19.16 ± 0.92	21.16 ± 1.07	21.62 ± 1.20	58.93 ± 8.3053	0	0	2.25 ± 0.42	1.90 ± 0.52	1.45 ± 0.25	1.33 ± 0.16	1.44 ± 0.17	1.68 ± 0.13	Jan	larval brains	19	4 ♀ 1 ♂	Ithaca, New York
Pherbillia grisescens M.		6.30 ± 1.17	15.14 ± 0.75	16.67 ± 0.84	18.46 ± 0.95	19.51 ± 1.22	23.92 ± 1.88	55.67 ± 4.7538		0	1.19 ± 0.13	1.17 ± 0.16	1.48 ± 0.33	1.58 ± 0.63	1.72 ± 0.59	1.43 ± 0.11	Jan	pupal brains	9	2	Kabul, Afghanistan
Pherbellia nana F.	3.00[9] ± 0.84	6.38 ± 0.76	15.74 ± 1.48	17.24 ± 0.48	18.32 ± 0.70	20.33 ± 1.01	22.09 ± 0.78	51.21 ± 8.1271	0	0	1.62 ± 0.30	1.72 ± 0.29	1.64 ± 0.31	1.56 ± 0.27	1.35 ± 0.20	1.58 ± 0.11	Jan	larval brains	9	3 ♂	Ithaca, New York
Pherbellia new sp.	1.48[10] ± 0.38	4.12 ± 1.43	14.72 ± 0.94	16.94 ± 0.86	18.31 ± 0.89	21.86 ± 1.01	24.07 ± 1.26	48.27 ± 5.2684	0	0	1.57 ± 0.24	1.41 ± 0.19	1.41 ± 0.20	1.20 ± 0.25	1.11 ± 0.14	1.34 ± 0.08	Jan	pupal brains	13	2 ♂	
Subfamily Tetanocerinae																					
Antichaeta melanosoma M.		10.50 ± 1.18	14.67 ± 1.02	16.24 ± 1.10	17.18 ± 0.85	19.60 ± 0.92	21.40 ± 1.07	74.19 ± 10.7404		0	1.88 ± 0.26	1.83 ± 0.41	1.46 ± 0.44	1.22 ± 0.12	1.54 ± 0.61	1.58 ± 0.14	Jan	larval brains	10	1 ♀	Ithaca, New York
Dictya atlantica Steyskal	3.07[11] ± 0.98	6.67 ± 1.04	15.98 ± 0.64	17.18 ± 0.54	18.95 ± 0.50	20.09 ± 0.54	21.14 ± 0.82	61.01 ± 7.8253	0	0	2.02 ± 0.38	1.88 ± 0.54	1.22 ± 0.18	1.29 ± 0.21	1.47 ± 0.38	1.58 ± 0.15	Jan	larval brains	14	1 ♀ 4 ♂	Scranton Pennsylvania
Dictya brimleyi Steyskal	3.14[10] ± 0.22	7.14 ± 1.35	15.25 ± 0.94	17.03 ± 0.91	18.67 ± 0.96	20.04 ± 0.95	21.37 ± 1.73	58.47 ± 7.5471	0	0	1.98 ± 0.26	1.71 ± 0.58	1.39 ± 0.33	1.49 ± 0.42	1.28 ± 0.13	1.58 ± 0.14	Jan	larval brains	10		Scranton Pennsylvania
Dictya sabroski Steyskal	2.93[4] ± 0.45	6.30 ± 0.51	15.96 ± 0.85	17.17 ± 0.95	19.07 ± 0.74	20.15 ± 0.73	21.36 ± 0.82	60.78 ± 5.8942	0	0	2.19 ± 0.34	1.97 ± 0.47	1.46 ± 0.49	1.40 ± 0.27	1.53 ± 0.26	1.71 ± 0.12	Jan	larval brains	11	2 ♀ 3 ♂	Lebanon Mo.

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No.of cells	No.of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Dictya texensis Curran	2.36[3] ± 0.42	6.38 ± 1.24	16.00 ± 1.95	16.48 ± 1.35	18.73 ± 1.12	20.63 ± 0.84	21.77 ± 1.27	74.04 ± 11.6347	0	0	1.91 ± 0.48	1.98 ± 0.43	1.73 ± 0.24	1.30 ± 0.20	1.39 ± 0.22	1.56 ± 0.18	Jan	larval brains	13	3 ♀ 2 ♂	Lubbock, Texas
Sepedon armipes Loew.		5.68 ± 2.07	15.82 ± 0.74	17.33 ± 0.80	18.53 ± 1.07	20.16 ± 1.00	22.47 ± 1.09	56.69 ± 8.3182		0	1.52 ± 0.29	1.47 ± 0.27	1.23 ± 0.25	1.20 ± 0.30	1.16 ± 0.12	1.32 ± 0.05	Jan	larval brains	9	3 ♀	Ithaca, New York
Sepedon fuscipennis Loew.	4.20[2] ± 0.33	15.01 ± 3.80	12.96 ± 0.54	15.45 ± 1.63	17.48 ± 0.88	19.05 ± 1.01	20.05 ± 1.17	83.92 ± 12.2507	0	1.37 ± 0.32	1.48 ± 0.35	1.70 ± 0.38	1.82 ± 0.53	1.54 ± 0.38	1.59 ± 0.38	1.63 ± 0.19	Jan	larval brains	7	2 ♂ 1 ♀	Ithaca, New York
Tetanocera loewi Steyskal	2.10[5] ± 0.60	4.20 ± 1.04	15.74 ± 1.21	16.87 ± 0.71	17.78 ± 0.45	21.42 ± 1.38	23.98 ± 1.22	79.43 ± 8.4187	0	0	1.66 ± 0.20	1.67 ± 0.58	1.70 ± 0.44	1.32 ± 0.18	1.14 ± 0.16	1.50 ± 0.12	Jan	adult testes	5	2 ♂	Ithaca, New York
Tetanocera sp.		13.04 ± 0.967	14.46 ± 0.652	15.92 ± 0.230	17.70 ± 0.859	18.59 ± 0.527	20.30 ± 0.767	107.98 ± 12.414		0	1.72 ± 0.436	1.31 ± 0.538	1.22 ± 0.192	1.31 ± 0.174	1.47 ± 0.177	1.41 ± 0.083	Jan	adult ovary	5	1 ♀	British Columbia
Tetanocera sparsa	1.5	4.6	16.3	17.4	18.5	21.2	22.4										Stevens 1908	adult testes			
Pscadina žerni Mayer	2.90[1]	16.14 ± 2.02	12.40 ± 1.10	15.12 ± 0.73	17.39 ± 0.93	18.73 ± 0.99	20.22 ± 1.10	77.96 ± 10.847	0	1.30 ± 0.18	1.94 ± 0.50	2.12 ± 0.71	1.27 ± 0.24	1.36 ± 0.33	1.55 ± 0.54	1.65 ± 0.26	Jan	larval brains	15	1 ♂ 4 ♀	Sor, Denmark
Family Lanxaniidae																					
Minettia flaveola Cog.	14.30[6] ± 0.12	21.35 ± 2.81	17.30 ± 0.47	17.84 ± 0.86	20.53 ± 2.25	22.98 ± 2.14	-	61.45 ± 8.0711	1.95[6] ± 0.27	2.08 ± 0.20	1.22 ± 0.16	1.33 ± 0.20	1.32 ± 0.20	1.11 ± 0.12	-	1.25 ± 0.02	Jan	adult testes	6	1 ♂	Pullman Washington
Physegenua vittata Macq.		4.6	16.7	17.5	19.1	20.0	21.6										Metz 1916				
Family Chamaemyiidae																					
Cremifania nigrocellulata Cz.		24.19 ± 2.65	33.54 ± 1.71	42.27 ± 3.19	-	-	-	27.19 ± 3.365		0	1.42 ± 0.14	1.20 ± 0.15	-	-	-	1.31 ± 0.10	Jan	larval brains	10	6	Winterthur, Switzerland
Leucopemyia obscura H.		10.93 ±	14.19 ± 0.437	15.97 ± 1.243	16.96 ± 0.610	19.10 ± 0.837	22.85 ± 1.555	46.86 ± 5.528		0	1.36 ± 0.282	1.16 ± 0.115	1.21 ± 0.227	1.31 ± 0.182	1.23 ± 0.281	1.25 ± 0.078	Jan	larval brains	6	3	Feldmeilen, Switzerland

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No. of cells	No. of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-IV					
Family Heleomyzidae																					
Suillia nemorum (Mg.)	3.06 ± 0.232	17.18 ± 0.546	14.74 ± 0.385	15.11 ± 0.558	15.70 ± 0.094	17.99 ± 0.316	19.47 ± 0.78	64.00 ± 6.788	0	1.11 ± 0.081	2.27 ± 0.094	1.43 ± 0.035	2.56 ± 0.080	1.35 ± 0.067	1.17 ± 0.027	1.75 ± 0.029	Jan	adult testis	2	1 ♂	British Columbi
Suilla nemorum (Mg.)	2.03 ± 0.522	4.05 ± 0.865	16.36 ± 0.433	17.73 ± 0.383	19.02 ± 0.781	20.11 ± 0.765	22.73 ± 0.871	46.67 ± 7.086	0	0	1.20 ± 0.116	1.92 ± 0.241	1.98 ± 0.349	1.19 ± 0.059	1.12 ± 0.074	1.48 ± 0.074	Jan	adult testis	3	1 ♂	British Columbi
Suilla sp.		5.33 ± 0.98	15.97 ± 1.30	16.91 ± 1.67	18.81 ± 0.77	20.24 ± 1.91	22.74 ± 2.04	52.88 ± 2.5631		0	1.75 ± 0.41	1.63 ± 0.31	1.36 ± 0.17	1.32 ± 0.13	1.52 ± 0.37	1.52 ± 0.10	Jan	adult ovary	4	1 ♀	British Columbi
Family Anthomyiidae																					
Subfamily Scatophaginae																					
Cordilura ciliata	4.37 ± 0.71	5.20 ± 0.79	16.93 ± 2.02	17.39 ± 0.97	19.10 ± 1.49	19.86 ± 1.11	21.52 ± 1.26	91.36 ± 8.1538	0	0	1.33 ± 0.10	1.65 ± 0.32	1.76 ± 0.52	1.67 ± 0.75	1.65 ± 0.31	1.61 ± 0.17	Jan	adult testis	5	1 ♂	Czechos lovakia
Cordilura ontario Cn.	5.00 ± 0.45	5.48 ± 0.70	16.44 ± 1.73	16.62 ± 0.80	19.00 ± 0.71	20.57 ± 0.59	21.88 ± 0.83	81.60 ± 12.7996	0	0	1.46 ± 0.37	1.96 ± 0.50	1.41 ± 0.34	1.35 ± 0.23	1.39 ± 0.25	1.51 ± 0.07	Jan	larval brains	15	4	Virgini
Achaetella varipes (Walk)		10.55 ± 0.53	14.55 ± 0.97	15.41 ± 0.69	16.64 ± 0.79	18.36 ± 0.76	24.49 ± 0.95	77.64 ± 9.9551	0	0	1.26 ± 0.06	1.94 ± 0.31	1.85 ± 0.11	1.16 ± 0.13	1.10 ± 0.03	1.46 ± 0.08	Jan	larval brains	5	1	Virgini
Orthochaeta hirtipes John.		4.17 ± 1.28	13.94 ± 1.58	16.84 ± 1.17	18.53 ± 1.94	22.07 ± 0.95	24.45 ± 1.75	64.44 ± 6.2698	0	0	1.76 ± 0.21	1.61 ± 0.25	2.47 ± 0.50	1.59 ± 0.16	2.54 ± 0.16	2.00 ± 0.09	Jan	adult ovary	3	♀	Port of Spain, Trinida
Scatophaga pallida Walk.		2.9	14.8	18.7	20.3	20.6	22.0										Stevens 1908				
Scatophaga stercoraria (L.)				5 pairs ± x y													Keuneke 1924				
Subfamily Fucellinae																					
Fucellia marina Macq.		12.0	16.6	17.6	16.10	17.3	20.0										Metz 1916				
Subfamily Anthomyiinae																					
Hylemya antigua Mg.		4.3 ± 0.46	17.1 ± 0.61	17.6 ± 0.60	17.8 ± 0.60	19.3 ± 0.55	23.9 ± 0.72	85.4 ± 0		0	1.50 ± 0.11	2.59 ± 0.17	2.08 ± 0.16	1.45 ± 0.11	1.30 ± 0.08	1.78 ± 0	Boyes 1954	larval brains	80	33	St.Jean Quebec
Hylemya brassicae (Bouche)		3.39	16.7	17.6	18.8	19.8	23.8	80.0		0	2.13	2.36	2.75	2.17	1.46	2.17	Boyes 1954	larval brains	13	8	Bellevil radish
Hylemya brassicae (Bouche)		3.33	16.5	17.8	18.7	19.9	23.8	73.5		0	2.01	2.35	2.83	2.31	1.47	2.19	Boyes 1954	larval brains	30	11	Bellevill cabbage

TABLE 1 (continued)

Classification	Percentage of TCL							Arm Ratio								Authorities	Materials studied	No.of cells	No.of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Hylemya brassicae (Bouché)		3.07	16.7	18.1	18.9	19.6	23.6	63.8		0	2.03	2.40	2.98	2.34	1.51	2.25	Boyes 1954	larval brains	10	4	Cloverdale radish
Hylemya brassicae (Bouché)		3.49	16.7	17.8	18.3	20.0	23.7	66.3		0	2.13	2.42	2.85	2.21	1.53	2.23	Boyes 1954	larval brains	11	5	Charlotte town turnip
Hylemya brassicae (Bouché)		3.52	16.9	17.8	18.3	19.8	23.7	71.1		0	2.03	2.41	3.10	2.11	1.55	2.24	Boyes 1954	larval brains	25	10	Guelph turnip
Hylemya brassicae (Bouché)		3.38	17.1	17.9	18.3	19.9	23.5	61.7		0	2.05	2.30	2.85	2.18	1.52	2.18	Boyes 1954	larval brains	20	7	Prestwick br.sprout
Hylemya brassicae (Bouché)		3.25	16.9	18.1	18.7	19.7	23.5	71.5		0	2.11	2.31	2.84	2.15	1.50	2.18	Boyes 1954	larval brains	20	9	St.John turnip
Hylemya cana Macquart		4.3 ± 0.59	16.1 ± 1.20	18.4 ± 0.76	19.9 ± 0.41	18.9 ± 0.61	22.5 ± 0.95	44.0		0	1.35 ± 0.09	2.63 ± 0.06	1.34 ± 0.09	1.81 ± 0.11	1.38 ± 0.07	1.70	Boyes 1954	larval brains	5		Belleville Ontario
Hylemya cilicrura (Rond.)		4.4 ± 0.46	16.4 ± 0.39	18.3 ± 0.71	19.1 ± 0.79	19.2 ± 0.49	22.5 ± 0.79	78.0		0	1.38 ± 0.08	2.34 ± 0.16	1.36 ± 0.11	2.04 ± 0.16	1.39 ± 0.09	1.70	Boyes 1954	larval brains	29	26	Brandon Manitoba
Hylemya crucifera Huck.		4.3 ± 0.366	16.0 ± 0.547	17.0 ± 0.744	18.1 ± 0.615	19.2 ± 0.685	25.4 ± 1.092	59.2		0	1.87 ± 0.185	2.19 ± 0.157	2.33 ± 0.174	2.16 ± 0.138	1.64 ± 0.064	2.05	Boyes 1954	larval brains	20	10	Brandon Manitoba
Hylemya cruficera Huck.		4.4 ± 0.385	15.6 ± 0.494	16.9 ± 0.732	18.0 ± 0.788	19.4 ± 0.692	25.7 ± 0.995	61.8		0	1.85 ± 0.109	2.16 ± 0.130	2.45 ± 0.128	2.09 ± 0.156	1.65 ± 0.078	2.03	Boyes 1954	larval brains	20	9	Saskatoon Sask.
Hylemya echinata (Séguy)	3.85	4.99 ± 0.871	17.17 ± 0.584	17.63 ± 0.660	18.66 ± 0.580	18.77 ± 0.659	22.78 ± 0.705	19.04 ± 13.57	0	0	1.78 ± 0.197	2.04 ± 0.172	2.20 ± 0.128	2.78 ± 0.249	1.50 ± 0.094	2.06 ± 0.066	Jan	larval brains	10	2 ♀ 1 ♂	Wye Coll Kent, England
Hylemya floralis (Fall.)		3.8 ± 0.30	15.7 ± 1.07	16.8 ± 0.51	18.1 ± 0.52	19.9 ± 0.64	25.8 ± 0.93	63.5		0	1.86 ± 0.12	2.06 ± 0.10	2.47 ± 0.13	2.19 ± 0.14	1.64 ± 0.07	2.04	Boyes 1954	larval brains	21		Elgin Scotland
Hylemya florilega Zett.		4.87 ± 1.30	16.63 ± 1.41	17.15 ± 0.54	17.91 ± 0.78	20.57 ± 1.4	22.88 ± 0.92	60.77 ± 4.920		0	1.48 ± 0.32	1.60 ± 0.51	2.16 ± 0.33	1.61 ± 0.40	1.48 ± 0.23	1.67 ± 0.11	Jan	adult ovary	7	1 ♀	Netherlands
Hylemya fugax (Mg.)	7.73	12.9* ± 0.72	12.7 ± 0.48	16.6 ± 0.50	17.8 ± 0.51	18.4 ± 0.64	21.7 ± 0.71	100.4	1.79	0	1.56 ± 0.17	1.65 ± 0.12	1.60 ± 0.13	1.30 ± 0.08	1.32 ± 0.09	1.49	Boyes 1954	larval brains	22	10	Wye England

* including x_1 and x_2

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No. of cells	No. of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Hylemya planipalpus (Stein)		3.5 ± 0.39	16.2 ± 0.63	17.8 ± 0.38	18.2 ± 0.55	20.7 ± 0.59	23.7 ± 0.78	66.6		0	2.07 ± 0.10	2.33 ± 0.16	2.63 ± 0.16	2.28 ± 0.13	1.58 ± 0.06	2.18	Boyes 1954	larval brains	20	8	Brandon Manitoba
Hylemya trichodactyla (Rond.)		3.8 ± 0.53	16.5 ± 0.56	18.0 ± 0.40	18.0 ± 0.52	20.4 ± 0.62	23.3 ± 0.70	68.5		0	1.45 ± 0.12	2.35 ± 0.15	1.37 ± 0.10	1.77 ± 0.17	1.40 ± 0.07	1.67	Boyes 1954	larval brains	20	4	Cloverdale, British Columbia
Phorbia brassica		11.8	14.8	14.8	18.3	19.0	20.6										Stevens 1908				
Hydrophoria conica Wied.		3.89 ± 0.48	14.97 ± 0.53	16.01 ± 1.05	18.71 ± 0.58	19.36 ± 0.66	27.06 ± 0.88	103.33 ± 14.183		0	1.55 ± 0.63	2.17 ± 0.39	1.43 ± 0.14	1.33 ± 0.09	1.26 ± 0.20	1.55 ± 0.09	Jan	adult testis & ovaries	5	1 ♂ 1 ♀	St.George Grenada Canada
Pegamya betae (C.)	2.16 (5) ± 0.314	5.82 ± 0.71	16.62 ± 0.721	16.90 ± 0.522	18.34 ± 0.696	19.41 ± 0.689	22.91 ± 1.380	112.54 ± 16.364	0	0	1.48 ± 0.069	2.29 ± 0.282	2.24 ± 0.188	1.32 ± 0.111	1.37 ± 0.159	1.74 ± 0.079	Jan	larval brains	10	3 ♀ 3 ♂	Wye Coll Kent, England
Pegomya bicolor (Wied.)	1.74 (2)	5.04 ± 0.382	16.49 ± 0.511	17.49 ± 0.468	17.50 ± 0.509	18.19 ± 0.392	25.29 ± 0.708	91.31 ± 16.849	0	0	1.53 ± 0.191	1.41 ± 0.149	2.10 ± 0.163	1.72 ± 0.235	1.49 ± 0.078	1.65 ± 0.046	Jan	larval brains	11	7 ♀ 3 ♂	Wye Coll Kent, England
Pegomya geniculata (Bouche)		5.6	13.9	17.5	18.1	20.5	24.4			0	1.92	2.00	2.12	2.00	1.27		Frolowa 1929				Measurements Boyes 1954
Family Muscidae																					
Subfamily Fanninae																					
Fannia canicularis (L.)	9.00 (6) ± 2.920	14.57 ± 1.578	12.72 ± 0.472	14.05 ± 0.678	15.51 ± 0.790	19.85 ± 1.00	23.30 ± 0.607	103.54 ± 27.827	1.31 (6) ± 0.185	1.15 ± 0.120	1.34 ± 0.136	1.85 ± 0.292	1.66 ± 0.258	1.22 ± 0.123	1.20 ± 0.104	1.45 ± 0.073	Jan	larval brains	11	3 ♂ 2 ♀	Montreal
Fannia glaucescens (Zett.)				6 pairs													Boyes 1954	larval brains			
Homalomyia (Fannia) sp.		11.0	13.0	16.0	17.5	19.0	22.7										Metz 1916	adult testes			
Subfamily Phaoniinae																					
Hydrotaea scambus Zett.		17.05 ± 0.73	18.62 ± 0.67	19.55 ± 0.81	21.04 ± 1.01	23.74 ± 0.64	-	88.97 ± 9.297			1.68 ± 0.30	1.74 ± 0.56	1.58 ± 0.55	1.64 ± 0.26	1.27 ± 0.09	-	1.56 ± 0.07	Jan	adult testis	7	1 ♂	Pullman Washington
Ophyra leucostoma Wied.		4.1	17.1	15.6	19.2	20.2	23.7										Metz 1916				

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No. of cells	No. of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Ophyra leucostoma Wied.		4.2 ± 0.61	17.1 ± 1.27	17.6 ± 0.71	18.5 ± 0.83	20.2 ± 1.17	22.4 ± 1.26	59.2 ± 8.83		[illegible] ± 0.15	1.27 ± 0.10	2.11 ± 0.33	2.61 ± 0.23	1.18 ± 0.15	1.63 ± 0.14	1.76 ± 0.08	Boyes et al 1964	larval brains	11	5	Algonquin Park, Ontario
Phaonia basalis Fabr.		32.8	10.4	12.0	13.2	14.2	17.4	96.0		0	1.24	1.85	1.12	1.39	1.27	1.37	Boyes et al 1964	adult testis			Netherlands
Phaonia variegata Fabr.		16,2 ± 1.17	19.0 ± 1.14	20.1 ± 0.61	21.1 ± 0.86	23.7 ± 1.33	-	70.3 ± 14.78		1.28 ± 0.10	1.49 ± 0.15	1.56 ± 0.21	1.25 ± 0.08	1.45 ± 0.09	-	1.41 ± 0.06	Boyes et al 1964	adult testis			Netherlands
Muscina stabulans Fall.		16.8 ± 0.66	17.4 ± 0.68	17.8 ± 0.76	21.7 ± 0.90	26.3 ± 1.09	-	56.7 ± 11.25		1.48 ± 0.11	2.18 ± 0.20	1.67 ± 0.11	1.15 ± 0.09	1.13 ± 0.07	-	1.52 ± 0.06	Boyes et al 1964	larval brains	16	10	Belleville Ontario
Subfamily Muscinae																					
Orthellia nudissima L.		16.2 ± 1.13	18.5 ± 1.50	18.3 ± 0.80	22.5 ± 0.82	24.6 ± 1.26	-	81.5 ± 17.01		1.46 ± 0.12	2.53 ± 0.31	1.66 ± 0.21	1.13 ± 0.06	1.31 ± 0.06	-	1.62 ± 0.10	Boyes et al 1964	larval brains	10	3	Naumu, Northern Natal
Musca autumnalis DeG.	2.2 ± 0.37	6.1 ± 0.87	15.3 ± 0.95	17.4 ± 0.74	18.0 ± 0.88	20.6 ± 1.05	22.7 ± 1.10	95.2 ± 15.69		1.59 ± 0.18	1.34 ± 0.27	2.27 ± 0.27	1.87 ± 0.31	1.22 ± 0.11	1.38 ± 0.14	1.62 ± 0.09	Boyes et al 1964	larval brains	12	10	Guelph, Ontario
Musca domestica Linne		9.3	10.7	16.3	18.5	20.7	24.7										Stevens 1908	adult testes & ovaries			
Musca domestica Linne		18.8	12.3	16.7	17.4	17.4	17.4			1.06	1.10	1.30	1.48	1.20	1.44	1.30	Metz 1916	adult ovary			
Musca domestica L.				6 pairs													Keuneke 1924	adult testis			
Musca domestica L.				5 pairs + x y													Perje 1948	adult testis			
Musca domestica L.				Description of karyotype													Ramade 1961	adult testis larval brains			
Musca domestica L.				Photomicrograph of ♀ karyotype													Franco 1962	larval brains			
Musca domestica L.				Allosome - autosome length relations													Boyes et al 1962	larval brains	50		Canadian & Powell strains

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No.of cells	No.of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Musca domestica L.	illustrated XX, XY, XO, XXX, XXY and OY in larvae																Rubini 1964	larval brains			
Musca domestica L.	♀ larvae 5 pairs + XX; ♂ larvae 5 pairs + XY or XO or XX																Hiroyoshi 1964	larval brains			
Musca domestica L.	found XX, XY, XO, XXX in larvae																Milani 1964	larval brains			
Musca domestica L.	7.5 ± 1.02	18.5 ± 2.27	13.7 ± 0.52	14.2 ± 0.76	15.5 ± 0.80	18.6 ± 1.19	19.5 ± 1.15	71.1 ± 18.75	1.44 ± 0.21	1.20 ± 0.10	1.45 ± 0.20	1.68 ± 0.10	2.36 ± 0.18	1.48 ± 0.14	1.13 ± 0.08	1.62 ± 0.04	Boyes et al 1964	larval brains	12	7	Algonquin Park, Ontario Powell strains
Musca domestica L.	7.2 ± 0.55	17.1 ± 0.47	13.9 ± 0.41	14.8 ± 0.68	15.4 ± 0.60	19.1 ± 0.80	19.8 ± 0.42	74.1 ± 7.41	1.35 ± 0.194	1.20 ± 0.14	1.38 ± 0.12	1.68 ± 0.15	2.40 ± 0.27	1.50 ± 0.10	1.11 ± 0.09	1.62 ± 0.05	Boyes et al 1964	larval brains	8	6	
Musca domestica L.	6.4 ± 0.67	17.0 ± 1.03	13.7 ± 0.57	14.8 ± 0.56	15.6 ± 0.92	19.2 ± 0.71	19.6 ± 1.27	81.2 ± 10.99	1.29 ± 0.16	1.12 ± 0.19	1.33 ± 0.11	1.69 ± 0.14	2.20 ± 0.19	1.50 ± 0.11	1.17 ± 0.15	1.58 ± 0.06	Boyes et al 1964	larval brains	12	10	Canadian strains
Musca domestica colleva Wal.	6.1 ± 0.62	17.8 ± 1.05	13.7 ± 0.70	14.7 ± 0.89	15.9 ± 1.00	19.2 ± 0.90	18.7 ± 1.06	78.5 ± 17.24	1.11 ± 0.09	1.10 ± 0.07	1.60 ± 0.21	1.41 ± 0.17	2.26 ± 0.29	1.55 ± 0.19	1.22 ± 0.13	1.61 ± 0.10	Boyes et al 1964	larval brains	11	3	Johannesburg, S.Africa
Musca domestica curviforceps S. & R.	8.4 ± 0.58	19.2 ± 1.83	1.30 ± 1.14	14.9 ± 1.02	15.2 ± 0.69	18.3 ± 0.87	19.4 ± 1.00	69.2 ± 9.74	1.36 ± 0.17	1.06 ± 0.03	1.58 ± 0.27	1.44 ± 0.13	2.40 ± 0.29	1.52 ± 0.14	1.09 ± 0.06	1.60 ± 0.08	Boyes et al 1964	larval brains	10	8	Swaziland
Musca sorbens Wied.	9.1 ± 0.80	21.3 ± 1.90	12.9 ± 0.69	14.4 ± 1.06	15.6 ± 0.82	17.2 ± 1.78	18.6 ± 1.78	60.2 ± 6.14	1.25 ± 0.13	1.13 ± 0.05	1.36 ± 0.15	1.34 ± 0.09	2.20 ± 0.29	1.60 ± 0.29	1.35 ± 0.24	1.57 ± 0.10	Boyes et al 1964	larval brains	11	2	Naumu, Northern Natal
Musca vetustissima Walk.	13.9 ± 1.33	18.5 ± 0.79	14.1 ± 0.91	14.8 ± 0.64	15.1 ± 0.70	18.1 ± 1.02	19.4 ± 1.09	68.8 ± 13.79	1.40 ± 0.20	1.58 ± 0.15	1.61 ± 0.12	1.53 ± 0.16	2.35 ± 0.24	1.24 ± 0.14	1.44 ± 0.22	1.64 ± 0.07	Boyes et al 1964	larval brains	11	4	Canberra Australia
Subfamily Stomoxyinae																					
Haematobia irritans (L.)		14.1	16.3	19.8	22.5	28.2	-			1.60	2.00	1.06	1.46	2.80	-		Lachance 1964				
Stomoxys calcitrans (L.)		15.1	17.4	20.3	21.7	25.0	-			1.61	2.05	1.23	1.71	1.00	-		Lachance 1964				

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No. of cells	No. of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Family Calliphoridae																					
Subfamily Chrysomyinae																					
Tribe Chrysomyini																					
Callitroga hominivorax (Coq.)	3.5	12.4	13.7	16.1	16.7	18.6	22.5			Acro.	5.15	1.07	1.63	1.93	1.72	2.30	Kaufman & Wasserman 1957				Measurements Boyes 1961
Callitroga hominivorax (Coq.)	4.70 ± 0.424	8.83 ± 1.028	16.53 ± 0.510	16.93 ± 0.917	17.52 ± 0.686	19.00 ± 0.964	21.18 ± 0.987	38.9 ± 5.937	0	0	1.38 ± 0.214	3.11 ± 0.752	1.38 ± 0.187	1.58 ± 0.279	1.43 ± 0.228	1.78 ± 0.197	Boyes 1961	larval brains	9		Univ.of Texas
Callitroga (Cochliomyia) hominivorax (Coq.)	2.60	7.8	16.1	17.2	17.8	19.4	21.8		0	0	1.48	2.93	1.72	1.37	1.38	1.78	Lachance et al 1964	adult testis			
Callitroga mocellaria (Fab.)	3.35 ± 0.459	4.54 ± 0.900	16.26 ± 1.176	18.13 ± 0.830	18.84 ± 1.005	19.79 ± 0.960	22.48 ± 1.353	41.6 ± 8.330	0	0	1.28 ± 0.170	1.46 ± 0.241	2.18 ± 02396	1.48 ± 0.155	1.30 ± 0.179	1.54 ± 0.114	Boyes 1961	larval brains	18		St.Georg Grenada
Chrysomyia albiceps (Wiedemann)		7.8	15.1	16.4	18.1	19.6	22.6			0	1.68	1.44	1.31	1.61	1.16	1.44	Ullerich 1963	adult ovaries			South Africa
Chrysomyia albiceps (Wiedemann)	5.10 ± 0.53	7.18 ± 0.72	15.85 ± 1.25	17.63 ± 0.80	18.06 ± 0.82	19.84 ± 0.46	21.44 ± 1.48	43.88 ± 7.210	0	0	1.66 ± 0.41	1.41 ± 0.23	1.30 ± 0.18	1.58 ± 0.54	1.21 ± 0.10	1.43 ± 0.05	Jan	larval brains	5	2 ♂	Johannesburg, S.Africa
Chrysomyia chloropyga (Wiedemann)	4.81 ± 1.07	12.33 ± 2.58	14.93 ± 1.05	16.38 ± 0.68	17.26 ± 0.90	18.62 ± 1.18	20.47 ± 0.96	64.37 ± 15.413	0	1.39 ± 0.32	1.22 ± 0.22	1.31 ± 0.26	1.40 ± 0.30	1.60 ± 0.19	1.30 ± 0.21	1.31 ± 0.14	Jan	larval brains & testes	15	3 ♀ 4 ♂	Johannesburg, S.Africa
Chrysomyia ? megacephala (Fabricius)	4.6	10.0	14.5	15.3	19.3	20.0	20.8		0	0	1.07	1.80	1.42	1.36	1.25	1.38	Ullerich 1963	adult testes			Japan
Chrysomyia putoria (Wiedemann)	5.13 ± 0.97	14.24 ± 2.55	14.33 ± 0.87	15.92 ± 1.16	16.95 ± 0.93	18.40 ± 1.07	20.16 ± 1.58	64.29 ± 15.514	0	1.26 ± 0.21	1.46 ± 0.55	1.39 ± 0.25	1.42 ± 0.19	1.34 ± 0.20	1.36 ± 0.30	1.39 ± 0.15	Jan	larval brains & testes	19		Johannesburg, S.Africa
Chrysomyia rufifacies (Macquart)		7.4	17.2	17.8	18.0	19.2	20.7		0	1.05	1.5	1.3	1.5	2.2	1.4	1.6	Ullerich 1963	adult ovary			Australia
Tribe Phormiini																					
Phormia regina M.	3.1	8.3	16.0	18.3	18.5	19.4	19.5		-	-	-	-	-	-	1.32	-	Metz 1916	adult testes			Measurements Boyes 1961
Phormia regina M.	3.9 ± 0.993	8.3 ± 0.784	16.8 ± 0.622	17.5 ± 0.369	18.0 ± 0.560	18.2 ± 0.706	21.2 ± 1.131	64.7 ± 7.051	0	0	1.29 ± 0.310	1.32 ± 0.148	1.95 ± 0.123	1.39 ± 0.187	1.38 ± 0.141	1.46 ± 0.063	Boyes 1961	larval brains	11	18	Algonquin Park

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No.of cells	No.of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Phormia regina M.	4.2 ± 0.893	9.8 ± 1.306	16.0 ± 0.672	17.4 ± 0.685	17.7 ± 1.142	18.3 ± 0.991	20.8 ± 1.066	56.5 ± 8.396	0	0	1.24 ± 0.158	1.38 ± 0.164	1.95 ± 0.263	1.33 ± 0.182	1.32 ± 0.126	1.45 ± 0.089	Boyes 1961	larval brains	10	18	St.Hilaire
Phormia regina M.	5.1	9.8 ± 0.920	15.9 ± 0.523	17.3 ± 0.626	17.7 ± 0.880	18.7 ± 0.759	20.6 ± 0.986	57.8 ± 6.629	0	0	1.27 ± 0.122	1.28 ± 0.134	1.93 ± 0.110	1.31 ± 0.164	1.30 ± 0.130	1.42 ± 0.045	Boyes 1961	larval brains	12	18	St.Hilaire
Phormia regina (Meigen)	3.5	8.7	15.0	17.3	17.5	20.6	20.8		0	1.14	1.17	1.82	1.65	1.44	1.25	1.47	Ullerich 1963	adult testis			
Phormia terrae-novae	-	7.3	16.4	17.8	19.0	19.1	20.4		-	Acro.	High	High	High	Low	Low		Naville 1932	adult ovary			Measurements Boyes 1961
Protocalliphora aenea S. & D.	4.0 ± 0.696	7.4 ± 0.595	16.3 ± 0.499	17.4 ± 0.758	17.7 ± 0.784	18.7 ± 0.791	22.6 ± 1.535	63.57 ± 15.258	0	0	2.08 ± 0.175	1.56 ± 0.142	1.29 ± 0.151	1.24 ± 0.149	1.19 ± 0.092	1.48 ± 0.059	Boyes 1961				
Protocalliphora avium S. & D.	5.4	6.8 ± 0.854	16.0 ± 0.523	16.9 ± 0.211	17.7 ± 0.558	19.2 ± 0.391	23.3 ± 1.132	68.8 ± 4.939	0	0	2.59 ± 0.250	1.46 ± 0.135	1.50 ± 0.195	1.41 ± 0.133	1.23 ± 0.087	1.65 ± 0.063	Boyes 1961				
Protocalliphora hirundo S. & D.					12 chromosomes												Boyes 1961				
Protocalliphora metallica (Tns.)	5.2 ± 0.804	10.0 ± 0.559	15.6 ± 0.833	16.4 ± 0.528	17.4 ± 0.379	18.5 ± 0.557	22.1 ± 0.892	75.5 ± 10.651	0	0	2.02 ± 0.133	1.58 ± 0.079	1.49 ± 0.114	1.26 ± 0.142	1.26 ± 0.093	1.52 ± 0.045	Boyes 1961	larval brains	10	5	
Protocalliphora sialia R. & D.					12 chromosomes												Boyes 1961				
Protocalliphora new sp. near sialia					12 chromosomes												Boyes 1961				
Protophormia terraenovae R.-D.	3.3	7.0	16.6	16.6	18.6	19.1	22.0	76.53	0	0	1.19	1.76	1.78	1.22	1.34	1.45	Boyes 1961	larval brains	2		Weybridge, England. Pullman, Washington
Subfamily Calliphorinae																					
Tribe Luciliini																					
Lucilia caesar L.					6 pairs												Stevens 1908				
Lucilia caesar L.	7.5	9.5	15.4	16.4	16.9	20.9	20.9		-	Acro.	1.33	-	-	-	1.22	-	Keuneke 1924	adult testes	mitotic metaphase		Measurements Boyes 1961
Lucilia caesar (Linne)					2n = 12												Ullerich 1963	neuroblast			

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No. of cells	No. of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Lucilia cuprina dorsalis (R.-D.)	14.7	20.0	13.4	15.0	15.3	15.9	20.0		2.5	1.7	1.5	1.4	1.7	1.5	1.1	1.44	Ullerich 1963	adult testis			
Lucilia illustria (Mg.)	9.4	16.2 ± 1.695	14.6 ± 0.789	16.0 ± 0.468	16.7 ± 0.734	17.5 ± 0.889	19.0 ± 0.532	76.5 ± 7.037	0	0	1.28 ± 0.134	1.21 ± 0.141	1.19 ± 0.022	1.21 ± 0.152	1.34 ± 0.158	1.24 ± 0.063	Boyes 1961	larval brains	6	5	Algonquin Park, Ontario
Lucilia illustria (Mg.)	7.1 ± 1.189	17.9 ± 0,775	13.8 ± 0.954	15.5 ± 0.518	16.4 ± 0.533	17.6 ± 0.476	18.0 ± 1.034	69.2 ± 7.567	0	0	1.18 ± 0.089	1.35 ± 0.105	1.12 ± 0.110	1.23 ± 0.130	1.25 ± 0.179	1.22 ± 0.032	Boyes 1961	larval brains	8	2	Algonquin Park, Ontario
Lucilia illustria (Mg.)		18.6 ± 0.866	13.7 ± 0.463	15.2 ± 0.494	16.7 ± 0.322	17.2 ± 0.514	18.5 ± 0.322	56.7 ± 2.127	0	0	1.11 ± 0.032	1.41 ± 0.212	1.15 ± 0.145	1.44 ± 0.161	1.32 ± 0.164	1.29 ± 0.045	Boyes 1961	larval brains	3	3	Montreal Quebec
Lucilia illustria (Mg.)	5.7 ± 0.597	15.9 ± 0.309	15.5 ± 0.292	15.9 ± 0.498	16.9 ± 0.546	17.7 ± 0.383	18.1 ± 0.394	57.4 ± 7.556	0	0	1.19 ± 0.095	1.30 ± 0.126	1.16 ± 0.071	1.13 ± 0.055	1.24 ± 0.055	1.20 ± 0.028	Boyes 1961	larval brains	6	4	Weybridge, England
Lucilia illustris (Meigen)	6.0	10.0	16.3	16.5	16.8	19.8	20.6		0	0	1.19	1.01	1.13	1.60	1.01	1.19	Ullerich 1963	adult testis			
Lucilia sericata (Mg.)																	Fish 1950				
Lucilia sericata (Mg.)	13.6	22.6	12.1	14.8	15.3	17.4	17.8		0	1.06	1.5		1.88	1.25	1.07		Ullerich 1963	adult testis			
Phaenicia caerulei-viridis Macq.	9.90 ± 2.16	14.78 ± 1.35	15.23 ± 0.61	15.60 ± 0.86	16.84 ± 0.42	17.76 ± 0.29	19.79 ± 0.51	67.90 ± 34.56	1.28 ± 0.35	2.27 ± 0.46	1.19 ± 0.12	1.35 ± 0.15	1.43 ± 0.14	1.45 ± 0.24	1.13 ± 0.10	1.31 ± 0.05	Jan	adult testis	4	1 ♂	Mississippi
Phaenicia eximia (Wd.)		5.3	14.3	17.7	19.4	19.9	23.3	50.7	-	-	1.14	1.56	1.60	2.35	1.14	1.56	Boyes 1961	larval brains	1		Port of Spain, Trinidad
Phaenicia sericata (Mg.)	11.3 ± 0.141	22.9 ± 1.479	13.3 ± 1.069	14.4 ± 0.652	15.3 ± 0.158	16.4 ± 0.321	17.6 ± 0.404	63.3 ± 8.630	0	0	1.24 ± 0.077	1.61 ± 0.197	1.63 ± 0.152	1.26 ± 0.084	1.37 ± 0.164	1.41 ± 0.045	Boyes 1961	larval brains	5		Montreal Quebec
Phaenicia sericata (Mg.)	10.4 ± 0.853	21.5 ± 1.016	13.3 ± 0.515	14.3 ± 1.175	15.5 ± 1.175	17.0 ± 0.923	18.5 ± 0.472	71.2 ± 9.934	0	0	1.27 ± 0.173	1.66 ± 0.126	1.84 ± 0.205	1.23 ± 0.118	1.25 ± 0.141	1.45 ± 0.077	Boyes 1961	larval brains	7		St.Hilaire Quebec
Phaenicia sericata (Mg.)	7.9 ± 1.288	19.9 ± 0.807	13.6 ± 0.438	15.0 ± 0.766	15.6 ± 0.766	17.2 ± 0.747	18.6 ± 0.420	64.0 ± 4.290	0	0	1.24 ± 0.870	1.59 ± 0.263	1.58 ± 0.213	1.21 ± 0.417	1.29 ± 0.220	1.38 ± 0.095	Boyes 1961	larval brains	6		Weybridge, England

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No. of cells	No. of individuals	Source of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Tribe Calliphorini																					
Eucalliphora lilaea (Walk.)				2n = 12													Boyes 1961	larval brains			Pullman, Washington
Calliphora erythrocephala M.		5.0	14.9	18.22	18.80	21.2	21.7										Metz 1916				
Calliphora erythrocephala Meign.	4.4	8.1	13.5	16.9	17.7	21.4	22.0		0	0		1.11	2.16	1.25	1.28		Keuneke 1924	adult testis			
Calliphora erythrocephala Meign.				5 pairs + xy													Frolowa 1929				
Calliphora erythrocephala Meign.																	Naville 1932				
Calliphora erythrocephala Meign.																	Strasburger 1933				
Calliphora erythrocephala Meign.																	Bier 1960				
Calliphora erythrocephala Meign.	3.42	4.57	15.1	17.1	19.8	20.2	23.3		0	2.2	1.3	1.54	1.77	1.06	1.40	1.42	Ullerich 1963	adult testis			
Calliphora erythrocephala Meign.		4.7	14.8	16.2	18.8	21.2	24.0		-	0	1.30	2.37	1.93	1.11	1.38	1.62	Melander 1963				
Calliphora vicina R.-D.	3.7 ± 0.095	4.7 ± 0.542	15.2 ± 0.829	16.7 ± 0.460	19.9 ± 1.179	21.2 ± 0.974	22.4 ± 0.699	75.7 ± 13.55	0	0	1.24 ± 0.100	2.15 ± 0.212	2.002 ± 0.210	1.18 ± 0.110	1.20 ± 0.118	1.55 ± 0.045	Boyes 1961	larval brains	12		Montreal Quebec
Calliphora vicina R.-D.		4.8 ± 0.436	15.5 ± 0.851	18.3 ± 0.514	18.5 ± 0.155	20.7 ± 0.578	22.2 ± 1.168	55.9 ± 3.920	0	0	1.53 ± 0.155	2.19 ± 0.134	1.94 ± 0.134	1.16 ± 0.089	1.20 ± 0.045	1.61 ± 0.141	Boyes 1961	larval brains	3		Montreal Quebec
Calliphora vicina R.-D.	3.6 ± 0.548	4.8 ± 0.488	15.7 ± 0.765	16.7 ± 0.919	19,9 ± 0.791	20.6 ± 0.881	22.3 ± 0.644	81.5 ± 3.533	0	0	1.25 ± 0.084	2.11 ± 0.228	1.39 ± 0.228	1.17 ± 0.095	1.26 ± 0.134	1.54 ± 0.077	Boyes 1961	larval brains	10		Montreal Quebec
Calliphora vicina R.-D.	3.4 ± 0.471	4.5 ± 0.572	16.9 ± 1.656	17.6 ± 1.261	18.5 ± 1.196	20.4 ± 0.851	22.1 ± 1.134	81.8 ± 16.111	0	0	1.25 ± 0.147	2.02 ± 0.146	1.95 ± 0.146	1.23 ± 0.434	1,22 ± 0.122	1.53 ± 0.084	Boyes 1961	larval brains	9		Weybridge, England
Calliphora viridescens Desr.									6 pairs								Metz 1916				
Calliphora vomitoria (L.)	4.2	7.1	14.1	17.6	18.2	18.9	23.8										Stevens 1908				

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No.of cells	No.of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Calliphora vomitoria (L.)	3.4 ± 0.579	5.3 ± 0.775	16.2 ± 0.594	17.8 ± 0.959	18.0 ± 1.243	19.4 ± 1.174	23.3 ± 1.558	75.8 ± 13.395	0	0	1.41 ± 0.190	1.86 ± 0.259	2.21 ± 0.197	1.36 ± 0.235	1.33 ± 0.148	1.63 ± 0.095	Boyes 1961	larval brains	12		Algonquin Park, Ontario
Calliphora vomitoria (L.)	3.8 ± 0.458	5.3 ± 0.240	16.3 ± 0.626	18.8 ± 0.537	18.3 ± 0.464	19.4 ± 0.572	22.0 ± 0.847	54.8 ± 6.053	0	0	1.55 ± 0.194	1.53 ± 0.183	2.03 ± 0.169	1.38 ± 0.130	1.33 ± 0.164	1.56 ± 0.063	Boyes 1961	larval brains	5		Weybridge, England
Calliphora vomitoria (Linne)	3.4	4.8	15.8	16.8	17.5	21.3	23.8		0	0	1.85	1.52	1.62	1.53	1.18	1.54	Ullerich 1963	adult testis			
Cynomyopsis cadaverina (R.D.)	2.5 ± 1.012	5.8 ± 1.608	16.2 ± 0.497	17.8 ± 0.673	18.4 ± 0.764	18.9 ± 0.513	22.5 ± 1.863	79.4 ± 20.958	0	0	1.47 ± 0.195	1.57 ± 0.322	3.66 ± 0.288	1.53 ± 0.089	1.38 ± 0.200	1.92 ± 0.110	Boyes 1961	larval brains	5		Algonquin Park, Ontario
Cynomyopsis cadaverina (R.-D.)	4.8	6.1 ± 0.499	16.2 ± 0.542	17.7 ± 0.609	18.6 ± 0.715	19.1 ± 0.723	22.4 ± 1.113	76.7 ± 6.362	0	0	1.31 ± 0.170	1.49 ± 0.200	2.25 ± 0.167	1.44 ± 0.214	1.34 ± 0.130	1.57 ± 0.055	Boyes 1961	larval brains	10		Montreal Quebec
Cynomyopsis cadaverina (R.-D.)	3.8 ± 0.604	6.6 ± 1.092	17.0 ± 0.228	17.8 ± 0.158	18.3 ± 0.476	18.4 ± 0.518	22.0 ± 0.785	84.0 ± 2.426	0	0	1.36 ± 0.100	1.66 ± 0.114	2.35 ± 0.226	1.29 ± 0.044	1.41 ± 0.110	1.61 ± 0.055	Boyes 1961	larval brains	5		Pullman, Washington
Cynomyopsis cadaverina (R.-D.)	3.6 ± 0.404	6.2 ± 0.569	17.0 ± 0.141	17.7 ± 0.153	18.9 ± 0.208	18.2 ± 0.311	22.0 ± 0.686	84.5 ± 3.051	0	0	1.38 ± 0.108	1.61 ± 0.020	2.30 ± 0.261	1.30 ± 0.014	1.43 ± 0.115	1.61 ± 0.155	Boyes 1961	larval brains	4		Weybridge, England
Cynomyopsis cadaverina (R.-D.)		7.89 ± 1.302	16.32 ± 0.042	16.64 ± 1.282	17.76 ± 0.636	18.59 ± 0.630	22.80 ± 0.029	65.22 ± 12.351		0	1.71 ± 0.675	1.54 ± 0.453	1.18 ± 0.025	1.57 ± 0.347	1.77 ± 0.190	1.55 ± 0.157	Jan	adult testis	2	1 ♂	Mississippi
Cynomyia mortuorum (Linne)	1.9	11.3	15.2	16.0	17.9	18.0	21.6		0	0	1.07	2.05	1.10	1.66	1.30	1.44	Ullerich 1963	adult testis			
Subfamily Polleniinae																					
Tribe Polleniini																					
Pollenia rudis (Fab.)		4.16 ± 0.511	17.2 ± 0.863	18.1 ± 0.891	18.6 ± 0.480	19.3 ± 0.710	22.6 ± 0.898	57.6		0	1.62 ± 0.161	3.07 ± 0.228	1.81 ± 0.145	1.57 ± 0.084	1.64 ± 0.138	1.95 ± 0.226	Boyes 1961	adult ovaries	13	2	Macdonald College, Quebec
Pollenia rudis (Fab.)		6.14 ± 0.67	15.90 ± 0.56	17.00 ± 0.78	18.01 ± 0.90	19.74 ± 1.14	23.21 ± 1.81	70.17 ± 8.644									Jan	adult testis	8	1 ♂	Mount Orford, Quebec

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No.of cells	No.of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Family Sarcophagidae																					
Subfamily Miltogramminae																					
Tribe Miltogrammini																					
Sphenometopa tergata (Coq.)	3.4 90 ± 0.72	5.13 ± 0.28	15.01 ± 0.99	15.99 ± 1.50	19.56 ± 1.04	20.18 ± 0.59	24.12 ± 1.30	63.22 ± 23.471	0	0	1.21 ± 0.17	1.41 ± 0.25	1.19 ± 0.11	1.55 ± 0.20	1.42 ± 0.26	1.35 ± 0.12	Jan	adult testis	4	1 ♂	Pullman, Washington
Tribe Paramacronychiini																					
Pseudosarcophaga affinis (Fall.)			9 pairs + 1 or 2 tiny					60.3			xy not distinguishable						Boyes 1953	larval brains	12		
Wohlfahrtia meigeni (Schin.)	19.8 4 ± 1.76	28.5 ± 1.59	12.0 ± 0.73	13.3 ± 0.73	13.9 ± 0.84	15.0 ± 0.89	17.3 ± 0.99	50.2 ± 6.83	0	0	1.23 ± 0.13	1.83 ± 0.11	1.44 ± 0.16	1.28 ± 0.14	1.78 ± 0.09	1.51 ± 0.08	Boyes 1963	larval brains	10	2 ♂ 3 ♀	
Wohlfahrtia opaca (Coq.)	18.2 ± 1.30	27.2 ± 1.95	12.2 ± 0.67	13.5 ± 0.80	14.2 ± 0.69	15.2 ± 0.76	17.7 ± 1.03	47.1 ± 7.12	0	0	1.21 ± 0.11	1.74 ± 0.16	1.46 ± 0.14	1.36 ± 0.14	1.57 ± 0.20	1.47 ± 0.096	Boyes 1963	larval brains	10	3 ♂ 3 ♀	
Subfamily Sarcophaginae																					
Acridiophaga aculeata (Ald.)	14.1	20.4 ± 1.08	13.4 ± 0.53	14.8 ± 0.54	15.7 ± 0.56	17.5 ± 0.75	18.2 ± 0.60	70.4	2.92	5.06	1.07 ± 0.06	1.34 ± 0.11	1.55 ± 0.08	1.33 ± 0.15	1.28 ± 0.104	1.31	Boyes 1953	larval brains	13	5 ♂ 2 ♀	Belleville, Ontario
Blaesoxipha hunteri (Hough)	5.2	7.1 ± 1.67	16.2 ± 1.05	16.9 ± 1.22	18.2 ± 0.69	19.5 ± 0.60	22.1 ± 0.69	76.8 ± 18.14	0	0	1.07 ± 0.045	1.31 ± 0.204	1.69 ± 0.138	1.38 ± 0.272	1.14 ± 0.092	1.32 ± 0.246	Jan	adult testis	4	2 ♂	Pullman, Washington
Blaesoxipha opifera (Coq.)	13.4 05 ± 1.91	14.68 ± 3.41	14.93 ± 0.66	15.84 ± 0.96	16.84 ± 0.93	17.68 ± 0.93	20.02 ± 1.20	75.73 ± 11.167	3.00 ± 0.73	1.10 ± 0.10	1.19 ± 0.12	1.73 ± 0.27	1.64 ± 0.33	1.50 ± 0.19	1.41 ± 0.10	1.50 ± 0.09	Jan	adult testis	4	2 ♂	Pullman, Washington
Kellymyia kellyi (Ald.)		10.7 ± 1.9	15.1 ± 0.67	16.1 ± 0.54	17.1 ± 0.96	19.8 ± 0.90	21.2 ± 0.89	74.6		3.76 ± 0.65	1.10 ± 0.05	1.31 ± 0.14	1.51 ± 0.11	1.16 ± 0.07	1.75 ± 0.12	1.37	Boyes 1953	larval brains	15	9	
Helicobia rapax Walk.	2.3 6 ± 0.26	4.0 ± 0.20	17.0 ± 1.01	18.2 ± 1.13	18.8 ± 0.70	20.2 ± 0.79	21.8 ± 1.21	51.2 ± 9.26	0	-	1.38 ± 0.12	1.80 ± 0.26	1.37 ± 0.11	1.37 ± 0.09	1.34 ± 0.07	1.45 ± 0.08	Boyes 1963	larval brains	6	1 ♀ 1 ♂	
Helicobia sp.		22.1 ± 0.55	12.4 ± 0.68	13.9 ± 0.64	14.2 ± 0.81	15.8 ± 0.48	21.7 ± 0.27	52.2 ± 2.13	0	1.44	1.54 ± 0.06	1.68 ± 0.11	2.07 ± 0.23	1.37 ± 0.38	1.12 ± 0.09	1.56 ± 0.13	Boyes 1963	larval brains	3	3 ♀	Guadeloupe
Neobellieria bullata (Park.)		8.0 ± 0.354	14.9 ± 0.566	18.2 ± 0.100	18.6 ± 0.424	19.4 ± 0.424	21.0 ± 0.141	62.8 ± 5.636			1.21 ± 0.191	1.62 ± 0.014	1.38 ± 0.156	1.30 ± 0.120	1.52 ± 0.177	1.41 ± 0.127	Boyes 1963	larval brains	2	1 ♀	
Hystricocnema plinthopyga (Wied.)		12.2 ± 0.52	15.1 ± 1.05	16.3 ± 0.84	16.5 ± 0.99	18.2 ± 1.06	21.6 ± 0.85	51.2 ± 7.46	0	0	1.72 ± 0.31	2.04 ± 0.30	1.37 ± 0.17	1.50 ± 0.14	1.15 ± 0.14	1.55 ± 0.09	Boyes 1963	larval brains	5	3 ♀	Martinique

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No.of cells	No.of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Paraphrissopoda chrysostoma (Wied.)	14.7 ± 1.191	26.0 ± 2.440	11.5 ± 0.479	13.6 ± 0.905	15.0 ± 1.138	15.4 ± 1.066	18.5 ± 0.396	52.4 ± 8.551		3.18 ± 0.562	1.15 ± 0.086	1.52 ± 0.268	2.07 ± 0.148	1.29 ± 0.140	1.19 ± 0.127	1.44 ± 0.091	Boyes 1963	larval brains	7	3 ♂	Port of Spain, Trinidad
Euboettcheria sp.		10.0 ± 0.848	12.0 ± 2.263	16.6 ± 3.747	18.1 ± 1.697	21.1 ± 0.990	22.2 ± 1.414	57.2 ± 20.128			1.80 ± 0.205	1.34 ± 0.057	1.44 ± 0.240	1.34 ± 0.071	1.36 ± 0.127	1.46 ± 0.035	Boyes 1963	larval brains	2	2 ♀	Basse Terre, Guadeloupe
Boettcheria cimbicis (Towns.)		9.6 ± 1.62	14.0 ± 0.72	17.1 ± 0.45	17.6 ± 1.47	20.3 ± 1.19	21.5 ± 0.67	60.5 ± 5.9		0	1.73 ± 0.19	1.12 ± 0.07	1.74 ± 0.17	1.17 ± 0.04	1.21 ± 0.10	1.39 ± 0.061	Boyes 1963	larval brains	4	3 ♀	
Protodexia australis (Blanch.)	2.97 ± 0.359	10.0 ± 0.48	16.1 ± 0.53	16.7 ± 0.41	17.3 ± 0.22	18.5 ± 0.67	21.5 ± 1.24	60.0	1.19 ± 0.17	5.0 ± 0.72	1.08 ± 0.07	1.36 ± 0.19	1.56 ± 0.15	1.56 ± 0.15	1.17 ± 0.09	1.34	Boyes 1953	larval brains	6	2 ♂ 1 ♀	Belleville, Ontario
Protodexia hunteri (Hough)	3.36 ± 0.60	7.2 ± 0.90	16.6 ± 0.71	17.5 ± 0.50	18.0 ± 0.83	19.2 ± 0.41	21.5 ± 0.88	64.1	1.00	1.38 ± 0.25	1.15 ± 0.07	1.35 ± 0.12	1.58 ± 0.12	1.32 ± 0.15	1.34 ± 0.06	1.35	Boyes 1953	larval brains	12	3 ♂ 1 ♀	Belleville, Ontario
Sarcophaga aldrichi Park.	3.5	6.7 ± 0.52	16.6 ± 0.79	17.4 ± 0.98	18.7 ± 0.40	19.8 ± 0.70	20.8 ± 0.88	48.0	0	1.55 ± 0.16	1.10 ± 0.07	1.48 ± 0.17	1.56 ± 0.12	1.17 ± 0.09	1.38 ± 0.16	1.34	Boyes 1953	larval brains	11	1 ♂ 4 ♀	
Sarcophaga argyrostoma R.D. (1) Parasarcophaga argyrostoma Desv.	12.2 ± 1.707	16.4 ± 1.734	14.2 ± 1.017	15.6 ± 0.824	16.7 ± 0.532	17.8 ± 0.864	19.3 ± 0.882	76.4 ± 15.609	1.11 ± 0.059	0	1.19 ± 0.121	1.73 ± 0.208	1.35 ± 0.155	1.25 ± 0.147	1.49 ± 0.165	1.41 ± 0.046	Boyes 1963	larval brains	12	1 ♀ 3 ♂	
(2) Sarcophaga argyrostoma R.D.	12.1 ± 1.50	17.2 ± 2.26	14.2 ± 0.68	14.9 ± 0.59	16.5 ± 0.84	17.9 ± 1.09	19.3 ± 1.07	25.4 ± 12.83	1.11 ± 0.11	0	1.20 ± 0.06	1.24 ± 0.18	1.56 ± 0.26	1.27 ± 0.24	1.26 ± 0.14	1.31 ± 0.12	Boyes 1963	larval brains	5	3 ♂	
(3) Sarcophaga falculata Pand.	10.5 ± 0.523	16.0 ± 1.652	15.1 ± 0.721	15.8 ± 0.529	16.5 ± 0.660	17.5 ± 0.654	19.1 ± 1.370	69.4 ± 12.457	1.11 ± 0.054	0	1.16 ± 0.129	1.95 ± 0.152	1.67 ± 0.212	1.22 ± 0.096	1.49 ± 0.147	1.50 ± 0.051	Boyes 1963	larval brains	10	4 ♂ 2 ♀	Montreal Quebec
Sarcophaga carnaria (L.)		7.7	13.0	17.3	18.8	19.8	23.4										Keuneke 1924	adult ovary			
Sarcophaga cooleyi (Ald.)		8.9 ± 0.50	16.8 ± 0.42	17.1 ± 0.37	17.7 ± 0.71	18.7 ± 0.38	20.9 ± 1.27	64.9		1.10	1.12 ± 0.07	1.98 ± 0.11	2.22 ± 0.06	1.37 ± 0.05	1.41 ± 0.08	1.62 ±	Boyes 1953	larval brains	5	2 ♀	

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No.of cells	No.of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Sarcophaga crassipalpus Macq.																					
(1) Sarcophaga securifera Vill.	13.4 ± 0.729	18.4 ± 0.818	14.6 ± 0.910	15.4 ± 0.672	16.6 ± 0.528	16.9 ± 0.729	18.2 ± 0.630	68.2 ± 8.014	1.41 ± 0.15		1.23 ± 0.110	1.80 ± 0.187	1.64 ± 0.222	1.37 ± 0.142	1.40 ± 0.133	1.49 ± 0.087	Boyes 1963	larval brains	10	2 ♀ 3 ♂	Montreal Quebec
Sarcophaga exuberans Pand.	10.6 ± 0.77	13.1 ± 1.030	15.3 ± 0.611	16.2 ± 0.556	17.1 ± 0.517	18.5 ± 0.777	19.8 ± 1.02	74.3 ± 13.42	1.29	0	1.26 ± 0.18	1.41 ± 0.29	1.35 ± 0.25	1.42 ± 0.21	1.50 ± 0.14	1.39 ± 0.09	Boyes 1963	larval brains	10	4 ♂ 2 ♀	
Sarcophaga "H" (near reversa)	5.86 ± 0.57	9.0 ± 0.56	14.8 ± 0.77	17.0 ± 0.62	18.1 ± 0.80	20.2 ± 0.72	20.9 ± 0.97	76.7	0	1.21 ± 0.45	1.09 ± 0.04	1.51 ± 0.10	1.68 ± 0.10	1.39 ± 0.10	1.37 ± 0.07	1.41	Boyes 1953	larval brains	17	7	
Sarcophaga latisterna parker		6.65 ± 2.25	13.04 ± 2.53	16.14 ± 0.62	18.83 ± 0.76	20.95 ± 1.32	24.39 ± 1.26	46.96 ± 12.830		0	1.39 ± 0.54	1.56 ± 0.37	2.59 ± 0.35	1.54 ± 0.04	1.32 ± 0.25	1.68 ± 0.13	Jan	adult testis	3	1 ♂	Missis-sippi
Sarcophaga occipitalis Thoms.		24.2 ± 0.70	12.7 ± 0.64	13.9 ± 0.50	14.0 ± 0.95	16.0 ± 1.21	19.2 ± 1.57	41.8 ± 4.31		2.21 ± 0.37	1.17 ± 0.05	1.22 ± 0.03	1.85 ± 0.21	1.30 ± 0.20	1.37 ± 0.08	1.38 ± 0.07	Boyes 1963	larval brains	3	1 ♀	Port of Spain, Trinidad
Sarcophaga reversa Ald.	4.76 ± 0.56	8.8 ± 0.44	15.1 ± 0.54	17.0 ± 0.49	18.6 ± 0.44	19.6 ± 0.56	20.9 ± 0.57	75.7	1.22 ± 0.35	1.12 ± 0.11	1.07 ± 0.04	1.61 ± 0.11	1.84 ± 0.11	1.35 ± 0.06	1.45 ± 0.08	1.47	Boyes 1953	larval brains	9	3	
Sarcophaga serraceniae Riley																					
(1) Sarcophaga tuberosa serraceniae Riley	2.4	8.7	16.7	17.5	18.7	19.0	19.6										Metz 1916				
(2) Sarcophaga sarraceniae	1.5	5.4	15.9	17.3	20.2	20.2	21.0										Stevens 1908				
Sarcophaga sp.		8.6	14.4	15.9	18.4	20.9	21.4										Metz 1916				
Ravinia communis Park.				2n = 12													Metz 1916				
Ravinia peniculata Park.		5.3	15.1	17.6	18.2	21.1	22.1										Metz 1916				
Ravinia querula (Walk.)	4.9 ± 0.4	6.16 ± 0.45	13.5 ± 0.76	16.88 ± 1.09	18.84 ± 0.69	21.17 ± 0.71	23.43 ± 0.85	70.84 ± 6.337	0	0	1.16 ± 0.06	1.20 ± 0.08	1.22 ± 0.22	1.26 ± 0.13	1.23 ± 0.06	1.22 ± 0.05	Jan	adult testis	5	1 ♂	Pullman, Washing-ton

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No. of cells	No. of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Family Tachinidae																					
Subfamily Tachininae																					
Peleteria iterans (Wlk.)		11.14 ± 1.64	14.72 ± 1.34	15.79 ± 1.17	16.15 ± 0.60	18.09 ± 0.29	24.12 ± 3.32	40.56 ± 2.411		1.38 ± 0.10	1.15 ± 0.11	2.01 ± 0.61	1.37 ± 0.13	1.51 ± 0.36	1.41 ± 0.10	1.49 ± 0.15	Jan	adult ovary	4	1 ♀	British Columbia
Archytas prob. apicifera (Wlk.)		7.47 ± 0.29	15.22 ± 0.76	16.45 ± 0.69	17.02 ± 0.73	19.38 ± 1.78	24.45 ± 1.01	50.62 ± 5.160		0	1.11 ± 0.06	1.13 ± 0.10	1.13 ± 0.07	1.27 ± 0.10	1.23 ± 0.12	1.17 ± 0.04	Jan	adult ovary	5	1 ♀	North Carolina
Mericia ampelus (Wlk.)	3.6	7.0	15.5	16.7	18.6	19.7	22.5	42.7	0	1.12	1.84	1.36	1.30	1.20	1.05	1.35	Boyes et al 1953	larval brains	2	♂	
Subfamily Goniinae																					
Tribe Acemyini																					
Ceracia dentata (Coq.)	5.6	6.2	16.8	17.1	17.9	18.7	23.4	52.7	1.25	2.61	1.09	1.67	1.23	2.38	1.27	1.53	Boyes et al 1953	larval brains	4	1 ♂	Belleville, Ontario
Tribe Blondelliini																					
Spathimeigenia sp.	4.4[5]	6.0	14.2	17.2	18.7	19.6	24.3	53.8	1.17[5]	2.80	1.32	1.67	1.50	2.06	1.49	1.61	Boyes et al 1953	larval brains	12	4 ♂ 2 ♀	
Tribe Exoristini																					
Bessa selecta (Mg.)		4.6	15.9	16.7	17.1	19.5	26.2				1.93	1.85	1.66	1.70	1.20	1.67	Smith 1943	mesateron			
Bessa selecta (Mg.)		6.87 ± 1.02	16.20 ± 0.66	16.99 ± 0.61	17.57 ± 0.86	19.27 ± 1.15	23.10 ± 1.12	61.74 ± 10.521		1.74 ± 0.47	1.38 ± 0.13	1.45 ± 0.18	1.61 ± 0.23	1.26 ± 0.18	1.14 ± 0.11	1.37 ± 0.05	Jan	larval brains	15	3 ♀	Winnipeg, Manitoba
Neophorocera hamata (A. & W.)	3.4[3]	4.8	16.5	17.5	18.4	19.6	23.2	68.3	1.10	1.41	1.72	1.60	1.53	1.84	1.37	1.60	Boyes et al 1953	larval brains	12	1 ♂ 4 ♀	
Phorocera hamata (A. & W.)					2 n = 12												Smith 1944	adult testis			
Tribe Sturmiini																					
Drino bohemica Mesn.	3.8[12]	7.4	14.7	16.5	17.5	19.1	24.8	63.7	1.21[8]	2.09	1.14	1.13	1.32	1.16	1.39	1.23	Boyes et al 1953	larval brains	27	6 ♂ 6 ♀	
Tribe Winthemiini																					
Nemorilla pyste (Wlk.)		13.0	15.3	15.7	16.6	18.4	21.0	55.4		1.18	1.34	1.07	1.37	1.19	1.10	1.21	Boyes et al 1953	larval brains	3	2	British Columbia
Omotoma fumiferonae (Tot.)	8.7	10.9	14.2	15.3	16.0	20.0	23.5	64.3			1.36	1.71	1.37	1.22	1.09	1.35	Boyes et al 1953	larval 4 pupal brains	12	4 ♂ 2 ♀	

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No.of cells	No.of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Winthemia datanae Tns.		31.0	12.5	13.1	13.8	14.3	15.4	54.0		1.13	1.25	1.40	1.20	1.42	1.47	1.34	Boyes et al 1953	larval brains	12	4 ♀	
Winthemia occidentis Rnh.	6.0	16.2	13.7	15.0	17.3	18.5	19.4	64.0		7.53	1.14	1.11	1.27	1.38	1.34	1.25	Boyes et al 1953	larval brains	12	2 ♀ 3 ♂	British Columbia
Winthemia pufopicta (Big.)		34.6	11.7	12.1	12.5	12.9	14.9	77.20		1.12	1.37	1.21	1.10	1.37	1.63	1.38	Jan	adult ovary	2	1	North Carolina
Tribe Eryciini																					
Aplomya caesar (Ald.)	3.5	11.3	14.6	15.6	16.6	18.2	23.6	57.7		1.68	1.54	1.63	1.71	2.14	1.50	1.70	Boyes et al 1953	larval brains	12	4 ♂ 3 ♀	Ontario
Aplomya mitis (Meig)	4.0	9.1	14.3	15.9	17.4	19.3	24.0	45.5		1.51	1.40	1.50	1.94	2.25	1.51	1.72	Boyes et al 1953	larval brains	12	4 ♂ 1 ♀	Europe
Lydella grisescens R.D.	18.4	19.8	14.2	14.8	15.8	16.5	19.0	69.8	1.24	1.25	1.20	1.12	1.17	1.23	1.35	1.22	Boyes et al 1953	larval brains	4	1 ♂	Ontario
Ceromasia auricaudata Tns.	4.4	6.0	15.7	17.0	17.8	18.5	25.1	54.8	1.22	1.67	1.20	1.22	1.32	1.13	1.27	1.23	Boyes et al 1953	larval brains	12	2 ♂ 5 ♀	British Columbia
Eumea westermanni (Zett.)		5.9	16.3	17.4	19.1	20.1	21.3	50.8		2.17	1.95	1.03	1.13	1.13	1.12	12.8	Boyes et al 1953	larval brains	1	1 ♀	Europe
Madremyia saundersii (Wlk.)	4.3	12.9	14.9	16.3	17.0	18.4	20.5	52.8	0	0	1.22	1.26	1.26	1.24	1.11	1.22	Boyes et al 1953	larval brains	12	3 ♂ 4 ♀	
Phryxe pecosensis (Tns.)	4.1[9]	6.6	16.4	17.3	18.1	19.5	22.2	48.9	0	2.60	1.11	1.19	1.22	1.21	1.10	1.17	Boyes et al 1953	larval brains	12	3 ♂ 2 ♀	
Family Cuterebridae																					
Cuterebra emasculator Fitch	6.7[4] ± 0.639	8.7 ± 1.041	15.7 ± 0.600	16.8 ± 0.878	17.3 ± 0.639	18.0 ± 0.770	23.7 ± 1.170	42.6 ± 7.662	0	0	1.76 ± 0.161	1.99 ± 0.364	1.98 ± 0.377	2.08 ± 0.403	1.52 ± 0.179	1.87 ± 0.146	Boyes 1964	larval brains	10	1 ♂ 6 ♀	Algonquin Park, Ontario
Family Oestridae																					
Subfamily Cephenemyiinae																					
Cephenomyia phobifer Clark	5.3[5] ± 0.572	11.2 ± 0.914	14.8 ± 0.777	16.9 ± 0.897	17.2 ± 0.623	18.0 ± 1.227	22.1 ± 1.215	58.7 ± 7.840	0	0	1.26 ± 0.118	3.27 ± 0.302	1.31 ± 0.158	1.56 ± 0.225	1.58 ± 0.080	1.79 ± 0.092	Boyes 1964	larval brains	7	3 ♂ 1 ♀	Algonquin Park, Ontario

TABLE 1 (continued)

Classification	Percentage of TCL								Arm Ratio								Authorities	Materials studied	No.of cells	No.of individuals	Sources of material
	Y	I	II	III	IV	V	VI	TCL in μ	Y	I	II	III	IV	V	VI	Average arm ratio II-VI					
Subfamily Oestrinae																					
Oestrus ovis L.		31.6 ± 2.414	12.2 ± 0.722	13.0 ± 0.328	13.6 ± 0.471	14.9 ± 0.838	15.3 ± 0.923	66.4 ± 12.467		1.11 ± 0.044	1.44 ± 0.201	1.58 ± 0.148	1.30 ± 0.204	2.37 ± 0.276	1.47 ± 0.171	1.63 ± 0.072	Boyes 1964	larval brains	12	2 ♀	Montreal Quebec
Subfamily Hypodermatinae																					
Hypoderma bovis L.	27.5^{10} ± 2.832	41.1 ± 2.712	9.5 ± 0.814	10.1 ± 0.844	12.1 ± 0.691	12.9 ± 0.940	14.1 ± 1.050	46.3 ± 6.798	8.14 ± 0.897	1.13 ± 0.094	2.39 ± 0.379	1.25 ± 0.174	1.45 ± 0.310	1.52 ± 0.263	1.48 ± 0.163	1.61 ± 0.090	Boyes 1964	larval brains	20	4 ♀ 1 ♂	Montreal Quebec
Hypoderma lineatum (de Villers)	$22.^{4}3$ ± 0.665	26.9 ± 0.971	12.2 ± 1.602	12.7 ± 0.929	14.5 ± 0.624	16.2 ± 1.153	17.3 ± 1.621	39.9 ± 6.892		0	2.34 ± 0.206	1.41 ± 0.286	1.34 ± 0.110	1.78 ± 0.134	1.64 ± 0.098	1.65 ± 0.073	Boyes 1964	larval brains	4	1 ♂	Montreal Quebec
Hypoderma lineatum (de Villers)	2n = 12; longest pair acrocentric, 2 other acrocentric pairs, and 3 metacentric pairs																Lachance 1964	larval brains	45	19	

V COMPARISONS OF KARYOTYPES

Striking differences, such as chromosome number and distinct chromosome morphological variations, are found between the karyotypes of different species in some cases whereas in a large number of cases, the karyotypes appear to be very similar. The casual observation alone is insufficient to reveal small differences. Therefore, a detailed analysis has been carried out with the intention of revealing such differences. Unfortunately, due to the difficulties of observation, this work is not always successful. The coefficient of variation of the less satisfactory chromosome complements of some species is so high that detailed comparisons are impossible. Errors of measurement are always unavoidable when dealing with poor figures. Secondary constrictions may be mistaken for centromeres. The distortion of the chromosomes may affect the measurement, consequently influencing the arm ratios and the assignment of pair number. Combining the chromosome lengths and their arm ratios helps in obtaining a more correct pair assignment. However, in practice, there are cases where the consideration of both factors at the same time is not entirely possible. For example, cases occur where in the first cell Pair A constitutes 18.6% of TCL and with an arm ratio of 1.30, Pair B 19.0% of TCL and with an arm ratio of 1.40; the second cell may have a measurement of Pair A of 18.8% of TCL and an arm ratio of 1.50, Pair B 19.0% of TCL and arm ratio of 1.40. In the above example considering the percentage of TCL alone the correctness of the arm

ratio will be sacrificed and the same kind of problem arises if arm ratios only are considered. An arbitrary correction is statistically unsatisfactory. Doubtful cases, such as the above mentioned, have been treated as has been defined in the methods section of this thesis "The chromosome pairs were numbered I-VI in the order of increasing size, on the basis of average lengths of the homologous pairs except that the X-chromosomes are always Pair I regardless of their relative lengths." This procedure reduces the standard error in the percentages of the TCL but raises the error of the arm ratios. In a few species a large standard error of arm ratios was obtained. Nevertheless, a detailed comparison of the karyotypes by the mean values will be made as follows, with the hope of shedding some light on the cytotaxonomical studies. It has been kept in mind that the detailed descriptions and comparisons may afford supplementary data for certain species identification.

Karyotypic data on the Otitidae are now available for seven species. Seioptera vibrans L. with three pairs of chromosomes has a very rare karyotype so far in Schizophora outside of Drosophila. Melieria crassipennis F. and Chaetopsis fulvifrons M. both have four pairs of chromosomes. However, the X-chromosome of M. crassipennis F. is much longer than that of C. fulvifrons M. The species Camptonoura picta Fabr., Ceroxys latiusculus (L.), Myrmecothea myrmecoides L. and Euxesta notata Wied. have six pairs of chromosomes. C. picta Fabr. and E. notata Wied. have very similar relative lengths for each

chromosome pair. Unfortunately, due to the lack of data on arm ratio in C. picta Fabr., a more detailed comparison is not possible. Appreciable differences in the relative length of each chromosomal pair are found among C. latiusculus (L.), M. myrmecsides L. and E. notata Wied. Furthermore, C. latiusculus (L.) has an average II-VI arm ratio of 2.27, whereas E. notata Wied. has an average II-VI arm ratio of only 1.48 and M. myrmecoides L. one of only 1.58. In general, so far the species of this family have distinct karyotypes.

Epochra canddensis L. is probably the only species so far in Tephritidae, which has only five pairs of chromosomes. Emmart's (1935) report of $2n = 10$ in Anastrepha ludens L. has been challenged by Bush's (1962) finding of $2n = 12$. Four pairs of autosomes have been reported in A. serpentina (Wied.), however, it has an X_1X_2Y type of sex chromosome mechanism (Bush 1962).

Karyotypes of two species of Dryomyzidae are available now. Although Metz's (1916) metaphase chromosomes illustration of Neuroctena analis F. did not show the details of the chromosomal morphology, it is possible by simply comparing the relative lengths of the individual chromosomes to find that the X-chromosome of Dryomyza anilis F. is not shorter than Pair II and Pair III; whereas in the species of Neuroctena anàlis F. this is not so.

Cytological data for thirteen species of Sciomyzidae are available now. The three species in the genus of Pherbellia are very similar with each other in karyotype. However, by careful comparison it is

found that Pherbellia new sp. and P. grisescens M. have relatively longer pairs of VI than P. nana F. The species Pherbellia grisescens M. has a high arm ratio on Pair VI, whereas the arm ratio on Pair VI of Pherbellia new sp. and P. nana F. is much lower. Furthermore, the X-chromosomes constitute 6.3% and 6.4% of TCL in P. nana F. and P. grisescens M. respectively, but only 4.1% of TCL in Pherbellia new sp. The species Atrichomelina pubera L. has a short X-chromosome (3.2% of TCL), and high arm ratio for Pair II. A. pubera L. has an average II-VI arm ratio of 1.68, P. grisescens M. 1.43, Pherbellia new sp. 1.34, and P. nana F. 1.35. It seems then that there is not much difficulty in distinguishing A. pubera L. from the Pherbellia species.

No appreciable difference in the relative length of any individual chromosome has been found in the species Dictya atlantica S., D. brimleyi S., D. sabroski S. and D. texensis C., not even in the size of the Y-chromosome. Slight differences are found in the arm ratios. Chromosome Pair II, of D. sabroski S. has a higher arm ratio than the other three Dictya species; Pair III of D. sabroski S. and D. texensis C. have higher arm ratios; Pairs IV and V of D. sabroski S. and D. brimleyi S. have higher arm ratios; Pair VI of D. atlantica S. has a higher arm ratio than in the other species. The average II-VI arm ratio in D. atlantica S. is 1.58, in D. brimleyi 1.58, in D. sabroski 1.71 and in D. texensis 1.56. Hence it would be easy to differentiate the karyotype of D. sabroski S. from the other three Dictya species. Antichaeta melanosoma M. has a noticiably longer X-chromosome in comparison to the four Dictya species.

Tetanocera loewi S. has long Pair VI and short Pair I, a high arm ratio on Pairs II, III, and IV, and a low arm ratio on Pairs V and VI. This is distinguishable from the other species in the Sciomyzidae family. Tetanocera sp. and Pscadina zerni Mayer have long but telocentric X-chromosomes, which are quite distinguishable. The X-chromosome of Tetanocera sp. is shorter than its chromosome Pair II, whereas in P. zerni M. the X-chromosome is longer than Pair II and Pair III. By measuring Steven's (1908) metaphase chromosomes illustrations of Tetanocera sparsa, it was found that in T. sparsa the relative length of each chromosomal pair is roughly similar to that of Tetanocera loewi S. Unfortunately, further comparison of arm ratios is not possible. So far, no general characteristics of karyotype at the subfamily level of the Sciomyzidae can be found.

Karyotypic data for two species of Lauxaniidae are now available. Metz (1916) presented illustrations of metaphase chromosomes of Physegenua vittata Macq. in which six pairs of chromosomes were shown. However, only five pairs of chromosomes were found for Minettia flavela Coq. in this study.

The karyotype study in the family of Chamaemyiidae has been started with Cremifania nigrocellulata Cz. and Leucopomyia obscura H. The species C. nigrocellulata Cz. has only three pairs of chromosomes. A more interesting finding is the microchromosomes of L. obscura H. This is the only case of the finding of microchromosomes in the Schizophora.

The family Helemyzidae is also karyologically new. Six pairs of chromosomes are found in both Suillia nemorum (Mg.) and Suillia sp. In comparison the karyotypes of the long X-chromosome cell population and the short X-chromosome cell population of the S. nemorum (Mg.), it was found that the chromosome configurations of Pairs IV, V and VI were similar in both cell populations. However, the centromeres of Pair II and Pair III in the short X-chromosome cell population were found in the median region and submedian region respectively, whereas in the long X-chromosome cell population they were just the opposite. On account of the small length difference between Pair II and Pair III of the long X-chromosome cell population, the pairs assignment could be mistaken for each other in the karyotype of the long X-chromosome population. If this assumption was right, then the difference between metacentric long X-chromosome and the telocentric short X-chromosome is not the result of any X-autosome or autosome-X translocation. There is a possibility that the X-chromosome may have been involved in the addition or subtraction of extra heterochromatic elements.

The karyotypes of Cordilura ciliata and C. ontario Cn. are similar to each other, no appreciable differences were found. The X-chromosome of Achaetella varipes constitutes 10.6% of the TCL, Orthochaeta hirtipes 4.2% of the TCL, Cordilura ciliata 5.2% of the TCL, C. ontario Cn. 5.5% of the TCL. On the other hand, Scatophaga pallida Walk. (Stevens 1908) has a small X-chromosome (2.9% of the TCL). Therefore,

there would be no difficulty in distinguishing Achaetella varipes and S.pallida Walk. simply by comparing the sizes of their X-chromosomes. Pair VI constitute 24.5% of the TCL in both Achaetella varipes and O. hirtipes whereas Pair VI of C. ontarie Cn. constitutes only 21.9% of the TCL; but Pair VI of O. hirtipes has an arm ratio of 2.54 whereas in A. varipes it is only 1.10. Big differences are also found in the length of Pair II; C. ciliata and C. ontario Cn. have a relatively longer Pair II than others.

Boyes (1954) was able to classify nine Hylemya species into four categories by their chromosome numbers and average II-VI arm ratios. This classification is still found suitable for the new cytological data of Hylemya echinata (S.) and H. florilegea Zett. Accordingly, H. echinata (S.) which has twelve chromosomes and an average II-VI arm ratio of 2.06 will be placed in the second category and H. florilegea Zett. which has twelve chromosomes and an average II-VI arm ratio of 1.67 will be placed in the third category of Boyes' (1954) classification. Pair II of H. florilegea Zett. has a comparatively low arm ratio (1.60) among the Hylemya species; this is also found in H. fugax (Mg.) (1.65) (Boyes 1954). However, H. fugax (Mg.) has thirteen chromosomes in male and fourteen chromosomes in female (Boyes ibid), which enables it to be easily separated from H. florilegea Zett. H. echinata (S.) has a relatively higher arm ratio for Pair V than the other Hylemya species.

Pair VI of Hydrophoria conica Wied. constitutes a very high percentage of the TCL (27.06%), which is quite distinct in the family of

Anthomyiidae. Also, a noticeably low average II-VI arm ratio (1.55) may be a valuable auxiliary point in distinguishing H. conica Wied. from the other species.

Frolow's (1929) metaphase picture of Pegomya geniculata (Bouché) was measured by Boyes (1953). P. geniculata (Bouché) is separable from P. betae (C.) and P. bicolor (Wied.) by the low percentage of TCL and high arm ratio of Pair II. The species P. betae (C). and P. bicolor (Wied.) are separable by the appreciable difference in the percentage of TCL which Pair VI constitutes, and the arm ratios of Pair II and Pair VI. The low arm ratio of Pair II in P. bicolor (Wied.) is distinct in the family of Anthomyiidae.

Boyes et al. (1964) have reported five pairs of chromosomes for Phaonia variegata Fabr., Muscina stabulans Fall. and Orthellia nudissima L. Lachance (1964) has also found five pairs of chromosomes in Haematobia irritans (L.) and Stomoxys calcitrans (L.). Adding to these, five pairs were found in Hydrotaea scambus Zett. Haematobia irritans (L.) has shorter Pair I and longer Pair V compared to the other five five-pair species. The length differences between Pair IV and Pair V in M. stabulans Fall., Haematobia irritans (L.) and S. calcitrans (L.) are more obvious than in Hydrotaea scambus Zett. and P. variegata Fabr. The arm ratio of Pair V is distinctly high in Haematobia irritans (L.) but very low in S. calcitrans (L.). The species of Hydrotaea scambus Zett. and S. calcitrans (L.) have relatively higher arm ratios on Pair IV than the other four five-pair species.

Haematobia irritans (L.) has a distinctly low arm ratio on Pair III. On Pair II, Hydrotaea scambus Zett. has an arm ratio of 1.74, P. variegata (Fabr.) 1.49, whereas the other four five-pair species have a much higher arm ratio. P. variegata Fabr. has a lower arm ratio on Pair I. In this context, it seems that the six five-pair species in the family of Muscidae can be separated karyologically simply by their differential arm ratios.

The chromosomes of Chryomyia albiceps (Wied.), C. megacephala (Fab.) and C. rufifacies (Macq.) have been studied by Ullerich (1963). The karyotypes of C. albiceps (Wied.) and two other species in Chrysomyia genus have been analysed in this study. For a detailed comparison, measurements were attempted on Ullerich's (1962) figures (Abb. 8a, Abb. 17c and Abb. 4b). The measurements of C. albiceps (Wied.) from Ullerich's (1963) picture agree very well with the results of this study. C. chloropyga (Wied.), C. putoria (Wied.) and C. megacephala (Fab.) have long X-chromosomes. However, the X-chromosomes of the former two species have their centromeres in the median region, whereas the latter species has a telocentric X-chromosome. In C. putoria (Wied.) the X-chromosome is about the same length as Pair II, whereas the X-chromosome of C. chloropyza (Wied.) is appreciably shorter than Pair II. The karyotypes of C. rubifacies (Macq.) and C. albiceps (Wied.) may be separated by the fact that the former has a higher arm ratio for Pair V than the latter, also Pair II of the former constitutes 17.2% of the TCL, whereas in the latter it constitues only 15.9% of the TCL.

The karyotype of Phaenicia caeruleiviridis Macq. is distinctly different from that of P. eximia (Wied.) and P. sericata (Mg.) (Boyes 1961). P. sericata (Mg.) has a telocentric X-chromosome which is the longest chromosome in the complement; the X-chromosome of P. caeruleiviridis Macq. is slightly shorter than the chromosome of Pair II, and has its centromere in the submedian region; on the other hand, P. eximia (Wied.) has a small X-chromosome, which constitutes only 5.3% of the TCL. The centromere of the Y-chromosome of P. caeruleiviridis Macq. is found in the median region, whereas in P. sericata (Mg.) the Y-chromosome is telocentric. Furthermore, Pair VI of P. eximia (Wied.) constitutes a distinctly higher percentage of the TCL and its Pair V has a high arm ratio, these two criteria make the karyotype of P. eximia (Wied.) quite distinguishable from those of the other two Phaenicia species.

Boyes (1961) has studied the karyotype of Cynomyopsis cadverina (R.-D.) from different collections. A significant difference in arm ratio was found between this study and Boyes' (op.cit.) results. However, due to the poor quality of the chromosomal figures photographed and the low number of cells analysed in this study, an argument will not be presented.

The karyotype of Sphenometopa tergata (Coq.) has short X- and Y-chromosomes and a long Pair VI, which is uncommon among the family of Sarcophagidae. The majority of Sarcophagidae flies for which cytological data are available so far, have long X- and long Y-chromosomes. Furthermore, the length differences between Pair II,

the X-chromosome and the Y-chromosome are very helpful in recognising the karyotype of S. tergata (Coq.); the average II-VI arm ratio in certain cases also provides valuable auxiliary data.

The karyotypes of Blaesoxipha hunteri (Hough) and B. opifera (Coq.) are distinctly different. The former has short X-and Y-chromosomes (7.1% and 5.2% of the TCL respectively), whereas the latter has long X-and Y-chromosomes (1.47% and 13.1% of the TCL respectively). Moreover, the X-and Y-chromosomes of B. hunteri (Hough) are telocentric, whereas an arm ratio of 1.10 was obtained for the X-chromosome, and one of 3.00 was obtained for the Y-chromosome of B. opifera (Coq.). Again, the length difference between Pair II, the X-chromosome and the Y-chromosome is found to be useful in both species for distinguishing their karyotypes from the others.

Sarcophaga latisterna Parker has a short telocentric X-chromosome and its Pair VI constitutes a relatively high percentage of the TCL (24.39%). These together with its high average II-VI arm ratio (1.68) make S. latisterna Parker distinguishable from the other species of Sarcophaga.

Metz (1916) has reported six pairs of chromosomes for Ravinia communis Pakr. and R.peniculata (Walk.). He also gave two mitotic metaphase figures of R. peniculata (Walk.). The new cytological data of R. querula (Walk.) from this study does not provide any distinct difference between R. communis Park. and R. peniculata (Walk.) in respect to the chromosome number or relative length of chromosomes.

The noticeable karyotype differences between Peleteria iterans (Walk.) and Archytas prob. apicifera (Walk.) are found in the percentage of the TCL of Pair I and the arm ratios of Pair I and Pair III. The telocentric X-chromosome and low average II-VI arm ratio (1.17) of A. prob. apicifera (Walk.) are very distinct in the family of Tachinidae.

Smith (1943) illustrated a very good mitotic figure of Bessa selecta (Mg.). The measurement of his picture is significantly different from the results of this study, both in the percentage of TCL and the arm ratios. Moreover, the average II-VI arm ratio is different in the two independent studies. Although Smith's figure was from mesenteron cell (whereas larval brain cells were used in this study), a satisfactory explanation is still needed.

Boyes et al (1953) studied the karyotypes of Winthemia datanae Tns. and W. occidentis Rnh. The species W. occidentis Rnh. has a low percentage of TCL and a high arm ratio for Pair I which is easily distinguished from those of W. datanae Tns. and W. rufopicta (Big.). The difference in the percentage of the TCL for Pair I between W. datanae Tns. and W. rufopicta (Big.) is probably the most distinct point of value in separating these two species karyologically. Other differences are also found in the arm ratios of Pair II, Pair IV and Pair VI.

VI GENERAL COMMENTS

Cytological data on 403 species of Schizophorous flies are available now. These include 273 species of acalyptratae and 130 species of calyptratae flies. The karyotypic studies of acalyptratae flies have been carried out for the families Diopsidae, Psilidae, Otitidae, Platystomatidae, Tephritidae, Dryomyzidae, Sciomyzidae, Lauxaniidae, Chamaemyiidae, Drosophilidae and Helemyzidae. Except for the family Drosophilidae, the cytological studies of the families of Tephritidae and Sciomyzidae are more extensive than those of the other families. In the Calyptratae, karyotype studies have been reported for the families Anthomyiidae, Muscidae, Calliphoridae, Sarcophagidae, Tachinidae, Cuterebridae and Oestridae, among which the families Calliphoridae and Sarcophagidae have been more extensively studied than other families.

The distribution of chromosome pairs in the families of Schizophora is summarized in Table 2. In the Acalyptratae the chromosome number is commonly six pairs. However, three pairs, four pairs, five pairs and even seven pairs have been found. 122 species of the Calyptratae have each six pairs of chromosomes but six species in the family Muscidae have each five pairs of chromosomes, and one species in the Anthomyiidae (Hylemya fugax (Mg.)) has five pairs plus X_1X_2Y in males and $X_1X_1X_2X_2$ in females, and one species in Sarcophagidae (Pseudosarcophaga affinis (Fall.)) has nine pairs plus one or two tiny chromosomes. In this context, two tentative assumptions may be put forward:

TABLE 2. DISTRIBUTION OF CHROMOSOME PAIRS IN THE FAMILIES OF SCHIZOPHORA, DIPTERA

Family	Number of Species								
	3 pairs	4 pairs	5 pairs	6 pairs	7 pairs	Total	Literature	This Thesis	Over-lapping
Diopsidae			1			1	0	1	
Psilidae		1				1	1	0	
Otitidae	1	2		4		7	2	5	
Platystomatidae		1				1	0	1	
Tephritidae				*19	1	20	19	1	
Dryomyzidae				2		2	1	1	
Sciomyzidae				15		15	1	14	
Lauxaniidae			1	1		2	1	1	
Chamaemyiidae	1			**1		2	0	2	
Drosophilidae	26	54	53	86	1	220	220	0	
Helemyzidae				2		2	0	2	
Total Acalyptratae	28	58	55	130	2	273	245	28	
Anthomyiidae				22	#1	23	14	9	
Muscidae			6	10		16	14	2	
Calliphoridae				31		31	28	3	3
Sarcophagidae				33		≠34	29	5	
Tachinidae				21		21	18	3	1
Cuterebridae				1		1	1	0	
Oestridae				4		4	4	0	
Total Calyptratae	0	0	6	122	1	130	108	22	4
Total Schizophora	28	58	61	252	3	403	353	50	4

* Anastrepha serpentina (Wied.) has 4 pairs plus X_1X_2Y in males.
** Leucopomyia obscura H. has 5 pairs plus 5 microchromosomes.
# Hylemya fugax (Mg.) has 5 pairs plus X_1X_2Y in males.
≠ Pseudosarcophaga affinis (Fall) has 9 pairs plus 1 or 2 tiny chromosomes.

TABLE 3. DISTRIBUTION OF CHROMOSOME PAIRS IN THE SUBORDERS AND DIVISIONS OF DIPTERA

Suborder and Division	Number of Species										Sources of data
	2 pairs	3 pairs	4 pairs	5 pairs	6 pairs	7 pairs	8 pairs	9 pairs	10 pairs	Total	
Nematocera	2	55	46	5	5	6	-	-	-	119	Boyes 1958
Brachycera	-	-	-	6	5	2	2	1	-	16	Boyes 1958
Cyclorrhapha	-	30	113	105	303	5	-	1	-	557	
(Aschiza)	-	2	55	43	52	2	-	-	-	154	Boyes et al. 1964
(Schizophora)	-	28	58	61	252	3	-	1	-	403	Table 2
Total Diptera	2	85	159	115	314	13	2	2	-	692	

(1) The value of cytotaxonomy seems greater in those families of Acalyptratae which have the advantage of greater chromosome number variation.

(2) Boyes et al. (1964) have reported the chromosomes of 154 species in the family of Syrphidae, in which two species had $n = 3$, fifty-five species had $n = 4$, forty-three species had $n = 5$, fifty-two species had $n = 6$ and two species had $n = 7$. The family of Syrphidae belongs to Aschiza. Chromosome numbers of more primitive forms of Diptera have also been collected by Boyes (1958). From Table 2 and Table 3, there seems to be a tendency for karyotype evolution in the Diptera to fix six-chromosome pairs. However, Patterson and Stone (1952) have certainly believed that the six pairs of chromosomes (unlike those of higher Diptera) are the basic chromosome number in Drosophila. Boyes et al. (1964) have also suggested that the six pairs of chromosomes are the more primitive condition in the family of Syrphidae.

A rough estimation has been made on the yield of metaphase chromosome figures from larval brains and adult testes and ovaries. About 80% of the third instar larval brains give good metaphase figures, whereas in the testes or ovaries from adult flies collected in the field, only about 30% of the flies give metaphase figures. Slides from old testes or old ovaries in which the mature sperms or eggs are seen, seldom give good metaphase figures. In slides full of thick fibres instead of a nice well-spread cell matrices, few metaphase figures are found. Furthermore, the mitotic metaphase chromosomes

are more concise and centromeric regions are clearer than in the meiotic metaphase chromosomes.

The results of this study also show that in the majority of species there is a distinct length difference between Pair I and Pair II. Also there is often a distinct difference in length between the longest pair and the next to longest pair. In a few cases the X-chromosomes are longer than Pair II, whereas in the great majority the X-chromosomes are much shorter than Pair II.

In the comparison of karyotypes at the interspecific level, the percentage of the TCL of the X-chromosomes were found to have more fluctuation than those of autosomes. Also, the Y-chromosomes are relatively more stable than the X-chromosomes.

With very few exceptions, the Y-chromosomes are telocentric. The great majority of the X-chromosomes are telocentric. No species has been found with a telocentric X-chromosome and with a Y-chromosome other than telocentric. On the other hand, the great majority of the centromeres of the autosomes are found in the median or submedian regions.

Lighty and Plaist (1960) and Maguire (1963) have shown that the variance of arm ratios tends to increase as the arm ratio increases. The results of this study support this conclusion. However, the following factors contribute to the variance of the individual chromosome arm ratios. (A) The distortion of the chromosomes, (B) mistaking a secondary constriction for a centromere, (C) the

incorrect pair assignment, and (D) the value of the arm ratio. Although a selection of representative figures is statistically not acceptable, it seems logical to accept that the measurement of few clear-cut figures is far better than to measure a quiver full of distorted and ambiguous figures. This deduction suggests an emphasis upon the technique of good slide preparation for the purpose of karyotype study.

The results of this study show that the variance of average II-VI arm ratios is smaller than the variance of individual chromosome arm ratios in every case. Although these two variances are not to be compared at the same level, the values of average II-VI arm ratios are entirely free from the incorrect pair number assignments. On account of the preciseness of the average II-VI arm ratio, this value may be very helpful for karyotypic comparisons in the groups where very similar karyotypes are found.

The inconsistency of the value of the total chromosome length (TCL) has been discussed in the introduction. In addition to this, the available data prove that the intrinsic variation of TCL is so large as to jeopardize the comparison of TCL at any taxonomic level. For example, a coefficient of variation of 35% was found for the TCL of the chromosomes from the larval brain cells of Euboettcheria sp. (Boyes 1963). It follows that data on the TCL of species must be used with great care in karyological comparisons.

On the basis of observations now available certain tentative statements can be made regarding the characteristics of the karyotypes of some families. In the Otitidae, the TCL's are shorter (below 60 μ); the chromosome pairs vary in number from three to six; the X-chromosomes are telocentric. In the Tephritidae, nearly all species have six pairs of chromosomes and in the genus Anastrepha, telocentric autosomes have been found in several species (Bush 1962). This is the only genus where telocentric autosomes have been found, except in Drosophila (Drosophilidae), so far in Schizophorous flies. In the Sciomyzidae, fifteen species all have six pairs of chromosomes but the author has seen five pairs of chromosomes in Pteromicra similis Steyskal; the X- and Y-chromosomes are often short and telocentric and the average II-VI arm ratios vary from 1.3 to 1.8. In the Anthomyiidae, twenty-two out of twenty-three species have six pairs of chromosomes, the X- and Y-chromosomes are telocentric and they are often short; the average II-VI arm ratios vary from 1.4 to 2.3. In the Muscidae, ten species have six pairs of chromosomes and six species have five pairs of chromosomes; the X- and Y-chromosomes are usually metacentric and they are often long; the average II-VI arm ratios vary from 1.3 to 1.8. In the Calliphoridae, the thirty-one species studied to date all have six pairs of chromosomes; the Y-chromosomes are nearly all short and telocentric; the X-chromosomes are often short and telocentric; the average II-VI arm ratios vary from 1.1 to 2.3. In the Sarcophagidae, thirty-three species have six pairs and one species is exceptional;

the X- and Y-chromosomes vary from short to long and from telocentric to metacentric; the average II-VI arm ratios vary from 1.2 to 1.7. In the Tachinidae, the twenty-one species reported all have six pairs of chromosomes; the X- and Y-chromosomes vary from short to very long; the Y-chromosomes are telocentric or metacentric whereas the X-chromosomes are rarely telocentric; the average II-VI arm ratios vary from 1.1 to 1.9. In general, however, it seems too early to decide whether or not a characteristic karyotype can be assigned to any particular genus or family.

SUMMARY

The karyotypes of 54 species of Schizophora flies, representing 40 genera and 14 families have been studied, among which 50 species and 4 families are karyologically new.

The comparisons of the above mentioned karyotypes and others previously reported show that the species are cytologically separable in almost all cases, however, it is too early to decide whether or not a characteristic karyotype can be assigned to any particular genus or family.

Microchromosomes were found in Leucopomyia obscura H. In Suillia nemorum (Mg.) two populations of cells, one with long X-chromosomes and the other with short X-chromosomes were found in the testis of an adult male.

Karyotypic studies were found to be more satisfactory using mitotic figures from third instar larval brains and from adult testes or ovaries than using meiotic figures.

The distribution of chromosome numbers in Diptera has been discussed in terms of cytotaxonomic and karyotypic evolution.

Distinct chromosome length differences are often found between Pair I (the X-chromosomes) and Pair II, also between the longest pair and the next to longest pair. In a great majority of cases the X-chromosomes are shorter than Pair II. The length of X-chromosomes fluctuates more at the interspecific level.

The Y-chromosomes are mostly telocentric; the X-chromosomes are often telocentric; the autosomes are mostly metacentric or submetacentric.

The cytotaxonomic value of arm ratio and TCL (Total Chromosome Length) has also been discussed.

ACKNOWLEDGEMENTS

I wish to express my deepest gratitude to Professor J.W. Boyes for his guidance and encouragement, and for supplying the microscopic slides as well as certain unpublished data; to Professors E.R. Boothroyd, B.B. Mukherjee and H. Tyson for their helpful suggestions on problems encountered during this work; to Drs. C.O. Berg and L. Knutson for providing microscopic slides of sciomyzids; to Dr. J.M. van Brink for providing microscopic slides of a number of species; to Mrs. B.C. Boyes for reading this thesis; to Mr. R. Pollard, Mr. S. Wood, Miss N. MacDonald, Miss K. Mann and Mr. W. Wright for their reading of the manuscript; to Mr. C. Verrusio, Mrs. C. Ritchie and Mr. S. Ghosal for their encouragement and suggestions; to Miss I. Turnbull, Miss K. Jastrzembska, Miss P. Turner, Mr. K. Wong and Mr. A. Klingner for their technical assistance, and also to Mrs. L. Jui and Miss J. Eason for their typing of this thesis.

The financial support received from the National Research Council of Canada is also gratefully acknowledged.

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