OBSERVATIONS

Order : Clupeiformes
Family : Notopteridae
Genus : Notopterus
Species : notopterus

Till now the chromosomes in the fam. Notopteridae were not worked out, therefore the author selected the only locally available species Notopterus notopterus as a type. The collection was done during the months of May & June 1959 and the material was fixed on the spots.

GONADS

The male specimens of 18.7cms. to 22.5 in length provided the testes of 1.8cms. The testes, in these specimens were found to be swollen, and sometimes there was only one testes enlarged and the other one reduced. Due to the flat shape of the fish, the testes also showed a flat character.

Anteriorly the testes are rounded and the vasa-deferentia of the two sides travel forwards from the inner magin of the case of the gonads and unite anteriorly before opening through the genital pore(Fig.1)

The fat marked on testes received in the month of June.

In the months of May and June, the males were found very active and were easily identified due to
their smaller size than those of the females. The male specimens of 18.7 cms to 22.5 cms in length provided the favourable material. In the fishes of this length, the testes were of 1.8 - 1.9 cms in length and compact. There was hardly any fat covering the testes in these mature males.

The division activity (Mitosis and Meiosis) in the cells of the testes in these fishes was highest. The fixation of the material was done on the spot (Saugor lake and the nearby streams) during the months of May and June (1959), after treating the testes with 0.33% hypotonic salt solution for 7 to 9 minutes.

**Spermatogonia**

The diploid number of chromosomes $2n = 48$, has been established on the counts of the spermatogonial metaphase plates (Fig.2). In this fish, the chromosomes are thin thread like in structure and do not stain deeply. Of the 24 pairs of the chromosomes, 3 pairs are $V$-shaped, 14 pairs $J$-shaped and 7 pairs are rod-shaped.
The 3 pairs of V's possess clear median centromeres occupying peripheral zone of the equatorial plate. Out of these 3 pairs of the V's, one pair is some what smaller in size than the rest two pairs.

The 14 pairs of J's possess sub-median centromeres and show variations in size. One of these pairs, shows some resemblance to a V but due to the extra length of one of the arms and also the sub-median position of the centromere, it has been adjudged and included among the J's only.

The 7 pairs of the rods show telomitic centromeres and vary greatly in size. Of these, 4 pairs are larger in size than the remaining 3 pairs.

The 2n chromosome formula of Notopterus notopterus is thus: \( 6V + 28J + 14r \).

**PRIMARY SPERMATOCYTE**

The haploid number \( n = 24 \) has been established on the counts of the primary spermatocyte.
metaphase plates (Fig. 3). The bivalents are more or less uniform in size but they differ in their shape from one another. One of the bivalents however is larger in size than the rest and shows a somewhat V-shaped structure. The other bivalents, however, are more or less similar in shape and size.

SECONDARY SPERMATOCYTE

The haploid number \( n = 24 \) has been confirmed from the secondary spermatocyte metaphase plates (Fig. 4). The chromosomes, which are dyads, are more condensed than the chromosomes of the primary spermatocytes and stain more deeply. All these dyads at this stage are more or less uniform in shape and size.
Order : Cypriniformes
Family : Cyprinidae
Genus : Garra
Species : lamta.

Among the Cyprinoids available, the species Garra lamta was selected for the type study since it was quite small in size and at the same time provided quite fleshy testes, suitable for squash purposes. The collection was made from the streams in the neighbourhood of Saugor.

GONADS

The active males of 8 cms to 12.5 cms provided the best and suitable material for the study. They were mostly collected during the months of May and June. The specimens collected after the above months were mostly found covered by fat on the testes and hence the squashes were not possible. The testes are embedded among the coils of the intestines and attached ventrally. They are fleshy and reddish in colour. In the above sized fishes the testes found are very small in size, 0.8 cms to 1.1 cms in length. They are some what oval in shape, rounded
at their tips and massive in character. The vasa-deferentia of the two sides are quite short and unite to open behind by the genital pore (Fig. 5). The testes which were fixed on the spot of collection only provided the suitable material for squash purposes.

**Spermatogonia**

In this fish, the spermatogonial chromosomes are rod-shaped and stain only moderately. The diploid number \(2n = 52\) has been clearly established on the spermatogonial metaphase plate counts (Fig. 6). Of these 26 pairs, 17 pairs are somewhat larger in size than the remaining 9 pairs. All the rods possess a clear telomitic centromere. The 2n chromosome formula can therefore be denoted as 52 r, since V's and J's are absent.

**Primary Spermatocyte**

The chromosomes of the primary spermatocytes (Fig. 7) show much condensation and the tetrads are also represented by rods only, which show very little difference in their size. The haploid number \(n = 26\)
has been established clearly from the metaphase plate counts.

SECONDARY SPERMATOCYTE

The haploid number $n = 26$ has been confirmed in the secondary spermatocyte chromosomes also (Fig.3) on the metaphase plate counts. The chromosomes due to further condensation stain more deeply in the secondary spermatocytes. All the dyads are rounded in shape and more or less uniform in size.
Order : Beloniformes
Family : Belonidae
Genus : Belone
Species : cancila

Belone cancila : The chromosomal studies of Beloniformes have been carried out on Belone cancila which is the only fresh-water species available in the local fauna. This was in fact the first fish studied by the author and a preliminary account of the chromosome study has been published by the author earlier (Saksena '59).

The male specimens of 17.5 cms to 25 cms in length, collected during the months of August and September, proved to be most suitable for the present work. The males can be easily distinguished from the females by their smaller size and darker colour.

GONADS

In Belone cancila, the testes are in the form of thin elongated structures attached on the ventral
side and travel along the body length. The sizes of the fish vary in proportion according to the fish lengths as given below:

<table>
<thead>
<tr>
<th>Size of fish</th>
<th>Size of testes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 18.7 cms</td>
<td>2.9 cms</td>
</tr>
<tr>
<td>2. 21.7 cms</td>
<td>3.1 cms</td>
</tr>
<tr>
<td>3. 22.5 cms</td>
<td>3.7 cms</td>
</tr>
<tr>
<td>4. 25 cms</td>
<td>4.5 cms</td>
</tr>
</tbody>
</table>

The division activity (Mitosis and Meiosis) was best seen in the testes taken out from the freshly caught fishes of 25 cms in length. In fishes of this length the testes are soft and whitish in colour, with black specks over them and very little deposition of fat was observed on them. In the months of January and February the testes are little compact and with more deposition of fat on them than in the months of maturity, i.e., August and September. The testes are free and rounded anteriorly and posteriorly they give rise to the two vasa - deferentia which join one
another to open by the common genital pore (Fig. 9).

SPERMATOGONIA

The diploid number of chromosomes \(2n = 48\) has been established on the counts of spermatogonial metaphase plates (Fig. 10). The chromosomes are thin and thread-like in appearance and stain faintly. The chromosomes include V's, J's and rods.

There are 4 pairs of V's which differ in their shape and size but are quite conspicuous. One of the V's is very open (\(\bigwedge\) - shaped) and its free ends bent inwards; it shows a median centromere. Another pair is more or less a fork-shaped with the free ends bent inwards. It is smaller in size than the one (\(\bigtriangleup\) - shaped) described above. The other two pairs are simple V's with a median centromere except that one of these is smaller in size than the other.
There are 16 pairs of J's which show variations in shape and size. Out of these J's, one pair has been found to have dissimilarity and has been adjudged as the pair of sex-chromosomes. In this pair, one of the chromosome bears a clear configuration with three segments while the other chromosome has only two segments and is also slightly smaller in size. The one having bigger size has been named as X and the smaller as Y. Rest of the 15 pairs of J's are typical hockey stick shaped with a shorter and longer arms and having a sub-median centromere. Each chromosome pair of the spermatogonial metaphase has been drawn individually (Fig. 11) in which one pair resembles the sex-chromosome pair, but this is found to be having similar chromosomes while that of the X and Y is having dissimilar ones.

The four pairs of rod-shaped chromosomes possess an ordinary configuration and terminal centromeres. Two out of these four pairs of rod-shaped chromosomes are smaller in size.

The 2n chromosome formula of Belone cancila is thus: \[ 3 \text{ V} + 32 \text{ J} \ (31+X-Y) + 8 \text{ r}. \]
PRIMARY SPERMATOCYTE

The haploid number \( n = 24 \) is clearly seen in the metaphase plates of the primary spermatocytes (Fig. 12). The chromosomes show a greater degree of condensation and stain more deeply than the chromosomes of spermatogonia.

In the primary spermatocytes, the tetrads or bivalents differ from one another in size and shape. In the present work, for describing the bivalents, the nomenclature adopted by Wilson, E.B., (1953, pp 515-548), has been followed. Accordingly, the Bivalents which are present in Belone cancila can be divided into ring-tetrads, double cross-tetrads, V-tetrads and rod-tetrads. Their detailed form as seen in the squash preparations has been shown in Fig. 13, in which each individual bivalent has been numbered.

The ring-tetrads are represented by bivalents number 1, 2 and 3. These are in the form of single ring-tetrads which have not fully condensed so that their two elements are separated from one another by small gaps.
These ring-tetrads are simple without being produced into arms on any side. Of the three, number 1 is largest, number 2 some what smaller and number 3 smallest in size.

The double cross-tetrads are represented by bivalents number 4, 5, 6, 7, 8, 9 and 10. Of these, numbers 4 and 5 are symmetrical and complete double crosses, which have not yet fully condensed so that a space is still visible in their middle part. Bivalents number 6 and 7 are fully condensed double crosses of an asymmetrical nature as all the arms are not of equal size, two being longer than the other two. The bivalents number 8, 9 and 10 are however symmetrical double crosses.

The V-tetrads are represented by bivalents number 11 and 12.

The rest of the bivalents, numbered 13 to 24 are included among the rod-tetrads, though they present difference in shape and size. Bivalents number 13, 14 and 15 are rod-tetrads of anaschistic type; these are more or less straight, rod-shaped bivalents, number 13 being the longest, number 14 some what smaller and number 15 smallest in size. Each of these appears in the form of a pair of longitudinal rods separated from one another.
by a gap throughout their length; they do not appear as four longitudinal rods or threads, because the secondary split in each half is obscure as happens in many animals due to condensation.

Bivalents, numbered 16, 17, 18 and 19 are elongated rod-like structures which however, show a somewhat dumb-bell shaped form due to the fact that they are somewhat narrower across their middle portion. Bivalents, numbered 20 and 21 also appear as elongated rods which are somewhat bent in such a way that one arm is longer than the other. Bivalent, numbered 15 is in the form of an elongated rod-like structure which shows a somewhat beaded appearance due to the presence of a pair of rounded thickenings along its length. The bivalent number 23 is also in the form of an elongated rod-like structure, but it presents a rounded knob-like thickening at one end and tapers off at the other. The last bivalent, that is number 24, is important in the fact that it presents an appearance which is quite distinctive from the other 23 bivalents. In the earlier stages, it appears as
an elongated rod-like structure with a rounded knob-like thickening at one end and tapering off at the other as in the case with the bivalent numbered 22, but it differs from the latter in the fact that at this stage it shows a double structure along its middle, the two portions being separated off from one another by a narrow gap (Fig. 14).

In the later stages, this bivalent appears in the form of a bent rod and the portion near the bend is much narrower than the two portion on either side of it. This narrower portion serves to differentiate the bivalent into two dissimilar portions, one portion consisting of a thickened elongated piece which tapers off distally while the other portion consists of a thick, rounded portion to which is attached distally a small rounded knob like portion by a small narrow, neck-like part. This bivalent is quite distinctive and morphologically different from the rest. Even in the spermatogonial metaphase plate, out of the 48 chromosomes as described earlier, 46 can be paired into 23 identical sets but two of them are dissimilar and have been
regarded as X and Y chromosomes in shape. It seems that bivalent number 24 represents the X - Y sex-bivalent.

SECONDARY SPERMATOCYTE

The haploid number n = 24 has been clearly confirmed from the metaphase plates of the secondary spermatocytes (fig. 15). The chromosomes are fully condensed here and have taken the deepest stain. They are of dyad nature and of small rounded structures except the fact that one of these possesses a large club shape and displays an enlarged size. This enlarged chromosome is presenting a clue for the sex-chromosome i.e. the X element. On further investigations this has come true and has been dealt further.
Order : Ophioccephaliformes
Family : Ophioccephalidae
Genus  : Ophioccephalus
Species : (1) striatus
          (2) punctatus
          (3) gachua
          (4) marulius

(1) Ophioccephalus striatus : The males of O. striatus of the length 18.5 to 22.8 cms were collected during the months of April, May and June. The fixation of the material was done on the spot of collection, the Sagar lake.

GONADS.

The males of the above mentioned lengths provided the suitable material for squash purposes. In such specimens the length of testes varied from 1.5 cms to 2.1 cms. The size of the testes varied according to the size of the fish. The testes were in flattened condition at the base and narrowed anteriorly, ending into fine tips. This tapering condition of the testes at the anterior end also showed a filamentous portion and distally the testes continued into small vasa differentia which united with one another before opening to the outside by the genital pore (Fig.29).
During the months of November, December and January, the testes are covered over by a thick deposition of fat, but from February onwards the fat gradually starts reducing in amount and finally it disappears altogether during the months of May and June.

**SPERMATOGONIA**

The chromosomal counts for ascertaining the diploid number of chromosomes in *O. striatus*, have been made on the metaphase plates of the spermatogonia. The diploid number has been established as $2n = 32, (\text{Fig. 30})$.

The chromosomes as seen in the metaphase plates of the spermatogonia are in the form of slender, thread-like structures which stain lightly by both basic Fuchsin and Feulgen method in squash preparations. They appear in the form of V's, J's and rods; the karyotype is represented by the following 2n chromosome formula: 16 V 8 J 8 r.
In figure 31, these different forms of chromosomes have been numbered after arranging them according to their shapes as V's, J's, and r's.

Out of the eight pairs of V's, number 1 and 2 pairs are much larger in size than the rest; number 3 and 4 pairs of V's are smaller than the first two pairs and are more or less of the same size; the rest of the V's i.e., the number 5, 6, 7 and 8 pairs are smaller in size than the preceding ones and show a graded reduction in size (Fig. 31). All the V's have limbs of equal length and show a distinct median centromere.

The J's are represented by 4 pairs of chromosomes in which the centromere is in a sub-median position. The pairs represented by numbers 9, 10 and 11 are approximately of the same size but the pair number 12 is much smaller in size than the preceding three pairs (Fig. 31).

The rod-shaped 4 pairs are represented by numbers 13, 14, 15 and 16; they are simple, straight and rod-like chromosomes which show a graded decrease in size in the order in which they have been numbered.
All of them show a distinct telomitic centromere.

**PRIMARY SPERMATOCYTE**

The haploid number \( n = 16 \) has been established from the chromosomal counts of the primary spermatocyte metaphase plates (Fig. 32). At this stage, all the bivalents appear in the form of more or less rounded, deeply staining structures due to the condensation of the chromatin material. All the bivalents, however, are not of the same size, some being larger than the others.

**SECONDARY SPERMATOCYTE**

The haploid number \( n = 16 \) has been confirmed in the secondary spermatocyte metaphase plates also (Figs. 33-34). The chromosomes show further condensation and stain very deeply. The size of the chromosomes is reduced further and the dyads appear in the form of small rounded bodies and do not show such marked variation in size as was seen in the primary spermatocyte metaphase plates.
Ophiocephalus punctatus:

The size of the testes varies with the size of the fish. In the younger specimens, the testes are in the form of elongated structures which become narrower anteriorly. In the larger and more mature specimens, they are comparatively thicker anteriorly. The vasa deferentia start from the posterior ends of the testes and are in the form of small tubes which join one another before opening to the outside by the genital pore (Fig. 35).

In the months of December and January the testes were covered over with fat. The amount of fat gradually decreases with the approach of summer. The best material available for the study of chromosomes in the testes was obtained from March to May, but even in these months, the amount of fat was so much that suitable squash preparations could not be made and recourse had to be taken to study them in sections.
From June onwards the amount of fat decreased still further but the testes were not suitable for the study of chromosomes because of full of ripe spermatozoa and early stages of spermatogenesis were absent. Material for the study of chromosomes in the spermatogonia and spermatocytes was therefore obtained from the male specimens of 16 cms to 24 cms in length, collected during March, April and May. In fishes of this length the testes varied from 1.6 cms to 5.2 cms. The testes were fixed in Champy's fluid and Aceto-alcohol (1:3) fixatives separately. Sections were cut at 4 to 6 μ and 10 to 14 μ in thickness; they were stained by modified Feulgen method and by Heidenhain's Iron Haematoxylin and light green.

Squash preparations of 2 - 3 days old embryos of 0.5 to 0.6 cms in length were also made to further check the diploid number of chromosomes in the fish, apart from the study of sections of testes.

**SPERMATOGONIA**

The diploid number of chromosomes as seen in spermatogonial metaphase counts is \(2n = 32\) and this
number was also obtained in the squash preparations of the early embryos. Thus the somatic number of chromosomes in these early embryos corresponds to the diploid number of chromosomes found in the spermatogonia.

All the chromosomes in the spermatogonial metaphase plates are small rod-shaped structures. They differ from one another in size, two of the 16 pairs being much smaller in size than the rest of the 14 pairs (Fig. 36); the difference in the size of the latter pairs being not very pronounced. All the chromosomes are with telomitic centromere.

**PRIMARY SPERMATOCYTE**

The haploid number $n = 16$ has been established from a study of chromosomal counts of the primary spermatocyte metaphase plates (Fig. 37). The bivalents are in the form of small rounded structures which due to greater condensation stain more deeply than in the earlier stages.
SECONDARY SPERMATOCYTE

The haploid number \( n = 16 \) was further confirmed by chromosomal counts of the secondary spermatocyte metaphase plates. The dyads are in the form of small rounded structures which are smaller in size than those seen in the metaphase plates of the primary spermatocytes and also stain more deeply due to the more condensed chromatin material (Fig. 38).

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Ophiocephalus gachua

GONADS

The testes in this fish are comparatively smaller than of O. striatus and O. punctatus and their shape is illustrated in Fig 39. They are also not so tapering but are instead bulged in the middle and with little rounded tips anteriorly. The small vasa - deferentia of the two sides start from the bases and join one another before opening to outside by the genital pore.

During the months of October to December, the testes are covered over by fat. The fat, however, starts reducing during the summer months and therefore those specimens collected during the months of May and June are practically free from fat. The best material for squash preparations was thus obtained from the male specimens of 21.5 to 23 cms in length which were collected during the months of May and June. The testes
in these specimens varied from 0.9 cms to 1.2 cms in length.

**SPERMATOCONIA**

The chromosomal counts for establishing the diploid number of *O. gachua* have been made on the spermatogonial metaphase plates. The diploid number of chromosomes as seen in these metaphase plates is 2n = 32.

The spermatogonial chromosomes are all rod-shaped and thus resemble those of the *O. punctatus*; they are, however, much smaller in size than those of the latter. Among the 16 pairs of the rods, 12 pairs show very little variation in size, but the other four pairs are much smaller in size (Fig. 40). All the chromosomes are with telomitic centromeres.

The 2n chromosome formula of *O. gachua* is therefore adjudged as 32 r, since the V and J forms of the chromosomes are absent.
PRIMARY SPERMATOCYTE

The haploid number \( n = 16 \) has been established by the chromosomal counts made on the primary spermatocyte metaphase plates. All the bivalents are rounded in shape and differ very little from one another in size (Figs. 41-42). Due to further condensation they stain more deeply than the chromosomes of the spermatogonia.

SECONDARY SPERMATOCYTE

The haploid number \( n = 16 \) has been also confirmed from the metaphase plates of the secondary spermatocytes. All the dyads are in the form of small rounded structures which stain very deeply and hardly show any variation in size from one another (Figs. 43-44).
Ophiocephalus marulius:

GONADS

The testes in *O. marulius* are larger in size than those of *O. striatus*, *O. punctatus* and *O. gachua*. They are fleshy and the size varies in different lengths of the males. The base of the testes are flat and anteriorly they gradually become narrower and form fine tapering tips (Fig. 45). The vasa - deferentia of the two sides arise from the hinder flat part and after a short course join each other to open to the outside by the genital pore.

During the months of November and December, and even upto January, the testes are covered over by fat; this, however, begins to get reduced from the month of February onwards and during the months of May and June, it is practically absent.

The best time for the collection of this species for a study of the chromosomes in the testes
was therefore May and June. In these months, the males varying from 10 cms to 12.5 cms were dissected and which yielded the testes varying from 0.7 cms to 1.9 cms in length. This material proved most satisfactory for squash preparations.

**Spermatogonia**

The chromosomal counts for establishing the diploid number in *O. marulius* have been made on the spermatogonial metaphase plates; the number has been determined as $2n = 32$.

The chromosomes as seen in the spermatogonial metaphase plates are slender, thread-like and do not stain deeply in the squash preparations by Aceto-orcein or even the Feulgen method. The chromosomes are in the form of V's, J's and rods (Fig. 46). The $2n$ chromosome formula is represented by $4V + 16J + 12r$.

The above forms of the chromosomes have been individually displayed in Fig. 47 which have been
numbered after arranging them according to their shapes as V's, J's and r's.

Of the two pairs of V's, number 2 is much smaller than number 1. The J's are represented by numbers 3, 4, 5, 6, 7 and 8 pairs and in all of them, one limb is much smaller than the other; among these, the number 3 and 4 pairs are somewhat larger than the rest. The pairs number 9 and 10 have been also included among J's, but in these the angle between the two limbs is much more obtuse than in the preceding six pairs. The rest of the pairs of the spermatogonial chromosomes, i.e., numbers 11, 12, 13, 14, 15 and 16 are represented by small rods, which show very little variation in size among themselves. The V's are with the median centromere; the J's with the sub-median, while the rods are with telomitic.

**PRIMARY SPERMATOCYTE**

The haploid number n = 16 has been established from the chromosome counts made on the primary spermatocyte metaphase plates (Figs. 48-49). In the primary spermatocytes, all the bivalents appear in the form of
more or less rounded structures which do not show much variation in size; they stain more deeply than the chromosomes of the spermatogonial metaphase plates, due to better condensation of the chromatin material.

SECONDARY SPERMATOCYTE:

In the secondary spermatocytes, the haploid number n = 16 has been confirmed from the chromosomal counts made on the secondary spermatocyte metaphase plates (Figs. 50-51). The dyads are in the form of rounded structures and their size is much smaller than those of the primary spermatocyte bivalent chromosomes. This reduction is due to further condensation of the chromatin material and consequently they stain more deeply.
Order : Mastacembeliformes
Family : Mastacembelidae
Genus : Mastacembelus
Species : armatus

Of the two species of Mastacembelus, i.e., M. armatus and M. punicalus, found in the stage of Madhya Pradesh, M. armatus is the only species available locally in any number. The best time when the fishes are suitable for a study of the chromosomes, is the months of April, May and June. The study has been carried on the squash preparations of testes dissected out of the male specimens during the months of April, May and early part of June.

GONADS

The testes of this fish are similar in shape to those of Belone cancila and are in the form of slender elongated structures. They are more or less uniform in diameter throughout their length and are
more or less bluntly pointed anteriorly (Fig. 52). The vasa deferentia of the two sides arise from the basal part of the testes and after completing a short course they join one another before opening to the outside by the genital pore.

During the winter months, like all other fishes, the testes in *M. armatus* are also found covered over by a dense layer of fat but from the month of March onwards, the amount of fat gets gradually reduced. In the months of April, May and June therefore, the males between 30 cms to 45 cms in length were collected and the testes in these lengths varied from 6 cms to 7.5 cms in length.

**SPERMATOGONIA**

The diploid number of chromosomes has been studied on the spermatogonial metaphase plates and found to be $2n = 48$. These chromosomes are very little in size as compared to those of the *Belone cancila* and *Notopterus notopterus* and stain faintly. All the chromosomes, however are not of the same size
and shape. Among these some are V-shaped, some J-shaped and others are rod-shaped (Fig. 53). The karyotype thus resembles those of the Belone cancilla and Notopterus notopterus much where also the V's, J's and r's are present and the diploid number of chromosomes is 48 (Figs. 10 and 2). The 2n chromosome formula of M. armatus is thus: 

\[ 8V + 16J + 24r. \]

The above forms of chromosomes have been numbered in pairs separately in the order of V's, J's and r's respectively (Fig. 54). Of the four pairs of V's, represented by numbers 1, 2, 3 and 4, the last or fourth pair is somewhat smaller than the preceding three pairs. All the V's show clear median centromere. Among the J's, the pairs numbered 5, 6, 7, 8, 9, and 10 show a well-marked smaller limb placed at an obtuse angle to the main limb; out of these the pair number 5 is conspicuously larger than the others which do not differ markedly from one another in size. The pairs number 11 and 12 are definitely J's due to the clear sub-median position of the centromere, but the angle between the longer and the shorter limb is very
little. The rest of the chromosome pairs i.e., number 13 to 24, are represented by rods which are telomitic in nature and show gradual reduction in size from the 13th pair onwards as shown in the plate (Fig. 54).

**PRIMARY SPERMATOCYTE**

The haploid number \( n = 24 \) has been established by a study of the metaphase plate counts of the primary spermocytes. The 24 bivalents appear in the form of small rounded structures which stain deeply due to the condensation of the chromatin material (Figs. 55-56). The bivalents, however, show very little variation in size among themselves.

**SECONDARY SPERMATOCYTE**

The haploid number \( n = 24 \) has been also confirmed by the metaphase plate counts of the secondary spermocytes (Fig. 57). At this stage, the dyads become still more smaller in size due to further condensation.
of the chromatin material and also stain more deeply.
All the dyads are in the form of small rounded
structures which are more or less of the same size.

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