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# Gonial Chromosomes, Their Behaviour and Metrical Data in Nine Species of Fulgorids (Homoptera)

A. K. Bhattacharya and G. K. Manna

Department of Zoology, Kalyani University,
Kalyani, West Bengal, India

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The superfamily Fulgoroidea includes plant bugs of diverse forms. The dissimilarities in morphological structures render it difficult for systematists to frame any comprehensive key for a satisfactory classification. However, according to Imms (1961) the classification proposed by Muir (1930) is better than that of others. He (Muir 1930) has put them in 20 families, some containing a few species. The cytological data obtained in different species of the superfamily are also not equally extensive. For example about 71 species of fulgorids (*vide infra*) cytologically investigated, several species are from Delphacidae (Areopidae) while other families are either unexplored or are known by one or two species. Besides our previous reports on fulgorids (Bhattacharya and Manna 1967, Bhattacharya 1971) and those of Rao (1955 a, b), no species from India has been studied. Moreover, families Tropiduchidae and Dictyopharidae were so far cytologically unknown to the world but the present investigation would remove such lacuna of knowledge. It would also add informations of one species each of families Delphacidae, Cixiidae, Derbidae, Ricaniidae and three species of the family Lophopidae. The present paper deals with the behaviour and metrical data of gonial chromosomes of nine species. Further, basing on the cytological data carried out so far, an attempt has also been made to assess the supergeneric classification and the caryotypic evolution in fulgorids. The chromosomes of two Flatids under this superfamily described elsewhere (Bhattacharya 1971) have also been considered.

## Material and methods

Several male and female individuals of nine species (Table 1) were collected from different sources in Kalyani, West Bengal, and their gonads constituted the material for this study. Chromosomes of ovaries were studied from temporary aceto-carmine squash preparations while testes were fixed in Carnoy and Sanfelice for squash and microtome preparations respectively. These were stained in iron-alum haematoxylin and leuco-basic fuchsin and mounted permanently following the normal procedure. The relative volume of the chromosomes of the first spermatocyte metaphase complement were measured from camera lucida drawings magnified by an epidiascope and redrawn on graph paper, according to the methods described by us (Manna 1951, Bhattacharya and Manna 1970). Since the sex chromosome and the autosomes underwent maximum condensation and they could

be identified very definitely, this stage of division was preferred.

Table 1. List of species of fulgorids with their families and source of collection

| Species | Family | Source of collection |
|---|---|---|
| 1. *Dictyophara pallida* (Don) | Dictyopharidae | near light |
| 2. *Oliarus hodgarti* (Dist) | Cixiidae | near light and at *Impereta cylindrica* roots 3″ below the soil. |
| 3. *Barunoides albosignata* (Dist) | Tropiduchidae | near light |
| 4. *Diostrombus carnosus* (Westwood) | Derbidae | leaf of *Zea Mays* |
| 5. *Pyrilla pusana* (Dist?) | Lophopidae | leaf of *Sorghum vulgare* |
| 6. *Elasmocelis platypoda* (Kirby) | 〃 | leaf of *Saccharum spontaneum* |
| 7. *Verma distanti* (Melich) | 〃 | near light |
| 8. *Ricania zebra* (Dist) | Ricaniidae | on grass—*S. spontaneum* and near light. |
| 9. *Eoeurysa flavocapitata* (Muir) | Delphacidae | leaf base of *Saccharum officinarum*. |

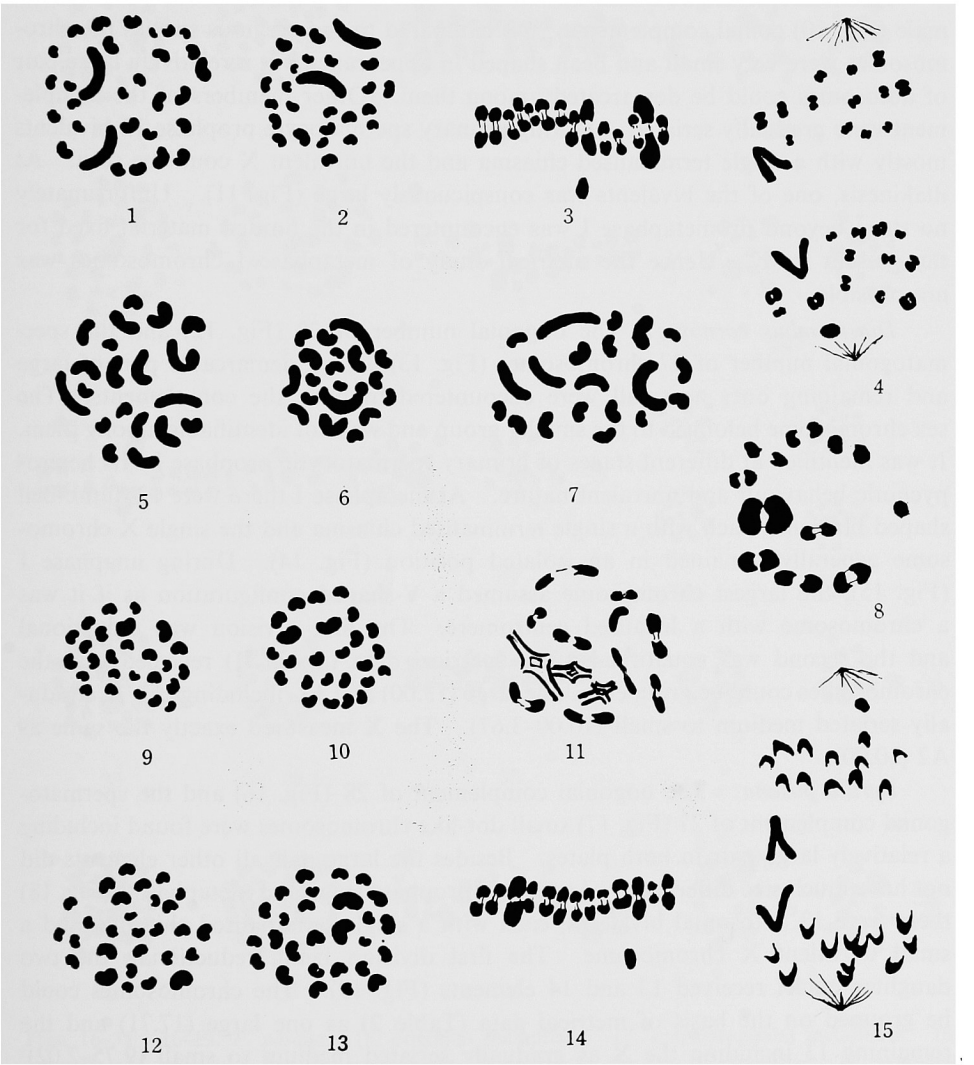
## Observations

The behaviour of meiotic chromosomes in different species was more or less the same but the number sometimes differed. For convenience the oogonial complements and some spermatocyte stages in each species have been described hereunder:

*Dictyophara pallida* had 30 in the oogonial (Fig. 1) and 29 in the spermatogonial metaphase complements (Fig. 2) which included a pair of outstandingly large autosomes. The remaining chromosomes were gradually seriated. The unpaired X could not be demarcated in the gonial complements either by its size or the stanining behaviour. This was identifiable at the primary spermatocyte prophase by its univalent nature and positively heteropycnotic behaviour but at metaphase I (Fig. 3) by its disposition and unpaired nature. Late prophase and metaphase I contained 14 bivalents and the X. First division anaphase was reductional for which the X moved to one of the poles (Fig. 4). It is interesting to note that the largest chromosome appeared to be V shaped in the anaphase complement (Fig. 4), a feature which is commonly seen in chromosome with a localised centromere. The second division was equational. According to the relative percentage volume of different chromosomes of metaphase I (Table 2) chromosomes may be grouped as one long (17.58), 1 medium (11.81) and 13 small including the X (8.24–1.92). The X measured 8.79 which was close to A3.

*Oliarus hodgarti* had 20 in the oogonial (Fig. 5) and 19 in the spermatogonial metaphase complement (Figs. 6, 7). A pair of relatively large chromosomes was found in both the gonial plates but in some spermatogonial plates it was not so obvious. The gonial chromosomes could broadly be grouped as 1 pair large, 8 pairs medium and the rest small. Sometimes one of the chromosomes of

the large pair in the spermatogonial complement (Fig. 6) showed a knob-like constriction. On the other hand some complements appeared to contain 20 chromosomes (Fig. 7) which was very likely due to the detachment of the terminal knob. The presence of constricted chromosomes in Hemiptera is very uncommon. It was all the more interesting to have its presence in one member of the homologuous pair. Chromosomal polymorphism for this constricted chromosome was present but details were not studied. During the primary spermatocyte prophase rod and




Figs. 1–15. 1–4. *D. pallida*. 1, oogonial metaphase. 2, spermatogonial metaphase. 3, spermatocyte metaphase I. 4, spermatocyte anaphase I. 5–8. *O. hodgarti*. 5, oogonial metaphase. 6, spermatogonial metaphase. 7, spermatogonial metaphase. 8, spermatocyte metaphase I. 9–11. *B. albosignata*. 9, oogonial metaphase. 10, spermatogonial metaphase. 11, spermatocyte late diakinesis. 12–15. *D. carnosus*. 12, oognial metaphase. 13, spermatogonial metaphase. 14, primary spermatocyte metaphase. 15, spermatocyte anaphase I.

cross shaped autosomal bivalents and a deeply stained X chromosome were present. Bivalents generally had one chiasma and at metaphase I they were condensed to form the dumb-bell shaped elements (Fig. 8). The X chromosome in some plates, becuase of its chromatid split, appeared like a bivalent. Owing to the anomalous situation for the presence of a constricted chromosome and the detachment of the knob in some plate, the extension of the data is intended. Therefore, the metrical study has not been made at present.

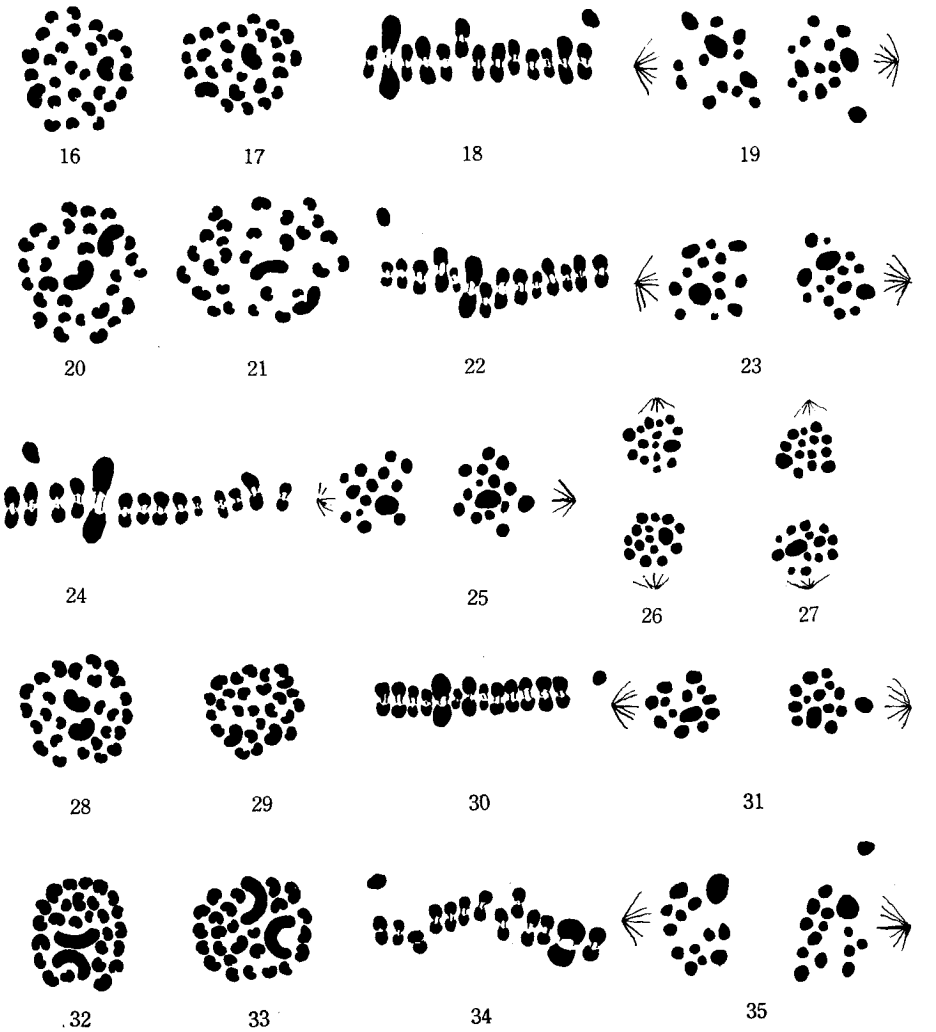
*Barunoides albosignata* had 2n=26 in female (Fig. 9) and 25 chromosomes in male (Fig. 10) gonial complements. As compared to the previous species the chromosomes were very small and bean shaped in appearance but a relatively large pair of autosomes could be demarcated among them. Other members of the complement were gradually seriated. During primary spermatocyte prophase 12 bivalents mostly with a single terminalised chiasma and the univalent X could be seen. At diakinesis, one of the bivalents was conspicuously large (Fig. 11). Unfortunately no stage beyond prometaphase I was encountered in the limited material fixed for the present study. Hence the metrical study of metaphase I chromosomes was not possible.

*Diostrombus carnosus*: The oogonial number of 28 (Fig. 12) and the spermatogonial number of 27 chromosomes (Fig. 13) with a demarcable pair of large and remaining ones as small were encountered in both the complements. The sex chromosome belonged to the smaller group and was not identifiable among them. It was identified at different stages of primary spermatocytic prophase by its heteropycnotic behaviour and univalent nature. At metaphase I there were 12 dumb-bell shaped bivalents, each with a single terminalised chiasma and the single X chromosome generally remained in an isolated position (Fig. 14). During anaphase I (Fig. 15), the largest chromosome assumed a V-shaped configuration as if it was a chromosome with a localised centromere. The first division was reductional and the second was equational. The metrical data (Table II) revealed that the chromosomes could be grouped as one large (13.00) and 13, including the X, gradually seriated medium to small (10.00–3.67). The X measured exactly the same as A2 (10.00).

*Pyrilla pusana*: The oogonial complement of 28 (Fig. 16) and the spermatogonial complement of 27 (Fig. 17) small dot-like chromosomes were found including a relatively large pair in both plates. Besides the large pair all other elements did not have much size difference. At the late prophase stage and metaphase I (Fig. 18) there were 13 autosomal bivalents, each with a single terminalised chiasma, and a small univalent X chromosome. The first division being reductional, the two daughter nuclei received 13 and 14 elements (Fig. 19). The chromosomes could be grouped on the basis of metrical data (Table 2) as one large (17.71) and the remaining 13 including the X as gradually seriated medium to small (9.75–2.02). The X measured 9.75 a little higher than A2.

*Elasmocelis platypoda* had 30 in the oogonial (Fig. 20) and 29 chromosomes in the spermatogonial complement (Fig. 21). As found in other species the gonial complements had a pair of large chromosomes while the rest were small bean shaped in appearance. The late primary spermatocyte prophase and the metaphase I

(Fig. 22) contained 14 autosomal bivalents and the univalent X chromosome generally in an isolated position. Bivalents were rod-like because of the presence of a single terminalised chiasma. The first division anaphase was reductional for which the daughter halves (Fig. 23) received 14 and 15 chromosomes. The metrical data (Table 2) also indicated that chromosomes were one large (17.71), and the remaining 14 inclusive of the X gradually seriated medium to small (9.44–1.96).




Figs. 16–35. 16–19. *P. pusana*. 16, oogonial metaphase. 17, spermatogonial metaphase. 18, spermatocyte metaphase I. 19, spermatocyte anaphase I. 20–23. *E. platypoda*. 20, oogonial metaphase. 21, spermatogonial metaphase. 22, primary spermatocyte metaphase. 23, spermatocyte anaphase. 24–27. *V. distanti*. 24, primary spermatocyte metaphase. 25, spermatocyte anaphase I. 26, second anaphase without the X. 27, second anaphase with the X. 28–31. *R. zebra*. 28, oogonial metaphase. 29, spermatogonial metaphase. 30, primary spermatocyte metaphase. 31, spermatocyte anaphase I. 32–35. *E. flavocapitata*. 32, oogonial metaphase. 33, spermatogonial metaphase. 34, primary spermatocyte metaphse. 35, spermatocyte anaphase I.

The X measured 9.05 which was close to A2.

*Varma distanti*: Only two males were available for the present study and no spermatogonial metaphase was found in them. However, the spermatogonial number of 29 chromosomes including a pair of large autosomes could be interpreted from the primary spermatocyte metaphase complements. The first spermatocyte metaphase (Fig. 24) contained 14 autosomal bivalents and an unpaired X chromosome. One of the bivalents was fairly large compared to others but all of them had a single chiasma terminalised in each. The large bivalent must have been formed by a pair of large autosomes. The first division anaphase (Fig. 25) was reductional. Two daughter nuclei so formed received 14 autosomes but one of them had the X in addition. The second division was equational for the chromosomes (Figs. 26, 27). Metrical data (Table 2) indicated two groups of chromosomes as, one large (19.89) and the remaining including the X, gradually seriated as medium to small (10.8–2.21). The X was smaller in size than the previous species and it measured 5.88 as A7.

*Ricania zebra*: The oogonial complement contained 28 (Fig. 28) and the spermatogonial 27 (Fig. 29) chromosomes. One pair of chromosomes in both the gonial complements was distinctly large while the remaining ones were small and very gradually seriated. The diplotene nucleus of spermatocytic prophase contained 13 autosomal bivalents, each with a single terminalised chiasma and an univalent spherical X. At metaphase I (Fig. 30) all the 13 bivalents were rodlike and the univalent X formed an accessory plate. The first division anaphase was reductional (Fig. 31) as a result one daughter half received 13 autosomes but the other had the X with 13 autosomes. The metaphase chromosomes, according to the metrical data (Table 2) can be grouped as one large (20.70) and the remaining 13 with the X as medium to small (9.25–3.08). The X (9.69) was larger than A2.

*Eoeurysa flavocapitata*: The gonial metaphase complements contained 28 in female (Fig. 32) and 27 chromosomes (Fig. 33) in male. There was a large pair in the complements but the rest were small in size. The size difference between the large pair and others was very conspicuous and it was almost the same as found in *D. pallida*. The X chromosome in the gonial complements was not identifiable by its size differnce or stainability. The typical metaphase I (Fig. 34) had 13 dumbbell shaped autosomal bivalents and the univalent X. The bivalent formed of the largest pair of autosomes was easily distinguishable from other. The first division was reductional (Fig. 35) which gave rise to two daughter nuclei—one with 13 autosomes and the other with the same plus the X. Based on the metrical data (Table 2), chromosomes could be grouped as one large (20.29) and the remaining 13 including the X as medium to small (11.43–2.58). The X measured 11.43 about 1.5% larger than A2.

## Discussion

Cytologically the family Delphacidae (Areopidae) is known better as we have the knowledge of 41 out of 71 species studied in the superfamily Fulgoroidea. These species belong to 17 genera (Halkka 1959 1962, Halkka and Heinonen 1964) in

Table 2. Relative volumes in percentage of the haploid set of metaphase I chromosomes

| Species | Serial number of chromosomes | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | $A_4$ | $A_5$ | $A_6$ | $A_7$ | $A_8$ | $A_9$ | $A_{10}$ | $A_{11}$ | $A_{12}$ | $A_{13}$ | $A_{14}$ | X |
| 1. *Dictyophara pallida* | 17.58 | 11.81 | 8.24 | 7.41 | 6.87 | 6.87 | 6.31 | 5.21 | 4.67 | 4.39 | 3.84 | 3.29 | 2.75 | 1.92 | 8.79 |
| 2. *Oliarus hodgarti* | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 3. *Barunoides albosignata* | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 4. *Diostrombus carnosus* | 13.00 | 10.00 | 9.67 | 7.67 | 7.67 | 7.00 | 6.33 | 6.33 | 5.33 | 5.00 | 4.67 | 3.67 | 3.67 | — | 10.00 |
| 5. *Pyrilla pusana* | 17.71 | 9.11 | 8.60 | 8.10 | 7.33 | 6.31 | 6.00 | 5.55 | 5.55 | 5.05 | 4.81 | 4.04 | 2.02 | — | 9.75 |
| 6. *Elasmocelis platypoda* | 17.71 | 9.44 | 7.87 | 7.87 | 7.08 | 6.69 | 6.29 | 5.51 | 5.11 | 4.72 | 4.33 | 3.54 | 2.75 | 1.96 | 9.05 |
| 7. *Varma distanti* | 19.89 | 10.08 | 8.40 | 7.56 | 7.00 | 6.16 | 5.88 | 5.60 | 5.32 | 4.47 | 4.47 | 3.61 | 3.33 | 2.21 | 5.88 |
| 8. *Ricania zebra* | 20.70 | 9.25 | 8.37 | 7.05 | 7.05 | 6.61 | 6.17 | 5.28 | 4.84 | 4.84 | 3.96 | 3.08 | 3.08 | — | 9.69 |
| 9. *Eoeurysa flavocapitata* | 20.29 | 9.96 | 8.48 | 7.01 | 6.27 | 6.27 | 5.90 | 5.16 | 4.79 | 4.42 | 4.05 | 3.32 | 2.58 | — | 11.43 |

which the spermatogonial number ranges between 24 and 37 with a peak at 29 chromosomes. The Y chromosome is absent except in *Conomelus limbatus*, *Calligypona lugubrina* and *Dicranotropis hamata* (polymorphic sex chromosomes). The genus *Calligypona* is formed of heterogeneous assemblage of species having 26, 29, 33 and 37 chromosomes.

*Family Cixiidae*: Only three species, *Cixius cumcularis* (2n=29), *Oliarus leporinus* (2n=31) studied by Halkka (1959) and *O. hodgarti* (2n=19) have OX: XX type of sex mechanism. The chromosome number in *O. hodgarti* appears to be aberrant among the fulgorids and differs from *O. leporinus* by 12 autosomes. The present data apparently indicate a heterogenous constitution of the family. The modal number is yet to be ascertained.

*Family Derbidae*: Males with 2n=27 in *Diostrombus carnosus* (Bhattacharya and Manna 1967), *Oticerus wolfi* (Halkka and Heinonen 1964), *Phenice bicornis* (Leston 1961) and 2n=37 in *Scolops sulcipes* (Halkka and Heinonen 1964) are cytologically known. It can reasonably be said that 2n=27 including the X would be the modal number of this family.

*Family Lophopidae*: Four species belonging to three genera with XO: XX type of sex determination are on record. The spermatogonial number of 27 have been reported in *Pyrilla perpusilla* (Rao 1955) and *P. pusana* (Bhattacharya and Manna 1967); in *Elasmocelis platypoda* and *Varma distanti* (Bhattacharya and Manna 1967). In the absence of the metrical data of *P. perpusilla* studied by Rao, a comparison of the caryotype of the two congeneric species could not be made.

*Family Ricaniidae*: Males of *Ricania japonica* having 2n=21 (Kurokawa, 1953) and *R. zebra* 2n=27 chromosomes (Bhattacharya and Manna 1967) are cytologically known. Besides the autosomal number, no difference in the sex mechanism is present.

*Family Flatidae*: It has been reported elsewhere that only 8 species are cytologically known (Bhattacharya 1971). They are heterogenous in constitution for the presence of both XO: XX and XY: XX types of sex chromosomes and variable spermatogonial numbers ranging between 22 and 27 but 27 seems to be the modal number.

*Families—Dictyopharidae* and *Tropiduchidae*: Only one species, *Dictyophara pallida* of Dictyopharidae having the spermatogonial number of 29 chromosomes, (Bhattacharya and Manna 1967), is typical for the fulgorids while *Barunoides albosignata* of Tropiduchidae having 2n=25, chromosomes (Bhattacharya and Manna 1967) is a deviation from the same.

The study of gonial chromosomes in 9 species of the present study and two reported elsewhere (Bhattacharya 1971) of fulgorids show more or less a similar behaviour in many respects. In the gonial complements all the species had a pair of large autosomes which could be easily demarcated from the rest. During spermatogenesis no bouquet arrangement was found as commonly met with in species of cercopids (Bhattacharya and Manna 1970) but the X chromosome was positively heteropycnotic upto the diakinesis stage and was situated in various positions in metaphase I. The sex chromosome mechanism of XO: XX type was uniformly maintained. In spite of these common features some differences could be brought

out when the metrical data were compared. In 7 of the 9 species the data (Table 2) would show that the autosome No. 1 and the X chromosome in different species were most variable while others were less so. The difference in the diploid number in different species could be accounted largely due to simple fusion/fission mechanism. Manna (1956) in Heteroptera and Whitten and Taylor (1969), in the leaf hopper envisaged similar mechanism. Such changes could be easier since insects of this order have diffuse centromeric activity. Besides the fusion/fission method of evolution other types of rearrangements might have taken place. In species with the same diploid number of (27) chromosomes e.g. *D. carnosus*, *P. pusana*, *R. zebra* and *E. flavocapitata*, the relative volume of autosome No. 1 was ranging between 13% to 20.70% and the X was between 9.69% to 11.43%. The relative difference in other chromosomes of these was mostly within the range of 1% as in A2, A3, A12 and A13 while it was still lower in the rest. The present analysis would, at least, indicate that possibly some structural changes have taken place in autosome No. 1 and in the X. *E. platypoda* and *V. distanti* had a very conspicuous difference in the measurement of the X and the next was $A_1$. This would also indicate the structural rearrangement in the said chromosomes.

Lastly attention may be drawn to the structure of the largest chromosome at anaphase 1. It was V-shaped in appearance which recalls the structure of the colchicimised acrocentric chromosome of mice at metaphase. Manna (1951) reported similar structure of anaphase I chromosomes in Heteroptera also. The diffuse centromeric activity in Hemiptera, shown under experimental and normal condition, is well accepted. The behaviour of the long chromosomes leaves us in a confusion.

## Summary

A cytological study of nine fulgorid species revealed that they had similar get up of oogonial and spermatogonial chromosomes. Chromosomes were bean-shaped with a large pair while the remaining were gradually seriated. In the gonial complements one sex chromosome in males and two in females showed no differential behaviour compared to the autosomes. The diploid number in female and male gonial complements was 20 and 19 respectively in *Oliarus hodgarti*; 26 and 25 in *Barunoides albosignata*; 28 and 27 in *Diostrombus carnosus*, *Pyrilla pusana*, *Ricania zebra*, *Eoeurysa flavocapitata*; 30 and 29 in *Dictyophara pallida*, *Elasmocelis platypoda*, *Varma distanti*.

The behaviour of spermatocyte chromosomes in all the above species was of orthodox nature with the single X chromosome showing heteropycnotic behaviour in prophase I. The first division was reductional and the second equational. The chiasma frequency was generally one per bivalent except the large bivalent which sometimes had two. Relative percentage volume of the chromosomes was determined from metaphase I. Results obtained in this investigation have been correlated with the published data and the probable mode of evolution in the group has been discussed.

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## References

Bhattacharya, A. K. 1971. Structure and behaviour of germinal chromosome in two species of flatid Homoptera. Proc. Ist All India Cogr. Cytol. and Genet, Chandigarh, p. 59.

— and Manna, G. K. 1967. A study of germinal chromosomes during meiosis in 50 species of Homoptera (Hemiptera). Proc. 54th. Ind. Sci. Congr. Part III: 618–619.

— and — 1970. Structure, behaviour and metrical studies of germinal chromosomes in four species of spittle bugs. Proc. Nat. Acad. Sci., India, **40**(B), III: 129–136.

Boring, A. M. 1907. A study of the spermatogenesis of 22 species of Membracidae, Jassidae, Cercopidae and Fulgoridae with special reference to the behaviour of odd chromosomes. Jour. Exp. Zool. **4**: 469–514.

Halkka, O. 1959. Chromosome studies on the Hemiptera, Homoptera, Auchenorrhyncha. Ann. Acad. Scient. Series A. IV, Biologica **43**: 1–72.

— 1962. The karyotype of six fulgorina. Arch. Soc. "Vanoma" **16**: 152–155.

— and Heinonen, L. 1964. The chromosomes of seventeen Nearctic Homoptera. Heriditas **52**: 77–80.

Imms, A. D. 1957. A general text book of Entomology. IX edition Methuen and Co., Ltd., London.

Kurokawa, H. 1953. A study of chromosomes in 12 species of Homoptera. La Kromosom **15**: 543–546.

Leston, D. 1961. The chromosome number of *Phenice bicornis* (Muir.) (Homop.–Derbidae). The Entomologist **94**: 84–85.

Manna, G. K. 1951. A study of chromosomes during meiosis in forty three species of Indian Heteroptera. Proc. Zool. Soc. Bengal. **4** (1 and 2): 1–116.

— 1956. Cytology and inter-relationships between various groups of Heteroptera. Proc. X Intern. Entomol. Congr. Canada. **2**: 919–934.

Rao, S. R. V. 1955a. Studies on the spermatogenesis of Indian Homoptera I. Meiosis in two species of *Eurybrachis* (Fulgoridae). Chromosoma **7**: 170–180.

— 1955b. Studies on the spermatogenesis of some Indian Homoptera II. Chromosomes of the sugarcane leaf hopper—*Pyrilla perpusilla* (Walk.) Fulgoridae. Cytologia **20** (3): 225–228.

Whitten, M. J. 1965. Chromosome numbers in some Australian leaf hoppers (Homoptera, Anchenorrhyncha). Proc. Linn. Soc. New S. Wales **90** (1): 78–86.

— and Tayler, W. C. 1969. Chromosomal polymorphism in an Australian leafhopper (Homoptera, Cicadellidae). Chromosoma (Berl.) **26** (1): 1–6.