126. *Preliminary Note on Cytological Studies on Gryllodea.*¹⁾

(Chromosome-numbers and sex-chromosomes of eighteen species.)

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Orthoptera Saltatoria has been a favourite order for cytological researches: many species of the two families, Tettigidae and Acrididae, have been studied by many able workers, with very suggestive results, which bear on various problems of Genetics, and which have been too much discussed to be enumerated here; the family Locustidae, though with less remarkable merits, has been investigated extensively by a dozen of authors; while for the family Gryllidae least attention has been paid.²⁾ Only a few species were studied and those are almost limited to the genus *Gryllus*.³⁾ Recently, Honda ('26) has announced the chromosome numbers of several species belonging to the subfamily Gryllinae, though all his accounts are not in accord with my present statement.

I was studying the germ-cells of a few species belonging to that family several years ago under the guidance of Prof. C. Ishikawa. My subsequent study, renewed in the present institute a few years since and extended to all the species available, has now enabled me to determine the chromosome numbers of eighteen species. They are listed in the following table and the figures of the spermatogonial metaphase are given in the plate.⁴⁾

1) I here adopt Gryllodea for the name of the superfamily. The reason for the adoption shall be given in my following paper. The two genera, *Gryllotalpa* and *Tridactylus*, are not considered here, as these take rather dubious positions among Gryllidae, leaving the full considerations for my later papers. Also the genus *Myrmecophila* was not taken into account, as I have not been able to obtain the material.

2) cf. McClung, '14, p. 660, and Robertson, '16, p. 183.

3) They are *Gryllus domesticus*, *G. desertus*, *G. assimilis*, and *G. campestris*, with one or two species from other genera.

4) At present I am concerning only with the spermatogonial chromosomes, giving a brief account and some considerations. Full studies about them and the details of cytological studies on each species shall be delivered in my later papers.

Names of Species ⁵⁾	Spermatogonial Chromosome Numbers.
<i>Gryllus mitratus</i> , Burm. (<i>Yemma-kohrogi</i>)	27
<i>G. tokyoensis</i> , Mats. (<i>Usuiro-kohrogi</i>)	21
<i>G. conspersus</i> , Schaum. (<i>Hime-kohrogi</i>) ?	17
<i>Gryllodes berthellus</i> , Sauss. (<i>Kohrogi</i>)	21
<i>Loxoblemmus arietulus</i> , Sauss. (<i>Okame-kohrogi</i>)	13
<i>L. frontalis</i> , Shir. (<i>Mitsukado-kohrogi</i>)	11
<i>Madasumma marmorata</i> , Haan. (<i>Matsumushi</i>)	11
<i>M. hibinonis</i> , Mats. (<i>Ao-matsumushi</i>)	15
<i>Ectatoderus kanetataki</i> , Mats. (<i>Kanetataki</i>)	19
<i>Homoeoxiphus insularis</i> , Sauss. (<i>Kusahibari</i>)	15
<i>Anaxiphus vittatipes</i> , Mats. (<i>Kinhibari</i>)	19
<i>Cirtoxiphus ritzemae</i> , Sauss. (<i>Yamato-suzu</i>)	17
<i>Nemobius yezoensis</i> , Shir. (<i>Yezo-suzu</i>) ?	17
<i>N. nigrofasciatus</i> , Mats. (<i>Madara-suzu</i>)	17
<i>N. chibae</i> , Shir. (<i>Chibi-suzu</i>)	15
<i>N. sp.</i>	11
<i>Homoeogryllus japonicus</i> , Haan. (<i>Suzumushi</i>)	21
<i>Oecanthus longicauda</i> , Mats. (<i>Kantan</i>)	20

As will be easily recognized in the table and in the plate, there are great diversities as to the number, shape, and size of the chromosomes among different species. As for the latter two facts, we can recognize every grade, from the smallest dots, through small spheres and spheroids, short and long rods, to the V-chromosomes, and the last differing among themselves in the length of the arms which is either equal or unequal. Again, the chromosome numbers vary so much. They are varied almost in a continuous series, from the lowest eleven to twenty-one, and thence abruptly to twenty-seven.

From their studies on Tettigidae and Acrididae, McClung ('08), Robertson ('16), and others have inferred that there are fundamental type-numbers of chromosomes among related groups of organisms. And the number they have given for these two families are thirteen and twenty-three respectively (for male). Based on that hypothesis, McClung assumed the number thirty-three for Locustidae. Further, Robertson argued that twenty-nine is the number frequently met with

5) As to the validity of these specific names I am not certain, as they are confused very much. So I have added Japanese names in parenthesis, leaving the correct scientific names for later identifications.

in Gryllidae. But, as stated above, my result does not conform to their assumptions. This fact indicates either that their theory has not such a broad significance as they assume, or that the family Gryllidae contains insects which are rather remote from each other in their relationship.

Also, the variation in number is so gradual and continuous and is not arranged as such that each number is the multiples of a standard base number, as is often the case with the plants. Neither can I show that the number-deviation is due to such facts as chromosome-association or fragmentation. It is only within nearly related species that such correlations can be observed. For instance, the number is the same between *Gryllus tokyoensis* and *Gryllodes berthellus*, and also I may reduce the number to a standard of the two species of *Loxoblemmus*.

Considered in general, the number itself has a slight significance, as Wilson remarks ('24, p. 866). I want, however, to lay stress on the fact that there are such relations between the number and the size, that the larger the number, the smaller each chromosome is. This fact may be recognized if comparisons be made among the chromosomes of the subfamily Gryllinae. For instance, the chromosomes of *Gryllus mitratus*, having the highest number of twenty-seven, contains certain number of small spheres beside short rods, while those of *Gryllus tokyoensis*, and *Gryllodes berthellus*, whose numbers are twenty-one, are all short rods. In *Gryllus conspersus*, a pair of V are found beside short rods and so the number is reduced to seventeen. In the two species of *Loxoblemmus*, having the lowest number of eleven and thirteen, long rods and Vs have almost entirely replaced the shorter ones. These relations tempt me to suspect that the whole amount of the chromatin element taken together is almost constant for every species within a certain group, though the number of the chromosomes formed by condensation varies so much.

Deviations from normal chromosome numbers have been observed and discussed recently by several authors. Honda mentions a case in *Loxoblemmus arietulus*, in which he finds three kinds of combinations, thirteen, fourteen, and fifteen, and which he explains as multiple chromosomes. But, as far as my observations go, I could not find such deviations in that species, although, in another one or two, I could perceive minor differences. But these must be left for further studies.

One more point of interest is that the diploid groups of a few species can rather easily and precisely be arranged into homologous pairs and for other species, if the whole chromosomes can not be dealt

with, such conditions can be observed in certain pairs. And also, in *Nemobius yezoensis*, a heteromorphic homologous pair can be observed, which may be of the same nature as those observed by Carothers ('13 and '17) and others in Acrididae and Tettigidae. These and other problems shall be discussed in my later papers.

The most remarkable feature in the chromosomes of the Gryllidae is the condition about the sex-chromosomes. They seem to have great significance bearing on certain problems on taxonomy and the evolution of the sex-chromosomes in general. Their shape and size are so remarkably constant for the greater part of the family (it may even be suspected that they are identical or rather homologous elements), while in a few species the difference is very remarkable, which shows that these are rather remote from other species in taxonomy. Again, in *Oecanthus longicauda*, the existence of the mate of the X-element is quite exceptional.

Gryllidae appears to belong to the XO-XX type. This can be deduced from the fact that a special chromosome is always found in the mitotic cycles of all the species, which proves to be the sex-chromosome. This unpaired X-chromosome can be very easily identified by the following facts; namely, that it is always of the largest size, often much larger than the autosomes, and that it has the V-shape peculiar to it, taking always the peripheral position in the metaphase. Sometimes, while the autosomes take compact body and smooth contour, the condensation of its chromatin substance is not complete, so that the sex-chromosome is in a granular state and its outline appears to be rough and rugged. And, though it divides with the autosomes in the spermatogonial mitosis, in the heterotypic division, one chromosome is found to go ahead prematurely to one pole undivided, which is the X-chromosome. Moreover, in a few species the ovogonial metaphase was obtained, in which two X-chromosomes were identified. All these observations tend to prove the condition of XO-XX type.

As has been mentioned the constancy of its shape is remarkable. It has the V-shape, the arm length of which is markedly unequal, the longer one being bent in the middle, and the apex of which is always turned toward the centre. A slight difference is, however, seen in the genus *Nemobius*, where both the ends and the middle portion are slightly swollen, the general shape assuming a U. This seems to indicate some corresponding differences in taxonomy. Great exceptions occur, however, among the subfamily Oecanthinae, where the sex-chromosomes, even of the largest, is of the rod type instead of V. This shows that the subfamily must be placed in a position rather remote from other

subfamilies. The more remarkable thing is that in *Oecanthus* a small Y-chromosome is observed, which is one of the smallest chromosomes playing as a mate to the X-chromosome. This fact can be demonstrated from the following observations; first, that several counts of the spermatogonial chromosomes always proved to be even, the larger and the smaller group having each an odd member, and secondly, that in the lateral view of the metaphase of the heterotypic division one bivalent chromosome is always found, the conjugated members of which differ widely in size, which correspond to the X- and the Y-element of the spermatogonium. The case like this seems to have a great significance for the problem of the evolution of the sex-chromosomes in general (Wilson, '24, p. 823).

The most perplexing instance is, however, found in *Cirtoxiphus ritzemae*, the species which is included in the subfamily Trigonidiinae, to which such genera as *Homoeoxiphus* and *Anaxiphus* also belong. The shape of the sex-chromosome in this species is, however, a long rod instead of V. This signifies that the taxonomical position of that species may be rather separate from other members of the subfamily, but further studies both cytological and taxonomical are wanted.

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EXPLANATION OF PLATE:

All the figures were faithfully traced with Abbe's Zeichenapparat at the level slightly below the microscopic stage, with the combination of a Zeiss 1.5 mm. apochromatic objective and a Zeiss compensating ocular 12, tube length 160 mm.

x : Sex-chromosome. c : Chromatoid body.

- Fig. 1. *Gryllus mitratus*.
- Fig. 2. *G. tokyoensis*.
- Fig. 3. *G. conspersus*.
- Fig. 4. *Gryllodes berthellus*.
- Fig. 5. *Loxoblemmus arietulus*.
- Fig. 6. *L. frontalis*.
- Fig. 7. *Madasumma marmorata*.
- Fig. 8. *M. hibinonis*.
- Fig. 9. *Ectatoderus kanetataki*.
- Fig. 10. *Homoeoxiphus insularis*.
- Fig. 11. *Anaxiphus vittatipes*.
- Fig. 12. *Cirtoxiphus ritzemae*.
- Fig. 13. *Nemobius yezoensis*.
- Fig. 14. *N. nigrofasciatus*.
- Fig. 15. *N. chibae*.
- Fig. 16. *N. sp.*
- Fig. 17. *Homoeogryllus japonicus*.
- Fig. 18. *Oecanthus longicauda*.