A Study of the Chromosomes of Some Lizards, with Special Remarks on the m-chromosomes

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The chromosome study of reptiles has recently been expanded to a large extent through the extensive studies performed by Nakamura ('28–'35), Matthey ('29–'39) and Oguma ('34). By reference to the chromosome list published by Makino ('51), one can find that in most species of the Lacertidae, the diploid number of chromosomes is 38. But exceptionally *Lacerta vivipara* is characterized by having 36 diploid chromosomes. Oguma ('34) interpreted the reduction of the chromosome number in this species to be due to an absence of a pair of the minute chromosomes, generally designated as the m-chromosomes. Wilson ('10) emphasized the view that the gradual reduction in size of certain chromosomes will constitute one of the possible modes of numerical variation.

Here the present author undertook the investigation of the chromosomes of some species of lizards belonging to the Lacertidae with special concern to the size-difference, if any, of the m-chromosomes by species. The work has been carried out under the direction of Professor Sajiro Makino of the Hokkaidô University to whom the author wishes to express his sincere gratitude. Cordial thanks must be extended to Professor Yaichiro Okada of the Mie Fishery College for identification of the animals used in this study.

Material and Method

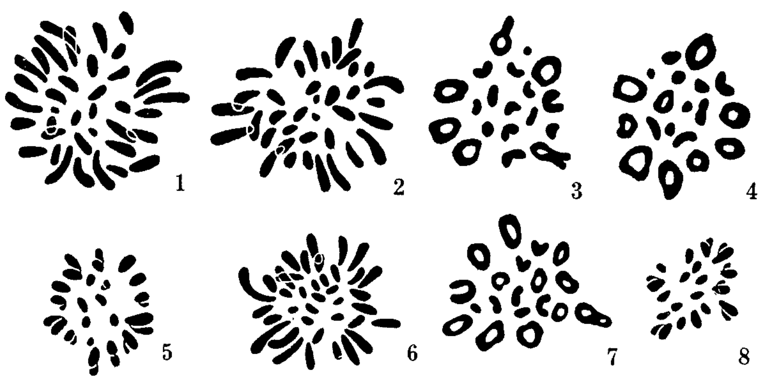
The material of the present observations consists of the testes obtained from *T. smaragdinus*, *T. tachydromoides*, and *Lacerta vivipara*. The first mentioned species was collected by Dr. Makino in Formosa and Okinawa, and the fixed material was kindly delivered to the author for study. *Takydromus tachydromoides* is a common lizard having a wide distribution through Japan-Hondô to Hokkaidô; the lizards obtained in Tokyo and Amagasaki provided the present material. *L. vivipara* is a species widely distributed through northern territories of Europe and Asia; the testes from some young specimens which were collected by Dr. Makino in Sakhalin comprised the material.

The testes were fixed with Nakamura-Champy's solution, Champy's original solution and Hermann's mixture, with satisfactory results in every case. Following the usual paraffin imbedding the sections were prepared, and stained with Heidenhain's iron-haematoxylin with a counter-stain of light-green.

Observations

1) *Takydromus smaragdinus*

The metaphase of the spermatogonial division shows 38 chromosomes (Figs. 1–2). The chromosomes are simple rod-shape tapering at their inner ends, and there is no evidence for the presence of the V-shaped one. Every metaphase plate is characterized by showing a pair of very minute chromosomes, generally designated as the m-chromosomes. By comparison of their size and shape, the diploid complement was found to be made up of 18 homologous pairs of rod-shaped elements plus a pair of the m-chromosomes, as shown by *a* to *s* in the alignmental arrangement of chromosomes (Fig. 16). The homologous pairs thus arranged form a graded series with the exception of the *s*-pair which are remarkable for their minute size. The members of the m-pair attain a size approximately one-half the size of the *r*-pair.



Figs. 1-8. **1-5**, Chromosomes of *Takydromus smaragdinus*. **1-2**, spermatogonial metaphases. **3-4**, primary spermatocyte metaphases. **5**, secondary spermatocyte metaphase. ×3500. **6-8**, Chromosomes of an exceptional specimen of *T. smaragdinus* **6**, spermatogonial metaphase. **7**, primary spermatocyte metaphase. **8**, secondary spermatocyte metaphase. ×3500.

The metaphase of the primary spermatocyte division shows 19 bivalents (Figs. 3–4). The larger tetrads, being 8 to 10 in number, are prominent by their horizontal ring- or thick V-shape, usually disposing themselves in the peripheral zone of the equatorial plate surrounding the smaller ones. The minute bivalent derived from the m-chromosomes is very apparent also in this stage. The secondary spermatocytes show again 19 chromosomes at metaphase (Fig. 5). The m-chromosome is also remarkable in this stage due to its minute size.

While working with this species, the author has encountered the size-variation occurring in the m-chromosomes of a certain specimen. This specimen is characterized by the m-chromosomes which are a little, but distinctly larger in size as compared with corresponding ones of the other specimens, the remaining elements are identical in size and shape. The size-variation observed in this specimen was constant through out the spermatogonia and the primary and secondary spermatocytes (Figs. 6–8). It is significant that the m-chromosomes exhibit the variation of size in an individual.

2) *Takydromus tachydromoides*

The chromosomes of this species have been studied by Nakamura ('28, '35). The results here obtained coincide fairly with those reported by him. The diploid number was found to be 38 in the spermatogonial division (Figs. 9–10). The chromosomes are all of simple rod-shape, being telomitic in structure. Mating up of the homologous chromosomes indicates 19 homologous pairs which range in length from *a* to *s* in the serial arrangement in a descending order as indicated in Fig. 18. The members forming the first and largest pair (*a*'s) are prominent among

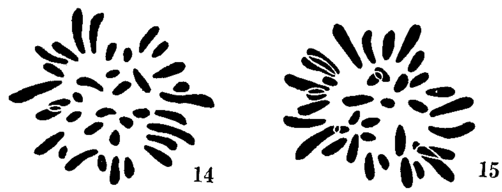
Figs. 9-13. Chromosomes of *Takydromus tachydromoides*. **9-10**, spermatogonia metaphases. **11-12**, primary spermatocyte metaphases. **13**, secondary spermatocyte metaphase. ×3500.

the others. The elements ranging from *b* to *r* show a uniformly graded diminution of length, and those of the *s*-pair are conspicuous on account of their small size. In relative magnitude they are smaller than one-third the *r*-chromosomes. These are much smaller in size than those of the former species.

There are 19 bivalents in the primary spermatocyte metaphase (Figs. 11–12). General morphology of the bivalents closely resemble that of the former species. The m-bivalent is also very distinctive amongst the others. The secondary spermatocytes show again 19 chromosomes, among which the m-chromosome is strongly evident (Fig. 13).

3) *Lacerta vivipara*

The chromosomes of this species have been investigated in datail by Oguma ('34) and Margot ('46). It is in this species that Oguma ('34) has established for the first time the evidence of female heterogamety in reptiles by demonstrating an X-chromosome in the female cell. The present study deals with the spermatogonial chromosomes alone. The male diploid complex consists of 36 chromosomes of varying sizes, all being of simple rod-type of telomitic nature (Figs. 14–15). As pointed out by Oguma ('34) the diploid number is two less than that of the species of *Takydromus*. The mating up of the homologous pairs shows that the diploid complex is made up of 18 homologous pairs as indicated by *a* to *r* in alignmental arrangement (Fig. 19). Among these pairs, the members of the first and second pairs (*a*'s and *b*'s) are considerably larger than others, and from the third largest pair downwards the elements form a closely graded series.



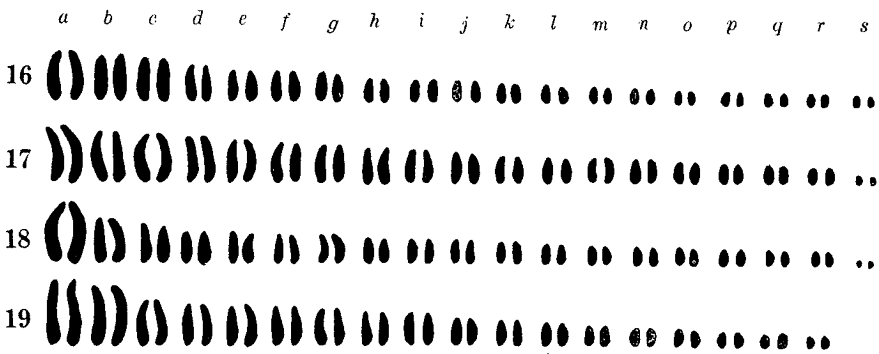
Figs. 14-15. Chromosomes of *Lacerta vivipara*; spermatogonial metaphases. ×3500.

As above noted, the diploid number of chromosomes in this species is 36, two less than that for *Takydromus*. From the observations of the serial arrangement of chromosomes (Fig. 19), it is highly probable that the reduction of the chromosome number in this species is due to the lack of the smallest chromosomes, the m-chromosomes.

Remarks on the size-diminution of the m-chromosomes in relation to the variation of the chromosome number

The basic number of chromosomes for *Takydromus* is 38 in diploid, consisting of 36 simple rod-shaped chromosomes and two minute ones, the m-chromosomes, whereas in *Lacerta vivipara* the diploid number is observed as 36, containing no m-chromosomes, which result in the reduction of the chromosome number by two. The chromosomes of the three species studied here are conveniently compared by the alignmental arrangment according to the order of length, as shown in Figs. 16–19. In *T. tachydromoides* the first pair is represented by prominently larger chromosomes, and from the second pair downwards the elements form a well graded series in diminution of length (Fig. 18), while *T. smaragdinus* is characterized by the chromosomes which show an evenly graded seriation in reduction of length (Fig. 17). The chromosomal condition in *L. vivipara* is highly different from that observed in *Takydromus*: the first and second pairs are both conspicuously large elements, and the third pair downwards the members show a closely graded series (Fig. 19).

As presented in the foregoing descriptions, there is present a pair of the *m*-chromosomes in both species of *Takydromus*. The size of the *m*-chromosomes varys by species: they are larger in size in *T. smaragdinus* than in *T. tachydromoides*. In *L. vivipara*, however, there is no element corresponding to the m, and as the result the chromosome number is two less than that of *Takydromus*. It is interesting to note here that the *m*-chromosomes exhibits a size-variation by individual in *T. smaragdinus*. In one specimen the m-chromosomes were found which are considerably larger in size than in other specimens under study (Fig. 16): they attain in size 4/5 the next smallest elements, the members of the *r*-pair. In some specimens of this species, the *m*-chromosomes are much smaller, being nearly one-half the members



Figs. 16–19. Serial alignments of paired chromosomes from the spermatogonial metaphase. **16**, an exceptional specimen of *Takydromus smaradinus*. **17**, *T. smaragdinus*. **18**, *T. tachydromoides*. **19**, *Lacerta viviparp*. ×3500.

of the *r*-pair (Fig. 17). The m-chromosomes of *T. tachydromoides* have an extremely small size; they seem to be even smaller than one-third the members of the *r*-pair (Fig. 18). Due to these characteristics the chromosome complex of *T. tachydromoides* is clearly distinguishable from that of the former species. In fact, the m-chromosomes of this species are so minute that one can hardly distinguish them from the centrosome, suggesting a condition one step prior to its total disappearance. Considered from this fact, it seems probable that the gradual reduction of size occurs in the m-chromosomes from species to species; in *L. vivipara* there is a disappearance of the m-chromosomes (Fig. 19). By this way, the reduction of the chromosome number in the lizards concerned here is explicable. Several such instances have been reported in insects and some others showing that gradual size-reduction of the m-chromosomes and their disappearance have taken place, for instance by Oguma ('30), Oguma & Asana ('32) and Kichijo ('39) in dragonflies, by Momma ('43) in grasshoppers, and some rodents by Makino ('41 '42 '43).

It is not uninteresting to note here an item about a correlation between the gradual reduction of the m-chromosomes and the geographical distribution of the lizards here under study. *Takydromus smaragdinus* occurs in the subtropical zone, while *T tachydromoides* is distributed through the temperate zones. *L. vivipara*, on the other hand, is an inhabitant of the subfrigid zone. The gradual diminution and final disappearance of the m-chromosomes show a condition which is quite parallel to the geographical distribution. That is, the m-chromosomes seem to be relatively large sized in the animals found in the subtropical zone, such as *T. smaragdinus*, while they become progressively smaller in the animals living in the temperate zone, as occurred in *T. tachydromoides*. Finally they entirely disappear in the species having distribution in the subfrigid zone, as was the case in *L. vivipara*. Though the data at hand are insufficient to make any decisive statement at present, the relation between the gradual diminution of certain chromosomes and the geographical distribution of animals is interesting in connection with animal evolution.

Summary

The comparative study of chromosomes in male germ cells of some species of lizards belonging to the Lacertidae were undertaken with the purpose to find, if any, the cytotaxonomic characteristics. *Takydromus tachydromoides*, and *T. smaragdinus* show 38 chromosomes in diploid, both having a pair of the m-chromosomes of minute size, while *Lacerta vivipara* possesses 36 diploid chromosomes containing no m-chromosomes. The m-chromosomes exhibit a size variation by species, or even by individuals: They are exceptionally in size in a specimen of *T. smaragdinus*, medium sized in the ordinary specimens of the same species, and extremely small in *T. tachydromoides*. In *L. vivipara* there are no m-chromosomes. By the evidence of a gradual diminution of the m-chromosomes by species and the assumption of their final disappearance, the numerical relation of chromosomes existing in *Takydromus* and *L. vivipara* may be explicable.

The correlation between the chromosome diminution and the geographical distribution of animals was considered.

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