Karyogram Studies in Birds
IX. The Chromosomes of Five Species of Thrushes (Turdidae)

By
Tatsuo Udagawa

(Government Forest Experiment Station, Asakawa, Tokyo)
(With 10 Text-figures)

The nature of organisms will be grasped more exactly from the viewpoint of the cytological knowledge involving the chromosome constitution than from the morphological standpoint, only since it is the genotype that determines the morphological pattern of an organism. Generally the differences in the chromosome number and shape are reflected in the distinction of one species from its reiatives, and therefore the cytological sequence contributes to a great extent to an understanding of the problems of taxonomy.

With this point in mind the author has been undertaking comparative studies of chromosomes in birds in order to accumulate data available for study of the cytotaxonomy of birds. The present parper deals with the chromosomes of five species of the Turdidae. Previously, the chromosomes of this family have been studied in eleven species by Unger (1936), Pogossianz (1937), Yamashina (1951), and Udagawa (1955a, b, 1957).

The author feels much pleasure to contribute this paper to the Jubilee Volume of Dr. Tohru Uchida. The author wishes to express his sincere thanks to Professor Sajiro Makino, Hokkaido University, for his kindness in revision of this manuscript. Further his thanks are extended to Dr. Yoshimaro Yamashina and Dr. R. Imazeki for their kind assistance in various ways.

Material and method

The species of the Turdidae coming under study are as follows : *Turdus aureus aureus* Holandre, *Turdus sibiricus davisoni* (Hume), *Turdus obscurus obscurus* Gmelin, *Turdus naumanni naumanni* Temminck, and *Luscinia komadori komadori* (Temminck). Both testicular and ovarial tissues derived from both adult and embryonal specimens furnished the material. The gonads were preserved in Hermann's mixture with reduced acetic acid. Ordinary paraffin sections were stained with Heidenhain's iron-haematoxylin.

Results

1. *Turdus aureus aureus* Holandre (Figs. 1–2)

The embryonal gonads from five incubated eggs constituted the present

Jour. Fac. Sci. Hokkaido Univ. Ser. VI, Zool. 13, 1957 (Prof. T. Uchida Jubilee Volume).

material.

The diploid number of chromosomes was determined to be 84 in the spermatogonial division (Fig. 1). Usually the diploid complement is divided into two distinct groups of macro- and micro-chromosomes. The macro-chromosomes comprise ten pairs, being 20 in number, and are represented by the formula, aV+bJ+cJ+dJ+ev+fj+gj+hj+iv+jv. The largest V-shaped chromosomes (aV) seem to have a submedian centromere, while the fifth(ev), ninth(iv) and tenth (jv) elements are of nearly median structure. The micro-group consists of 64 rod-shaped elements, ranging from small rod to spherules in configuration.

The oogonial chromosomes were observed in the embryonal ovaries; they are 83 (♀, 2*n*) in number (Fig. 2). Closer examination revealed that the element of a medium V-shape (ev), ranging the fifth in serial order, remains without mate. The others show no difference between the two sexes. This clearly indicates that the fifth-shaped element represents the sex-chromosome of this form.

It is then evident that the chromosome formula of this species is 2 V's+6 J's+6 v's+6 j's+64r's for the male, and 2 V's+6 J's+5 v's+6 j's+64 r's for the female.

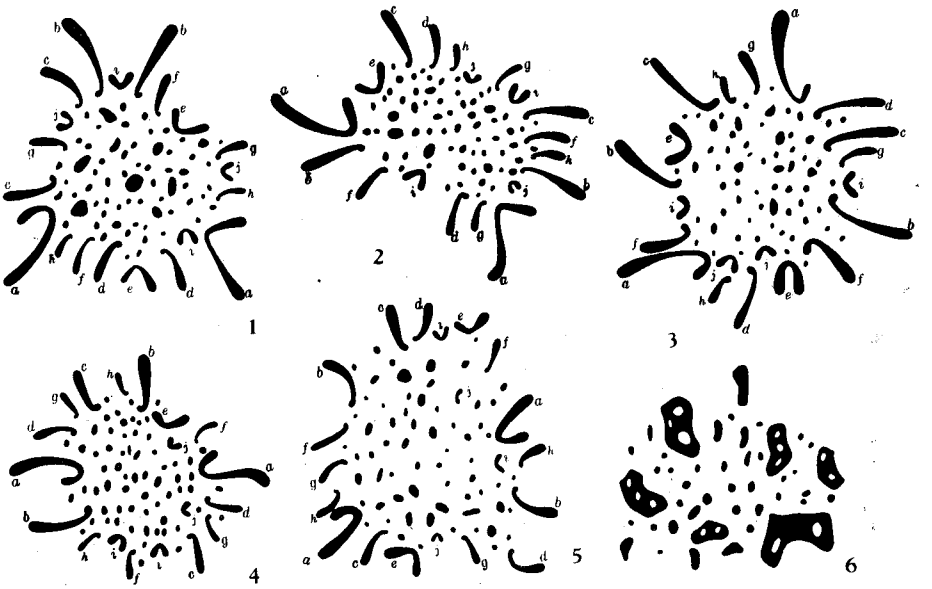

Fig. 1. Spermatogonial metaphase of *Turdus a. aureus*. Fig. 2. Oogonial metaphase of *T. a. aureus*. Fig. 3. Spermatogonial metaphase of *Turdus sibiricus davisoni*. Fig. 4. Oogonial metaphase of *T. sibiricus davisoni*. Fig. 5. Spermatogonial metaphase of *Turdus o. obscurus*. Fig. 6. 1st spermatocyte metaphase of *T. o. obscurus*. Camera-lucida drawings, ×2800.

2. *Turdus sibiricus davisoni* (Hume) (Figs. 3–4)

The eggs from one clutch obtained in June furnished the material.

Every spermatogonium showed at metaphase 84 chromosomes (Fig. 3). Morphologically, the chromosomes fall into a macro- and micro-group. Morphological analysis revealed that the former group consists of aV+bJ+cJ+dJ +ev+fj+gj+hj+iv+jv. The largest V-shaped chromosomes(aV) seem to carry a submedian centromere, while the fifth (ev), ninth(iv) and tenth(jv) V-shaped ones seem to be median in attachment. The micro-group comprises 64 chromosomes of rod-type varying in shape and size from small rods to spherules.

The female diploid number of chromosomes studied in the embryonal ovaries was established as 83 (♀, $2n$); it is one less than the number of the spermatogonium (Fig. 4). Comparative analysis of chromosomes between the two sexes made it evident that the fifth submedian V-shaped element(ev) was destitute of its mate in female cells, whereas the other elements show no difference between the two sexes. Apparently, sexual difference of the chromosomes is caused by the fifth element which represents the sex-chromosome of this bird.

In conclusion, the chromosome formula of this form is given as 2V's+6J's+ 6v's+6j's+64r's for the male, and 2V's+6J's+5v's+6j's+64r's for the female.

3. *Turdus obscurus obscurus* Gmelin (Figs. 5–6)

The present material consisted of a pair of testes taken from an adult male which was reared in the author's aviary.

The spermatogonial chromosomes are 84 in number (Fig. 5). The macro-chromosomes are 20 in number, and are represented by the formula, aV+bJ+cJ+ dJ+ev+fj+gj+hj+iv+iv. The largest V-shaped chromosomes (aV) carry a submedian centromere. The fifth (ev), ninth (iv) and tenth (jv) ones each having a V-shape, appear to be of median structure. The remaining elements seem to be of subterminal J-shape. The micro-chromosomes, 64 in number, are rod-shaped in appearance, varying from small rods to spherules.

The meiotic chromosomes were observed in the primary spermatocyte and the haploid number of 42 was determined at metaphase (Fig. 6).

It is then evident that chromosome number of this bird is 84 in diploid and 42 in haploid, showing the chromosome formula, 2V's+6J's+6v's+6j's+64r's for the male.

4. *Turdus naumanni naumanni* Temminck (Figs. 7–8)

The material for study was provided by a pair of testes obtained from an adult male specimen in May. The bird was reared in the author's aviary.

There are 84 chromosomes (♂, $2n$) in the spermatogonial metaphase (Fig. 7); the macro-chromosomes showed ten pairs in the formula of aV+bJ+ cJ+dJ+ev+fj+gj+hj+iv+jv. The largest V-shaped elements (aV) clearly show a submedian centromere, while the fifth (ev), ninth (iv) and tenth (jv) ones seem to carry a median centromere due to their nearly similar arms. The micro-chromosomes are 64 in number and all are rod-shaped in appearance.

The primary spermatocyte showed 39 bivalents as the haploid complex of this species (Fig. 8).

The above observations have revealed that the chromosome number of this species is 84 in diploid and 42 in haploid, giving the male formula : 2V's+6J's+6v's+6j's+64r's.

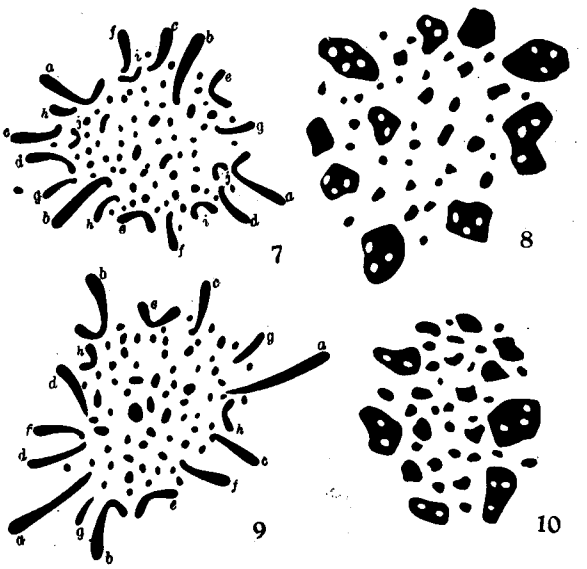

Fig. 7. Spermatogonial metaphase of *Turdus n. naumanni*. Fig. 8. 1st spermatocyte metaphase of *T. n. naumanni*. Fig. 9. Spermatogonial metaphase of *Luscinia k. komadori*. Fig. 10. 1st spermatocyte metaphase of *L. k. komadori*. Camera-lucida drawings, ×2800.

5. *Luscinia komadori komadori* (Temminck) (Fig. 9–10)

The testes from a male bird which was reared in the author's aviary provided the material; it was fixed in May.

The spermatogonial complex was found to contain 78 chromosomes (Fig. 9). The macro-chromosomes form eight pairs with the following formula, aR+bV+cJ+dR+ev+fr+gr+hv. The bV elements seem to be submedian, while ev and hv elements are of median structure on account of their similar arms. The micro-chromosomes are represented by 62 rod-shaped elements which vary from rods to spherules in a graded series.

The haploid complex was observed in the primary spermatocytes and showed 39 chromosomes at metaphase (Fig. 10).

In summary the present species possesses the diploid number of 78 and the haploid number of 39 with the male chromosome complex represented by the formula, 4R's+2V's+2J'+4v's+66r's.

Considerations

Reference to the literature indicates that the chromosomes of eleven species of thrushes (Turdidae) have been studied by Yamashina (1951) and Udagawa (1952, 1955a, b, 1957). They reported the formula 2V's+6J's+6v's+6j's+64r's for *Turdus c. chrysolaus, T. naumanni eunomus, T. pallidus, T. c. celaenops* and *T. cardis*, and 4R's+2v's+2J's+4v's+66r's for *Luscinia a. akahige* and *L. akahige tanensis*. In comparison with the chromosomes of the following four species : *Turdus a. aureus, T. sibiricus davisoni, T. o. obscurus* and *T. n. naumanni* reported in this paper, it is obvious that there is a close similarity among the former and the latter groups of thrushes. They are all closely related either in the number of chromosomes or in other morphological details. This indicates that the cytological features correspond to the taxonomical kinship among the birds as mentioned above. Austin and Kuroda (1953) treated *Turdus aureus* and *T. sibiricus* as members of the genus *Zoothera*. The cytological evidence presented by the author fails to substantiate the view of Austin and Kuroda (1953), based on the fact that these two species possess chromosomes closely allied to the other forms of *Turdus*.

There is no visible difference in the chromosomes between *Luscinia komadori* and *L. akahige*. This is in accordance with the fact that these two birds are recognized as closely allied in morphological and taxonomical relationship.

Summary

The chromosomes of five species of the Turdidae were observed in germ cells. The results are summarized in Table 1.

Table 1. Species under study and their chromosomes.

Species	2n	n	Formula	Notes
Turdus a. aureus	84 *spg**	42 (I)	2V's+6J's+6v's+6j's+64r's	X−X, ♂
	83 *oog*		2V's+6J's+5v's+6j's+64r's	X−O, ♀
T. sibiricus davisoni	84 *spg*	42 (I)	2V's+6J's+6v's+6j's+64r's	X−X, ♂
	83 *oog*		2V's+6J's+5v's+6j's+64r's	X−O, ♀
T. o. obscurus	84 *spg*	42 (I)	2V's+6J's+6v's+6j's+64r's	
T. n. naumanni	84 *spg*	42 (I)	2V's+6J's+6v's+6j's+64r's	
Luscinia k. komadori	78 *spg*	39 (I)	4R's+2V's+2J's+4v's+66r's	

* *spg*=spermatogonium. *oog*=oogonium. (I)=primary spermatocyte.

It was ascertained that the medium-sized V-shaped chromosomes holding fifth place in approximate order of size represent the sex-chromosomes of *Turdus aureus* and *T. sibiricus*, since they are paired in the male while unpaired in the female.

In morphological taxonomy, *Turdus aureus* and *T. sibiricus* have been treated as members of the genus *Zoothera*. The cytological evidence seems not to support that view.

References

Austin, O. L. and N. Kuroda 1953. The birds of Japan. Harvard College Press, Mass.
Makino, S. 1956. An atlas of the chromosome numbers in animals. 2nd ed. Tokyo.
Pogossianz, H. 1937. Biol. Zhurnal. 3 : 665-688.
Udagawa, T. 1952. Cytologia 17 : 311-316.
———— 1955a. Annot. Zool. Japon. 28 : 20-25.
———— 1955b. Annot. Zool. Japon. 28 : 256-261.
———— 1957. Jap. Jour. Zool. 12 : 105-111.
Unger, H. 1936. Z. Zellf. mikr. Anat. 25 : 476-500.
Yamashina, Y. 1951. Papers Coord. Committ. Res. Genet. 2 : 27-38.