STUDIES ON RODENT CHROMOSOMES—VII. CHROMOSOMES OF *FUNAMBULUS TRISTRIATUS* (WATERHOUSE) AND CONSIDERATIONS ON INTRAGENERIC RELATIONSHIPS

By
S. R. V. RAO, S. C. LAKHOTIA *and* SURESH C. JHANWAR

Reprinted from the Proceedings of the Indian National Science Academy
Vol. 38 Part B, Nos. 1 & 2, February-April, 1972, pp. 8-13

STUDIES ON RODENT CHROMOSOMES

VII. CHROMOSOMES OF *Funambulus tristriatus* (WATERHOUSE) AND CONSIDERATIONS ON INTRAGENERIC RELATIONSHIPS*

by S. R. V. RAO, S. C. LAKHOTIA† *and* SURESH C. JHANWAR, *Cytogenetics and Tissue Culture, Department of Zoology, University of Delhi, Delhi*-110007

(Communicated by M. R. N. Prasad, F.N.A.)

(*Received 7 September 1971; after revision 5 November 1971*)

The diploid number in *F. tristriatus* is 46 in both sexes. A comparison of karyotypes of other two species, *F. palmarum* (2n=46) and *F. pennanti* (2n=54), indicates that despite the variation in the diploid number, the total chromosome arms (N. F.) remain the same. A probable mode of origin of different karyotypes has been discussed.

INTRODUCTION

The genus *Funambulus* (Indian striped squirrels) which is endemic to the Indian subregion is represented by five species (Moore and Tate 1965). However, chromosomes of only *F. pennanti* are known in detail (Rao and Sharda 1964; Chopra and Pai 1965; Sharma *et al.* 1970; Srivastava and Bhatnagar 1971). Diploid chromosome number of another species, *F. palmaum*, was reported by Ray Chaudhuri *et al.* (1968), Satyaprakash and Aswathanarayana (personal communication). In the present paper, we describe the chromosomes of the jungle striped squirrel, *F. tristriatus*.

MATERIALS AND METHODS

The squirrels were trapped from forests near Sagar, Mysore State (S. W. India). Three females and two males were utilized for the study. Bone-marrow chromosomes prepared by the usual air-dry technique, have been examined. For sex chromatin in female, liver nuclei in interphase were examined.

OBSERVATIONS

The diploid chromosome number in *F. tristriatus* is 46 (determined on the basis of chromosome counts from at least 50 metaphase plates from each individual). Figs. 1 a, b present the karyotypes of female and male, respectively. The chromosomes fall into three well differentiated groups on the basis of centromere position

*Supported by the funds from the Indian National Science Academy, New Delhi, and the University Grants Commission to the Centre of Advanced Studies in Zoology, Department of Zoology, University of Delhi, Delhi-110007.

†*Present address* : Department of Zoology, Gujarat University, Ahmedabad,.

viz., metacentrics, submetacentrics and acrocentrics (nomenclature after Levan *et al.* 1964). Within each group, the chromosomes form a graded series. In the female (Fig. 1 a), there are 14 pairs of meta-submetacentric and 9 pairs of acrocentric chromosomes. In the male (Fig. 1 b) on the other hand, there are 13 pairs of meta-submetacentric, 9 pairs of acrocentric and a heteromorphic pair comprising one large metacentric and one smallest acrocentric chromosome. One of the larger metacentrics (3rd pair) is probably the X-and the smallest acrocentric is the Y-chromosome. The number of major chromosome arms (N. F., *Nombre Fundamentale*) is 74.

One of the submetacentric chromosome pair (no. 7) exhibits a characteristic morphology. In almost all the plates examined, this pair shows heteromorphism, in the sense that one of them has a small 'satellite' on its short arm—the arm itself

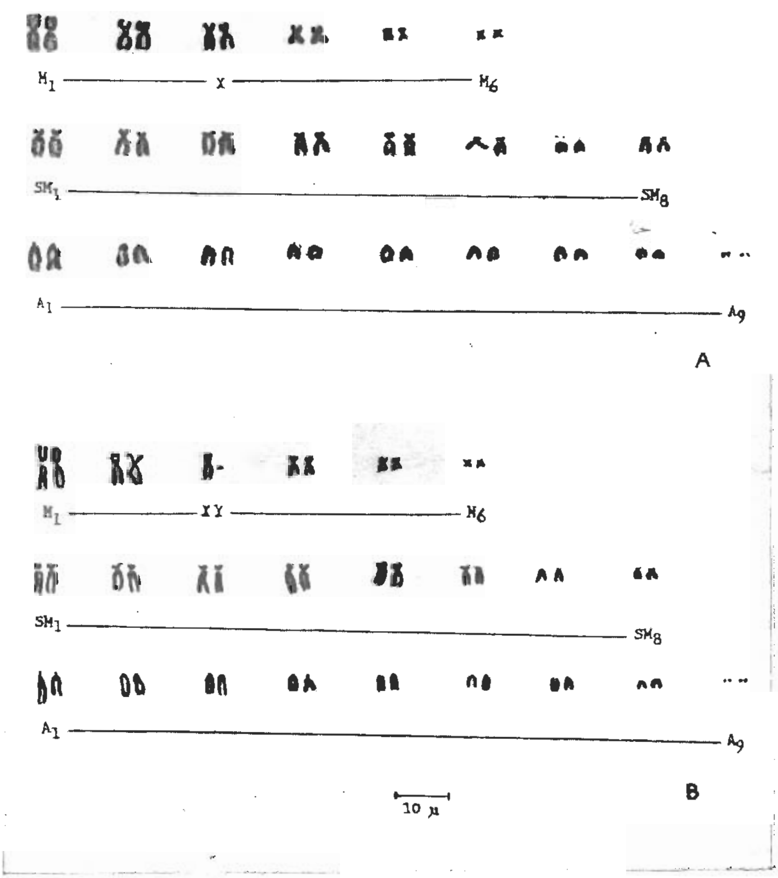

FIG. 1. The karyotype of female (A) and male (B) *Funambulus tristriatus*. [Note the sex chromosome appears to be the third pair in the complement. The satellite chromosome (no. 7 in the submetacentric series) shows heteromorphism.]

appearing as very fine and light stained gap; the other member of the pair does not show the satellite—the short arm appears slightly thicker (compared to the homologue, but much thinner when compared to the long arm) but light stained. A similar situation has also been noted in *F. pennanti* (unpublished data). All the liver nuclei from the female showed sex chromatin which is of the magnitude as found in *F. pennanti* (Seshadri *et al.* 1969).

Discussion

Cytotaxonomical studies in recent years have led to an increasing realization that chromosomal rearrangements have played an important role in evolution (White 1969; Gropp *et al.* 1970). Mammals display this phenomenon abundantly. With the amount of DNA per diploid cell being nearly the same in all mammals (Atkin *et al.* 1965; Ohno 1967) the great variability in the karyotypes observed between closely related taxa is suggestive of chromosomal rearrangements. One of the means to bring about such rearrangements is the process of centric fusion or fission, generally termed as "Robertsonian changes", wherein a meta-or submeta-centric (biarmed) chromosome is believed to be derived from two acrocentric (single armed) chromosomes, or vice-versa; this process maintains the F.N. but reduces (by fusion) or increases (by fission) the 2n-chromosome number.

Prior to a comparison of the karyotypes of different species of *Funambulus*, a discussion on the standard karyotype of *F. pennanti* is desired. Chromosomes of *F. pennanti* have been described by Rao and Sharda (1964), Chopra and Pai (1965), Seshadri *et al.* (1969), Sharma *et al.* (1970), and recently by Srivastava and Bhatnagar (1971). However, the karyotypes given by these authors differ. Identification of the X-chromosome also varies. Chopra and Pai (1965) have identified the X as one of the larger acrocentrics; Srivastava and Bhatnagar (1971) identify X as a medium metacentric, while Rao and Sharda (1964), Seshadri *et al.* (1969) and Sharma *et al.* (1970) have identified X as a large submetacentric chromosome. A careful analysis of different karyotypes suggests that the identification by Sharma *et. al.* (1970) is correct since their study includes detailed karyological and graphic observations on various tissues, both *in vivo* and *in vitro*. Identification of X chromosome is also confirmed by autoradiography (Seshadri *et al.* 1969; and Sharma *et al.* 1970). It must be mentioned here that Technical procedures may produce small variations in the morphology of chromosomes and the "process of chromatid condensation may not always be uniform in all chromosomes at a given stage of mitotic cycle" (Sasaki 1961) and which would have substantially contributed to the discrepancies. The discrepancies could also be due to intraspecific polymorphism; however, this seems very unlikely since evidences for polymorphism are inconclusive. In the following discussion, the karyotype described by Sharma *et al.* (1970) is taken as the standard for comparison.

A comparison of the karyotypes of *F. tristriatus*, *F. pennanti*, *F. palmarum* reveals some interesting points. The 2n chromosome number in *F. pennanti* is 54, with 10 pairs of meta-submetacentrics and 17 pairs of acrocentrics in the female. In *F. tristriatus*, on the other hand, the diploid number is less (2n=46); the number of acrocentric pairs is also less (9 pairs), while the number of meta-submetacentric pairs is higher (14 pairs). Despite the difference in the diploid number, the total number of chromosome arms remained same (F. N.=74) in both the species. Another common palm-squirrel of South India, *F. palmarum* has also 2n=46 and the karyotype (Satyaprakash and Aswathanarayana, personal communication) is almost similar to that of *F. tristriatus,* except for the presence of a large submetacentric Y. This remarkable constancy in the fundamental number is explained on the basis of Robertsonian mechanism of centric fusion or fission.

According to Moore's (1960) model of the origin of the existing five species of this endemic genus, *F. tristriatus* appears to have arisen first and the other four species subsequently in the following order; *pennanti, palmarum, sublineatus* and *lyardi.* If this is so, the 2n=54 (*pennanti*) karyotype could have been derived from the 2n=46 (*tristriatus*) karyotype by "Centric fission" mechanism. This derivation seems likely because among the three species whose karyotypes are known, two show a diploid number of 46, which probably appears to be the model number for the genus. However, data for the other two species , *Viz sublineatus* and *lyardi* are needed to arrive at a definite conclusion. A tentative scheme of interrelationships is shown in Fig. 2.

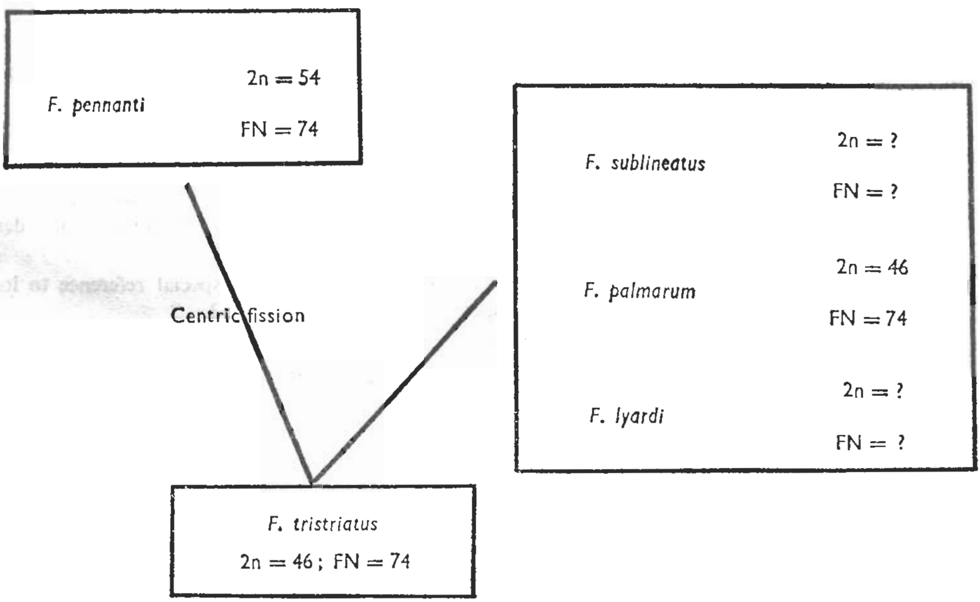

FIG. 2. Schematic representation of interrelationships of *Funambulus.*

In this chromosomal remodelling, only a few chromosomes appear to have been involved. It is interesting that the X chromosome (X-chromatin), the marker chromosome pair with satellites and the smallest pair of autosomes have apparently not been affected and are present in all the species of *Funambulus* studied so far.

Thus cytologically *Funambulus* complex falls into two major categories, .e. the northern form (*F. pennanti*) characterised by 2n=54 and the other two southern forms (*F. tristriatus* and *F. palmarum*) with 2n=46. It is interesting that among the five species, only *pennanti* possesses five white stripes instead of three, as found in the other four species. Anatomically, on the basis of bacula, Prasad (1954, 1957) separated *pennanti* from the other species. The rod-like baculum in *pennanti* lacks any suggestion of bifurcation that is reported to occur in the other four species (Hill 1936; Prasad 1954, 1957). Thus, both anatomical and cytological evidences are most compelling for considering the northern population unique; and the establishment of a new subgenus, *Prasadsciurus*, comprising exclusively *F. pennanti*, is fully justified (Moore and Tate 1965).

Acknowledgements

We thank Prof. B. R. Seshachar, F.N.A. Emeritus Scientist, Department of Zoology, University of Delhi, for his sustained interest, and to Prof. M. R. N. Prasad, F. N. A. and Dr. V. K. Gupta, for many useful discussions. The karyotype of *F. palmarum* was kindly provided by Dr. N. V. Aswathanarayana, Department of Zoology, University of Mysore, for comparison. Mr. E. A. Daniels assisted in microphotography.

References

Atkin, N. B., Mattinson, G., Becak, W., and Ohno, S. (1965). The comparative DNA content of 19 species of placental mammals reptiles and birds. *Chromosoma* (Berl), **17,** 1-10.

Chopra, V. L., and Pai, R. A. (1965). Chromosomes of the striped Indian squirrel (*Funambulus pennanti*). *Nature, Lond.*, **207,** 1110.

Gropp, A., Marshall, J., Flatz, G., Olbrich, M., Manyanondha, K., and Santadusit, A. (1970). Chromosomenpolymorphismus durch uberzahlige Autosomen Beobachtungen an der Hausrattee (*Rattus rattus*). *Z. F. Saugetierk.*, **35,** 363-371.

Hill, W. C. O. (1936). The penis bone in the Ceylonese squirrels, with special reference to its taxonomic importance. *Ceylon J. Sci.* (Spolia Zeylonica), **20,** 99-113.

Levan, A., Fredga, K., and Sandberg, A. A. (1964). Nomenclature for centromeric position in chromosomes. *Hereditas*, **52,** 201-220.

Moore, J. C. (1960). Squirrel geography of the Indian subregion. *Syst Zool*, **9,** 1-17.

Moore, J. C., and Tate, G. H. (1965). A study of the diurnal squirrels, Sciurinae of the Indian and Indo-chinese subregions. *Fieldiana* (Zoology). Vol. 48, Chicago Natural History Museum.

Ohno, S. (1967). Sex chromosomes and sex-linked genes. Springerverlag, Berlin.

Prasad, M. R. N. (1954). The male genital tract of two genera of Indian squirrels. *J. Mammal.*, **35,** 471-485.

———(1957). Male genital tract of the Indian and Ceylonese palm squirrels and its bearing on the systematics of the Sciuridae. *Acta Zool.*, **38,** 1-26.

Rao, S. R. V., and Sharda (1964). Somatic chromosomes of the Indian five striped squirrel *Funambulus pennanti* Wroughton. *Cytogenetics*, **3,** 342-346.

Ray-Chaudhuri, S. P., Rajini, P. V., and Sharma, T. (1968). Karyological studies of 16 species of Indian mammals. *MCN*, **9,** 82-84.

Sasaki, M. (1961). Observations on the modification in size and shape of chromosomes due to technical procedure. *Chromosoma*, **11,** 514-522.

Seshadri, C., Rao, S. R. V., and Shah, V. C. (1969). Studies on Rodent chromosomes. I. The sex chromatin and chromosomes in *Funambulus pennanti*,. *Chromosomes Today*, **2,** 148-153.

Sharma, V. K., Rao, S. R., and Shah, V. C. (1970). Autoradiographic studies on DNA synthesis in sex chromosomes of five-striped squirrel, *pennanti* Wroughton. *Indian. J. expl. Biol.*, **8,** 249-254.

Srivastava, M. D. L., and Bhatnagar, V. S. (1971). Somatic chromosomes of the Indian five-striped squirrel, *Funambulus pennanti* Wroughton. *MCN*, **12,** 51-53.

White, M. J. D. (1969). Chromosomal rearrangements and speciation in animals. *A. Rev. Genetics* , **3,** 75-98.