

Fig. 4. Karyotype of a female *B. b. bengalensis* collected from Rohru, Himachal Pradesh. $\times 2000$.

sample and it is large-sized acrocentric chromosome in the other two samples. This variation in the morphology of the *X* chromosome could have been brought about by a pericentric inversion. Specimens with acrocentric *X* chromosome are separated by more than 800 miles from those with submetacentric *X* chromosome. Since the detailed karyotypic data of the other two species of *Bandicota*^{3,4}, studied by modern technique, are not available it is not possible to compare the karyotype of *B. b. bengalensis* reported in this paper.

At present, it is very difficult to speculate the direction of change in the morphology of the *X* chromosomes in these populations. The *X* chromosome equation, $SM \frac{1}{2} A$ could be reversible. Examination of additional specimens may reveal further course of *X* chromosome variation, if any, in this subspecies¹⁰.

Résumé. Des préparations de moëlle osseuse ont permis d'établir le nombre diploïde ($2N = 42$) et le nombre fondamental ($NF = 52$) de *Bandicota b. bengalensis* (Gray), les spécimens étudiés appartiennent à trois popu-

lations distinctes (Rohru, Varanasi, Belonia, Indes). Le nombre et la forme des autosomes sont les mêmes dans les trois échantillons alors que l'*X* peut être acrocentrique ou submetacentrique; l'*Y* est petit et submetacentrique.

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Second Discovery of Multiple Sex Chromosomes Among Fishes

The viviparous fishes of the family Goodeidae (suborder Cyprinodontoidae) are confined to Mexico. Their chromosome number and some facets of their biology and classification were recently summarized by MILLER and FITZSIMONS¹, who included the first karyotype for the family. They noted that the chromosome number varies from 24 to 48 in 35 (of perhaps 38) species. None of these species showed any detectable differences between the sexes in chromosome number or form. However, one undescribed genus, subsequently karyotyped, appears to be unique for this family in having a diploid number of 42 in the female and 41 in the male. Like the genus of a related group (the Cyprinodontidae) with $2n = 48$ in the female and $2n = 47$ in the male², this species is known only from a single drainage basin in Mexico.

In order to obtain the chromosome figures gill epithelium was used, following the method of MCPHAIL and JONES³ with some modifications⁴. 60 cells of 4 females and 60 cells of 5 males were observed. Several pieces of testis tissue were squashed to obtain meiotic figures.

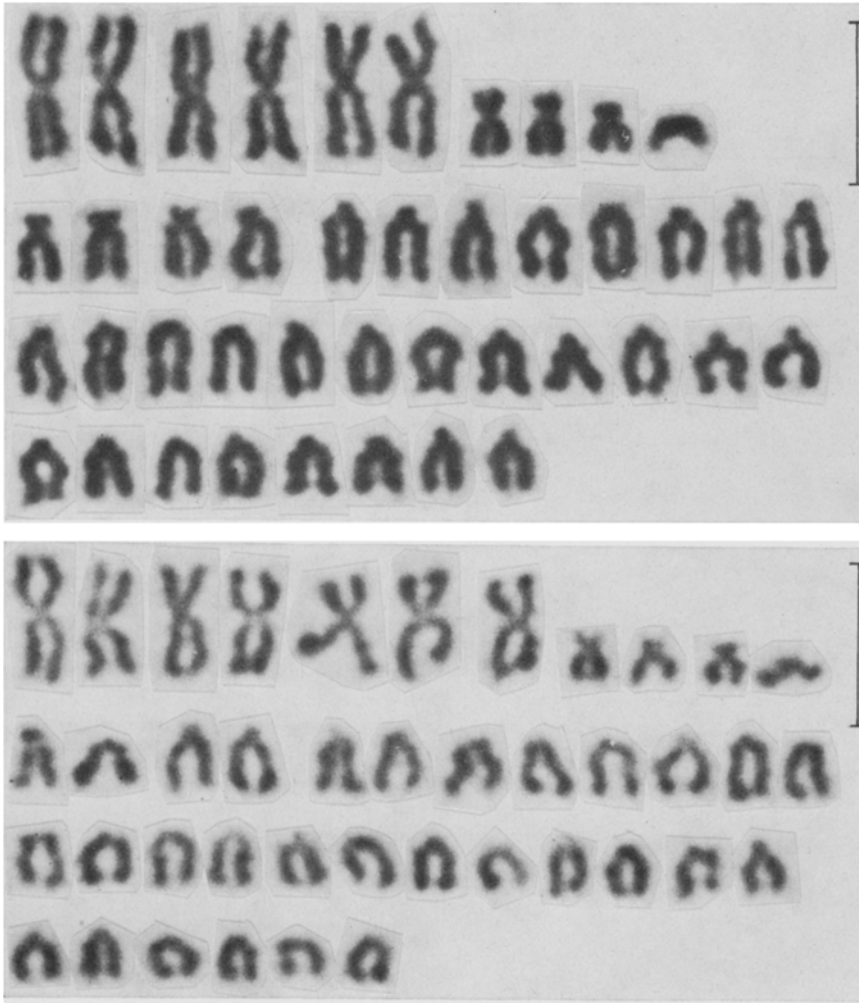
The female karyotype has a diploid number of 42 including 6 large metacentrics, 2 small metacentrics, 2 small

¹ R. R. MILLER and J. M. FITZSIMONS, *Copeia* 1, 1 (1971).

² T. UYENO and R. R. MILLER, *Nature*, Lond. 237, 452 (1971).

³ J. D. MCPHAIL and R. L. JONES, *J. Fish. Res. Board, Canada* 23, 767 (1966).

⁴ R. BEAMISH, Ph. D. thesis, Dept. Zool., Univ. of Toronto 1970.



Figs. 1 and 2. Karyotype of the unnamed Mexican goodeid fish: female above, male below. Scale (in all figures) is 5 μ m.

submetacentrics or subtelocentrics, 2 medium-sized subtelocentrics, and 30 acrocentrics of medium to small size. In contrast, the male karyotype invariably possesses 41 chromosomes including 7 large metacentrics, 2 small metacentrics, 2 small submetacentrics or subtelocentrics, 2 medium-sized subtelocentrics, and 28 acrocentrics of medium to small size. Thus the male has 1 more large metacentric chromosome and 2 fewer acrocentric chromosomes than the female (Figures 1-2). We therefore consider 1 of the large metacentrics in the male karyotype to be a Y chromosome and believe that 2 of the acrocentrics are probably X_1 and X_2 chromosomes; in the female karyotype, we consider that 4 acrocentrics of similar size represent $X_1X_1X_2X_2$ chromosomes, because the 2 arms of the Y chromosome of the male, which represent the original Y and counterpart of X_2 , are of equal length. The origin of the multiple sex chromosomes in this species is probably similar to the case we reported earlier² and to the process suggested by MATTHEY⁵ in a rodent, *Mus minutoides* Smith. In the testis squash, at the diakinesis in meiosis, there are 18 bivalents, 3 quadrivalents which represent large metacentrics of the somatic metaphase, and a trivalent in which X_1 and X_2 chromosomes seem attached to the Y chromosome in an end-to-end association (Figure 3).

If the multiple sex chromosomes originated by centric fusion of an acrocentric autosome with the acrocentric sex chromosome, which was otherwise indistinguishable, we suspect that other species of the family Goodeidae also

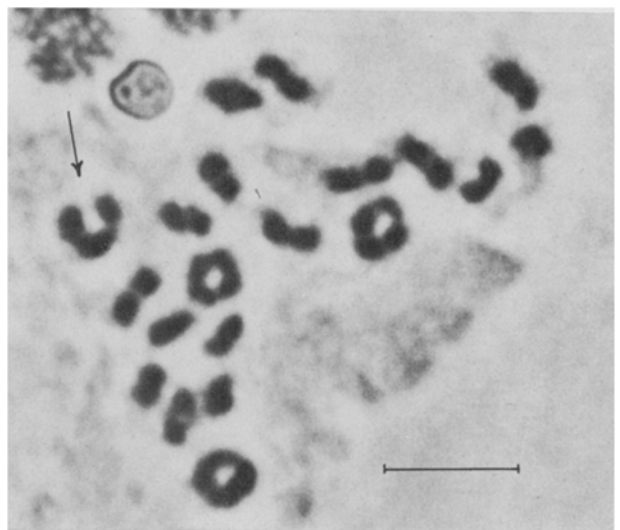


Fig. 3. Diakinesis in meiosis of the unnamed goodeid, prepared by testis squash; the arrow indicates the sex trivalent.

⁵ R. MATTHEY, *Chromosoma* 16, 35 (1965).

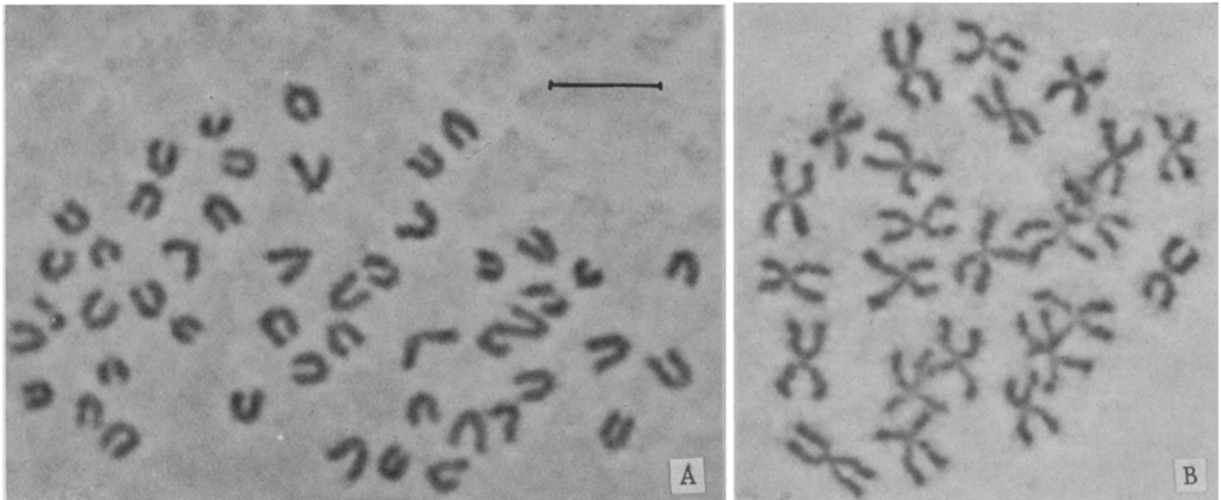


Fig. 4. Somatic chromosomes at metaphase of 2 goodeid fishes: A) *Hubbsina turneri* $2n=48$, and B) *Characodon lateralis* $2n=24$.

have XY chromosomes though they are similar and undetectable by present techniques.

Among the karyotypes of goodeid fishes, *Hubbsina turneri* de Buen has the simplest pattern, with 48 acrocentric chromosomes in both sexes (Figure 4a). The species with the most derived karyotype is *Characodon lateralis* Günther, which has 24 large metacentrics (Figure 4b) plausibly formed by Robertsonian fusions. Other goodeid species have karyotypes comprising various patterns and diploid numbers that are often reduced by centric fusions.

The ancestral karyotype of the species reported here probably had 48 chromosomes, as in the majority of species in the Goodeidae (26 among 38 examined). The diploid number was subsequently reduced by successive Robertsonian fusions, as in some other goodeids. But the involvement of the Y chromosome in the fusion with an autosome produced the multiple sex chromosome system so far unique in this family, and only the second known example among fishes.

The 2 species, 1 in the family Cyprinodontidae and 1 in the Goodeidae, which were found to possess multiple sex chromosomes have several features in common: 1. both species have a very limited distribution and are localized as small populations; 2. both are small and exhibit distinct sexual dimorphism; 3. both species belong to the suborder Cyprinodontioidea; 4. both families representing these 2 fishes have species in which the karyotypes include large

metacentrics derived by Robertsonian fusions; 5. both live in Mexico; and 6. both species possess unique morphological characters among the species in their respective families (to be described elsewhere).

The specimens used in this study are preserved in the collections of the Museum of Zoology, University of Michigan⁶.

Zusammenfassung. Bei einer bisher nicht beschriebenen mexikanischen Fischart werden 41 Autosomen beim Männchen und 42 beim Weibchen gefunden. Die Befunde sprechen für ein System multipler Sexualchromosomen dieser Fische.

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New Evidence of a 38-Chromosomes Karyotype in South American Populations of the Roof Rat, *Rattus Rattus* L. (Rodentia, Muridae)

In previous issues of this periodical, the occurrence of new cases of chromosome multiformity¹ in the species *Rattus rattus* has been described^{2,3}. The known 'normal' karyotype of this wide-spread and highly polytypic Eurasiatic species was reported by several authors⁴⁻⁶ to be composed of 42 chromosomes, among which no pair of large metacentrics is present. This karyotype was studied from strains probably derived from Japanese and European populations. More recently, it was confirmed in

wild *Rattus rattus* from Japan, Formosa, Thailand, Philippines, Java and Celebes⁷, as well as from India⁸.

Disagreements with these results were reported earlier for strains from North America^{9,10} of the same species, which showed 40 chromosomes, and later by the occurrence of monomorphic populations with 38 chromosomes comprising 2 large metacentrics in populations from Argentina and Brasil^{2,11} and in island and inland populations from Tuscany, Italy³. Similar monomorphic $2n = 38$ forms