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Multiple Sex Chromosomes in a Monodactylid Fish

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Since Uyeno and Miller (1971) first reported on multiple sex chromosomes in a cyprinodontid fish, the occurrence of the $X_1X_1X_2X_2$-X_1X_2Y multiple sex chromosome mechanism has been found in eight species of fishes (Uyeno and Miller, 1971, 1972; Miller and Walters, 1972; Murofushi et al., 1980; Murofushi and Yoshida, 1984; Pezold, 1984; Ojima and Kikuno, 1986). In the course of our karyological study of fingerfishes of the family Monodactylidae, we found that, while the Indo-West Pacific *Monodactylus argenteus* has morphologically identical karyotypes in both sexes, the West African *M. sebae* has sexually dimorphic karyotypes with a large unpaired chromosome and a fewer chromosome number by one in the male. Our finding on *M. sebae* furnishes the second example of the XXY type multiple sex chromosome mechanism among perciform fishes.

Material and methods

Two female and three male specimens of *Monodactylus sebae* (48.5–58.5 mm SL) and one female and three male specimens of *M. argenteus* (27.5–33.5 mm SL) were used for chromosome observations. The sexes of the specimens were determined on the basis of gonadal morphology in *M. sebae* and gonadal histology in *M. argenteus*. Chromosome preparations were made from kidney, gill and testis cells employing the air-drying method (cf. Suzuki and Taki, 1981). Classification of chromosomes followed Levan et al. (1964).

Results

The karyotype of female *Monodactylus sebae* consisted of 2n=48 chromosomes which were all acrocentrics in morphology (Fig. 1A, C). Satellite associations were seen in one pair of chromosomes (Fig. 1A, C). In contrast, the male karyotype of this species had 2n=47 chromosomes comprising a large metacentric and 46 acrocentrics (Fig. 1B, D). Two pairs of acrocentrics showed satellite associations (Fig. 1B, D). The large metacentric chromosome was about twice as long as the acrocentrics. In the first meiotic division in the testis preparations there were 22 bivalents and one trivalent (Fig. 2).

In *Monodactylus argenteus*, both sexes had morphologically identical karyotypes composed of 2n=48 acrocentric chromosomes with no heteromorphic pair (Fig. 3A, B). One pair of acrocentrics had satellites which sometimes had the appearance of short arms (Fig. 3A, B).

Discussion

Male *Monodactylus sebae* has an odd chromosome number (2n=47) which is fewer by one than the female chromosome number (2n=48), a large metacentric chromosome which is not seen in the female, and a trivalent at the first meiotic metaphase. All these facts point to the occurrence of the $X_1X_1X_2X_2$-X_1X_2Y sex determination mechanism in this species as in the cyprinodontid *Megupsilon aporus* (Uyeno and Miller, 1971, reported as an unnamed species; later described as *M. aporus* by Miller and Walters, 1972), goodeid *Allodontichthys hubbsi* (Uyeno and Miller, 1972, reported as an undescribed species; later described as *A. hubbsi* by Miller and Uyeno, 1980), monacanthid *Stephanolepis cirrhifer* (Murofushi et al., 1980), callionymid *Callionymus beniteguri* and *C. ornatipinnis* (Murofushi et al., 1983), ophichthid *Muraenichthys gymnotus* (Murofushi and Yoshida, 1984), berycid *Beryx splendens* (Ojima and Kikuno, 1986) and gobioid *Gobionellus shufeldti* (Pezold, 1984). Female *M. sebae* is considered to have 44 autosomes and $X_1X_1X_2X_2$ sex chromosomes and male *M. sebae* 44 autosomes and X_1X_2Y sex chromosomes, though the X_1 and X_2 chromosomes are indistinguishable from autosomes. The large metacentric chromosome, which is about twice as long as the autosomes in the male, is considered to be the Y chromosome derived from a Robertsonian fusion between the original acrocentric Y chromosome and an acrocentric autosome (counterpart of X_2). The trivalent seen in the first meiotic division should represent X_1-Y-X_2 associations.

In contrast to *Monodactylus sebae*, both sexes of *M. argenteus* show morphologically identical

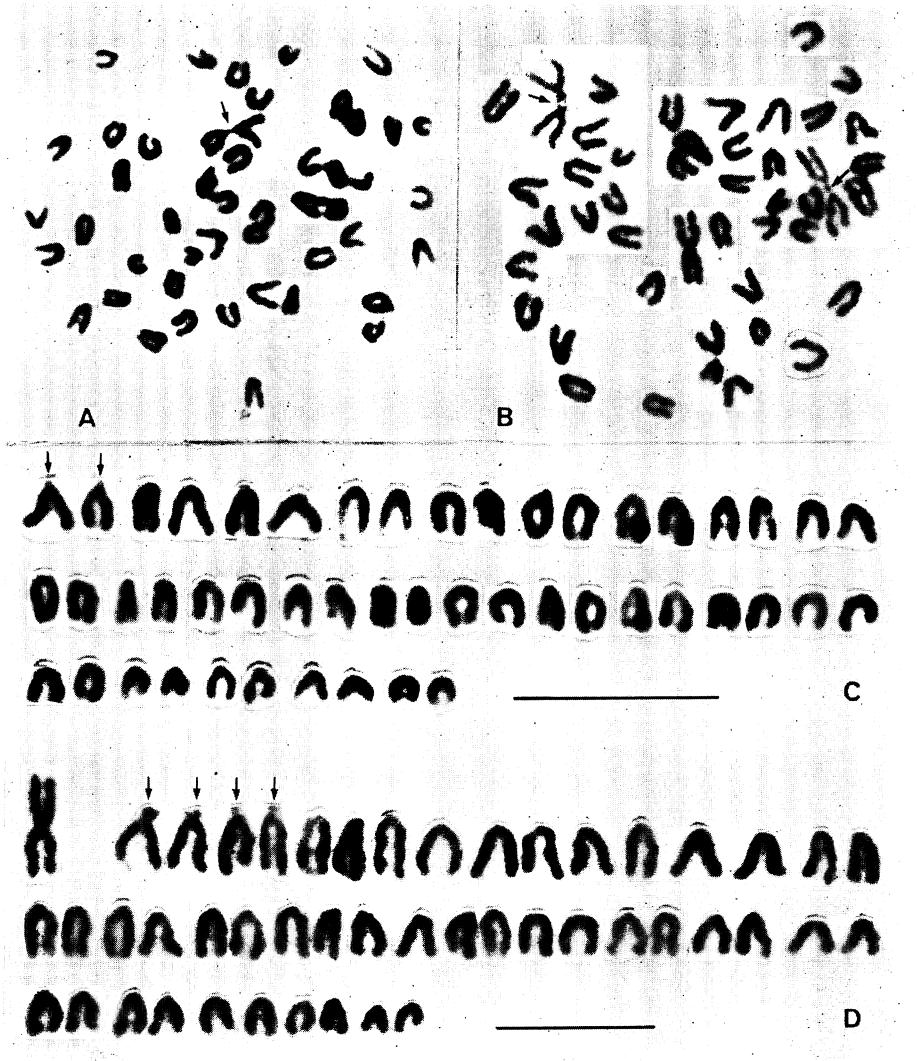

Fig. 1. Somatic metaphase chromosome complements and karyotypes of *Monodactylus sebae*. A and C, female (2n=48); B and D, male (2n=47). Arrows indicate satellite chromosomes. Scale bars: 10 μm.

karyotypes that consist of 48 acrocentric chromosomes. Natarajan and Subrahmanyan (1974) stated that all the elements in the karyotype of *M. argenteus* were metacentric with median centromeres. However, they apparently misidentified acrocentrics as metacentrics not only in this species but in many other species they dealt with in the paper.

That the Y chromosome has differentiated morphologically in a few fish species implies the existence of genetically functional sex chromosomes in many fishes though the sex chrosmosomes are morphologically unidentifiable. The fusion of the Y chromosome with an autosome seems to have occurred sporadically in different groups; the families to which the above-noted species having the multiple sex chromosome mechanism belong contain many confamilial species that show morphologically identical karyotypes in both sexes. The cyprinodontid *Megupsilon aporus* and goodeid *Allodontichthys hubbsi* are both confined in a single drainage basin (Uyeno and Miller,

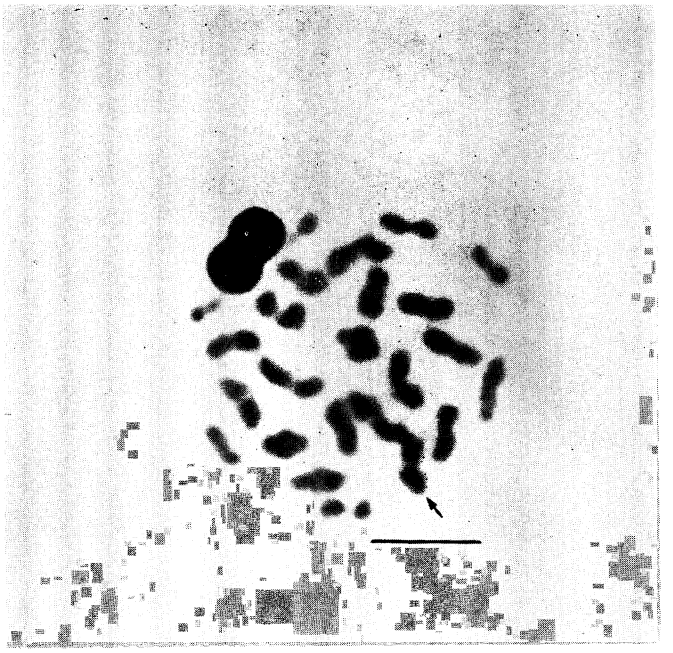

Fig. 2. First meiotic metaphase of *Monodactylus sebae*. Arrow indicates trivalent. Scale bar: 5 μm.

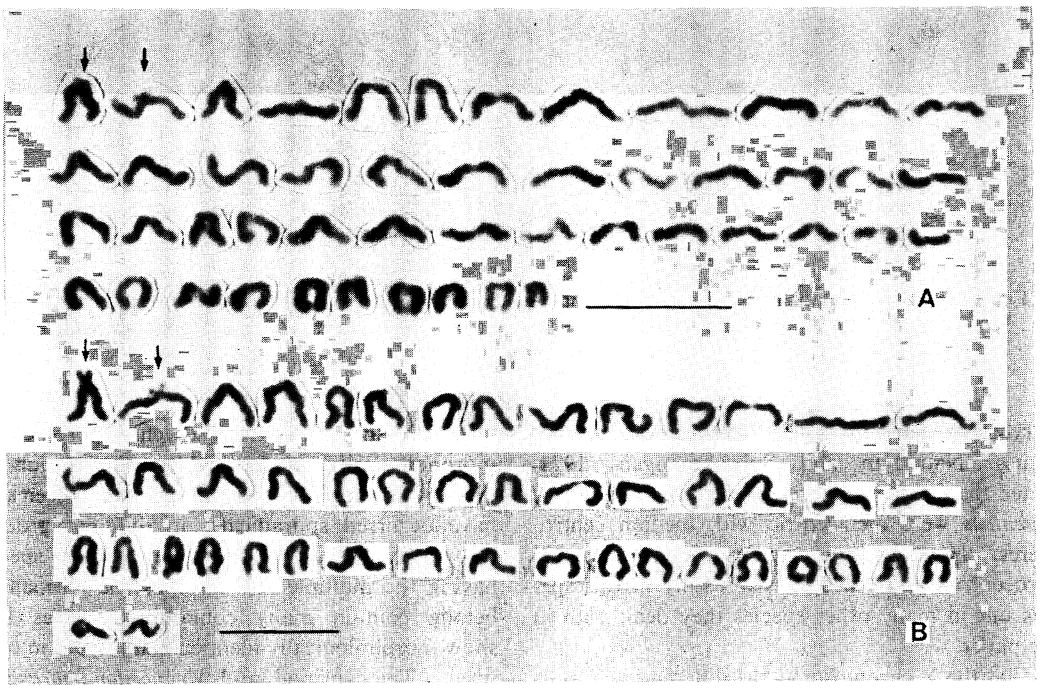

Fig. 3. Karyotypes of *Monodactylus argenteus*. A, female (2n=48); B, male (2n=48). Arrows indicate satellite chromosomes. Scale bar: 10 μm.

1972). In the Monodactylidae, *Monodactylus argenteus* occurring in the Indo-West Pacific does not show the multiple sex chromosome system, whereas its West African counterpart, *M. sebae*, has developed the XXY sex chromosome system.

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ヒメツバメウオ科魚類にみられた複合性染色体

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ヒメツバメウオ科 *Monodactylus* 属の 2 種の染色体を調査したところ，インド・西太平洋産の *M. argenteus* では雌雄とも染色体数は 2n=48 ですべて acrocentric 染色体からなる同一の核型を示したのに対し，西アフリカ産の *M. sebae* では，雌は 48 個の acrocentric 染色体をもつが，雄の染色体数は 2n=47 で，その核型は 1 個の大型の metacentric 染色体と 46 個の acrocentric 染色体から構成されていた．また，この種の雄の成熟分裂中期には 22 個の二価染色体と 1 個の三価染色体が観察された．以上から，*M. sebae* は雌 $X_1X_1X_2X_2$，雄 X_1X_2Y の複合性染色体をもつものと判定される．XXY タイプの性決定機構は魚類ではこれまでに 8 種で知られているが，スズキ目魚類では本報が 2 種めである．

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