EVIDENCE FOR MULTIPLE SEX CHROMOSOMES IN THE FRESHWATER GOBY, 
Gobiomorus shuffeldti (PISCES: GOBIIDAE).—Heteromorphic sex chromosomes have been observed in very few fish species. Of the 810 species of ostechthyan fishes listed by Sola et al. (1981), there is evidence of heterogamety for only 29. In fishes with intersexual chromosomal polymorphism, sex chromosomes usually cannot be distinguished from autosomes. Their existence is frequently inferred from sexual differences of general karyotype composition (e.g., male has 19 acrocentric and 29 metacentric chromosomes, while the female has 18 and 30, respectively). Less frequently, heterogamety has been determined by observing atypical meiotic bivalent associations or recognizing two distinct haploid complements during meiosis II (Gold, 1979).

Sex determination in the aforementioned 29 species has most often been inferred to be XY, ZZ:ZZ or XX:XX. Recently, multiple sex chromosomes have been reported in isolated species of seven families. As XY, X,X,X,X,X,Y system was proposed by Kishi (1976) for Calli- 
chronus hamaculatus (Siluridae). Filho et al. (1980) suggested a ZZ:ZW,W,Y system for Aeroperodon 
affinis (Parodonidae). All other species for which multiple sex chromosome systems have been de- 
scribed are believed to have an X,X,X,X,X,X,Y mechanism (Filho et al., 1980; Levin and Foster, 1972; Murofushi et al., 1980; Thorgaard, 1978; and Uyeno and Miller, 1971, 1972)—males have one less chromosome yet equal arm numbers compared with females. Males in these species consistently have one more biarmed element than females. This suggests that each species experienced a fusion of an autosome and the Y chromosome that incorporated an autosomal pair into the sex-determining mechanism. Ad- 
ditional evidence for this mechanism in Meg- 
upislon aporus (the cyprinodontid species of Uyeno and Miller, 1971), Allosodonichthys hubbi (the goodeid species of Uyeno and Miller, 1972) and Garmanella pulchra (Levin and Foster, 1972) was found in the formation of a trivalent during late spermatogonial phase. In Stephanolepis 
carvanj (Balistidae), this system was confirmed by the presence of two karyotypes in secondary spermatocytes—one with 17 acrocentric and the other with 15 acrocentric and one metacentric 
chromosomes (Murofushi et al., 1980). The het- 
eromorphic sex chromosomes are indistin- 
guishable from autosomes in all of these cases of presumed multiple sex chromosomes, except for the Y chromosomes in Gobiomorus, Megup- 
silon and S. carvanj.

I am reporting the occurrence of multiple sex chromosomes in Gobiomorus shuffeldti. Evidence was obtained from mitotic and meiotic chromo- 

some spreads for sex determination by the X,X,X,X,X,X,Y model.

Results and discussion.—Twelve specimens of G. shuffeldti from Irish Bayou in New Orleans, LA were karyotyped by using gill epithelium and 
tests according to methods developed by Kil- 
german and Bloom (1977) and modified by J. 
R. Gold (pers. comm.). Voucher specimens were 
deposited in the Texas Natural History Collec- 
tion (TNHC 11549). Both mitotic and meiotic chromosome spreads were obtained. Eighty-nine
mitotic cells from four females and 132 cells from eight males were examined for chromosome type and number. Of the female somatic cells observed, 55% had 48 acrocentric or telocentric chromosomes in metaphase (Fig. 1). In males, 60% of the somatic cells showed 46 acrocentric elements and a single, large metacentric chromosome (Fig. 1). Complete spreads from which the karyotypes were compiled are also shown in Fig. 1. Acrocentric chromosomes were measured and arranged in a descending series and, where possible, were associated with nearest neighbors. Inferences of homology are tentative for most chromosomes because factors such as morphological contraction, differential staining, and differential contraction are sus-
Fig. 2. Late prophase spread from primary spermatocyte illustrating the trivalent and 22 bivalents. Arrows indicate large X (A), small X (B) and Y (C) chromosomes.

Occasionally the larger of the two X chromosomes was dissociated from the trivalent: this produced meiotic spreads which included an end-co-end bivalent association between the Y and the smaller X, one univalent, and 22 bivalents. Dissociation could have been an artifact of chromosome preparation. It could also have resulted from an absence of chiasmata (White, 1975), which may be attributable to genetic differentiation between the large X and its homologous arm of the Y. Differentiation could be the result of heterochromatinization or inversions in either element, which would presumably be greater for the original X chromosome. Although heterochromatinization is thought to play an important role in evolution of sex chromosomes (Bull, 1978; Kornfeld, 1981; Singh et al., 1980) its role in the evolution of sex chromosomes in fishes (Kornfeld, 1981; Thorgaard, 1976; de Almeida Toledo et al., 1981) and lower vertebrates in general (Mengden, 1981; Sites et al., 1979) is unclear. The degree of differentiation involved in sex determination in fishes may not need to be very great (Gold, 1979).

There are only two previous reports of heterogamy in teleost fishes. From histological sections, Nogua (1955) presented evidence for an XY system in Odontobutis obscura (Eleotridae), but with recent methods, Nishioawa et al. (1974) and Arai et al. (1974) found 44 acrocentric chromosomes with no evidence of heterogamy. Arai and Sawada (1974) discovered male heterogamy in Gobioniscicornis (Gobidae) in which males have one sex chromosome and two fewer sex chromosomes than females. Although not stated, sex determination is presumably XO-XX. This species is not closely related to G. shufeldti.
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LITERATURE CITED


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