

A Comparative Study of Chromosomes in the Teleostean Fish Order Osteoglossiformes

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Abstract Karyological information on 8 genera in 5 families of the teleostean fish order Osteoglossiformes are presented and compared. Among notopterids, *Xenomystus nigri* and *Notopterus chitala* have 42 acrocentric chromosomes in diploid number, whereas *Papyrocranus afer* has 34 including 4 non-acrocentrics. Two species of mormyrids, *Gnathonemus petersii* and *Marcusenius brachistius* have 48 chromosomes. Diploid chromosome numbers of other species examined are *Hiodon alosoides*, 50; *Osteoglossum bicirrhosum*, 56; *Pantodon buchholzi*, 48. Some comments are made on interpretations of their karyotypes.

The osteoglossiformes, one of the most primitive and archaic teleostean fish orders, contain six families: Osteoglossidae, Pantodontidae, Mormyridae, Gymnarchidae, Hiodontidae, and Notopteridae (Gosline, 1971). They are distributed in Africa, the Indo-Australian region, and North and South America. Among these families, the Pantodontidae and Gymnarchidae are monotypic, and Hiodontidae comprise two species in one genus. The most divergent family is the Mormyridae. Osteoglossiform fishes are mostly carnivorous and retain many primitive osteological features. Recent discussions on the relationships of this order, on the basis of anatomical characters, are found in the reports by Greenwood et al. (1966), and Nelson (1969; 1972). The fossil record of this group goes back to the Jurassic period, for the Asian family Lycoperidae is recently included in this order (Greenwood, 1970). Thus osteoglossiform fishes have had a long evolutionary history. The purpose of this report is to provide chromosome information on representative genera in each family of the Osteoglossiformes, excepting the Gymnarchidae which was unavailable and is often included in the Mormyridae.

Material and methods

In the following, the length in parentheses represents the standard length unless otherwise stated. Six specimens of *Hiodon alosoides* (Rafinesque) (20~32 mm in total length) were collected at the mouth of Terrepene Creek in Missouri River, near Columbia, Missouri, on

June 16, 1970, by W. L. Pflieger, G. R. and K. B. Smith, and T. Uyeno. Five specimens of *Osteoglossum bicirrhosum* Vandelli (54~105 mm) and 7 specimens of *Xenomystus nigri* (Günther) (111~120 mm) and 3 specimens of *Papyrocranus afer* (Günther) (about 50~100 mm) were donated by Mr. R. B. Socolof. Two specimens of *Notopterus chitala* (Hamilton) (57~58 mm), 3 specimens of *Pantodon buchholzi* Peters (55~56 mm), 1 specimen of *Marcusenius brachistius* Gill (82 mm) and 1 specimen of *Gnathonemus petersii* (Günther) (117 mm) were purchased from tropical fish stores in Ann Arbor and Detroit, Michigan.

Mitotic chromosomes at metaphase were obtained from gill epithelium by the method described by Beamish (1970) with some modifications. After the injection of 0.05% Velban (Lillie Co., Ltd.), specimens were kept alive for 2 to 4 hours. Slides were made permanent by the use of dry ice. Photographs of chromosomes were taken with a Wild M 20 microscope at 1500× magnification with 15× ocular and 100× phase contrast objective lenses, using Polaroid type-57 (ASA 3000) film mounted on a Leitz "Aristophot".

Results

The family Osteoglossidae which are distributed in South America, Africa, Southeast Asia, and Australia) are represented in this study by 5 specimens of *Osteoglossum bicirrhosum* from South America. One specimen died immediately after the injection and no good

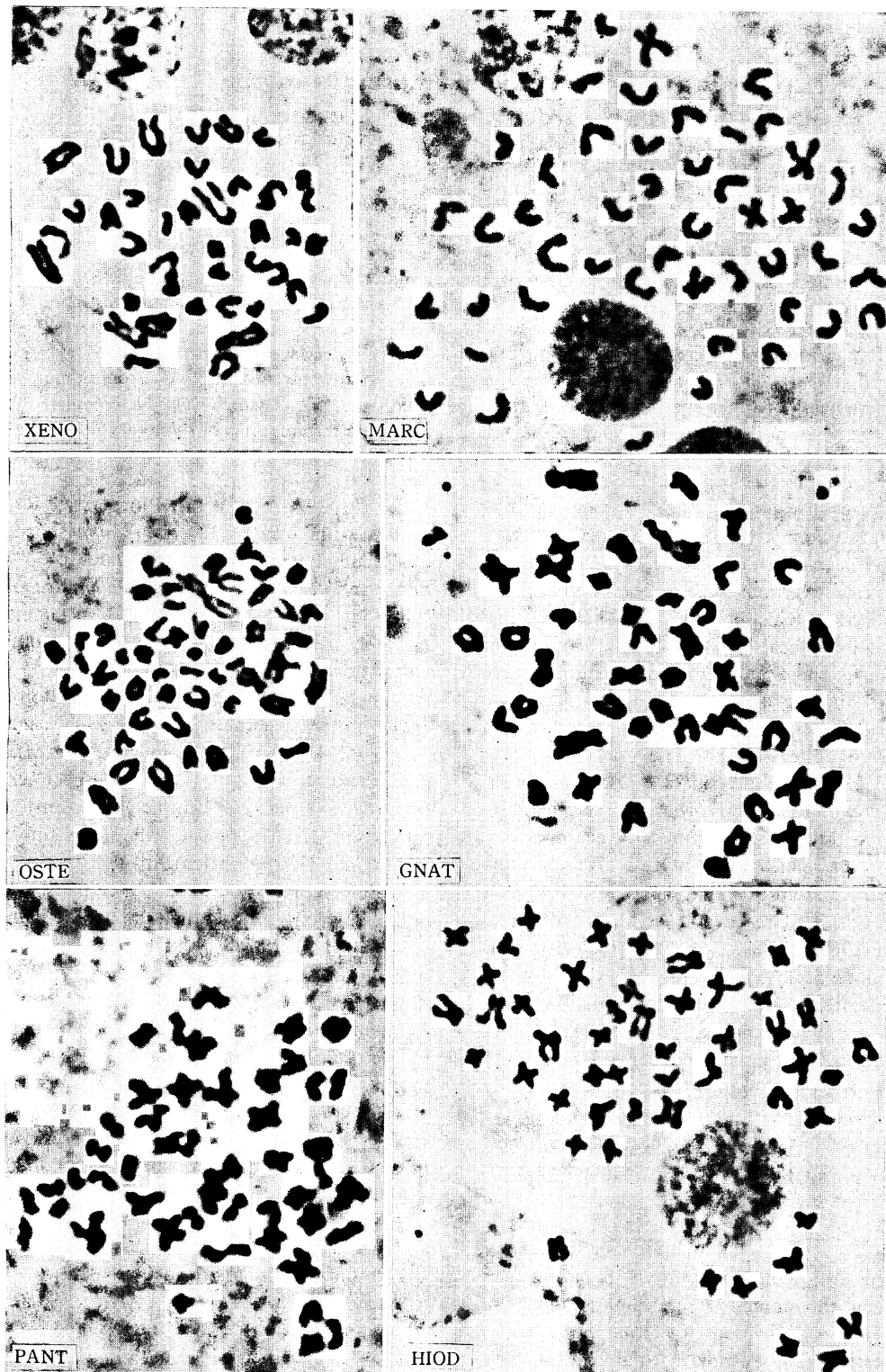


Fig. 1. Photomicrographs of somatic chromosomes at metaphase. XENO, *Xenomystus nigri*; MARC, *Marcusenius brachisti*; OSTE, *Osteoglossum bicirrhosum*; GNAT, *Gnathonemus petersii*; PANT, *Pantodon buchholzi*; HIOD, *Hiodon alosoides*.

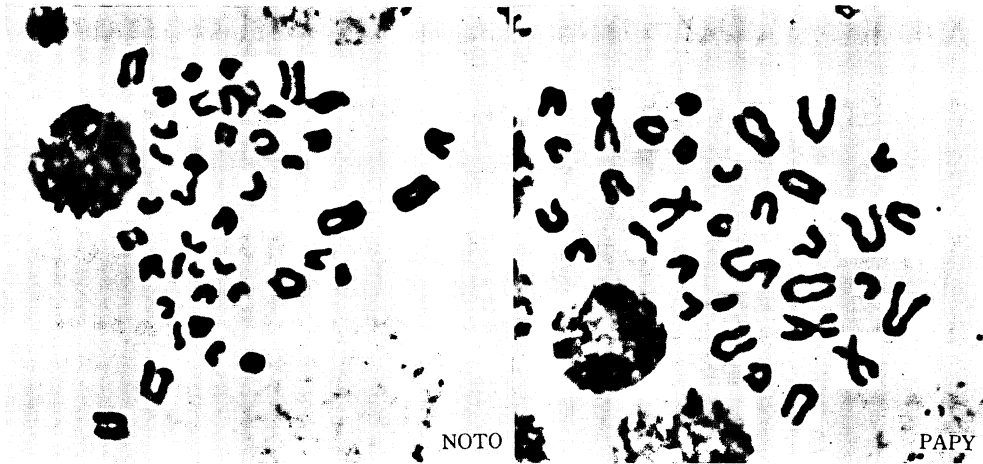


Fig. 2. Photomicrographs of somatic chromosomes at metaphase. NOTO, *Notopterus chitala*; PAPY, *Papyrocranus afer*.

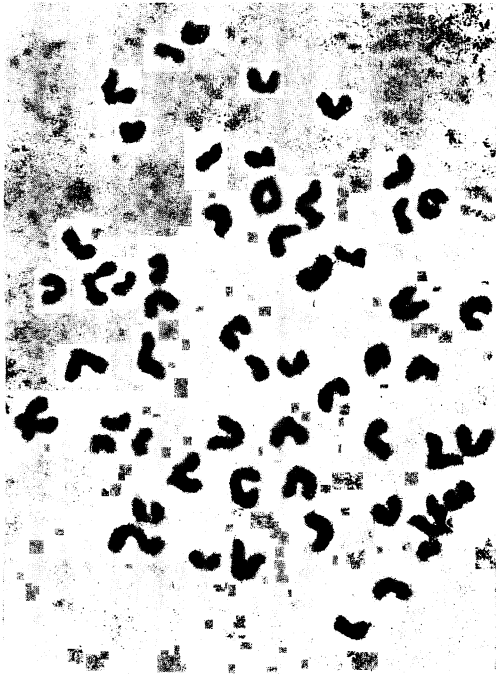


Fig. 3. Photomicrograph of somatic chromosomes at metaphase. *Osteoglossum bicirrhosum*, female.

cells were obtained from the individual. From other 4 specimens, 89 cells were observed. The diploid number is 56. The female karyotype includes 1 submetacentric, 1 subtelocentric, and 54 acrocentric chromosomes. The submetacentric and subtelocentric chromosomes

form a heteromorphic pair (Fig. 4). The sex was indeterminable in 4 specimens because of the immature (attached yolk sac) state, but the largest specimen was female with ovary. At present, I am not able to state the nature of the heteromorphic pair.

The family Pantodontidae which are distributed in Africa is represented by two specimens of *Pantodon bucholzi*. Fifteen cells with chromosome figures were obtained. Among them 3 cells definitely had 48 chromosomes, but others were not clear enough to determine if they contained 46 or 48. The diploid number is probably 48. The karyotype includes 12 metacentric, 12 submetacentric-subtelocentric, and 24 acrocentric chromosomes.

The family Mormyridae which are distributed in Africa is represented by 2 genera in this study. *Marcusenius brachistius* has a diploid number of 48. Chromosome figures from 9 cells were obtained from a single specimen. The sex was indeterminable. The karyotype includes 1 metacentric, 4 submetacentric, 2 subtelocentric, and 41 acrocentric chromosomes. The nature of this heteromorphic chromosome is indeterminable at present. *Gnathonema petersii* has 48 chromosomes in diploid. Eight cells from a specimen were observed. The karyotype includes 10 metacentric, 6 submetacentric, and 32 acrocentric chromosomes.

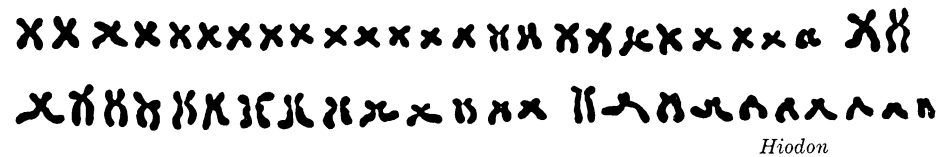
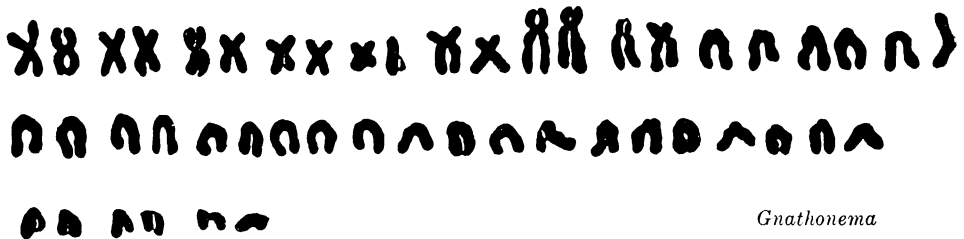
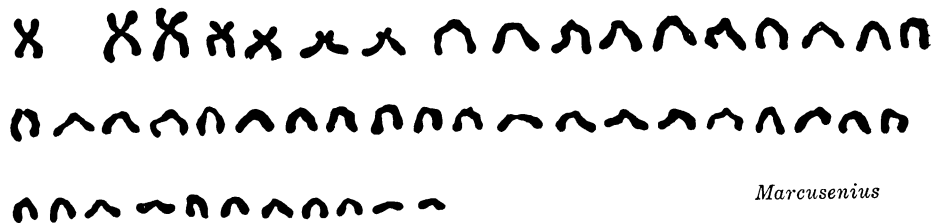
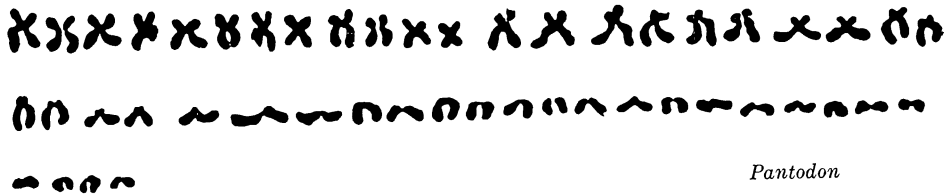
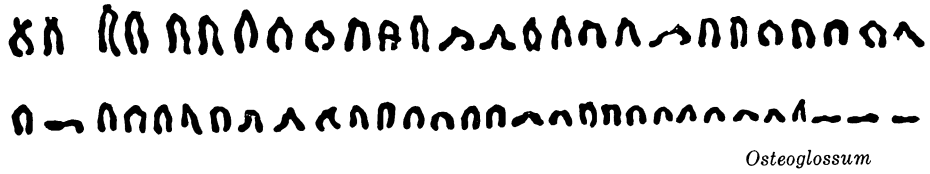


Fig. 4. Karyotypes of osteoglossiform fishes. From top to bottom: *Osteoglossum bicirrhosum*, *Pantodon buchholzi*, *Marcusenius brachistioides*, *Gnathonemus petersii*, *Hiodon alosoides*.

The family Hiodontidae which are distributed in North America is represented here by *Hiodon alosoides*. Among 7 specimens used, 4 specimens produced 29 cells with chromosome figures. The diploid number is 50. The karyotype

includes 40 metacentrics and submetacentrics, and 10 subtelocentrics.

The family Notopteridae with 3 genera and 6 species are distributed in Africa and South-east Asia. Among 7 specimens of *Xenomystus*

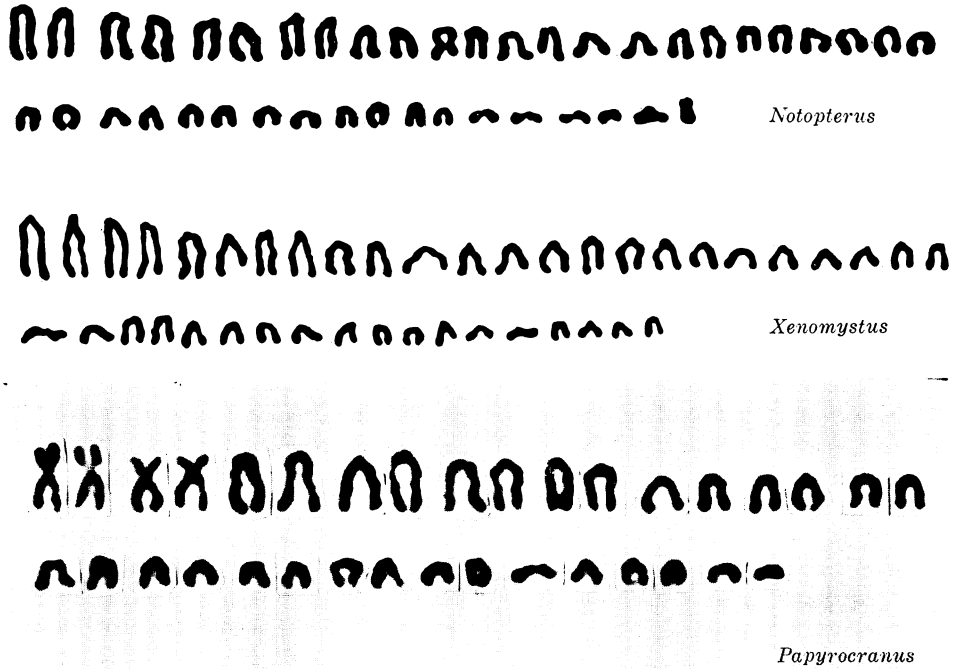


Fig. 5. Karyotypes of 3 genera of notopterid fishes. From top to bottom: *Notopterus chitala*, *Xenomystus nigri*, and *Papyrocranus afer*.

nigri from Africa, 4 specimens produced 44 cells with chromosome figures. The diploid number is 42. The karyotype includes 42 acrocentric chromosomes in a graded series of sizes. Three specimens of *Papyrocranus afer* from Africa were used, and 7 good cells were observed. The diploid number is 34. The karyotype included 4 submetacentrics and 30 acrocentrics in a graded series. *Notopterus chitala* which is distributed in Southeast Asia and India has the diploid number of 42. The karyotype includes 42 acrocentric chromosomes in a graded series, as in *Xenomystus*. This observation contradicts with the counts of chromosomes in *Notopterus chitala* in India by Nayyar (1965) who reported the chromosome number of the species as 48.

Discussion

On the basis of chromosome examinations, the following comments can be made.

1) The most frequent form of the chromosome in karyotypes of osteoglossiform fishes is acrocentrics. *Hiodon* is an exception having no

acrocentrics, and *Pantodon* has at least 50% non-acrocentrics.

2) Though karyotypes of *Osteoglossum*, *Pantodon*, *Xenomystus*, and *Notopterus* include some relatively small chromosomes, there are no dot-like "microchromosomes" found in karyotypes of a chondrosteian *Scaphirhynchus platorhynchus*, holosteans *Lepisosteus productus* (Ohno and others, 1969), and *Lepisosteus platostomus* (unpublished data).

3) On the basis of anatomical characters, Greenwood (1963) considered that *Xenomystus* is significantly different from the genera *Notopterus* and *Papyrocranus*, and placed it in a monotypic subfamily Xenomystinae. Nelson (1969), however, stated that the African notopterids are more closely related to one another than to any of the Asian species, and placed *Papyrocranus* in the subfamily Xenomystinae. In the case of karyotypes, however, *Xenomystus nigri* and *Notopterus chitala* are similar in having 42 acrocentrics, but *Papyrocranus afer* differs from them in having only 34 chromosomes including 4 non-acrocentrics.

4) If the osteoglossiformes are monophyletic group, as suggested by recent investigators (Greenwood et al., 1966; Gosline, 1960; Nelson, 1969), their karyotypes must have originated from a common, ancestral number. There seems 3 alternatives in the direction of changes in chromosome numbers: a) from a higher number such as 56 in *Osteoglossum* to a lower number such as 34 in *Papyrocranus* by means of fusion and deletion; b) from lower number to higher number by means of fission and aneuploidy; or c) from a certain intermediate number to both directions. In the case of the third alternative (c), 48 might be the most probable basic number because of the wide distribution not only among karyotypes of the Osteoglossiformes, but also in karyotypes of teleostean groups in general (Post, 1965). Karyotypes of the osteoglossiform fishes are certainly diverse, and differences in chromosome numbers are not explainable by simple Robertsonian rearrangements as in the case of the Cyprinodontidae in North America (Chen, 1969) and Goodeidae (Miller and Fitzsimmons, 1971; Uyeno and Miller, 1972).

5) Recently the comparative study of karyotypes among closely related cyprinids in the Colorado River indicated that chromosomal differences are correlated to morphological specialization (Uyeno and Miller, in press). But interpretations of karyotypic differences in fishes are still at the stage of infancy, and difficult to ascertain especially at the higher taxonomic level. The data presented here probably neither oppose nor support the idea of the monophyletic origin of the order Osteoglossiformes in recent classifications. But the diversity in their karyotypes seem to indicate their ancient origin, if the group is monophyletic.

6) On the basis of paleontological evidence, Patterson (1967) stated that in the evolutionary history of teleosts crossing the line between the halecostomes (Holostei) and the teleosts was "on a narrow front, the most likely candidates being the leptolepids, the lycoperids and the elopids". Recently Greenwood (1970) concluded that the Mesozoic genus *Lycoptera* and members of the family Hiodontidae are closely related, and proposed to place the family Lycoperidae in the superfamily Hiodontoidea of the order Osteoglossiformes. If this action is correct, the

order Osteoglossiformes has the oldest fossil record among Recent teleostean orders (Andrews et al., 1967). The absence of microchromosomes in the species of the Osteoglossiformes and in teleostean fishes in general might indicate that the crossing of the line between Holostei and Teleostei was made by a group which did not possess microchromosomes in their karyotype.

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オステオグロッサム目魚類の染色体の比較研究

上野 輝弥

オステオグロッサム目は地史的に現生の真骨魚類中最古の記録をもつ一群で、主として熱帯地方の淡水に分布しているが、最近その系統・類縁関係が少しずつ明らかにされてきた。併し染色体に関する詳しい資料はほとんどない。この度オステオグロッサム目の5科8属8種の染色体を調査したのでここに報告する。ノトプテルス科の *Xenomystus nigri* と *Notopterus chitala* は $2n=42$ で染色体は全て端部着糸型であるが、*Papyrocranus afer* は34で4個の中部または次中部着糸型を含む。モルミルス科の *Gnathonemus petersii* と *Marcusenius brachistiis* は48である。その外の種の染色体数は *Hiodon alosoides* が50, *Osteoglossum bicirrhosum* が56, *Pantodon buchholzi* が48であった。これらの魚類の核型と分布、古生物学的資料などに関して若干の考察を行なった。

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