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A Chromosome Study of Nine Species of Korean Cyprinid Fish

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Recent advances in cytogenetic techniques have rendered it possible to obtain detailed karyotypic data of approximately 300 species which correspond to 1/5 of the existing cyprinid fish (Ojima et al., 1972; Uyeno and Miller, 1973; Cataudella et al., 1977; Gold and Avise, 1977; Manna and Khuda-Bukhsh, 1977; Taki et al., 1977; Arai, 1982; Lee et al., 1983; Li et al., 1983; etc.). However, there is little information concerning the fish along the Asian Continent, where numerous species exist. The present paper gives a detailed account of the karyotype of nine species of Korean cyprinid fishes with some karyosystematical discussions. An investigation into the karyotypes of two Japanese species closely related to Korean fish was carried out to add to these discussions.

Materials and methods

Localities and analytical population of the various types of fish are summarized in Table 1. Chromosome preparations were made from kindey tissue by the conventional air-drying method. The karyotype analysis was carried out on approximately 30 well-delineated metaphase plates per fish, in which no element showed obscurity or overlapping. A morphological classification of the chromosomes was made by Levan et al. (1964). Tentatively, the chromosomes were grouped into three series, i.e., metacentric, submeta-subtelocentric and acrocentric element, and aligned serially from larger to smaller, respectively.

Results

Sarcocheilichthys czerskii (Berg) and *S. variegatus* (Temminck et Schlegel) (Fig. 1 A, B): Diploid chromosome number of *S. czerskii* was 50 and consisted of 9 pairs of metacentrics and 16 pairs of submeta-subtelocentrics. One of the metacentric pairs (No. 1) was conspicuously larger than all the other chromosomes. It showed approximately twice the length of the other metacentric chromosomes. The submeta-subtelocentrics showed a serial variation in size. The karyotypic pattern of *S. variegatus* showed the same as that of *S. czerskii*. The largest metacentric pair observed in both species was recognized as the characteristic marker chromosome in this genus.

Phoxinus phoxinus (Linnaeus) and *Moroco jouyi* (Jordan et Snyder) (Fig. 2 A, B): *P. phoxinus* had 50 diploid chromosomes consisting of 5 pairs of metacentrics, 17 pairs of submeta-sub-

Table 1. Specification of fishes used for analysis.

Spacies	Name Japanese (Korean)	Locality*	No. of specimen ♀	♂	unknown
Sarcocheilichthys czerskii	Kouraihigai (중고기)	III		1	1
Sarcocheilichthys variegatus	Higai	IV		3	
Phoxinus phoxinus	Himehaya (연준모치)	II	1	2	
Moroco jouyi	Takahaya	V	5	5	
Acheilognathus rhombeus	Kanehira (납자리)	III	2	1	
Hemibarbus longirostris	Zunaganigoi (참마자)	III	1	1	
Gonoprokopterus mylodon	Yagatanigoi (어름치)	II			2
Coreoleuciscus splendidus	Yagatamugitsuku (쉬 리)	I		3	
Microphysogobio longidorsalis	Hotatekobukurokamatsuka (배가사리)	I		3	
Microphysogobio yaluensis	Munaitakamatsuka (돌마자)	III		1	1
Gobiobotia brevibarba	Samegashira (돌상어)	I		2	

*I. The Han River, Yeongweol-gun, Gangweon-do (漢江水系, 江原道寧越郡寧越邑三玉里).
II. The Han River, Jeongseon-gun, Gangweod-do (漢江水系, 江原道旌善郡旌善邑三禹里).
III. The Geum River, Nonsan-gun, Chungcheongnam-do (錦江水系, 忠清南道論山郡論山邑城坪里).
IV. The Yoshii River, Okayama prefecture, Japan.
V. The Kikuchi River, Kumamoto Prefecture, Japan.

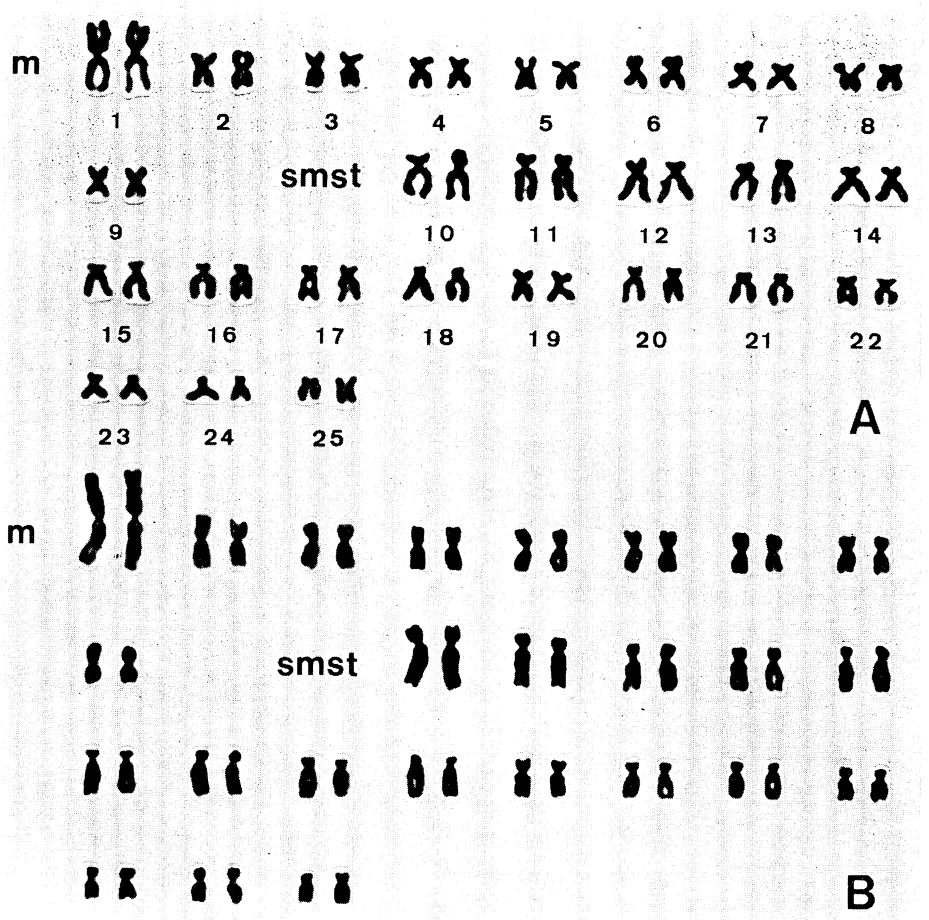

Fig. 1. Karyotypes of A) *Sarcocheilichthys czerskii* and B) *S. variegatus*.

telocentrics and 3 pairs of acrocentrics. The metacentric paris showed a little variation in size when compared against each other. The submeta-subtelocentric pairs showed a gradual variation in size and the largest corresponded to twice the size of the smallest. The largest acrocentric pair (No. 23) was conspicuously observed on the metaphase plates, and the chromosomes was 1.5 times as long as the other acrocentrics. The karyotype of *M. jouyi* was regarded as identical with that of *P. phoxinus*.

Acheilognathus rhombeus (Temminck et Schlegel) (Fig. 2C): The diploid chromosome number was 44 with 5 pairs of metacentrics, 10 pairs of submeta-subtelocentrics and 7 pairs of acrocentrics. The largest acrocentric pair (No. 16) had minute short arms and satellites.

Hemibarbus longirostris (Regan) (Fig. 3A): The chromosome number was 50 in the diploid, characterized by 8 pairs of metacentrics, 14 pairs submeta-subtelocentrics and 3 pairs of acrocentrics. The metacentric pairs were approximately the same size as each other; however, the submeta-subtelocentric pairs showed a gradual variation in size. The large chromosomes were 1.5 times as long as the small ones. Satellites were observed in one pair (No. 14) of submeta-subtelocentric series.

Gonoprokopterus mylodon (Berg) (Fig. 3B): The diploid chromosome number was 50 with 6 pairs of metacentrics, 14 pairs of submeta-subtelocentrics and 5 pairs of acrocentrics. Among them, Nos. 7, 8 and 21 were distinguishable from the others by their large size. The acrocentric pair (No. 23) was observed to have satellites.

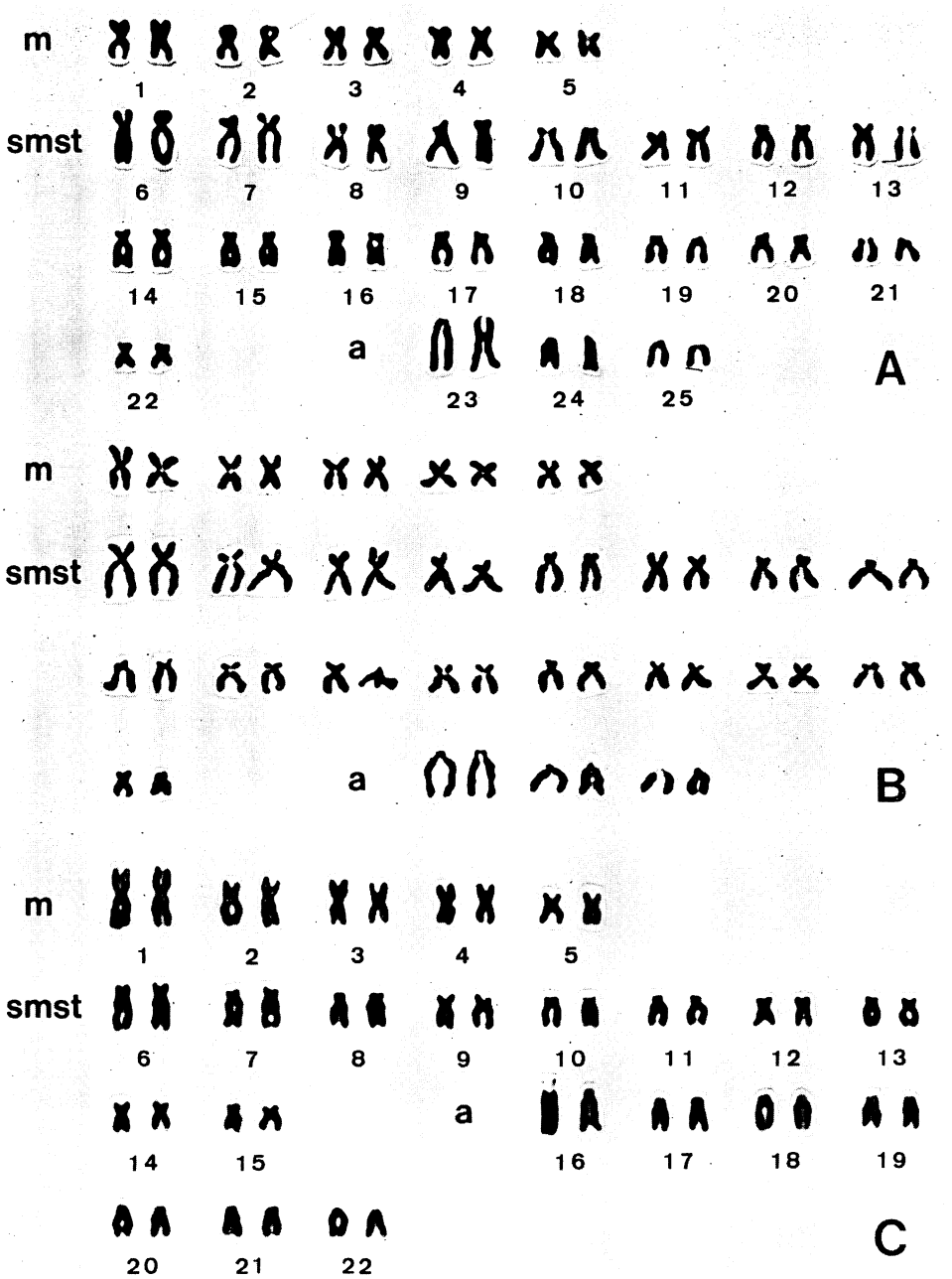

Fig. 2. Karyotypes of A) *Phoxinus phoxinus*, B) *Moroco jouyi* and C) *Acheilognathus rhombeus*.

Coreoleuciscus splendidus Mori (Fig. 3C): The chromosome number was 50 in the diploid each having short arms, consisting of 7 pairs of metacentrics, 15 pairs of submeta-subtelocentrics and 3 pairs of acrocentrics. Satellites were observed in a large submetacentric pair (No. 9).

Microphysogobio longidorsalis Mori, *M. yaluensis* Mori and *Gobiobotia brevibarba* Mori (Fig. 4 A–C): The diploid chromsome number of *M. longidorsalis* was 50, consisting of 9 pairs of metacentrics and 16 pairs of submetacentric-

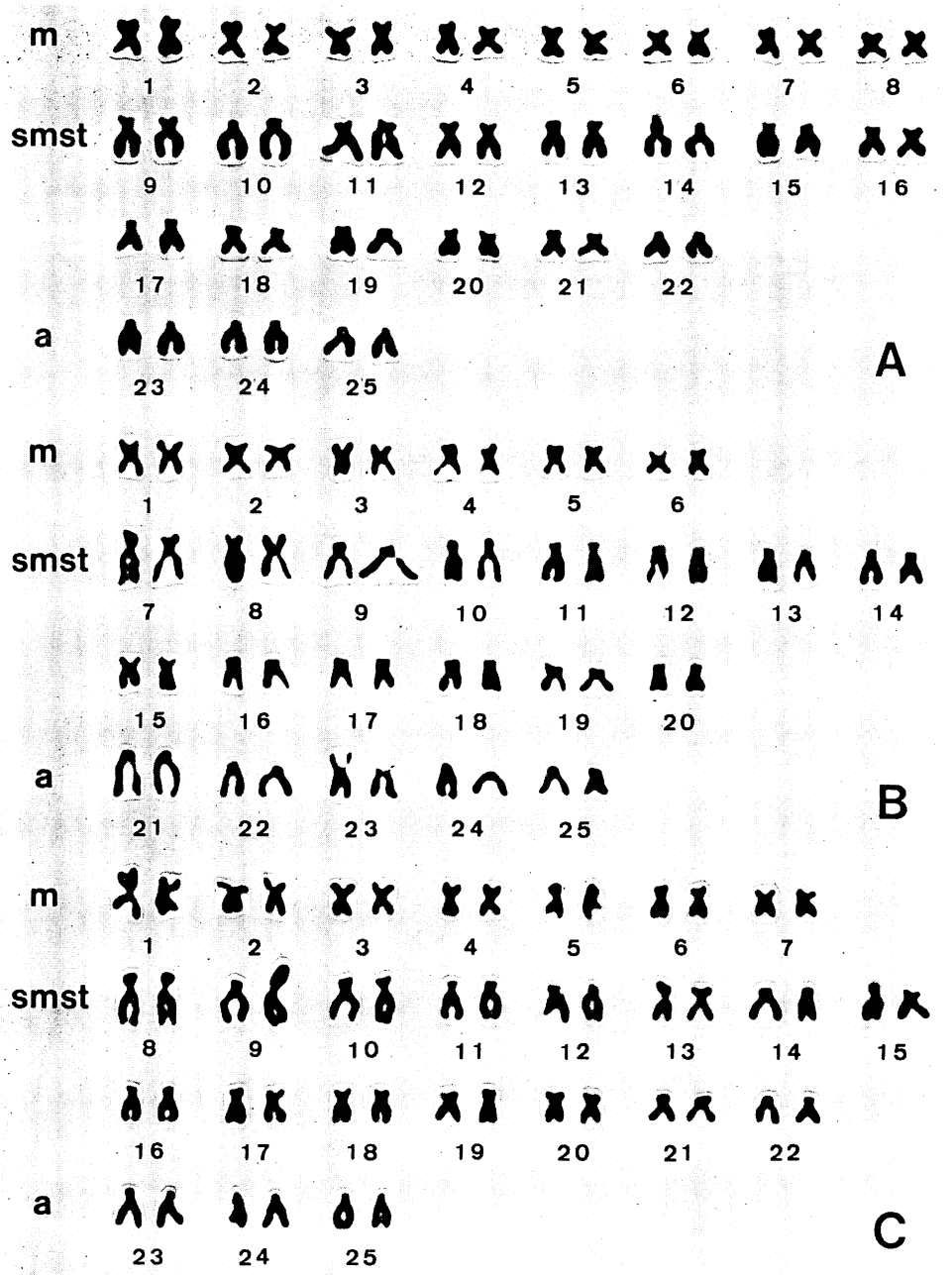

Fig. 3. Karyotypes of A) *Hemibarbus longirostris*, B) *Gonoprokopterus mylodon* and C) *Coreoleuciscus splendidus*.

subtelocentrics. The metacentric pairs showed a serial variation in size, however, the submeta-subtelocentric pairs had a wide variation. The largest chromosome was approximately 3 times as large as the smallest. The karyotype of *M. yaluensis* was similar to that of the *M. longidorsalis*. However, in particular, the largest pair (No. 10) of the second series of this species was submetacentric, while that of the former species was subtelocentric. The karyotype of *G. brevibarba*

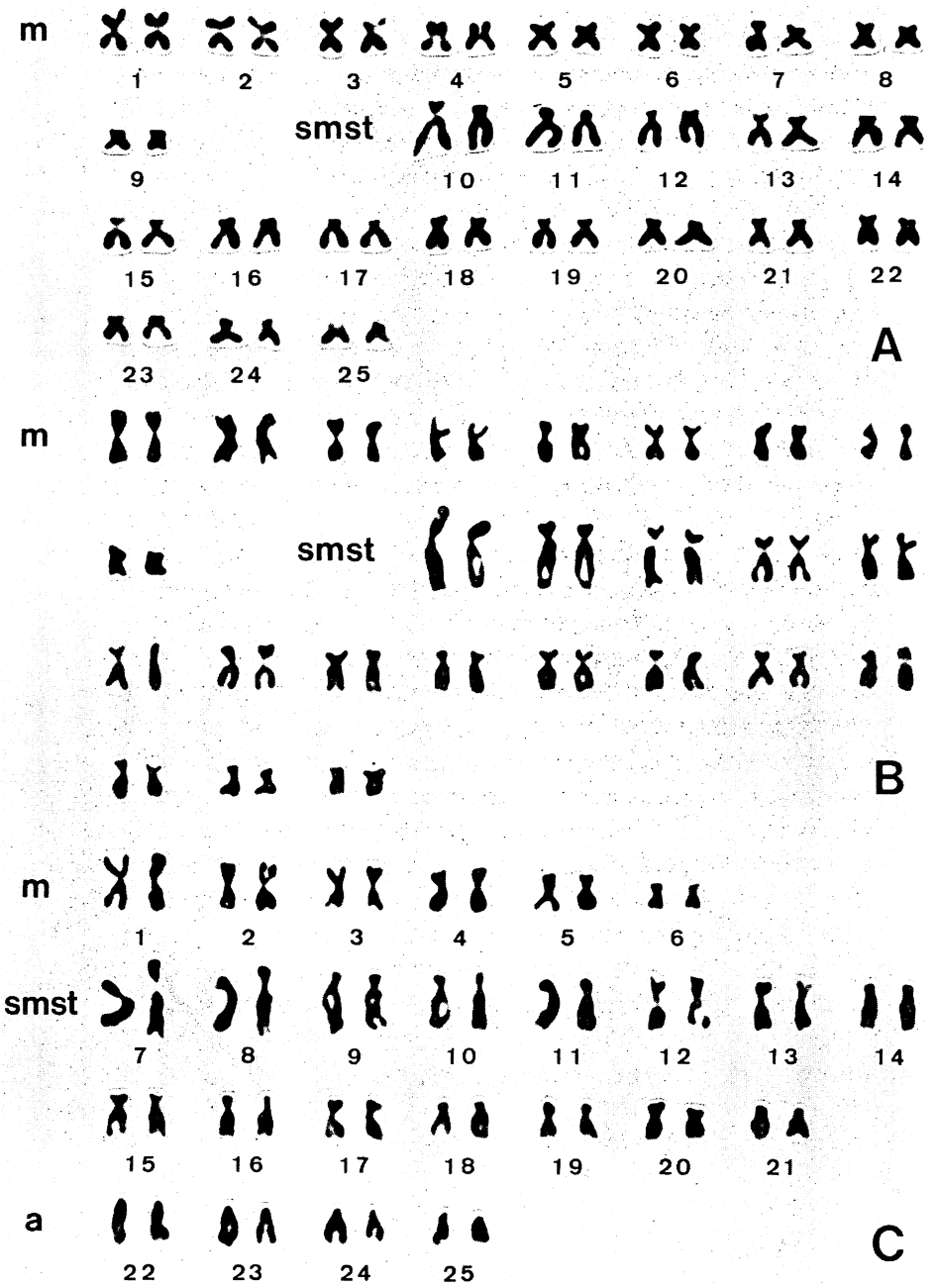

Fig. 4. Karyotypes of A) *Microphysogobio longidorsalis*, B) *M. yoluensis* and C) *Gobiobotia brevibarba*.

was quite different from the above mentioned two species. It consisted of 50 diploid chromosomes including 4 pairs of acrocentrics, with 6 pairs of metacentrics and 15 pairs of submeta-subtelocentrics.

Discussion

The karyotypes of *A. rhombeus*, *H. longirostris*, *C. splendidus*, *M. longidorsalis* and *M. yaluensis* that appeared in this paper have already been

revealed by Korean workers (Kang and Park, 1973; Lee, 1983; Lee et al., 1983). Also, the karyotypes of *P. phoxinus* and *A. rhombeus* have been reported in Yugoslavia (Berberovic and Sofradzija, 1974) and Japan (Ojima et al., 1973) respectively. In comparison with those reports, the karyotypes revealed here coincided with them in chromosome number, while differing somewhat regarding the chromosome complement. These differences in the complements are probably due to a personal interpretation of the arm ratio, so far as can be seen from the photographs of the chromosomes supplied in these papers. The Korean *S. czerskii* and the Japanese *S. variegatus* bear a close relationship to each other. In the present paper, it was proved karyosystematically. The karyotype of *P. phoxinus* was closely similar to that of *M. jouyi*. The karyotype of the two Japanese species, *Moroco steindachneri* (Sauvage) and *M. percnurus sachalinensis* (Breg) were identical with that of *M. jouyi* (unpublished data). In addition, the karyotype of the two Korean species, *Moroco oxycephalus* (Bleeker) and *M. lagowskii* (Dybowski) (Kang and Park, 1973) were considered to be identical with that of the Japanese *Moroco*. These results support that genus *Moroco* Jordan et Hubbs could be included in the genus *Phoxinus* Agassiz, karyosystematically.

It has so far been reported that some fishes belonging to the order Cypriniformes have undergone a polyploid evolution, showing a diploid-tetraploid relationship (Ohno et al., 1967; Uyeno and Smith, 1972; Ueno et al., 1980; Khuda-Bukhsh, 1982; etc.). All fish belonging to the Cyprinidae dealt with in this paper were of the diploid-type. Gobiobotine fish are a special group having intermediate morphological characteristics between the Cyprinidae and the Cobitididae. The karyotypes of cyprinid fishes are generally constructed by more biarmed chromosomes than monoarmed ones, while in almost all the species of cobitidid fish the chromosome complements consist of more monoarmed chromsomes than biramed ones (Hitotsumachi et al., 1969; Ueno et al., 1980; etc.). The Korean Cyprinidae showed the same in their general pattern of karyotypes, while those of the Gobiobotinae were more closely similar to the Cyprinidae than the Cobitididae. In this study, neither inter-individual polymorphism nor heteromorpic chromosomes were observed.

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韓国産コイ科魚類9種の核型

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韓国産コイ科魚類9種の核型（複相数，構成）は次のように分析された．

コウライヒガイ，50，18 m+32 sm·st，ヒメハヤ，50，10 m+34 sm·st+6a，カネヒラ，44，10 m+20 sm·st+14a，ズナガニゴイ，50，16 m+28 sm·st+6a，ヤガタニゴイ，50，12 m+28 sm·st+10a，ヤガタムギツク，50，14 m+30 sm·st+6a，ホタテコブクロカマツカ，50，18 m+32 sm·st，ムナイタカマツカ，50，18 m+32 sm·st，サメガシラ，50，12 m+30 sm·st+8a.

多型現象ならびに異形対染色体は種を通じて観察できなかった．核学的分類学の立場からすると，*Moroco* 属は *Phoxinus* 属に統一できること，ドジョウカマツカ類は類縁的にドジョウ科よりもコイ科に近いことを論じた．

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