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Osteological and morphological evidence for lack of close affinity between the genera *Abramis* CUV. and *Notemigonus* RAF. (Pisces, Cyprinidae)

[With 19 text-figures and 2 plates]

INTRODUCTION

The genus *Notemigonus* RAFINESQUE, 1819 includes only one species, *N. crysoleucas* (MITCHILL, 1814). It is a small minnow living in fresh waters of North-east America.

JORDAN and EVERMAN (1896) recognized *Notemigonus* as the subgenus of the Old World genus *Abramis* CUV. According to them, the most important character of the genus *Abramis* are as follows: "Body strongly compressed, belly behind ventral fins forming a keel over which the scales do not pass. Dorsal fin inserted behind the ventrals. Anal fin with the base more or less elongated, of from 13 to 40 rays. Teeth 5-5, hooked, with grinding surface, the edges of which, in American species, are more or less crenate". The subgenus *Notemigonus* differs only by having "much shorter anal fin, from 9 to 18 rays instead of 20-40" and "the teeth more or less crenate".

Many other ichthyologists have shared the idea of an affinity between the two genera. BERG (1916: 306; 1949: 768); in 1933 (p. 178) he wrote: "Beim Vergleich hingegen der Donau mit Mississippi finden sich folgende gemeinsame Gattungen ... ferner *Notemigonus*, eine *Abramis* nahe Gattung". Of the same opinion are NIKOLSKIJ (1954: 220), RAS (1971: 307), BĂNĂRESCU (1961: 63) and (1964: 304).

Most American research workers, except NELSON (1976), affirm that native *Cyprinidae* of North America (including *Notemigonus*) belong to the subfamily *Leuciscinae* (MILLER 1958: 203; MILLER 1976: 8; LIEPPMAN and HUBBS

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1969: 434; McPHAIL and LINDSEY 1970: 216; and others). However, according to NELSON (1976: 125) all American *Cyprinidae* belong to the subfamily *Leuciscinae*, with the exception of *Notemigonus* which, in his opinion, is a member of the Old World and belong to the subfamily *Abramidinae*. NELSON's opinion is therefore similar to that of BERG (1912: 12) who also distinguished the subfamily *Abramidini* on the basis of one feature only — “a keel without scales on the belly in front of the anus”. This feature is really common to both genera *Abramis* and *Notemigonus*, but it is not a sufficient evidence to prove their affinity. The author's investigations have provided evidence that the shape of certain internal organs and some osteological elements of the cranium exclude entirely their affinity at generic level. Their common features indicate that they belong, as two valid genera, to the subfamily *Leuciscinae*.

In the light of more detailed investigations, the subfamily *Abramidinae* (*Abramidini* sensu BERG 1912: 22) has been included into the subfamily *Leuciscinae* (BERG 1940; KRYŽANOVSKIJ 1949: 15 on the basis of embryological and zoogeographical data; NIKOLSKIJ 1954: 205).

MATERIAL AND METHOD

Comparative studies were carried out on the following material:

Abramis brama (L.) — 20 specimens, Poland (the Vistula R. and Masovian Lakes), 1970–1976.

Abramis ballerus (L.) — 10 specimens, Poland, Dąbie Lake, basin of the Odra R., 1975–1976.

Abramis sapa (PALL.) — 3 specimens, the Danube, Czechoslovakia, 1957. I would like to express my great thanks to Dr. J. HOLČÍK, The Laboratory of Fishing and Hydrobiology, Bratislava, Czechoslovakia, for the material I obtained for my studies.

Notemigonus crysoleucas (MIT.) — 6 specimens, Canada, Quebec, Russel Stream, Iberville, 1966–1967. This material, belonging presently to the collection of the Institute of Zoology of the Polish Academy of Sciences, was given many years ago by Dr. E. J. Crossman, Curator in the Department of Ichthyology and Herpetology, Royal Ontario Museum, Toronto, Canada.

A part of the material studied was fresh, a part was preserved in alcohol or in formalin. In some cases alizarin staining by means of HOLLISTER's method (1933) was applied.

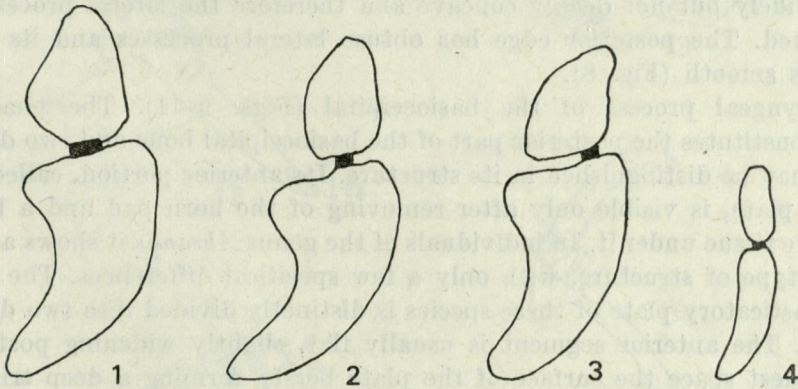
DIAGNOSTIC CHARACTERS

Air-bladder (Figs. 1–4). The two discussed genera differ distinctly in the shape of the air-bladder. In species of the genus *Abramis* the posterior chamber is markedly curved crescent-like and strongly widened in its anterior part, but

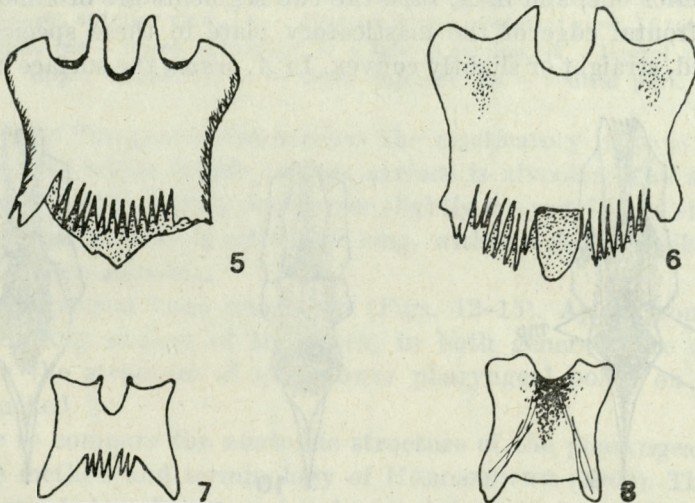
rapidly narrowing posteriorly. In the genus *Notemigonus* this chamber is only slightly crescent-like, it is more in the shape of a sac of almost equal width along the whole of its length.

A comparison of osteological elements of the cranium of individuals of both species reveals distinct differences in the shape of the following bones:

Supraethmoid (Figs. 5-8). In representatives of the genus *Abramis* this bone has common generic character, though there are certain specific differences. In general this bone is a little wider than long in the genus *Abramis*. In *A. brama* and *A. ballerus* the dorsal surface of the supraethmoid is usually flat, whereas



Figs. 1-4. Air-bladder. 1 - *Abramis brama*, 2 - *A. ballerus*, 3 - *A. sapa*, 4 - *Notemigonus crysoleucas*.



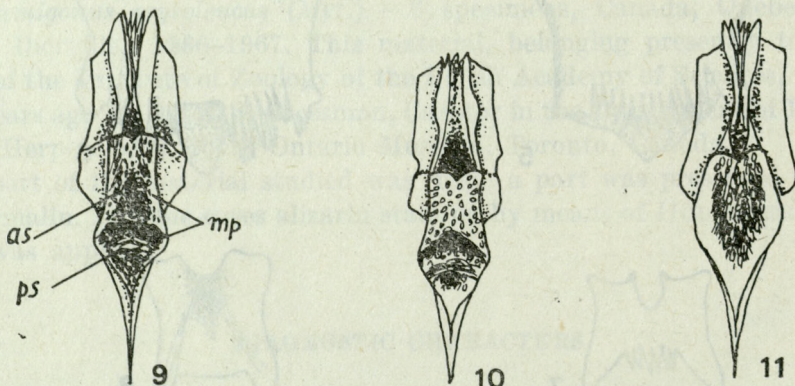
Figs 5-8. Supraethmoid. 5 - *Abramis brama*, 6 - *A. ballerus*, 7 - *A. sapa*, 8 - *Notemigonus crysoleucas*.

in *A. sapa* it is slightly concave anteriorly. In the first two species the anterior edge is deeply and narrowly incised and therefore the anterior lateral processes are well developed and deeply incised as well. In *A. sapa* the incision of the anterior edge is not so deep and the lateral processes are poorer developed. In all the three species the posterior edge is laterally elongated to irregular processes and the space between them is filled with osseous teeth, sometimes embedded in a cartilage layer. In some cases, however, the cartilage may be lacking any osseous notch (Fig. 6).

In *Notemigonus* the supraethmoid is longer than wide.

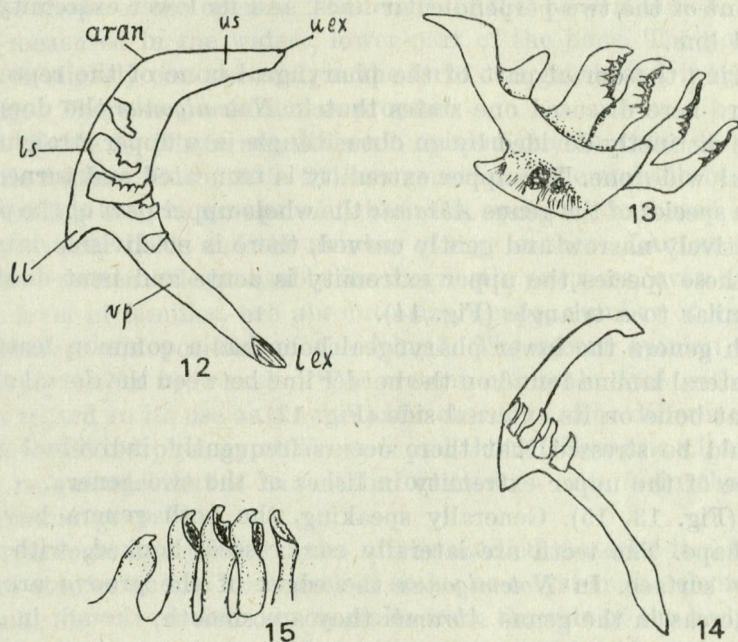
The dorsal surface is concave, especially in its anterior part. The anterior edge is widely but not deeply concave and therefore the lateral processes are less marked. The posterior edge has obtuse lateral processes and its central portion is smooth (Fig. 8).

Pharyngeal process of the basioccipital (Figs. 9–11). The pharyngeal process constitutes the posterior part of the basioccipital bone and two different portion may be distinguished in its structure. Its anterior portion, called a masticatory plate, is visible only after removing of the horn pad and a layer of connective tissue under it. In individuals of the genus *Abramis* it shows a certain common type of structure, with only a few specific differences. The surface of the masticatory plate of these species is distinctly divided into two different segments. The anterior segment is usually flat, slightly widening posteriorly. At its widest space the surface of the plate bends, forming a deep triangular concavity — the posterior segment. In the discussed species there occur different proportions of the sizes of the anterior and posterior segments of the masticatory plate. In *A. brama* the anterior segment is usually longer than the concave posterior one, and in *A. sapa* the two segments are of almost the same length. The frontal edge of the masticatory plate in these species is usually slightly incised, straight or slightly convex. In *A. brama* the surface of the masti-



Figs. 9–11. Pharyngeal process of basioccipital. 9 — *Abramis brama*, 10 — *A. ballerus*, 11 — *Notemigonus crysoleucas*. *as* — anterior segment of the masticatory plate, *mp* — masticatory plate, *ps* — posterior segment of the masticatory plate.

catory plate has a net-like structure of elongated mesh, and in *A. ballerus* and *A. sapa* the mesh is rather round. The posterior portion of the pharyngeal process is laterally compressed, elongated and it slightly differs in the above species. In *A. brama* the ventral edge of that portion is usually straight and the dorsal one is slightly convex, in *A. ballerus* and *A. sapa* both edges are slightly convex.



Figs. 12-15. Lower pharyngeal bone and teeth. 12 - *Notemigonus crysoleucas*, posterior view, 13 - *N. crysoleucas*, anterior view, 14 - *Abramis brama*, posterior view, 15 teeth of *A. brama*. *aran* - arc angle, *lex* - lower extremity, *ll* - lateral lamina, *ls* - lateral segment, *uex* - upper extremity, *us* - upper segment, *vp* - ventral part.

In species of the genus *Notemigonus* the masticatory plate is oval, deeply concave along its whole length and its surface is alveolar. The anterior edge of the plate is straight, slightly concave or slightly convex. The posterior portion of the pharyngeal process is relatively long, with its shape similar to that in fishes of the genus *Abramis*.

Lower pharyngeal bone and teeth (Figs. 12-15). Apart from differently developed grinding surface of the teeth, in both genera there are recorded differences in the structure of even lower pharyngeal bones on which these teeth are stuck.

In order to compare the anatomic structure of the pharyngeal bone I am following the method and terminology of HOROSZEWICZ (1960). The bone consists of a vertical dorsal part and a horizontal ventral one. The dorsal part may have a shape of regular arch or it may be curved at an angle. In this last case that author distinguishes in the arch an upper segment ending with an

upper extremity and a lateral segment. The curvature of the arch may be more or less obtuse and is called the arc angle (angulus arcus of HOROSZEWICZ, 1960; anterior angle of UYENO, 1961) (Fig. 12).

To show anatomical elements of the pharyngeal bone the following position of it is accepted. The bone is placed on a plane by its upper extremity at the crossing point of the two perpendicular lines, and its lower extremity touching the vertical line.

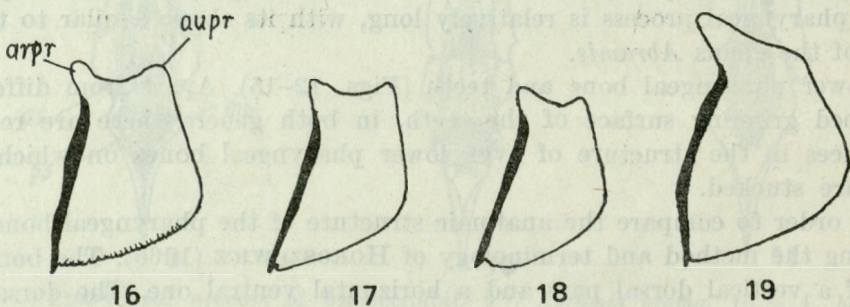
Comparing the dorsal part of the pharyngeal bone of the representatives of the genera here discussed one states that in *Notemigonus* the dorsal part of that bone is distinctly divided by an obtuse angle into upper straight segment, and a lateral wide one. The upper extremity is truncated and turned upwards (Fig. 12). In species of the genus *Abramis* the whole upper part of the pharyngeal bone is relatively narrow and gently curved, there is no division into two segments. In these species the upper extremity is acute and bent down, and its shape is similar to a triangle (Fig. 14).

In both genera the lower pharyngeal bone has a common feature — presence of a lateral lamina found on the border line between the dorsal and ventral parts of that bone on its external side (Fig. 12).

It should be stressed that there occurs frequently individual variability in the shape of the upper extremity in fishes of the two genera.

Teeth (Fig. 13, 15). Generally speaking, the both genera have teeth of a similar shape. The teeth are laterally compressed, hooked, with a grooved masticatory surface. In *Notemigonus* the edges of the groove are distinctly crenate, whereas in the genus *Abramis* they are smooth, though in *A. ballerus* there is recorded a slight sinuosity of these edges.

Opercle (Figs. 16–19). Certain generic difference is found in the shape of the opercle. In species of the genus *Abramis* this bone shows great similarity. Its shape is close to a rectangle slightly widening towards its back. Its length is visibly greater than its width. In *A. brama* and *A. sapa* the posterior edge forms a distinct bend when it turns into the ventral one. In *A. ballerus* the posterior edge turns in the form of a gentle arch into the ventral one. In *A. brama*



Figs. 16–19. Opercle. 16 — *Abramis brama*, 17 — *A. ballerus*, 18 — *A. sapa*, 19 — *Notemigonus crysoleucas*. arpr — articular process, aupr — auricular process.

the ventral edge is usually slightly crenate, while in the other two species it is smooth. In fishes of the genus *Abramis* the opercle has well developed articular process (RAMASWAMI, 1955a = opercular arm of NELSON, 1949), the bone has also distinct, though not very tall, auricular process (NELSON, 1949).

In specimens of the genus *Notemigonus* there occurs great individual variability in the shape of the opercle. The length of this bone is almost the same as its width, measured in the widest, lower part of the bone. The posterior edge is straight or slightly concave and, in the form of a gentle arc, it turns into the ventral edge. There is no auricular process.

Scales (Table I). There are different opinion on the value of the scale as a systematic feature. CHU (1935: 21) has considered the scale to be very useful in characterizing certain groups of fishes. His opinion was based on the character of particular fields and the number of rays in them. LAGLER (1947: 153), however, has written: "least usable for diagnostic purposes, even at the major taxonomic level of families, are absolute size, shape, number of various countable structures, and position of the focus". The recent opinion of JENKINS and LACHNER (1971: 6) is such: "We present our scale data with a cautious attitude in regard to its use as a systematic character. The difference, however, between the scale morphology of *Nocomis* and that of *Hygopsis* s.l. and *Notropis* is of such magnitude that it cannot be omitted as criteria in the evaluation of these generic groups".

A morphologic analysis of scales of the studied material is a further contribution to studies on the usefulness of scales as a systematic element. A comparative analysis was carried out on scales from the side of the body below the dorsal fin. In representatives of the genus *Abramis* the scales were wider than long, the focus was centrally situated. In the caudal field there usually were some primary radii. In *A. brama* secondary radii were sometimes numerous, while in *A. ballerus* and *A. sapa* there were only a few or none at all. In *A. brama* the oral field has 1-2 primary radii, but in *A. ballerus* and *A. sapa* there are no radii there.

In fishes of the genus *Notemigonus* the length of the scale is greater than its width, the focus is shifted to the oral field. In the caudal field there are 4-7 primary radii, but between them there are no secondary radii. Very seldom one secondary radius is recorded outside primary radii.

The above data show that two morphological elements of the scale (shape and position of the focus) distinctly differentiate the two discussed genera.

CONCLUSIONS

The osteological differences (supraethmoid, pharyngeal process of the basioccipital, lower pharyngeal bone, teeth, opercle) and selected morphological elements (air-bladder, scales) prove that there is no close affinity between

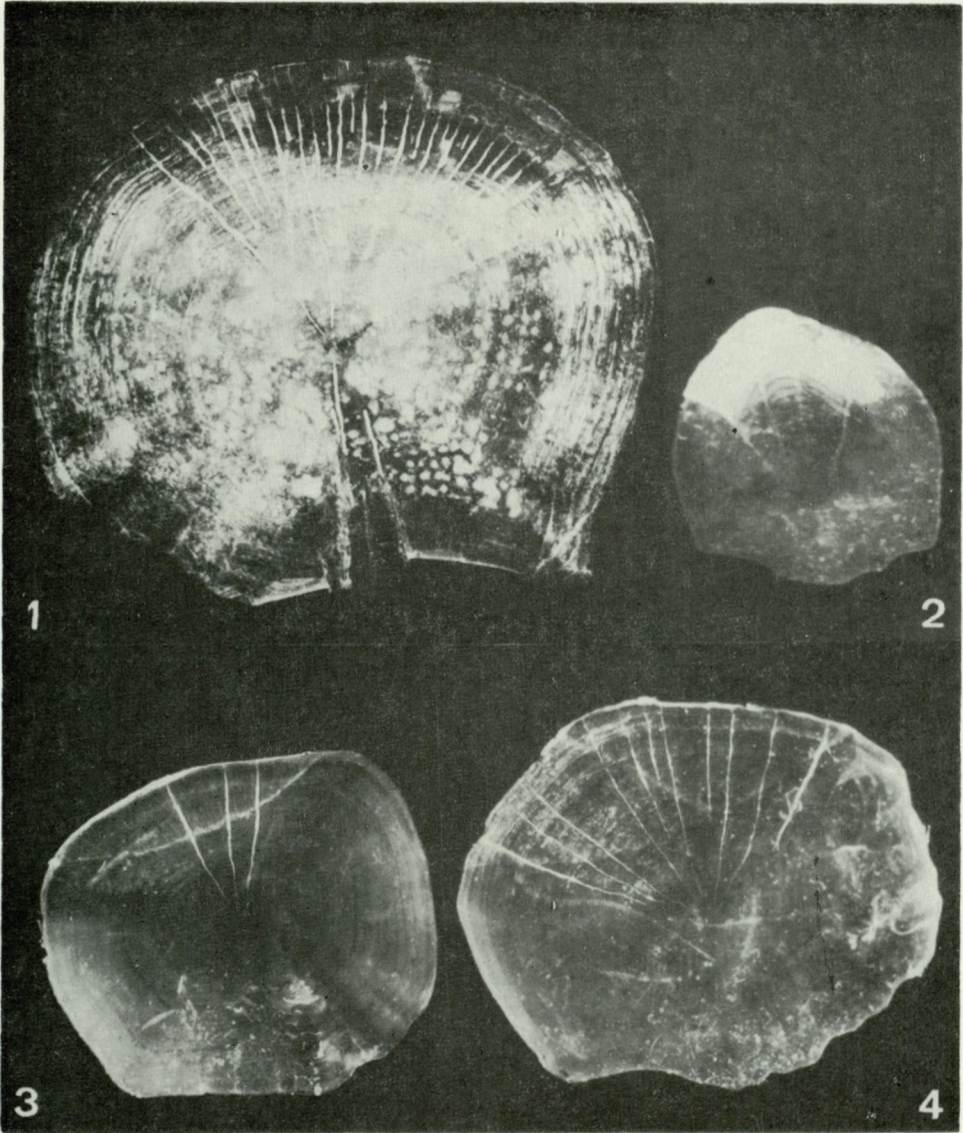
Euro-Asiatic species of the genus *Abramis* and the North American genus *Notemigonus*. They are undoubtedly two valid genera belonging to the subfamily *Leuciscinae*. In the light of the more recent investigation (BERG, 1940; KRYŽANOVSKIJ, 1949; NIKOLSKIJ, 1954) the subfamily *Abramidinae* has been included into the subfamily *Leuciscinae*.

Similarities between these genera (the keel not covered with scales on the belly behind the ventral fins) are a result of a convergence in the evolution of these fish. This character evolved as a result of an environmental influence on the organism during its historic development under local, ecologically similar conditions in Eurasia and America. It is well known that both genera prefer similar habitat. They live in rivers and lakes. In rivers the best for them is the middle course where water is clear and the current weak, and well developed aquatic vegetation.

REFERENCES

- BĂNĂRESCU P. 1961. Einige Fragen zur Herkunft und Verbreitung der Süßwasserfischfauna der europäisch-mediterranen Unterregion. Arch. Hydrobiol., Stuttgart, **57**: 16–134, 8 ff, 1 tab.
- BĂNĂRESCU P. 1964. Fauna Republicii Populare Romine. *Pisces — Osteichthyes*, Acad. Repub. Pop. Romine, București, **13**: 1–959, 402 ff.
- BERG L. S. 1912. Fauna Rossii i sopredel'nyh stran, Ryby (*Marsipobranchii* i *Pisces*), *Ostariophysi*. S.-Peterburg, **3**: 1–336, 26 ff, 2 tab.
- BERG L. S. 1916. Ryby presnyh vod Rossijskoj Imperii. Moskva, XXII + 563, 359 ff.
- BERG L. S. 1933. Übersicht der Verbreitung der Süßwasserfische Europas. Zoogeogr., Jena **1**: 107–208, 16 ff.
- BERG L. S. 1940. Classification of Fishes, both Recent and Fossil. Trudy zool. Inst. Akad. Nauk SSSR, Moskva-Leningrad **5**: 87–517, 190 ff.
- BERG L. S. 1949. Ryby presnyh vod SSSR i sopredel'nyh stran. Opredeliteli po faune SSSR, Moskva-Leningrad, **29**: 469–925, 288–674 ff.
- CHU Y. T. 1935. Comparative Studies on the Scales and on the Pharyngeals and Their Teeth in Chinese Cyprinids. With Particular Reference to Taxonomy and Evolution. Biol. Bull. St. Jons's Univ., Shanghai, **2**, 225 pp, 30 plates.
- HOLLISTER G. 1934. Clearing and Dyeing Fish for Bony Study. Zoologica, New York, **12**: 89–101, 4 ff.
- HOROSZEWICZ L. 1960. Wartość kości gardłowych dolnych (ossa pharyngea inferiora) jako kryteriów gatunkowego oznaczania ryb karpowatych (*Cyprinidae*). Roczn. Nauk roln. Warszawa, **75-B-2**: 237–258, 35 ff., 2 tab.
- JENKINS R. E. and E. A. LACHNER. 1971. Criteria for Analysis and Interpretation of the American Fish Genera *Nocomis* GIRARD and *Hybopsis* AGASSIZ. Smithson. Contr. Zool., Washington, No. 90; 1–15, 3 tables.
- JORDAN D. S. and B. W. EVERMANN. 1896. The Fishes of North and Middle America. Bull. U. S. nat. Mus., Washington, No. 47, part I: LX + 1–1240.
- KRYŽANOVSKIJ S. G. 1949. Ekologo-morfologičeskie zakonomernosti razvitija karpovyh, vjunovyh ryb (*Cyprinoidei* i *Siluroidei*) Trudy Inst. Morf. Živ., Moskva-Leningrad. vyp. 1: 5–332, 100 ff., 93 tb.
- LAGLER K. F. 1947. Lepidological Studies. 1. Scale Characters of the Families of Great Lakes Fishes. Trans. Amer. micr. Soc., Lancaster, **66**: 149–171, 7 plates.

PLATE I



Figs. 1-4. Scales. 1 - *Abramis brama*, about $5\times$; 2 - *Notemigonus crysoleucas*, about $15\times$; 3 - *Abramis ballerus*, about $6\times$; 4 - *Abramis sapa*, about $7\times$. Phot. T. Plodowski.

PLATE II

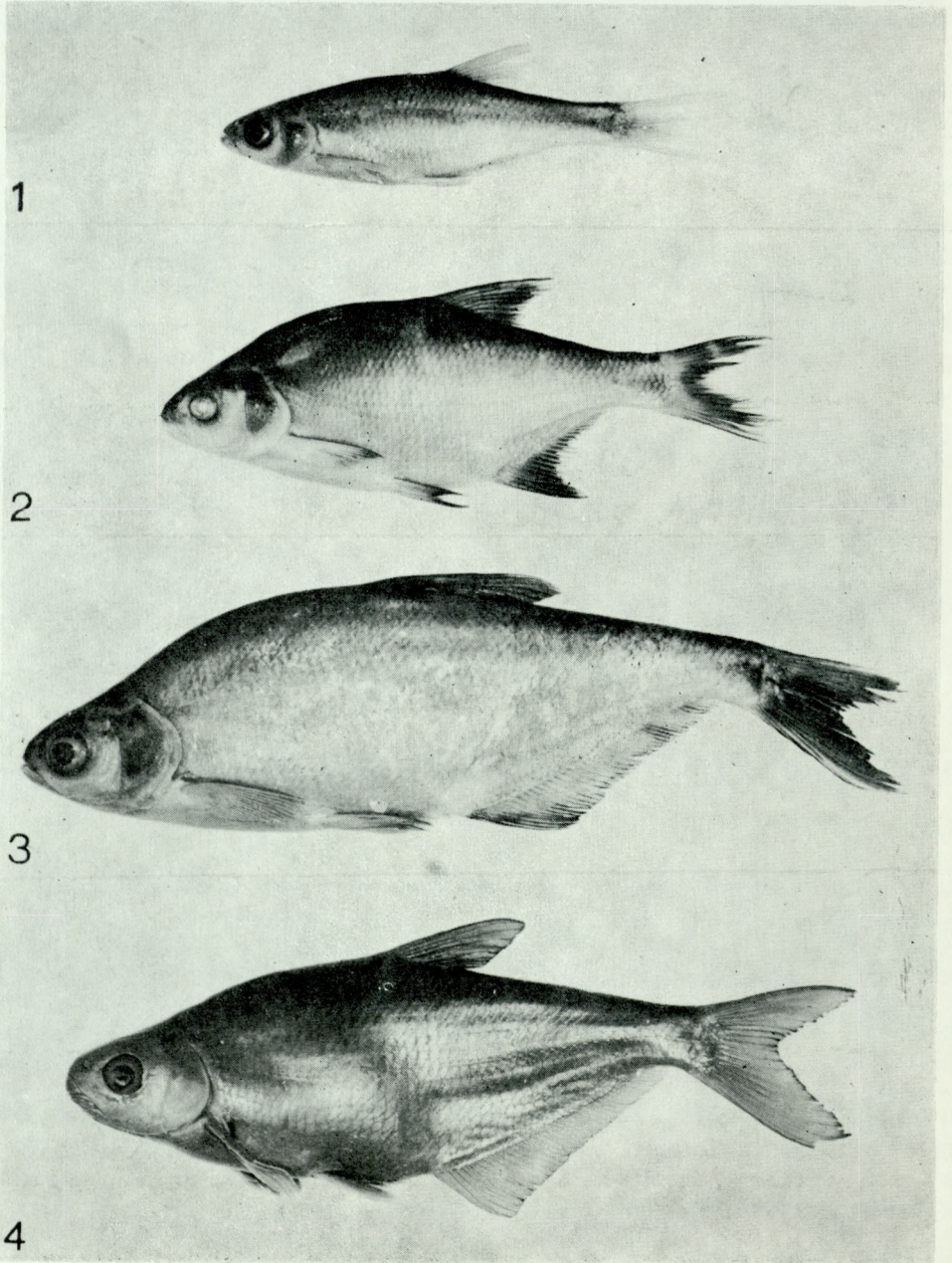


Fig. 1 - *Notemigonus crysoleucas*, 2 - *Abramis brama*, 3 - *Abramis ballerus*, 4 - *Abramis sapa*. Phot. T. Płodowski.

- LIEPPMAN M. and C. HUBBS. 1969. A Karyological Analysis of two Cyprinid Fishes, *Notemigonus crysoleucas* and *Notropis lutrensis*. Texas Rep. Biol. and Medic., Austin, **27**: 427-435, 4 ff.
- MCPHAIL J. D. and C. C. LINDSEY. 1970. Freshwater Fishes of Northwestern Canada and Alaska. Bull. Fish. Res. Bd. Can., Ottawa, **173**: 381 pp.
- MILLER R. R. 1958. Origin and Affinities of the Freshwater Fish Fauna of Western North America. Publ. Amer. Ass. Advanc. Sci., Washington, **51**: 187-222, 19 ff.
- MILLER R. R. 1976. An Evaluation of Seth E. MEEK's Contributions to Mexican Ichthyology. Fieldiana Zool., Chicago, **69**: 1-31.
- NELSON E. M. 1949. The opercular series of the *Catastomidae*. J. Morph., Philadelphia, **85**: 559-569, 2 ff.
- NELSON J. S. 1976. Fishes of the World. New York-Toronto. V-XIII + 1-416 pp., 45 maps.
- NIKOLSKIJ G. V. 1954. Časťnaja Ihtiologija. Moskva. 458 pp., 310 ff.
- RAMASWAMI L. S. 1955. Skeleton of Cyprinoid Fishes in Relation to Phylogenetic Studies. 6. The Skull and Weberian Apparatus in the Subfamily *Gobioninae* (*Cyprinidae*). Acta Zool., Stockholm, **36**: 127-158, 15 ff.
- RASS T. S. 1971. Žizn Životnyh. Ryby. Moskva, **4**, 655 pp., 221 ff., 54 plates.
- UYENO T. 1960. Osteology and phylogeny of the American cyprinid fishes allied to the genus *Gila*. Univ. Mich. Micr. Mic., Ann Arbor, Mich. **174** pp., 10 ff., 35 plates.

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STRESZCZENIE

[Tytuł: Osteologiczne i morfologiczne dowody na brak bliskiego pokrewieństwa między rodzajami *Abramis* CUV. i *Notemigonus* RAF. (*Pisces*, *Cyprinidae*)]

Opierając się na jednej cesze: kil na brzuchu za płetwami brzuszными nie pokryty łuską, upatrywano bliskie pokrewieństwo (rodzaj i podrodzaj) między eurazjatyckim rodzajem *Abramis* i amerykańskim *Notemigonus* (JORDAN i EVERMAN 1896; NIKOLSKIJ 1954). Jednakże osteologiczne badania czaszki obu rodzajów, jak też budowa niektórych narządów wewnętrznych (pęcherz pławny) oraz budowa łusek, wskazują na brak bliższego pokrewieństwa. Jak wynika z analizy porównawczej, są to dwa dobre rodzaje należące do podrodziny *Leuciscinae*. Ich wspólna cecha — charakter kila — rozwinęła się konwergencyjnie w wyniku procesu oddziaływania środowiska na organizm podczas jego historycznego rozwoju w podobnych ekologicznie warunkach środowiska Eurazji i Ameryki.

РЕЗЮМЕ

[Заглавие: Osteологические и морфологические доказательства отсутствия близкородственных связей между родами *Abramis* Cuv. и *Notemigonus* Raf. (*Pisces*, *Cyprinidae*)]

На основании одного признака „киль на брюхе за брюшными плавниками, не покрытый чешуей” считалось, что между европейско-азиатским родом *Abramis* и американским *Notemigonus* имеются близкородственные связи (род — подрод) (Жордан и Эверман 1896, Никольский 1954). Однако, остеологические исследования черепа обоих родов, а также строения внутренних органов (плавательный пузырь) и чешуи указывает на то, что между ними нет близкородственной связи. Сравнительный анализ показал, что это два хороших рода, относящиеся к подсемейству *Leuciscinae*. Их общий признак — характер киля развился конвергентно в процессе исторического развития в сходных экологических условиях среды Евразии и Северной Америки.

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