STUDY ABOUT THE ONTOGENETIC DEVELOPMENT OF CEPHALIC SENSORY SYSTEM OF *Cottus gobio* Linaeus 1758 (Pisces; Cottidae)

Ilie C. TELCEAN[1], István SAS[1] & Nicoleta R. RADU[2]

[1]University of Oradea, Facultaty of Sciences, Department of Biology,
Str. Univrsităţii nr. 1, Oradea 410087 e-mail: itelcean@uoradea.ro
[2] BSc. Student, University of Oradea, Facultaty of Sciences, Department of Biology

Abstract. The lateral-cephalic channels system of *Cotus gobio* L. was studied for a number of 66 juveniles originated from the upper Tisa River. The topography of cephalic channels system and the number of their opening pores present a lot of similarities between different fishes groups that is close related in their phylogeny. The jointly characters are in fact the results of convergent evolution.

The study on the ontogenesis of cephalic-laterals channels system and its pores at *Cottus gobio* can offer an image on the main stages of their phylogeny. The first channels which are forming are the preoperculo-mandibularis (POM) followed by the infraorbitalis (IO), supratemporalis (ST) and the occipital (OC) channel. The last formed seem to be the supraorbital channels (SO). The main stages of this ontogeny suggest that the sensory channels from the mandible and upper head have the priority in their development. A number of genipores are the forerunner for the cephalic pores. The beginning genipores from the infraorbital and supratemporal cephalic surface are the most similar with those from the Gobiidae fish family. The secondary process in sensory system ontogeny consists in developing of the channel structure. The channels structure development occurred principally in the fresh water fishes it seems to be related with their environment.

The total length of lateral line at the populations of *Cottus gobio* from the upper Tisa River is already complete at the individuals with 35-40 mm standard length. That earliest development of the cannels and its opening pores are distinctive for *Cottus gobio* from the Tisa River system or generally for the entire lower Danube rivers system. The mature individuals have an average number of 30-33 pores on the lateral line. The comparative study of the lateral line lengthiness correlated with the standard length of specimens reveal that the individuals from Tisa River have similarities with the populations of *Cottus gobio* from Czech Republic and from Polish rivers, (based on L. Koli and Witkowski data, 1969, 1995). The number of the pores on lateral line does not increase after that channel reaches the final length.

Key words: *Cottus gobio*, lateral-cephalic sensory system, fish ontogeny

INTRODUCTION

The lateral-cephalic sensory system is present along the aquatic vertebrates starting with Agnates of the Cephalaspidomorphes group till the Chondropterigian and Osteopterigian fishes. The evolutionary trends in that sensorial system are correlated with the improvements on behalf of fishes. The prey detection based on lateral-cephalic sensory system allows more efficiency in prey catching on the predator fishes. As a consequence in many of the fishes species is started the evolutionary process of diversification and specializations of their cephalic sensory systems. *Cottus gobio* is a fresh water representative of Cottidae family, which belongs to the bigger group of Scorpaeniformes fishes. The majority of representatives of Cottidae are marine dweller. *Cottus gobio* is a typical inhabitant in fast running fresh waters and its sensory system contribute to prey detection and to keep away for the other predators or too strong swirl waters. The efficiency of the lateral-cephalic sensory system is the same during the night or in the darken places like in a day lighting conditions.

On despite of their more similar evolutionary history and the analogy of marine environmental conditionality the organization of the sensitive cephalic channels system at Cottidae is different from Gobiidae or other fish families with marine species from the Scorpaeniformes group. For example the species of genera *Neogobius*, *Pomatoschistus* and *Apollonia* present several rows of suborbital and occipital genipores, which are not included in the channels themselves. The species *Pomatoschistus (Bubyr) caucasius* is an inhabitant in the seaside freshwater or brackish lakes. It distinctively present short portion of supraorbital and supratemporal channels. It is possible that the evolution of the circumorbitalis, supratemporalis and occipitals cephalic channels from the species belonging at the *Cottus* type (freshwater exclusively) represents an adjustment to life in fresh waters (lakes and rivers).

The ontogenetic developments of the cephalic channels system include a progressive process of shaping for each channel type. The number of pores that opened in different stages of development is related with the position of these channels in the cephalic surface.

The relation between the lateral line length and its number of opening pores at different age stage was studied by Koli (1969). The results establish that exist a difference in the number of lateral pores from the juveniles specimens originated in different rivers system. *Cottus gobio* from northern Europe show differences between various populations with different geographic locations. The juveniles of *Cottus gobio* from Romanian rivers Dâmboviţa and Argeş present in early stages an increased number of genipores along the lateral line (L. Koli, 1969). The lateral line is completely developed at the specimens with 40 mm in standard length and their pores number is about 30-35.

The observations of the way in which the channels and opening pores are formed on the surface of the tegument during the ontogeny offers possible conclusions about the phylogeny of that sensory system.

MATERIALS AND METHODS

The study of cephalic channels and their opening pores was made on a sample containing 205 individuals of *Cottus gobio* L., originated from Tisa River and its tributary Vişeu. A number of 66 juvenile specimens (with 19-39 mm standard length) were examined for cephalic sensory system ontogeny. The material was collected during the years 1995-2000, from Carpathian Ukraine and the river sector located at the border of Romania.

The specimens over the 40 mm in standard length had all the characteristics of the lateral-cephalic sensory system completely formed and were not included in the juvenile's lot.

The channels and their pores were cleared and stained with black ink. The procedure was to fill in the channels capillary using a micro syringe. In some cases the channels aeration was necessary in order to facilitate the ink's intrusion. Because of the small dimensions of the pores and channels, the coloration and observation of these is realized under the stereomicroscope.

The channels present in the cephalic region of mature individuals are: infraorbital (IO), supraorbital (SO), preoperculo-mandibular (POM), supratemporal (SO) and occipital (OC). We add to these channels the lateral line (LL), situated on the body's sides. The counting of the pores along the channels was made from the anterior cephalic region to the caudal end.

For the young individuals, which have an incompletely developed cephalic system, the channels or their first formed portions were examined, as well as the tegument's formations that precede the structures of the sensory channels.

RESULTS AND DISCUSSIONS

During the development of the lateral-cephalic sensory system at *Cottus gobio*, the first to form are the cephalic channels, followed by the lateral line. The priority in the development of some channels as opposed to others might be caused by the importance that these have for the individuals' orientation in their first developmental stages.

The sensitive structures that precede the deveopment of channels resemble some unpigmented spots or a pits that sink into tegument. Their aspect reminds of the Gobiidaes' genipores. In very young stages before they reach the age of one year, and 19-24 mm in standard length, the cephalic channels are incompletely developed.

At the infraorbital channels' area (IO), where the properly pores will be formed, there are present several circular unpigmented spots covered by mucus (fig.1). When the first infraorbital pores appear, they are doubled by unpigmented spots which disappear at more developed stages.

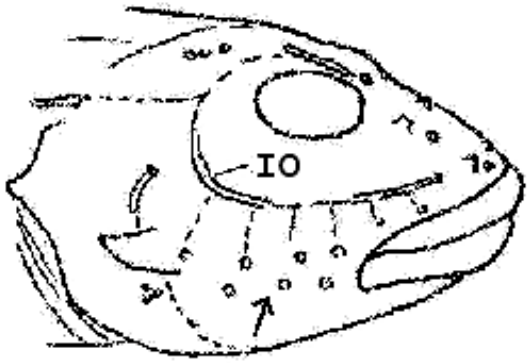

Fig. 1. The infraorbital (IO) channel in the first stages of development of *Cottus gobio* L.
The arrow point to unpigmented tegument's pits with mucus that precede the pores sensory structure.

The tegument deepens in the channels' precursory structure, then the pores appear and the channel's lumen is formed. There exists a tegument's invagination process. The first channels formed are the preoperculo-mandibularis (POM). The pores from the mandibles have a bigger diameter than the channel's lumen in the first stages. The infraorbital, supratemporal, occipital and supraorbital channels are forming in the next stage. In the supratemporal (ST) cephalic surface the apparition of several pairs of unpigmented dips can be observed in the beginning. These disappear after the pores are formed (Fig. 2).

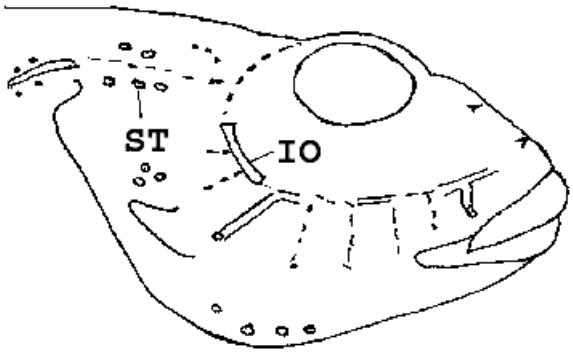

Fig. 2. The ST channel in the pre-developmental stage of *C. gobio.*
ST and IO are abbreviating names of the channels.

The different cephalic channels are joined but it was not possible to emphasize it in the studied material.

The development of the lateral-cephalic sensitive channels in the stages between 40-45 mm lengths:

In this stage all the sensory cephalic system's channels have already been developed, and the lateral line (LL), can still present small portions where the pores are not entirely opened.

The IO channel has the terminal pores already formed (the pores number 8 and 9).

The POM channel has the pores number 1-3 well developed and they have a bigger opening comparing to those of the other channels. The pores disposed in pairs (4-5) appear when the channels are completely formed.

The SO channel is already completely developed in the case of the individuals with 34 mm in standard length. The coronary pore, situated at SO intersection in the inter-orbital space is also visible.

The OC channel is fully developed. Sometimes some unpigmented spots that double the pores from the ends of this channel (fig. 3) are also visible.

The ST channel has all the pores formed. There are still some unpigmented spots deepened into the tegument near the suborbital spike. Sometimes there are 3 such spots disposed in line, near the intersection of the ST and SO channels, on each side of the head and which are also kept in mature stages (Fig. 4)

The LL channel is the only one who continues the developing of their pores in the final stage. The direction in which the lateral line is developed is from head to tail. The way in which the lumen of this channel is formed is different from that of the other cephalic channels. In the undeveloped area, it looks like an unpigmented ditch which in some places has the structure of a channel (Fig. 4). It seems that the appearance of this channel's lumen is due to a rising process of the tegument in the area of the formed ditch and to the appearance of the pores at the end of the process.

The fully developed lateral-cephalic sensory system contains the following channels and connections (fig. 5):

- The supraorbital channel (SO) - begins before the anterior nasal opening and continues above the orbits up to the postorbital region, where it is connected to the infraorbital and supratemporal channels. The two supratemporal channels (left and right) are interconnected between the two orbits, where a coronary pore exists. There are 3 pores (exceptionally a number of 4 pores) on each supraorbital channel, the first being always near the anterior nasal opening, the second between the nasal openings, and the third in the interorbital space, a bit anterior to the coronary pore.

- The infraorbital channel (IO) is situated below the orbit, having the anterior end situated under the anterior nasal opening, where it is not connected to the supraorbital channel. There are 8 or 9 pores on this channel and are opening at the end of their own short arms. The channel connects with the supratemporal and supraorbital channels behind the orbits.

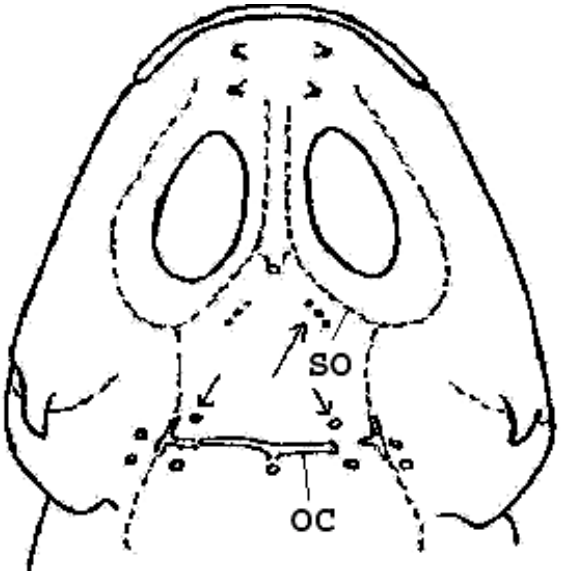

Fig. 3. Dorsal view of the occipital channel in incipient stage.
The arrows point to the unpigmented spots near the occipital and supraorbital channels.

- The preoperculo-mandibular channel (POM) is situated along the mandibular arch, from where it continues in the preopercular area, above the infraorbital spike, and does not connect to the other channels. The two branches from the left and right sides of the mandible are interconnected at the symphysal pore level. Most of the individuals have 10 pores on each branch and only one symphysal pore. The pores 4 and 5 are disposed in pair at most of the individuals.

- The supratemporal channel (ST) is short and situated above the operculum. The anterior part is connected with supraorbital and infraorbital channels (behind the orbit) and the posterior part continues with the lateral line. There are 3 or 4 pores when the first pore is situated very close to the connection point with the infraorbital channel.

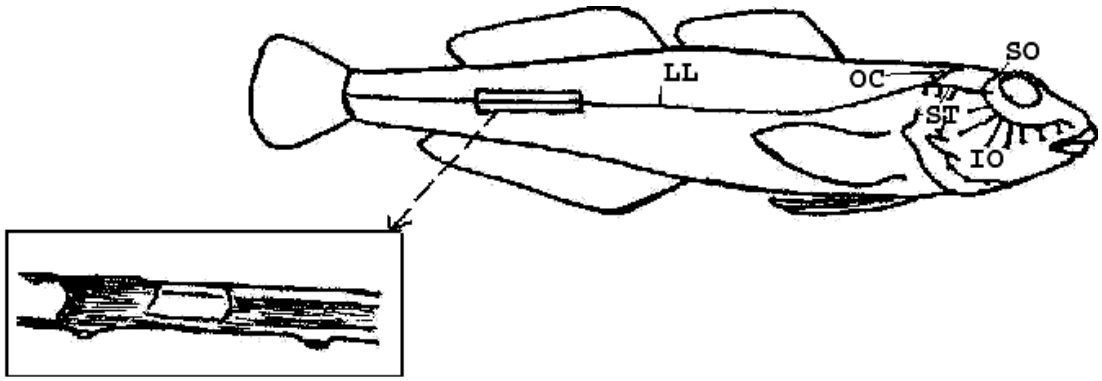

Fig. 4. Lateral view of sensitive system and the lateral line channel of *Cottus gobio*
(details of the channel lumen development).

- The occipital channel (OC) is only one and bounds transversally the two supratemporalis channels (commissural channel). Through this, it interconnects the two branches (left and right) of the lateral-cephalic system, excepting the preoperculo-mandibular channels.

- The lateral line's channel (LL) continues the supratemporal, starting after the opercula opening. At the fully developed individuals, the lateral line has from 30 to 32 pores and reaches to the base of the caudal fin.

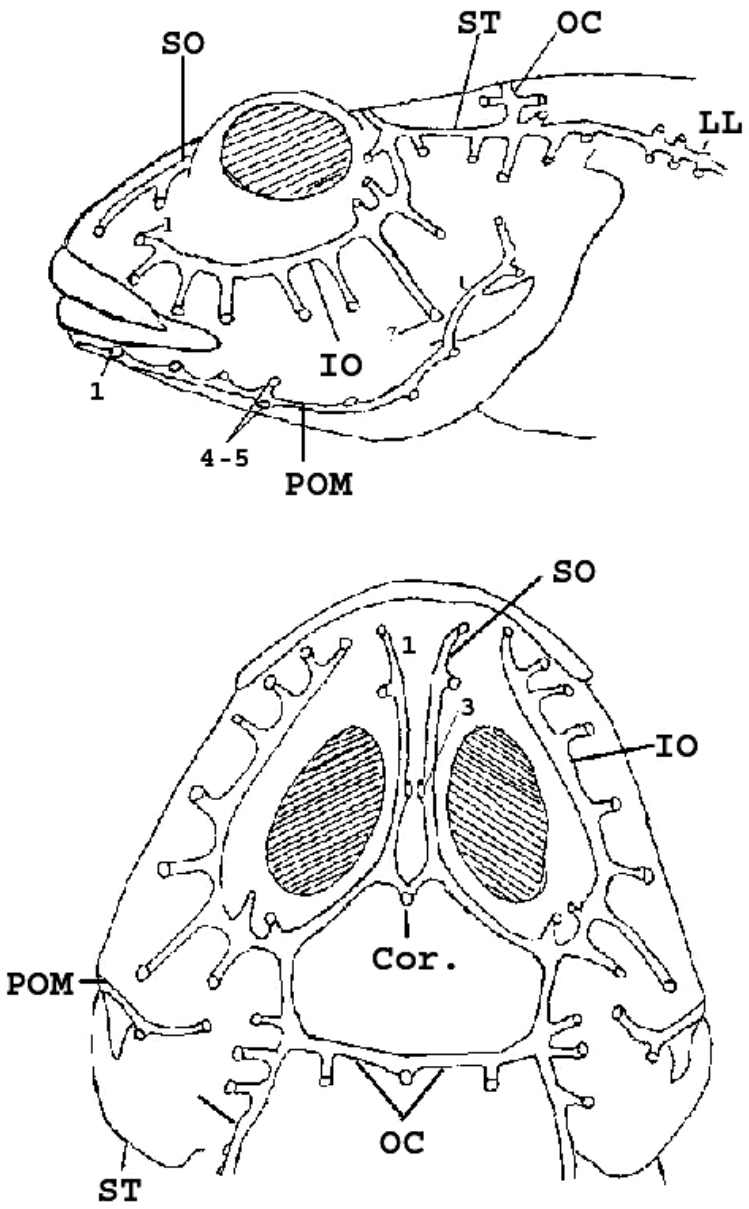

Fig.5. Cephalic channels of *Cottus gobio* L.-lateral view. SO, ST, OC, IO, LL, is the channels names abbreviations. Cor. =coronary pore. The number are indicated the pores openings.

The development of the lateral line and its geographic variability

The studies about the European populations of *Cottus gobio* L. (L. Koli, 1969; A. Witkowski, 1979, 1995), revealed the existence of a geographic variability regarding the number of pores on the lateral line. The two European forms, *Cottus gobio gobio* and *Cottus gobio koshewnikowi*, differ by the length of the lateral line and the presence or the absence of tegumentary prickles. The typical form of *Cottus gobio koshewnikowi*, spread in Eastern Europe, has a shorter lateral line (it doesn't reach the caudal fin); it has fewer pores and presents a lot of tegumentary prickles. The Western European subspecies *Cottus gobio gobio* has a complete lateral line, with a bigger number of pores and unpicked tegument. The European populations, with few exceptions, present intermediate morphological characters if reported to these two formes. This is due to the secondary intergradations of the two subspecies in the postglacial period. The populations from Holland have a complete lateral line and a lot of tegumentary prickles. In the hydrographic basins from Poland both forms could be found. Southward, the basins of the Oder, Vistula, Elba and Danube rivers are

populated with the western form, (*C. gobio gobio*) with the complete lateral line, and in the north-east there are different hybrid forms morphologically close to *Cottus gobio koshewnikowi*.

Our research made on material from the upper Tisa revealed the fact that mature individuals of *Cottus gobio* have the lateral line completely developed and present an average of 30-33 pores. The characters of the lateral line and the lack of tegumentary prickles indicate that they belong to the *Cottus gobio gobio* subspecies. As far as the number of pores is concerned, if we compare it to that of the individuals from Poland, we can observe a small number (an average of 32-33 as opposed to 35). The individuals from Poland Rivers with 33-34 pores have a complete lateral line and a prickled tegument which makes them different from those from Tisa, with a nude tegument. This probably happens because of the West European origin of the populations from Tisa River.

The study of the lateral line's development degree, comparing with the individuals' standard length indicates geographical differences (L. Koli, 1969). Individuals from Sweden, with a standard length of 30 mm, have the lateral line incompletely developed, and only 10-13 pores along it. These are immature until they became 50 mm standard length. Individuals from the Elba basin present a large variability; one can find individuals of 25 mm standard length, having 16 pores and incomplete lateral line, and also individuals with 26-28 pores and 43-47 mm standard length. All these populations have a completely developed lateral line only when they reach 50 mm in standard length.

Individuals from Tisa and other rivers from our country present a complete development of the lateral line, starting with 35-40 mm standard length. In most of the cases, the number of the pores is complete after the lateral line reaches the caudal fin's base. The number of pores is not completed as they grow in length till they reach sexual maturity. It is possible that this phenomenon could be caused by geographical position in the southward region of the species area. The Southern populations of the species have a higher rhythm of development.

CONCLUSIONS

The first channels of the lateral-cephalic sensory system which start to develop are the cephalic ones, followed by the lateral line. Their development takes place in the order of their importance for the orientation of the fishes. The POM channel is the first, followed by IO, ST and OC channels. The last developing channel seems to be SO (especially its pores).

The sensory structures which precede the development of cephalic pores and channels are different from those of the lateral line. In the cephalic surface are developing tegumentary ditches and pits with mucus situated in some cases in a row or in pairs.

The development of the lateral line takes place from the cephalic region to the caudal end. The sensory structures which are formed before have the aspect of an unpigmented line. Above this line is forming the lumen of the channel itself.

The immature individuals (juveniles) of the species *Cottus gobio* from the Tisa River have an incomplete lateral line with 25-28 pores and their standard length is of 28 mm. The individuals with 40 mm standard length have all the sensitive system's characters developed.

The *Cottus gobio* populations from the Tisa River are very similar from the point of view of the latero-cephalic sensitive system morphology with the other central-European populations of this species. The number of the pores is already complete when the lateral-line channel reaches the base of the caudal fin. No supplementary pores add on this channel after the complete development.

REFERENCES

Andreasson, A., 1969: Hybridis between Cottus gobio L. and Cottus poecilopus Heck. Faune och flore, 6: 42-51.

Bailey, M., Bond, E., 1963: Four new species of freshwater sculpins genus Cottus, From western north America, Occasional papers of the Museum of Zoology. University of Michigan, 634:1-25.

Bailey, M., Fitzgibbon, Dimick, M.,1949: Cottus Hubbsi, a new Cottid fish from the Columbia river system in Washington and Idaho, Occasional papers of the Museum of Zoology. University of Michigan Press. 513:1-19.

Bănărescu, P.,1963: Date biometrice şi sistematice asupra genului Cottus (Pisces,Cottidae) în R. P. R. 2: 119-134.

Bănărescu, P., 1964: Pisces-Osteichthyes. Fauna R. P. R. 13, Edit. Acad. Rom., Bucureşti.

Bănărescu, P., 1973: Principiile şi metodele zoologiei sistematice, Ed. Acad. R. S. R., p 219

Bogutskaya, N., G., 1988: Canal Topography of the Seimosensory System of the Subfamilies Leuciscinae, Xenocyprininae and Cultrinae. Voprosy Ikhtiologii, 28(4):91-105.

Gosline, W., A., 1974: Certain Lateral-Line Canals of the Head in Cyprinid Fishes with Particular Reference to the Derivation of North American Forms. Japanese Journal of Ichthyology 21.1:9-14.

Hosoya, K., 1986: Interrelationships of the Gobioninae (Cyprinidae) , Ichthyological Society of Japan, Tokyo.484-501.

Koli, L., 1969: Geographical variation of Cottus gobio L. (Pisces, Cottidae) in Northern Europe. Ann. Zool. Fennici 6: 353-390.

Oliva, O., Hensel, K., 1961: Studies on Sculpins (Cottus gobio L.) from the River Pruth. Acta Societatis Zoologicae Bohemslovenicae. Prague.26.3:244-249.

Takagi, K., 1988: Cephalic Sensory Canal System of the Gobioid fishes of Japan: Comparative Morphology with special reference to philogenetic significance, Journal of the Tokyo University of Fisheries, 75.2:499-568.

Telcean, **I.,** 1998, -"Aspecte ale variabilităţii topografice a sistemului senzitiv latero-cefalic la *Cottus gobio* L. (Pisces, Cottidae) din bazinul Someşurilor". Analele Univ. din Oradea, Fascicula de Biologie, Tom.V, pp. 101-114, Ed. Univ. Oradea.

Telcean, I., 1999 -"Cercetări asupra sistemului senzitiv latero-cefalic la *Cottus gobio* L. (Pisces, Cottidae),din bazinul Mureşului". Analele Univ. din Oradea, Fascicula de Biologie, Tom.VI, pp. 101-114, Ed. Univ. Oradea.

Telcean, I., 2000 –"Organizarea sitemului senzitiv latero-cefalic la *Cyprinus carpio* şi *Tinca tinca* (Pisces, Cyprinidae)". Analele Univ. din Oradea, Fascicula de Biologie, Tom.VI, Ed. Univ. Oradea.

Telcean. I., 2000, -"Topografia sistemului senzitiv latero-cefalic la *Rhodeus sericeus amarus* (Bloch 1782), (Pisces, Cyprinidae)". apărut în "Învăţământul Universitar din Moldova la 70 ani", vol. 2. Chişinău.

Witkowski, A., 1979: A taxonomic study on fresh-water Sculpins of genus Cottus Linnaeus, 1758 (Cottus gobio L. and C. poecilopus Heck) in Poland. Acta Universitatis Wratislaviensis, Prace Zoologiczne 458.10. Wydawnictwa Universytetu Wroclawskiego- Wroclaw.

Witkowski, A., 1984: Morphological variability in lake and river populations of Cottus poecilopus Heck.(Pisces, Cottidae) Acta Ichthyologica et Piscatoria, Szecin 14 (1-2).: 43-45.

Witkowski. A., 1995: Phenotypic variability of Cottus gobio L. in Polish waters. (Teleostei: Scorpeniformes : Cottidae) Zoologische Abhandlungen, Staatliches Museum fűr Tierkunde Dresden 12:178-183.