TWO MEDITERRANEAN GOBIID FISHES WITH AN UNUSUAL CEPHALIC LATERAL LINE CANAL SYSTEM

by

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ABSTRACT. – *Gobius ater* (Belloti's goby) and *G. paganellus* (rock goby) are the only known species of Gobiinae in the northeastern Atlantic, the Mediterranean and the Ponto-Caspian region with continuous oculoscapular canals. These continuous canals are seen as the result of a secondary reconnection of the anterior and posterior oculoscapular canals. *Gobius ater* and *G. paganellus* differ from Pacific species of Gobiinae with continuous oculoscapular canals. The latter have a single pore /^{l} while *G. ater* and *G. paganellus* have pores and ^{l} well separated.

RÉSUMÉ. – Deux espèces de gobies de Méditerranée possédant un système latéral céphalique inhabituel.

Gobius ater (le gobie de Bellott) et *G. paganellus* (le gobie paganel) sont les seules espèces de Gobiinae de l'Atlantique Nord-Est, de la Méditerranée et de la région pontocaspienne présentant des canaux oculoscapulaires continus. Ces canaux sont considérés comme le résultat d'une fusion secondaire des canaux oculoscapulaires antérieur et postérieur. *G. ater* et *G. paganellus* diffèrent des autres espèces de Gobiinae du Pacifique par des canaux oculoscapulaires continus. Les Gobiinae du Pacifique ont un pore unique /^{l} tandis que *G. ater* et *G. paganellus* ont les pores et ^{l} distinctement séparés.

Key words. – Gobiidae - *Gobius ater* - *Gobius paganellus* - MED - Cephalic lateral line system - Head canals.

The cephalic canals of the lateral line system in Gobiidae (*sensu* Pezold, 1993) are characteristically developed with the anterior oculoscapular, posterior oculoscapular and preopercular canals present (Sanzo, 1911; Miller, 1986). This canal system may be reduced or lost in some gobiid genera and species. These three cephalic canals are each separated from the two others in most gobiids, a character state derived from a continuous head canal system as seen in percomorph fishes with supraorbital, postorbital and infraorbital canals connected by anastomosis (Miller, 1973; Akihito *et al.*, 1984). In the Gobiidae, species in at least nine genera show a continuous oculoscapular canal, but most of them are Gobionellinae and Sicydiinae (Harrison, 1993; Parenti and Maciolek, 1993; Pezold, 1993; Shibukawa and Iwata, 1998).

In the Gobiinae (*sensu* Pezold, 1993) the anterior and posterior oculoscapular canals are generally separated from each other by a gap (summarized in Pezold, 1993, table 2). This situation seemingly is derived from the loss of a connection between these oculoscapular canals (Miller, 1973; Akihito *et al.*, 1984; Akihito, 1986, fig. 2, 632; Takagi, 1988, fig. 1, 508).

Species in the genus *Gobius* typically exhibit three cephalic canals including the fused interorbital section of the anterior oculoscapular canal characteristic of gobiines (Miller, 1986; Pezold, 1993, fig. 1). In this paper I describe a continuous oculoscapular canal observed in

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two species of *Gobius*, *Gobius ater* Bellotti, 1888 (Bellotti's goby) and *Gobius paganellus* L., 1758 (rock goby). This condition is rare within the Gobiinae and, to date, not known from a gobiid of the northeastern Atlantic, the Mediterranean and the Ponto-Caspian region. Both species also share a short side branch from the oculoscapular canal along lower edge of the orbit terminating with pore □, a feature not known from other gobiids of this geographic region (Miller, 1986).

MATERIAL, METHODS & ABBREVIATIONS

The following preserved specimens were examined (sampling site, number of specimens, sex, standard length□+□caudal fin length in mm (d□=□damaged caudal fin), collection number, type status, acquisition or date, collector).

Gobius ater

France.□Nice. Two males, 51.4+11.7 and 53.7+13.5, NMW 28551 - 28552, syntypes, acqu. 1888 14; One male, 49.4+11.7, NMW 29041, syntype, acqu. 1888 14a; all Coll. Bellotti; Two females, 47.1+10.8 and 56.3+11.8, seven males, 39.1+d - 58.8+12.8, 19 July 1898, Coll. Bedriaga.

Croatia.□Spalato [Split]. Three males, 47.1+11.8 - 59.4+12.7, NMW 28572 - 28574, acqu. 1890 48, Steindachner, Kolombatovic. Previously not recorded for the Adriatic Sea (Gramitto, 1993).

Gobius paganellus

Italy.□Trieste. Two females, 86.5+19.5 and 86.7+19.6, one male, 99.4+20.2, NMW 29828 - 29830, 24-30 Dec. 1880, don. Steindachner; Porto Fino (south of Genova), two females, 71.9+16.5 and 77.7+17.5, five males, 79.4+18.2 - 82.9+19.2, NMW 80592, 1953?, König; NE Elba, Golfo della Biodola, four males, 41.5+19.2 - 96.7+22.8, 6-10 Oct. 1984, NMW 84937, leg. K. and H. Ahnelt; NE Sardinia, Baja Sardinia, one female, 76.9+17.5, IZUW 1990/49, 19-21 Sep. 1990; leg.□?

Croatia.□Lesina [Hvar]. Three males, 69.7+14.7 - 70.9+15.5, NMW 30585 - 30587, acqu. 1-2 Aug. 1900 3e, Coll. Bucchich.

Slovenia.□Capodistria [Izola]. Two males, 75.3+16.8 and 77.8+17.9, IZUW 2000/2, July 1916, leg.□?; Rovinj, Isola Rossa, one female, 57.6+11.9, IZUW 1992/7, 1989, leg. ?

Spain.□Balearic Islands, Ibiza, Portinatx. One male, 67.8+15.5, Sept. 1993; one juvenile, 32.9+7.2, IZUW uncatalogued, Aug. 1991, R.A. Patzner.

France.□Banyuls-sur-Mer. Two males, 56.9+13.4 and 62.4+13.7, two females 49.1+10.3 and 86.2+19.8□mm, IZUW uncatalogued, May 1995; Ille Grosse, two males, 42.5+10.6 and 53.0+13.2, one female, 40.8+10.2, IZUW uncatalogued, Sep. 1992, R.A. Patzner.

Gobius niger

Croatia.□Krk, Punat. One male, 77.2+18.6, one female, 52.8+12.9, IZUW 2000/3: 1-2, date□?, leg.□?

In the Gobioid classification I follow Pezold (1993). Terminology for the lateral line system follows Miller (1986), based on Sanzo (1911). Pores are marked with greek lettering. I injected air in the oculoscapular canal and reinjected ethanol in the empty canal to test its continuity.

IZUW, Institut für Zoologie, Universität Wien; NMW, Naturhistorisches Museum Wien.

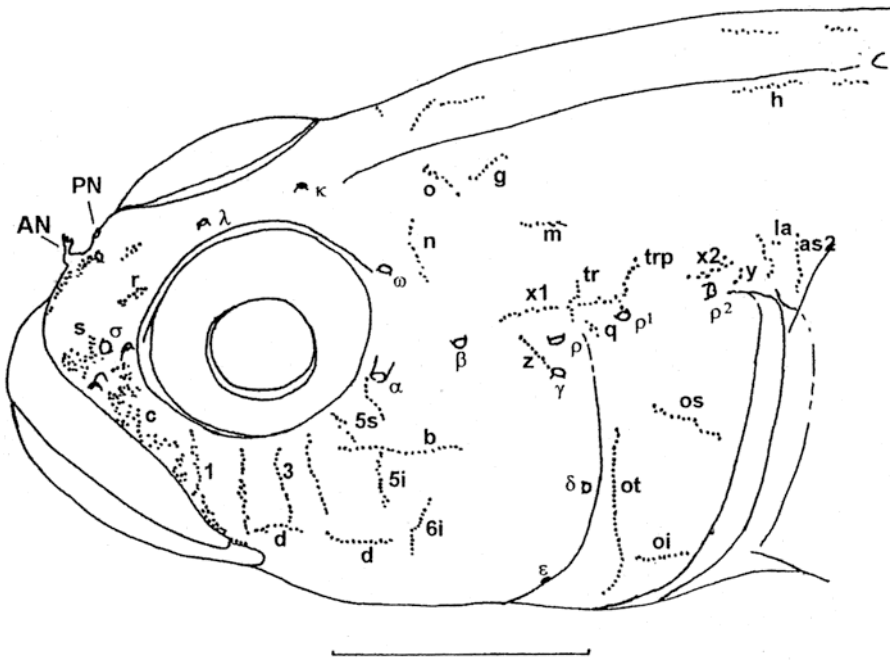

Fig. 1. *Gobius paganellus*. Lateral line system of the head in dorso-lateral view (pores = Greek letters). Male, 67.8+15.5 mm, Balearic Islands, Ibiza; AN, PN, anterior and posterior nostrils. Scale bar = 3 mm.

RESULTS

Head lateral line system

Sensory papillae (free neuromasts) and cephalic lateral line canals are present in *Gobius ater* and *G. paganellus* (Fig. 1).

Sensory papillae

For both species as in Miller (1984, figs 7, 16a; 1986, 1036, 1044); "transverse" (vertical) type of suborbital papillae rows (Miller, 1986). Specimens of *G. ater* in poor condition with sensory papillae of the lateral line system hard to detect, but arrangement of oculoscapular series of sensory papillae as in *G. paganellus*. In the following I refer to the sensory papillae of *G. paganellus* along the course of the horizontal postorbital canal (oculoscapular rows of neuromasts) only.

Oculoscapular

Five transversal (**z**, **q**, **tr**, **trp** and **y**) and two longitudinal (**x1** and **x2**) rows; row **u** absent. Row **z** ending close to and anterior to dorsal pore ( ) of the preopercular canal; **x1** long, divided by **tr**, anteriorly reaching over rear of cheek, posteriorly ending close to or at pore ρ^1; **x2** short, above dorsal edge of opercle; **y** vertical and immediately posterior to **x2**, close to ρ^2; **q** and **tr** posterior and near to pore , former extending ventral to oculoscapular canal, latter dorsal to it; **trp** immediately posterior **x1** and dorsal to pore ρ^1; axillary series **as** and **la** are not discussed here.

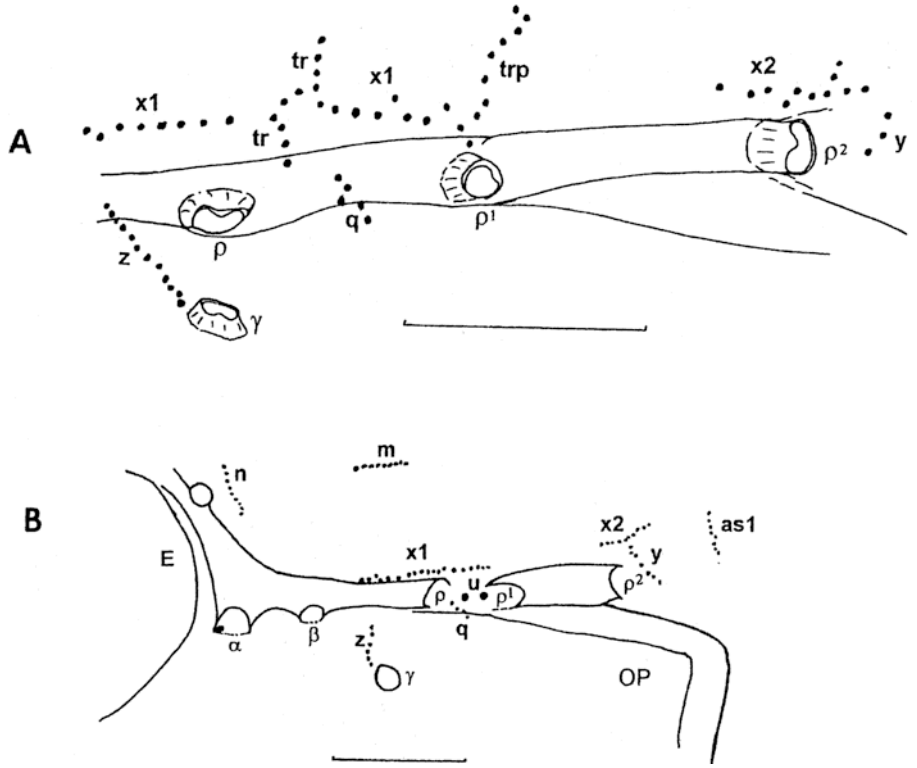

Fig. 2. **A**: *Gobius paganellus*. Posterior part of continuous oculoscapular canal with pores (greek letters) and adjoining sensory papillae. Male, 67.8+15.5 mm, Balearic Islands, Ibiza. β = pore at origin of preopercular canal. **B**: *Gobius niger*; IZUW 2000/3. Posterior part of anterior and posterior oculoscapular canals with pores (greek letters) and adjoining sensory papillae. Female, 52.8+12.9 mm, Adria, Island of Krk. Note gap between ρ and ρ¹ = oculoscapular groove with two longitudinaly arranged replacement neuromasts (**u**). β = pore at origin of preopercular canal; E = eye; OP = rear dorsal corner of opercle. Scale bars = 2 mm.

I follow Sanzo (1911; 319-320; tab. 12, fig. 39) and distinguish between two transverse rows posterior and close to pore ρ, **q** and dorsal to it **tr** (latter unnamed by Sanzo (1911)). In gobies of the northeastern Atlantic and the Mediterranean with suborbital papillae transversly arranged, row **q** seemingly does not extend above **x1** (compare figures in Miller, 1986; Kovacic and Miller, 2000). Two transverse rows (**tr**, **trp**) between pores ρ and ρ¹ and both extending above **x1** is unique in the species of the genus *Gobius*, as already mentioned by Sanzo (1911), occurring only in *G. ater* and *G. paganellus*. In species with anterior and posterior oculoscapular canals and a transversal row close to or dorsal to pore ρ¹ (*Mauligobius maderensis* (Valenciennes in Cuvier and Valenciennes 1837) and *Zebrus zebrus* (Risso, 1826)) no transversal row is found dorsal to row **q** (Sanzo, 1911; Miller, 1977, 1984).

Head canals

For both species (Figs 1, 2A): oculoscapular and preopercular canals developed; oculoscapular canal continuous, not divided into anterior and posterior parts; supraorbital canals with a pair of nasal pores (pore α) and a single, unified interorbital section with one median anterior interorbital pore (pore δ) (Type III of Takagi (1988)).

Oculoscapular canal with seven paired and two single pores (terminology of Akihito (1986) in parentheses): □ (B'), □ (C) single, □ (D) single, □ (E), □ (F), □ (G), □ (H), □[1] (K) and □[2] (L'); supraorbital canal with terminal pore □ from the snout at height of the posterior nostril, extending posteriorly between the eyes and ventrally along the posterior edge of the orbit to pore □ located on a short side-branch along the ventral edge of the orbit; interorbital sections fused, with interorbital pores □ and □ single; postorbital canal from posterior border of orbit extending posteriorly, dorsal to cheek and opercle, from pore □ to terminal pore □[2]; pores □ and □[1] well separated and section between these two pores not replaced by sensory papillae; pore □ opens ventral, pore □[1] postero-ventral (rarely lateral) and the terminal pore □[2] rearwards; in all specimens the pores are located on short tubes, most distinct in □[2] (Fig.□A). Preopercular canal with three pores: □(M'), □(N) and □(O').

In species of the genus *Gobius* and related genera (e.g. *Thorogobius*, *Zebrus*) with the oculoscapular canal separated into anterior and posterior parts, the pores □ and □[1] open posteriorly and anteriorly respectively and an oculoscapular groove extends between the two canals; in the species of the genus *Gobius*, row **q** originates anteriorly in this groove followed usually by a few neuromasts in longitudinal arrangement (Miller, 1974, fig.□; 1984, figs□, 4; Kovacic and Miller, 2000, fig.□) (*G.□iger*, Fig.□B); these usually large papillae are primary replacement neuromasts and represent row **u** (Sanzo, 1911; Wongrat and Miller, 1991). Due to a continuous oculoscapular canal such replacement neuromasts are not developed in *G.□ater* and *G.□aganellus*.

DISCUSSION

In almost all species of the Gobiinae with cephalic oculoscapular canals these canals are separated by a shallow oculoscapular groove into anterior and posterior oculoscapular canals (Akihito and Meguro, 1980; Akihito, 1986). With continuous oculoscapular canals, *G.□ater* and *G.□aganellus* are unique among the gobiid fishes of the northeastern Atlantic, the Mediterranean and the Ponto-Caspian region (Sanzo, 1911; Iljin, 1930; De Buen, 1931; Berg, 1949; Miller, 1986).

A continuous oculoscapular canal in species of the Gobiinae is considered to be a secondary reconnection of the anterior and posterior oculoscapular canals (Akihito, 1986). This is seemingly also the case for *G.□ater* and *G.□aganellus*. As in all Gobiinae with continuous oculoscapular canals (Pezold, 1993) both species lack supratemporal pores (I, J of Akihito (1986)) between □ and □[1]. Nevertheless, the situation in *G.□ater* and *G.□aganellus* differs distinctly from those of the western Pacific gobies *Bathygobius cotticeps* (Steindachner, 1879) and *B.□yclopterus* (Valenciennes *in* Cuvier and Valenciennes, 1837) (Akihito and Meguro, 1980; Akihito, 1986; Takagi, 1988). While in these two species of *Bathygobius* the anterior and posterior oculoscapular canals are fused with a single pore (□/□[1]), in *G.□ater* and *G.□aganellus* the pores □ and □[1] are well separated from each other (Sanzo, 1911; Miller, 1984, 1986) thus retaining five pores in the horizontal postorbital course instead of the four seen in both *Bathygobius* species (Akihito and Meguro, 1980, fig.□, 217; Akihito, 1986, fig.□, 632). The orientation of these pore openings also differ for *G.□ater* and *G.□aganellus* from the typical gobiine condition. Gobies with disjunct oculoscapular canals have posterior (□) and anterior (□[1]) pore openings while the two *Gobius* species have ventral (□) and postero-ventral (□[1]) pore openings (Fig.□A).

These novel configurations of pores □ and □[1] undoubtedly contributed to the continuous oculoscapular canal being overlooked in previous studies of these gobiids.

Sanzo (1911; plt. 12, fig. 319; 319-320) figured the cephalic lateral line system for *G. paganellus* (*G. ater* was not included in his study) with openings of pores α and α^1 turned ventrally as described here, but failed to realize that the canal is continuous between these two pores. Cavinato (1952, fig. 10A; 195, 203) mentions that contrary to other species of the genus *Gobius* he investigated, pores α, α^1 and α^2 of *G. paganellus* are completely round, but he also assumed a separation of the anterior and posterior oculoscapular canals. Miller (1984, figs 7, 16a; 377, 408-409) describes the cephalic lateral system of adult and juvenile specimens of the rock goby with "postorbital anterior and posterior oculoscapular canals well separated…" Pezold (1993) similarly interpreted the canal structure in two species of *G. paganellus* (Pezold, pers. comm.).

It should be mentioned that in two gobies from the NE Atlantic and the Mediterranean the anterior and posterior oculoscapular canals are separated only by a short oculoscapular groove: *Gobius cruentatus* Gmelin, 1789 and *Mauligobius maderensis* (Valenciennes *in* Cuvier and Valenciennes, 1837). The former resembles type B of Akihito (1986) with pores α and α^1 separated but close together (Sanzo, 1911; tab. 10, figs 26-27; De Buen, 1931; figs 13-14), and the latter type C with these pores contiguous (Miller 1984; fig. 10, 385, 387). Pezold (1993) interpreted pores α and α^1 as fused from illustrations for these species and convergent with a situation seen in *Bathygobius* (tab. 3, state # 30) (Pezold, pers. comm.). Though the conditions in *G. cruentatus* and *M. maderensis* resemble character state types B and C of Akihito (1986; fig. 3) (a gradual "row" of four types with type A, both canals separated by a distinct gap, to type D, both canals fused) *G. ater* and *G. paganellus* do not exhibit type D (single pore). In both species pores α and α^1 are separated, but the anterior and posterior oculoscapular canals fused.

I cannot explain why in a few species of the Gobiinae the anterior and posterior oculoscapular canals are secondarily reconnected. In almost all gobiines with cephalic canals these two canals are separated. This is accepted as a derived character state in light of the accompanying loss of the supratemporal canal and the supratemporal bones in most Gobioidei (Akihito, 1971). *Gobius ater* and *G. paganellus* are both marine species. The former inhabits lagoons, where it lives among sea grasses, and the latter inhabits intertidal and rocky shores, where it lives under stones and in pools with much weed cover (Miller 1984, 1986). What advantage the reconnection of the anterior and posterior oculoscapular canals could offer in these habitats is not obvious. Associated with the continuous oculoscapular canal is the orientation of the pores α and α^1 compared with other *Gobius* species. In the latter they open congruent to the axis of the canals, in *G. ater* and *G. paganellus* they open downwards. This may cause a change in the sensitivity to water movements, especially in combination with the downward and forward shift of the pore α along the lower border of the orbit.

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