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The free neuromast pattern on the caudal fin of pelagic Gobiidae (Teleostei)

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Abstract

A common character of the lateral line system in transparent pelagic Gobiidae is presented. Nine rows of free neuromasts (sensory papillae) on the caudal fin in derived gobiid fishes seem to be the result of convergent evolution as an adaptation to nektonic life style in pelagic habitats.

Key words: Gobiidae, neuromast pattern

Zusammenfassung

Ein gemeinsames Merkmal des Seitenliniensystems transparenter pelagischer Gobiidae wird vorgestellt. Die Ausbildung von neun Neuromasten- (Sinnespapillen)reihen auf der Schwanzflosse abgeleiteter Gobiiden scheint einen Hinweis auf konvergente Entwicklung in Anpassung an die nektonische Lebensweise dieser Fische im Pelagial darzustellen.

Introduction

The arrangement of the neuromasts on the body of a fish is the primary importance for detecting hydrodynamic stimuli (DIJKGRAAF 1962, COOMBS & al. 1988, WEBB 1989). Therefore the mechanosensory lateral line is not only adapted to the various life styles of fishes (e.g. COOMBS & al. 1988, POPPER & PLATT 1993) but is also closely related to the habitat (HOFER 1907, DIJKGRAAF 1962, DISLER & SMIRNOV 1977, COOMBS & al. 2001; MONTGOMERY & al. 1997). Typically the total number of neuromasts of a fish is some hundreds (CARTON & MONTGOMERY 2004) but it can reach some thousands in gobiid fishes.

Such extremely high numbers of free neuromasts are found in pelagic gobies such as *Aphia minuta* (RISSO 1810) and *Leucopsarion petersii* HILGENDORF 1880 (MORTARA 1918, SCATTOLIN 2003).

Gobiidae also show a high amount of free neuromasts not enclosed in sensory canals on their body surface and on the head. The whole taxon is lacking a lateral line canal on the trunk and displays highly modified cephalic canals in various degrees of reduction up to complete loss of canals. The alignment of the sensory canals and the distribution of sensory papillae (free neuromasts) on the head has been widely used as a feature of taxonomic importance (e.g. SANZO

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1911, ILJIN 1930, MILLER 1986, GILL & al. 1992, LARSON 2001, AHNELT & GÖSCHL 2003). Recently more attention has been paid to the pattern of free neuromasts on body and caudal fin of gobiid fishes (AHNELT & al. 2000, AHNELT & DUCHKOWITSCH 2001, AHNELT & SCATTOLIN 2003, 2005, AHNELT & GÖSCHL 2004). Typically, Gobiidae show a benthic mode of life with nektonic larval and post-larval stages. Some species however have adapted to the pelagic environment and do not descend to a bottom life as adults. Paedomorphic features like high relative eye diameter a transparent body and an oblique mouth are common in pelagic gobies (PILLAY & SAROJINI 1950, IWATA & al. 2001) in adaptation to life in the water column (BRUNELLI & ATELLA 1914). Sexual dimorphism in dentition occurs in some species and a short life span of one year or less seems to be characteristic (MILLER 1973, IWATA & al. 2001). In some of these pelagic gobies such as *Aphia minuta* (RISSO 1810) and *Leucopsarion petersii* HILGENDORF 1880 extremely high numbers of free neuromasts are found (MORTARA 1918, SCATTOLIN 2003). MORTARA (1918) describes the free neuromast pattern of two European pelagic gobies *A. minuta* and *Pseudaphya ferreri* DE BUEN 1931 including the rows of sensory papillae on the caudal fin. The aim of this paper is the redescription of the distribution of the free neuromast pattern on the caudal fin for *A. minuta* and *P. ferreri* and the comparison of these data with the respective character set in gobies from the Indo-Pacific, *Gobiopterus* cf. *chuno* HAMILTON 1822 and *Leucopsarion petersii* HILGENDORF 1880.

Materials and Methods

The distribution of the sensory papillae was studied using a binocular microscope (Wild M-8) with oblique lighting. Segmented and branched caudal fin rays are counted from dorsal to ventral. The nomenclature of the lateral line system on the caudal fin follows AHNELT & GÖSCHL (2004). The plesiomorphic pattern of the free neuromasts on the caudal fin for Gobioidei are a transversal (**lct**) and three longitudinal rows: dorsal (**lcd**), median (**lcm**) and ventral (**lcv**). The median longitudinal row **lcm** extends in elongation of the median trunk lateral line, a series of transversal rows of free neuromasts in Gobiidae. In species with two longitudinal rows on the caudal fin the ventral row **lcv** is reduced.

Institutional abbreviations are as listed in LEVITON & al. (1985) except IRPEM = Istituto di Ricerche sulla Pesca Marittima, Ancona, Italy.

Aphia minuta, 19 specimens; IRPEM uncatalogued (n = 10 of 41), Italy, off Ortona; NMW 31463 (n = 5 of 10), as *Latrunculus pellucidus*, Slovenia, Izola; NMW 31463 (n = 1), as *Latrunculus albus*, Sweden, Andosholmen; NMW 88030 (n = 3 of 119), Italy, Messina; NHRM 46688 (n = 5 of 39), Sweden, Skagerrak, Gullman Fjord, bay at Finnsbo.

Gobiopterus* cf. *chuno, 14 specimens; uncatalogued (n = 8 of 53), Thailand, Ubol Ratana Reservoir; uncatalogued (n = 6 of 19); Thailand, Bangkok, Kasetsart University, ponds and canals.

Leucopsarion petersii, 12 specimens, FAKU 103091 (n = 10 of 30), Japan, Kyoto Prov., Miyazu; uncatalogued (n = 2), Japan, Kyoto Prov., Maizuru City.

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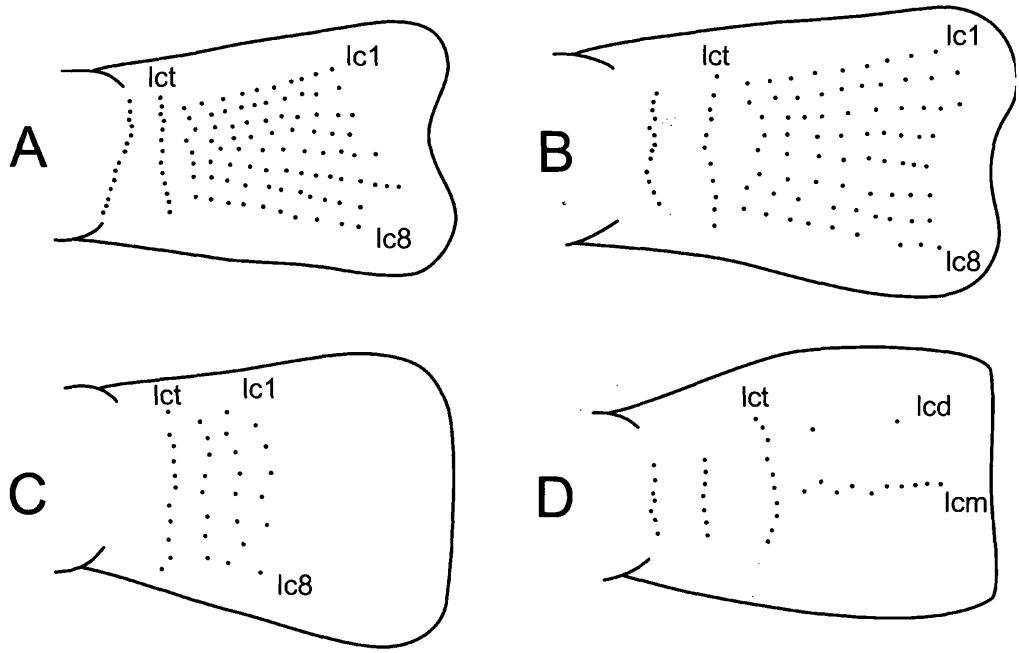

Fig. 1: Stylised pattern of the lateral line system of the caudal fin in pelagic Gobiidae. A: *Aphia minuta*, B: *Leucopsarion petersii*, C: *Gobiopterus* cf. *chuno* and D: *Pseudaphya ferreri*. Rows of free neuromasts on the caudal fin: lc1 – lc8: longitudinal rows 1 - 8, lcd – dorsal row, lcm – median row, lct – transversal row. The neuromasts are not drawn to scale. Further explanations in the text.

Pseudaphya ferreri, 29 specimens; NMW 37424-37429 (n = 6), Croatia, Split; NMW 37431-37433 (n = 3), Croatia, Split; NMW 87144 (n = 20 of 79), Croatia, Rovinj.

Results

The free neuromasts on the caudal fin are located on the interradial membranes between the fin rays. *A. minuta*, *L. petersii* and *G.* cf. *chuno* show a similar pattern of these superficial neuromasts on the caudal fin with a highly elevated number of sensory papillae compared to other members of the Gobiidae (Fig. 1, A – C). In all three species nine rows of free neuromasts are displayed, one transversal and eight longitudinal rows. The transversal row is located close to the base of the caudal fin extending from dorsally the first segmented and branched fin ray to ventrally the eleventh segmented and branched fin ray. Posterior to this transversal row eight longitudinal free neuromast rows extend between the second and tenth segmented and branched caudal fin ray. These longitudinal rows are always separated by one fin ray. In *A. minuta* and *L. petersii* the sensory papillae of the longitudinal rows decrease in size caudally and almost reach the posterior end of the caudal fin. Due to damaged caudal fins in all specimens of *G.* cf. *chuno* the posterior ends of the longitudinal rows were not detectable. Contrary to these three species *P. ferreri* displays only three rows of sensory papillae (Fig. 1 D). The transversal row runs somewhat posterior to the caudal fin base from dorsally the third segmented

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and branched fin ray to ventrally the fourteenth segmented and branched caudal fin ray. The transversal row terminates ventrally of the thirteenth segmented and branched fin ray. Two longitudinal rows run between the fifth and sixth segmented and branched fin ray (lcd) and between the eight and ninth fin ray (lcm) respectively as in MORTARA (1918). The median trunk lateral line, a series of transversal rows of free neuromasts extends on the base of the caudal fin in *A. minuta*, *L. petersii* and most distinct in *P. ferreri* (Fig. 1 A-B, D) but not in *G.* cf. *chuno* (Fig. 1 C).

Discussion

Most gobiid species checked for the distribution of free neuromasts on the caudal fin show one transversal row and three longitudinal rows (SANZO 1911, AHNELT & DUCHKOWITSCH 2001) or one transversal row and two (the dorsal and the median) longitudinal rows (AHNELT & al. 2000, AHNELT & SCATTOLIN 2003, AHNELT & GÖSCHL 2003). The occurrence of four rows of sensory papillae on the caudal fin, one transversal and three longitudinal rows is regarded as the plesiomorphic state of lateral line organs on the caudal fin (AHNELT & GÖSCHL 2004). MORTARA (1918) presents a third pattern in *A. minuta* with nine rows on the caudal fin which is now found to be occurring in two additional pelagic gobies, *Gobiopterus* cf. *chuno* and *L. petersii*. [Note: MUNRO (1949; Figs. 8, 10) figures two specimens of the pelagic *Gobiopterus semivestitus* (MUNRO 1949) with only three longitudinal rows and no transversal row of sensory papillae on the caudal fin]. These three genera of Gobiidae can be considered as derived forms since they do not exhibit cephalic canals. *P. ferreri* still possesses reduced cephalic canals thus being regarded as more basal than gobies having replaced their sensory canals by free neuromasts (MILLER 1973, TAKAGI 1988).

Nevertheless, the increase of neuromast rows on the caudal fin above the plesiomorphic four rows is not necessarily linked to pelagic life as reported from several pelagic species (MORTARA 1918, SCATTOLIN 2003). *Deltentosteus quadrimaculatus* (VALENCIENNES 1837) with five rows and *D. collonianus* (RISSO 1820) with seven rows are the only benthic gobies known so far with an increased number of lateral line rows on the caudal fin (AHNELT & SCATTOLIN 2005).

The possible affinities of transparent pelagic gobies have been indicated by various authors (e.g. MUNRO 1949, MILLER 1973). In BIRDSONG & al. (1988), who grouped about 500 species of gobiid fishes after osteological criteria, *A. minuta*, *Gobiopterus chuno* (HAMILTON 1822) and *L. petersii* were treated but no closer relations of these pelagic gobies were suggested. A recently discovered pelagic species *Paedogobius kimurai* IWATA, HOSOYA & LARSON 2001 is assigned to the *Gobiopterus* group of BIRDSONG & al. (1988) (IWATA & al. 2001). The pattern of the lateral line system on the caudal fin of this species is not known.

From the examined material a characteristic distribution of free neuromasts on the caudal fin of evolved pelagic gobiid fishes can be deduced. It is likely that more longitudinal rows than the plesiomorphic number are developed in gobies with a specialized lifestyle like *A. minuta* or *L. petersii*. Like in these species nine rows of sensory papillae on the caudal fin can be expected in other pelagic Gobiidae. An increase in the amount of free neuromasts may be connected to low-noise environments (COOMBS & al.

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1988, MOGDANS & al. 2003, KASUMYAN 2003) like the open water column in comparison to intertidal habitats. Since superficial neuromasts seem to be under fewer morphological constraints than neuromasts enclosed in canals and more labile in evolutionary sense (COOMBS & al. 1988) convergent evolution of free neuromast pattern on the caudal fin in adaptation to similar habitat conditions is assumed for evolved pelagic gobiid fishes.

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