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First record of parasitic copepod *Peniculus fistula* von Nordmann, 1832 (Siphonostomatoida: Pennellidae) from garfish *Belone belone* (Linnaeus, 1761) in the Adriatic Sea

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Abstract: During the investigation of garfish biology in the eastern Adriatic Sea in 2008, a number of fish infested with the pennellid copepod *Peniculus fistula* von Nordmann, 1832 was recorded. This is the first record of *P. fistula* in the Adriatic Sea and the first record of garfish as a host of this parasite. Morphological characteristics of *P. fistula* from the Adriatic Sea and some ecological parameters of this parasite-host association are presented.

Résumé : *Premier signalement du copépode parasite* Peniculus fistula *von Nordmann, 1832 (Siphonostomatoida : Pennellidae) sur l'orphie* Belone belone *(Linné, 1761) en Mer Adriatique.* Au cours d'une étude réalisée en 2008 sur la biologie de l'orphie en Mer Adriatique orientale, un certain nombre de poissons infestés par le copépode *Peniculus fistula* von Nordmann, 1832 été observé. C'est le premier signalement de *P. fistula* en Mer Adriatique et la première observation de ce parasite sur l'orphie *Belone belone*. Les caractères morphologiques de *P. fistula* sont présentés de même que quelques paramètres écologiques de cette association hôte-parasite.

Keywords: Parasitic copepod • *Peniculus fistula* • Garfish • Adriatic Sea

Introduction

During the investigation of the garfish *Belone belone* (Linnaeus, 1761) biology from the eastern Adriatic Sea in 2008, a number of fish infested with the parasitic copepods firmly attached to the fins was observed. The parasite was identified as the pennellid copepod *Peniculus fistula* von Nordmann, 1832 (von Nordmann, 1832).

P. fistula is relatively common in Mediterranean fishes (Candeias, 1955; Zúñiga & Suau, 1967; Raibaut et al., 1998), but there is little information concerning its life cycle. Distribution area of *P. fistula* is wide and, apart from the Mediterranean Sea, includes the Atlantic (Gooding, 1957) and Indo-Pacific waters (Boxshall, 1986). This is the first record of *P. fistula* in the Adriatic Sea as well as the first record of garfish as its host.

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Material and Methods

A total of 224 garfish were caught from February to March 2008 by purse seine and beach seine near the islands of Korčula (42º55'N, 16º35'E) and Dugi Otok (44º00'N, 14º50'E) in the eastern part of the middle Adriatic Sea. In

the laboratory the fish were measured and weighed, then inspected for parasites and the locations of the ectoparasites were recorded. The following measures of the parasitic infestation were used: prevalence (number of infested fish divided by the number of examined fish, expressed as a percentage) and mean intensity (total number of parasites divided by the number of infested fish) (Bush et al., 1997). Spearman correlation coefficient was applied and the level of $p < 0.05$ was considered significant.

The Fulton's condition factor ($K = 100 \cdot W/LT^3$) was used to estimate the fish condition (Le Cren, 1951). To avoid the influence of body length on fish condition, only fish from 39.0-50.0 cm were included in the analysis. Data distribution was tested with Shapiro-Wilk W test and the possible condition differences between infested and non-infested garfish specimens were tested with Student's *t*-test using the statistical package StatSoft Inc. (2000) STATISTICA for Windows version 5.5 (http://www.statsoft.com).

Parasites were removed together with the part of fin tissue to avoid the damage to the head region and preserved in 70% ethanol. Selected specimens were briefly cleared in lactic acid, sorted and measured using an ocular micrometer under the stereomicroscope, and observed under the microscope at 100-1000x magnification. Identification was carried out according to the key to pennellid genera (Boxshall & Halsey, 2004), key to *Peniculus* species (Alexander, 1983) and redescription of the type species *Peniculus fistula* in Boxshall (1986). Drawings were made with the aid of *camera lucida*, using an OLYMPUS microscope with differential interference contrast. The descriptive terminology largely follows Boxshall & Halsey (2004). Examined material is deposited at the Laboratory of plankton of the Institute of Oceanography and Fisheries, Split, Croatia.

Results

Total body lengths and weights of the 224 analysed garfish individuals ranged from 34.1-55.8 cm (43.9 ± 4.67 cm) and 37.1-239.8 g (105.7 ± 38.84 g), respectively. 22.3% garfish were infested with *P. fistula*, with a mean intensity of 1.64 and the range from 1-7 ectoparasites per host. Parasites were attached to the host with their antennae embedded in the fin ray and their longitudinal axes more or less parallel to the host body. Highest number of parasites was attached to the ventral fins (62.2%), 20.7% to the pectoral fins, 11.0% to the anal fin, 4.9% to the dorsal fin and 1.2% to the caudal fin.

No significant correlation between the total length of the host and the number of ectoparasites was found ($p = 0.622$). The mean values of Fulton's condition factor of infested ($\bar{K} = 0.116 \pm 0.011$) and non-infested ($\bar{K} = 0.121 \pm 0.012$) individuals showed similar variation tendencies. Normal distribution of condition factors was established ($W > 0.92$, $p > 0.09$) and no significant difference between the condition of infested and non-infested garfish specimens was recorded ($t = -0.861$, $p > 0.05$).

Main morphological features of the Adriatic *P. fistula* are presented in Fig. 1 (A-H). Body lengths excluding egg sacs of the examined parasites varied from 5.5-7.1 mm (6.1 ± 0.60 mm, N = 8). Oval head was about 1.7 times longer than wide, carrying chelate antennae and typically pennelid mouth parts at the base of oral cone. Leg 4 bearing somite was about 1.1 times wider than long, globular (Fig. 1A), trapezoidal (Fig. 2A), rectangular (Fig. 2B) or squarish (Fig. 2C) in shape. Elongate, subcylindrical trunk was 6.1-8.5 times longer than wide with attached linear egg sacs longer than body.

Discussion

All *Peniculus* specimens collected from garfish corresponded well to the characteristics of *P. fistula* listed in Alexander (1983) and redescription of the type species *P. fistula* von Nordmann, 1832 in Boxshall (1986). Some of our specimens had a slightly more prominent abdominal flap than illustrated in Boxshall (1986), but we found this character to be variable in the examined material. In addition, total body lengths of 5.5-7.1 mm are higher than 3.3 mm and 4.1 mm reported from the Indo-Pacific individuals (Boxshall, 1986), but are within the range of 3.5-10.5 mm observed in the Mediterranean specimens (Brian, 1906; Delamare Deboutteville & Nunes, 1951). The existence of distinct morphotypes in *P. fistula* was reported by Delamare Deboutteville and Nunes (1951), based on the shape of somite bearing leg four. This character was regarded as host specific, exhibiting rectangular shape in *P. fistula* f. *caprosi*, trapezoidal in f. *mulli* and squarish in f. *pagelli* (Delamare Deboutteville & Nunes, 1951). Among our material we have recorded all of the above mentioned shapes, but since they were all collected from garfish, this could be regarded as variability within the species.

The literature reports on *P. fistula* hosts include the representatives of at least seven families of fishes (Boxshall, 1986) and Belonidae are now added to the list. All of the reported hosts are demersal or semipelagic fish species except *B. belone* which is pelagic, but during spawning period habitats at the sea bottom, depositing eggs on the *Posidonia* blades. It is less mobile then, and presumably more susceptible to the infestation by this parasite.

Based on the condition factor, the infestation with *P. fistula* produced little effect on the general health of garfish. Fish fins are considered a less critical site of parasite attachment compared to gills or internal organs (Lester & Hayward, 2006). The absence of significant correlation between the total length of garfish and the prevalence of

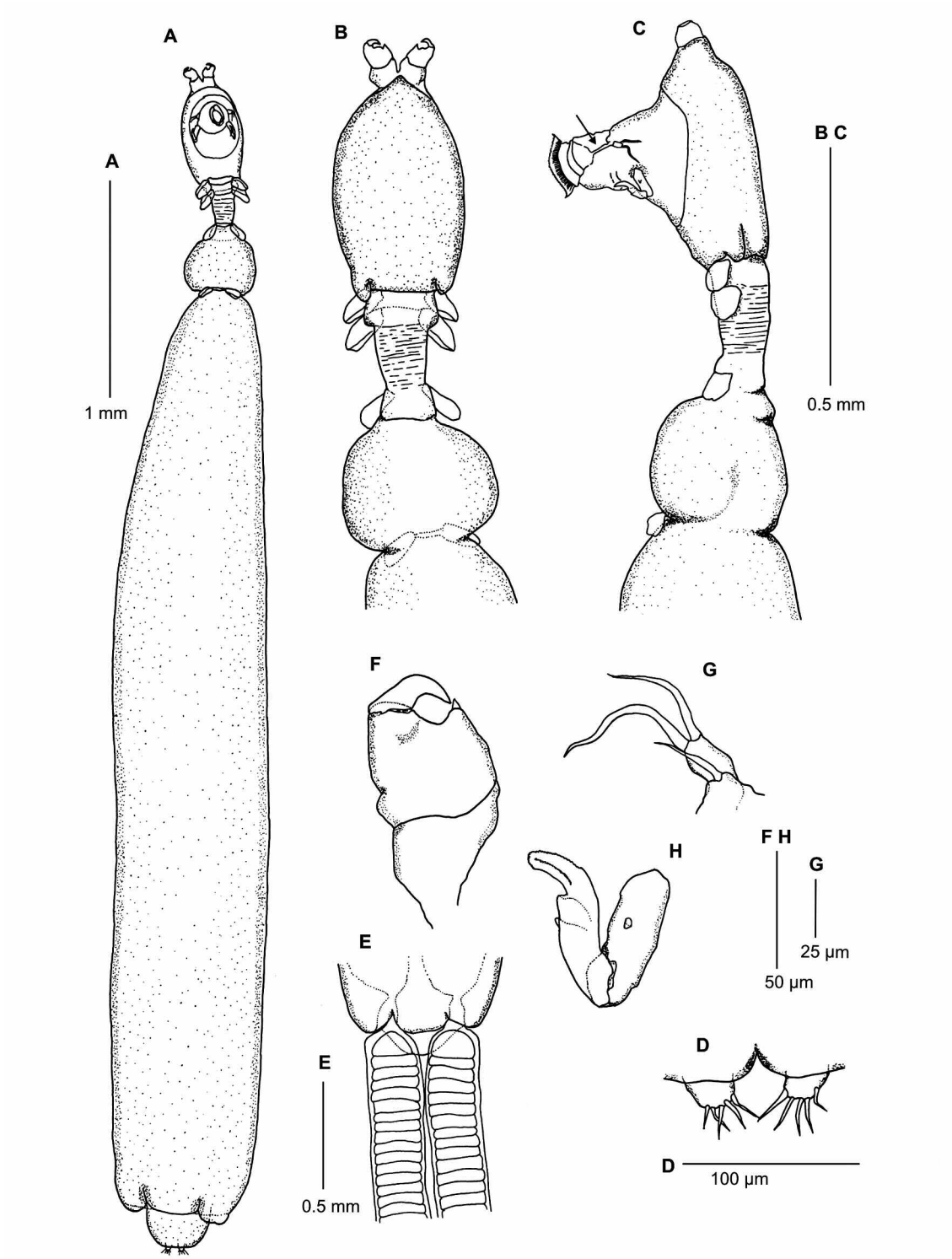

Figure 1. *Peniculus fistula*. Postmetamorphic female. **A.** Habitus, ventral view. **B.** Head, neck and somite bearing leg 4, dorsal view. **C.** Head with oral cone and mouth parts (mandible arrowed), lateral view. **D.** Caudal rami. **E.** Terminal part of trunk with egg sacs, ventral view. **F.** Antenna. **G.** Maxillule. **H.** Maxilla.

Figure 1. *Peniculus fistula*. Femelle postmétamorphique. **A.** Habitus, vue ventrale. **B.** Tête, cou et segment avec quatrième paire de pattes, vue dorsale. **C.** Tête avec le cône buccal et appendices orales, vue latérale (la mandibule identifié par la flèche). **D.** Rames caudales. **E.** Partie terminale de tronc avec des sacs d'œufs, vue ventrale. **F.** Antenne. **G.** Maxillule. **H.** Maxille.

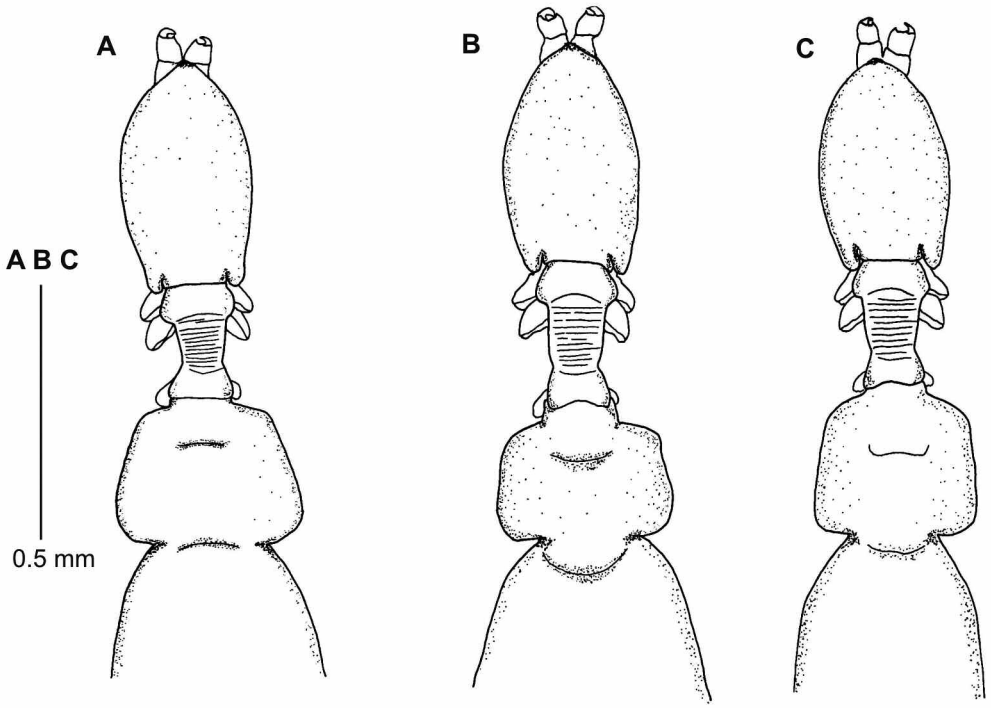

Figure 2. *Peniculus fistula*. Postmetamorphic females, showing different shapes of somite bearing leg 4. **A.** Trapezoidal. **B.** Rectangular. **C.** Squarish.

Figure 2. *Peniculus fistula*. Femelles postmétamorphiques, présentant différentes formes du segment portant la quatrième paire de pattes. **A.** Trapézoïdal. **B.** Rectangulaire. **C.** Quadrangulaire.

this ectoparasite suggests that *P. fistula* does not actively select host individuals of longer or shorter body length.

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