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SHORT COMMUNICATION

ODD ASSOCIATION AND RANGE EXTENSION OF *CALIGUS RUFIMACULATUS* WILSON, 1905; CALIGIDAE, SIPHONOSTOMATOIDA, COPEPODA

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Introduction

The Caligidae (Siphonostomatoida, Copepoda) comprises more than 465 parasitic species, over 250 of which belong to *Caligus* Müller, 1785 (Boxshall and Halsey 2004). *Caligus* spp. are primarily marine; but some representatives routinely inhabit brackish or fresh water (Margolis et al. 1975). Some *Caligus* spp. have been widely reported from several oceans, others have been documented from a single location, and a few have only been collected as free-swimming individuals not associated with a host (Margolis et al. 1975). *Caligus* spp. range from being stenoxenous to euryxenous, with most species infecting actinopterygians (Actinopterygii), a much smaller group exclusively or non—exclusively infecting chondrichthyans (primarly elasmobranchs; Elasmobranchii, Chondrichthyes) (Margolis et al. 1975, Tang and Newbound 2004), and one species non—exclusively infecting an invertebrate (Ruangpan and Kabata 1984). Herein, we report a modest range extension for *Caligus rufimaculatus* Wilson, 1905 based on specimens collected in an odd association with a dead dolphin in the northern Gulf of Mexico (GOM) and we contribute new details regarding the morphology of the parasite.

Materials and Methods

Copepods were collected from a bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821) (Delphinidae, Odontoceti). The dolphin (juvenile male, 199.5 cm total length) was discovered dead on 26 December 2005, partially submerged under a dock in shallow water at the southern edge of Choctawhatchee Bay in Miramar Beach, Florida. Responders from the Southeast Fisheries Center (Panama City Beach, FL) collected the carcass on 30 December 2005 (the only dead animal noted in the area at that time) and moved it to a refrigerator. Copepods were collected during necropsy on 31 December 2005 from the skin of the ventral caudal region of the body and fixed in 10% formalin. It is not known if the copepods were alive at the time the dolphin was removed from the water and no lesion was grossly apparent where the copepods were attached. This dolphin stranded during a brevetoxin—associated unusual mortality event in which 93 dolphin strandings were documented from 19 September 2005 to 30 April 2006 (Gaydos et al.[1]). For taxonomic study, copepods were cleared in lactic acid into which a small amount of lignin pink had been dissolved. Fine pins mounted in the tips of thin wooden dowels were used to dissect copepods, and the wooden slide technique of Humes and Gooding (1964) facilitated the study of intact specimens and dissected appendages. Copepods were examined using bright-field microscopy. Measurements were made using a stage micrometer and illustrations were made using a camera lucida. Three specimens (2 females, 1 male) were studied using a scanning electron microscope (SEM) after routine preparation (CO_2 critical point drying, gold-palladium sputter coating, mounting on metal stubs with 2-sided sticky tape). Copepod terminology used herein conforms mostly to that of Boxshall and Halsey (2004) and host nomenclature and systematics follows Compagno (2005) for members of Chondrichthyes, FishBase (Froese and Pauly 2008) for other fishes, Reynolds III and Powell (2002) for manatees, and Jefferson et al. (1993) for other marine mammals. Copepod vouchers remain in the personal collection of the senior author.

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Results and Discussion

About 30 copepods were collected from the dead dolphin and 24 individuals (6 ovigerous females, 11 non–ovigerous adult females, and 7 adult males) were each identified as *C. rufimaculatus* Wilson, 1905 (Figure 1A) based on information in Cressey (1991) and Suárez–Morales et al. (2003). In their remarks regarding *Caligus amblygenitalis* Pillai, 1961, Ho and Lin (2004) noted that few *Caligus* spp. possess an accessory process on all three outer elements of the second exopodal segment of leg 1. They included *C. rufimaculatus* as one of said species based on the illustration of leg 1 provided by Cressey (1991). However, in his text description of *C. rufimaculatus*, Cressey (1991) stated that the outermost element did not exhibit an accessory process. In his original description of *C. rufimaculatus*, Wilson (1905) did not report any of the three outermost elements (referred to by Wilson as claws) as possessing an accessory process and most recently, Suárez–Morales et al. (2003) reported that their non-type exemplars exhibited an accessory process on elements 2 and 3 (referred to by those authors as spines) among the three outer elements. Our observations corroborate the illustration of leg 1 (but not the text description) of Cressey (1991) in that we observed adult females and adult males to possess three outer elements each with an accessory process (Figure 1B). Ho and Lin (2004) also remarked that *C. amblygenitalis* can be distinguished from *C. rufimaculatus* in that the former species possesses a large patch of spinules ventrally on the basis of leg 2. Here it is noted that there seems little doubt, based on their detailed description of *C. amblygenitalis*, that Ho and Lin (2004) mistakenly remarked that the aforementioned patch of spinules is found on leg 2, as clearly their text description and illustrations establish the patch as residing on the basis of leg 1. Our observations of the adult female and male of *C. rufimaculatus* revealed tiny cuticular bumps on the ventral surface of the basis of leg 1 (Figure 1C) and no cuticular projections on the ventral surface of the basis of leg 2. These bumps (not reported by others) seem smaller than the homologous spinules illustrated by Ho and Lin (2004). Lastly, Ho and Lin (2004) remarked that another feature distinguishing *C. amblygenitalis* from *C. rufimaculatus* is an "unipectinate outer spine with strong teeth" on the second segment of leg 2. Our observations of the homologous feature of *C. rufimaculatus* revealed it to be a spine with a marginal membrane on each side, described as a "fringes" by Cressey (1991).

Few copepod species infect or otherwise associate with mammals (Boxshall and Halsey 2004) and we believe the following to be a complete accounting of said species: *Pennella balaenopterae* Korea and Danielson, 1877, (Siphonostomatoida) is a mesoparasite that infects mysticets (Mysticeti) and odontocets (Odontoceti) (Hogans 1987) and the northern elephant seal, *Mirounga angustirostris*, (see Dailey et al. 2002); *Balaenophilus unisetus* Aurivillius, 1897

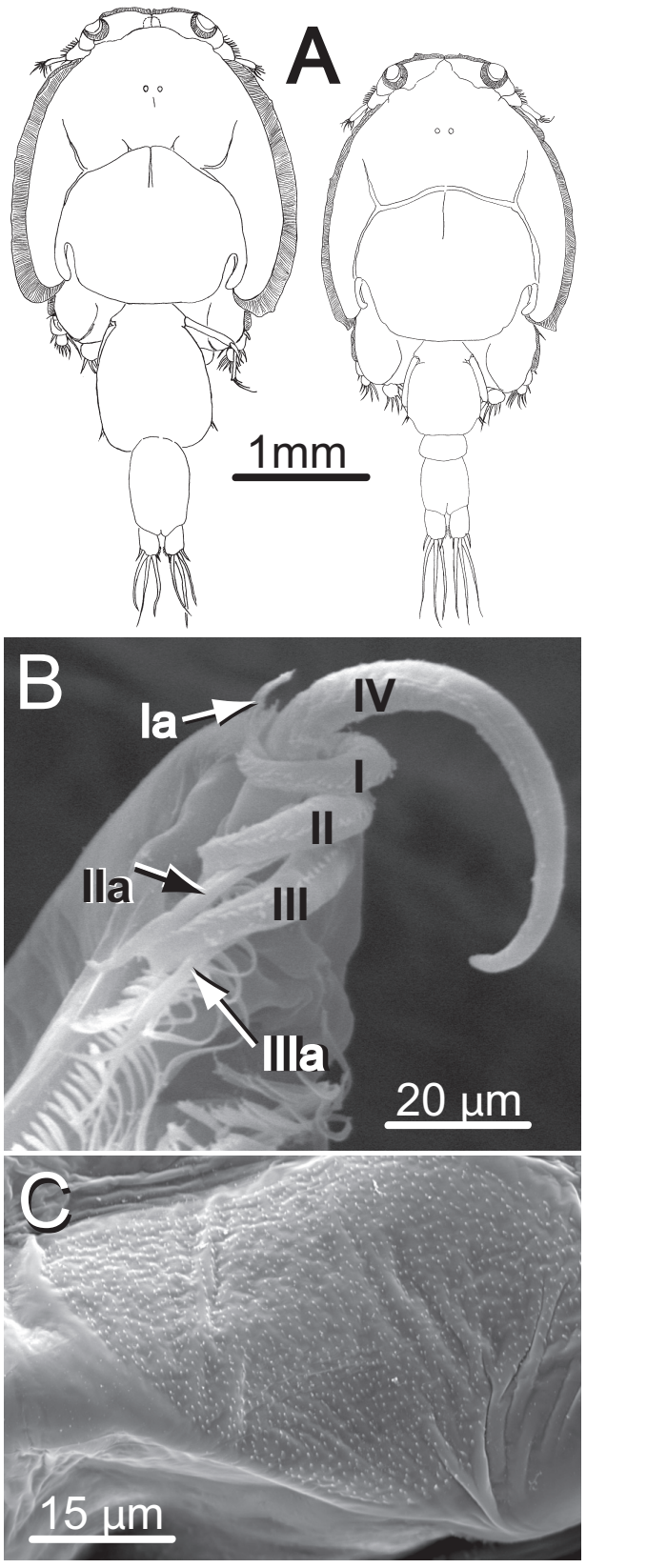

Figure 1. Caligus rufimaculatus *collected from a dead bottlenose dolphin,* Tursiops truncatus*, in Choctawhatchee Bay, Florida. A. Adult female (left) and adult male (right). B. Tip of leg 1 exopod (adult female) showing three outermost elements (I, II, III) and their accessory processes (one per element; Ia, IIa, IIIa). Note: the base of seta IV (not visible in image) lies just medial to the base of element III. C. Ventral view of the basipod of leg 1 showing a patch of tiny cuticular bumps.*

TABLE 1. *Published host fish records for Caligus rufimaculatus Wilson, 1905.*

Class / ***Order*** / ***Family*** / ***Species***	***Location***	***Attachment site on host***	***Reference***
Chondrichthyes			
Rajiformes			
Rhinobatidae			
*Rhinobatos lentiginosus**	in or about Lemon Bay, FL	body surface	Bere 1936
Myliobatidae			
*Aetobatus narinari**	in or about Lemon Bay, FL	body surface	Bere 1936
Mobulidae			
"devilfish"[1]	in or about Lemon Bay, FL	about mouth	Bere 1936
Actinopterygii			
Mugiliformes			
Mugilidae			
Mugil cephalus	not reported	not reported	Wilson 1905, 1932
	in or about Lemon Bay, FL	mouth, body surface	Bere, 1936
	Biscayne Bay, FL	skin	Skinner 1975
	Sapelo Island, GA	gills, body surface	Rawson 1977[2]
Beloniformes			
Belonidae			
Strongylura timucu	in or about Lemon Bay, FL	body surface	Bere 1936
Cyprinodontiformes			
Fundulidae			
Fundulus heteroclitus	Woods Hole , MA	body surface	Wilson 1905, 1932
	about Beaufort, NC	body surface	Wilson 1908
F. majalis	Woods Hole, MA	body surface	Wilson 1905, 1932
Perciformes			
Serranidae			
*Centropristis striata**	about Placida, FL	not reported	Cressey 1991
Pomatomidae			
Pomatomus saltatrix	in or about Lemon Bay, FL	mouth	Bere 1936
	Maricá, Rio de Janeiro, Brazil	body surface	Luque et al. 1998
Carangidae			
Oligoplites palometa	Sepetiba Bay, Brazil	gills	Takemoto & Luque 2002
O. saliens	Sepetiba Bay, Brazil	gills	Takemoto & Luque 2002
O. saurus	in or about Lemon Bay, FL	mouth, body surface	Bere 1936
Lutjanidae			
Lutjanus synagris	about Placida, FL	not reported	Cressey 1991
Gerreidae			
Eucinostomus gula	about Placida, FL	not reported	Cressey 1991
E. pseudogula[3]	in or about Lemon Bay, FL	body surface	Bere 1936
Haemulidae			
*Haemulon plumierii**	about Placida, FL	not reported	Cressey 1991
Orthopristis chrysoptera	about Placida, FL	not reported	Cressey 1991
Sparidae			
*Diplodus holbrookii**,[4]	about Placida, FL	not reported	Cressey 1991
Lagodon rhomboides	about Placida, FL	not reported	Cressey 1991
Scaridae			
Nicholsina usta	about Placida, FL	not reported	Cressey 1991
Ephippidae			
Chaetodipterus faber	in or about Lemon Bay, FL	body surface	Bere 1936
Trichiuridae			
Trichiurus lepturus	on North American coast	not reported	Wilson 1905[5]
Tetraodontiformes			
Monacanthidae			
*Stephanolepis hispidus**	about Placida, FL	not reported	Cressey 1991
Ostraciidae			
*Acanthostracion quadricornis**	about Placida, FL	not reported	Cressey 1991

* indicates that the host name used in that record was herein changed to conform to nomenclature in FishBase (Froese and Pauly 2008).

[1] *Mobula hypostoma* noted by author as the most probable host species.

[2] Results published in Rawson (1977) represent a portion of the dissertation results presented in Rawson 1973.

[3] Host binomen not listed in FishBase (Froese and Pauly 2008); also referred to as "the mojarra" by author (Bere, 1936; p. 582-583).

[4] Family entry of host in appendix of Cressey (1991; p. 18) signals an error regarding host name in text (p. 14).

[5] Wilson's (1905; p. 573) identification reassigned as *C. rufimaculatus* by Parker (1969).

(Harpacticoida) inhabits the baleen of several rorqual species (*Balaenoptera*, Balaenopteridae) (see Bannister and Grindley 1966); *B. manatorum* (Ortíz, Lalana, and Torres–Fundora, 1992) inhabits the skin of the Antillean manatee, *Trichechus manatus manatus*, (see Suárez–Morales 2007); *Harpacticus pulex* Humes, 1964 (Harpacticoida) was discovered on sloughed skin of a captive–held bottlenose dolphin and captive–held Florida manatee, *T. m. latirostris*, (see Humes 1964); and *Caligus elongatus* Nordmann, 1832 (Siphonostomatoida) was reported attached to a dead bottlenose whale, *Hyperoodon ampullatus*, (see O'Reilly 1998). This report adds another *Caligus* sp. to the list of copepods associated with mammals; and for completeness we add that occurrences of caligids temporarily attaching to humans have been reported (Kurochkin and Kazachenko 1975, as reported by Ruangpan and Kabata 1984, O'Reilly 1998). Cases of copepods attaching to humans aside, it is notable that amongst the aforementioned copepods, only *C. elongatus* and *C. rufimaculatus* have been reported from mammals as well as representatives of other classes. Considering numbers of species and phylogenetic scope, *C. elongatus* and *C. rufimaculatus* have each been reported from a numerous and diverse variety of hosts (Margolis et al. 1975; Table 1). However, whether being euryxenous regarding fish hosts is a prerequisite for their ability to associate with marine mammals is unknown and certainly there are other euryxenous *Caligus* spp. that are not known to associate with mammals (Margolis et al. 1975). In the present case, no data support or refute the notion that the specimens of *C. rufimaculatus* were actually feeding on the bottlenose dolphin, and whether or not the copepods had attached to the dolphin prior to its death likewise remains unknown. A lack of dead fish in the immediate vicinity of the dead dolphin did not support a notion that the copepods had abandoned moribund fish hosts and settled on the dolphin; however, red tide related fish kills had occurred in Choctawhatchee Bay for months before and during the time of the dolphin stranding. This case is more curious because it involved about 30 copepods, unlike the case reported by O'Reilly (1998) of two *C. elongatus* attached to a dead whale.

The known geographic distribution of *C. rufimaculatus* has expanded significantly since the species was first discovered (Table 1). Prior to this report the species was considered to patchily inhabit western North Atlantic coastal waters from Woods Hole, Massachusetts to Biscayne Bay in southern Florida (Wilson 1905, 1908; Rawson 1973, 1977; Skinner 1975), GOM coastal waters off southern Florida and the Yucatán Peninsula, Mexico (Bere 1936, Cressey 1991, Suárez–Morales et al. 2003), and western South Atlantic waters off Maricá and in Sepetiba Bay, Rio de Janeiro, Brazil (Luque et al. 1998, Takemoto and Luque 2002). This report extends the species range to include the northern GOM and in doing so it negates the comment of Cressey (1991) that *C. rufimaculatus* does not occur in said region. *Caligus rufimaculatus* has been collected from at least 22 species of fishes, together representing 18 families and 6 orders (Table 1). The phylogenetic scope of these hosts (elasmobranchs to members of the Tetraodontiformes) is remarkable, as is their ecological scope, ranging from small, shallow–water, and euryhaline species (e.g., *Fundulus heteroclitus*) to larger constantly swimming and wide–ranging nearshore species (e.g., *Pomatomus saltatrix*), as well as a species known to be capable of inhabiting relatively deep water (*Trichiurus lepturus*) (Froese and Pauly 2008). In addition, *C. rufimaculatus* is capable of attaching to a wide array of host surfaces, from smooth and scaleless skin (e.g., *Rhinobatos lentiginosus*, *Trichiurus lepturus*, *Tursiops truncatus*) to heavily scaled skin (*Mugil cephalus*) to hard plated skin (*Acanthostracion quadricornis*) to gills (*M. cephalus*, *Oligoplites palometa*) (Table 1). Its ability to move about freely away from a host and associate with many species would seem to predispose *C. rufimaculatus* to be a sea louse capable of negatively impacting a wide variety of aquaculture operations. Yet we are unaware of any such reports. Based on its aforementioned abilities, its known distribution within the GOM, and the general pattern of water flow within the GOM, we expect that future records of *C. rufimaculatus* will document much more of the GOM as part of its range.

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