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ON THE IMMATURE STAGES OF *PALLISENTIS* (*PALLISENTIS*) *CELATUS* (ACANTHOCEPHALA: QUADRIGYRIDAE) FROM OCCASIONAL FISH HOSTS IN VIETNAM

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***ABSTRACT.* –** Immature stages of *Pallisentis* (*Pallisentis*) *celatus* Van Cleave, 1928, were collected from the intestine of three species of occasional fish hosts in the Red River near Hanoi (21°1'N; 105°52'E). These are new records from *Clarias fuscus* (Valenciennes in Cuvier & Valenciennes, 1840), *Ophiocephalus maculatus* (Lacépède, 1801) and *Mastacembelus armatus* (Lacépède, 1800). Worms reached moderate size but did not reach sexual maturity or develop eggs and sperm. Measurements and illustrations are compared with those of sexually mature adults from China and Vietnam as previously reported by other observers. Attachment structures (hooks and spines) reached their (previously measured) maximum size compared to other anatomical structures in the youngest worms. Information on certain diagnostic features, e.g., giant nuclei, not recorded for the original and subsequent descriptions, are provided in this study. An additional pathway in the life cycle of *P*. (*P*.) *celatus* involving occasional fish hosts is proposed.

***KEY WORDS.* –** Morphology, *Pallisentis celatus*, immatures, Acanthocephala, occasional hosts, Vietnam.

INTRODUCTION

Pallisentis (*Pallisentis*) *celatus* Van Cleave, 1928, was placed in the subgenus *Pallisentis* by Amin et al. (2000). It was described by Van Cleave (1928) from an unknown number of specimens collected from three species of fish at Peking, China. Van Cleave (1928) illustrated the proboscis and the anterior end of two specimens and measured only the trunk of males and females, size of proboscis hooks and body spines and eggs and counted 16 giant nuclei in the cement gland. Moravec & Sey (1989) provided the only other description of *P. celatus* from *Monopterus albus* (Zuiew, 1793) in the Red River, near Hanoi, Vietnam; the location of our present study. Moravec & Sey (1989) provided a more comprehensive description and illustrations that were, however, based only on two males and an anterior fragment of one female. Wang (1966, 1981) and Chen (1973 in Moravec & Sey, 1989) reported adult *P*. (*P*.) *celatus* from six species of fish, three species of amphibians and two species of reptiles.

The present collection of immature *P*. (*P*.) *celatus* from the intestine of three other species of fish allowed the observation of developmental stages of immatures and of an additional pathway in its life cycle.

MATERIALS AND METHODS

Immature *P*. (*P*.) *celatus* were collected by one of us (NVH) from the intestine of *Clarias fuscus* (Valenciennes in Cuvier & Valenciennes, 1840) (Clariidae), *Mastacembelus armatus* (Lacépède, 1800) (Mastaceembelidae) and *Ophiocephalus maculatus* (Lacépède, 1801) (Channidae) in the Red River near Hanoi, Vietnam (21°1'N; 105°52'E) between May and July, 2002. The worms were removed, extended in cold water, fixed in 10% formalin and shipped in 70% ethanol. Worms were stained in Mayer's acid Carmine, dehydrated in ascending concentrations of ethanol, cleared in graduated concentrations of terpineol in 100% ethanol and whole mounted in Canada balsam. Measurements are in micrometers unless otherwise stated. Width measurements refer to maximum width. Body length does not include neck, proboscis or bursa. Drawings were made by tracing light projections using a Ken-A-Vision microprojector. Specimens were deposited in the United States National Parasite Collection nos. 93202, 93203, Beltsville, MD, USA.

Table 1. Specimens of *Pallisentis* (*P.*) *celatus* examined from fishes in three Red River locations near Hanoi, Vietnam, 2002.

Fish Species	Fish examined			Number of Worms			Location on Red River
	Length (mean)(cm)	Number examined	No. infected (prevalence)	Collect.	Range	Mean	
Clarias fuscus	17-25 (22)	31	5 (16%)	16	1-8	3.2	Kim Son District Ninh Binh Province
Mastacembelus armatus	12-19 (16)	23	11 (48%	36	1-7	3.3	Kim Bang District Ha Nam Province
M. armatus	12-16 (14)	35	12 (34%)	27	1-5	2.2	Tu Son District Bae Ninh Province
Ophiocephalus maculatus	15-37 (26)	44	5 (11%)	12	1-6	2.4	Kim Son District Ninh Binh Province

RESULTS AND DISCUSSION

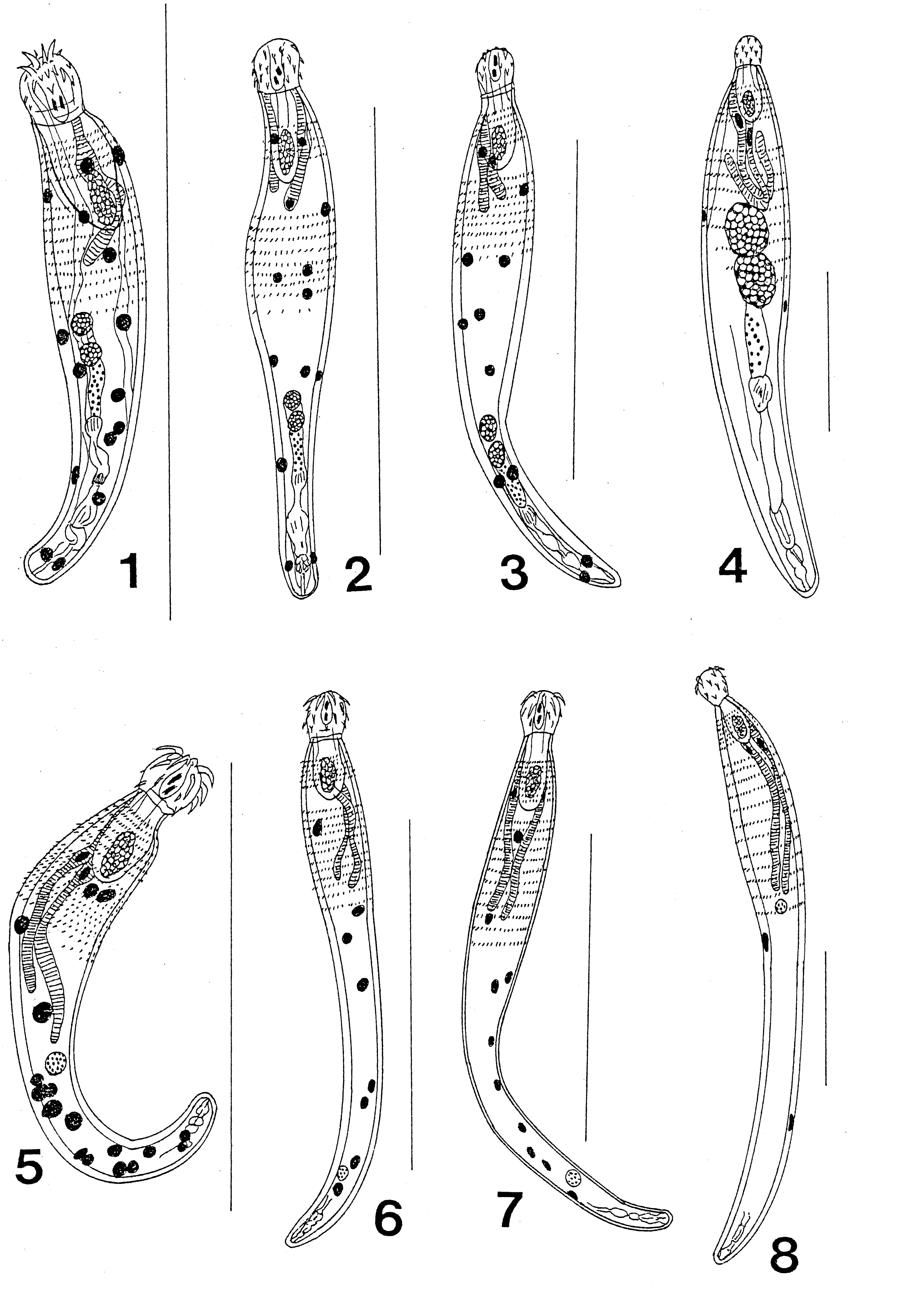
Material examined. **–** Ninety one worms were collected from the intestine of 33 infected individuals (133 examined) of three species of fish in three locations of the Red River near Hanoi between May and July, 2002 (Table 1). Fifty two specimens (28 males, 24 females) were made available for this study.

Morphology. **–** Except for the underdeveloped reproductive system, all worms had anatomical structures similar to those of the adults, which is characteristic of the cystacanth stage (Figs. 1-8). The younger forms, however, still contained a large number of giant hypodermal nuclei (GHN) (Figs. 1-3, 5-7) as is characteristic of the acanthella stage (Amin, 1982; Schmidt, 1985). The number of GHN gradually decreased in larger immatures until it reached 2 (1 dorsal, 1 ventral) in the older cystacanths (Figs. 4, 8) as is characteristic of the adults. The number of giant nuclei in the proboscis (2), lemnisci (1, 1) and cement gland (15-18) were consistently observed in all immature stages studied (Figs. 1-8; Table 1). These observations are reported for the first time in *P.* (*P.*) *celatus*. The largest number of GHN observed (14-17) (Table 2) was similar to those observed in acanthella of other species of acanthocephalans, e.g., up to 22 in *Acanthocephalus dirus* (Van Cleave, 1931) Van Cleave & Townsend, 1936; 12 in *A. galaxii* Hine, 1977; 30 in *A. anguillae* (Müller, 1780) Lühe, 1911; 18 in *A. lucii* (Müller, 1776) Lühe, 1911; 14 in *Leptorhynchoides thecatus* (Linton, 1891) Kostylev, 1924; 18 in *Echinorhynchus lageniformis* Ekbaum, 1938; 24 in *Polymorphus minutus* (Goeze, 1782) Lühe, 1911 by Amin (1982), Hine (1977), Leuckart (1876), Andryuk (1979), DeGiusti (1949), Olson & Pratt (1971) and Nicholas & Hynes (1963), respectively.

Except for the immature reproductive system, even the youngest worms collected had the full set of adult features including collar and trunk spines. All structures were somewhat smaller than those reported for the adults, except for the attachment structures, especially the proboscis hooks which develop to the adult size at the cystacanth stage (Table 2). The significance of the accelerated differential growth of proboscis hooks in the successful establishment of recruits into the gut of the definitive host was previously observed in other acanthocephalan species by Amin (1986, 1987a) and Schmidt (1985). In the youngest specimens examined, the lemnisci appeared proportionally longest reaching about half the length of trunk, e.g., Fig. 5. Subsequent differential growth restores the lemnisci to their usual proportion in the adult body cavity (Figs. 4, 8). These observations have been delineated for all anatomical structures of *Neoechinorhynchus* (*N.*) *cylindratus* (Van Cleave, 1913) Van Cleave, 1919, and *Pomphorhynchus bulbocolli* Linkins in Van Cleave, 1919 by Amin (1986, 1987a).

Dimensions of the cement gland and the number of giant nuclei in the proboscis, body wall, lemnisci and cement gland are given here (Table 2) for the first time; they were not reported in the original or subsequent descriptions of *P. (P.) celatus*.

Life history observations. **–** Most acanthocephalans have a direct life cycle involving an arthropod intermediate host and a vertebrate definitive host. Certain acanthocephalans utilize one or more species of a second class of vertebrate as a paratenic, or rarely as a postcyclic, host. Postcyclic development involves the transmission of worms from a prey fish to a predator vertebrate in which the parasite can reestablish. Nickol (2003) listed ten species of acanthocephalans in which post cyclic transmission was demonstrated under laboratory conditions. The extent to which such transmission occurs in nature or its significance in the life cycle of involved species are not known. Possible postcyclic transmission in *P.* (*P.*) *celatus* is discussed at the end of this section. Aquatic acanthocephalans maturing in fish may use other fish, or rarely amphibians, as paratenic hosts. The crustacean intermediate host is known from only one species of *Pallisentis* Van Cleave, 1928, i.e., *P.* (*P.*) *nagpurensis* (Bhalerao, 1931) Baylis, 1933; it is *Cyclops sternuus* (Fischer, 1851) (Cyclopoida). Six species of fish and one amphibian paratenic host, *Rana tigrina* Wiegmann, 1835, were also reported for *P.* (*P.*) *nagpurensis* by George & Nadakal (1973). Acanthocephalans, however, rarely use three classes of vertebrates in their life cycle. For example, Amin et al. (1998) described immature adult *Sphaerechinorhynchus macropisthospinus* Amin, Wongsawad, Marayong, Saechoong, Suwattanacoupt and Sey, 1998 from lizards, frogs and fish in Thailand. A similar situation appears to exist for *P.* (*P.*) *celatus* in neighboring Vietnam. *Pallisentis* (*P.*) *celatus* was originally described by Van Cleave (1928) from three species of fish from China:



Figs. 1-8. Immature *Pallisentis* (*P.*) *celatus* from the intestine of fish intermediate hosts. 1-4- Progressively developing males from young (Fig. 1) to fully developed cystacanth (Fig. 4); 5-8- Progressively developing females from young (Fig. 5) to fully developed cystacanth (Fig. 8). Measurement bars = 1.0 mm.

Table 2. Comparison between immatures of *Pallisentis celatus* from the vertebrate intermediate hosts (this paper) and adults from the definitive hosts (Van Cleave, 1928; Moravec & Sey, 1989). Measurements are in micrometers unless otherwise stated.

	Males		Females	
	Immatures	Adults	Immatures	Adults
Trunk LxW* (mm)	0.87-4.25 x 0.20-0.55	6.38-13.90 x 0.76-1.56	1.25-6.25 x 0.20-0.46	?-17.0 x ?-1.70
Collar spines L	8-13	12-24	13-15	12-15
Rings, no./ ring	5-6, 22-38	5-6, 20-40	6-8, 26-38	5-6, 20-40
Trunk spines L	13-15	15-30	13-16	15-18
Rings, no./ ring**	9-10, 30-40	10-13, 30-41	11-14, 28-40	10-13, 30-41
Proboscis LxW	92-177 x 105-218	218-313 x 218	146-187 x 146-218	326 x 204
Ant. hook L	45-63	53-66	67-72	53-75
2nd hook L	38-50	53-60	60	53-63
3rd hook L	32-40	35-42	50	35-48
Post. hook L	25-34	30-42	40-43	30-42
Prob. Recept. LxW	260-500 x 125-166	408-503 x 190-204	214-406 x 114-198	NG***
Lemnisci LxW	280-1, 350 x 20-80	2,049-3,131 x 110-160	624-1, 383 x 30-55	NG
Ant. testis LxW	50-364 x 40-270	710-1, 900 x 480-610	_____________	_____
Cement gland LxW	80-520 x 20-165	NG***	_____________	_____
Giant nuclei:				
Proboscis	2	NG	2	NG
Trunk (dorsal, vent.)	14-2 (1D, 1V)	NG	17-2 (1D, 1V)	NG
Lemniscus	1 each	NG	1 each	NG
Cement gland	15-18	14-16	_____ _____	_____
Eggs LxW	_____ _____	_____	_____ _____	53-77 X 30-35

* LxW: length x width

** An additional 2-4 incomplete rings of 2-20 trunk spines each may also be present.

*** NG = not given.

Anguilla pekinensis Temminck & Schlegel, 1846 (= *Anguilla japonica* Temminck & Schlegel, 1846), *Monopterus javanensis* Lacépède, 1800 (= *Monopterus albus* (Zuiew, 1793) and *Parasilurus asotus* Linnaeus, 1758 (= *Silurus asotus* Linnaeus, 1758). It was later reported from *M. albus* by Wang (1966, 1981) and Chen (1973 in Moravec & Sey, 1989) in China and by Moravec & Sey (1989) in Vietnam. Fish hosts reported by Wang (1981) include *A. japonica* and *P. asotus* as well as three additional fish species: *Ctenopharyngodon idellus* (Valenciennes in Cuvier & Valenciennes, 1844), *Misgurnus anguillicaudatus* (Cantor, 1842) and *Pseudobagrus fulvidraco* (Richardson, 1846). Wang (1981) also reported *P.* (*P.*) *celatus* from three species of amphibians: *Rana guentheri* Boulenger, 1882, *Rana plancyi fukiensis* Pope, 1929 and *Rana tigrina rugulosa* Wiegmann, 1835 (Ranidae) and two species of reptiles: the Asian soft shell turtle *Amyda sinensis* (Wiegmann, 1835) (Trionychidae) and the many- banded krait *Bungarus multicinctus* Blyth, 1861 (Elapidae). The above vertebrates are listed as hosts based only on reports of occurrence; no other information is available.

It appears from the above that at least six fish species are known definitive hosts of *P.* (*P.*) *celatus* to date. The frogs, e.g., *R. tigrina regulosa,* become infected as they feed under water on arthropods and small fish as well as on frogs and snakes. *Amyda sinensis* lies partly hidden in bottom sand or debris in ambush for invertebrates and small fish on which they prey (Pough et al., 1989). The turtle and the frog hosts appear to occupy the same ecological niche as hosts for *P.* (*P.*) *celatus. Bungarus multicinctus*, however, is a nocturnal venomous surface forager near aquatic areas where it feeds on fishes, frogs and reptiles such as snakes (McCarthy, 1986). The immature *P.* (*P.*) *celatus* reported in this study were not encysted in the body cavity, as in paratenic hosts, but were free in the gut of *C. fuscus*, *M. armatus* and *O. maculatus* in which they did not reach sexual maturity. These three fish species cannot thus be considered paratenic or principal definitive hosts but are regarded as occasional hosts rather than accidental hosts that represent dead-end infections. An occasional host "allows the establishment and survival of a few worms, which may undergo little growth or maturation (in which) gravid females are not usually seen" (Amin, 1987b). The concept of occasional host roughly corresponds to that of "additional host" (Lyndon & Kennedy, 2001) in which worms undergo growth but remain sexually immature; i.e., females do not produce eggs. The criteria for the designation of occasional hosts, among other host types, include fish species, host feeding behavior, temperature, availability of intermediate host, type of water body, fish movement and changes in fish host community (Amin, 1987b). While this does not appear to be a major transmission route of *P.* (*P.*) *celatus* in its definitive host system, it may, however, be a secondary route accessible at least to the reptilian hosts of this acanthocephalan.

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