First Finding of High Infestation of *Nemesis robusta* on Gill Filaments of *Alopias pelagicus* from the Andaman Sea, Thailand

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ABSTRACT

Parasitic copepod, *Nemesis robusta*, was firstly found in the pelagic thresher (*Alopias pelagicus*) in the Andaman Sea between the depths of 500-1,000 m. The pelagic threshers were highly infested with *N. robusta* at the distal part of gill filaments. Mean intensity was 39.25 individuals per shark. The copulatory activity of this parasite was also found. Such high infestation occurred only in this shark which may be a seasonal occurrence.

Keywords: Parasite, *Nemesis robusta*, pelagic thresher, *Alopias pelagicus*, Thailand

INTRODUCTION

The Andaman Sea is a non-enclosed sea with deep oceanic waters possessing a rich marine ecosystem. The deep-sea fishery resources in the Andaman Sea mainly are of the pelagic group. Pelagic resources are generally exploited by purse seines, drift gillnets, lift nets and other surrounding nets. There are 17 species and groups of pelagic resources which are considered economically important. Approximately 30 families, comprising more than 300 species, have been recorded (Chullasorn, 1998).

Among the group of sharks in the Andaman Sea, pelagic thresher (*Alopias pelagicus*) is a large lamniform shark belonging to family Alopiidae which is commonly found in neritic through oceanic tropical areas (Yamada *et al*., 1995; Myers, 1999). The distribution of this species is circumglobal. From the Indian Ocean, it can be found in the Red Sea, Arabian Sea, Maldives through Western Australia (Anderson *et al*., 1998). Utilization of this shark for human consumption consists of its liver oil for vitamin extraction, and leather and fins for soup (Compagno, 1998). Pelagic thresher can be caught together with tuna, swordfish and marlins by long liners and drift net fisheries (White *et al*., 2006). IUCN (2010) categorized pelagic threshers as a “vulnerable” species. Biology of this

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species in Thailand is less reliable based on the small specimens captured from deep sea fisheries outside the continental shelf of the Andaman Sea.

There was a previous study on ectoparasites of pelagic thresher in Thailand by Purivirojkul *et al*. (2009), in which only *Echthrogaleus denticulatus* and *Nogagus ambiguous* were found on the body surface. The current study aimed to gain a better knowledge of the parasites of *Alopias pelagicus* in Thailand. The results were compared with the literature on parasite infestation of these deep-sea sharks in other areas. Consequently, they can be applied as selected parasites for use in biological tagging of the deep-sea shark.

MATERIALS AND METHODS

Eight samples of pelagic thresher were captured by pelagic longline conducted by R.V. Chulabhorn of Department of Fisheries in May 2010. The sampling areas were located at the depths of between 500 m to 1,000 m in the Thai Exclusive Economic Zone in the Andaman Sea (latitude 07° 41.09′ N-09° 25.43′ N; longitude 97° 27.24′ E-97° 57.49′ E) (Figure 1). Identification of the shark species was undertaken according to Compagno (1984). Parasite identification was based on morphological features, according to Cressey (1967); Hewitt (1969); Kabata (1979); Pillai (1985); Boxshall (2004). The prevalence of parasitic infestation and mean intensity of parasite were calculated following Margolis *et al*. (1982).

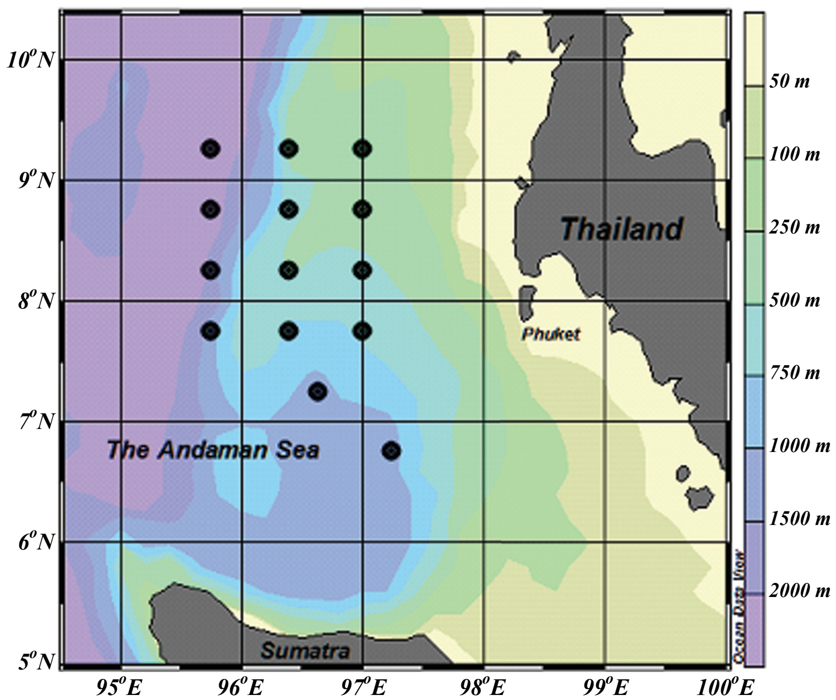

Figure 1. Locations of collecting station in the Andaman Sea (●).

RESULTS AND DISCUSSION

All examined samples of *A. pelagicus* were highly infested with parasitic copepods, *N. robusta* (van Beneden, 1851). This parasite was found attached to the distal part of the gill filaments. Mean intensity was 39.25 individuals per shark, and 8-73 samples of *N. robusta* were observed. Each gill filament could carry *Nemesis* at a maximum number of 8 individuals on its tip which is similar to the report on *Nemesis aggregates* from *Alopias vulpinus* (Benz, 1980).

The details of *N. robusta* (Figures 2 to 3) from this study are described as follows:

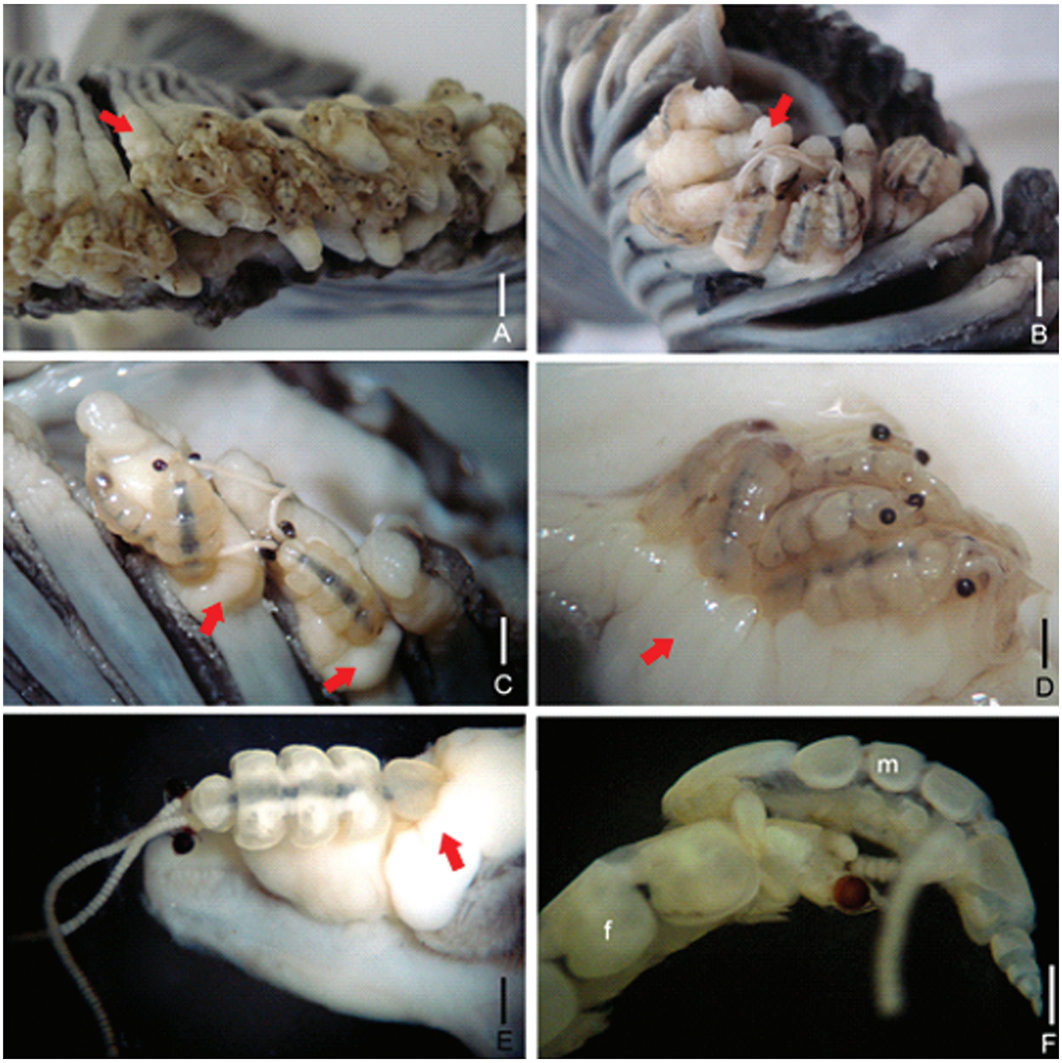

Figure 2. *Nemesis robusta* on gill filaments of *Alopias pelagicus*. A.-E. *N. robusta* attached only at the free distal tips of the gill filaments, tissue proliferation of gill filaments were observed (arrow); C. 1-2 parasites per one gill filament; D. 8 parasites per one gill filament; E. dorsal view of *N. robusta*; F. Lateral view of male (m) and female (f) in presumed copulatory embrace (scale bar A= 2 cm; B= 1.8 cm; C and D= 600 µm; E= 500 µm; F= 300 µm)

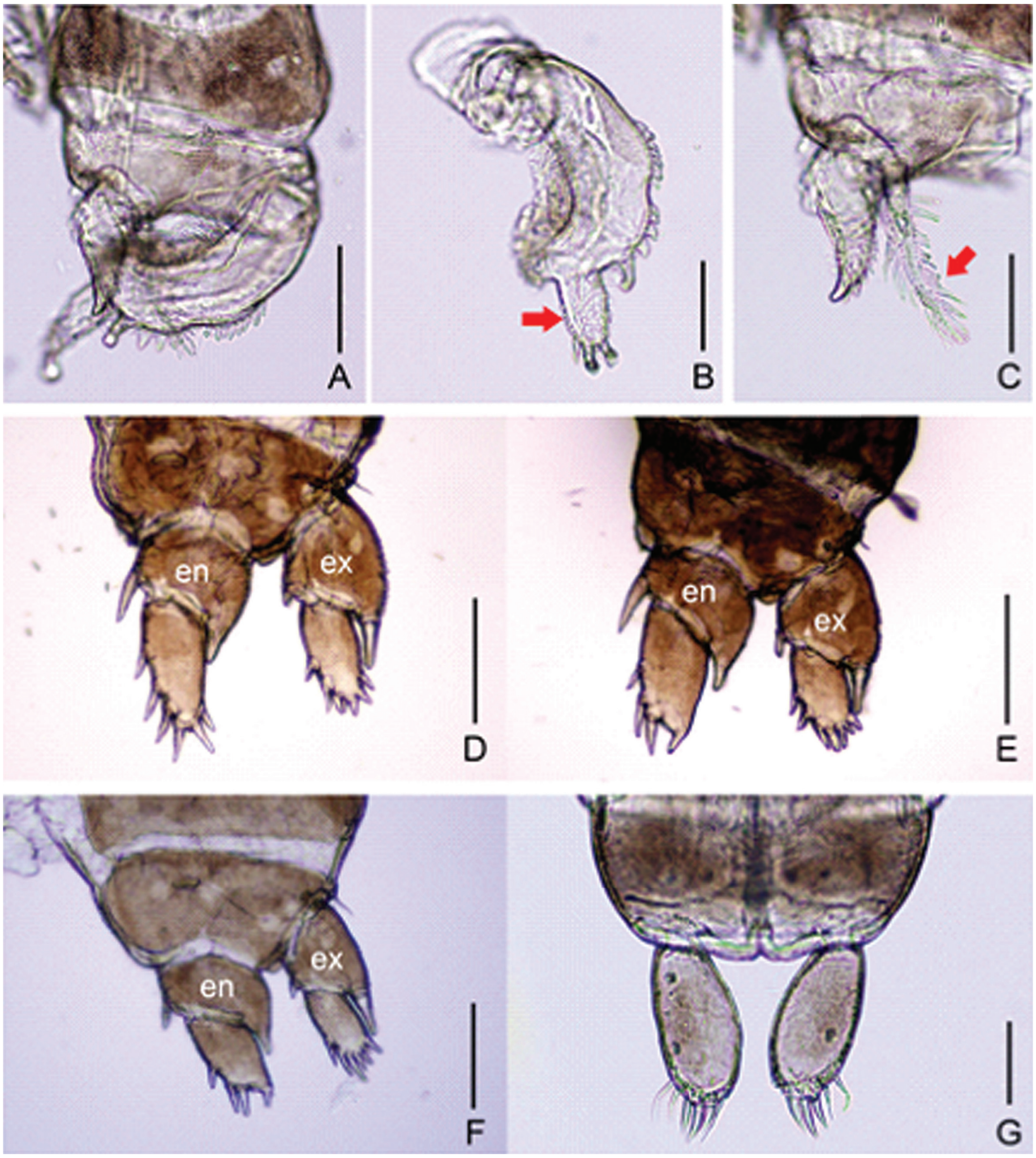

Figure 3. *Nemesis robusta* (female) from *Alopias pelagicus*.
A.-C. first pereiopod
B. exopod (arrow=2nd segment of exopod)
C. endopod (arrow=plumose seta)
D. second pereiopod
E. third pereiopod
F. fourth pereiopod
G. caudal lamina
(scale bar A= 150 µm; B,C=100 µm; D-F= 200 µm; G= 100 µm)

Total length was 3.4-5.7 mm. Cephalothorax with suboval dorsal shield was separated from the second thoracic segment by a short neck. The first three free thoracic segments were broader than the cephalothorax and had equal widths. The lateral margins of genital segment rounded. The abdomen is three-segmented. The caudal laminae subovate had six spines on distal margin, the outermost two were the smallest. Egg strings were as long as the body length and contained more than 77 eggs.

The first antenna was straight, apparently of twelve segments. The second antenna had four segments, and the terminal segment had a terminal claw. maxilliped subchelate. The first pereiopod is biramous, exopod had two segments, and the distal margin of second segment had three long spines. The basal segment of endopod had a long plumose seta at outer proximal angle, and with two large processes on distal margin.

For the second pereiopod biramous, each ramus had two segments - the second narrower than the first. The first segment of exopod had a large spine on outer distal angle, while the second segment had seven to eight spines on distal margin, with the endopod having very large spines on outer and inner distal angles, and the second segment had six spines on distal margin.

For the third pereiopod biramous, the distal margin of exopod had seven spines, and the endopod segment had four spines on distal margin. For the fourth pereiopod biramous, the second segment of exopod had six spines on distal margin; and the second endopod segment had three to six spines on distal margin.

All the characteristics agreed with the findings of Hewitt (1969). However, Hewitt (1969) did not describe the detail of egg string as they were missed or damaged

The parasitic copepod, *Nemesis* Risso, 1896, is a siphonostomatoid species composed of 10 species namely, *N. atlantica*, *N. carchariaeglauci*, *N. lamna* (syn. *N. carchariarum, N. mediterranea, N. vermi*) *N. macrocephalus, N. pilosus, N. robusta* (syn. *N. aggregatus, N. pallida*), *N. sphyrnae*, *N. spinulosus, N. tiburo,* and *N. versicolor* (Walter, 2010). All species are marine types and specific to elasmobraches especially sharks and rays (Kabata, 1979). The examples of specific hosts for *Nemesis* are shown in Table 1. However, only *N. lamna* and *N. robusta* are universal species among elasmobranches (Kabata, 1979).

Table 1. Host specific of *Nemesis* to elasmobranches.

Species of *Nemesis*	**Host**	**Reference**
N. atlantica Wilson, 1922	*Scoliodon terrae-novae*	Wilson (1922)
	Carcharinus leucas	Cressey (1970)
	Carcharinus maculipinnis	Cressey (1970)
	Carcharinus acronotus	Cressey (1970)
	Sphyrna mokarran	Cressey (1970)
N. carchariaeglauci Hesse, 1883	*Carcharias glaucus*	Hesse (1883)
N. macrocephalus Shiino, 1957	*Carcharinus melanopterus*	Shiino (1957)
N. pilosus Pearse, 1951	*Carcharias littoralis*	Pearse (1951)
	Negaprion brevirostris	Cressey (1970)
	Carcharinus maculipinnis	Cressey (1970)
	Carcharinus limbatus	Cressey (1970)
N. sphyrnae Rangnekar, 1984	*Sphyrna zyguena*	Rangnekar (1984)
N. spinulosus Cressey, 1970	*Carcharinus milberti*	Cressey (1970)
	Carcharinus obscurus	Cressey (1970)
N. tiburo Pearse, 1952	*Sphyrna tiburo*	Pearse (1952)
N. versicolor Wilson, 1913	*Sphyrna zygaena*	Wilson (1913)
	Carcharhinus brevipinna	Cressey (1967)
	Carcharhinus maculipinnis	Dippenaar (2005)

N. lamna has been reported to be found from *A. vulpinus* (Raibaut *et al*., 1998), *Carcharodon carcharias* (Cressey, 1970; Dippenaar *et al*., 2008), *Cetonurus crassiceps* (Holmes, 1998; Raibaut *et al*., 1998), *Cetorhinus maximus* (Hewitt, 1969) *Dasyatis centroura* (Raibaut *et al*., 1998), *Isurus guentheri* (Cressey, 1967; Cressey, 1968; Raibaut *et al*., 1998), *Isurus oxyrinchus* (Benz, 1980; Oldewage and Smale, 1993), *Lamna nasus* (Raibaut *et al*., 1998), *Lichia amia* (Raibaut *et al*., 1998) and *Odontaspis ferox* (Raibaut *et al*., 1998). *N. robusta* was found in 28 host species as shown in Table 2.

From Table 2, it could be said that *N. robusta* has a wide geographic distribution (Newbound and Knott, 1999) but the infestation of this parasitic copepod in *A. pelagicus* has never been reported before. To the author's knowledge, this is the first finding of *N. robusta* in *A. pelagicus* in the Andaman Sea, Thailand.

Nemesis spp. commonly infects the distal part of the gill filaments except in the study of Oldewage and Smale (1993) which found this parasite in the mouth of *Isurus oxyrinchus*. In the current study, all *N. robusta* were found attached to *A. pelagicus* at the gill filaments' free distal tips. This is similar to the reports of Benz (1980) and Benz and Adamson (1990) which also found the epidemic phenomenon of *N. robusta* in all pelagic thresher samples. However, high infestation was reported only in *A. vulpinus* by Benz and Adamson (1990). Moreover, we also recognized the copulatory activity of this parasite (Figure 2F).

Table 2. Host range and distributed areas of *N. robusta* in elasmobranches

Host	Area	Reference
Alopias vulpinus	Northwest Atlantic	Wilson (1932)
	South Africa	Barnard (1948)
	British waters	Leigh-Sharpe (1936)
	northern Atlantic waters, New York	Benz and Adamson (1990)
Carcharhinus amblyrhynchos	Western Australia	Newbound and Knott (1999)
Carcharhinus brevipinna	Mediterranean	Raibaut *et al*. (1998)
Carcharhinus leucas	Indian Ocean	Cressey (1967)
	southern Africa	Dippenaar (2005)
Carcharhinus limbatus	Carolina	Pearse (1947)
Carcharhinus milberti	Northwest Atlantic	Wilson (1932)
Carcharhinus obscurus	Northwest Atlantic	Wilson (1932)
Carcharhinus plumbeus	Western Australia	Newbound and Knott (1999)
Carcharodon carcharias	Northwest Atlantic	Wilson (1932)
Carcharias taurus	Canada	Margolis and Kabata (1988)
Dasyatis aspersa	Adriatic	Valle (1880)
Dasyatis centroura	Mediterranean	Raibaut *et al*. (1998)
Dasyatis pastinaca	Belgium	van Beneden (1851)
Galeocerdo cuvieri	Northwest Atlantic	Wilson (1932)
Hexanchus griseus	Adriatic	Valle (1884)
	Mediterranean	Raibaut *et al*. (1998)
Mustelus sp.	Namibian coast	Kensley and Grindley (1973)
Mustelus asterias	Mediterranean	Raibaut *et al.* (1998)
Mustelus mustelus	Belgium	van Beneden (1851)
	Mediterranean fish	Raibaut *et al*. (1998)
Mustelus punctulatus	Mediterranean fish	Raibaut *et al.* (1998)
Negaprion brevirostris	Dry Tortugas	Wilson (1935)
Prionace glauca	Belgium	van Beneden (1851)
	Cape Peninsula	Kensley and Grindley (1973)
	Mediterranean fish	Raibaut *et al.* (1998)
	southern Africa	Dippenaar (2005)
Raja batis	Mediterranean fish	Raibaut *et al.* (1998)
Raja oxyrinchus	Mediterranean fish	Raibaut *et al.* (1998)
Sphyrna sp.	Mauritania	Brian (1924)
Sphyrna lewini	Atlantic	Capart (1959)
	Indian Ocean	Cressey (1967)
	southern Africa	Dippenaar (2005)
Sphyrna mokarran	Indian Ocean	Cressey (1967)
	southern Africa	Dippenaar (2005)
Sphyrna zygaena	Atlantic Ocean	Rokicki and Bychawska (1991)
	Mediterranean fish	Raibaut *et al.* (1998)
	southern Africa	Dippenaar (2005)
Trygon pastinaca	Norfolk, England	Hamond (1969)

The effect of *N. robusta* epidemic in shark was reported by Benz and Adamson (1990). They found tissue erosion associated with the rasping effects of various copepod appendages and clearly saw this parasite ingesting the shark's gill. Host response to parasites was seen as swollen and blanched zones at the infected regions. The tissue proliferation reduced respiratory efficiency by blocking water flow through the lamella channels underlying the affected area (Benz, 1980).

From a previous study (Purivirojkul *et al*., 2009), only two species of ectoparasites, *E. denticulatus* and *N. ambiguous*, were found on the body surface of *A. pelagicus* collected in March 2008. We did not find the infestation of *N. robusta*. Two years later, in May 2010, all examined samples of *A. pelagicus* did not have *N. ambiguous* but there was an epidemic phenomenon of *N. robusta* at the gill filaments. It could be a seasonal effect on parasitic life cycle in relation to its host. Such case is very interesting wherein a monitoring of the effects of environmental or climate change on aquatic animal health could be necessary.

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