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Research article

Prevalence study of gill parasites of sillaginid fish from the upper Gulf of Thailand and new host records

Nussaba Niyom, Watchariya Purivirojkul*

Animal Systematics and Ecology Speciality Research Unit (ASESRU), Department of Zoology, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand.

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Abstract

Ectoparasite surveys were undertaken on 228 sillaginid fish samples from the upper Gulf of Thailand during February 2016–February 2017. Six sillaginid fish species were identified: *Sillago aeolus*, *S. asiatica*, *S. indica*, *S. ingenuua*, *S. maculata* and *S. sihama*. *S. indica* was observed in the highest number, while *S. maculata* was observed in the lowest number. This report is the first to describe *S. indica* in the Gulf of Thailand. All the sillaginid fish samples were examined for gill parasites. Eight species of gill parasites were identified: three species of monogenean (*Paradiplectanum blairense*, *P.sillagonum* and *Monoplectanum australe*) and five species of copepods (*Nothobomolochus lateolabracis*, *Lernanthropus sillaginis*, *Caligus epinepheli*, *Caligus* sp. and *Branchiella* sp.) *Paradiplectanum* spp. and *Lernanthropus sillaginis* were found in all samples. *Paradiplectanum blairense* and *P. sillagonum* were parasitized with *S. indica*, *S. sihama* and *S. ingenuua*; *Monoplectanum australe* was found in *S. aeolus* and *S. maculata*; *Nothobomolochus lateolabracis* was found in *S. indica* and *S. sihama*; *Branchiella* sp. was found in *S. indica*; and *Caligus epinepheli* was found in *S. sihama*. Three new host records were found: *Monoplectanum australe* was found in *S. aeolus,* while *Paradiplectanum blairense* and *P. sillagonum* were found for the first time in *S. ingenuua*. This report is the first to identify *M. australe*, *N. lateolabrachis* and *C. epinepheli* in the upper Gulf of Thailand.

Introduction

The sillaginid fish species, or sand whiting, are in the family Sillaginidae, Order Peciformes. There are 35 species belonging to five genera—*Sillago*, *Sillaginopsis*, *Sillagonodes*, *Sillaginopodys* and *Sillaginops* (Kaga, 2013). These sillaginid species are widespread throughout the Indian Ocean and the western Pacific Ocean (McKay, 1992). In Thailand, they are found in the Gulf of Thailand and the Andaman Sea (McKay, 1992). In the past, only two of these species have been recorded in Thailand, namely *Sillago sihama* and *S. maculata* (Department of Fisheries, 1964). However, according to McKay (1992), the swimbladder is an important organ in the identification of this fish group. Therefore, the current research aimed to update the species of sillaginids in the Upper Gulf of Thailand. Parasitic surveys from this group of fish were also studied. Parasites are important because they absorb nutrients from their host body, which can result in the weakness and death of the host (Moller and Anders, 1986). Moreover, parasites can be used as biological tags to assess the host population structure (Catalano et al., 2013).

* Corresponding author.
E-mail address: fsciwyp@ku.ac.th (W. Purivirojkul)

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Many species of monogeneans show host specificity at the species level, but some monogeneans show host specificity at the genus level; the specificity is also recorded in the parasitic copepod (Whittington et al., 2000). Hence, the objective of this study was to identify sillaginid fish species in the upper Gulf of Thailand and to examine them for gill parasites. The results from this study will update the knowledge of the diversity of sillaginid fish populations in the upper Gulf of Thailand and their gill parasites.

Materials and Methods

Samples of dead sillaginid fish were collected during February 2016–February 2017 (228 samples) from the upper Gulf of Thailand. The samples were immediately transported to the laboratory in the Department of Zoology, Kasetsart University, Bangkok, Thailand. All samples were preserved frozen. Sillaginid fish species have external morphological similarities, such as shape and color, which can cause much confusion among the species. Therefore, they are often identified based on the swimbladder because this organ shows obvious differences (McKay, 1992). The weight in grams and the measured total length (TL) in centimeters were recorded, and ectoparasites were detected in the gills by cutting each gill filament in a Petri dish filled with water and examining them for ectoparasites under a stereomicroscope. Monogeneans were fixed in ammonium picratum glycerine, Parasitic copepods were kept in 70% ethanol, cleared in lactic acid and observed microscopically. The parasites were identified based on their morphological characteristics according to Adday (2003), Hayward (1996), Ho and Lin (2003), Jivaluk (1991), Khamees and Adday (2013), Lin and Ho (2005), Pillai (1985), Purivirojkul and Areechon (2008) and Sirikanchana (2003). The prevalence and mean intensity of the ectoparasites were calculated according to Bush (1997).

Results

Samples of sillaginid fish species

In total, 228 sillaginid fish were collected and identified into six species: *Sillago aeolus*, *S. asiatica*, *S. indica*, *S. ingenuua*, *S. maculata* and *S. sihama*. *Sillago indica* was found in the highest numbers (105 samples), followed by *S. aeolus* (71 samples) and *S. sihama* (24 samples), respectively (Table 1). The swimbladder shapes of the sillaginid fish in each species had different characteristics. *Sillago aeolus* have three rudimentary anterolateral extensions and a single

Table 1 Prevalence and mean intensity of gill parasites of sillaginid fish from the Upper Gulf of Thailand

Fish species	Number of fish	Species of parasites	Number of parasites	Number of infected fish	Prevalence (%)	Mean intensity (number of parasites/fish)
Sillago aeolus	71	*Monoplectanum australe*	6	2	2.82	3.00
		Lernanthropus sillaginis	14	13	18.31	1.08
S. asiatica	11	*L. sillaginis*	1	1	9.09	1.00
		Caligus sp.	1	1	9.09	1.00
S. indica	105	*Paradiplectanum blariense*	422	70	66.67	6.03
		P. sillagonum	97	29	27.62	3.34
		L. sillaginis	57	38	36.19	1.50
		Nothobomolochus lateolabracis	6	5	4.76	1.20
		Branchiella sp.	2	2	1.90	1.00
S. ingenuua	12	*P. blairense*	3	2	16.67	1.50
		P. sillagonum	3	1	8.33	3.00
		L. sillaginis	1	1	8.33	1.00
S. maculata	5	*Monoplectanum australe*	2	1	20.00	2.00
		L. sillaginis	2	2	40.00	1.00
S. sihama	24	*P. blairense*	64	13	54.17	4.92
		P. sillagonum	27	6	25.00	4.50
		L. sillaginis	33	7	29.17	4.71
		Caligus epinepheli	4	4	16.67	1.00
		N. lateolabracis	2	2	8.33	1.00
6 species	228		747			

posterior extension are different from *S. maculata* in lacking a well-developed anterolatoral extension instead of four and a single posterior extension. *Sillago indica* and *S. sihama* have two anterior extensions and two posterior extensions, but the *S. sihama* swimbladder has a smooth edge. *Sillago asiatica* has three anterior extensions with the middle one projecting forward with the anterolateral ones recurved backward along half length of the swimbladder and one posterior extension. Finally, *S. ingennua* has a short median anterior extension and one posterior extension (Fig. 1).

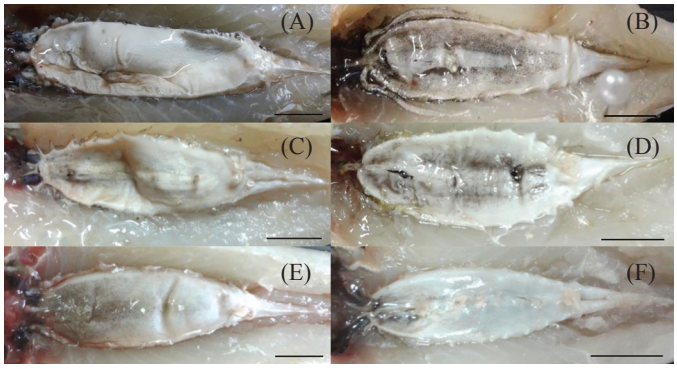

Fig. 1 Swimbladder of Sillaginid fishes: (A) *Sillago aeolus*; (B) *S. asiatica*; (C) *S. indica*; (D) *S. ingenuua*; (E) *S. maculata*; (F) *S. sihama* (scale bars: 1 cm)

Ectoparasites in sillaginid fish from the upper Gulf of Thailand

The 228 sillaginid fish samples were examined for ectoparasites and eight species (747 samples) were found on gill filaments (Table 1). There were three species of monogeneans (*Paradiplectanum blairense*, *P. sillagonum* and *Monoplectanum australe*) and five species of parasitic copepods (*Nothobomolochus lateolabracis*, *Lernanthropus sillaginis*, *Caligus epinepheli*, *Caligus* sp. and *Branchiella* sp.) as shown in Fig. 2. *Paradiplectanum blairense* was identified in the highest number, followed by *P. sillagonum* and *L. sillaginis*. ~~P~~*Paradiplectanum blairense* and *P. sillagonum* parasitized *S. indica*, *S. sihama* and *S. ingenuua*, while another species of monogene, *Monoplectanum australe* was found in *S. aeolus* and *S. maculata.*

Paradiplectanum blairense was identified by the presence of two small squamodiscs, male copulatory organ long with the terminal end of copulatory tube curved, posterior prostatic reservoir elongate and recurved conical tip, vagina large round and chambered while *P. sillagonum* was identified by the presence of two large squamodiscs, male copulatory organ short, posterior prostatic reservoir thin flat blade-like and vagina small bead-like. *Monoplectanum australe* had one squamodisc, male copulatory organ long with the terminal end of the copulatory tube slightly curved, posterior prostatic reservoir curved and conical tip.

Nothobomolochus lateolabracis was identified by the presence of a cephalothorax wider than long, 2nd thoracic segment similar rectangular shape at the base curved, antennule and antenna with setae, 5th thoracic with egg sac, legs one large and four short with only two endopods at the tip, caudal ramus longer than wide with a long terminal setae, egg sac shorter than body. *Lernanthropus sillaginis* was identified by the presence of a cephalothorax roughly circular, antennule small and seven-segments, antenna large curved and 2 segments, terminal segments slightly bent claw, trunk large with

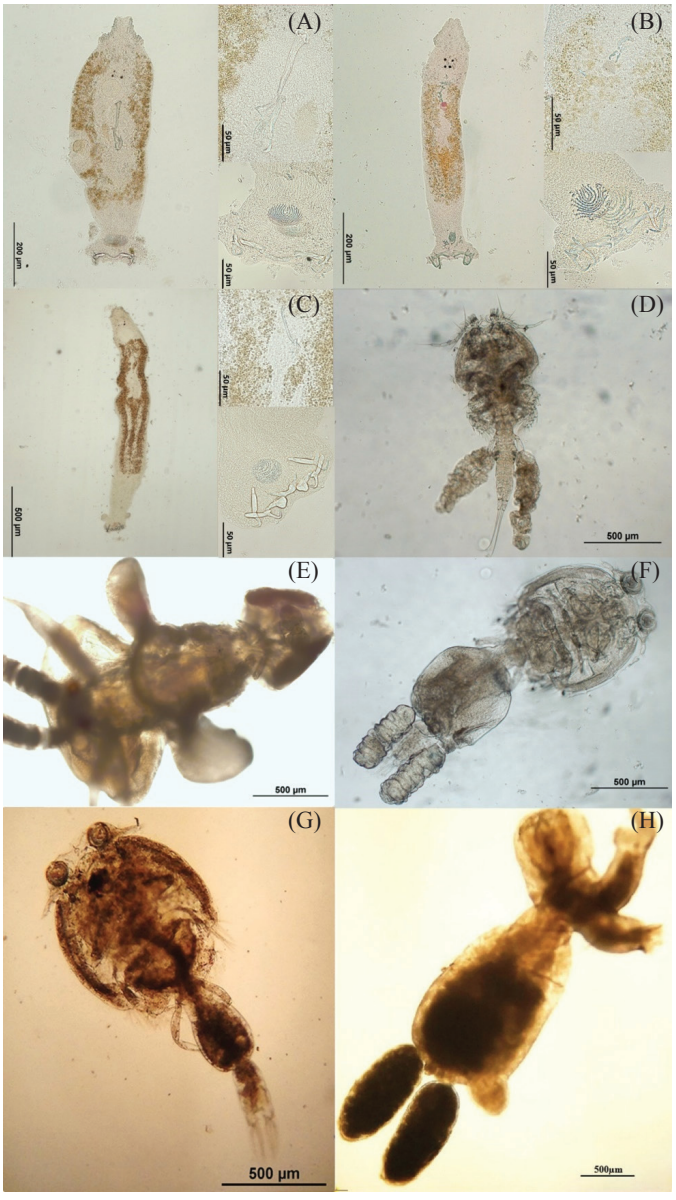

Fig. 2 Ectoparasites found in sillaginid fish from the Upper Gulf of Thailand: (A) *Paradiplectanum blairense*; (B) *P. sillagonum*; (C) *Monoplectanum australe*; (D) *Nothobomolochus lateolabracis*; (E) *Lernanthropus sillaginis*; (F) *Caligus epinepheli*; (G) *Caligus* sp.; (H) *Branchiella* sp.

leg 3 at lateral parts of trunk, leg 4 a pair of long, bifid processes with sub equal rami, egg sac half of body length. *Caligus epinepheli* was identified by the present of cephalothorax shield and subcircular, frontal plate with lunule, antennule with two segmented, antenna with three segmented, genital complex wide and square shape, caudal ramus longer than wide with three short and three long setae, egg sac half of body length. Two unidentified species of parasitic copepods were reported: *Caligus* sp. and *Branchiella* sp. *Caligus* sp. was identified by the presence of a cephalothorax shield, frontal plate with lunule, genital complex small and triangular shape, caudal ramus longer than wide with three short and three long seta while *Branchiella* sp. was identified by the presence of two maxillipeds, first maxilla with bulla, second maxilliped large with hook and shorter than trunk, trunk large, egg sac short.

Sillago indica and *S. sihama* had the highest species diversity of gill parasites (five species) while *S. aeolus* and *S. asiatica* had the lowest infection species diversity of gill parasites (two species) as shown in Table 1. *Paradiplectanum blariense* was a parasite of *S. indica, S. ingenuua* and *S. sihama* and its highest prevalence and mean intensity were in *S. indica* (66.67%, 6.03 parasites/fish) and its lowest prevalence and mean intensity were in *S. ingenuua* (16.67%, 1.50 parasites/fish). *Paradiplectanum sillagonum* was a parasite of *S. indica*, *S. ingenuua* and *S. sihama* and its highest prevalence was in *S. indica* (27.62%) and its lowest prevalence was in *S. ingenuua* (8.33%). The mean intensity of *P. sillagonum* was highest in *S. sihama* (4.50 parasites/fish) followed by *S. indica* (3.34 parasites/fish) and *S. ingenuua* (3.00 parasites/fish). *Monoplectanum australe* was a parasite of *S. aeolus* and *S. maculata* and its highest prevalence was in *S. maculata* (20.00%) and its lowest prevalence was in *S. aeolus* (2.82%) with mean intensity values of 2.00 and 3.00 parasites/fish, respectively.

Nothobomolochus lateolabracis was a parasite of *S. indica* and *S. sihama* and its highest prevalence was in *S. sihama* (8.33%) and its lowest was in *S. indica* (4.76%) with mean intensity values of 1.00 and 1.20 parasites/fish, respectively. *Lernanthropus sillaginis* was a parasite found in all the sillaginid fish samples and its highest prevalence was in *S. maculata* (40.00%) and its lowest was in *S. ingenuua* (8.33%). The mean intensity of *L. sillaginis* was highest in *S. sihama* (4.71 parasites/fish) followed by *S. indica* (1.50 parasites/fish) and *S. aeolus* (1.08 parasites/fish). *Caligus epinepheli* was found only in *S. sihama* with a prevalence of 16.67% and a mean intensity of 1.00 parasite/fish. *Caligus* sp. was found only in *S. asiatica* with a prevalence of 9.09% and a mean intensity of 1.00 parasite/fish. *Branchiella* sp. was found only in *S. indica* with a prevalence of 1.90% and a mean intensity of 1.00 parasite/fish (Table 1).

Discussion

The published literature indicates that nine sillaginid fish species have been recorded in Thailand (Department of Fisheries, 1964; McKay, 1992; Sirimontaporn and Choonhaparn, 1995). Six sillaginid fish species— *Sillaginopsis panijus, Sillago aeolus*, *S. ingenuua*, *S sihama*, *S. lutea* and *S. soringa*—were found in lower Southern Thailand (Sirimontaporn and Choonhaparn, 1995) and seven species were found in the Gulf of Thailand and the Andaman Sea, consisting of *Sillaginopsis panijus*, *Sillago aeolus*, *S. asiatica*, *S. chondropus*, *S. ingenuua*, *S. intermedius* and *S. sihama* (McKay, 1992). However, the current study did not find *Sillaginopsis panijus*, *Sillago chondropus*, *S. lutea*, *S. soriga* and *S. intermedius*, though *S. indica* was recorded for the first time in the Gulf of Thailand.

Both the monogenean and parasitic copepods found in this study showed specificity to their host. Based on previous literature, *P. blairense* has been reported in various sillaginid fish species around the world: in *S. sihama* from the Gulf of Thailand in Chon Buri province (Sarapon and Purivirojkul, 2015); in *S. sihama* (Hayward, 1996); in *S. sihama* in China (Jianying et al., 2003); in *S. indica* and *S. sihama* in midsouthern Indonesia to southern China to the Persian Gulf (Hayward, 1997a); and in *S. indica* and *S. sihama* in Asia (Hayward, 1997b). *Paradiplectanum sillagonum* has been reported in various sillaginid fish species: in *S. sihama* from the Gulf of Thailand in Chon Buri province (Sarapon and Purivirojkul, 2015); in *S. sihama* in Malaysia (Hayward, 1996); in *S. sihama* in Kuwait (Kritsky et al., 2000); in *S. attenuata*, *S. sihama* and *S. vincenti* from tropical Australia to southern China to the Persian Gulf (Hayward, 1997a); and in *S. sihama* in Australia and in *S. attenuata*, *S. sihama* and *S. vincenti* in Asia (Hayward, 1997b). However, *S. ingenuua* is new host record for *P. blairense* and *P. sillagonum*. *Monoplectanum australe* was previously found in *S. maculata* and *S. burrus* from Australia (Hayward, 1996); in *S. burrus* and *S. maculata* from midwestern, northern and mideastern Australia (Hayward, 1997a); and in *S. maculata* and *S. burrus* from Australia (Hayward, 1997b). Finding *M. australe* in *S. aeolus* is a new host record. Based on these data, monogeneans in all the sillaginid fish sampled were specific to their hosts.

Nothobomolochus lateolabracis was found in *Sillago sihama* and *S. indica*. *Nothobomolochus lateolabrachis* was reported in *S. sihama* from Taiwan (Lin and Ho, 2015). However, this parasite was first reported in Thailand, and *S. indica* is a new host record for this parasite. *Lernanthropus sillaginis* parasitized all the sillaginids in this study. These results were the same as in previous records for sillaginids in India (Pillai, 1985) and Thailand (Sirikanchana, 2003). This parasite was also reported in the gills of both *S. arabica* and *S. sihama* from the coastal marine waters of the Arabian Gulf (Adday, 2013). Thus, *L. sillaginis* showed specificity to this fish group. *Caligus epinepheli* has a wide distribution and can parasitize various groups of fish, such as *S. sihama* from Malaysia (Maran et al., 2009), *Epinephelus septemfasciatus* from India (Pillai, 1985), *Drepane punctata* form Sri Lanka (Kirtisinghe, 1964), *Scolopsis vosmeri* from Taiwan (Ho et al., 2000), *Epinephelus merra* from Australia

(Kabata, 1965), Malaysia (Leong, 1984) and the Caribbean Sea (Cressey, 1991), *Nemipterus japonicas* from the Arabian Gulf (Khamees and Adday, 2013) and *N. tolu* and *N. delagoae* from the Persian Gulf (Ho and Sey, 1996). In the current study, *C. epinepheli* was found in *S. sihama,* as it had been in Malaysia and India. The identification of *C. epinepheli* is the first report for Thailand. *Branchiella* sp. was found in *S. indica;* however, previous records have reported this parasite in *S. sihama* from the Gulf of Thailand (Jivaluk, 1991; Purivirojkul and Areechon, 2008).

Ethics Statements

This research was approved by the Institutional Animal Care and Use Committee, Faculty of Science, Kasetsart University, Bangkok, Thailand under project number ACKU61-SCI-019.

Conflict of Interest

The authors declare that they are no conflicts of interest.

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