

Parasite fauna of seabass (*Lates calcarifer*) under mariculture conditions in Lampung Bay, Indonesia

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Summary

Fish parasites have been repeatedly reported to be a major threat to the developing industry of finfish mariculture in Indonesia, due to severe parasite and disease outbreaks. The aim of this study was to identify the metazoan parasite fauna and trichodinid ciliates that infect *Lates calcarifer* in a representative mariculture farm in Indonesia. Examined were 105 *L. calcarifer* (seabass) for the metazoan parasite fauna and trichodinid ciliates. Thirty-five specimens each from the net cages of the National Sea Farming Development Centre (Balai Budidaya Laut, BBL) in Lampung Bay, South Sumatra, Indonesia were investigated in three consecutive seasons (two dry and one rainy season from 2002 to 2003). Nineteen parasite species were identified; all fish specimens were infected with two to 10 parasite species, demonstrating a species-rich parasite fauna. Protozoans (1 species), myxozoans (1), digeneans (3), monogeneans (5), cestodes (3), nematodes (5) and acanthocephalans (1) were found, including 11 new host records in cultured *L. calcarifer* from Indonesia. Larval and adult parasite stages were isolated, demonstrating that this fish species, although kept inside the net cages, still functions as an intermediate and final host for marine fish parasites. During all seasons, the six detected monoxenous (single host life cycle) parasite species showed a higher prevalence than the 13 heteroxenous (multiple hosts) species. Most abundant were the fish pathogenic monogeneans *Pseudorhabdosynochus epinepheli*, *Pseudorhabdosynochus lantauensis*, *Benedenia epinepheli* and *Neobenedenia melleni* with a high prevalence. Most heteroxenous parasites (Digenea, Cestoda, Nematoda and Acanthocephala) occurred with a low prevalence below 26%, caused by the specific culture conditions. Diversity of the heteroxenous parasites was higher in the dry seasons than in the rainy season. Though some seasonality could be observed for the fish pathogenic monogeneans, severe disease outbreaks of these ectoparasites cannot be excluded in either the dry or rainy season.

Introduction

Indonesia has a vast potential for marine aquaculture development with more than 17 500 islands and a coastline of more than 81 000 km. According to Harris (2001) and the DGA (2004), an area between 140 000 ha to 3 780 000 ha has potential use for marine finfish culture. Of this estimate, only 981 ha (0.03%) are currently in use (FIRI, 2006), however, this sector enjoys an annual increase of 7.9% (Lowther, 2006).

To date, more than 3250 marine fish species are known from Indonesian waters (Froese and Pauly, 2006), of which 60 species have the potential for future cultivation in finfish farms. Mass production in general is always accompanied by parasites and pathogens threatening cultured fish. Especially parasites with single host life cycles (monoxenous parasites) such as protozoans, monogeneans and crustaceans can spread rapidly under high stocking density conditions (Leong, 1992; Diamant et al., 1999; Williams and Bunkley-Williams, 2000). Among others, the following parasite outbreaks led to high fish mortalities: the monogenean *Neobenedenia melleni* in a fish farm in Australia (Deveney et al., 2001), *Diplectanum latesi* in captive *Lates calcarifer* (Rajendran et al., 2000) and crustaceans belonging to the family Caligidae in different parts of the world (e.g. Ho, 2004; Johnson et al., 2004), as well as isopods like *Cymothoa indica* under laboratory conditions in India (Rajkumar et al., 2005).

Seabass (*L. calcarifer*) is one of the main target species currently cultivated in brackish water and marine environments throughout the Asian-Pacific region. Previous parasitological studies described a wide parasite spectrum in the Asian and Australian regions (Kasernchan and Boonyaratpalin, 1984; Glazebrook and Campbell, 1987; Leong and Wong, 1992a; Kordi, 1997). Some 75 parasite species are known to infect this fish species. Leong and Wong (1986) revealed 17 different parasite species for *L. calcarifer* from Thailand and Malaysia. Leong and Wong (1992a) studied *L. calcarifer* from a mariculture farm in Lampung, Indonesia, and detected four parasite species. Regional differences were examined by Leong and Wong (1992b) in Malaysia and by Ruangpan (1992) in Thailand; the authors could not detect distinct regional variations at the sampling sites. Studies on the seasonal occurrence of fish parasites on *L. calcarifer* are still lacking.

Lampung Bay is located at the southern tip of Sumatra, the second largest island in the archipelago. It covers an area of approximately 600 km, with a mean depth of 22 m (maximum depth 75 m) and a coastline of about 160 km (Wirawan et al., 1999). Within the bay, six areas are currently in use for intensive fish production in floating net cages: Condong Island, Lahu Island, Puhawang Island, Ringgung, Tanjung Putus and Hurun Bay. Square wooden cages are used for the cultivation of groupers (e.g. *Epinephelus* spp., *Cromileptes altivelis*) and seabass (*L. calcarifer*). The aim of the present study was to identify the parasites that infect *L. calcarifer* in a representative mariculture farm in Hurun Bay, Indonesia, including an analysis of seasonal variation in the parasite load, as this is important for health management. The occurrence of

pathogenic parasite species and their disease-causing potential is discussed.

Materials and methods

Specimens of *L. calcarifer* were investigated at the National Sea Farming Development Centre (Balai Budidaya Laut, BBL) in Lampung, Sumatra. The net cages (8 × 8 m, consisting of 4 units of 3 × 3 × 3 m each) were located in Hurun Bay (05°31'S, 105°15'E) in the western part of Lampung Bay (Fig. 1). A total of 105 fish, 35 specimens each in three consecutive seasons from 2002 to 2003 (dry season, June–August 2002; rainy season, March–April 2003 and dry season, September 2003), were examined for fish parasites. The fish in the net cages were fed daily with trash fish, which were small fish species cut into pieces.

Parasitological examination

Smears were taken from the gills and the inner opercula of the living fish. The fish were examined directly after catch from the net cages. Measurements of total fish length (TL, to the nearest 0.1 cm) and total fish weight (TW, to the nearest 0.1 g) were taken (Table 1). The skin, fins, eyes, gills and the mouth- and gill cavity were studied for ectoparasites. The digestive tract, liver, gall bladder, spleen, kidneys, gonads, heart and swim bladder were separated and transferred into petri-dishes filled with saline solution. The internal organs were examined under a stereomicroscope, while the gall bladder was removed and studied using a phase-contrast microscope. Belly flaps and musculature were examined on a candling table.

The isolated parasites were fixed in 4% formalin and preserved in 70% ethanol. Smears from the gills and the opercula were stained using silver nitrate impregnation after Klein (1926, 1958). The slides were rinsed and covered with 5% silver nitrate solution and impregnated for 30 min in the dark. The AgNO₃ was removed and the slides were covered with distilled water and exposed to ultraviolet light for 40–50 min. The smears were dried after exposure and directly studied under the microscope. Acanthocephala were transferred to freshwater until the proboscis everted prior to fixation. For identification purposes, Nematoda and Acanthocephala were dehydrated in a graded ethanol series and transferred to 100% glycerine (Riemann, 1988). Digenea,

Table 1

Size characteristics of *Lates calcarifer* sampled from a mariculture farm at Hurun Bay: season and number, mean length and mean weight (range in parentheses)

Season	n	TL [cm]	TW [g]
Dry season 2002	35	33.3 (26.5–41.5)	523.2 (262.7–1020.1)
Rainy season 2002/2003	35	36.0 (25.0–44.5)	652.0 (201.1–1228.4)
Dry season 2003	35	30.0 (26.0–33.5)	359.6 (229.6–490.0)

n, number; TL, total length; TW, total weight.

Monogenea and Cestoda were stained with acetic carmine, dehydrated, cleared with Eugenol and mounted in Canada balsam. Parasite identification followed standard identification literature and original descriptions.

Data analysis

The parasitological terms follow Bush et al. (1997): prevalence (*P*) is the number of fish infected with one or more individuals of a particular parasite species (or taxonomic group) divided by the number of hosts examined (expressed as a percentage):

$$\text{Prevalence} = \frac{\text{No. of hosts infested}}{\text{No. of hosts examined}} \times 100.$$

Intensity (of infection, *I*) is the number of individuals of a particular parasite species in a single infected host (expressed as a numerical range); mean intensity (of infection, *mI*) is the average intensity, or the total number of parasites of a particular species found in a sample divided by the number of infected hosts:

$$\text{Mean intensity} = \frac{\text{Total no. of a particular parasite}}{\text{No. of infected hosts}}.$$

Density equals intensity, but the number of parasites refers to approximately 1 cm² of mucus from the gill and skin surface.

Diversity of the heteroxenous parasite fauna was estimated using the Shannon–Wiener diversity index (*H'*) and the evenness index (*E*) of Pielou (Magurran, 1988):

$$H' = - \sum P_i * \ln P_i \quad E = H' / \ln S,$$

with *H'* being the diversity index, *P_i* the proportion of the individual (*i*th) species to the total and *S* the total number of

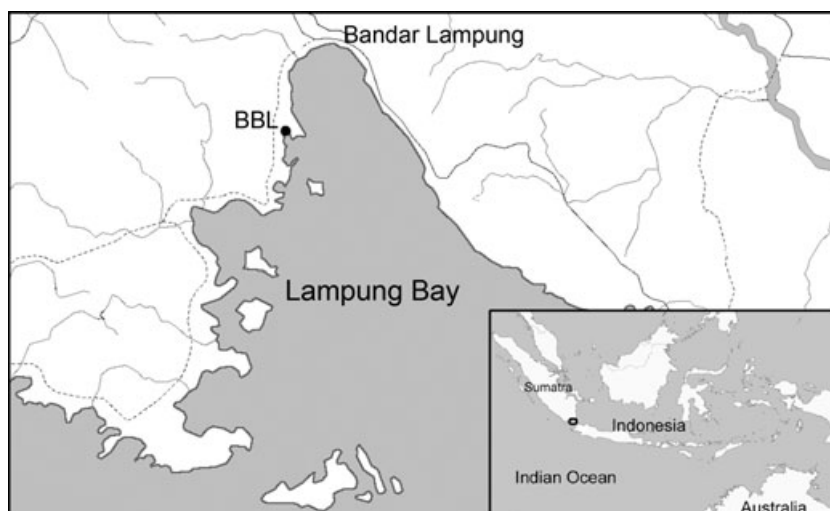


Fig. 1. Map of study area in Lampung Bay, with the National Seafarming Development Centre in Hurun Bay (Balai Budidaya Laut, BBL). Inset, lower right hand corner = location of Lampung Bay, southern tip of Sumatra, Indonesia

species in the community (species richness). The calculated index does not include monoxenous parasites (all ectoparasites in the present study) because the total number of parasite specimens is insecure due to sampling and handling procedures. Unidentified taxa such as Nematoda gen. et sp. indet. or *Prosorhynchus* indet. are also not included, as they can consist of more than one parasite species.

Results

The analysis of 105 specimens of *L. calcarifer* revealed high parasite diversity. A total of 19 different parasite species were found, six with a monoxenous (single host) and 13 with a heteroxenous (multiple hosts) life cycle. Of these, 11 parasite species represent new host records. All fish specimens were infected with at least two parasite species. The lowest species number (14) occurred in the dry season 2003. Sixteen parasite species were isolated from *L. calcarifer* in the dry season 2002 and the rainy season 2002/2003. The prevalence, intensity and mean intensity for each parasite species and season are given in Table 2.

Dry season in 2002

A total of 16 parasite species were isolated from the 35 dissected specimens of *L. calcarifer* (Table 2). The parasites belonged to the Protozoa (1 species), Myxozoa (1), Digenea (2), Monogenea (5), Cestoda (2) and Nematoda (5). All specimens of *L. calcarifer* harboured four to nine parasite species (Figs 2 and 3), and the diversity was of medium height ($H' = 0.39$, $E = 0.18$). The infection rate was not size

dependent (Fig. 2). Predominant parasites were the Protozoa, Myxozoa and Monogenea.

The Protozoa *Trichodina* spp. was found on the gills and the inner operculum. Except for two specimens, all fish were infested with these trichodinids. The gall bladder harboured all developmental stages of an unidentified Myxozoa gen. et sp. indet. Infecting only two fish, the Digenea occurred with low infection rates. A single *L. calcarifer* was infected with preadult *Prosorhynchus* indet. in the stomach. Adult *Pseudometadena celebensis* was detected in the intestine and pyloric caeca. Larval Cestoda (*Nybelinia indica*, *Scolex pleuronectis*) were isolated from the stomach, stomach wall (the former), intestine and pyloric caeca. The Monogenea occurred as adult (*Benedenia epinepheli*, *Neobenedenia melleni*, *Pseudorhabdosynochus* spp.) and larval (Oncomiracidae) as well as preadult stages (Capsalidae gen. et sp. indet.) on the gills and body surface. Highest prevalence of infestation was detected for *Pseudorhabdosynochus epinepheli* and *Pseudorhabdosynochus lantauensis* (as *Pseudorhabdosynochus* spp. in Table 2). Three larval (*Hysterothylacium* sp., *Terranova* sp., *Raphidascaris* sp. I) and one adult stage (*Raphidascaris* sp. II) of Nematoda were isolated from the internal organs. The highest infection rate was calculated for *Hysterothylacium* sp.

Rainy season in 2002/2003

A total of 16 parasite species were detected (Table 2) as belonging to the Protozoa (1 species), Myxozoa (1), Digenea (2), Monogenea (5), Cestoda (2), Nematoda (4) and Acanthocephala (1). All fish were infected with two to 10 parasite species (Figs 2 and 3) and the diversity was low ($H' = 0.09$,

Table 2

Parasites in/on *Lates calcarifer* sampled from a mariculture farm at Hurun Bay: prevalence (P%), mean intensity (mI), range of the intensity (I) and site of infection

	<i>Lates calcarifer</i>						Site
	Dry season 2002 (n = 35)		Rainy season 2002/2003 (n = 35)		Dry season 2003 (n = 35)		
	a/1	P (%) mI (I)	P (%) mI (I)	P (%) mI (I)	P (%) mI (I)		
Monoxenous parasite species							
<i>Trichodina</i> spp. (P)		94.3 156.7 ¹ (1–1251)	97.1 141.9 ¹ (2–593)	91.4 130.6 ¹ (2–1084)			Gills, operculum
<i>Benedenia epinepheli</i> (M)	a	57.1 16.1 (1–61)	37.1 2.5 (1–10)	71.4 4.7 (1–16)			Gills, body surface
<i>Neobenedenia melleni</i> (M)	a	68.6 8.4 (1–45)	47.3 5.8 (1–28)	77.1 5.1 (1–15)			Gills, body surface
Capsalidae gen. et sp. indet. (M)	1	91.4 16.7 (1–107)	91.4 9.5 (1–75)	91.4 8.2 (1–42)			Gills, body surface
<i>Pseudorhabdosynochus</i> spp. (M)	a	100.0 164.2 (32–537)	100.0 140.2 (14–269)	100.0 84.1 (47–167)			Gills
Heteroxenous parasite species							
Myxozoa gen. et sp. indet. (MY)		74.3 –	85.7 –	97.1 –			Gall bladder
<i>Prosorhynchus</i> indet. (D)	1	2.9 2.0 (2)	– –	– –			Stomach
<i>Pseudometadena celebensis</i> (D)	a	5.7 1.0 (1)	2.9 1.0 (1)	– –			Intestine, pyloric caeca
Sanguinicolidae gen. et sp. indet. (D)	a	– –	2.9 1.0 (1)	– –			Blood
<i>Nybelinia indica</i> (C)	1	22.9 1.4 (1–2)	– –	– –			Stomach, stomach wall
<i>Parotobothrium balli</i> (C)	1	– –	25.7 1.8 (1–5)	5.7 1.5 (1–2)			Stomach wall, mesenteries
<i>Scolex pleuronectis</i> (C)	1	57.1 30.2 (1–188)	100.0 47.2 (1–472)	48.6 4.6 (1–43)			Intestine, stomach, pyloric caeca
<i>Hysterothylacium</i> sp. (N)	1	42.9 1.8 (1–5)	11.4 1.0 (1)	11.4 1.3 (1–2)			Intestine, liver, stomach wall, mesenteries
<i>Terranova</i> sp. (N)	1	11.4 1.3 (1–2)	2.9 1.0 (1)	2.9 1.0 (1)			Intestine, liver, mesenteries, pyloric caeca
<i>Raphidascaris</i> sp. I (N)	1	5.7 1.5 (1–2)	– –	2.9 1.0 (1)			Stomach wall
<i>Raphidascaris</i> sp. II (N)	a	8.6 1.3 (1–2)	2.9 1.0 (1)	– –			Intestine
Nematoda gen. et sp. indet. (N)		14.3 1.0 (1)	2.9 1.0 (1)	2.9 1.0 (1)			
<i>Serrasentis sagittifer</i> (A)	1	– –	2.9 1.0 (1)	5.7 1.0 (1)			Mesenteries

a, adult; 1, larva; P, Protozoa; M, Monogenea; MY, Myxozoa; D, Digenea; C, Cestoda; N, Nematoda; A, Acanthocephala.

¹Mean density.

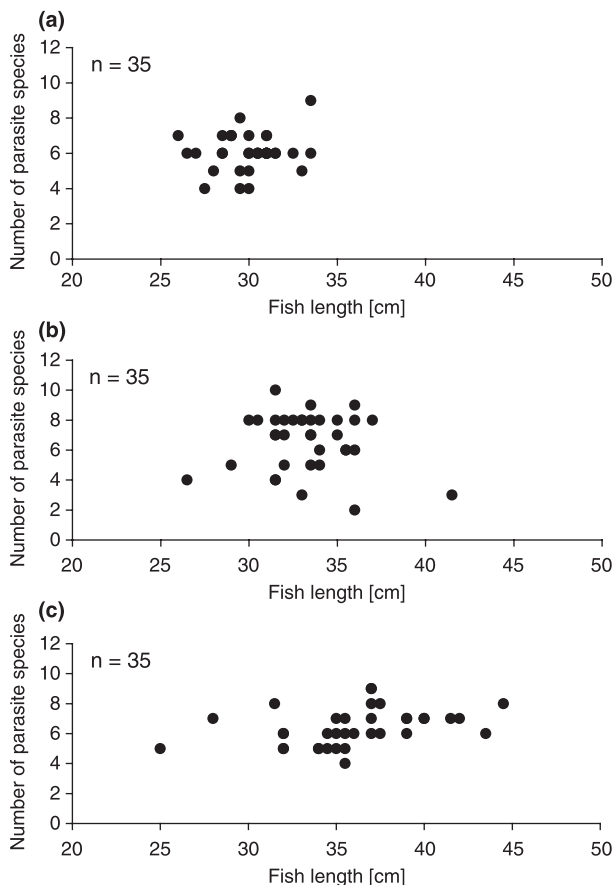


Fig. 2. Parasite species richness of *Lates calcarifer* in relation to fish length. (a) dry season 2002, (b) rainy season 2002/2003, (c) dry season 2003

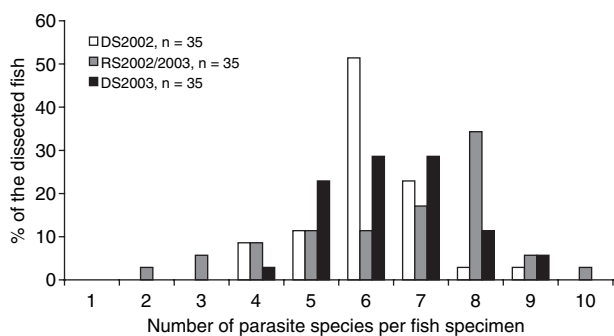


Fig. 3. Parasite species richness of *Lates calcarifer* in three consecutive seasons. DS2002 = dry season 2002, DS2003 = dry season 2003, RS2002/2003 = rainy season 2002/2003

$E = 0.04$). The infection rate was not size dependent (Fig. 2). The parasite fauna was dominated by the Protozoa, Myxozoa, Monogenea and Cestoda.

Except for a single fish, all investigated specimens were infested with *Trichodina* spp. on the gills and the inner operculum. Myxozoa (Myxozoa gen. et sp. indet.) showed high infection rates and were located in the gall bladder. Two adult Digenea specimens were found, *P. celebensis* from the pyloric caeca and Sanguinicolidae gen. et sp. indet. from a blood vessel in the swim bladder. Five Monogenea (*B. epinepheli*, *N. melleni*, Capsalidae gen. et sp. indet., *P. epinepheli* and *P. lantauensis*) infested the gills and the body surface. Adult *B. epinepheli* and *N. melleni* occurred in

lower infestation rates compared with larval and preadult Capsalidae gen. et sp. indet. and adult *Pseudorhadosynochus* spp. The highest infestation rates were calculated for the latter species. Two larval Cestoda were identified, with the plerocerci of the trypanorhynch *Parotobothrium balli* infecting the stomach wall and mesenteries. Highest infection rates were calculated for the tetraphyllidean larvae *Scolex pleuronectis* in the stomach, intestine and pyloric caeca. Four Nematoda, *Hysterothylacium* sp., *Terranova* sp., *Raphidascaris* sp. II and *Nematoda* gen. et sp. indet. were isolated with low prevalence and intensities. *Hysterothylacium* sp. and *Terranova* sp. were in the 3rd larval stage, whereas *Raphidascaris* sp. II was adult. A single acanthocephalan larva (*Serrasentis sagittifer*) was detected in the mesenteries.

Dry season in 2003

The dissected specimens of *L. calcarifer* were infected with 14 parasite species (Table 1), belonging to the Protozoa (1 species), Myxozoa (1), Monogenea (5), Cestoda (2), Nematoda (4) and Acanthocephala (1). The fish specimens harboured four to nine parasite species (Figs 2 and 3), and the calculated diversity was high ($H' = 0.58$, $E = 0.28$). The infection rate was not size dependent (Fig. 2). The Nematoda and Acanthocephala were less dominant.

High infestation rates were found for *Trichodina* spp. on the gills and the operculum. Except for a single specimen, all fish were infected with Myxozoa (Myxozoa gen. et sp. indet.) in the gall bladder. Four adult (*B. epinepheli*, *N. melleni*, *P. epinepheli* and *P. lantauensis*) and one larval/preadult (Capsalidae gen. et sp. indet.) Monogenea were isolated from the gills and operculum. Highest infestation rates were found for Capsalidae gen. et sp. indet. and the *Pseudorhadosynochus* species. Larval cestodes, *P. balli* and *Scolex pleuronectis*, were located in the intestine, stomach, stomach wall, mesenteries and pyloric caeca. Four nematode species (third larval stage) occurred with low infection rates (*Hysterothylacium* sp., *Terranova* sp., *Raphidascaris* sp. I, and an unidentified species); they were isolated from the intestine, liver, stomach wall, mesentery and pyloric caeca. Two fish were infected with Acanthocephala (*S. sagittifer*) in the mesentery.

Seasonal comparison

Both dry and rainy seasons showed a higher prevalence of monoxenous parasites compared with that of heteroxenous species (Fig. 4). Most abundant monoxenous species were the monogeneans *P. epinepheli* and *P. lantauensis*. Among the heteroxenous parasites, Myxozoa gen. et sp. indet. and larval cestodes *Scolex pleuronectis* were the most abundant. Most of the endoparasitic helminths occurred with a prevalence below 26%. Differences in the prevalence and intensity of infestation between the seasons could be observed for the adult monogeneans *B. epinepheli* and *N. melleni* that had a lower prevalence in the rainy season than in both dry seasons. In contrast, the prevalence of *Scolex pleuronectis* was much higher in the rainy season compared with that of both dry seasons. In all other parasite species, no distinct pattern between the two seasons could be observed, although prevalence and intensity data showed minor variation (see Table 2, Figs 3 and 4). The Protozoa, Myxozoa, Monogenea, *Scolex pleuronectis*, and the nematodes *Hysterothylacium* sp., *Terranova* sp. and Nematoda gen. et sp. indet. were found in each season. *Pseudometadena celebensis* (Digenea), *P. balli*

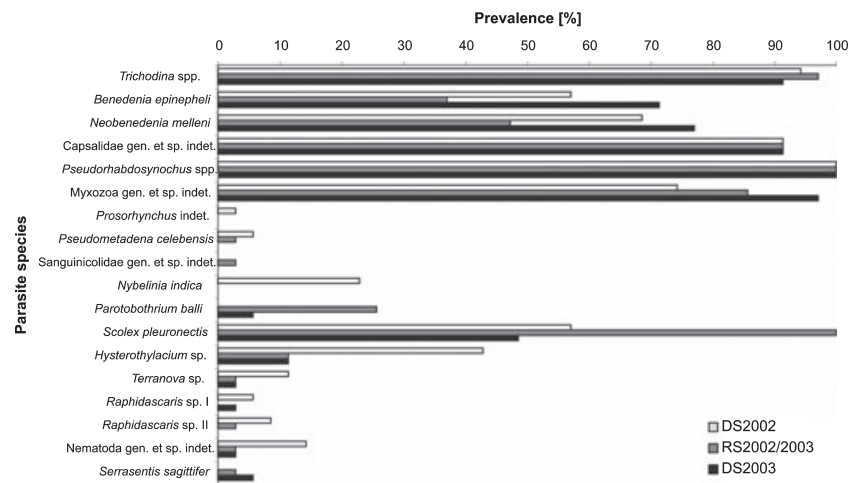


Fig. 4. Prevalence data of *Lates calcarifer* parasites in three consecutive seasons. DS2002 = dry season 2002, DS2003 = dry season 2003, RS2002/2003 = rainy season 2002/2003

(Cestoda), *Raphidascaris* sp. I and II (Nematoda) and *S. sagittifer* (Acanthocephala) occurred in two seasons with a low prevalence (< 26%). *Prosorhynchus* indet. and Sanguinicolidae gen. et sp. indet. (Digenea) as well as the Cestoda *N. indica* were detected in one season only.

Fish parasite diversity of *L. calcarifer* in the net cages was highest in the dry season 2003 ($H' = 0.58$, $E = 0.28$). Most of the dissected specimens harboured five to seven parasite species (Fig. 3). Diversity in the dry season of 2002 showed lower values ($H' = 0.39$, $E = 0.16$). More than 50% of studied *L. calcarifer* were infected with six parasite species (Fig. 3). Fish from the rainy season showed the lowest parasite diversity ($H' = 0.09$, $E = 0.04$). More than 30% of dissected fish specimens harboured eight parasite species and 2.9% up to 17.1% of the fish were infected with two to 10 parasite species (Fig. 3).

Discussion

Indonesia has a high potential for the development of finfish mariculture. Fish parasites have been repeatedly reported to be a major threat to this developing industry, due to severe parasite and disease outbreaks. The present study of the seabass *L. calcarifer* from Lampung Bay, Indonesia, revealed a species-rich parasite fauna, consisting of 19 species belonging to 12 different families. A seasonal comparison revealed some species that showed variation in prevalence and intensity of infection between the dry and the rainy season. Similarly, the parasite diversity varied between the seasons, although the species composition was similar. Four of the recorded parasites are known to be major pathogens in finfish mariculture.

Indonesia is known to be one of the areas with the highest marine aquatic biodiversity (Gray, 1997). This is due to the geographical position and geological history of the Indonesian Archipelago. Previous parasitological studies have revealed great parasite diversity. Of a total of about 242 different fish species studied so far, over 400 fish parasites have been recorded from Indonesian waters (Jacob and Palm, 2006). Palm (2000, 2004) recorded a total of 23% of the worldwide known trypanorhynch cestode fauna from Indonesian waters. Yuniar et al. (2007) demonstrated a high ectoparasitic crustacean fauna on commercially important fish species in a brackish water mangrove ecosystem in South Java, including some species with fish pathogenic potential. Jacob and Palm (2006) recorded a species-rich endohelminth fauna in benthodemersal and deep-water fishes from the southern Java coast,

including the zoonotic *Anisakis* sp. It can be expected that any parasitological study in Indonesian waters will reveal a species-rich fauna, including the identification of many new species.

The parasite fauna of cultured *L. calcarifer* comprises a total of about 90 known species, including the results of the present study. Because of its economical importance as a mariculture fish in Southeast Asia, several studies explored the occurrence of fish parasites. Some of these specifically focused on single parasite taxa (Rasheed, 1965; Velasquez, 1975) or species (Herbert et al., 1994). Other publications list the parasite fauna of *L. calcarifer* in Asian countries, e.g. the Philippines (Arthur and Lumanlan-Mayo, 1997; Regidor and Somga, 1999), Thailand (Ruangpan, 1989), Indonesia (Kurniastuty and Dewi, 1999; Minjoyo et al., 1999; Kurniastuty et al., 2000) and Southeast Asia in general (Leong, 1997). The present study adds 11 new parasite species records, including the fish pathogenic monogeneans *P. epinepheli*, *P. lantauensis* and *B. epinepheli*, plus six parasites that could not be identified to the genus level. This result demonstrates that cultured *L. calcarifer* is susceptible to a high number of pathogens as well as health-threatening fish parasites (e.g. *B. epinepheli*, *N. melleni*).

Parasite fauna of cultured *L. calcarifer* in Lampung Bay was dominated by monoxenous parasites on the gills and the body surface, monogenean species (*P. epinepheli* and *P. lantauensis*, *B. epinepheli*, *N. melleni*, Capsalidae gen. et sp. indet.) and trichodinid ciliates *Trichodina* spp. With the exception of the rainy season, at least 50% of the fish were infested with monogeneans and over 90% had trichodinid ciliates. This is caused by the monoxenous, single host life cycles that do not require any intermediate host. The monogenean eggs are mostly attached directly to the host, the larvae hatch and develop to the adult stage on the same host, or they can detach and swim to search for another host. High stocking densities in net cages increase the probability of the larvae to successfully infest other fish (Leong and Wong, 1992a). Balasuriya and Leong (1994) showed a relationship between the intensity of *Pseudorhabdosynochus latesi* and the fish stocking density. *Trichodina* species are the most common fish parasitic protozoans and have been recorded to cause mass mortalities, e.g. in the ornamental Sumatra barb (*Puntius tetrazona*) in a farm in Korea (Kim et al., 2002), in cultured gilthead seabream (*Sparus aurata*) in Elat, Israel (Paperna et al., 1977) and in cultured Atlantic cod (*Gadus morhua*) (Khan, 2004). Again, the problem is the rapid development by binary fission (dividing in two) or by conjugation.

Both trichodinid ciliates and monogenean parasites are known to cause severe problems in aquaculture. After a first infestation, they can spread rapidly and drastically increase in numbers; in such cases, they can severely affect the infested fish. *Neobenedenia melleni* was responsible for mass mortalities in sea cages in Australia (Deveney et al., 2001). Diplectanidae (Monogenea) are generally considered to represent health hazards to captured hosts (Santos et al., 2000). Rajendran et al. (2000) studied captive seabass mortality caused by *Diplectanum latesi*, and González-Lanza et al. (1991) demonstrated the pathological importance of Diplectanidae in the cultivation of *Dicentrarchus labrax* in the Spanish Mediterranean. A large trichodinid ciliate and monogenean population is a potential and constant stress to seabass in net cages, and is one of the major contributing factors to disease outbreaks (Leong, 1997). Control of these parasites is extremely difficult.

The predominant heteroxenous parasites were the Myxozoa (Myxozoa gen. et sp. indet.) in the gall bladder, with infection rates of more than 70%; the larval stages of tetraphyllidean cestodes (*Scolex pleuronectis*) in the gastro-intestinal tract, with a prevalence over 45% and the larval stages of the nematode species *Hysterothylacium* sp. located in the stomach wall; and the mesentery with about 42%. All other parasites had low infection rates below 26%. Heteroxenous parasites are mainly transmitted via trash fish fed daily to cultured *L. calcarifer* (Rückert, 2006). In the present study the fish were fed with small fish species cut into pieces without removing any body parts. Heteroxenous parasites are dependent on intermediate hosts to complete their life cycles. Consequently, the infection rate of cultured finfish depends directly on the access to the intermediate hosts, thus on the availability of prey and fresh, untreated feed.

The present study was carried out in three consecutive seasons. Our results show some differences in parasite diversity, being low during the rainy and high during the dry season. The monoxenous fish pathogenic *B. epinepheli* and *N. melleni* had higher prevalences in both dry seasons compared with the rainy season. In contrast, the heteroxenous tetraphyllidean cestode larvae (*Scolex pleuronectis*) had a higher prevalence in the rainy season. However, because all other detected parasite species showed only minor differences in prevalence and intensity of infection between seasons, the seasonal effect on the parasite composition at the studied locality was low. Fish parasites (ectoparasites and free swimming stages or intermediate hosts of endoparasites) can react sensitively to environmental conditions and changes. According to Santoso et al. (2004), water conditions in terms of salinity and temperature are relatively stable in Hurun Bay during the different seasons. This suggests that merely the presence of the parasite itself, caused by the actual presence of the final or potential intermediate hosts and not the environmental conditions at this tropical locality, determine the observed parasite infection. Future studies must clarify whether this is a local phenomenon or a minor seasonal effect that can be generalized for a tropical marine ecosystem such as the Indonesian coastal waters.

Conclusion

The present study demonstrates a species-rich parasite fauna for cultured *L. calcarifer* in Lampung Bay, Indonesia. Monoxenous parasites have higher infection rates than do heteroxenous parasites under culture conditions. This is caused by high stocking densities in the net cages and an inaccessibility of

the cultured fish to potential parasite intermediate hosts. Minor seasonality in the parasite composition on the cultured fish is explained with the relatively stable water conditions in Hurun Bay. Some seasonality could be observed in the infestation with two fish pathogenic ectoparasites, however, severe monogenean disease outbreaks cannot be excluded either in the dry or the rainy season. This and future studies will enable fish farmers and the farming management to better understand the natural occurrence of fish parasites in/on cultured fish. Knowledge of the parasite diversity of *L. calcarifer*, combined with information on the life cycles and transfer mechanisms, will enable the fish farming industry to apply adequate measures to treat, control or avoid parasite outbreaks in the future.

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