Aquaculture 303 (2010) 101–104

Contents lists available at ScienceDirect

Aquaculture

journal homepage: www.elsevier.com/locate/aqua-online

Short communication

Harmful parasitic crustaceans infecting wild arripids: A potential threat to southern Australian finfish aquaculture

Sarah R. Catalano [a], Kate S. Hutson [a,b,*]

[a] Marine Parasitology Laboratory, DX 650 418, School of Earth and Environmental Sciences, The University of Adelaide, North Terrace, Adelaide, South Australia 5005, Australia
[b] Discipline of Aquaculture, School of Marine and Tropical Biology, James Cook University, Townsville, Queensland 4811, Australia

ARTICLE INFO

Article history:
Received 18 November 2009
Received in revised form 7 February 2010
Accepted 4 March 2010

Keywords:
Caligidae
Argulidae
Arripis spp.
Parasite
Aquatic animal health
Fish interaction

ABSTRACT

Parasitic crustaceans are responsible for severe disease outbreaks in finfish aquaculture. We provide the first report of five marine ectoparasitic crustacean species including *Argulus diversicolor* Byrnes, 1985 (Branchiura: Argulidae), *Caligus bonito* Wilson, 1905, *C. longipedis* Bassett-Smith, 1898, *C. pelamydis* Hewitt, 1963, and *C. punctatus* Shiino, 1955 (Copepoda: Caligidae) on wild arripid hosts, *Arripis georgianus* (Valenciennes, 1841), *A. trutta* (Forster, 1801) and *A. truttaceus* (Cuvier, 1829) (Perciformes: Arripidae) in southern Australian waters. *Caligus pelamydis* and *C. punctatus* are new Australian records. All five crustacean species exhibit low host-specificity and *Argulus* spp., *C. longipedis*, *C. pelamydis* and *C. punctatus* have been associated with mass mortalities in cultured fishes outside Australia. Given the propensity for arripids to aggregate at sea-cage aquaculture sites, awareness of these five parasitic crustacean species may allow health managers to identify and anticipate potential outbreaks on southern Australian fish farms.

1. Introduction

Sea-cage farms are highly attractive to wild fishes and attract large and diverse aggregations in their immediate vicinity. Increased availability of food due to waste feed and faeces from caged fish (Fernandez-Jover et al., 2008) and the use as a refuge from predators (Castro et al., 2002) may explain the attraction of fish to floating structures. Aggregations of wild fish at individual farms have been documented in warm temperate (Mediterranean Sea, Dempster et al., 2002) and cool temperate (Norway, Dempster et al., 2009; Australia, Dempster et al., 2004) environments. Many parasite taxa may be shared between farmed and wild fishes. Parasites can have severe impacts on farmed fish production, while high densities of farmed fish may elevate parasite prevalence and intensity in surrounding wild populations, as has been observed for sea lice infestations of wild salmonids in the northern hemisphere (e.g. Krkošek et al., 2007; MacKenzie et al., 1998; Morton et al., 2005).

Parasitic crustaceans are widely recognised to cause serious problems in the culture of many fish species (see Johnson et al., 2004 for review). They are likely to establish and proliferate in aquaculture because most have direct life-cycles consisting of free-living, free-swimming and attached parasitic stages. They also may reproduce rapidly and directly reinfect their hosts. Parasitic crustaceans can act as vectors of bacterial and viral infections as well as protozoans and metazoans (e.g. Overstreet et al., 2009). Research is required to identify sources of parasitic crustaceans, to recognize taxa with low host-specificity, and to document potentially harmful species.

In Australia, fish farming is intensifying in Spencer Gulf, South Australia (SA), where southern bluefin tuna *Thunnus maccoyii* (Castelnau, 1872), yellowtail kingfish *Seriola lalandi* Valenciennes, 1833, and mulloway *Argyrosomus japonicus* (Temminck & Schlegel, 1843) are farmed in sea-cages. Fish species in the Arripidae have a tendency to aggregate near structure (Dempster and Kingsford, 2004; Neira, 2005) and have been observed in, and around, sea-cages in SA (KSH pers. obs.). The Arripidae comprises a single genus *Arripis* (Jenyns) which includes four species. Three species comprise important commercial and recreational fisheries in southern Australian waters; Australian herring or tommy ruff *Arripis georgianus*; eastern Australian salmon *A. trutta*; and western Australian salmon *A. truttaceus*. *Arripis georgianus* and *A. truttaceus* share similar distributions, found in temperate waters from Western Australia (WA) through to New South Wales (NSW), and around Tasmania (Gomon et al., 2008). *Arripis trutta* overlaps in distribution with these two species in waters off SA, Victoria, NSW and Tasmania, but is also found off the coast of New Zealand (NZ) (Smith et al., 2008).

In a broad parasitological survey of the Arripidae, we made a remarkable discovery of five species of parasitic crustaceans not previously known from arripid fishes in southern Australian waters, including two new Australian parasite records. The majority of crustacean parasite species reported here have been associated with

* Corresponding author. Discipline of Aquaculture, School of Marine and Tropical Biology, James Cook University, Townsville, Queensland 4811, Australia. Tel.: + 61 7 4781 6216; fax: + 61 7 4781 4585.
E-mail address: kate.hutson@jcu.edu.au (K.S. Hutson).

0044-8486/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.aquaculture.2010.03.005

mass mortalities in aquaculture overseas. This study documents five parasitic crustacean species from three species of *Arripis* in southern Australian waters, reviews associated problems with these parasite species elsewhere and draws attention to the potential threat of these species for southern Australian finfish aquaculture.

2. Materials and methods

A total of 183 *Arripis georgianus* (mean [range] = 179 [154–220] mm fork length (FL)) and 67 *A. truttaceus* (350 [185–601] mm FL) obtained from Gulf St Vincent, Spencer Gulf, northern Kangaroo Island and Coffin Bay in SA waters was examined for ectoparasites (Fig. 1). Nineteen *A. trutta* (483 [400–545] mm FL) were examined from Bermagui, NSW (Fig. 1). Fish were identified using the key by Gomon et al. (2008). Fish were collected by line fishing or from fish markets, namely Safcol fish market, Mile End, Adelaide, SA, and the Sydney Fish Market, Pyrmont, NSW (University of Adelaide, Animal Ethics Committee Science project S-098-2007). Tissue samples were collected from each fish, stored in undenatured ethanol and lodged with the Australian Biological Tissue Collection (ABTC 108509–108777) at the South Australian Museum (SAMA), North Terrace, Adelaide, 5000, SA.

Fish were examined for ectoparasites with the naked eye on all exterior surfaces, including branchiostegal membranes, fins, fin sulcus, mouth and operculum. The gills were removed, placed in seawater and examined under a dissecting microscope for ectoparasites. Parasitic crustaceans were removed with fine forceps, fixed in 70% ethanol and cleared in lactophenol prior to morphological examination using a compound microscope. All parasitic crustaceans were identified from their original published descriptions, redescriptions and reference to information in Ho and Lin (2004). Identifications were confirmed by Prof Geoff Boxshall, Natural History Museum, London (NHM). Voucher specimens were lodged in the SAMA Crustacean collection (SAMA C) and at the NHM.

3. Results and discussion

Five species of parasitic crustaceans were recorded from arripid hosts; *Argulus diversicolor* (Branchiura: Argulidae), *Caligus bonito*, *C. longipedis*, *C. pelamydis* and *C. punctatus* (Copepoda: Caligidae). Microhabitat, host species, host localities and museum accession numbers are shown in Table 1. This is the second record of *A. diversicolor* which was originally described from the sparid *Acanthopagrus latus* (Houttuyn, 1782) from Point Samson, WA (Byrnes, 1985). Although *C. pelamydis* and *C. punctatus* are cosmopolitan caligid species (see Hewitt, 1963; Ho and Lin, 2004), this is the first time they have been recorded in Australian waters.

Argulus spp. infect fish hosts distributed on and around all continents, except Antarctica, in marine and estuarine (n = 44) and freshwater (n = 85) habitats (Poly, 2008). *Argulus* spp. are problematic ectoparasites in freshwater fish culture and several epizootics have occurred in wild freshwater fisheries (e.g. Hakalahti-Siren et al., 2008; Hewlett et al., 2009; Menezes et al., 1990). *Argulus japonicus* (Thiele, 1900) has been introduced all over the world, primarily due to stockings of goldfish *Carassius auratus* (Linnaeus, 1758) and carp *Cyprinus carpio* Linnaeus, 1758 but may also parasitize brown trout *Salmo trutta* Linnaeus, 1758, as well as stickleback *Gasterosteus aculeatus* Linnaeus, 1758, roach *Rutilus rutilus* (Linnaeus, 1758), perch *Perca fluviatilis* Linnaeus, 1758, tench *Tinca tinca* (Linnaeus, 1758), pike *Esox lucius* Linnaeus, 1758 and bream *Abramis brama* (Linnaeus, 1758) (see Poly, 2008). *Argulus* have also been reported from marine fish farming facilities in Chile, Canada and Norway and can cause mortality in farmed salmonid stocks (Boxshall, 2005; Schram et al., 2005).

Argulids attach to fish skin by means of suckers and spines and feed on blood and external tissues (Boxshall, 2005). They are capable of changing their position on their host as well as changing their host individual (Pasternak et al., 2000, 2004), and may enhance severity of bacterial infections (Bandilla et al., 2006; Cusack and Cone, 1986). Although there is no published record of *A. diversicolor* from farmed fishes in SA, a photograph of this species (or a similar species) is

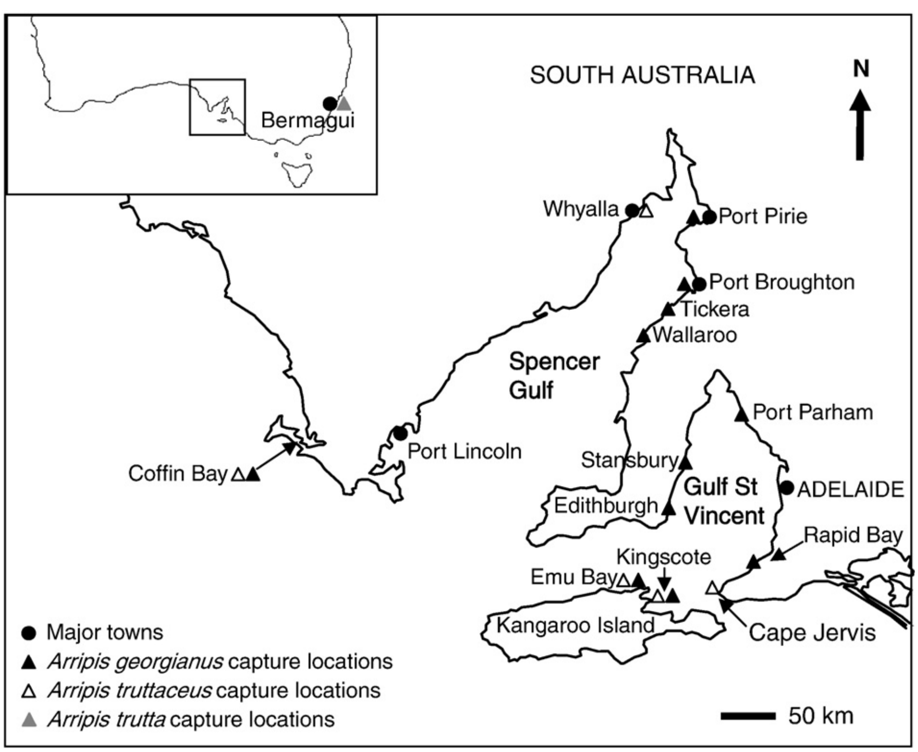

Fig. 1. Collection localities for three *Arripis* spp. in southern Australian waters and one site off the coast of New South Wales.

Table 1
Parasitic crustaceans of *Arripis georgianus, A. trutta* and *A. truttaceus* from southern Australian waters, indicating microhabitat, host locality and museum accession number.

Parasite	Microhabitat	Host species	Locality	Accession no.
Branchiura				
Argulidae				
Argulus diversicolor	Skin	[b] *Arripis georgianus*	[c] SA	NHM 2009.261
		[b] *A. truttaceus*	[c] SA	SAMA C6845
Copepoda				
Caligidae				
Caligus bonito	Gills	[b] *A. trutta*	NSW	SAMA C6821
		[b] *A. truttaceus*	[c] SA	SAMA C6819
Caligus longipedis	Gills	[b] *A. truttaceus*	[c] SA	SAMA C6815-6
[a]*Caligus pelamydis*	Gills	*A. trutta*	[c] NSW	SAMA C6822
[a]*Caligus punctatus*	Skin	[b] *A. georgianus*	[c] SA	SAMA C6814
		[b] *A. trutta*	[c] NSW	SAMA C6820
		[b] *A. truttaceus*	[c] SA	SAMA C6817-8

[a] = new Australian record; [b] = new host record; [c] = new state locality record; SA = South Australia; NSW = New South Wales.

presented on the cover of an illustrated guide to the parasites of wild and captive southern bluefin tuna *Thunnus maccoyii* (Scombridae) from SA (Rough, 2000). However, there is no further reference to the cover image or to an *Argulus* species in the publication. The presence of *A. diversicolor* on arripids is a cause for concern for farmed southern Australian fishes given the likely similarities in pathology to other *Argulus* spp. and its report from two fish families (i.e. Arripidae and Sparidae).

Of the four caligid copepod species identified here, three are recognised as being problematic in aquaculture: *Caligus longipedis, C. pelamydis* and *C. punctatus*. *Caligus longipedis*, which infected *Arripis truttaceus* in SA, can cause bruising to the body of farmed striped jack *Pseudocaranx dentex* (Bloch & Schneider, 1801) (Carangidae) in Japan and make it unmarketable (Ogawa, 1992). Also, Madinabeitia et al. (2009) demonstrate that *C. longipedis* could act as a potential vector for the transmission of the bacterium *Lactococcus garvieae*, which has caused severe mortalities to *Seriola* spp. (Carangidae) and *P. dentex* in Japan. Although *C. longipedis* primarily infects carangids, it has been reported previously from 18 fish species representing 10 fish families including acanthurids, carangids, haemulids, monacanthids, ostraciids, paralichthyids, pomacanthids, scarids, serranids and trichiurids (see Ho and Lin, 2004). We provide the second record of this species in Australian waters. *Caligus longipedis* was documented previously by Heegaard (1962) in NSW (as *C. lucidus*; verified by Ho and Lin, 2004) from the Chinaman-leatherjacket *Nelusetta ayraud* (Quoy & Gaimard, 1824) (Monacanthidae) (as *Cantherhines ayraud*).

Caligus pelamydis, documented on *A. trutta* in this study, has been associated with mass mortalities of cultured Japanese sea perch *Lateolabrax japonicus* (Cuvier, 1828) (Lateolabracidae) in South Korea (Choi et al., 1995). This widely distributed species has been reported from eight fish species in five families (arripids, gempylids, lateolabracids, sciaenids and scombrids) from NZ, the Mediterranean, the British Isles, the east coast of the United States and South Africa (see Hewitt, 1963). This is the first time this species has been recorded in Australian waters.

Caligus punctatus, which we documented on all three arripid species, has caused mass mortality of numerous cultured fishes in Taiwan including carangids, charids, cichlids, lateolabracids, latids, mugilids, serranids, sparids, and terapontids (see Ho and Lin, 2004). This parasite species is particularly problematic due to its low host-specificity (21 species in 14 families) and its ability to survive in the plankton (Ho and Lin, 2004). This species is known from Taiwanese, Japanese and Korean waters and is reported here from Australian waters for the first time.

Caligus bonito is a cosmopolitan caligid that primarily infects scombrids (10 species) but has also been recorded from a carangid, coryphaenid, mugilid, pomatomid, serranid and two lutjanids (see Ho and Lin, 2004). In Australia, it has been previously reported from three wild scombrids including *Euthynnus affinis* (Cantor, 1849) and *Sarda australis* (Macleay, 1881) in NSW, and *E. alleteratus* (Rafinesque, 1810) from Queensland (reported as *C. kuroshio* by Kabata (1965), verified by Ho and Lin, 2004). There is no recorded pathology associated with *C. bonito* species in the literature.

Although the parasite species identified in this study have not been recorded on farmed Australian fishes to date, an epizootic of *Caligus chiastos* Lin & Ho, 2003 was recently documented on farmed southern bluefin tuna *Thunnus maccoyii* (Scombridae) in southern Spencer Gulf, SA (Hayward et al., 2008). Infestations by *C. chiastos* were associated with cornea damage of farmed *T. maccoyii* and peaks in infection occurred in summer months (Hayward et al., 2009). *Caligus chiastos* has also been detected on the gills of farmed *Argyrosomus japonicus* (Sciaenidae) and *Seriola lalandi* in the same region (Hayward et al., 2007). As no attached chalimus stages of any caligids have been detected on *T. maccoyii*, Hayward et al. (2008) suggested that *C. chiastos* infections are transmitted to tuna from other species of infected wild fish that are attracted to tuna cages. Indeed, the only previous record of *C. chiastos* in Australia is on wild snapper *Chrysophrys auratus* (Forster 1801) (Sparidae) from eastern Australia (Ho and Lin, 2004) (as *Pagrus auratus*), a fish species that is known to associate with sea-cage sites in SA (KSH pers. obs.).

Given the low degree of host-specificity exhibited by parasitic crustaceans detected in this study and the tendency for arripids to aggregate at sea-cage farms, it is highly likely that, in suitable conditions, the argulid and caligid species reported here may establish and proliferate in farmed fish populations in southern Australia.

4. Conclusion

Discovery and documentation of parasite fauna of wild and farmed fish should be incorporated into an ongoing sampling program for effective parasite management and risk assessment. Effective mitigation of parasite species infecting fishes in sea-cage farms can only be achieved through reliable parasite identification, knowledge of their biology and assessment of appropriate management methods. Recognition of parasite species that may decrease profitability through mortality, morbidity and reduced marketability of stocks is crucial. Considering the previous history of *Argulus* spp., *Caligus longipedis*, *C. pelamydis* and *C. punctatus* in finfish farming overseas, these parasites are of immediate priority for research into their biological attributes. This will enable development of the most suitable management strategies to avoid outbreaks in southern Australian aquaculture.

Acknowledgements

We are grateful to Prof Geoff A. Boxshall (GAB) from the Natural History Museum, London, UK, for assistance with parasite identifications. Thank you to Leonie Barnett, Kieran Brazell, Dr Mieke Burger, Angelo, Domenico, Margaret and Pepperoni Catalano, Bruce Jackson, Dr Matt Padula, Dr Richard and Brian Saunders, Pep Severino, and Dr Mike Steer for assistance in the field. Dr Terry Bertozzi and Dr Thierry Laperousaz from the South Australian Museum and Miranda Lowe from the NHM kindly curated accessioned material. Assoc Prof Ian D. Whittington (IDW) from the South Australian Museum and the University of Adelaide, kindly read and commented on the manuscript. Scholarship support for SRC was provided from Unibooks (University of Adelaide) and Playford Memorial Trust. This research was funded by an Australian Biological Resources Study (207-44) and Fisheries Research and Development Grant (207/225) awarded to KSH and IDW. Travel funds were awarded by the Australian Research Council and the National Health and Medical Research Council (ARC/NHMRC) Research Network for Parasitology to KSH for travel to London to work with GAB.

References

Bandilla, M., Valtonen, E.T., Suomalainen, L.R., Aphalo, P.J., Hakalahti, T., 2006. A link between ectoparasite infection and susceptibility to bacterial disease in rainbow trout. Int. J. Parasitol. 36, 987–991.

Boxshall, G.A., 2005. Crustacean parasites: Branchiura (fish lice). In: Rohde, K. (Ed.), Marine Parasitology. CSIRO publishing, Collingwood, Australia, pp. 145–147.

Byrnes, T., 1985. Two new *Argulus* species (Branchiura: Argulidae) found on Australian Bream (*Acanthopagrus* spp.). Aust. Zool. 21, 579–586.

Castro, J.J., Santiago, J.A., Santana-Ortega, A.T., 2002. A general theory on fish aggregation to floating objects: An alternative to the meeting point hypothesis. Rev. Fish Biol. Fish. 11, 255–277.

Choi, S.D., Hong, S.Y., Lee, J.M., 1995. Two species of *Caligus* (Siphonostomatoida, Copepoda) parasites on marine cultured fishes from Kamak Bay in Korea. Bull. Fish. Res. Dev. Agency 49, 157–166.

Cusack, R., Cone, D.K., 1986. A review of parasites as vectors of viral and bacterial diseases of fish. J. Fish Dis. 9, 169–171.

Dempster, T., Kingsford, M., 2004. Drifting objects as habitats for pelagic juvenile fish off New South Wales, Australia. Mar. Freshw. Res. 55, 675–687.

Dempster, T., Sanchez-Jerez, P., Bayle-Sempere, J.T., Gimenez-Casalduero, F., Valle, C., 2002. Attraction of wild fish to sea-cage fish farms in the south-western Mediterranean Sea: spatial and short-term temporal variability. Mar. Ecol., Prog. Ser. 242, 237–252.

Dempster, T., Sanchez-Jerez, P., Bayle-Sempere, J.T., Kingsford, M., 2004. Extensive aggregations of wild fish at coastal sea-cage fish farms. Hydrobiologia 525, 245–248.

Dempster, T., Uglem, I., Sanchez-Jerez, P., Fernandez-Jover, D., Bayle-Sempere, J., Nilsen, R., Bjørn, P., 2009. Coastal salmon farms attract large and persistent aggregations of wild fish: an ecosystem effect. Mar. Ecol., Prog. Ser. 385, 1–14.

Fernandez-Jover, D., Sanchez-Jerez, P., Bayle-Sempere, J.T., Valle, C., Dempster, T., 2008. Seasonal patterns and diets of wild fish assemblages associated with Mediterranean coastal fish farms. ICES J. Mar. Sci. 65, 1153–1160.

Gomon, M., Bray, D., Kuiter, R., 2008. Fishes of Australia's southern coast. Reed New Holland, Sydney. 928 pp.

Hakalahti-Siren, T., Mikheev, V.N., Valtonen, E.T., 2008. Control of freshwater fish louse *Argulus coregoni*: a step towards an integrated management strategy. Dis. Aquat. Org. 82, 67–77.

Hayward, C.J., Bott, N.J., Itoh, N., Iwashita, M., Okihiro, M.S., Nowak, B.F., 2007. Three species of parasites emerging on the gills of mulloway, *Argyrosomus japonicus* (Temminck and Schlegel, 1843), cultured in Australia. Aquaculture 265, 27–40.

Hayward, C.J., Aiken, H.M., Nowak, B.F., 2008. An epizootic of *Caligus chiastos* on farmed southern bluefin tuna (*Thunnus maccoyii*) off South Australia. Dis. Aquat. Org. 79, 57–63.

Hayward, C.J., Bott, N.J., Nowak, B.F., 2009. Seasonal epizootics of sea lice, *Caligus* spp., on southern bluefin tuna, *Thunnus maccoyii* (Castelnau), in a long-term farming trial. J. Fish Dis. 32, 101–106.

Heegaard, P.E., 1962. Parasitic Copepoda from Australian waters. Rec. Aust. Mus. 25, 149–234.

Hewitt, G.C., 1963. Some New Zealand parasitic Copepoda of the family Caligidae. Trans. R. Soc. N.Z. 4, 61–115.

Hewlett, N.R., Snow, J., Britton, J.R., 2009. The role of management practices in fish kills in recreational lake fisheries in England and Wales. Fisheries Manag. Ecol. 16, 248–254.

Ho, J.S., Lin, C.L., 2004. Sea Lice of Taiwan Copepoda: Siphonostomatoida: Caligidae. Sueichan Press, Taiwan. 388 pp.

Johnson, S.C., Treasurer, J.W., Bravo, S., Nagasawa, K., Kabata, Z., 2004. A review of the impact of parasitic copepods on marine aquaculture. Zool. Stud. 43, 229–243.

Kabata, Z., 1965. Copepoda parasitic on Australian fishes. IV. Genus *Caligus* (Caligidae). Ann. Mag. Nat. Hist. 13, 109–126.

Krkošek, M., Ford, J.S., Morton, A., Lele, S., Myers, R.A., Lewis, M.A., 2007. Declining wild salmon populations in relation to parasites from farm salmon. Science 318, 1772–1775.

MacKenzie, K., Longshaw, M., Begg, G.S., McVicar, A.H., 1998. Sea lice (Copepoda : Caligidae) on wild sea trout (*Salmo trutta* L.) in Scotland. ICES J. Mar. Sci. 55, 151–162.

Madinabeitia, I., Ohtsuka, S., Okuda, J., Iwamoto, E., Yoshida, T., Furukawa, M., Nakaoka, N., Nakai, T., 2009. Homogeneity among *Lactococcus garvieae* isolates from striped jack, *Pseudocaranx dentex* (Bloch & Schneider), and its ectoparasites. J. Fish Dis. 32, 901–905.

Menezes, J., Ramos, M.A., Pereira, T.G., da Silva, A.M., 1990. Rainbow trout culture failure in a small lake as a result of massive parasitosis related to careless fish introductions. Aquaculture 89, 123–126.

Morton, A., Routledge, R., Williams, R., 2005. Temporal patterns of sea louse infestation on wild Pacific salmon in relation to the fallowing of Atlantic salmon farms. North Am. J. Fish. Manage. 25, 811–821.

Neira, F.J., 2005. Summer and winter plankton fish assemblages around offshore oil and gas platforms in south-eastern Australia. Estuar. Coast. Shelf Sci. 63, 589–604.

Ogawa, K., 1992. *Caligus longipedis* infection of cultured striped jack, *Pseudocaranx dentex* (Teleostei: Carangidae) in Japan. Fish Pathol. 27, 197–205.

Overstreet, R.M., Jovonovich, J., Ma, H., 2009. Parasitic crustaceans as vectors of viruses, with an emphasis on three penaeid viruses. Integr. Comp. Biol. 49, 127–141.

Pasternak, A.F., Mikheev, V.N., Valtonen, E.T., 2000. Life history characteristics of *Argulus foliaceus* L. (Crustacea: Branchiura) populations in Central Finland. Ann. Zool. Fenn. 37, 25–35.

Pasternak, A.F., Mikheev, V.N., Valtonen, E.T., 2004. Growth and development of *Argulus coregoni* (Crustacea: Branchiura) on salmonid and cyprinid hosts. Dis. Aquat. Org. 58, 203–207.

Poly, W.J., 2008. Global diversity of fishlice (Crustacea: Branchiura: Argulidae) in freshwater. Hydrobiologia 595, 209–212.

Rough, K.M., 2000. An illustrated guide to the parasites of southern bluefin tuna, *Thunnus maccoyii*. Tuna Boat Owners Association of South Australia, Australia, p. 74.

Schram, T.A., Iversen, L., Heuch, P.A., Sterud, E., 2005. *Argulus* sp. (Crustacea: Branchiura) on cod, *Gadus morhua* from Finnmark, northern Norway. J. Mar. Biol. Assoc. U.K. 85, 81–86.

Smith, P.J., Hartill, B., Hamer, P., McKenzie, A., 2008. Stock structure of kahawai, *Arripis trutta*. New Zealand Fisheries Assessment Report 2008/20, Wellington.