

Prevalence of the parasitic cymothoid isopod *Anilocra nemipteri* on its fish host at Lizard Island, Great Barrier Reef

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Abstract. Parasites are ubiquitous in nature but assessing their prevalence in wild fish populations is often challenging due to their cryptic nature. Low abundance can also hinder detailed studies. Here, we report a relatively high prevalence (4.3%; range = 0–28%) of an ectoparasitic cymothoid isopod (*Anilocra nemipteri*) infecting the bridled monocle bream (*Scolopsis bilineatus*) on reefs surrounding Lizard Island on the northern Great Barrier Reef (GBR). The prevalence of infected and previously infected fish at this location was nearly 15%, which greatly exceeds reports from other localities on the GBR. At least one parasitised fish was observed at 75% of the reefs surveyed, although prevalence varied across sites. Parasitised *S. bilineatus* were, on average, 25% smaller than unparasitised or previously parasitised fish. Given that these parasites have known detrimental effects on host growth, survivorship and swimming ability, our observations suggest that *A. nemipteri* may influence the size structure of its host population in the wild. Since *A. nemipteri* is large, conspicuous and relatively abundant, it provides an ideal study system to examine a range of important questions on the evolutionary ecology of parasites.

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Parasites can substantially alter host fitness by negatively affecting physiological, behavioural and morphological traits (Minchella and Scott 1991; Lehmann 1993; Poulin and Thomas 1999; Barber *et al.* 2000; Wood *et al.* 2007). Despite their ecological importance (Poulin 1999; Wood *et al.* 2007; Kuris *et al.* 2008), assessing the prevalence of parasites can be challenging (Justine 2010) due to their often cryptic nature (Minchella and Scott 1991; Kuris *et al.* 2008) and sometimes low abundance in natural populations (e.g. Grutter 1994, 1995). However, some ectoparasites are highly conspicuous (Adlard and Lester 1995; Bunkley-Williams and Williams 1998), making them ideal study systems to examine the potential effects of parasitism on host fitness (Lehmann 1993). In fishes, ectoparasites can pose additional challenges as streamlining is important to reduce the cost of locomotion in water (Vogel 1994). Therefore, parasites may increase host susceptibility to predation in addition to decreasing host nutritional status and growth, all of which can influence the population dynamics and structure of the host species (Minchella and Scott 1991; Barber *et al.* 2000).

On the Great Barrier Reef (GBR), the bridled monocle bream (*Scolopsis bilineatus*) is parasitised by the cymothoid isopod *Anilocra nemipteri*, which attaches posterodorsally to the eye of

its host on the right or left side of the midline using its pereopods (Bruce 1987; Grutter 1994) (Fig. 1*a, b*). Infections leave a scar that is visible long after the parasite has detached (Bunkley-Williams and Williams 1998) (Fig. 1*c*). Ectoparasitic isopods in the family Cymothoidae infect a wide range of fishes on coral reefs worldwide (Bruce 1987; Bunkley-Williams and Williams 1998). Their large size (up to 23 mm or 30% of host total length; Grutter 1994; Adlard and Lester 1995; D. G. Roche, unpubl. data) and asymmetric attachment probably interfere with a range of fitness-enhancing activities (Adlard and Lester 1994; Östlund-Nilsson *et al.* 2005; Fogelman *et al.* 2009). However, the prevalence of infections on *S. bilineatus* reported to date at various sites on the GBR are either low or nil (Lester and Sewell 1989; Grutter 1994; A. E. Boaden, pers. comm.). Here, we assess current and past infections of *S. bilineatus* by *A. nemipteri* using counts of currently infected and parasite-scarred individuals at Lizard Island on the northern GBR. We also examine possible effects of the parasite on the size structure of the host population.

We used 50 × 4 m belt transects ($n = 3–7$ per site) to record infections of *S. bilineatus* by *A. nemipteri* on 12 reefs above 6 m depth at Lizard Island, northern Queensland (14°40'S, 145°28'E). Two snorkelers swimming at a constant speed of 0.2 m s⁻¹ surveyed fish 2 m on either side of the transect tape. We recorded

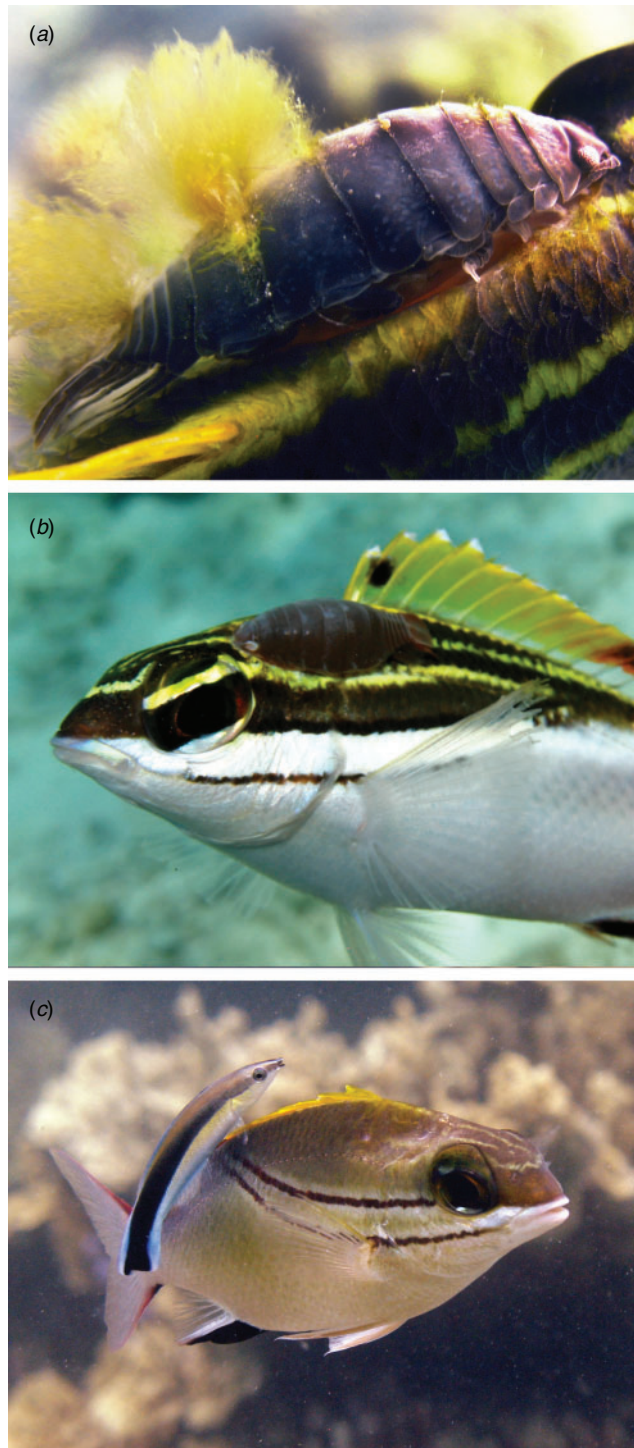


Fig. 1. Bridled monacle bream (*Scolopsis bilineatus*) with (a, b) an ectoparasitic isopod (*Anilocra nemipteri*) attached above the eye, and (c) scarring from a past infection.

four variables for each *S. bilineatus* observed: fish size (total length), colour phase (juvenile or adult), condition (unparasitised, parasitised or scarred from a previous infection), and the location of parasite attachment or scarring (left or right side of the body).

Juveniles were identified as such by having distinct yellow and black stripes on the upper half of the body (Randall *et al.* 1997).

Prior to data collection, we practiced estimating fish lengths to the nearest 1 cm using model fishes underwater (deviations from actual sizes were <1 cm). We tested for differences in the proportion of infected or scarred individuals among sites using two generalised linear models with binomial error terms to account for the underlying distribution of the data. We tested for differences in size among parasitised, unparasitised and previously parasitised fish using a one-way ANOVA and a *post hoc* Tukey test. Normality and homoscedasticity were assessed with diagnostic plots of the residuals and size was power-transformed using a boxcox function to meet the assumptions of the model. We used a binomial test to determine whether parasites preferentially attached to one side of the body midline, including data from both parasitised and parasite-scarred fish.

Transects by snorkelers on 12 different reefs revealed an overall current *A. nemipteri* prevalence of 4.3% (12 800 m² surveyed; $n = 374$ fish). Prevalence was 3.6% on adults and 9.8% on juveniles. An additional 9.8% of adult fish had marks of past infection. Prevalence differed significantly across reef sites (range = 0–28%; $F_{11,51} = 1.99$, $P < 0.05$) with the highest average prevalence of infected fish at Bird Islets (28%) and Bird Lagoon (23%) (Fig. 2). The proportion of previously infected fish also differed across sites (range = 0–34%; $F_{11,51} = 2.95$, $P < 0.01$) with the highest average ratio of scarred individuals occurring at Big Vickies (34%), Mermaid (16%) and Watson's Bay (9%).

Juveniles (mancae) of *A. nemipteri* only infected juvenile hosts and not adult hosts. Host size differed among parasitised, unparasitised and previously parasitised fish ($F_{2,371} = 8.76$, $P < 0.001$). Overall, parasitised *S. bilineatus* tended to be ~25% smaller (TL = 10.75 ± 0.79 cm, mean \pm s.e.m) than unparasitised (TL = 14.12 ± 0.19 cm; Tukey HSD, $P < 0.001$) and previously parasitised (TL = 14.84 ± 0.32 cm; Tukey HSD, $P < 0.001$) fish. There were no size differences between parasitised and previously parasitised fish (Tukey HSD, $P > 0.65$). Finally, parasites did not attach on one side of the host more than the other (30 left versus 27 right; binomial test, $P > 0.75$).

We found that overall infection of the bridled monacle bream, *S. bilineatus*, by the cymothoid ectoparasitic isopod, *A. nemipteri*, was high at our study sites compared with other sites on the GBR. Although *S. bilineatus* is an abundant coral reef fish (Boaden and Kingsford 2012), previous studies have reported nil or very few infections by *A. nemipteri* at a variety of locations along the GBR, including Heron Island, Lizard Island, One Tree Island and Orpheus Island (Lester and Sewell 1989; Grutter 1994; A. E. Boaden, pers. comm.). In a survey of parasites infecting fishes at Lizard Island and Heron Island, Grutter (1994) reports a single *S. bilineatus* parasitised by *A. nemipteri*. A prevalence of 4.3% for adult fishes and 9.8% for juveniles observed in our study at Lizard Island is therefore comparatively high for this species. An additional 9.8% of adults bore marks of past infection, raising the total number of fish affected by parasites to nearly 15%. Tissue damage is thought to result from a necrotic reaction of the host's tissues underneath the parasite or the host growing around the parasite, creating a deformation of the body (Bunkley-Williams and Williams 1998). Previous studies have examined the biology and host–parasite interactions of congeneric anilocrid species using laboratory and field experiments (Adlard and Lester 1994,

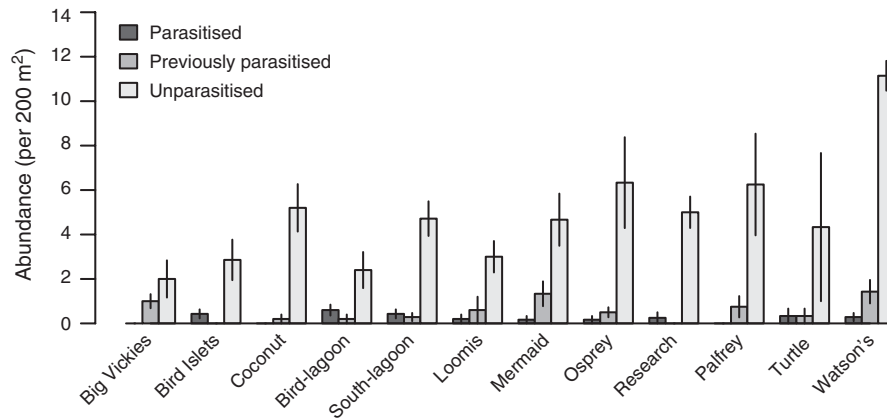


Fig. 2. Abundance (\pm s.e.m) of parasitised (black bars), previously parasitised (grey bars) and unparasitised (white bars) bridled monocle bream (*Scolopsis bilineatus*) at 12 sites around Lizard Island.

1995; Östlund-Nilsson *et al.* 2005; Fogelman and Grutter 2008; Fogelman *et al.* 2009); however, none of these studies reported prevalence in the wild, which is essential to assess the frequency of infections in host populations and to compare prevalence among different cymothoid species infecting fishes on the GBR.

Our reef sites at Lizard Island were separated by hundreds of metres to a few kilometres. Differences in prevalence across this small spatial scale likely result because cymothoids are highly site specific (Bunkley-Williams and Williams 1998) and tend to occur in aggregations (Adlard and Lester 1994). The fact that mancae probably have limited dispersal abilities (see Adlard and Lester 1995; Fogelman and Grutter 2008; Jones *et al.* 2008) and that *S. bilineatus* is site-attached (Boaden and Kingsford 2012) suggests that there is little opportunity for infection to spread across sites that are separated by large sand patches (e.g. 50–100 m long) and therefore not well connected. Nonetheless, 75% of the reefs we surveyed harboured at least one parasitised fish (Fig. 2), and the prevalence of infections reached 28% at one site (Lagoon-Bird Islets) (Fig. 2). The parasite had no preference for attaching on the right or left side of its host.

Infected fish were considerably smaller than unparasitised or scarred individuals at Lizard Island (Fig. 3). This skewed size distribution of infected individuals could result from a simple preference of the parasite for smaller hosts since mancae (larvae) of parasitic cymothoids preferentially infect juvenile fish and subsequently grow with their host (Adlard and Lester 1995; Fogelman and Grutter 2008). However, parasitic cymothoid isopods associate with their hosts for long periods (Bunkley-Williams and Williams 1998) and experimental studies have shown that they can inflict deep wounds, stunt growth (Adlard and Lester 1994; Fogelman and Grutter 2008), impair reproduction (Adlard and Lester 1994; Fogelman *et al.* 2009) and ultimately kill their host (Adlard and Lester 1994; Bunkley-Williams and Williams 1998; Fogelman and Grutter 2008). Therefore, by impeding growth and removing individuals from the population before they attain full maturity, the parasite may have notable effects on the size structure of the host population. Interestingly, scarred *S. bilineatus* that were previously parasitised did not differ in size from unparasitised individuals, suggesting that compensatory growth might allow fish to reach their full size if the

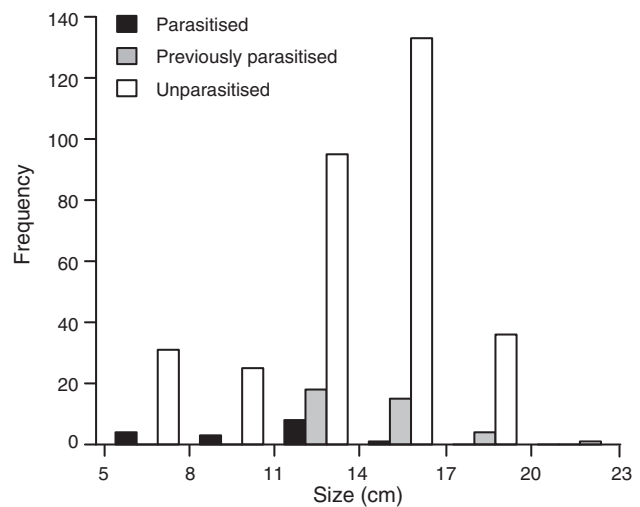


Fig. 3. Size distribution of parasitised (black bars), previously parasitised (grey bars) and unparasitised (white bars) bridled monocle bream (*Scolopsis bilineatus*) at Lizard Island.

parasite detaches. The possibility of resumed growth is supported by recent data showing that parasite removal reverses the negative physiological effects of *A. nemipteri* on its host in as little as 24 h (Binning *et al.* 2013). However, distinguishing between a preference of the parasite for small individuals and detrimental effects on growth and survivorship would require a detailed study using otolith microstructure analysis to age fish.

Finally, being abundant as well as easily observed and manipulated, parasitic cymothoid isopods such as *A. nemipteri* provide ideal systems to conduct observational and experimental studies and answer a range of ecological and evolutionary questions on host–parasite interactions. For example, due to its large size, *A. nemipteri* was recently found to decrease streamlining and swimming abilities of its host by directly altering the surface of the host's body and increasing drag (Binning *et al.* 2013). Further studies would greatly improve our understanding of the evolutionary ecology of parasites by using this system to examine the effects of ectoparasitism on host fast-start

performance (escape response, burst swimming), handedness (lateralisation), physiology (anaemia, cortisol levels), demography (age determination with otoliths), habitat use (distribution across water flow gradients) as well as inter- and intrasexual selection (female mate choice and male–male competition).

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