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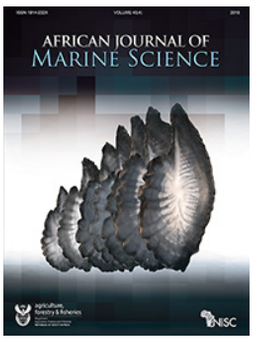

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Short communication

Unique co-occurrence of two genera of cymothoid ectoparasitic isopods on the same individual fish host

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Parasitism of a host fish by a single species of cymothoid is regularly reported. For the first time on a temperate-fish host and in South African waters, we observed two species of cymothoids, the flesh-infesting *Anilocra capensis* and the tongue-infesting *Ceratothoa africanae*, simultaneously infesting the same individual hottentot seabream *Pachymetopon blochii*. Each *P. blochii* harboured an ovigerous and non-ovigerous *A. capensis* and an ovigerous and non-ovigerous *C. africanae*. Cymothoid co-occurrence is rarely reported, and this is the first report of two cymothoid species infesting a single fish host from Africa. Globally, it is the first record of flesh- and tongue-infesting cymothoids parasitising the same individual fish.

Keywords: *Anilocra, Ceratothoa*, Cymothoidae, marine fish, parasite, South Africa, southeastern Atlantic Ocean

Members of the isopod family Cymothoidae are among the most conspicuous parasites of fishes because of their large size (up to 75 mm in length) and external attachment. Cymothoids permanently infest the buccal cavity, gill chamber or flesh of their hosts after a brief juvenile phase during which they swim and locate a host to parasitise (Bunkley-Williams and Williams 1998; Smit et al. 2014). In South Africa, *Anilocra capensis* Leech, 1818 and *Ceratothoa africanae* Hadfield, Bruce and Smit, 2014 are two of the most frequently observed flesh- and tongue-infesting cymothoids, respectively (Wright et al. 2001; Hadfield et al. 2014a). These two species typically inhabit the temperate marine waters of southern Africa, and commonly infest the hottentot seabream *Pachymetopon blochii* (Valenciennes, 1830) (Wright et al. 2001; Hadfield et al. 2014a).

A targeted field collection of *Anilocra*-infested *P. blochii* in Cape Town, South Africa, took place in April 2018 for genetic and ecotoxicological research projects. Infested fish were speared during SCUBA diving and subsequently sacrificed, following permitted protocols, and then stored on ice until dissection. During the dissections, we observed that two fish harboured pairs of ovigerous and non-ovigerous *A. capensis* and *C. africanae* parasites, such that each fish was infested with a total of two *A. capensis* and two *C. africanae* cymothoids (Figure 1). One of these fish was collected at a depth of 9–11 m in ~12 °C water at the breakwater adjacent to the entrance of Cape Town Harbour, and the other fish was collected at 2–4 m in ~14 °C water at the False Bay Yacht Club marina.

Prior to these observations, no temperate fish species from Africa has been reported to be infested simultaneously by two genera of cymothoid. Cymothoid genera co-occurrence has rarely been reported, and a single study by Williams and Bunkley-Williams (1985) has mentioned two different co-occurrences in the Caribbean. These co-occurrences included the gill-dwelling *Kuna insularis* (Williams and Williams, 1986) (=*Cuna insula*ris Williams and Williams, 1985) and the flesh-infesting *Anilocra abudefdufi* Williams and Williams, 1981 both parasitising the sergeant-major *Abudefduf saxatilis* (Linnaeus, 1758), and *Anilocra acanthuri* Williams and Williams, 1981 and the gill-dwelling *Agarna cumulus* (Haller, 1880) parasitising the doctorfish *Acanthurus chirurgus* (Bloch, 1787). It is probable that cymothoid co-occurrence has also been observed in Australia, but the record is ambiguous, as the work by Lanzing and O'Connor (1975) does not discern whether a single fish was observed with two cymothoid genera attached, or if individuals of the same fish species were infested by one type of cymothoid each. To the best of our knowledge other examples of cymothoid co-occurrence have not been published.

The underlying mechanism explaining why certain fishes have been observed with infection by two cymothoid genera is unknown, and the host specificity of cymothoids appears to vary greatly. The genus *Ceratothoa* Dana, 1852 currently encompasses 30 accepted species, and host specificity within this genus varies. As examples, fishes of the family Hemiramphidae have only been known to be infested by *Ceratothoa retusa* (Schioedte and Meinert, 1883), whereas fishes of the family Sparidae have been reported to be infested by *Ceratothoa famosa* Hadfield, Bruce and Smit, 2014 or *C. africanae* (Hadfield et al. 2014a, 2014b). In the marine isopod genus *Anilocra* Leach, 1818, one of the most speciose genera of Cymothoidae, host specificity appears to be mainly at the genus level

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Figure 1: Photographs of the ectoparasitic isopods *Anilocra capensis* (left) and *Ceratothoa africanae* (right) infesting an individual hottentot seabream *Pachymetopon blochii*; the wound on the fish seen below *A. capensis* is a result of spearing during collection and not from infection. (Photographs by A Greyling and D van Rooyen, respectively)

of the fish host (e.g. Bunkley-Williams and Williams 1981; Bruce 1987). For example, *Anilocra chaetodontis* Williams and Williams, 1981 parasitises fish of the genus *Chaetodon*, and *Anilocra acanthuri* Williams and Williams, 1981 parasitises fish of the genus *Acanthurus*. Originally, *Anilocra haemuli* Williams and Williams, 1981 was reported to parasitise fishes of three genera: *Haemulon*, *Paranthias* and *Epinephelus*. Yet, recently, molecular data provided evidence that *A. haemuli* infests the French grunt *Haemulon flavolineatum* (Desmarest, 1823), and the new-to-science species *Anilocra brillae* Welicky, Hadfield, Sikkel and Smit, 2017 infests the red hind *Epinephelus guttatus* (Linnaeus, 1758) (see Welicky et al. 2017). Considering that new species of cymothoids are still being described while others are being synonymised (Hadfield and Smit 2017; Hadfield et al. 2017; Welicky et al. 2017), and that there is often an incomplete record of all susceptible hosts, patterns in host specificity remain difficult to glean. To better understand such patterns, associating genetic information from both host and parasite and examining correlations among taxa are essential. Such studies are just beginning to be approached (i.e. Hata et al. 2017).

The fact that we observed two *P. blochii* infected with both *A. capensis* and *C. africanae* within 3 days of targeted sampling in one region suggests that these particular cymothoid species are abundant in some localities and that their co-occurrence may be more common than otherwise expected. The prevalence of cymothoids is typically low and sporadic (Welicky and Sikkel 2014). Therefore, the specific fish populations from which we collected provide a unique opportunity to better understand the environmental correlates of cymothoid parasitism and the costs of infection (Fogelman et al. 2009; Welicky et al. 2017, 2018) on an artisanal and commercially important fish species (Farthing et al. 2018).

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