

NOTE

Dynamics of *Kudoa camarguensis* (myxosporean) infection in two gobiid species, *Pomatoschistus microps* and *P. minutus* (Teleostei: Pisces), in the Rhône River delta, France

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ABSTRACT: The occurrence of the myxosporean parasite *Kudoa camarguensis* was surveyed monthly during 1997 in a brackish-water lagoon of the Rhône River delta (France). *K. camarguensis* was found on its typical host, *Pomatoschistus microps*, and on an additional host, *P. minutus*. Prevalence and mean abundance were higher in the typical host than in the additional host due to differences in the temporal occupancy of the lagoon by the 2 species. The temporal occurrence of this myxosporean parasite is discussed in relation to the migratory habits of *P. minutus* and the sedentary habits of *P. microps*.

KEY WORDS: Myxosporean parasite · *Kudoa camarguensis* · Goby migration · Spawning strategy

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The myxosporean parasite *Kudoa camarguensis* Pampoulie et al. 1999 has been found on its type host *Pomatoschistus microps* (Krøyer, 1838), and on its additional host *P. minutus* (Pallas, 1770) (Pampoulie et al. 1999a), 2 gobies that inhabit Mediterranean lagoons. This parasite, which has been recorded exclusively from the Rhône delta (southern France), infects muscle tissue, especially the abdominal wall, causing liquefaction in less than 1 h after death of infected fish (Pampoulie et al. 1998). Several studies have dealt with the economic impact of myxosporean parasites, which are generally observed in fish from commercial farms (Paperna 1982, Kent et al. 1994), with *Kudoa* spp. infections occurring in the muscle of economically important fish such as tilapias (Gbankoto et al. 2001a,b) and salmon (St-Hilaire et al. 1998). *K. camar-*

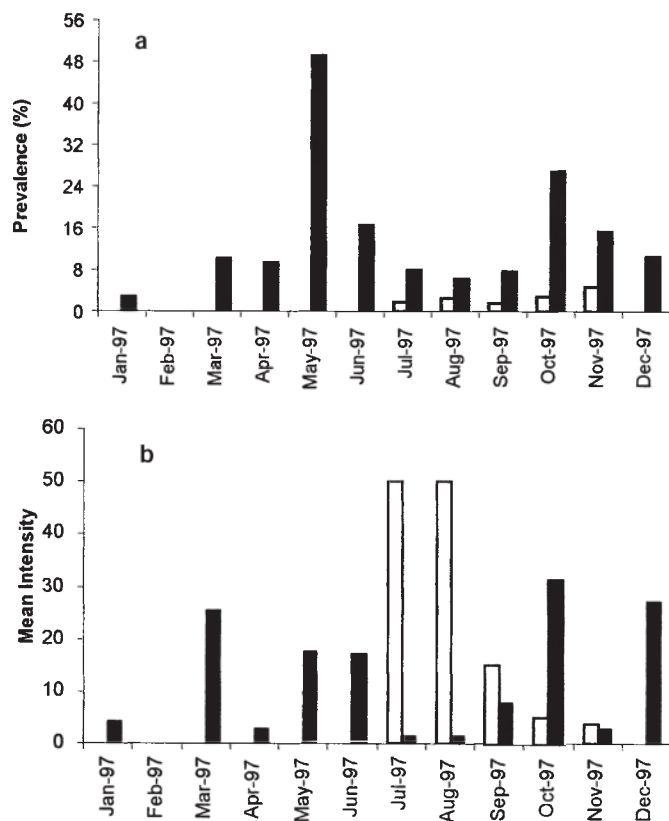
guensis infects wild, non-commercial fish, with different survival strategies, that occupy lagoons. In the Malagroy lagoon, *P. microps* and *P. minutus* are annual species and repeat-spawners. The former reproduces in the lagoon during spring (Pampoulie et al. 2000), whereas the latter migrates from the lagoon to the open sea to spawn in winter (Pampoulie et al. 1999b). Throughout the year, the size distribution of these fishes indicates that their populations are represented by a single cohort (Pampoulie 1999). In July and August adult *P. microps* die, and recruitment of young-of-the-year (YOY) occurs (Pampoulie et al. 2000); *P. minutus* undergoes the same process in March and April (Pampoulie et al. 1999b). My 1997 data thus monitored the impact of the parasite on 1 cohort and contribute to the knowledge of *K. camarguensis* distribution dynamics in the Rhône delta. The aim of this work was (1) to describe the pattern of infection of *K. camarguensis* in a sedentary (*P. microps*) and a migratory (*P. minutus*) goby species, and (2) to consider the possible impact of this myxosporean parasite on its hosts.

Materials and methods. In 1997, monthly sampling took place from January to December in the Malagroy lagoon (Rhône delta, France), with a fyke net (6 mm mesh size) set on 5 consecutive days per month. The Malagroy is a Mediterranean lagoon belonging to the large Vaccarès lagoon complex which covers 11 000 ha. Its average depth and salinity are 1 m and 19.9 g l⁻¹, respectively, and its connection with the sea is regulated by sluices in the sea dyke (Chauvelon et al. 1999).

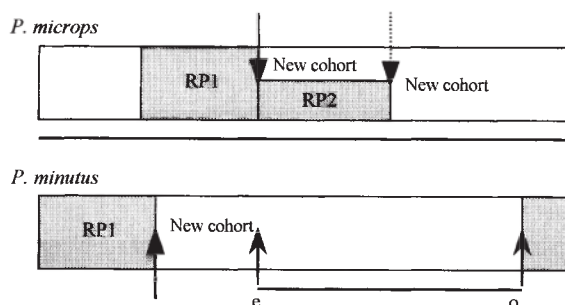
Gobies were preserved in 10% formalin. To ensure that all monthly samples were of comparable total length, fish belonging to the same size range were grouped into 2 mm size classes for *Pomatoschistus*

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microps and 4 mm for *P. minutus*. A minimum of 5 fish per size class was examined. Plasmodia of *Kudoa camarguensis* were counted under a dissecting microscope. The parasitological indices used to document the monthly status of the host-parasite system were



Life cycle of the hosts



- Migration, e: fish enter the lagoon, o: fish migrate to the sea.
- Death of the breeding cohort
- Death of some individuals after the breeding season

Fig. 1. *Kudoa camarguensis*. (a) Prevalence and (b) mean intensity of parasite on the hosts *Pomatoschistus microps* (black bars) and *P. minutus* (white bars) in the Malagroy lagoon, Rhône River delta. Life cycle of the hosts is also shown (RP1, RP2: first and second reproductive periods, respectively)

prevalence and mean intensity as defined by Margolis et al. (1982).

Results. Of 811 individuals of *Pomatoschistus microps* examined, 102 were infected with *Kudoa camarguensis*, whereas of the 495 *P. minutus* individuals examined, only 10 were infected. Monthly prevalence (Fig. 1) varied from 0 to 49.23% for *P. microps* and from 0 to 4.76% for *P. minutus*; mean intensity varied from 0 to 31.29 and 0 to 50.00, respectively. Prevalence and mean intensity peaked in May and October for *P. microps*, while for *P. minutus* prevalence peaked in November and intensity in July (Fig. 1). YOY of this species entering the lagoon in June were not infected. The frequency distribution of *K. camarguensis* on *P. microps* fitted a negative binomial distribution (Kolmogorov-Smirnov test, $p < 0.05$). The aggregation coefficients were $k = 0.18$ and $k = 0.10$ with means (m) of 52.38 and 104.45 for males and females, respectively. *P. minutus* was not tested in this respect, as very few individuals were infected.

Discussion. The prevalence of *Kudoa camarguensis* on brackish-water *Pomatoschistus microps* was higher than the frequencies of *Kudoa* sp. on flounder from the lagoon of Venice (Pellizzato & Canzonier 1985), but lower than the frequencies reported for 2 species of hake in the marine environment (Kabata & Whitaker 1986, Sardella et al. 1987). Its frequency on *P. minutus* was close to that in the lagoon of Venice. *P. minutus* spends part of the year (from February to May/June) in the sea during the breeding season (Bouchereau et al. 1991, Pampoulie et al. 1999b), but in 1997 YOY entering the Rhône delta lagoon were not infected. This suggests that *K. camarguensis* infections originate in brackish-waters and that *P. minutus* comes into contact with the parasite in the lagoon and not the sea. This was confirmed by the large size of the infected *P. minutus* individuals and the prevalence of the parasite, which increased from June to November. The greater the fish density in the lagoon, the higher the number infected.

Pomatoschistus microps was present in the lagoon throughout the year; YOY occurred in June and July, while the parent individuals did not survive the reproductive effort (Pampoulie 1999, Pampoulie et al. 2000). These YOY spawned from July to September (Fig. 1: RP2), becoming increasingly infected over time, until up to 10% of the population were infected in September. Some individuals died during the breeding season (Pampoulie et al. 2000), resulting in variations in the prevalence values from June to September.

Basically, the difference in the prevalence between these 2 species could result from 3 main factors: (1) differential immunity between the 2 species; (2) differences in their temporal and spatial occupancy of the lagoon; (3) specificity of *Kudoa camarguensis*.

There is no information available on the possible differential immunity of these 2 species. Further investigations need to be carried out to test this factor, whereby it will be necessary to examine the life cycle of *Kudoa camarguensis*.

The difference in the temporal and spatial occupancy of this Mediterranean lagoon by these 2 species (described by Bouchereau 1997a,b and Pampoulie 1999), could well be responsible for the observed difference in infection. *Pomatoschistus microps* is present year-round in the lagoon, while *P. minutus* enters the lagoon from June to December, and then undertakes a spawning migration to the open sea, where it remains until the death of the breeding individuals in the following June. Based on their different temporal occupancies of the lagoon, differences in the prevalence of the parasite on these 2 gobies are to be expected. *P. minutus* entering the lagoon in June were not infected; they probably became infected as soon as they entered the lagoon. It is not known what happens to the parasites released into the marine environment by *P. minutus* when these die after reproduction. They could be sources of infection for marine species since, in some cases, transmissions can occur from fish-to-fish (Diamant 1997). Further investigations on this Mediterranean myxosporean parasite are necessary, especially in closely related marine species of gobies.

The differences in prevalence could also be due to the incapacity of *Kudoa camarguensis* to develop in *Pomatoschistus minutus*, which is not a typical host of this myxosporean parasite. These 2 goby species are not really phylogenetically closely related (Wallis & Beardmore 1984), having diverged a long time ago. This, combined with the difference in their temporal occupancy of the lagoon, could explain why *K. camarguensis* did not develop well on *P. minutus*.

This study has shown that differences in the temporal occupancy of an environment can induce changes in the infection pattern of a parasite such as *Kudoa camarguensis*. The possible release of the parasites into the sea still remains an open question. Recent studies have demonstrated that myxosporean parasites may affect host fecundity and survival (Adlerstein & Dorn 1998). Thus, further field and experimental investigations should be carried out on this host-parasite system, especially in regard to *Pomatoschistus minutus*.

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