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Occurrence of myxosporean parasites in the gills of two tilapia species from Lake Nokoué (Bénin, West Africa): effect of host size and sex, and seasonal patterns of infection

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ABSTRACT: The gill myxosporean parasites of 2 euryhaline tilapias from Lake Nokoué, *Sarotherodon melanotheron melanotheron* (Rüppel, 1853) and *Tilapia zillii* (Gervais, 1852), were investigated from October 1987 to October 1989. A total of 391 *S. m. melanotheron* and 222 *T. zillii* were examined. Both of the fish species studied were infected by 3 host-specific myxosporean parasites for which prevalence greatly varied during our investigations. The 2 most common ones were *Myxobolus* sp. and *M. zillii*, which were located in the branchial filament. No significant fish sex effect was found for these 6 different myxosporean parasites. As seasonal pattern was clearly demonstrated for *M. zillii* while a host size effect was found for *M. dossoui*. However, further investigations of these myxosporean infections are necessary to determine the real effect of these parasites on their host, as host fecundity and survival was not assessed.

KEY WORDS: Tilapia · *Myxobolus* sp. · *M. zillii* · *M. sarotherodoni* · *M. dossoui* · *M. beninensis* · *M. microcapsularis* · Occurrence · Lake Nokoué

INTRODUCTION

Myxosporeans cause several kinds of damage and recent studies have highlighted their impact on the ovaries of their host (Gbankoto et al. 1999, Swearer & Robertson 1999), suggesting that reproduction in infected females could be affected. In West Africa, fish farms are said to offer a solution to the problem of low fish catches in countries such as Bénin (Morissens et al. 1986) and Côte d'Ivoire (Doudet 1991). In these regions, tilapia species could offer a real potential for fish farms and for the local economy (Stickney 1986). Tilapia farms in West Africa should be located in lagoons and estuaries (Payne 1983) where salinity may vary from 0 to 90 g l^{-1} (Alabaret 1987); it is necessary, therefore, to rear fishes resistant to variations in salinity (Doudet 1992, Lahav & Ra'anan 1997) that affect osmoregulation (Bone & Marshall 1982). Constant changes in salinity involve energetic costs (Bone & Marshall 1982) that render tilapia more susceptible to parasites. In light of the fact that gills are the most important regulator of osmoregulation in fishes (Maetz & Bornancin 1975, Foskett et al. 1981, Li et al. 1995) and that myxosporean parasites occur on fish gills, decreasing the respiratory capacity of the fish (McCraren et al. 1975, Molnár & Székely 1999), we decided to study myxosporean diseases in 2 tilapia species, *Sarotherodon melanotheron melanotheron* (Rüppel, 1853) and *Tilapia zillii* (Gervais, 1852), which are 2 important species in tilapia aquaculture (Pauly 1976, Legendre 1983) known to be affected by myxosporean parasites

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of the gills (Fomena 1986, Sakiti et al. 1991). The aim of this study was to investigate the occurrence of myxosporean parasites that affected these 2 species in Lake Nokoué (Bénin, West Africa) and the principal factors (seasonality and length of fish) that influenced their occurrence.

MATERIALS AND METHODS

Environment. Samples were collected from October 1987 to October 1989 in Lake Nokoué (Fig. 1). The maximum area of this lake was 160 km^2. The weather here was characterised by 2 dry seasons and 2 wet seasons. The sampling months were grouped per season that were designated S1 (long dry season from December to March), S2 (long wet season from April to July), S3 (short dry season from August to September) and S4 (short wet season from October to November). Thus, the long wet season of 1988 was designated S2-88.

Mean water temperature varied from 25.6 to 31.5°C (Fig. 2) while salinity greatly varied during the year (Fig. 2), with a minimum of 0.02 g l^{-1} and a maximum of 29.77 g l^{-1}. Salinity increased with the arrival of marine water through the Cotonou channel and decreased during the wet season. Precipitation was usually high from May to August (Fig. 2).

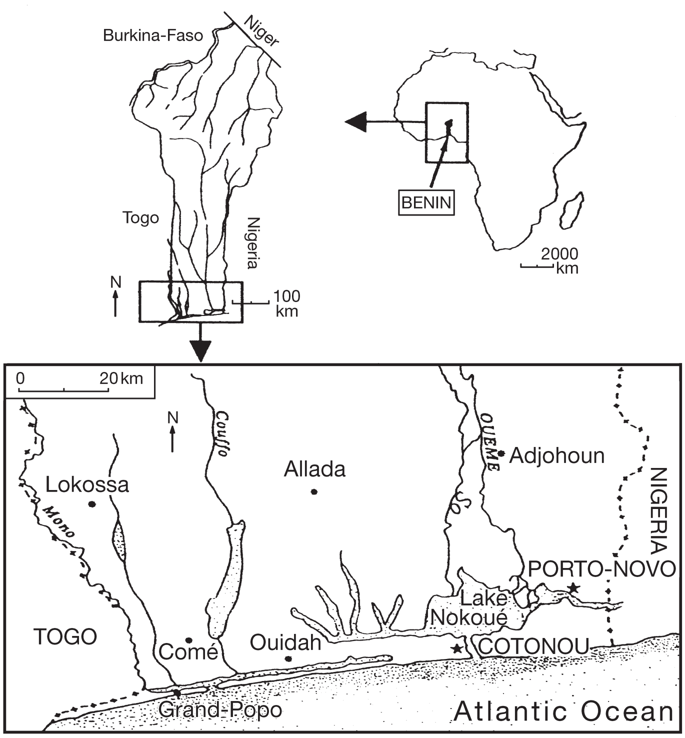

Fig. 1. Sampling sites in Lake Nokoué (Bénin, West Africa)

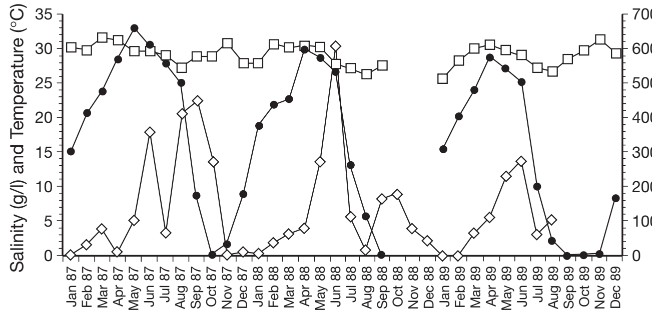

Fig. 2. Seasonal changes in the salinity (●), temperature (□) and precipitation (◇) of Lake Nokoué (Bénin, West Africa)

Data collection. A total of 391 *Sarotherodon melanotheron melanotheron* (Rüppel, 1853) and 222 *Tilapia zillii* (Gervais, 1852) individuals were examined. Fish were brought alive to the laboratory for species and sex determination. The total length (mm) and the weight (mg) were measured. Size frequency distributions were done for both species. Each month, approximately 30 fishes of both species were investigated for parasite infection and determination. Parasites were detected by the presence of white cysts on the gills under the stereomicroscope and by observation of these cysts *in vivo* in phase contrast. Prevalence was calculated as the ratio of the number of individuals containing at least 1 visible white cyst to the total number of fish examined. The effect of fish size, sex and season on prevalence was tested using the χ^2 test.

RESULTS

Population structure of hosts

Fish were placed in different size groups (50 to 100, 100 to 150, 150 to 200 and 200 to 250 mm). In *Sarotherodon melanotheron melanotheron*, 1.28% of the individuals ranged between 50 and 100 mm, 53.45% between 100 and 150 mm, 43.74% between 150 and 200 mm and 1.53% between 200 and 250 mm. In *Tilapia zillii*, individuals were distributed as follows: 5.41% in the class 50 to 100 mm, 68.47% in the class 100 to 150 mm, 25.22% in the class 150 to 200 mm and 0.90% in the class 200 to 250 mm. A total of 119 male and 103 female *T. zillii* were caught while 271 male and 113 female *S. m. melanotheron* were caught.

Seasonal patterns of prevalence

Myxobolus sp. and *M. zillii* are respectively parasites of the branchial filament of *Sarotherodon melano-*

theron melanotheron* and *Tilapia zillii*. The prevalence of these 2 parasites was 20.20% (79 affected fishes out of 391 examined) and 14.86% (33 affected fishes out of 222 examined) respectively. *Myxobolus* sp. was found in *S. m. melanotheron* throughout our study except during S4-87 (Fig. 3a) and its occurrence varied significantly from one season to another (χ^2 test, $\chi^2 = 96.86$, df = 8, $p < 0.001$). The prevalence of *M. zillii* (Fig. 3a) found in *T. zillii* varied significantly from 0 (S4-87, S3-88) to 30.77% (S4-89) (χ^2 test, $\chi^2 = 17.28$, df = 8, $p < 0.05$).

Myxobolus sarotherodoni and *M. dossoui* are parasites of the branchial arch cartilage of *Sarotherodon melanotheron melanotheron* and *Tilapia zillii* respectively. The prevalence of these 2 parasites was 4.86% (19 affected fishes out of 391 examined) and 13.51% (30 affected fishes out of 222 examined) respectively. *M. sarotherodoni* (Fig. 3b) was found in *S. m. melanotheron* in (S1-88) to the end of our study, and its occurrence did not vary significantly from one season to another (χ^2 test, $\chi^2 = 8.60$, df = 8, ns: non significant). The prevalence of *M. dossoui* (Fig. 3b) found in *T. zillii* did not vary significantly (χ^2 test, $\chi^2 = 0.62$, df = 8, ns).

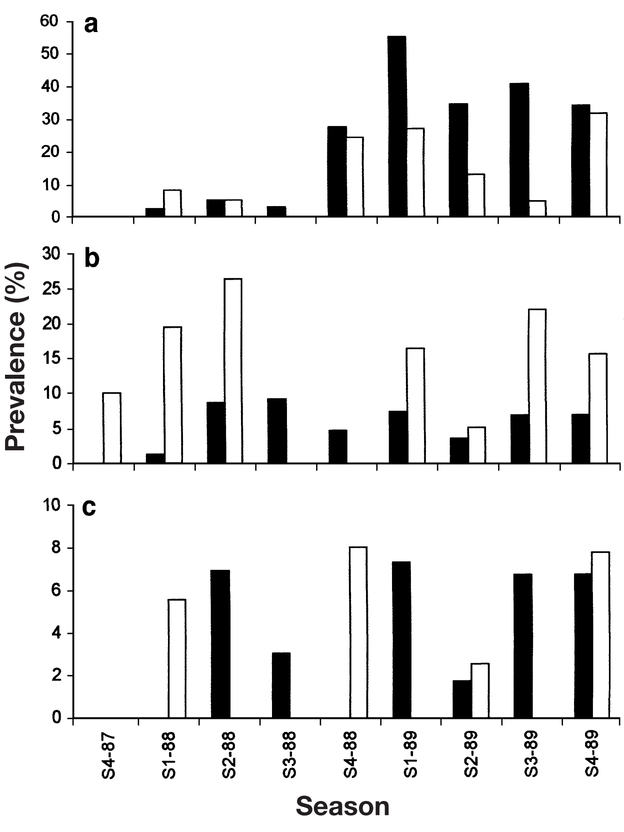

Fig. 3. Prevalence of myxosporean parasites in *Sarotherodon melanotheron melanotheron* and *Tilapia zillii* in Lake Nokoué (Bénin, West Africa). Myxosporean parasites of the (a) branchial filament: *Myxobolus* sp. (filled bars), *M. zillii* (open bars); (b) branchial arch cartilage: *M. sarotherodoni* (filled bars); *M. dossoui* (open bars); (c) branchial arch: *M. beninensis* (filled bars); *M. microcapsularis* (open bars). Sampling season and year given on *x*-axis

Myxobolus beninensis and *M. microcapsularis* are parasites of the branchial arch of *Sarotherodon melanotheron melanotheron* and *Tilapia zillii* respectively. The prevalence of these 2 parasites was 3.32% (13 affected fishes out of 391 examined) and 2.70% (6 affected fishes out of 222 examined) respectively. *M. beninensis* (Fig. 3c) was found in *S. m. melanotheron* throughout the study except during S4-87, and S4-88. Its occurrence did not vary significantly form one season to another (χ^2 test, $\chi^2 = 11.88$, df = 8, ns). The prevalence of *M. microcapsularis* (Fig. 3c) found in *T. zillii* did not vary significantly (χ^2 test, $\chi^2 = 8.02$, df = 8, ns).

Prevalence within host size

In *Sarotherodon melanotheron melanotheron*, prevalence of *Myxobolus* sp. did not vary significantly (χ^2 test, $\chi^2 = 0.51$, df = 3, ns) with respect to fish size (Fig. 4a) or prevalence of *M. sarotherodoni* (χ^2 test, $\chi^2 = 1.96$, df = 3, ns) (Fig. 4b) or *M. beninensis* (χ^2 test, $\chi^2 = 1.05$, df = 3, ns) (Fig. 4c). In *Tilapia zillii*, prevalence of *M. zillii* (χ^2 test, $\chi^2 = 3.34$, df = 3, ns) did not vary significantly with respect to fish size (Fig. 4a) or prevalence of *M. dossoui* (χ^2 test, $\chi^2 = 13.47$, df = 3, ns) (Fig. 4b) or *M. microcapsularis* (χ^2 test, $\chi^2 = 0.97$, df = 3, ns) (Fig. 4c).

Prevalence by sex

Prevalence of *Myxobolus* sp. in male (20.66%, 56 affected fishes out of 271 examined) and female (20.35%, 23 affected fishes out of 113 examined) *Sarotherodon melanotheron melanotheron* did not differ significantly (χ^2 test, $\chi^2 = 0.004$, df = 1, ns), nor did prevalence of *M. zillii* in male (13.44%, 16 affected fishes out of 119 examined) or female (16.50%, 17 affected fishes out of 103 examined) *Tilapia zillii* (χ^2 test, $\chi^2 = 0.41$, df = 1, ns).

Prevalence of *Myxobolus sarotherodoni* in male (5.53%, 15 affected fishes out of 271 examined) and female (3.54%, 3 affected fishes out of 113 examined) *Sarotherodon melanotheron melanotheron* did not differ significantly (χ^2 test, $\chi^2 = 0.68$, df = 1, ns), nor did the prevalence of *M. dossoui* in male (11.76%, 14 affected fishes out of 119 examined) or female (15.53%, 16 affected fishes out of 103 examined) *Tilapia zillii* (χ^2 test, $\chi^2 = 0.62$, df = 1, ns).

Prevalence of *Myxobolus beninensis* in male (4.06%, 2 affected fishes out of 271 examined) and female (1.77%, 2 affected fishes out of 113 examined) *Sarotherodon melanotheron* did not differ significantly

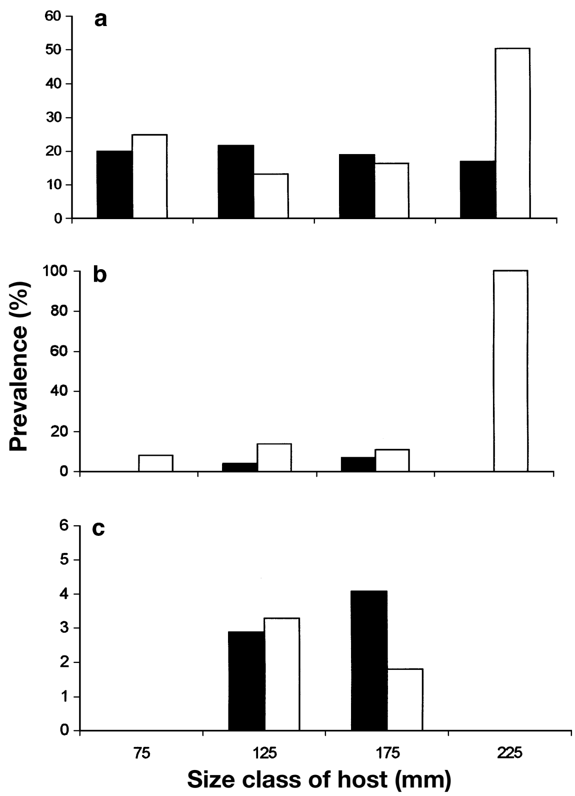

Fig. 4. Prevalence of myxosporean parasites in relation with the size of their hosts *Sarotherodon melanotheron melanotheron* and *Tilapia zillii* in Lake Nokoué (Bénin, West Africa). Myxosporean parasites of the (a) branchial filament: *Myxobolus* sp. (filled bars), *M. zillii* (open bars); (b) branchial arch cartilage: *M. sarotherodoni* (filled bars), *M. dossoui* (open bars); (c) branchial arch: *M. beninensis* (filled bars), *M. microcapsularis* (open bars)

(χ^2 test, $\chi^2 = 3.84$, df = 1, ns), nor did the prevalence of *M. microcapsularis* in male (3.36%, 4 affected fishes out of 119 examined) or female *Tilapia zillii* (1.94%, 2 affected fishes out of 103 examined) differ significantly (χ^2 test, $\chi^2 = 0.42$, df = 1, ns).

DISCUSSION

Prevalence data

Our results clearly showed that the prevalence of the different myxosporean parasites that infected *Sarotherodon melanotheron melanotheron* and *Tilapia zillii* was high and greatly varied. The most common parasites were *Myxobolus* sp. (20.20%) found in *S. m. melanotheron*, *M. zillii* (14.86%) in *T. zillii*, which are both located in branchial filaments, and *M. dossoui* (13.51%), which is located in the branchial arch cartilage. The prevalence of *Myxobolus* sp. in *S. m. melanotheron* was higher than that found in the gills of *Labeo niloticus* (between 12 and 20% for different *Myxobolus* sp.) or *Clarias lazera* (14% for *Henneguya branchialis*) (Ghaffar et al. 1995) but lower than that found in the gills of *Abramis brama* (Molnár & Székely 1999). In contrast, the prevalence of *M. zillii* and *M. dossoui* was close to that which was observed in the gills of *C. lazera* (Ghaffar et al. 1995). The other parasite species studied were found only sporadically (2 to 4%), as are parasite species usually observed on freshwater fishes (Ghaffar et al. 1995, Molnár & Székely 1999). Myxosporean parasites on gills are known to induce mortality such as *Henneguya* sp. in catfishes (McCraren et al. 1975), distorsion in branchials lamellae such as *H. chrysichthyi* in *Chrysichthys nigrodigitatus* (Obiekezie & Enyenihi 1988) and liquefaction of cartilaginous tissues of gills such as *M. cartilaginis* in *Lepomis macrochirus* (Hoffman et al. 1965). These diseases which cause a reduction in the respiratory capacity of fish pose a threat to the fish and thus to the farms. The high prevalence of myxosporea and their presence on tilapia gills suggested that further studies on the potential effect of these parasites on their hosts are needed, as myxosporea probably causes a reduction in the respiratory capacity of the fish and negatively affect their fitness.

Parasites and sex of host

Males are known to be usually more sensitive to parasites than females due to testosterone synthesis which may exert a cost, decreasing immune competency. In our study, prevalence did not vary significantly with the sex of the host, showing that males were not more sensitive than females to these parasites and revealing that this sex difference could be irrelevant (Poulin 1996).

Parasites and age of fish

When parasites do not induce host mortality, the continued acquisition of parasites through time tends to increase the parasite load in the older age classes of the host. Thus, the highest prevalence was observed in larger fish (Lester 1984). In myxosporean parasites, Gonzalez-Lanza & Alvarez-Pellitero (1985) have already mentioned the effect of host size and sex on the prevalence of *Myxobolus pseudodispar*, *M. leuciscini* and *M. ellipsoides*. Mitchell (1989) highlighted the fact that the prevalence of *M. muelleri* and *M. dujardini*, parasites of *Psychocheilus oregonensis*, *P. caurinus* and *Richardsonius blateatus*, was higher in the oldest fish, suggesting that host death is independent of parasite load. During our study, the prevalence of *M. dossoui* was the only one that differed significantly within host sizes. This species is located in the cartilaginous tissues of the branchial arch, i.e. it is not in contact with the external environment except during host death or the destruction of the branchial arch. Therefore, in order to release its infective forms into the environment, this parasite needs to wait for the death of its host or to induce it. Parasites which are not in contact with the environment have already been considered to be parasites which induce host death (Pampoulie et al. 1999, 2000). Thus, the low prevalence of *M. dossoui* in the large size class of fish was probably due to a die-off of the highly infected fishes.

Prevalence of *Myxobolus zillii* and *M. dossoui* did not vary significantly within host size but peaks were observed in the larger size class, suggesting an increase in parasite load with fish age. These results should be viewed with caution, as only a few individuals (1 to 2%) in this size class were caught.

Seasonal variations in parasitosis

The seasonal pattern of prevalence did not vary significantly except for species affecting the branchial filaments, e.g. *Myxobolus* sp. and *M. zillii*. In these particular environments, we believe that the seasonal pattern of these 2 myxosporea cannot be explained directly by temperature variations, which has been shown to be the case for *Sphaerospora renicola* in common carp (Grupcheva et al. 1985) and for different species of the genus *Ceratomyxa* (Alvarez-Pellitero & Sitja-Bobadilla 1993). On the contrary, the combination of fluctuations in salinity, temperature and pH between dry and wet seasons probably affects the parasite cycle by causing modifications in host behaviour (migration to avoid decreases in salinity or changes in the environment) and/or by rendering the host more sensitive to the parasite by increasing the osmoregulatory cost. Thus, the associated changes in these parameters probably affect the parasite cycle by modifying the contact zone between parasites and their hosts. The parasite cycle may also be synchronised with the host cycle (Pampoulie et al. 2000), inducing a modification of prevalence in relation with the life cycle of host.

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