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Sexual selection of parasites in Nile tilapia (*Oreochromis niloticus* L.)

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Abstract
This study was specifically conducted in order to determine the possible influence of host sex in the prevalence and intensity of parasites in Nile tilapia (*Oreochromis niloticus* L.). The present study recorded six genera of ectoparasites and three taxa of endoparasites from the gills, skin and intestine of the examined Nile tilapia that were collected from grow-out farms in Central Luzon, Philippines. Female tilapia had higher prevalence in most of the parasites identified such as *Trichodina*, *Dactylogyrus*, *Gyrodactylus*, *Coleps*, *Euplotes*, *Ergasilus* and digenean as compared to male samples. Meanwhile, the prevalence of *Camallanus* was higher in males as compared to females. Female tilapia parasitized with *Trichodina*, *Dactylogyrus*, *Euplotes*, *Ergasilus* and digenean showed higher intensities as compared to males. In contrary, the intensities of *Gyrodactylus*, *Coleps* and *Camallanus* were higher in male tilapia than in females. The main reason for the differences in parasitic load with sex is thought to be physiological.

Keywords: Nile tilapia, ectoparasite, endoparasite, prevalence, intensity, host sex

1. Introduction
Tilapia (*Oreochromis* spp.), like other aquatic animals, can be exposed to various infectious and non-infectious diseases. Tilapia diseases have attracted attention in recent years because of wide expansion of tilapia culture, extensive introduction of tilapia into other countries, increase awareness about the role of fish culture in the spread of human diseases, increase public concern about environmental protection and increase global exportation and importation of tilapia with high quality standards [1].
All fishes are potential host to many different species of parasites that cause significant mortalities among cultured and wild fish stocks. Endoparasites of fish inhabit the digestive tract or other organs (e.g. stomach) in the body while ectoparasites attach themselves to the gills, skins and fins of fish [2]. The presence of these parasites on fish stocks in ponds indicates poor husbandry practices and environmental conditions [3, 4, 5, 6].
The intensification of fish culture creates parasitic disease problems that originate from overcrowding or deteriorating water quality such as unsuitable water temperature, pH, carbon dioxide and free ammonia concentrations [7, 8, 9]. However, some factors might also directly or indirectly influence the parasite fauna of fishes like host size, age and sex, spleen size [10, 11, 12, 13, 14], diet, abundance of fishes, independent number of a parasite within the fish, season [15] and relative condition [16]. The main problem is that results available to date show very little consistency [17].
The role of parasites in sexual selection has been extensively used in several studies predominantly using birds as a model [18, 19, 20]. Recently, several fish models have been applied in studies examining the pattern of sexual ornamentation as a measure of sexual showiness and parasite exposure [21, 22, 10, 11]. Therefore, this study was specifically conducted in order to determine the possible influence of host sex in the prevalence and intensity of parasites in Nile tilapia.

2. Materials and Methods
2.1 Sample collection and preparation
Pond-reared Nile tilapia samples were collected from the four leading tilapia-producing provinces in Central Luzon, Philippines namely Pampanga, Bulacan, Nueva Ecija and Tarlac. Sampling was carried out during dry season in a monthly interval from January to April 2011.

Ten per cent (10%) of the number of freshwater tilapia pond owners in each province operating ≥ 5 ha fish farm were selected. Forty (40) fish samples in every farm were collected using cast net and/or gill net. The samples were placed in aerated plastic bags and/or in a tub with pond water. The sex of the collected samples was determined by examining the genital papilla. Males have pointed genital papilla as opposed to rounded and swollen in females.

Smears of gills, skin, fin, stomach and intestine were made and examined under the microscope for the presence of parasite. The parasite specimens were identified to genus or family level using the keys of Kabata[15]. Recovered parasites were treated with physiological saline to retain morphological definition [23].

2.2 Computation of per cent prevalence and intensity of parasites

Prevalence and intensity were computed following the formulae proposed by Margolis *et al* [24]. as:

Prevalence = (number of host parasitized/number of host examined) x 100

Intensity = number of parasite/number of host parasitized

2.3 Statistical analysis

Differences in parasite prevalence and intensity between male and female tilapia samples were analyzed using Independent Sample T-test.

3. Results and Discussion

The present study recorded six genera of ectoparasites (*Trichodina* spp., *Coleps* spp., *Euplotes* spp., *Dactylogyrus* spp., *Gyrodactylus* spp. and *Ergasilus* spp.) and three taxa of endoparasites (*Camallanus* spp., and unknown digenean and acanthocephalan) from the gills and skin, and intestine, respectively of the examined Nile tilapia in Central Luzon, Philippines.

Female tilapia had higher prevalence in most of the parasites identified (*Trichodina* = 85.2%±14.49; *Dactylogyrus* = 49.6%±19.07; *Gyrodactylus* = 35.2%±17.91; *Coleps* = 17.70%±14.68; *Euplotes* = 14.25%±15.12; *Ergasilus* = 0.60%±1.64; Digenean = 0.4%±2.47) as compared to male samples (*Trichodina* = 52.4%±33.89; *Dactylogyrus* = 33.35%±20.68; *Gyrodactylus* = 25.35%±18.60; *Coleps* = 11.25%±10.57; *Euplotes* = 9.00%±10.73; *Ergasilus* = 0.4%±1.37; Acanthocephalan = 0.33±1.26). Statistical significance was observed in the parasites *Trichodina*, *Dactylogyrus* and *Gyrodactylus* ($p<0.05$) (Figure 1A). Meanwhile, the prevalence of *Camallanus* was statistically higher in males (12.2%±12.38) as compared to females (5.4%±9.26) ($p<0.05$) (Figure 1B).

Female tilapia parasitized with *Trichodina* (21.1±62.59), *Dactylogyrus* (2.73±2.53), *Euplotes* (1.96±1.75), *Ergasilus* (1.25±0.5) and digenean (1.2±0.42) showed higher intensities as compared to males (*Trichodina* = 16.19±32.83; *Dactylogyrus* = 2.59±2.58; *Euplotes* = 1.87±1.60; *Ergasilus* = 1.00±0.00; Digenean = 1.00±0.32). Significant difference was only observed in the compared intensity of *Trichodina* in males and females (Figure 2A). In contrary, the intensities of *Gyrodactylus* (2.14±2.10), *Coleps* (2.14±2.09) and *Camallanus* (2.02±1.90) were higher in male tilapias than in females (*Gyrodactylus* = 1.89±1.62; *Coleps* = 1.74±1.52; *Camallanus* = 1.73±1.72) but statistical analysis showed no significant result (Figures 2A and 2B).

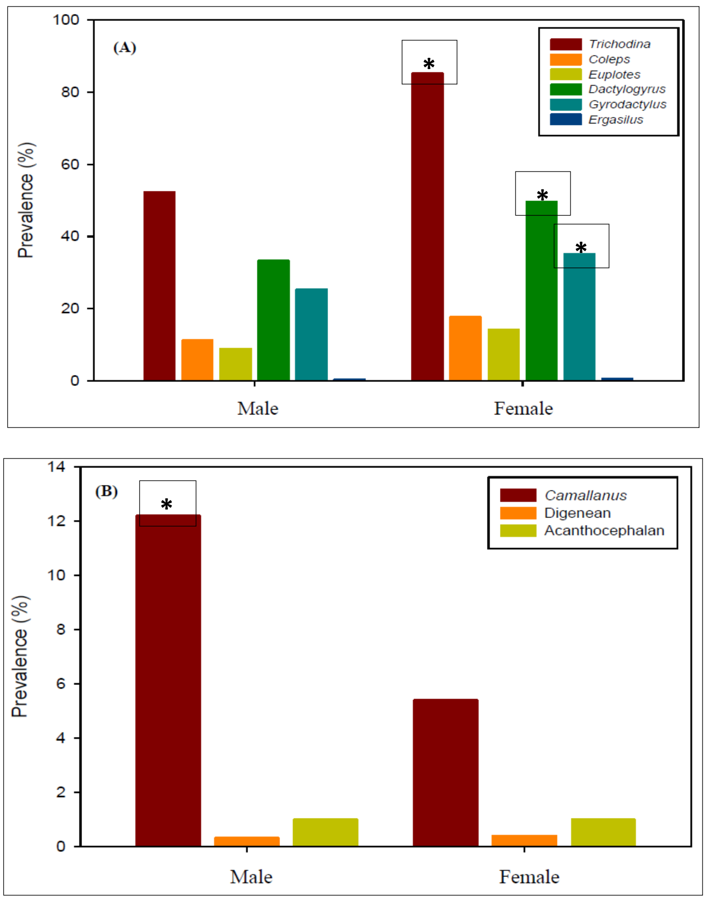

Fig 1: Mean prevalence (%) of ectoparasites (A) and endoparasites (B) in male and female Nile tilapia (*O. niloticus*) collected from selected ponds in Central Luzon, Philippines (asterisk denotes statistical significance).

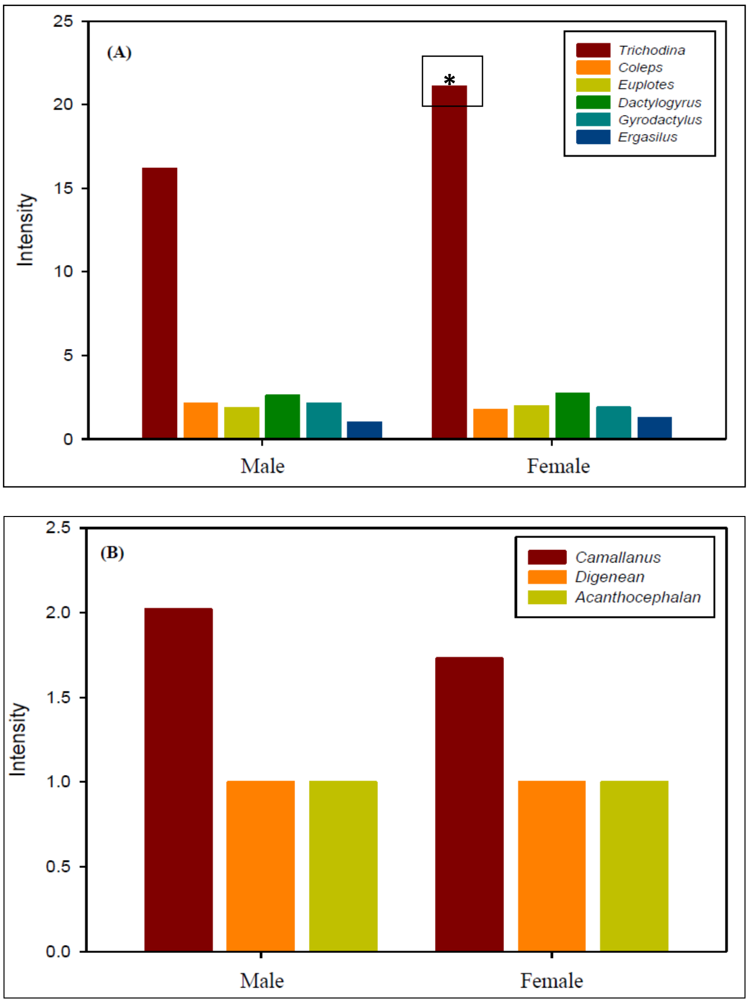

Fig 2: Mean intensity of ectoparasites (A) and endoparasites (B) in male and female Nile tilapia (*O. niloticus*) collected from selected ponds in Central Luzon, Philippines (Asterisk denotes statistical significance).

Male and female fishes invest differently in reproduction with females investing more in gamete production, and males investing more in mate attraction through the display of sexual ornamentation, which are exacerbated during the spawning period [22, 10]. Higher level of infestation (prevalence and intensity) of most of the parasites in female tilapia can be due to the existence of an energetic trade-off between the investment in reproduction and the investment in immune responses [25], with the assumption that energy for reproduction is costly and reduces the energy for other tasks such as immunocompetence. However higher parasite level in male tilapia may be due to production of steroid hormones (mainly testosterone) that could directly affect the production of immune cells [26-27]. The immunosuppression by steroid hormones could result in higher parasites level in breeding individuals or in individuals with high expression of sexual ornamentation [12, 28].

Males of common bream (*Abramis brama*) with more intensive sexual ornamentation were found more susceptible to metazoan ectoparasite infestation [12]. These results are consistent with the findings of Skarstein and Folstad [22] and Kortet *et al* [21]. But are in opposition to those of Wedekind [21], who reported a negative relationship between number of tubercles on the head and body and the presence of *Diplozoon* sp. and nematodes. A study of sexual coloration and parasite infection in three-spined stickleback showed that high expression of sexual coloration is related to a higher intensity of infection of some parasite species, but a lower intensity of infection of other parasite species [29].

Ramadan [30] found that *Tilapia zillii* in Lake Manzala, Egypt, were more infected with *Dactylogyrus* than *O. niloticus*. Furthermore, females were more susceptible to the disease than males. The gill myxosporean parasites of two euryhaline tilapias (*Sarotherodon melanotheron melanotheron* and *T. zillii*) from Lake Nokoué were investigated by Gbankoto *et al*. [31]. Both of the fish species studied were infected by three host-specific myxosporean parasites (*Myxobolus* sp., *M. zillii* and *M. dossoui*). Prevalence of *Myxobolus* spp. in male (20.66%) and female (20.35%) tilapia species did not differ significantly [31]. In a separate study by Poulin [32], 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 sex difference could be irrelevant.

A parasitological investigation on the helminth parasites of *Malapterurus electricus* of Lekki lagoon was carried out by Akinsanya *et al*. [33]. The fish specimens were found to be infected with gastrointestinal helminth (*Electrotaenia malapteruri*, *Nilonema* spp., *Tenuisentis niloticus*). The authors found that male specimens had higher rate of gastrointestinal infections than female specimens.

The incidence of helminth parasites in relation to sex was examined by Goselle *et al*. [34] in *Clarias gariepinus* and *T. zilli*. Male fingerlings of *C. gariepinus* had higher infections (73.90%) than the female fingerlings (70.40 %). In *T. zilli*, the males also had the highest percentage of infection (53.13%) than the females (50.00%).

Commercially important fish species (e.g. rabbitfish, mackerel, parrot fish, sardine, tuna and needle fish) in Kenyan coast showed a slight variation in mean intensity of metazoan parasite with the sex of the host, where males showed a slightly heavier parasite burden (nematode and trematode), though this was not statistically significant. Similar findings have been reported in many freshwater fish species that males were more parasitized than females [35, 36, 37, 38, 39].

4. Conclusion

This study has proven that host sex can influence the prevalence and intensity of some parasites in tilapia and the main reason for the differences in parasitic load with sex is thought to be physiological.

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