SOCIAL STRUCTURE, NEST GUARDING AND INTERSPECIFIC RELATIONSHIPS OF THE CICHLID FISH *(Julidochromis marlieri)* IN LAKE TANGANYIKA

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ABSTRACT Social structure, nest guarding and interspecific relationships of the Tanganyikan cichlid *Julidochromis marlieri* were investigated at Gitaza, Republic of Burundi. Six social groups were found and classified into 3 types by the composition of the members: branching group with the largest adult (first adult [FA]), 2 smaller adults (second adult [SA] and third adult [TA]), and juveniles; linear group-α with one member each of FA, SA, and TA and juveniles and linear group-β with one FA, one SA and juveniles. The time the TA, SA, and FA each stayed at the nest declined with size.

When potential predators on juveniles (*Lepidiolamprologus elongatus* and *L. profundicola*) approached, *J. marlieri* vigorously intercepted. *J. marlieri* nests were located near the home ranges of *Neolamprologus savoryi*, which also attacked such predators. *N. savoryi* also attacked *J. marlieri*, but the nest proximity may be beneficial for the latter, because *N. savoryi* excluded the approaching predators near the nest of *J. marlieri*.

Key Words: Lake Tanganyika; Cichlidae; *Julidochromis marlieri*; Social structure; Interspecific relationships.

INTRODUCTION

Reproductive ecology of the cichlid fishes in Lake Tanganyika have been studied by many authors (reviewed by Kuwamura, 1997). The characteristics of cichlid fishes are their parental care for eggs and juveniles for long period after mating. Parental care patterns in the cichlid fishes, such as mouth brooding or guarding (substrate brooding) by biparental or uniparental care, are associated with different mating systems of monogamy and several patterns of polygyny (Kuwamura, 1997).

The mating system of the tribe Lamprologini is monogamous with biparental guarding or polygynous with maternal guarding (Kuwamura, 1997). *Julidochromis marlieri*, one species of the tribe Lamprologini, is monogamous, and in some nests, helpers join juvenile guarding (Yamagishi & Kohda, 1996). But what has not been reported in fishes is that the mating system of this species is polyandry, because a female occupies 2 territories each with a male.

One of the functions of parental care is to exclude predators for juveniles. The removal experiments of one parent in cichlids of Lake Tanganyika reveal that biparental care is essential to avoid predation on offsprings (Nagoshi & Yanagisawa, 1997), because there are several piscivorous fishes with various foraging tactics (Kohda *et al*., 1997). In bluegill sunfish, *Lepomis macrochirus*, males establish colo-

nial breeding nests and guard eggs until hatching. Brood predation may be reduced in a colony rather than in a single nest (Gross & MacMillan, 1981). In *J. marlieri*, such colonial nesting is not known (Yamagishi & Kohda, 1996). If *J. marlieri* nest among the nests of the other species with parental guarding, reduction in brood predation may be expected.

The aim of this study is to describe social structure and nest guarding of *J. marlieri* at Gitaza, Republic of Burundi. As *Neolamprologus savoryi* is the most abundant species in the study area, I will clarify interspecific relationships between *J. marlieri* and *N. savoryi* in terms of the predator avoidance.

MATERIALS AND METHODS

The study was conducted at Gitaza, Republic of Burundi (3°38'S, 29°20'E). Observation was made by scuba diving from 09:00 to 14:00 for 11 days between October 2 to 19, 1993. A 20×6 m study area, divided by 2×2 m grids, was set on a slope about 10-20 m offshore where *Julidochromis marlieri* was abundant, at the depth of 3-9 m. The bottom of the study area was mostly covered with various sizes of boulders.

Total length (TL) of individuals in the study area was estimated by the eye. They were classified into 2 categories: adult, usually in open areas and large (3 cm TL≤); juvenile, usually hiding in the nest and small (3 cm TL≥). Adults were identified on the basis of different color patterns on the head and nape. Their location and feeding sites were recorded on the map of the study area 3-5 times a day. Home ranges were determined by enclosing the location points.

Several adults and juveniles established social groups. As the adults were different sizes, they were discriminated as the first adult (FA), the second adult (SA) and the third adult (TA) in order of size.

To observe the investment for juvenile guarding by the FA, SA and TA, time for staying at the nest was recorded. Twenty minutes observation for each nest was made 5 times on October 2, 4, 5, 8 and 9 (100 minutes in total). When they attacked other fishes, the species was recorded. The fishes attacked were regarded as a potential predator for juveniles.

Interspecific relationships between *J. marlieri* and *Neolamprologus savoryi*, the most abundant species at the study area, was investigated. The location points of individual *N. savoryi* were plotted on the map on October 15. Species attacked by *N. savoryi* were recorded. The number of the species attacked by *J. marlieri* and *N. savoryi* in the study area was counted on October 19. Attack rate was calculated by dividing the number of attacks with the number of individuals of attacked species. Detailed observations were conducted at one of the *J. marlieri* nests on October 15-16. All the *N. savoryi* which appeared within 1m radius of this nest were identified by the shape of a blotch at the left side of opercular or a natural scar. To estimate home range, their swimming routes were recorded for 5 minutes. As *J. marlieri* and *N. savoryi* frequently attacked the piscivorous fishes of *Lepidiolamprologus elongatus* and *L. profundicola*, the attack points and the swimming routes before and after attacks were recorded.

RESULTS

I. Social Structure

Sixty-seven individuals of *Julidochromis marlieri* were identified during the study period. Six social groups, which contained 18 adults and 31 juveniles, were found in the study area, and 18 other adults appeared as solitary individuals. Juvenile nests were located under rocks. The social groups were classified into 3 types by the composition of the members (Table 1): the branching group with a FA occupying 2 nests with a SA, a TA and juveniles (Group I); the linear group-α, composed of a FA, a SA, a TA and juveniles, occupying a nest (Group II, III and IV); and the linear group-β, composed of a FA, a SA and juveniles, occupying a nest (Group V and VI). TL of solitary individuals (mean$\pm$SD$=6.2\pm2.6$ cm, range$=$3-12 cm) was significantly different from that of FAs (Mann-Whitney U-test, $U=16.0$, $p<0.05$), but did not differ from those of SAs and TAs ($U=39.5$ and 40.5, respectively, both $p>0.05$).

This species pecked on rocky surface to feed. Irrespective of the categories of the groups, the home ranges of the smaller members (6 cm TL$\geq$) were located around the nest entrance (about 30-50 cm in diameter), and they fed in these area. The home ranges of the larger members (7cm TL$\leq$) were comprised of 2 parts: nest and remote home range. As the larger members left the nests, they did not stay around the nest, but swam to their remote home ranges. The remote home range of the largest individual (the FA of Group I) was the farthest, about 30 m from the nest, among all the group members. The solitary individuals maintained home ranges where other individuals' remote home ranges were located, and fed there (Fig. 1). No territorial behavior was observed among the solitary individuals and/or the group members, and their home ranges overlapped.

II. Nest Guarding and Interspecific Relationships

The FAs, SAs and TAs guarded the juveniles against their potential predators when they stayed at the nest. Ten cichlids and 2 non-cichlids were driven out from the vicinity of the nests (Table 2). Of these species, attack rates against *Lepidiolamprologus elongatus* and *L. profundicola* were high (Table 2). These species usually swam at 2-3 m above the bottom, and sometimes approached the bottom. In one case, *L. profundicola* attacked one of the nests of *J. marlieri* by dashing.

The detailed observation for Group I showed that there was a territory around the

Table 1. TL (cm) of the members of the each social group in the study area. Number of juveniles in each size is given in parentheses.

	Group						
Members	I		II	III	IV	V	VI
FA	13		10	10	8	8	6
SA	12	10	7	7	7	5	5
TA	8	5	6	5	4		
Juveniles	1(6)	3(3)	1(3), 3(1)	2(4)	1(5), 3(1)	1(4)	1(3)

Table 2. Attacked species, number of individuals in the study area and frequency of aggressive interaction with *Julidochromis marlieri* and *Neolamprologus savoryi*. The attack rate is given in parentheses. Food habits of Cichlidae and non-Cichlidae from Hori *et al*. (1983) and Abe (1997), respectively. A, Aufwuchs eater; B, zoobenthos feeder; O, omnivore; P, piscivore; Pl, plankton feeder.

Species	N	Attacks by		Food habit
		J. marlieri	*N. savoryi*	
Cichlidae				
Altolamprologus compressiceps	11	3(0.3)	1(0.1)	B
Gnathochromis pfefferi	10	—	5(0.2)	B
Julidochromis marlieri	36	5(0.1)	23(0.7)	O
Lamprologus lemailei	4	3(0.8)	—	P
Lepidiolamprologus elongatus	5	18(3.6)	15(3.0)	P
L. profundicola	2	17(8.5)	22(11.0)	P
Neolamprologus brichardi	8	1(0.1)	4(0.5)	Pl
N. savoryi	175	7(0.04)	1(0.01)	Pl
Telmatochromis bifrenatus	138	27(0.2)	39(0.3)	O
T. tempolaris	23	5(0.4)	3(0.1)	A
Non-Cichlidae				
Caecomastacembelus moorii	2	3(1.5)	—	P
Synodontis multipunctatus	18	1(0.1)	1(0.1)	B

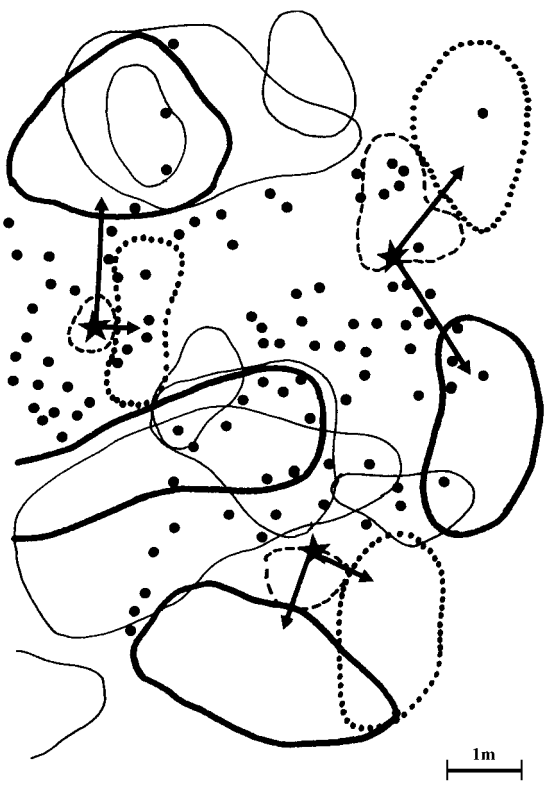

Fig. 1. Arrangement of the home ranges of the FAs, SAs, TAs and solitary individuals in *Julidochromis marlieri* in the part of the study area, which are shown with thick, dotted, broken and thin lines, respectively. Solid circles are the location of *Neolamprologus savoryi*. Stars show the location of the nests. Arrows show the swimming routes for the feeding sites.

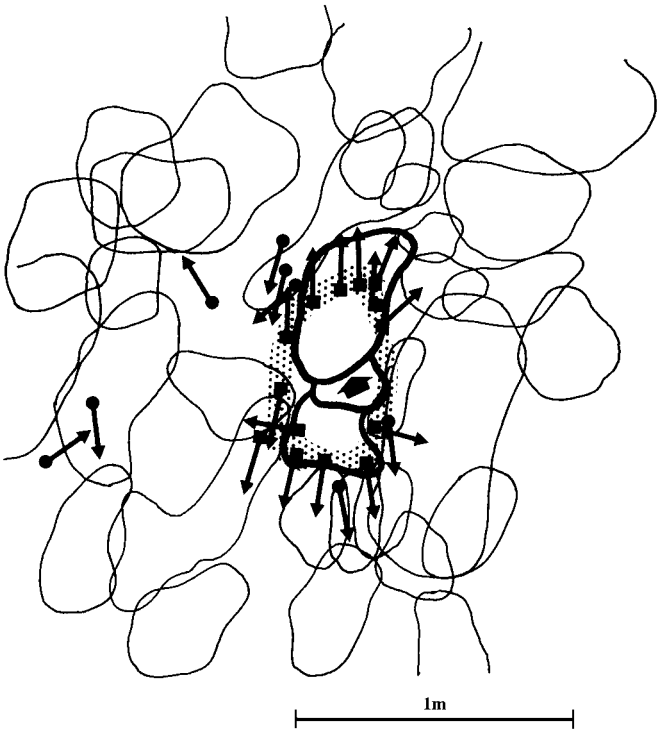

Fig. 2. Location points which *Lepidiolamprologus elongatus* and *L. profundicola* were attacked. The attack points by *Julidochromis marlieri* and *Neolamprologus savoryi* are indicated with solid squares and circles, respectively. Shaded area is the border of juvenile guarding territory in *J. marlieri*. Bold arrow are the entrance to the nest of *J. marlieri* and the other arrows show the direction the attacked predators swam away. Thick and thin lines indicate boulders for the nest of *J. marlieri* and home ranges of *N. savoryi*, respectively.

nest entrance. *L. elongatus* and *L. profundicola* did not cross the line linking the points where these intruders were attacked (Fig. 2). In the branching group and the linear group-α, the TAs stayed at the nest longer (mean±SD=84.3±23.7 minutes in total, range=46.0-100) than the SAs (15.8-64.3) ($p=0.043$, Wilcoxon-signed rank test, $z=-2.023$, $n=5$), and in all the groups, the SAs stayed longer (63.4±30.5, 15.8-99.6) than the FAs (39.0±27.4, 7.7-93.5) ($p=0.018$, $z=-2.366$, $n=7$).

N. savoryi was the most abundant species in the study area (Table 2). They were distributed mainly in the rocky area. The nests of *J. marlieri* were located near the home ranges of *N. savoryi* (Figs. 1 & 2). When *J. marlieri* tried to feed in the visinity, *N. savoryi* attacked it, and the former failed to feed in the home range of the latter in most cases. The attack rate by *N. savoryi* against *L. elongatus* and *L. profundicola* was high (Table 2).

DISCUSSION

Julidochromis marlieri at Bemba, Democratic Republic of the Congo has 3 types

of social group (Yamagishi & Kohda, 1996): a female maintaining 2 territories with a male and helper, and groups containing a female and male with or without a helper. Yamagishi & Kohda (1996) suggested that the mating system of this species was monogamy and polyandry. Although the sex of individuals was not determined in the present study, the results were similar to those of Yamagishi & Kohda (1996), where in each group, the female is the larger than the male, and the male was larger than the helper (Yamagishi & Kohda, 1996). If the FAs and SAs are female and male, respectively, the mating system of *J. marlieri* may also be monogamy and polyandry at Gitaza. The TAs can be regarded as a helpers as they engaged in parental care.

As *Lepidiolamprologus elongatus* and *L. profundicola* are piscivorous (Table 2) and *L. profundicola* attacked the nest of *J. marlieri* by dashing, these species should be considered the main predator for juveniles. The territory around the nest entrance may function as juvenile guarding in *J. marlieri*.

There may not be a competition for food between *Neolamprologus savoryi* and *J. marlieri*, because feeding habits of both species are different (Table 2). But *N. savoryi* attacked *J. marlieri*, when the latter tried to feed in the former's home range. Since the slender body shape of *J. marlieri* is similar to that of *L. elongatus* and *L. profundicola*, *N. savoryi* may mistakingly attack *J. marlieri*, as observed in the pomacentrid fish (Kohda, 1981). As Fig. 1 shows, *J. marlieri* seemed to select their home ranges at remote places where there are small *N. savoryi* to guard against attacks by *N. savoryi*. Interspecific aggression by *N. savoryi* may even be beneficial for *J. marlieri*, because *N. savoryi* excluded the piscivorous fishes, *L. elongatus* and *L. profundicola*, before approaching the *J. marlieri* nest, as seen in the breeding colony of bluegill sunfish *Lepomis macrochirus* (Gross & MacMillan, 1981).

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