Sex-role reversal in *Julidochromis* species: Studying strong females in Lake Tanganyika.

Dr. Susan C.P. Renn and Dr. Hans A. Hofmann
Harvard University, Bauer Center for Genomics Research, 7 Divinity Avenue, Cambridge, MA, 02138, USA.

The broad scope of my scientific research combines laboratory-based molecular studies of gene expression as well as controlled behavioral experiments with field-based observation and experimentation. The Guy Jordan Fund provided me the opportunity to establish field sites and collect preliminary data which will be necessary for my future applications to the National Science Foundation, in order to continue this work. Species of the genus *Julidochromis* are central to my work because they offer an excellent model system to address important questions in evolutionary biology as well as behavioral neuroscience.

Most animal species exhibit sex-specific behaviors in competition for mates (Darwin, 1871). Usually, males compete with each other in order to gain access to more, or more desirable mates. Therefore males can be considered to be the "dominant sex" (Anderson, 1994).

"Dominance" comprises a complex set of behavioral, anatomical, and physiological traits which are influenced by both genetic mechanisms and the physical and social environment experienced by the individual.

When females of a species exhibit dominance behaviors that are typically associated with males, the species is said to exhibit "sex-role reversal." Males assume a less aggressive, more "subordinate" role and females exhibit "dominance" behaviors. Species that exhibit sex-role reversal are very useful to scientists who want to understand the evolution, ecology, and physiology of sex-role behavior. The natural habitat may favor either conventional or reversed sex-role species but at this time we have very little understanding about what these ecological factors might be. Furthermore, researchers have not been able to identify many of the physiological and genetic mechanisms that control sex-role and sex-role reversal.

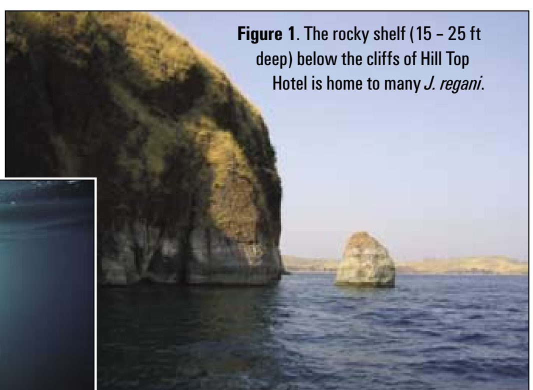


Figure 1. The rocky shelf (15 – 25 ft deep) below the cliffs of Hill Top Hotel is home to many *J. regani*.

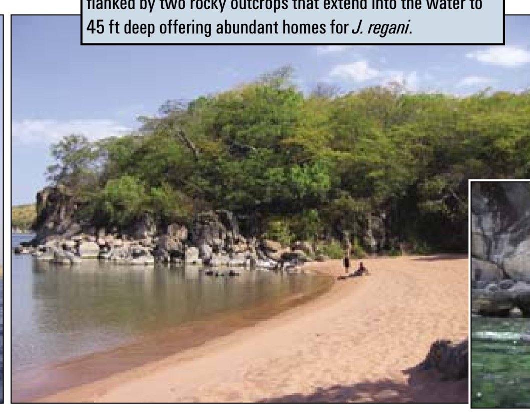
While sex-role reversal is not very common, examples of sex-role reversed species can be found among fish (Vincent *et al.*, 1992), amphibians (Verrell and Brown, 1993), birds (Lignon, 1999), and insects (Gwynne and Simmons, 1990). This wide spread occurrence of sex-role reversal suggests that it is an advantageous mating strategy under some natural conditions.

The explosive evolution of East African cichlids over the past several million years has produced over 2000 species, which exhibit incredibly diverse morphology and social systems (Barlow, 2000). In a captive setting many of these species are able to mate with each other to produce fertile hybrids. But in nature reproductive isolation between these closely related species can be maintained through behavioral mechanisms.

Among the five species of *Julidochromis* (*regani, marlieri, dickfeldi, ornatus* and *transcriptus*), published accounts describe one, *J. marlieri*, as showing characteristics of sex-role reversal (Yamagishi and Khoda, 1996). The females of this species are larger than the males. The females are reported to venture farther from the nest. Finally it was suggested that the females may mate with more than one male. A wealth of observations and unpublished data (Lee and Barlow, personal communication) support these findings and also suggest a similar mating strategy for *J. regani*. Nevertheless, there remains much work to be done on the subject, both in captive and wild settings.

With this information in mind I headed to Africa for my first serious attempt at real field biology. I traveled with Dr. Hans Hofmann and Dr. Caroly Shumway for whom this trip was their 3rd to Lake Tanganyika. We were accompanied by one graduate student and two undergraduates. We worked together to collect data and samples for each of our projects, as well as for other colleagues

Figure 2. Jakobsen's Beach, accessible by boat or 4WD, is flanked by two rocky outcrops that extend into the water to 45 ft deep offering abundant homes for *J. regani*.



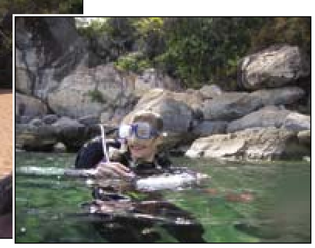


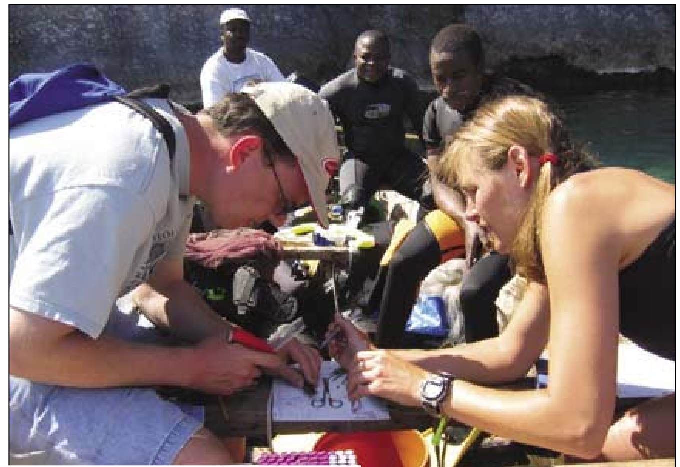
Figure 3. A dive team lays out the quadrate and sets about collecting relevant data.

back home. This study was conducted in Lake Tanganyika at three sites on the eastern coast of the lake. We were based in Kigoma at the southern edge of Kigoma Bay. From there I was able to access two good sites, Hill Top Cliffs (figure 1) and Jakobsen's Beach (figure 2). At both sites we found abundant populations of *Julidochromis regani*.

In order to determine population density for *Julidochormis regani* at these two sites we used "transect counts." With the help of my SCUBA buddy I laid out an approximately 100 foot (30 meter) measure. We each swam the length, counting every *Julidochromis* that we could find within 10 feet (3 meters) of the line. Finding *J. regani* in the wild is actually a skill, it took us a few practice "transects" to learn where to look for them. I discovered that they like similar shaped spaces to those inhabited by *Neolamprologus brichardi*, but the two species never shared a home. The *Julidochromis* did live in harmony with *N. furcifer* and even seemed happy to share cramped quarters with large *Petrochromis*.

In order to characterize the social and physical environment of the Julies we used quadrate measurements (figure 3). Using SCUBA, underwater video and still cameras, we quantified "habitat complexity" within 5,625 square foot (25 square meters) quadrates. We used measurements called "normalized rugosity" and "normalized optical density" to quantify the structural complexity of the environment. The number of vertical and horizontal landmarks, available crevices, and surfaces of different height were recorded. The number of individuals of the same species (conspecifics) and the number of individuals of different species (heterospecifics) were counted to be used as a measure of social complexity. Furthermore, we measured depth, ambient light level, and temperature at each site.

Figure 4. The Kazumbe brothers collect *J. regani* at the Hill Top site.



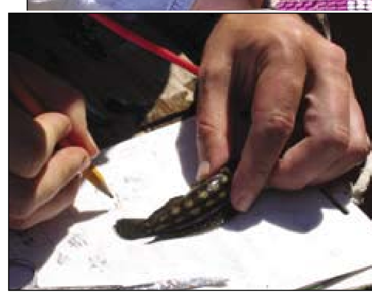


Figure 5. Measurements and tagging of *J. regani* was done on the boat on site so that animals could be returned to their homes. (left to right Hans Hofmann, Mr. Kushushu, Wilibrod Kazumbe, George Kazumbe and Suzy Renn)

The more exciting part of the project involved focal observations of *Julidochromis* nests as well as observations of individual fish over the course of several days. The *Julidochromis* do not venture far from their nests, thus individuals could almost be identified by location. Nonetheless, due to the strong similarity in striping patterns we decided that it was necessary to tag the fish in order to confidently identify a particular fish on subsequent dives. To accomplish this we enlisted the assistance of two expert cichlid divers, George and Wilibrod Kazumbe. They have been working with ornamental fish collectors for many years and have fish catching skills that would take me years to develop.

By not only knowing the species, but also by being familiar with their behavior, George and Wilibrod are able to capture up to 30 *Julidochromis* in a single dive! Using a fine mist net and an amazing ability to communicate with each other underwater (figure 4) the fish were brought to the boat unharmed where we measured, weighed and tagged them. The fish were tagged through the dorsal muscle with a plastic clothing tag and a colorful bead (figure 5). About 80% of the tagged fish at Hill Top Cliffs were seen again (figure 6). On subsequent dives, I carried a bag of numbered colorful small rocks which I would drop wherever I saw a tagged fish. This way I could measure the natural range of the fish and was not "chasing" the fish. Two fish were seen to range over 45.5 feet (14 m) and 58.5 feet (18 m), but most stayed within a 16 foot (5 m) radius of their nest. Similar to the observations of Yamagishi and Kohda (1996), I found two individuals which appeared to have two nests. In both instances it was a larger fish which visited two smaller individuals in nests 12-16 feet (4-5 m) from each other. Unfortunately I was not able to identify the sex of those individuals. I was surprised to find that most nests contained more than two adult fish.

I plan to return to Kigoma and continue my studies of the *Julidochromis regani* at these two sites. On this trip I developed the techniques and strategies that I will use to more fully characterize the behavior and ecology of these species. On future trips I will tag more fish and conduct observations over a longer timescale. I would like to have nests in which multiple adults of known sex were tagged in order to determine if the females are in fact always the largest animal in the nest and in order to determine how often a female has multiple male partners. I have returned home with several video tapes of behavior at different nests. This tape will be analyzed by recording interactions of all individuals in the nests. I found that it could take 5 – 10 minutes for the fish to get used to my presence but then they seemed to go on with business as usual. At most nests only 3 – 10 juveniles could be found but one nest with a particularly large individual contained ~30 juveniles which, by size, appeared to be all from one clutch (figure 7).

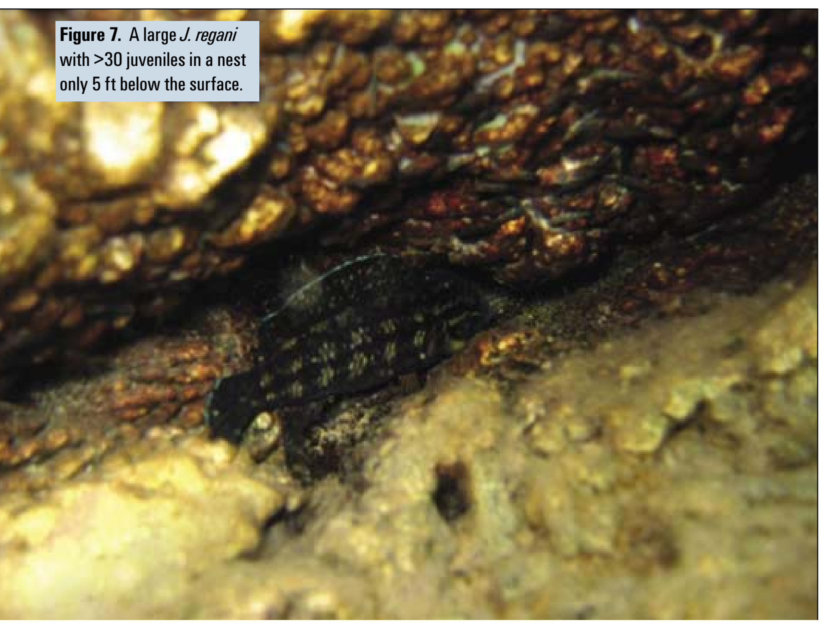


Figure 7. A large *J. regani* with >30 juveniles in a nest only 5 ft below the surface.

I look forward to the opportunity to return to Africa to continue my work with these species. I plan to use the techniques that I have developed and expand my project to a more comparative approach in order to identify similarities and differences in behavior and ecology of sex-role reversed species with that of sex-role conventional species such as *J. transcriptus*. Very little is known about the sex-role behavior of *J. dickfeldi* and *J. ornatus*. I look forward to writing again when I have analyzed the data that I have collected and am able to combine it with my laboratory experiments. I would like to get all of these species in the lab in order to begin to understand their behavior at a more detailed level, under controlled conditions where I can manipulate specific conditions.

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Susan would like to hear of your own personal observations, anecdotal or scientific, regarding sex-role reversal in Julies, as well as any new ideas for future studies in the lab or in the lake. Please contact her with your accounts at **Harvardcichlid@yahoo.com**.