Cichlid Science:
Lessons in Parenting

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Your *Julidochromis* have finally spawned. The larger of the pair patrols the tank as it ruthlessly chases away would-be egg gourmands from getting anywhere near the rock cave you built for it. Inside the cave, the smaller mate secretively mouths the eggs stuck to the ceiling before it positions itself over the brood to aerate them with its fins. If you're lucky, the pair will continue to breed, and soon you'll have multiple generations of fry foraging around the nest. Not only are these fish beautiful; the behavior of Julies is intriguing to observe.

These same behaviors that engage you at home are under close scientific scrutiny at Reed College in Portland, Oregon. In the lab of Dr. Susan Renn (Figure 1), students study the sex differences in parental behavior in the five species of this genus.

Figure 1. Part of the Renn Lab cichlid facility installed in 2006.

While other labs have focused on the behavior of different *Julidochromis* species in the lab and in the field, none have conducted a large comparative study of the sex differences within and between all five species. The quantification of such subtle behavioral differences is not a trivial task.

It is our goal to determine if these sex-biased traits are rigid, or if they respond to changing social conditions. We want to understand the degree to which sex-biased behaviors have a genetic basis, and the degree to which the biases differ between the five closely related species. Eventually we hope to test what we have learned in the lab through field studies in Lake Tanganyika, where we can tag individuals and observe natural behavior of mated pairs.

The initial phase of our study is focused on natural parental care. We record both direct and indirect parental care behaviors. Direct care includes care of eggs and wrigglers (Figure 2a), while indirect care includes patrolling and territory defense around the nest (Figure 2b). *Julidochromis* are monogamous, bi-parental breeders, meaning one male

pairs with one female, and both participate in raising offspring. In most bi-parental monogamous cichlids, females generally provide the direct care and males the indirect care (Keenleyside 1991). George Barlow's research suggests that *J. marlieri* are sex-role reversed for dominance and aggression (Barlow and Lee 2005). We are interested in finding out of they are "reversed" for parental care.

Figure 2.A) Brood care in *J. regani*, viewed from below. B) *Julidochromis transcriptus* defending their territories across a clear divider.

It is known in some bi-parental cichlids that both sexes are capable of performing all parental care behaviors in the absence of a mate. Dr. Murray Itzkowitz (Lehigh University) has tested this in the convict cichlid by removing one parent from a mated pair. He showed that the remaining parent added the duties of its mate to its own parental repertoire. He concluded that in addition to inherent dispositions, the mates must use social cues to decide what sort of parental care to provide and when to provide it (Itzkowitz et al. 2001). This coordination of roles may be flexible, and may depend upon predation risk, reproductive cycles and pair interactions. Such flexibility may not come as a surprise. Satoshi Awata et al. (2006) showed that mating system is flexible in *J. transcriptus*. Fish may be monogamous, polygynous or polyandrous depending the size of available mates.

At the same time, however, we do see general patterns for mating system and parental care for a species, even though they may be some variation. Therefore we are interested in the environmental conditions (both physical and social) that have lead to different patterns of mating system or parental care in different species. Eventually we would like to know how the different behavioral patterns evolved in *Juliochromis*, and what the different acting forces, or selective pressures, caused these evolutionary changes.

To examine some of these evolved behaviors in her senior thesis, Reed student Victoria Zero (Figure 3) created an ethogram, a detailed list of the quantifiable behaviors of interest. Initially she will focus on just two species: *J. marlieri* and *J. transcriptus*. Using the freely available, computer based event recorder software called JWatcher (www.jwatcher.ucla.edu), she records the activities of many pairs of both species in a standardized setup.

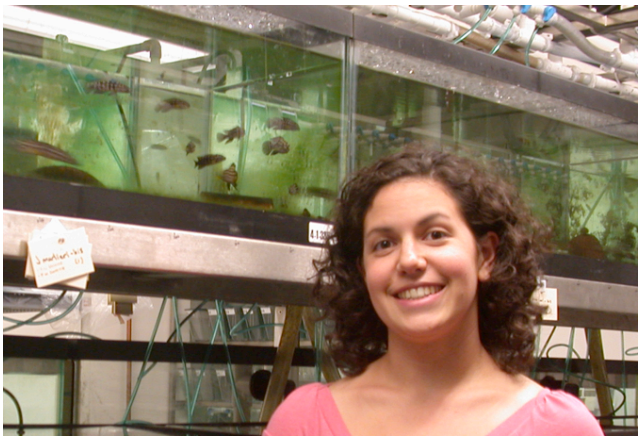

Figure 3. Vicky Zero, Reed graduate 2007, will pursue Julie behavior as a Mellon post-baccalaureate research assistant.

Vicky's results show that for *J. marlieri*, females provide the majority of territory defense, while males spend most of their time in the nest. These differences are even more exaggerated when a potential egg predator is temporarily added to the tank. The opposite is true in *J. transcriptus* (Figure 4). This species fits the "typical" pattern of care, in that females provide the majority of the direct parental care while males perform more indirect brood care. This behavioral difference also correlates with the size relationship of the mated pairs. In *J. marlieri*, large females prefer to mate with males as small as 50% their size, but *J. transcriptus* form male-largest pairs.

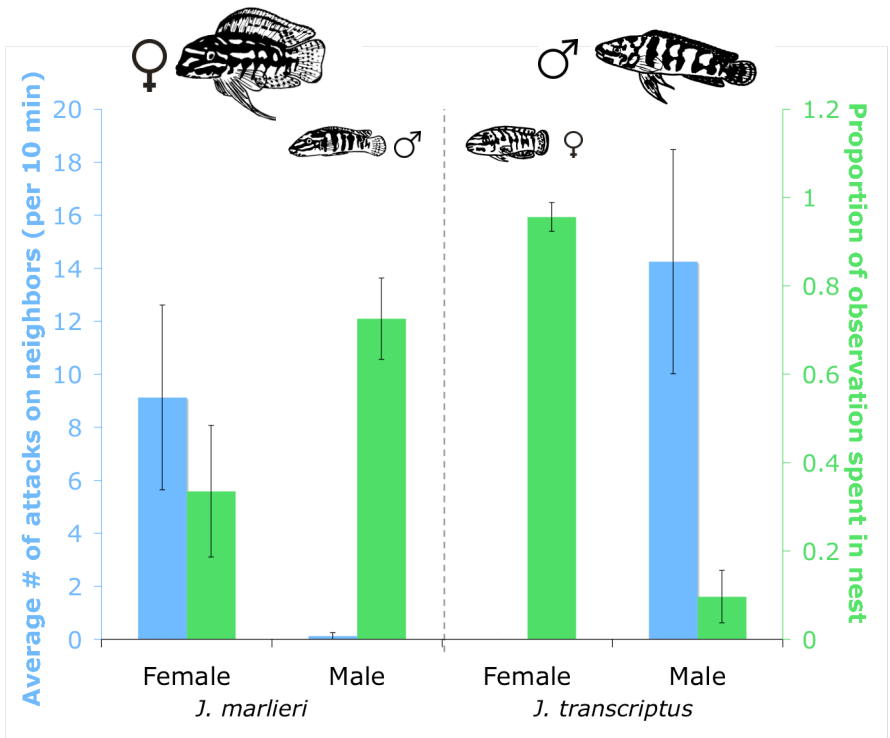

Figure 4. Results from intruder experiments show that females of *J. marlieri* and males of *J. transcriptus* are more aggressive toward intruders than their mates (shown in blue). Males of *J. marlieri* and females of *J. transcriptus* spend the majority of their time within the nest (shown in green). Therefore, *J. marlieri* seems to exhibit what is considered, for a bi-parental monogamous cichlid, reversed parental roles.

Through a post-baccalaureate fellowship from the Mellon Foundation, Victoria will work in the lab for one more year and tackle additional questions about the behavior of *Julidochromis* species. She would like to know the answer to questions such as:

Which sex performs courtship behaviors during pair formation?
Which sex is choosy about with whom it mates?
How do pairs form?
Once a pair is established, how is the division of labor established, and how might this change according to a number of different variables, such as reproductive stage?

Answers to these questions are only the beginning of a long-term research program. The lab aims to identify the hormonal and genetic bases for these sex and species differences. Using cutting edge genomic techniques and hormonal assays students will determine what differences in hormones, and what differences in genes are important for the differences we see.

Another cichlid fish studied in our lab, *Astatotilapia burtoni*, has been the focus of hormonal and molecular studies of aggression. In this species, males switch between a territorial, aggressive reproductive stage and a non-reproductive, non-territorial stage during which they put all of their energy into growth (Fernald 2003). Researchers in the lab of Dr. Russell Fernald (Stanford University) have studied these aspects for several years. More recently, Dr. Hans Hofmann (University of Texas) has taken this species to the level of "genomic research". While working with Dr. Hofmann, Dr. Renn built a tool called a microarray that is specific to *A. burtoni*. This microarray allows researchers to measure the gene expression level of thousands of genes all at once (Renn et al. 2004). Reed students are using this microarray, not only to study gene expression in *A. burtoni*, but also to identify gene expression differences in male and female *Julidochromis*.

The cichlids provide an ideal system to study the evolution of interesting social behaviors such as parental care because these closely related species display a dramatic diversity of behavioral forms (called behavioral phenotypes). There is much work to be done on these topics, and the work discussed here will keep Reed students busy for several years.

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