International Journal of Agricultural Sciences ISSN: 2167-0447 Vol. 4 (8), pp. 248-251, August, 2014. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Review

Review: Reproductive biology of Cichlidae

Christian Larbi Ayisi

Key Laboratory of Fresh water Fishery Germplasm Resources, Ministry of Agriculture, Shanghai Ocean University, 999 Huchenghuan Road, Shanghai 201306, P.R China.
E-mail: 2012application@gmail.com , Tel: 008613621770965

Accepted May, 2014

The Cichlidae family is in the order perciformes. The fish family Cichlidae presents an array of fishes with great diversity. Production of eggs and fry in tilapia are affected by several factors within its environment which includes temperature, day length, density and sex-ratio of broodstock, length and/or weight of breeders, food quality, and stress as well as the water quality (oxygen, salinity, pH etc.) but also the overall spawning capacity of a group. The mating system of the African cichlid fish Oreochromis mossambicus resembles that of other lekking animals; males defend mating territories where the spawning pits they dig are sites only for mating and oviposition and are not used for rearing offspring.

Key words: Reproductive, biology, cichlidae, perciformes, oreochromis.

INTRODUCTION

The Cichlidae family is in the order perciformes. The fish family Cichlidae presents an array of fishes with great diversity. Many cichlids are herbivores that feed on algae, but some are predatory and consume other small fish or insects. These species of fish dominated African freshwater bodies with over 200 species reported in inland waters of West Africa (Harbot 1975, Holden and Reed 1978). One factor that affects mating systems employed by fish is the ecological conditions of its habitat. Breeding habits therefore differ markedly within the family (Trewavas 1983) due to the diversity in habitats occupied by Cichlidae. Adequate knowledge in the reproductive biology of Cichlidae will help in establishing its production potential and invariably its exploitation and management. The purpose of this current review therefore seeks to highlight the reproductive biology of the Cichlidae, an important commercially cultured fish family.

MATING, EGG AND FRY PRODUCTION IN CICHLIDS.

The Cichlidae uses basically two modes of reproduction, these are the substrate brooding and mouth brooding. The evolutionary (initial) reproductive strategy is represented by the substrate brooding also known as the nest building. Cichlids that practice substrate brooding are normally monogamous and sexually monomorphic. The mouth brooders are however polygamous and sexually dimorphic even though some of them could be monogamous. The eggs of cichlids range from few to several based on the species and most of them have the ability to mate all year round (Keenleyside, 1991).

Baroiller *et al*. (1997) documented that the production of eggs and fry in tilapia, can be affected by several factors within its environment which includes temperature, day length, density and sex-ratio of broodstock, length and/or weight of breeders, food quality, stress as well as the water quality (oxygen, salinity, pH etc.) but also the overall spawning capacity of a group. This spawning ability relies upon some females spawning more than the others, (Mires, 1982; Desprez and Mélard, 1998), suggests an influence of social and behavioural interactions in a population of breeders (Baroiller and Jalabert, 1989). This social hierarchy, characterised by a few female breeders reproducing more frequently, is not disrupted by frequent and complete harvest controls in *Oreochromis aureus, O. niloticus* and in a complex Oreochromis hybrid, the red tilapia (Baroiller *et al*., 1997; Desprez and Mélard, 1998).

MALE SIZE, SPAWNING PIT SIZE AND FEMALE MATE CICHLID FISH

Female mating preferences and differences between the abilities of males to compete with one another may each contribute to the evolution of sexually selected traits (Darwin 1871). Although the effects of female choice and male-male competition on male mating success have been investigated for many animals with different mating systems the relative importance of these two mechanisms of sexual selection for most organisms is tentative. This problem arises because of the difficulty in both isolating the two mechanisms and separating the direct and indirect effects of correlated traits (Andersson 1994). In one recent review, fewer than half of the empirical studies that attribute sexual selection to female choice experimentally eliminate male-male competition as a factor (Andersson 1994). Some authors have used a statistical approach to accomplish this while allowing both mechanisms to act (Hews, 1990; Moore, 1990; Warner and Schultz, 1992).

Dominance interactions between males and/or frequent courtship and mating disruptions found in some lekking species support this contention (Trail, 1985; Trail and Koutnik, 1986).

Females may be choosing between males even during intense male combat, although female choice is difficult to detect under these conditions.

The defining characteristics of the lek mating system are that males defend clustered territories and females visit males solely for courtship and mating (Bradbury and Gibson 1983). Although males provide no resources to females, if female mating preferences are important, several interrelated characteristics could influence a female's mate choice.

In some species, male mating success is correlated with male morphology (Andersson, 1989, 1992; Hoglund *et al*., 1990; Petrie *et al*., 1991). In other species, a male's mating success is influenced by the particular site that he occupies, either because of its spatial location (Kruijt *et al*., 1972; Wiley, 1973; Lill, 1974; Shelley, 1988; Apollonio *et al*., 1990; Balmford *et al*., 1992) or because of its appearance (Borgia, 1985; Andersson, 1991). The presence of correlations between such male morphological traits, male behaviour and display site characteristics pose problems in isolating exactly which cues females do assess (Borgia and Gore, 1986; Andersson, 1991).

The mating system of the African cichlid fish Oreochromis mossambicus resembles that of other lekking animals; males defend mating territories where the spawning pits they dig are sites only for mating and oviposition and are not used for rearing offspring (Baerends and Baerends-van Roon, 1950; Fryer and Iles, 1972). Soon after the eggs are fertilized, the female mouth broods the eggs, larvae and fry at sites away from the leks (Fryer and Iles, 1972). Although occurrences of courtship and spawning interruptions by male 0. Mossambicus have been observed both in the field and in the laboratory (personal observation), females have ample opportunity to exercise mate choice.

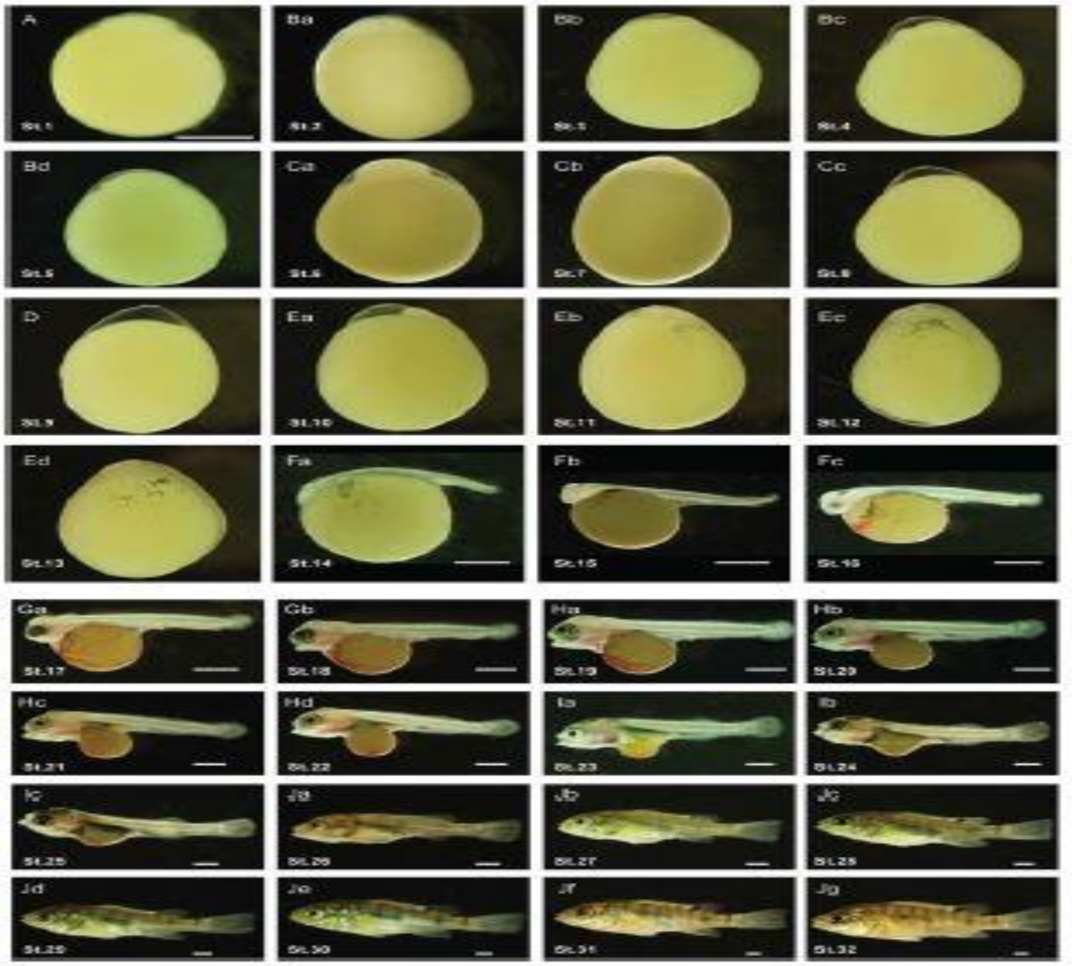
Females are not herded and because they have external fertilization, females maintain a great deal of control over which males are successful.

Among cichlid fishes with this mating system, sexual differences in body size and colour are prevalent (Fryer and Iles, 1972; Trewavas, 1983). These traits are potential vehicles of sexual selection. Dominey (1984) suggested that mate choice has played a large role in the divergence of male breeding colour and speciation between African cichlids. Furthermore, enormous variation exists between these species in the sizes and shapes of display and spawning sites (Fryer and Iles, 1972; McKaye, 1991). Intraspecifically, the sizes of these display sites vary; it has been suggested that the behaviour of individual males resulting in the construction and defence of the display site is another potential vehicle of sexual selection (McKaye 1983, 1991; Dominey, 1984). In the Lake Malawi cichlid, *Cyrtocara conophorus,* visitation rates by females are correlated with sizes of males and mounds (McKaye *et al*., 1990) unknown, however, whether male mating success is directly determined by female choice, which trait females actually assess if they do so, and whether a relationship between mound size and other male characteristics results from male-male interactions.

Gender Differences in Aggressive Behaviour in Cichlids

In Cichlidae males and females of many species engage in agonistic encounters (Draud and Lynch, 2002; Briffa and Dallaway, 2007) for a variety of resources such as food and space. This notwithstanding, different selection pressures on each sex are expected to result in sex differences in aggressive behaviour during such competitions (Archer, 1988). Some have done so because the specific type of contest is unique to one gender, for instance, male–male contests for access to females in orb web spiders, *Metellina mengei* (Bridge *et al*., 2000), jumping spiders, *Phidippus clarus* (Elias *et al*., 2008), and amphipods, *Gammarus pulex* (Dick and Elwood 1990; Prenter *et al*., 2006), and female–female contests in parasitoid wasps, *Goniozus nephantidis*, over egg hosts (Petersen and Hardy, 1996; Goubault *et al*., 2007) and iguanas, *Iguana iguana*, over nest burrows (Rand and Rand, 1976). Others have been restricted to one sex specifically to reduce variation in the data because of potential gender differences (e.g. hermit crabs, *Pagurus bernhardus*: Elwood *et al*., 2006; Arnott and Elwood, 2007).

However, comparing male and female intra sexual contests can yield intriguing differences, shedding light on the forces shaping the use of particular aggressive tactics. Studies on fish have arguably yielded the most detailed information on gender-related differences in aggression. For example, in black-chinned tilapia, Sarotherodon melanotheron, females were more aggressive than males, performing more bites, chases and mouth wrestling (Balshine- Earn and McAndrew, 1995).



Development of *O. niloticus,* a member of the cichlid family (Meijide and Guerrero. 2000).

Selection has probably favoured increased aggression in female S. melanotheron compared to males because males exclusively care for offspring and have lower potential reproductive rates than females. Males take longer to brood eggs than females take to lay another clutch Keenleyside (1991), leading to female–female contests for males. In contrast, male salmonids are more aggressive than females (rainbow trout, *Oncorhynchus mykiss*: Johnsson and Akerman, 1998; brown trout, Salmo trutta: Johnsson *et al*., 2001), a likely consequence of sexual selection, since male salmonids compete for access to females (Johnsson *et al*., 2001). Gender differences in fight tactics have also been observed in a number of other fish species (e.g. sailfin molly, *Poecilia velifera*: Bildsoe, 1988; Texas cichlid, *Herichthys cyanoguttatum*: Itzkowitz 1985).

Convict cichlids, *Amatitlania nigrofasciata*, are small, highly aggressive, territorial freshwater fish, native to Central America.

These fish form monogamous pairs and jointly excavate a lair from under a large stone or similar object on the substratum (Wisenden *et al*., 2008), subsequently engaging in extended care of the young (Keenleyside 1991). A resource defense social system exists, with breeding territories being defended by both members of monogamous pairs of fish (Draud and Lynch, 2002) because the offspring are highly vulnerable to predation from conspecific intruders and other predators (Wisenden, 1994; Alonzo *et al*., 2001; Itzkowitz *et al*., 2001). However, within breeding pairs of convict cichlids there are considerable sex differences in parental care, with males taking on more of a territorial defense role, whereas females spend more time with the offspring (e.g. Keenleyside *et al*., 1990; Wisenden, 1995; Itzkowitz *et al*., 2001, 2005; Wisenden *et al*., 2008).

Each sex, none the less, possesses considerable flexibility and they change roles to support the other parent, particularly when the other parent is not present (Itzkowitz, 1984; Lavery and Reebs, 1994; Itzkowitz *et al*., 2001). The territory is likely to be of equal high value to both sexes, as territory loss will severely disrupt the reproductive performance of males and females.

Studies involving breeding pairs of convict cichlids have noted gender-related differences in aggression. For example, Wisenden *et al*. (2008) found females of a pair performed more aggressive attacks in defense of the brood against territorial intrusion, while Budaev *et al*. (1999) found that within breeding pairs, females bit significantly more than males in a mirror image aggression test.

Similarly, within breeding pairs of Texas cichlids males emphasize lateral displays, whereas females emphasize chasing and biting when defending offspring against intruders (Itzkowitz 1985).

Embryonic and Larval Development

The embryonic and larval developments of cichlids as reported by Meijide and Guerrero., 2000 are summarized below;

➢ Stages of embryonic development

✓ Zygote (Oocyte): Fertilization activates cytoplasmic movements

✓ 2-blastomere: cleavage appears near animal pole and progress towards vegetal pole.

✓ 4-blastomere: second cleavage emerges.

✓ 8-blastomere: cleavage appears in two separate planes

✓ 64- blastomere: The sixth cleavage is the first to occur along latitudinal plane.

✓ Blastomere : the onset of gastrulation

➢ Stages of larval development

✓ Free swimming stage- dorsal and anal fins appear; larvae starts swimming freely

✓ Unpaired fin stage- dorsal and anal fin rays differenciate simultaneously; gills are formed and the yolk is completely consumed

✓ Pre-juvenile stage- the pelvic fins, which are the last to form, have differenciated. Dorsal and anal fins are more developed.

✓ Juvenile stage- fins are complete, well-pigmented, slightly transparent. Nostrils are observed.

REFERENCES

Alonzo JJ, McKaye KR, van den Berghe EP (2001). Parental defense of young by the convict cichlid, Archocentrus nigrofasciatus, in Lake Xiloa, Nicaragua. J. Aquaricul. Aquat. Sci., 9: 208–227.

Andersson M (1994). Sexual Selection. Princeton, New Jersey: Princeton University Press.

Apollonio M, Festa-Bianchet M, Mari F (1989). Correlates of copulatory success in fallow deer lek- Behav. Ecol. Sociobiol. 25: 89-97.

Archer J (1988). The Behavioural Biology of Aggression. Cambridge: Cambridge University Press.

Arias-Rodriguez L, Páramo-Delgadillo S, de la Luz Durán-González A (2006). Estudio citogenético en la mojarra pinta Parachromis managuensis (Pisces: Cichlidae). Rev. Biol. Trop. 54(1): 35-42.

Arnott G, Elwood RW (2007). Fighting for shells: how private information about resource value changes hermit crab pre-fight displays and escalated fight behaviour. Proceedings of the Royal Society B, 274, 3011–3017.

Baerends GP, Baerends-van Roon JM (1950). An introduction to the study of the ethology of the cichlid fishes. Behaviour, supplement 1: 1–242.

Balmford A, Albon S, Blakeman S (1992). Correlates of male mating success and female choice in a lek-breeding antelope. Behavioural Ecology, 3: 112–123.

Balshine-Earn S, McAndrew BJ (1995). Sex-role reversal in the black chinned tilapia, *Sarotherodon melanotheron* (Ruppel) (Cichlidae). Behaviour 132, 861-874.

Baroiller JF, Desprez D, Carteret Y, Tacon P, Borel F, Hoareau MC, Mélard C, Jalabert B (1997). Influence of environmental and social factors on the reproductive efficiency in three tilapia species, Oreochromis niloticus, O. aureus and the red tilapia (Red Florida strain). In: Fitzsimmons, K. (Ed.), Proceedings of the Fourth International Symposium on Tilapia Aquaculture, Orlando, Florida, pp. 238–252. NRAES 106.

Baroiller JF, Jalabert B (1989). Contribution of research in reproductive physiology to the culture of tilapias. Aquat. Living Resour. 2, 105–116.

Borgia G (1985). Bower quality, number of decorations and mating success of male satin bowerbirds (*Ptilonorhynckus violaceus*): an experimental analysis. Anim. Behav. 33: 266-271.

Bradbury JW, Gibson RM (1983). Leks and mate choice. In: Mate Choice (Ed. by P. Bateson), pp. 109-138. Cambridge: Cambridge University Press.

Bridge AP, Elwood RW, Dick JTA (2000). Imperfect assessment and limited information preclude optimal strategies in male–male fights in the orb-weaving spider Metellina mengei. Proceedings of the Royal Society B, 267, 273–279.

Briffa M, Dallaway D (2007). Inter-sexual contests in the hermit crab Pagurus bernhardus: females fight harder but males win more encounters. Behavioral Ecology and Sociobiology, 61, 1781–1787.

Budaev SV, Zworykin DD, Mochek AD (1999). Individual differences in parental care and behaviour profile in the convict cichlid: a correlation study. Animal Behaviour, 58, 195–202.

Darwin C (1871). The Descent of Man and Selection in Relation to Sex. London: J. Murray.

Desprez D, Mélard C (1998). Influence du génotype sexuel sur les caractéristiques de la reproduction de femelles (génotype WZ) et de pseudofemelles (génotype ZZ) chez le tilapia Oreochromis aureus. Aquat. Living Resour. 11, 145–153 (in French with English abstract).

Dick JTA, Elwood RW (1990). Symmetrical assessment of female quality by male Gammarus pulex (amphipoda) during struggles over precopula females. Animal Behaviour, 40, 877–883.

Draud M, Lynch PAE (2002). Asymmetric contests for breeding sites between monogamous pairs of convict cichlids (Archocentrus nigrofasciatum, Cichlidae): pair experience pays. Behaviour, 139, 861–873.

Draud M, Lynch PAE, (2002). Asymmetric contests for breeding sites between monogamous pairs of convict cichlids (Archocentrus nigrofasciatum, Cichlidae): pair experience pays. Behaviour, 139, 861–873.

Elias DO, Kasumovic MM, Punzalan D, Andrade MCB, Mason AC (2008). Assessment during aggressive contests between male jumping spiders. Animal Behaviour, 76, 901–910.

Elwood RW, Pothanikat RME, Briffa M (2006). Honest and dishonest displays, motivational state and subsequent decisions in hermit crab shell fights. Animal Behaviour, 72, 853–859.

Fryer G, Iles TD (1972). The cichlid fishes of the Great Lakes of Africa: their biology and evolution. Oliver and Boyd, Edingburgh, UK.

Goubault M, Mack AFS, Hardy ICW (2007). Encountering competitors reduces clutch size and increases offspring size in a parasitoid with female– female fighting. Proceedings of the Royal Society B, 274, 2571–2577.

Harbott BJ (1975). Preliminary observations on the feeding of *Tilapia nilotica* Linn. in Lake Rudolf. Afr. J. Trop. Hydrobiol. Fish. 4: 27-37.

Hews DK (1990). Examining hypotheses generated by field measures of sexual selection on male lizards, Uta palmeri. Evolution, 44, 1956-1966.

Hoglund J, Eriksson M, Lindell LE (1990). Females prefer male with white tails in the lekking great snipe (*Gallinago media*)- Animal Behaviour 40: 23-32.

Holden MJ, W Reed (1978). West African freshwater fish (West African nature handbooks). Longman Group, London, England. p. 68.

Itzkowitz M (1984). Parental division of labor in a monogamous fish. Behaviour, 89, 251–260.

Itzkowitz M (1985). Sexual differences in offspring defense in a monogamous cichlid fish. Zeitschrift fu¨r Tierpsychologie, 70, 247–255.

Itzkowitz M, Santangelo N, Richter M (2001). Parental division of labour and the shift from minimal to maximal role specializations: an examination using biparental fish. Animal Behaviour, 61, 1237–1245.

Johnsson JI, Åkerman A (1998). Intersexual differences in aggression in juvenile rainbow trout. J. Fish Biol. 52:1292-1294.

Johnsson JI, Sernland E, Blixt M (2001). Sex-specific aggression and antipredator behavior in young brown trout. Ethology 107: 587-599.

Bildsoe M (1988). Aggressive, sexual and foraging behaviour in Poecilia velifera (Pices: Poeciliidae) in captivity. Ethology, 79, 1–12.

Keenleyside M (1991). Parental Care. pp. 191-208 in M. Keenleyside, *ed*, Cichlid Fishes: Behaviour, Ecology and Revolution. London: Chapman and Hall.

Kruijt JP, de Vos GJ, Bossema I (1972). The arena system of the black grouse. Proc. 15th Ornith congr. 399-423.

Lavery RJ, Reebs SG (1994). Effect of mate removal on current and subsequent parental care in the convict cichlid (Pisces: Cichlidae). Ethology, 97, 265–277.

Lill A (1974). Sexual behavior of the lek-forming white-bearded manakin (Manacus manacus trinitatis Hartert). Ethology, 36, 1–36.

Mires D (1982). A study of the problems of the mass production of hybrid tilapia fry. In: Pullin, R.S.V., Lowe McConnell, R.H. (Eds.), Proceedings on the Biology and Culture of Tilapias, ICLARM Conf. Proc., 7: 317–329.

Moore AJ (1990). The evolution of sexual dimorphism by sexual selection: the separate effects of intrasexual selection and intersexual selection. Evolution, 44, 315-331.

Petersen G, Hardy ICW (1996). The importance of being large:parasitoid intruder-owner. Contests and their implications for clutch size. Animal behavior, 72 861-868.

Prenter J, Elwood RW, Taylor PW (2006). Self-assessment by males during energetically costly contests over precopula females in amphipods. Animal Behaviour, 72, 861–868.

Rand WM, Rand AS (1976). Agonistic behavior in nesting iguanas: stochastic analysis of dispute settlement dominated by minimization of energy-cost. Zeitschrift fu¨r Tierpsychologie, 40, 279–299.

Trail PW, Koutnik DL (1986). Courtship disruption at the lek in the Guianan cock-of-the-rock. Ethology, 73, 197-218.

Trail PW (1985). Courtship disruption modifies mate choice in a lek-breeding bird. Science, 227, 778-780.

Trewavas E (1983). Tilapini Fishes of the genera *Sarotherodon*, *Orechromis* and *Danakilia*. British Mus. Nat. Hist., London, England. p. 583.

Warner RR, Schultz ET (1992). Sexual selection and male characteristics in the blue head wrasse, Thalassoma bifasciatum: mating site acquisition, mating site defense and female choice. Evolution, 46, 1421-1442.

Wiley RH, (1973). Territoriality and non-random mating in sage grouse, *Centocerais urophasianus*- Animal Behaviour Monogr 6: 87-169.

Wisenden BD (1994). Factors affecting reproductive success of convict cichlids in Costa Rican streams. Canadian J. Zool., 72, 2177–2185.

Wisenden BD, Snekser JL, Stumbo AD, Leese JM (2008). Parental defence of an empty nest after catastrophic brood loss. Animal Behaviour, 76, 2059–2067.

Wisenden BD, Snekser JL, Stumbo AD, Leese JM (2008). Parental defence of an empty nest after catastrophic brood loss. Animal Behaviour, 76, 2059–2067.