

## MULTI DIMENSIONAL ACTIVITIES OF PROLACTIN IN FISH PHYSIOLOGY

**Role of PRL in reproduction:** It has been found that PRL plays an important role in fish reproductive development and sexual maturity. During gonadal development PRL level increases along with gonadotropin in freshwater cat fish (*Clarius batrachus*) and reaches to maximum level during spawning (Singh and Singh, 1981) whereas in Japanese eel no differences in PRL level was found during sexual maturation (Ozaki et.al, 2007). A number of studies have demonstrated that PRL exerts its effect on fish reproductive cycle. PRLR mRNA and protein have been detected in the gonads of various fish species such as Mozambique tilapia, Seabream, Gold fish and Nile tilapia (Edery et.al, 1984; Cavaco et.al,2003; Tse et.al, 2000; Sandra et.al, 2000). PRL may effect spermatogenesis, vitellogenesis and ovulation. PRL levels changes during breeding cycle. Tacon et.al, (2000) demonstrate that in Nile tilapia plasma PRL level in females is highest after spawning. PRL is also involved in steroidogenesis of both male and female fish. PRL directly stimulates testosterone synthesis in Mozambique tilapia and also stimulates 17- $\beta$  oestradiol production in Guppy (*Poecilia reticulata*) oocytes during their development (Rubin and Specker, 1992, Tan et.al,1988).

**Role in parental care:** It was already known that PRL has a vital role in parental behaviour in mammals and birds (Ziegler, 2000). Mouth brooding is common in several lineages of fish. Recent research in cichlids showed that combinatorial effect of oestrogen and PRL promotes oral egg carrying behaviour (Blum, 1968). In Nile tilapia increased plasma tiPRL177 variance was observed in brooding females though the function of these elevated variance remains unknown (Tacon et.al, 2000). Several fish species display nest building behaviour. Mucous secretion is associated with nest building is under the regulation of PRL. Experimental administration of PRL increases mucus secretion and also increased the number of mucous cells in paradise fish (*Macropodus opercularis*) (Machemer, 1971; Machemer and Fiedler, 1965). Nest fanning behaviour stimulates a flow of oxygenated water to develop eggs in the nest and this parental fanning activity has been reported to be under the regulation of PRL in various fish species (Pall et.al, 2004). PRL sensitive neurons are found in the forebrain of fish that regulate fanning behaviour (Hoar et.al, 1983). PRL influences a range of other brooding behaviour such as pit-digging, nest guarding and defense (Kindler et.al,1991). PRL has an evident role in nutrient provisioning in mammals and birds. Nutritive mucus secretion associated with nutrition to offspring is under regulation of PRL. In hypophysectomized guppy and gold fish, administration of PRL elevated the number of mucus producing cells (Schwerdtfeger, 1979; Ogawa, 1970). This parental mucus known as 'discus milk' involved in fry nutrition and offspring or parent immune function (Chong et.al, 2005;2006). Majority of the research demonstrate a positive relationship between PRL level and brood care, there is one exceptional study on Daffodil cichlids (*Neolamprologus pulcher*) showed that females providing brood care have lower PRL mRNA expression than non-brooding one (Bender et.al, 2008)

**Role in migration:** Migration plays an important role in many aspects of life cycle of vertebrates. In fish migration is associated with reproductive cycle of several species. In chum

salmon PRL mRNA expression is increased with the onset of anadromous migration (Onuma et. al,2010). It is assumed that this effect may be due to osmoregulatory function of PRL necessary for the transition from salt water to fresh water but experiments demonstrated that pre-spawning fish reared in salt water also shows elevated PRL mRNA expression in the final stage of maturation (Onuma et. al,2003). Similarly, in *Anguilla japonica* PRL mRNA expression is reduced when the fish mature and migrate downstream where as in sticklebacks (*Gasterosteus aculeatus*) PRL level increased during migration from saline water to fresh water (Whittington and Wilson, 2013). These facts highlight that PRL is related with the migratory behaviour in many fish.

**Role in immunomodulation:** Research regarding role of PRL in fish immune system is relatively recent. It is evident that PRL is an important modulator of fish immune function. It enhances the immunoglobulin production and phagocytic activity of leucocytes, also exerts mitogenic effects on leucocytes (Yada et.al, 1999; Sakai et.al, 1996; Yada et.al, 2004).

**Role in egg and larval development:** Till date there are relatively few studies have been done regarding the role of PRL in fish development. However, in Seabream presence of PRL mRNA is detected and gradually elevated during somitogenesis and embryogenesis respectively (Santos et.al, 2003). In mozambique tilapia PRLR transcripts are detected soon after fertilization and markedly increase during the time of gastrulation (Santos et.al, 2003; Shiraishi et.al, 1999). This sudden increment in the PRLR concentration during gastrulation raises the questions regarding the involvement of PRL in fish organogenesis (Kimmel et.al, 1990). The role of PRL in the osmoregulation of egg is yet to be studied. An in vitro experiment demonstrated that chloride cells of fish embryo respond to the changes in salinity through autonomous regulation (Kaneko et.al, 2002). However, the mechanism of PRL action in regulating egg osmoregulation remains to be detected (Santos et.al, 2003).

**Role in osmoregulation:** Freshwater fish face two primary challenges: inhibiting ion loss to the external to the hypoosmotic environment and preventing influx of water. PRL plays a giant role in the regulation of these activities during the adaptation period. Gill is the one of the main site for the regulation of ion and water exchange. This is well established that chloride cells play a central role in the chloride ion balance of fresh water fish; PRL appears to have a prominent effect on the number, morphology and distribution of chloride cells. Receptor for PRL have also been found in the chloride cells of *Oreochromis mossambicus* (McCormick, 1995; Weng et.al,1997). The main threat to freshwater fish is the loss of ion by diffusion and regulation of water balance is the secondary in importance with regards to freshwater survival. Experimental studies demonstrated that PRL lowered the osmotic permeability of the gills and also increase the mucus secretion that may help in the regulation of water and ion balance by impeding the passage of molecules in and out of the gill cells (Brown and Brown,1987; Horseman, 1987; Bentley, 1998). PRL increases sodium ion reabsorption and water excretion. Although how PRL exerts this effects are yet to be fully understood. Specific PRLR was observed in the kidney and recent studies have demonstrated that PRL administration increased the renal Na<sup>+</sup> / K<sup>+</sup> ATPase activity in hypophysectomized *Fundulus*

*heteroclitus* (Epstein et.al, 1969) In addition to that PRL elevate the urine output by increasing glomerular filtration rate and also lowered the urine osmolality (Clarke and Bern, 1980). Earlier studies demonstrated that PRL lowered the Na<sup>+</sup>, Cl<sup>-</sup> and water absorption in intestine (Colie and Hirano, 1987). Administration of ovine PRL decreases the intestinal fluid and salt absorption in Japanese eel and in trout but interestingly opposite effect was observed in the anterior intestine of *Oreochromis mossambicus* (Utida et.al, 1972; Morley et.al, 1981; Mainoya 1982). Recent experimental studies shown that ovine PRL administration increases the Na<sup>+</sup> / K<sup>+</sup> ATPase activity in Sparus sarba (Kelly et.al, 1999). The osmoregulatory action of PRL is closely associated to its hypercalcemic action. PRL enhances the calcium absorption in branchial tissue (Anderson and Itallie, 2009). In *Oreochromis mossambicus* PRL administration promote the gill calcium influx also simultaneously inhibit the calcium efflux results in hypercalcemia (Flik et.al, 1994). PRL also enhance Calcium accretion in bones and scales of female gold fish (Takahashi et.al, 2008)

## **ROLE OF PROLACTIN IN AMPHIBIA**

PRL in Amphibians Structurally, PRL is significantly different from teleost PRL. There is a specific amphibian PRL bioassay, called the “**water drive**”. Terrestrial newts start out as tadpoles (fully aquatic). The tadpoles undergo a two-stage metamorphosis. First stage: They develop into and “eft”. This stage is an immature adult, with legs, lungs, etc. They are sexually immature and live on land. Second stage: Involves a migration back to water. Individuals will migrate back into water full-time and undergo a sexual maturation. **PRL induces this water drive, as well as stimulating sexual maturation (in both sexes).**

PRL appears to be required for adult forms **to re- enter the aquatic environment**. In this situation, they tend to take up water and lose electrolytes (same problems as fish in freshwater). **PRL stimulates ion uptake across skin**. This is also associated with the water drive. In amphibians there is significant ion uptake across the urinary bladder and this is stimulated by PRL. PRL stimulates Na<sup>+</sup> transport across bladder epithelium. PRL stimulates Na<sup>+</sup> transport across bladder epithelium.

PRL stimulates the **proliferation of melanocytes**. This has been used as a bioassay, like the goby colouration assay, but it has proved unreliable. This has been used as a bioassay, like the goby colouration assay, but it has proved unreliable. Interestingly, in the frogs where this occurs, the colour induced is yellow.

**PRL stimulates growth of gills, tails, and brain in tadpoles**. PRL is also involved in regulating **limb regeneration**. PRL regulates secretion by the oviducts and regulates ovulation (in part).

## ROLE OF PROLACTIN IN BIRDS

PRL stimulates the **production of crop milk in pigeons**. As already mentioned, PRL stimulates the production of crop milk in pigeons. In particular, PRL stimulates hyperplasia and sloughing of the crop sac mucosa. This forms a milky-white liquid with the epithelial cells in suspension (a process similar to production of mammalian milk). This liquid is fed to young.

As mentioned, crop milk formation can be stimulated with all tetrapod PRLs, as well as with lungfish PRL. Formation of the brood patch in both sexes. Brood patch is an area of the chest that becomes highly vascularized and loses its feather covering. Used to transmit body from adult to the eggs, to promote egg development. After breeding is over, the hyperangiogenesis regresses.

PRL has a strong **antigonadotropic effect** in birds. Reproductive timing in birds is very tightly regulated (will be discussed later). PRL strongly suppresses courtship behaviour. Strongly promotes nesting, brooding and food gathering behaviours associated with chick rearing.

PRL stimulates moulting. Also appears to be involved in feather pigmentation.

Osmoregulation functions is primarily seen in sea birds with nasal glands. This is primarily seen in sea birds with nasal glands. Nasal gland secretes a very concentrated NaCl solution. This allows them to drink seawater directly. PRL stimulates Na<sup>+</sup> directly, which results in increased fluid secretion.