COMPARITIVE STUDY ON THE FECUNDITY AND RELATIONSHIP OF FECUNDITY WITH VARIOUS BODY PARAMETERS OF FISHES

Dissertation submitted to the University of Kerala in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF SCIENCE IN ZOOLOGY

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DEPARTMENT OF ZOOLOGY
TKM COLLEGE OF ARTS AND SCIENCE KOLLAM-05

Comparitive study on the Fecundity and Relationship of Fecundity with various body parameters of *Etroplus suratensis* and *Oreochromis mossambicus* from Kadinamkulam lake, Thiruvananthapuram district, Kerala.

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CERTIFICATE

This is to certify that the dissertation entitled **"Comparitive study on the Fecundity and Relationship of Fecundity with various body parameters of *Etroplus suratensis* and *Oreochromis mossambicus* from Kadinamkulam lake, Thiruvananthapuram district, Kerala"** is a bonafide work done by ....AMINA. SABIR......................under my supervision as partial fulfillment of the requirements for the ***Degree of Bachelor of Science in Zoology*** and this report has not been submitted earlier for the award of any degree or diploma or any other similar titles anywhere.

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DECLARATION

I do hereby declare that this dissertation entitled **"Comparitive study on the Fecundity and Relationship of Fecundity with various body parameters of *Etroplus suratensis* and *Oreochromis mossambicus* from Kadinamkulam lake, Thiruvananthapuram district, Kerala"** is a bonafide work done by me under the supervision of Dr. Rohini Krishna M. V., Assistant Professor, Department of Zoology, TKM College of Arts and Science, Kollam as partial fulfilment of the requirements for the award of ***Degree of Bachelor of Science in Zoology***. No part of this has been presented earlier for any degrees or diploma of any university.

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CONTENTS

INTRODUCTION

Fecundity of fish is the most important aspect of reproductive biology in fish which must be understood to explain the variations in the level of production as well as to make efforts to increase the amount of harvest. The number of eggs contained in the ovary of a fish is termed as fecundity. The term fecundity denotes the egg laying capacity of a fish and it refers to the number of fish or the number of ripe eggs produced by a fish in a particular spawning season. Fecundity is otherwise defined as an individual's (typically females) physiological maximum potential or reproductive production across their lifespan, and it is one of the primary pillars of theoretical and applied population biology. Fecundity measurements are of particular importance in animal biology and ecology since they are used for assessing population reproductive dynamics and energetics. The knowledge about fecundity of a fish is essential for evacuating the stock, life history and actual management of the fishery. It is used to calculate the reproductive potential of a stock and the survival from egg to describe a fish which is spawning for the first time. It varies between species and also within a species. Bigger the fish, higher will be the fecundity and vice versa. Fecundity increases with weight and length. It can be expressed in two ways – absolute fecundity and relative fecundity (ICAR, 2010).

Reproductive strategies including fecundity of the threatened species are among the most vital biological information needed to plan and formulate strategies for sustainable management and conservation of fish (Hunter *et al.* 1992). However, marked differences in fecundity among species often reflect different reproductive strategies (Helfman *et al.,* 1997; Murua & Saborido, 2003). Fecundity may vary as a result of various adaptations to environmental habitats even within a given species (Witthames *et al.,* 1995). Reduced condition of fish may cause a decline in fecundity and can be reflected in a lower number of oocytes that develop in a given spawning season or through atresia. In worst cases, low condition can stimulate reproductive failure leading to skipped spawning seasons (Bell *et al.,* 1992; Livingston *et al.,* 1997). This entire phenomenon clearly indicates the importance of knowing the potential number of offspring in a season and reproductive capacity of fish stocks specially the threatened ones. Conservation of the threatened and prevention of the extinction fish through sustainable management has gained utmost significance in the world (Rahman *et al.,* 2016).

Hence the present study was aimed to evaluate the fecundity and gonadosomatic index of two fish species namely, *Etroplus suratensis* and *Oreochromis mossambicus* which were collected from the wild.

The pearl spot, *Etroplus suratensis*, the state fish of Kerala is a brackishwater teleost belonging to the family Cichlidae. It is widely distributed in peninsular India and Sri Lanka and inhabits both in freshwater and in brackish water (Hora and Pillay, 1962). Besides its high demand as food source, this species gain popularity as ornamental fish due to their brilliant coloration. This fish shared a good percentage (8–10 %) of the total fish landings in the backwaters and in brackish water lake during the sixties (George and Sebastain, 1970), which has been reduced drastically owing to overfishing. The demand for pearl spot has been increased owing to the boom of tourism in backwaters and lakes which augmented exploitation of the fishery (Padmakumar *et al.*, 2002). Recently, pearl spot has been gaining popularity as a candidate aquaculture species in inland saline regions (Kumar *et al.*, 2009).

Oreochromis mossambicus (Mozambique Tilapia) is a predominantly freshwater fish, but it has the capability of surviving and breeding in marine and hypersaline waters. Like most members of the family Cichlidae, it has a roughly oval, laterally compressed body, long dorsal and anal fins, containing both spines and soft rays, prolonged posteriorly, and the pelvic and pectoral fins are pointed. Cichlids have one nostril on each side, a two-part lateral line, with the anterior part of the lateral line higher up on the body, and extremely protractile premaxillaries (Page and Burr, 1991). Tilapias are a group of Middle Eastern and African fishes that were formerly grouped in one genus, which was later subdivided into many genera. The tilapias of the genus *Oreochromis* are widely cultured around the world and frequently are hybridized and selectively bred for food production (Lever, 1996; Costa-Pierce, 2003).

O. mossambicus has been widely introduced around the world as a food fish to be raised in ponds, or stocked in the wild, for food and sport. One of the advantages of tiliapias is their ability to subsist heavily on plant matter, although their lack of cellulase limits their ability to digest plants efficiently (Moyle, 2002). Their reception as a food-fish varies around the world culturally. In some regions of India and Indonesia, it has replaced more preferred native fishes, but has also provided a new source of nutrition for poor people (Lever, 1996).

In addition to its significance, the biology and reproductive ability of females, fecundity statistics, and its relationship with additional physical traits such as size, length, and weight provide information on factors influencing population size (Gomez-Marquez, 2003). Because fecundity increases with fish size (Bagenal, 1978), data on fecundity can be utilised to understand fish survival, specific races, population or stock estimations, and hatchery estimates (Lasker, 1985). The relationship between fertility and female size allows us to assess the potential of egg output (Chondar, 1977), the number of offspring in a season, and the reproductive capacity of fish stocks (Qasim and Qayyum, 1963).

For the present study the indigenous fish species, *Etroplus suratensis* and exotic species *Oreochromis mossambicus* were sampled from Kadinamkulam Lake located at Thiruvananthapuram district. The wild samples were evaluated for the comparitive study, analysing the fecundity and related aspects.

Objectives of the study

The present work was undertaken in the light of following objectives:

1. To compare and ascertain the fecundity of *Etroplus suratensis* and *Oreochromis mossambicus,* for estimating the reproductive potential of both the fishes.

2. To assess the gonado somatic index (GSI) of *E. suratensis* and *O. mossambicus* for understanding and comparing the reproductive condition across the species.

3. To evaluate the relationship between Fecundity with other body parameters such as total body length (TL), total body weight (TW), ovary/ gonad length (GL) and ovary/ gonad weight (GW).

REVIEW OF LITERATURE

Knowledge about the fecundity of a species is an important factor in fish stock management. It is used to calculate the reproductive potential of a stock and the survival from egg to describe a fish which is spawning for the first time. For all other animals the term 'maturity' is used because an animal reaches maturity (the ability to reproduce) once. 'First maturity' implies more than one 'maturity'. The inconsistency of the expression and the use of the term 'maturity stage' probably arose because the first fish for which 'maturity stages' were described had one, clearly marked, annual breeding cycle with a long interval in which the gonads returned almost to their virgin stage. However, it would be more logical to talk of 'maturity' and 'spawning' stages. Routine assessment of maturity stages is normally done by assigning individuals to stages by characters which can be differentiated with the naked eye. A more refined distinction between stages can be made by histological examination but this is not a practical approach in routine sampling because it takes too long (Vibudh, 2020).

Growth, maturation, fecundity and timing of spawning are interrelated and vary both within and among fish stocks and have been used to identify natural stock units as well as estimate spawning stock sizes in wild fish populations (Begg *et al.,* 1999). In most of the tropical marine fishes, maturation is a continuous process resulting in the occurrence of mature fishes throughout the year (Longhurst and Pauly, 1987).

There are several methods for the estimation of fecundity of fish. These are (a) Volumetric Method, (b) Gravimetric method and (c) Von Vayer method (Lagler, 1956). Volumetric Method and Von Vayer method have been found to be suitable for relatively large eggs. But the eggs of local Sarpunti are comparatively smaller than that of any major carps which may lead to error in the estimation of fecundity by Von Vayer method and Volumetric method. Gravimetric method was found to be more efficient than the other methods and gave fairly accurate results (Phillips, 1969). Several workers, viz, Rao (1963), Gupta (1968), Evans (1969), Doha and Hye (1970), Shafi and Quddus (1974 b), Dewan and Doha (1979), Islam and Hossain (1984) and Miah and Dewan (1984) have used this method in the estimation of fecundity of various fishes. Therefore, gravimetric method may offer the best possibility of minimizing error due to its simple and easy sampling technique.

Egg size is an important determinant of egg and larval survival (Bagarinao and Chua, 1986) and many authors have reported positive correlation between egg size and fish (deMartini and Fountain, 1981; Eenennaam and Doroshov, 1998). Greater size of larvae from larger eggs have been recorded in several fishes which positively influences their growth and survival and variations (inter specific and intra specific) in egg size in fishes and its ecological implications have been reported (Ware, 1975).

The most striking life history characteristic of the members of the family Cichlidae is the long duration of parental care of the young after spawning, a feature not found in most other fish species (Keenleyside, 1991). Although this behavior is directed at increasing the fitness of the offspring (Smith and Wooten, 1995), it always compromised with fecundity of the fish (Noakes and Balon, 1982). Owing to its omnivorous feeding habit, it is much suited to aquaculture (Bindu and Padmakumar, 2008). The fish breeds naturally in confined conditions and is ideally compatible for polyculture with both freshwater and brackish water fish and prawn species (Thampy, 1980).

Pearlspot, *Etroplus suratensis* commonly known as “Karimeen” in Kerala is an indigenous fish extensively found along the east and south-west coasts of Peninsular India. It is an important candidate species for aquaculture in ponds in both brackish water and freshwater environments. It is cultured in traditional ponds in Kerala where it is considered a delicacy fetching a high price. It is economically valued as a high-priced food fish and is gaining importance as an ornamental fish. Pearlspot is farmed in polyculture ponds with other fish species. Low volume cage culture of pearlspot is found to be a viable option to improve the livelihood of small-scale fish farmers (Kiran *et al.*, 2014). Pearl spot is essentially a brackish water fish that has become naturally acclimated to freshwater. The species grow faster among other *Etroplus* species and are more preferable for culture in confined brackish and freshwaters (De Silva *et al.*, 1984; Costa, 2007).

Fecundity of pearl spot is low and has been estimated to be around 3000-6000; hence a successful hatchery production of seeds is difficult. The mass scale seed production of pearlspot is limited by unique parental care, monogamous mating habits, small clutch size and their exclusive substrate breeding nature (Padmakumar *et al.*, 2009). Young ones of the cichlid fish *Etroplus maculatus* actively clean all age groups of *Etroplus suratensis*. They are naturally inhibited from attacking small fish while *E. maculatus* do so frequently. Cleaning territories are established by the young *E. maculatus.* Cleaning activity shows a daily circadian rhythm. Removal of fungus from fins and tail appear to be an important adaptive function of this symbiosis. The unique behavior during parental care of both species and other specific behavioral traits may have aided in the evolution of the relationship (Wyman and Ward, 1972). After spawning, about 500 eggs are laid and are attached to a submerged log, rock or sometimes roots and weeds, in still or slow flowing water. Parents guard and fan the eggs until hatching, usually for about 4 days. The fry shoal around their parents during the first weeks of growth. Parents refrain from feeding from the time of spawning until the fry become independent (Froese and Pauly, 2013).

The water temperature and photoperiod are found to be important physical factors influencing spawning in pearlspot. The water temperature of 27 to 30°C are ideal for getting continuous spawning. Adopting an integrated breeding approach can achieve production cost effectively (Bini *et al.*, 2022). The pattern of gonadosomatic index and proportion of mature individuals suggest two peaks in the spawning season of *E. suratensis* which occurred between May to August and November to January. The results of the above study provided option to develop sustainable fishery management practices such as closed season, mesh size regulations and development of fishing sanctuaries to conserve this commercially important cichlid species (Roshini, 2021).

Assessment of the breeding habits of *E. suratensis*, in different peninsular waters viz., Pulicat lake, Chilka lake, Kali estuary, Nethravathi- Gurpur estuary have been attempted by several workers (Prasadam, 1971; Jhingran and Natarajan,1969; Raju *et al.*, 1987; Keshava *et al.*, 1988). However, detailed reproductive biology with reference to the conservation management, has not been attempted. It is well known that even within a species and among populations surviving at different geographical locations, there occur major variations in life history patterns. Such variations in reproduction, growth and life history fitness traits are of crucial significance for assessing the long-term variability of the fish species (Ponniah and Lal, 2000).

Tilapia is a genus of fish in the cichlid family. These freshwater fish are native to Africa but have been widely introduced to warm waters in many countries. Their natural habitat is lakes but they are now extensively bred and reared in fish farms. In their breeding behaviour, the cichlids may be divided into two groups, the substrate spawners and the mouth brooders. The former lay eggs in a pit dug in the bottom of the lake or pond. The eggs are aerated and guarded by the parents.

The mouth brooders, on the other hand, may lay their eggs in pits, but then take them up into the mouth and keep them there till the young hatch (Mackean, 2018).

Oreochromis mossambicus (Mozambique Tilapia) is mouth-brooder. Females incubate eggs and larvae in their mouths. They become mature at 120 to 140 mm, and can reach that size in less than 6 months. Breeding males develop distinctive coloration and establish territories in shallow, weedy areas. They clear circular areas of plants, and actively defend and maintain their breeding arenas. Males display at the edges of the territory. An interested female will follow the male, and occasionally bite the sand or soil at the bottom of the pit. Then the female releases a clutch of eggs, which she takes into her mouth. The male releases milt onto the spot where the eggs were dropped. The female takes the milt into her mouth and makes 'mumbling' motions, which ensure fertilization. The female may do this repeatedly, until she has 100–400 eggs in her mouth. The male then chases the female away, and she retreats to a secluded spot to incubate the eggs (Moyle, 2002). Eggs hatch in about 3–5 days, and the larvae continue to be incubated in the mouth. The larvae remain in the mother's mouth for about 10–14 days, and then, as early juveniles, remain near the mother, and retreat into her mouth when disturbed. They leave the mother after about 3 weeks, and continue to school in shallow water. A female may have several broods in a season. Lifetime fecundity can range from 300 to 3000 eggs (Froese and Pauly, 2018).

Tilapia are more tolerant than most commonly farmed freshwater fish to high salinity, high water temperature, low dissolved oxygen, and high ammonia concentrations (Lucy Towers, 2005). Tilapia is a hardy fish. It is becoming increasing important as food fish. These fish are suitable for farming because they can breed easily and are high yielding. Beside its ecological role is that tilapia is harmful for aquaculture along with Indian major carps because of the adverse effect it causes on the growth and production of carps, and carp fry (Talwar and Jhingran, 2001).

O. mossambicus also undergoes ontogenetic change in feeding with a shift from macrophages in fry and fingerlings (e.g., bacteria, diatoms, micro crustacea, rotifers) to predominantly macrophagy in adults (Vaas and Hofstede 1952; Le Roux 1956; Bowen 1976; Bowen & Allanson 1982). There have also been reports of *O. mossambicus* opportunistically feeding on other small fish and eggs (Riedel, 1965; Eyeson, 1983; Webb, 1994) and aquatic macroinvertebrates, such as dipteran larvae (Legner and Medved, 1973; Legner, et al., 1980), The study also analysed the minimum size at which the vitellogenic onset, spermiation and final oocyte maturation in pearl spot gonad takes place. External morphological analyses revealed early maturation in females in comparison to males (Selvaraj, 2017).

Like other cichlids such as *Oreochromis sp*., *Etroplus suratensis* also exhibits some degree of sexual dimorphism, males being larger than females of equivalent age. Variations in morphology of gonad is linked to the breeding habit of the fish (Billiard *et al.*, 1982). Large testis and high GSI values are characteristic to species with sperm competition whereas males that invest energy in parental care will have a small testis (Munro *et al.*, 1990; Valdes *et al.*, 2004).

The Asian cichlid fishes, *Etroplus maculatus* and *E. suratensis* were observed in the natural habitat of Sri Lanka and their ecological and behavioural interactions were not discussed earlier. *E. suratensis* benefits from being cleaned by *E. maculatus.* It is doubtful that *E. maculatus* may ingest parasites and fungi. So *E. maculatus* gain survival and reproductive success of adult *E. suratensis*, which lay eggs and eleutheroembryos for young predatory habit of *E. maculatus*. Predation is lessened by age-specific crypticity of *E. suratensis*. *E. maculatus* (both parents) defend their young during parental cycle until young attain sexual maturity. Adult *E. suratensis* show altruistic multiple parental care where several adults care for single brood. Such caring behavior of fish were not discussed and reported previously (Ward & Wyman, 1977).

It has been observed that in males the coloration and iridescence become more intense close to spawning. This peculiar coloration of the fish earned the popular name 'green chromide' to it. This coloration enables the male partner to lure the gravid female to the spawning site and the colour patterns are identified to be good communication systems to ensure synchronization of courtship to signal the mate as regards to the readiness of spawning activities (Mckaye *et al.*, 1979). It appears that the black belly of *E. maculatus* is a signal that invites its mate for spawning (Keenleyside, 1991). One sex in a population is apparently linked to the sexual difference in growth rate; individuals with faster rate of growth is exposed to low predation and loss from population and this influences sex ratio (Qasim, 1966). Pandian *et al.*, (2001) observed that in many oviparous fishes where the duration of reproductive cycle is short and a single male can satisfy several females, the sex ratio is skewed in favor of females.

GSI is a reliable indicator of gonadal maturity; as naturally the weight of the gonad increases with maturity and when it spawns, there is a reduction in the weight of the gonad on account of the release of gametes (de Vlaming *et al.*, 1982). The breeding season of *E. suratensis* in Vembanad lake is indicated to be synchronized with the cessation of monsoons and high tidal amplitudes (Thampy, 1980).

A description has been given of the communicative activities and colour patterns occurring during the reproductive behaviour of *Tilapia mariae*. The temporal relationships between the various activities and between the activities and colour patterns in this fish has been quantitatively studied with the aim of testing whether behaviour systems can be distinguished which, in interaction with each other brings about agonistic, sexual and parental behaviour. The evidence obtained fits the hypothesis that at least three factors are involved in the causation of the reproductive displays, namely a tendency to stay in, and defend a territory, tendency to stay in a certain place but to escape attack and a tendency to move about and aggregate in a school (Baldaccini, 1973).

A study on *Tilapia zilli* (Ogunleye *et al.*, 2002) shows a positive and significant relationship between fish weight and standard length, and fish weight and weight of gonad. On the other hand, there exist a weak and positive relationship between fish weight and GSL standard length and GSI. *Oreochromis mosambicus* and *Oreochromis aureus* are the most salinity-tolerant tilapia species and can grow, survive and reproduce at 10 to 30% depending on the species, size and sex. Hogg (1976) reported that GSI values are better observed in the rainy season during the peak spawning period. Generally, the GSI of female fish is usually higher than that of male because of the weight of the eggs. Sexes are somewhat difficult to distinguish. Females, however, are usually paler than males and have two white spots at the base of their dorsals, whereas males have a peacock-coloured eyespot on their first ray of their broad dorsal fin. The genital papillae are rounded in females and are pointed in males. Males tend to have longer dorsal and caudal fin which are decorated with shimmering white spots which are absent in females. In addition, male have a steeper rise to their foreheads (Riehl & Baensch, 1991).

Gonadosomatic index revealed that spawning season lasted from June to September with peak in July. Macroscopic examination for the gonads of *T. zillii* indicated that adult females had 4 stages of gonadal development (mature II; vitellogenic stage III; ripe stage IV and spent V). The maturity stages of males were three (mature II, mature III, and ripe stage). The microscopic features of gonadal sections of both females and males showed that *T. zillii* gonads developed like other tilapian fishes inspite of their hyper saline habitat. Condition factor showed similar trend between both sexes of increase and decrease. Hepatosomatic index in females attained higher values over males (Moharram, 2007).

The study conducted by (Shoko *et al.*, 2015) to assess the reproductive biology and early breeding behaviour of female *Oreochromis niloticus* reared in monoculture and polyculture with *Clarias geriepinus* in earthen ponds for 8 months, it was obtained that there is no significant difference in length at first maturity between females reared in monoculture and polyculture system and also no differences were detected in absolute fecundity, relative fecundity, GSI and also the early breeding of *O. niloticus* in captivity is not affected by the culture systems used.

Fecundity and oocyte size of *Oreochromis niloticus* females were studied over a period of two annual cycles in six small agropastoral and three large hydroelectric reservoirs of Côte d'Ivoire. An inverse correlation was found between size and number of oocytes produced by females. This inverse relationship occurred for a constant spawn weight during the first year of study and changes during second year. Monthly mean residuals of regressions between fecundity and female body weight have shown a seasonal variation in fecundity. The peak of fecundity corresponded with the maximum resource availability and the flooding eminence, which may have a great impact on parents and offspring fitness (Diponchelle *et al.*, 2000)

A study was conducted aimed to investigate some aspects of the reproductive biology of *Tilapia sp.* inhabited damietta branch of the River Nile, Egypt, to manage these species in this important fish resource. *Tilapia* sp. fishes were taken on a seasonally basis over a complete year-round from the studied area. Sex ratio, maturity stages, gonadosomatic index (GSI), absolute fecundity and egg diameters were studied. The overall sex-ratio of male to female deviates significantly from the hypothetical distribution for *Oreochromis niloticus* and *Tilapia zillii*, respectively. The maturity stages of *Tilapia spp*. were classified macroscopically into five stages. The breeding period (expressed by GSI) of *Tilapia* spp. exhibited several peaks. Variations found in fecundity and egg diameter were due to differences in reproductive habits of studied species. Fecundity and egg diameter, in Tilapia species were found to depend on length, weight or age of the fish. The data generated in this study provide knowledge on rational stock utilization, protection of new recruits and the prediction of recruitment variability. So, to protect *Tilapia spp.* in Damietta branch of the River Nile, Egypt, from exploitation, it is recommended to ban the use of gears with illegal mesh sizes and other destructive fishing methods to allow the fish to breed, grow and recruit into the fishery (Authman *et al.*, 2013)

A description has been given of the communicative activities and colour patterns occurring during the reproductive behaviour of Tilapia mariae (Boulanger). The temporal relationships between the various activities and between the activities and colour patterns in this fish has been quantitatively studied with the aim of testing whether behaviour systems can be distinguished which, in interaction with each other, bring about agonistic, sexual and parental behaviour. The evidence obtained fits the hypothesis that at least three factors are involved in the causation of the reproductive displays, namely a tendency to stay in, and defend a territory, tendency to stay in a certain place but to escape attack and a tendency to move about and aggregate in a school(Baldaccini, 1973).

One of the nutrients that can be given to brood feed fish to improve reproductive performance and egg quality is vitamin E. Vitamin E has a very important role in increasing fish reproduction because vitamin E functions as an antioxidant that can maintain the presence of fatty acids and prevent fat oxidation in the fish cell membrane and can accelerate the secretion of reproductive hormones. The study aims to determine the effect of vitamin E in feed at different doses on the level of gonad maturity of tilapia. The samples of fish tested were tilapia (*Oreochromis niloticus*) obtained from the Teratai fishing pond, Sanur Bali. Administration of vitamin E mixed in the feed at different doses had a significant effect on the achievement of gonad maturity level, gonad somatic index (GSI), and Fecundity. Provision of vitamin E at a higher dose of feed was the best dose for ripening tilapia (Tarigan *et al.*, 2021).

Mouth brooding species exhibit higher levels of parental care but fecundity is lower and egg size larger than in substrate-spawning species. Fecundity, the number of eggs oviposited per spawning act, can be < 350 in mouthbrooders such as *Oreochromis mossambicus* but can exceed 12 000 in substrate-spawners such as *Tilapia zillii*. Eggs produced by mouthbrooders normally exceed 2 mm in diameter whilst those of substrate spawners average only 1.5 mm. Interspawning intervals of mouthbrooders generally average 30-50 days whether the fish are held in natural or artificial conditions, although substrate-spawning species such as *Tilapia zillii* can re-spawn after only 6 or 7 days. The dynamics of the asynchronous pattern of ovarian development adopted by tilapiines are complex and result in the ovary being dominated by late-vitellogenic/maturing oocytes as early as 8-10 days after spawning. Advancement of our understanding of these key areas will be essential if the present constraints on tilapia culture are to be overcome (Coward and Bromage, 2000).

The reproductive biology of two invasive tilapia species, *Oreochromis mossambicus* and *Tilapia mariae*, resident in freshwater habitats in north-eastern Australia was investigated. *Oreochromis mossambicus* exhibited plasticity in some of its life-history characteristics that enhanced its ability to occupy a range of habitats. These included a shallow, weed-choked, freshwater coastal drain that was subject to temperature and dissolved oxygen extremes and water-level fluctuations to cooler, relatively high-altitude impoundments. Adaptations to harsher conditions included a decreased total length (L(T) and age (A) at 50% maturity (m50), short somatic growth intervals, early maturation and higher relative fecundities. Potential fecundity in both species was relatively low, but parental care ensured high survival rates of both eggs and larvae. No significant difference in the relative fecundity of *T. mariae* populations in a large impoundment and a coastal river was found, but there were significant differences in relative fecundities between several of the *O. mossambicus* populations sampled. Monthly gonad developmental stages and gonado-somatic indices suggested that in coastal areas, spawning of *O. mossambicus* and *T. mariae* occurred throughout most of the year while in cooler, high-altitude impoundments, spawning peaked in the warmer, summer months (Russell *et al.*, 2012).

MATERIALS AND METHODS

Collection site

The fishes for the experiment (*Etroplus suratensis* and *Oreochromis mossambicus*) were collected randomly from Kadinamkulam lake of Thiruvananthapuram district, Kerala during the month of February to March, 2023. Kadinamkulam Lake (lat. 8°35'-8°40'N and long. 76°45'-76°52'E) opens into the sea at Perumathura by a temporary barmouth. The Vamanapuram River flows into the sea through this opening. It is connected to the Anchuthengu Backwater on the north and the Veli Lake on the south.

Sampling and analysis

Samples of *E.suratensis* and *O.mossambicus* were collected randomly and the fishes were caught using a cast net during the early morning time and 9 to 11 castings were employed for getting the desired numbers of fish. About 200 fishes were sampled out of which, only 24 pearlspot and 20 tilapia females were observed and evaluated for detailed statistical analysis. Immediately after collection, fishes were transported alive from the site to the lab with a minimum disturbance. The sampled fishes were sexed by observing the genital spines between males and females. After measuring total length (TL in cm) and total weight (TW in gram) the fishes were dissected to remove the ovary. The ovary was then weighed to the nearest 0.1 mg using a precision balance. The separated eggs were counted using fine brush and pointed needles. Fecundity was estimated by counting the number of eggs or ova from a known-weight of mature or ripe ovary. The eggs were weighted and three known subsamples were obtained from the anterior, middle and posterior regions of the ovary. the subsample was spread evenly on a petridish with few drops of water and the number of eggs were counted using a colony counter and average number of three portions used to determine the fecundity by the gravimetric method.

Gravimetric method

The gravimetric method is currently the most common method used to estimate fecundity. It is based on the relation between ovary weight and the oocyte density in the ovary. Using this method, the fecundity was calculated using the formula given below:

Absolute fecundity (F) = (Total weight of ovary/ weight of sub sample) × number of mature ova in the subsample

The absolute value is number of eggs estimated in total weight of ovary of the fish at particular length and weight. Divide this number by total weight of fish. This gives the fecundity as number eggs per unit body weight of the fish, known as relative fecundity (number of eggs/kg body weight of fish). The fecundity is also expressed as number of eggs per 100 or 10 gram of ovary (Murua *et al.*, 2003).

Relative fecundity

Relative fecundity is the number of eggs per unit body weight and it was obtained by dividing absolute fecundity with total weight of fish.
The relation of fecundity "F" with total length "TL", total weight "TW" and ovary weight "OW" was estimated as per the formula given by Bagenal (1978).

$$F = a\,TL^{b}\ ;\quad F = a\,TW^{b}\ ;\quad F = a\,OW^{b}$$

Where, a & b are constants, L is the total length (mm), TW is body weight (g) and OW is the ovary weight (g).

Gonadosomatic index (GSI)

The gonado somatic index (GSI) is the percentage of gonad weight to the total weight of the fish. The GSI is particularly helpful in identifying days and seasons of spawning, as the ovaries of gravid females swiftly increase in size just prior to spawning (Bithy *et al.*, 2012). The GSI of the collected fish was calculated for each of the female separately and using by the following formula:

$$GSI = (GW/BW) \times 100$$

Where 'GW' is the weight of the gonad/ ovary and 'BW' is the body weight of the fish in (Howaida *et al*, 1998).

Fecundity-length/weight relationship

Fecundity-length Relationship as well as the Fecundity-weight were estimated as per the formula given by Bagenal (1978): $F= a\ SL^b$; $F = a\ TW^b$

Where 'a' and 'b' are constants, 'SL' is the standard length (cm), 'F' is the fecundity and 'TW' is body weight (g).

Statistical Analysis

The observed datas were further analysed using MS Excel 2019 and regression analysis was evaluated to determine the strength and significance of the connections between absolute fecundity, total length and weight and gonad weight.

Experimental fishes

I. Etroplus suratensis

The green chromide, *Etroplus suratensis* is a species of cichlid fish that is native to fresh and brackish water habitats in some parts of India. It mainly feeds on aquatic plants, including filamentous algae and diatoms, but it occasionally consumes mollusk and other animal matter. The adult appears to be oval in shape with a short snout. It is grey green with dark barring and a dark spot at the base of the pectoral fin (Abraham, 2011). With length: 20.0 cm TL male/unsexed and Max length: 40.0 cm TL male/unsexed. This species is a bi-parental substrate spawner which forms temporary pair bonds when reproductively active. After spawning, about 500 eggs are laid and are attached to a submerged log, rock or sometimes roots and weeds, in still or slow flowing water. Parents guard and fan the eggs until hatching. Parents refrain from feeding from the time of spawning until the fry become independent (FAO, 2010).

Taxonomic Classification

Kingdom	**:**	**Animalia**
Subkingdom	**:**	**Bilateria**
Infrakingdom	**:**	**Deuterostoma**
Phylum	**:**	**Chordata**
Subphylum	**:**	**Vertebrata**
Infraphylum	**:**	**Gnathostomata**
Superclass	**:**	**Actinoptergii**
Class	**:**	**Teleostei**
Superorder	**:**	**Acanthoptergii**
Order	**:**	**Perciformes**
Suborder	**:**	**Labroidei**
Family	**:**	**Cichlidae**
Genus	**:**	***Etroplus***
Species	**:**	***Etroplus suratensis*** **(Bloch, 1790)**

Source : IT IS (Integrated Taxonomic Information System- Report)-https://www.itis.gov

II. Oreochromis mossambicus

Mozambique Tilapia, *Oreochromis mossambicus* are opportunistic omnivores and will eat algae, plant matter, organic particles, small invertebrates and fish. Such a broad diet enables them to colonise different environments, since they don't rely on any particular food source. In situations where there are many tilapias in one spot, adults sometimes cannibalise younger fish. Mozambique Tilapia are polygynous (ie; males mate with multiple females) and brood embryos and young fry in their mouth known as mouth brooding. They can reproduce under a variety of different ecological conditions. Due to their ability to stunt their own growth, Mozambique tilapia can also vary greatly between populations in their reproductive characteristics. Mozambique tilapia are capable of surviving in a wide range of different habitat types, such as this example of a degraded urban drainage (Russell *et al.*, 2010).

Taxonomic Classification

Kingdom	:	**Animalia**
Subkingdom	:	**Bilateria**
Infrakingdom	:	**Deuterostoma**
Phylum	:	**Chordata**
Subphylum	:	**Vertebrata**
Infraphylum	:	**Gnathostomata**
Superclass	:	**Actinoptergii**
Class	:	**Teleostei**
Superorder	:	**Acanthoptergii**
Order	:	**Perciformes**
Suborder	:	**Labroidei**
Family	:	**Cichlidae**
Genus	:	***Oreochromis***
Species	:	***Oreochromis mossambicus*** **(Peters, 1852)**

Source : IT IS (Integrated Taxonomic Information System- Report)-https://www.itis.gov

Fig. 1: Site map

Source :https://mapcarta.com/W383753872/Map

Fig. 2: Measuring the length of *Etroplus suratensis*

Fig. 3: Measuring the length of *Oreochromis mossambicus*

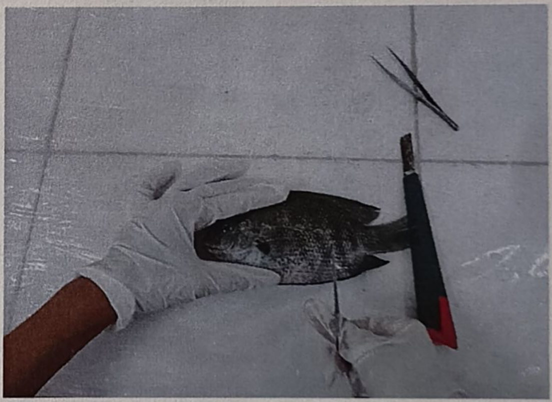


Fig. 4: Dissecting the fish sample

Fig. 5: Mature and immature ovaries of *Etroplus suratensis*

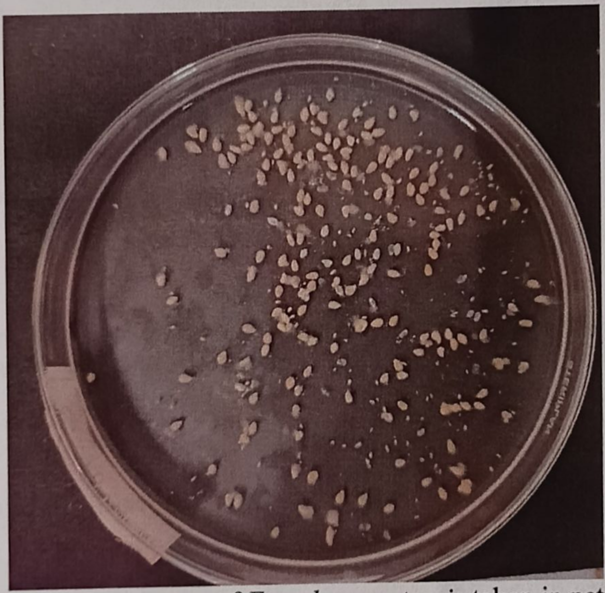


Fig. 6: Mature eggs of *Etroplus suratensis* taken in petridish

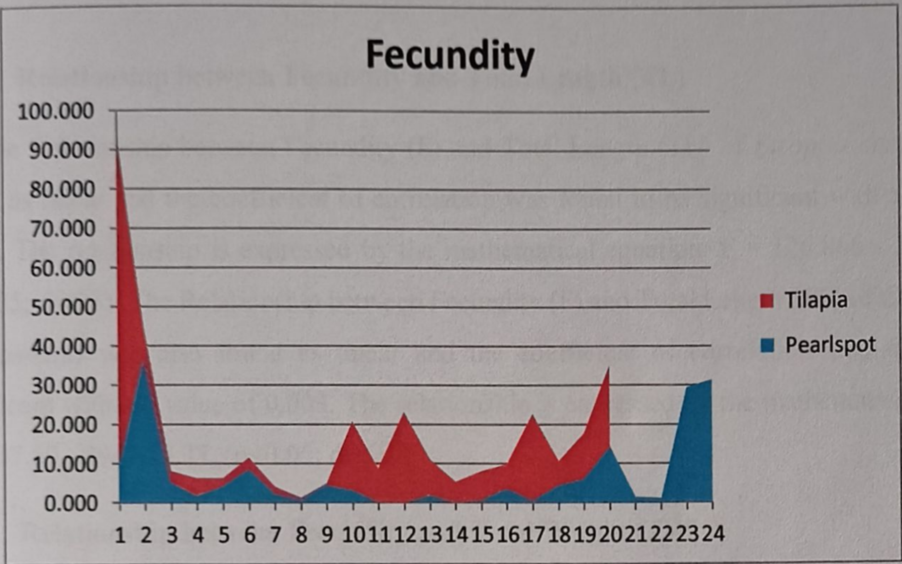
RESULTS

Fecundity is the measure of reproductive capacity of a species and is studied to determine the productivity dynamics of a species concerned. It is studied both in relative as well as absolute context. The data obtained by the fecundity analysis of *Etroplus suratensis* and *Oreochromis mossambicus* showed slight variation in both Absolute (F) and Relative fecundity. Relative fecundity is the number of eggs per unit body weight and the total (absolute) fecundity is the total number of eggs that are likely to be spawned in one spawning season.

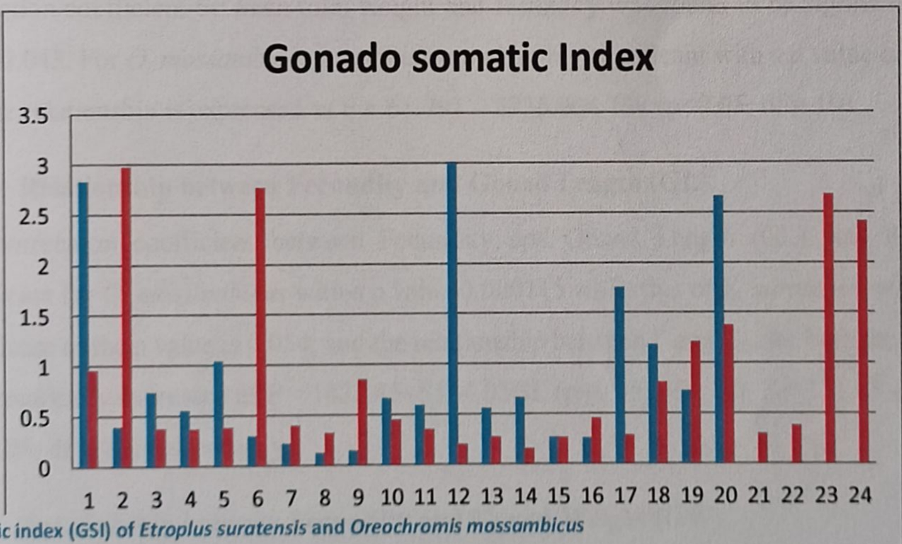
Species	Absolute fecundity(F)	Relative Fecundity	Gonado Somatic Index (GSI)
Etroplus suratensis	**624.416**	**7.167**	**0.877**
	SD ±407.806	SD ±10.436	SD ±0.897
Oreochromis mossambicus	**1087.878**	**12.2**	**0.933**
	SD ±2138.796	SD ±18.6	SD ±0.907

Table 1: Average Absolute & Relative Fecundity and GSI values of *Etroplus suratensis* and *Oreochromis mossambicus* (NB: SD for Standard deviation)

During the course of present investigations, the Absolute Fecundity (F) of *Etroplus suratensis* varied from 50.66 to 1240.79 with an average F value of 624.416 ±407.806 SD while the Relative Fecundity ranged from 1 to 36.922 with an average value of 7.167 ±10.436 SD. The average total length of the samples was 14.98cm while the average weight of the fishes was 87.08g with an average number of 128 eggs in the ovary. The average Gonado Somatic Index (GSI) was observed to be 0.877±0.907 SD (Table 1). Out of the 20 female fishes analysed the average total length of *Oreochromis mossambicus* was observed to be 13. 86 cm while the average weight of the fishes was 53.77g and the average number of eggs in the ovary was found to be around 99. The absolute fecundity ranged from 152 to 9982.60 with an average value of 1087. 878 ±2138.796 SD while the relative fecundity ranged from 1 to 85 with an average value 12.2 ±18.6 SD, which was higher compared to *E. suratensis* (Fig. 7). The average GSI value was 0.933 ±0.907 SD (Fig. 8).



ure 7: Fecundity of *Etroplus suratensis* and *Oreochromis mossambicus*



onadosomatic index (GSI) of *Etroplus suratensis* and *Oreochromis mossambicus*

Fecundity in relation to different parameters

The relationship between total length (TL) and fecundity (F), Total weight of fish (TW) and Fecundity, Gonad Length (GL) and Fecundity (F), and Gonad Weight (GW) and Fecundity (F) were estimated.

1. **Relationship between Fecundity and Total Length (TL)**

1a. The Relationship between Fecundity (F) and Total Length (TL) of *Etroplus suratensis* was found as linear and the coefficient of correlation was found to be significant with a p value of 0.036. The relationship is expressed by the mathematical equation: $F = 126.866 - 1276.99\ TL$ ($p<0.05$; df=23). The Relationship between Fecundity (F) and Total Length (TL) of *Oreochromis mossambicus* was also found as linear and the coefficient of correlation was found to be significant with a p value of 0.003. The relationship is expressed by the mathematical equation: $F = 507.59 - 5947.42\ TL$ ($p<0.05$; df= 19).

2. **Relationship between Fecundity and Total Weight (TW)**

The relationship between fecundity and total weight of the fish (TW) showed a linear relationship for *E. suratensis* expressed by the equation: $F = 7.913 - 62.631\ TW$ ($p<0.05$; df = 22). The correlation coefficient between total weight and fecundity was found to be significant with a p value 0.043. For *O. mossambicus* it was linear and highly significant with a p value of 1.03 E- 05 and the relationship is expressed as $F = 61.791 – 2235.004\ TW$ ($p<0.05$; df= 19).

3. **Relationship between Fecundity and Gonad Length (GL)**

The correlation coefficient between Fecundity and Gonad Length (GL) was found to be significant for *O. mossambicus* with a p value 0.000115 while that of *E. suratensis* was not much significant as the p value is 0.054; and the relationship between F and GL for both the fishes were mathematically expressed as $F = 1422.45 - 5114.03GL$ ($p<0.05$; df= 19), $F = 121.87 – 105.29\ GL$ ($p= 0.05$; df = 23) respectively.

4. **Relationship between Fecundity and Gonad Weight (GW)**

The relationship between Fecundity and Gonad weight for *E. suratensis is expressed as F = 183.88 +474.93* ($p<0.05$; df = 23), while that of *O. mossambicus* is F = 1772.78 -53.79 ($p<0.05$;

df= 19). A highly significant ($P<0.05$) relationship was found between the two parameters for *O. mossambicus* (7.33E-06) while it was 0.043 and significant for *E. suratensis.*

Length- weight relationship

The relationship between the length and weight of *Etroplus suratensis* showed an 'a' value of 0.271775 and 'b' value was found to be 0.003613. The p value was 9.21189E -12 which is highly significant. The R square was 0.883 which is a good fit. *Oreochromis mossambicus* showed an 'a' value of 0.399494 while the 'b' value was observed to be 0.003045. The p value was significant ($P<0.05$) and it was 0.0423.

DISCUSSIONS

In fisheries science, several methods have been applied to estimate fecundity (Arnold *et al.*, 1997; Irwin and Murdoch *et al.*, 1991). The two most common methods still in use to count fish eggs involved soaking the ovaries in Gilson's fluid and counting a sub-sample of the eggs (Volumetric method) on the basis of certain volume (Simpson, 1951) or certain weight (Gravimetric method). The present study has adopted Gravimetric method for the assessment of Fecundity in *Etroplus suratensis*, the indigenous variety and *Oreochromis mossambicus*, the exotic variety. Fecundity is generally defined as the egg laying capacity of a fish. Important contributions to the study of fecundity in relation to other parameters of body have been made by Jyoti and Malhotra (1972); Desai (1973); Joshi and Khanna (1980); Pathani (1981); Thakare and Bapart (1981); Singh *et al.* (1985); Sundra and Subba (1984); Bisht (1985); Dobriyal and Singh (1987, 1989, 1993); Rautela (1999); Dobriyal *et al.*, (2000); Uniyal (2003); Singh (2004); Hina (2010) and Vohra (2011).

While comparing the Absolute Fecundity and Relative Fecundity, it showed slight variation in both species. The Absolute Fecundity (F) of *Etroplus suratensis* varied from 50.66 to 1240.79 with an average F value of 624.416 ±407.806 SD while the Relative Fecundity ranged from 1 to 36.922 with an average value of 7.167 ±10.436 SD. For *Oreochromis mossambicus;* the absolute fecundity ranged from 152 to 9982.60 with an average value of 1087. 878 ±2138.796 SD while the relative fecundity ranged from 1 to 85 with an average value 12.2 ±18.6 SD, which was higher compared to *E. suratensis.*

Variation in the fecundity among the fishes of the same as well as different species is very common depending upon the various factors such as size of the fish, age and condition of the fish, and also depends upon the space and food intake by the fish. Bagenal (1967) has reported that length and weight are reliable indicators of the capacity of egg production; hence the fecundity increases with the increase of the fish in size and weight. This condition was true up to a certain extent in the present study, even though there were variations among many samples especially in case of mosambique tilapia. Fecundity in *O. mossambicus* is highly variable as reported by different investigators. According to Hora and Pillay (1962), the female tilapia lays 75-250 eggs at a time. Vaas and Hoftstede (1952) also found that the fecundity of *T. mossambica* ranged from 80 to 300 ova for fish with length ranging from 8 to 11 cms in total length. Presence of several maturity stages during most part of the year is noteworthy in this species. If there is periodicity in spawning, at a given time all fish collected must have same degree of gonadal development (Clark, 1934). This is not so in *E. suratensis*. The modes of mature/ripe ova are not distinctly separated from each other and therefore spawning would be continuous between August and November and January and February with peak activity in August. This fish is believed to spawn when the water is clear so that parental care is effective (Samarakoon, 1981). In the backwaters of Kerala, *E. suratensis* breeds throughout the year with two peaks, February to May and October to November.

The Gonadosoamtic index (GSI) is regarded as a reliable indicator of gonad maturity and spawning in any species. The GSI value increases with fish maturation and reaches its maximum during the peak stage of maturity. Generally, it is used for the study of maturation and spawning. It is also used to assess the degree of ripeness of the ovary. For the present experiment, average Gonado Somatic Index (GSI) was observed to be 0.877±0.907 SD for pearlspot while that of tilapia was observed to be 0.933 ±0.907 SD. Fecundity varies widely for fishes of the same length, as found in the horse mackerel by Macer (1974) and reported by other workers for many species of fishes. Much of this variation is probably because of real differences in fecundity, but some may be caused by the stage in developmental maturity of the ovary at sampling. The exact timing of sampling is likely to be the most critical factor influencing the accuracy of fecundity determinations for serial spawning fishes. Yeldan and Avsar (2000) have also reported that GSI is widely used especially for the bony fishes in order to examine the spawning period because its value is directly related to the development of the gonad. Changes in the gonadosomatic index (GSI) helps to determine the reproductive season of the fish (Arruda *et al.*, 1993)

Various relationships between fecundity and body parameters, such as fish length, fish weight, ovary length and ovary weight have been evaluated for the present work. The regression analysis showed a linear relationship between fecundity and most of the parameters observed for both fish species. The regression between Total Length and fecundity, Length of the ovary and fecundity, Weight of ovary and fecundity indicated a direct proportionality and the values and were highly significant in case of ovary weight and fecundity especially for *Oreochromis mossambicus*; while the fecundity and ovary length of *Etroplus surtensis* was not that much significant.

CONCLUSION

Fecundity is an important parameter in fishes for determining the reproductive potential of fish species (Zin *et al.*, 2011). For the present investigation the fecundity of *Etroplus suratensis* and *Oreochromis mossambicus* collected from Kadinamkulam Lake were evaluated. Both Absolute Fecundity and Relative fecundity were analysed for the two species and the overall analysis and comparison showed a higher fecundity value for *O. mossambicus* compared to *E. suratensis*. Even though the collection period, February to March was one of the peak seasons for the spawning period of pearlspot, it showed a comaparitively lower value for fecundity. This must be attributed to the fact that, the higher fecundity in fishes is observed not only due to its gonadal maturity but also due to good food supply, good water condition, favorable water temperature, rainfall and various other environmental factors. Fecundity is an adaptation to varying environmental conditions that work through the food supply (Wu and Kawasaki, 2001). Nikolskii (1969) observed that the quality and quantity of food consumed by the parent population determine not only the fecundity but also the quality of sexual products. Scott (1973) reported that fecundity is lowered by poor intake of food. The low fecundity in *E. suaratensis* could well be attributed to the parental care. Furthermore, the low fecundity of the fish also might be due to prolonged breeding season.

Fecundity along with other indices such as gonadosomatic index (GSI) and hepatosomatic index (HSI) are used to access the reproductive condition of a fish. In this experiment, GSI value was also observed along with the relationship of different body parameters of fish with its fecundity. In fish, GSI is a good indicator of reproductive activity, so the spawning season is determined by an association of the GSI and the frequency distribution of the gonadal maturity stages. Similar to the fecundity, the GSI value was also higher for *O. mossambicus*. The relationship study by evaluating the regression analysis between Total Length and fecundity, Body weight and fecundity, Length of the ovary and fecundity, Weight of ovary and fecundity indicated a linear relationship and the values were significant especially for fecundity and ovary weight in both the fishes. From the above observations it is concluded that the fecundity was more dependent on ovarian weight than body related parameters such as body weight, total length and ovarian length.

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