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Gonadal Developments of West African Freshwater Crab (Sudanonautes Africanus, Milne–Edwards, 1869) on the Banks of Asejire Reservoir, Nigeria

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Abstract
This paper was on the developmental changes that take place inside the eggs of the fresh water crab (*Sudanonuates africanus*) from Asejire reservoir in Ibadan Nigerian. The egg consist of two layers a thick outer membrane and a thin inner membrane that encloses the fluid- filled embryonic sac. Development in this species took up to 77 days, after which the free- living juvenile hatching crab emerged from the egg. During developmental the embryo underwent a series of morphological changes that corresponded to the free living larval stages of marine crabs and the yolk mass decreased in size and changed color (from yellow, to orange brown and finally off- white) the eggs remained attached to the pleopods in the females abdominal brood pouch during development and showed a great deal of independence from water embryos developed normally whether they were immersed in water or in air.
Keywords: Crab, Egg, Fecundity, Fresh water, Gonads

INRODUCTION

Arthropoda is the largest and most diverse animal phylum. It includes insects and crustacean members are distinguished by an exoskeleton that is periodically shed to make room for growth known as molting. The body is segmented and bear paired jointed appendages. The most popular body segmentation is into three segments the head, thorax and abdomen. Crustacean is a successful class of arthropods in terms of both number of living species and colonization of different habitats. Their habitats include the deep oceans, coastal estuarine regions, semi terrestrial, terrestrial and freshwater environments of ponds and lakes (Ruiz *et al.,* 1993). Crustaceans are primarily aquatic arthropods.

The popular and largest crustaceans belong to the order decapoda which include shrimps, lobsters, prawns and crayfish. Brachyurans are the most advanced of the decapods this represents the true crab genus further divided into two families. Oxyrhyncha species are marine crabs and branchyncha species are freshwater crabs.

Freshwater crab lives on land in burrow and under what can cover them well. They are active at night (Cumberlidge, 1999). There are primarily vegetarian and scavengers, and can run very fast, with eyes are well developed to see from distance and very sensitive to the environment. Freshwater crabs were originally known as river crabs and were given family names such as Thelphusidae and Potamonidae, the latter name derived from the Greek word freshwater crabs are mostly found in burrow made by them as a house to escape from predators (Grimes *et al*., 1989). Freshwater crabs demonstrate a broad range of habitat preference (Yeo *et al*., 2008, Cumberlidge *et al*., 2009) Many species of true freshwater crab are fully aquatic and spend their entire life cycle in water (Liu and Li, 2000). They live most of their lives in water (Ng and Naiyanetr, 1995, 1998). And hide under stones on the stream bed during the day and forages either in the stream or on land at night. The West African freshwater crab belong to the family Potamonutidae are hardy, with over 88 species present in the streams and river systems across Africa (Cumberlidge, 1999). Potamonutidae crabs are found in large number in nearly all the available freshwater bodies in Nigeria, but they are underutilized except for local consumption (Bello–Olusoji *et al.,* 2010). *S. africanus* is a common, brachyuran, freshwater crab that is widely distributed throughout Nigeria, Central Africa, South Africa, Cameroun, Congo, Gabon and Zaire (Cumberlidge, 1999). These work focus on the development of gonad and fertilizd eggs of *S. africanus* a common species of freshwater crab found in and around the Asejire reservoir, Nigeria. This species hides under stones on the reservoir bed and mud. Females carrying between 80- 120 eggs move into shallow water during the early breeding season and typically feed on land at night

S. africanus was selected to investigate changes that occur inside the developing embryos.

MATERIALS AND METHODS

STUDY AREA

This study was carried out on the banks of Asejire reservoir in Egbeda Local Government Area of Oyo State Southwestern Nigeria (Figure I). Egbeda Local Government is one of the 33 local government areas in Oyo State.

The reservoir took its source form Osun river and flows through Oluwo and Alaye- ala down to Asejire. The reservoir supplies water to the Ibadan and Osun municipality for domestic uses. Ibadan is the largest city in West Africa, with a high population of inhabitants cutting across people from different tribes which include Hausas, Igbo, Yoruba and Efiks etc.

The study area is located at the south-western part of Nigeria. It is a man-made reservoir. The reservoir is bi-focated with two unequal arms surrounded by large mass of land the left longer arm is fed by Rivers Oba and Oshun while the right arm is supplied by River Agboiro (Adebisi, 1981). The catchment area in the reservoir is 7800km^2 and the impounded area is 2,342 hectares. The reservoir has a normal pool elevation (water level) of 150m and maximum flood elevation of 152.4m. The reservoir has an approximate gross storage of 7,403 million litres. The construction of reservoir divides the fishing area into two main zones i.e. the upstream and the downstream (Ogunleye, 1982). It has a rainy season (April-October) with a monthly water mean of 10.3-15.9mm while dry season is between (November–March) with water mean of 3.78 – 4.2mm.

Asejire reservoir lies between longitudes 4^E and 4^{0}07^E and latitudes 7^{0N} and 7^{0}21^N. The total area covered by the study area is about 10,000 hectares from Ibadan along Ibadan –Ife expressway, The reservoir flows approximately 5km from its source before breaking into series of rivers and streams (Anatekahi, 1997), with emerging 20 communities dispersed around the reservoir which traverse different settlements (Adebisi, 1981). The occupations of majority of the populace are trading, fishing and farming. For a longtime, traditional fishing has been known in this reservoir. About twenty –five species were identified in the reservoir by Ogunleye, (1982). Some of the commercial important fish and shell fish found include; *Heterobranchus*, *Hemichromis spp*, *longifilis*,*Clarias gariepinus*, *Clarias anguillaris*, *Oreochromis niloticus*, *Tilapia zillii*, *T. mariea*, *Macrobrauchium vollenhovennii* and *Sudannautes africanus.*

Crabs catch reaches the peak between April and September during the wet season when the reservoir water level is high and low catch is recorded from November to March during the dry season when the water level of the reservoir is low. The study area was selected based on the high activities of aquaculture and accessibility,

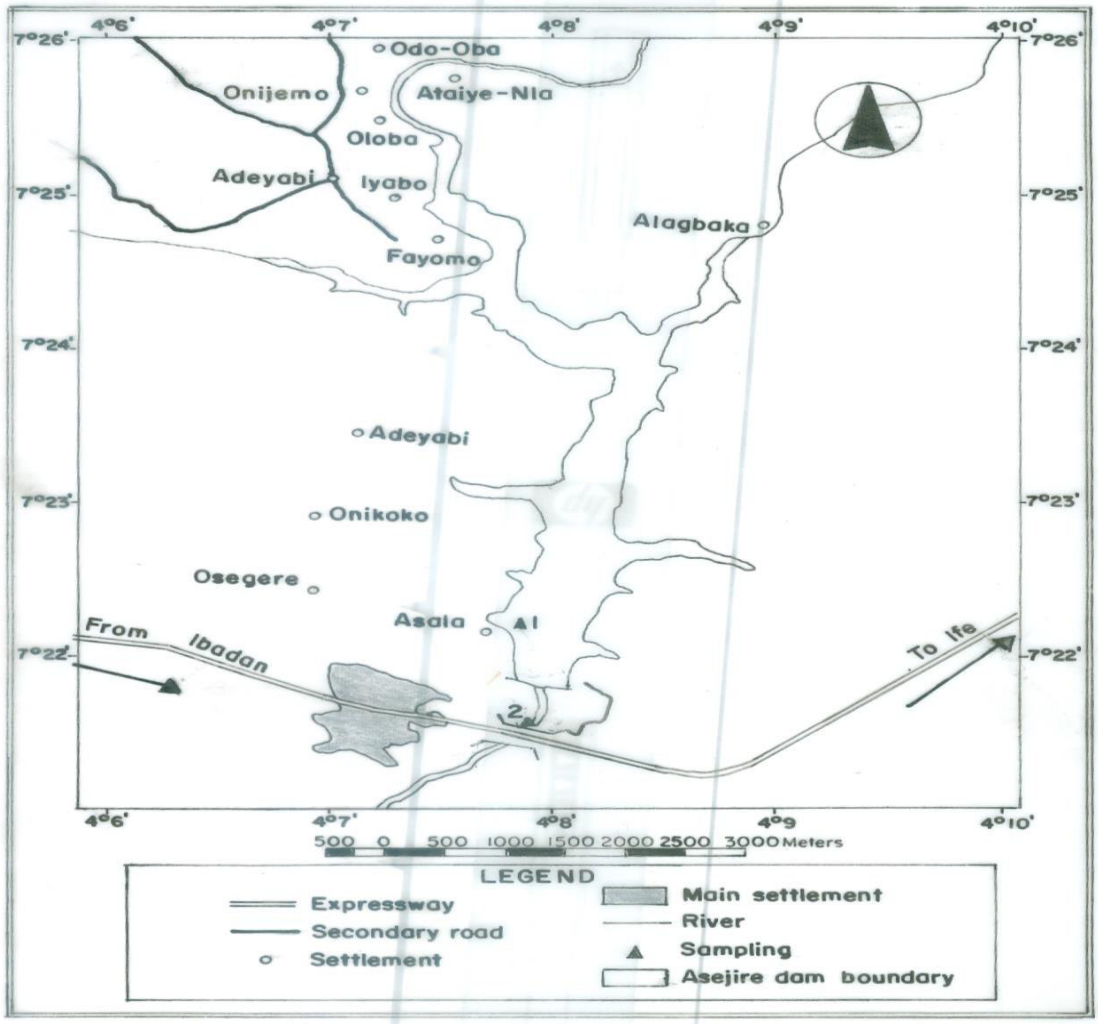

Fig. 3.1: Map of Asejre reservior showing the sampling areas

Gonad Weight GW (g): This was carried out by slit opening each crab pouch removing the gonad and weighing on Mettler digital balance. Fourty Freshwater crabs (*S. africanus)* were maintained in the laboratory in one plastic tank(0.50×0.30×0.35 m) supplied with shallow fresh water that did not completely immerse the crabs, and with a raised platform that allowed crabs to spend time out of water. The water was maintained at 25±1°C, leached with a water purifier (MF-1 Filter), and replaced every two days. Crabs were fed every evening with coconut and earthworms the female crabs were allowed to spawned, at which point they were separated and cultured in individual tank. Twenty ovigerous females were observed every day from spawning until hatching of the eggs. Crabs divided their time equally between periods of immersion in shallow water and periods when they were resting out of the water. Two to four eggs were removed daily at 9:00 am from each female and fixed in 70% ethanol for analysis. A scapel was used to with the careful peeling away of the developing embryos from the inner membrane, and the embryos were photographed using a digital camera fitted to the microscope.

Gonadal Stages: The stages of egg development were identified as described by Kennan *et al.,* (1998). Each specimen was kept in separate specimen bottle with a label bearing date caught and stage of gonad on each specimen bottle. The specimen bottle was shaken vigorously at 30 minutes intervals, to disengage the egg from the ovarian tissue and also for deeper penetration of formalin which serves as a preservative. The stages of the egg were observed by using five stages of egg development based on the colour as described by Cumberlidge, (1999).

Stage I	Immature	(yellow)
Stage II	Developing	(orange)
Stage III	Mature	(brown)
Stage IV	Ripe	(dark brown)
Stage V	spent	(off-white)

3.6.5 Gonado-Somatic Index

$$GSI = \frac{Weight\ of\ ovaries}{weight\ of\ crab - Weight\ of\ ovary}$$

RESULTS

Fertilized eggs were removed from the pleopods of the twenty ovigerous females of *S. africanus*, eggs were(3.5-4.5mm diameter), round, and a uniform creamy yellow color each embryo was found to be completely surrounded by a two layered membrane a thick outer membrane and a thinner inner membrane that formed a fluid – filled sac around. Newly laid eggs consisted almost entirely of creamy pale yellow yolk(plate 1)the developing embryo and yolk mass membrane and with a fluid – filled sac around the developing embryo and yolk mass. Later the yolk became dark yellow and a small fluid transparent sac (the inner membrane) was visible that contained a small white mass (the developing embryo) on one side of the egg (plate 2) (Wu *et al*., 2010) after 19 days the embryo was visible on one side of the sac as a large brown mass after 65days (plate3) the yolk had changed color from brown to dark brown(which now had recognizable larval features such as compound eyes) and the fluid –filled sac . After 75 days the embryo had developed to a stage that resembled a juvenile crab (termed the egg juvenile crab by Wu *et al*., 2010) the embryo burst to release a free – living hatchling crab. The complete developmental process inside the egg case was therefore observed to take about 77 days from fertilized egg to free living hatchling crab.

Table 1: Mean and Range for gravid *S. africanus* female on Asejire reservoir

Mean	Length (cm)	6.76
	Weight (g)	87.5
	Fecundity	292
Range	Length (cm)	7.5 – 14.5
	Weight (g)	80.5 – 165
	Fecundity	120-451

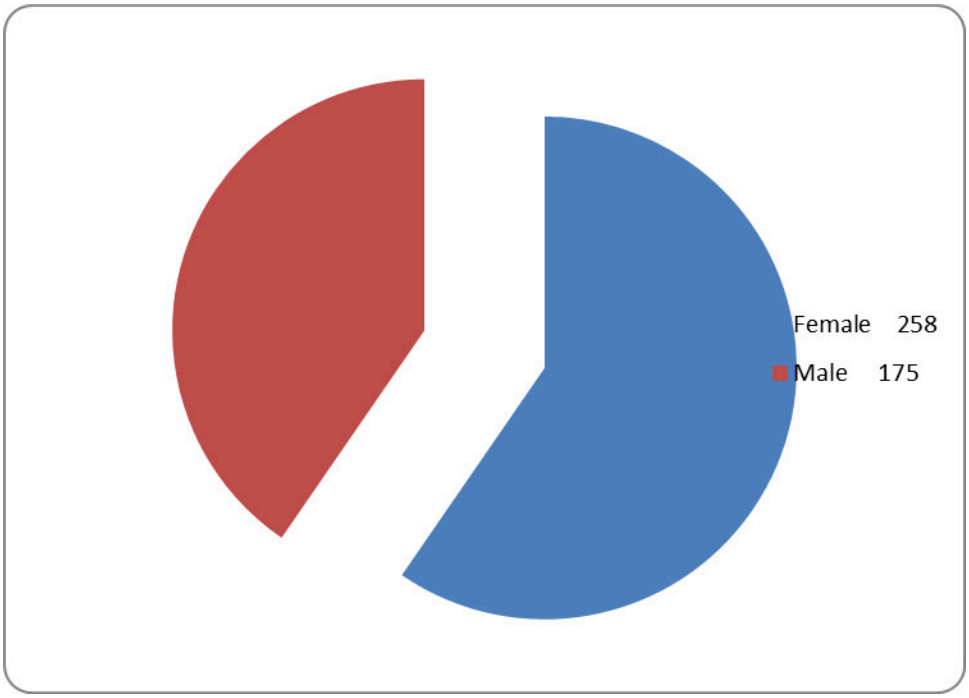

Figure1: Sex ratio of Male:Female *S.africanus* on banks of Asejire reservoir

Male and female *S. africanus* crabs were randomly collected and examined. A total number of 433 *S. africanus* freshwater crabs were collected in which 258 were females and 175 were males and the sex ratio was 3:2 (62% female and 38% male). It was observed that there were more females than males both in the wet and dry seasons.

Plate 1: Developed stage of egg in *S. africanus* crab at bank of Asejire reservoir.

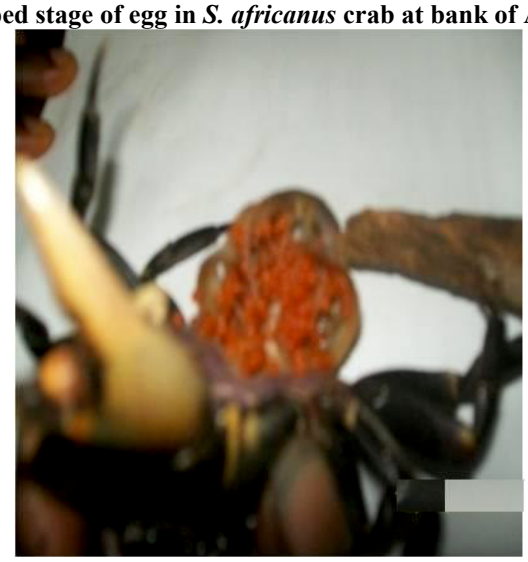

Plate 2: Developing stage of egg in *S. africanus* crab at bank of Asejire reservoir.

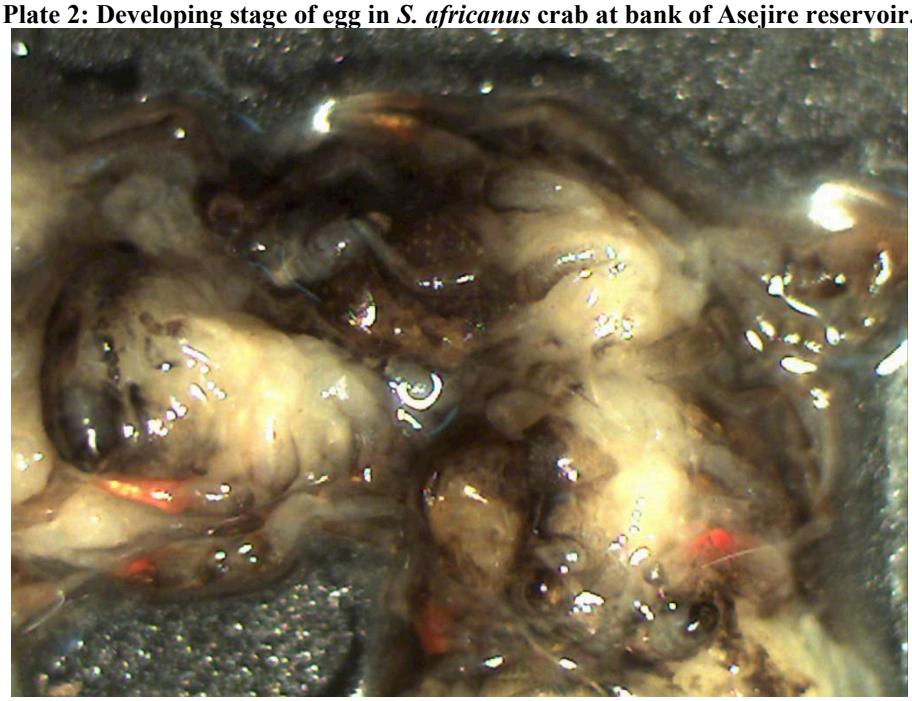

Plate 3: Viewed under microscope, scale bar = 1mm

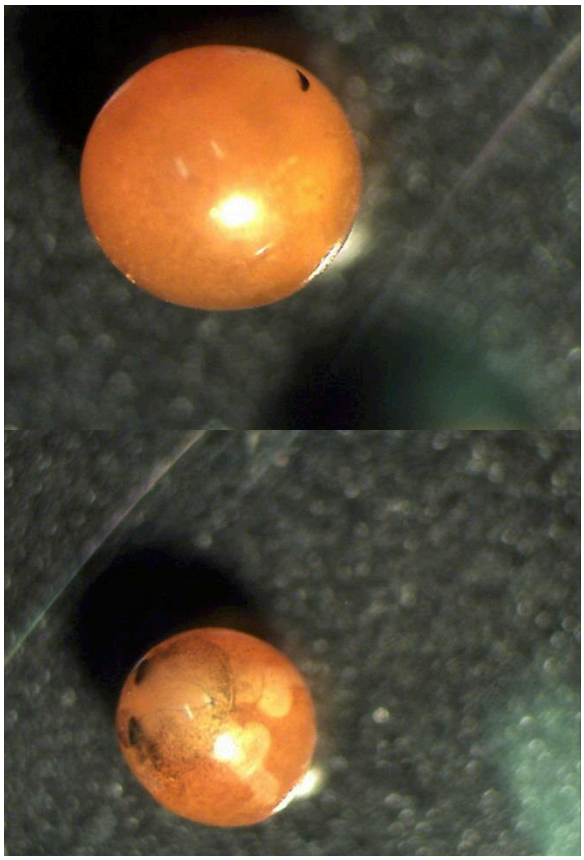

Plate 4
Developmental changes inside eggs (from 13 – 19 days), Scale bar = 1mm

Plate 1a: Gravid female of *S. africanus* on Asejire reservoir

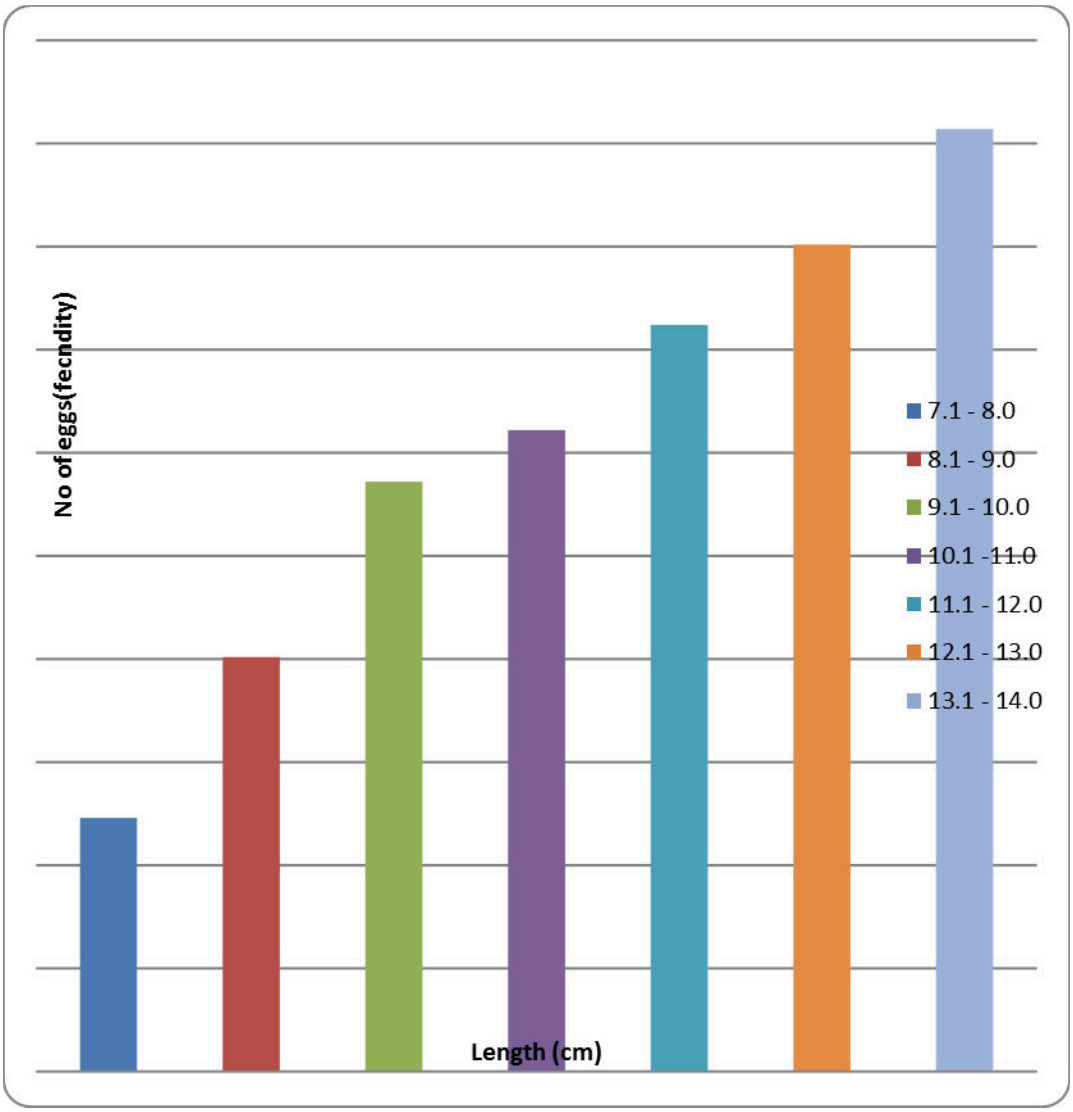

Figure 2: Fecundity of *S. africanus* on banks of Asejire reservoir

Gravid females were used for fecundity studies (Table 1). Result of fecundity showed that the number of eggs carried by crabs ranged from 120 to 451 with an average diameter of 1mm-2mm per egg and increased to between 3 to 4.5mm as they develop towards hatching. This indicates that gravid female of *S. africanus* lay up to half a thousand eggs. The result also indicates that female crabs with the highest fecundity (451eggs) was 12.5cm in length while the female crab with the lowest fecundity (120 eggs) was 6.5cm in length indicating that the number of eggs carried by matured female crabs depends on their size. This also implies that there is a relationship between the carapace length of the crabs and the number of egg carried.

This further shows that there is a strong correlation between the fecundity and the weight of the gravid crabs. As the gonads mature, there was change in the colour of egg, at every developmental stage from orange to yellow and finally to brown It was also observed that the female crab usually carry the newly hatched young ones in their chest (pleopods) for about (2-3weeeks). Plate 1-4 shows the different changes in color of egg from one developmental stage to the other.

Discussion

Eggs were observed to hatch directly into juvenile stages, as reported by Cumberlidge, (1999) for freshwater crabs, and Gross and Kaus, (2005) also reported that female crab was found with egg and hatchling in their abdominal pleopods showing early care for their offspring which is a modification for adaption in freshwater habitat (Cumberlidge, 1999).

It was observed that females mostly reside in their holes, taking care of their un-hatched eggs and young ones especially in the wet season while males are found outside, searching for food and mating. This result agrees with Lawal-Are, (2009) who reported more female crabs' occurrence than males during the wet season in Lekki Lagoon and Badagry with a ratio of 1:2 and also with the report of Bello-Olusoji *et al*., (2010)

that there are more female crabs than male in Abule Akure. The percentage of male crab seen at the study area is good for reproduction and this agrees with Arana, (2000).

The result of *S. africanus* with average egg of 250 agrees with the report of Cumberlidge and Sachs (1991) that a typical freshwater crab will carry up to 500 eggs around 1mm in diameter

Disney (1971) on *Plathythelphusa* in lake Tanganyika, reported average egg size recorded was 1.5-1.9mm in diameter similar to Cumberlidge, (1999) that newly laid eggs of freshwater crabs react 1.5mm in diameter carried in the abdominal brood pouch for brooding and hatchlings unlike the blue crabs *C. sapidus* that lay several thousand to a million eggs in high salinity water and develop into juvenile with average diameter of 0.25-0.35mm (Sharov *et al*., 2003).

Ng, (1988), reported that the deposition of the yolk in female takes place mostly in April–June with most of the eggs reaching maturity at the end of June, while the main brooding season is from June to October although breeding can occur all year round in agreement with *S. africanus* at Asejire reservoir where female crabs were observed carrying eggs mostly in the wet season showing that Males have sperm available for mating throughout the year.

The present result is incomparable with Carsen *et al*., (1996) that sexual maturity occurs at 40–50mm carapace length in female *P. patagonicus*. This indicates that *Platyxanthus patagonicus* reach maturity at early sizes than *S. africanus* which is a freshwater crab. Also various factors may be responsible for the differences in parameters of length-weight relationships in different seasons and species. Sparre (1992) stated that this may be due to temperature, salinity, food (quantity and quality), sex and maturity stage The correlation co-efficient (r= 0.069) of the length–weight relation was very high, indicating that changes in total length and weight of the crabs were proportional, in agreement with an earlier report of Younger (1985). Some other factors such as food availability, sex and season may contribute to the variation in weight of the samples. During wet and dry season, the crabs showed a slight increase in the total length and weight especially during the wet seasons.

A comparison of the weight range of *S. africanus* and *C. sapidus* shows that *S. africanus* have a low weight range compared to other crabs. According to Bello-Olusoji *et al.*, (2006), the weight of adult Portunid crabs (*C. palidus*) is greater than that of *S. africanus*. The results show that marine crabs are bigger than *S. africanus* freshwater crabs.

Study of Portunid crabs *C. pallidus* from the gulf of Guinea (Stickney, 1972) and *S. africanus* result of Bello-Olusoji *et al*., 2010 is similar to results observed on *S. africanus* that there was a positive correlation between the fecundity and weight of gravid crabs. Crabs with bigger sizes carry more eggs and those with smaller sizes can carry low number of eggs because fecundity seem to depend on the length and weight of the crabs. The relationship between fecundity and female size has shown a potential trend.

The five gonadal developmental stages of *S. africanus* observed show large eggs and different yolk colour change at each developmental stages in correlation with the result of Ng, (1988), that eggs of freshwater crabs are large with orange colour yolk. and it hatch directly into young crab.

The change in colour of egg in *S. africanus* freshwater crabs from green to yellow and to orange to brown and finally off white are similar to those described by Guillory and Hines (1997). Bardarch, *et al.,* (1972). also reported that the newly laid eggs of African freshwater crabs have bright orange colour and change slowly to dull brown, dirty grey and then to black before they finally hatch into a tiny larva (zoea).

The number of eggs brood by *S. africanus* is very small compare with hermit crab *Diogenes pugilator* which can brood 900 and 2838 eggs depending on the size of the female (Manjon-Cabeza and Garcia- Raso, 2000). The number of eggs per brood is determined by the size of the species at maturity. The large *P. armata* may carry up to 900 eggs whereas the marine crabs may produce hundred of thousand of much smaller eggs. Brood sizes are small because of the parental care shown by freshwater species. Eggs and hatchlings are cared by the female in her abdominal brood pouch until they are large enough to fend for themselves. Gardner, (1995) reports a female *Sudanonautes orthoslis* with a carpace length of 24mm captured in the process of releasing her brood up to thirteen juveniles each 3.5mm CW were found in her brood. A problem noticed affecting the rate of eggs laid by *S. africanus* was also reported by Cumberlidge, (1991). In a specimen of *S .africanus* captured with carapace length 81mm carry 261 eggs with a chamber not tightly sealed and several juveniles were escaping through the opening . This observation is similar to what obtained in *S. africanus* females carrying eggs loses some when moving fast.

Majority of the females collected during the wet season were incubating eggs. This suggests that spawning and hatching take place more during the wet season and all the crabs with eggs weigh more than those without eggs which cause an increased weight and length. The Mortality report of *S. africanus* at Asejire was in agreement with Cumberlidge, (2002) that mortality of *S. africanus* in the natural habit could be due to harsh season, old age, predators and pollution from the environment. All true freshwater 1crabs complete their entire life cycles in fresh water or terrestrial habitats and never enter the sea at any stage of their life (in fact, they actively avoid salt water environments) (Cumberlidge, 2008). This option is possible in true freshwater crabs because their reproductive strategy is modified so that their embryos hatch directly to produce juvenile crabs. It

has been shown that in true freshwater crabs all of the normal brachyuran larval stages (e.g. nauplius, zoea, megalopa) are passed through during a lengthy embryonic development within the egg resulting in young hatchling crabs emerging directly out of mature eggs (Wu et al., 2010). This strategy adopted by freshwater crabs replaces that used by the majority of marine crabs, in which eggs hatch in seawater and release a free-living aquatic larva that metamorphoses while floating in the plankton.

The evolution of fluid-filled waterproof egg cases, however, has allowed direct development to take place in the true freshwater crabs and has freed them from having to return to the sea to complete their life cycle.

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