# *CHAPTER 9 - REPRODUCTIVE BIOLOGY*

## 9.1. INTRODUCTION

Study on the reproductive biology is not only important for knowing the life cycle of the fish but also important for their captive maturation and breeding protocol establishment. Studies on maturation and breeding of fish were studied by various workers on different species. The scale for classifying gonad into different maturity stages based on microscopic examination was originally invented by Heincke, 1898 on herrings and later it is modified by Hjort, 1910 which is known as International Maturity scale or Hjort Scale. Qasim, 1973 proposed that gonadal maturity stages as- i) immature virgins, ii) maturing virgins or recovered spent, iii) ripening, iv) ripe and v) spent. Scott and Pankhurst, 1992 classified maturity stages in females as i) immature, ii) regressed, iii) vitellogenic, iv) hydrated, v) ovulated and vi) spent and in males as i) immature, ii) spermatogenic, iii) partially spermiated, iv) fully spermiated and v) spent in snapper gonads.Study on sex ratio indicates the proportion of male and females in the population which expected to be 1:1 in nature. But deviation may occur in fish because of behaviour of sexes, different experimental conditions and biased sampling. The ratio between gonad weight and fish weight is known as Gonadosomatic index or GSI. This index is used as avital indicator for determining the spawning season of the fishes. The knowledge of fish fecundity is also important in the estimation of reproductive potential. Study on fecundity of the fish was done by different previous workers (Mahapatra *et al.,* 2004; Mahapatra and Vinod, 2011; Banik and Saha, 2012; Sahoo *et al.,* 2014; Pal and Mahapatra, 2016). Clark, 1934 first made a study on ova diameter measurement. Some scattered information available for reproductive biology of *C. nobilis* (Rossman, 2008; Britz *et al*., 1995) but there is an urgent need of detail study on reproductive biology i.e. maturity, GSI, fecundity.

### 9.2. MATERIALS AND METHODS

The reproductive biology will include: i) sexual diamorphism, ii) sex ratio iii) maturity cycle, iv) age of sexual maturity, v) fecundity, vi) spawning season, vii) Gonado somatic index (GSI), viii) fecundity and ix) ova diameter in captive condition.

#### 9.2.1. Sexual dimorphism, sex ratio and maturity stage:

A total of 325 live fish specimens covering all the size ranges were measured, weighed, aged and sexed for studying the sexual dimorphism, different maturity stages, sex ratio and size at first maturity. Ratio of male and female fish was also calculated.

#### 9.2.2. Morphology of gonad:

After taken the total length in nearest millimeter and weight in nearest gram, the ovary from each fish were removed carefully. The moisture was thoroughly wiped out from the ovaries with a blotting paper. The length of the ovaries was recorded to the nearest millimetre and weight of ovaries was noted down to gram (**Figure 43**). The morphological characters of the gonads will then preserve in Gilson's fluid (Simpson, 1951) for further microscopic examination. Relationship between ovary length and weight and fish total length and weight were determined by: $\text{Log } Y = a + b \text{ Log } X$


**Figure 43. Length and weight data collection of the gonad**

**(See colour photo in Plate No. X, Fig. 28)**

**9.2.3. Gonadosomatic index:**

The Gonadosomatic index (GSI) was also calculated. Seasonal changes in gonadosomatic index was calculated.

$$\text{GSI} = \frac{\text{Weight of gonads}}{\text{Total weight of fish}} \text{x} 100$$

**9.2.4. Fecundity:**

A total number of 22 females of *C. nobilis* were observed during the breeding season were used for fecundity studies. After about 6 weeks of fixation, ova were washed with tap water and left on a filter paper to dry. Four subsamples (air dried) were taken and counted separately for the number of ova present. The formula used for fecundity calculation is:

$$\text{F} = \frac{\text{W}}{\text{W1} + \text{W2} + \text{W3} + \text{W4}} \text{x} \,(\text{N1} + \text{N2} + \text{N3} + \text{N4})$$

Where F= Fecundity; W= total weight of the ovary; W1, W2, W3 and W4 = weight of the each subsample and N1, N2, N3 and N4 = ova number of each subsample.

The relationships between fecundity and fish length; fecundity and fish weight; fecundity and ovary weight; fecundity and ovary length were analysed. The relationships were determined by the method of least squares (Snedecor, 1946). The fecundity factor (No. of ova per gram body weight of fish) was also calculated.

**9.2.5. Ova diameter:**

Some female were selected for ova diameter studies. As recommended by Clark, 1934 and Qasim and Qayyum, 1961; 100 ova from both the lobes will collect randomly and will measure with the aid of an ocular micrometer.

All statistical relations were measured with the aid of computer using MS Excel.

**9.3. RESULT**

**9.3.1. Sexual dimorphism of the fish:**

For breeding purpose it was very necessary to separate male and female accurately and rapidly through some external characters. In the early stages, it was very difficult to separate the male and female from each other. But the adult male fish are clearly recognizable with their broad “spouts” (**Table 66**). The dorsal fin base of male is more curved than the female (**Figure 44**). The males are comparatively brighter and colourful than the females.

**Table 66. Sexual dimorphism of *C. nobilis***

| Characters | Male | Female |
|---|---|---|
| **Body size** | Comparatively larger and mascular body | Small body with broad belly |
| **Throat** | Broad and bigger throat | Comparatively smaller throat |
| **Colour** | Darker colour | Dull in colour |
| **Fin colour** | End of fin is reddish | End of fin is gray |
| **Special colour at dorsal side** | White V shaped colour combination just in front of dorsal fin | This special character absent |
| **Curve at dorsal side** | End of dorsal fin more curved | End of dorsal fin little curved |


**Figure 44. Sexual dimorphisms of *C. nobilis***

**(See colour photo in Plate No. X, Fig. 29)**

### 9.3.2. Sex ratio:

Among the 325 specimens studied, 207 and 118 have been observed to be male and female respectively (**Table 67**). The average ratio of males to females has been observed to be 1.97:1. Overall males have shown significant dominance over females in all seasons.

**Table 67. Seasonal variation in sex ratio of *C. nobilis***

| Month | Sample size | No. of Male (Observed value) | | No. of Female (Observed value) | | Ratio | |
|---|---|---|---|---|---|---|---|
| | | No. | % | No. | % | Male | Female |
| Pre-Monsoon | 97 | 69 | 71.13 | 28 | 28.86 | 2.46 | 1 |
| Monsoon | 63 | 38 | 60.31 | 25 | 39.68 | 1.52 | 1 |
| Post-Monsoon | 86 | 57 | 66.27 | 29 | 33.72 | 1.96 | 1 |
| Winter | 79 | 43 | 54.43 | 36 | 45.57 | 1.94 | 1 |

**9.3.3. Length and weight at first maturity:**

50% of all female specimens attaining their first maturity at the length of 75-85 mm and weight of 5.50-6.45g. In case of male, 50% specimens attaining their maturity at length of 68-72mm and weight of 4.75-5.82g get matured. During the spawning season (July to September) maximum females above the 80 mm have been observed with mature ovaries and males above the 70 mm have been observed with mature testes.

### 9.3.4. Gonad of the fish:

The gonad of the fish is very small in length and asymmetric lobes. At immature stage it is nearly transparent in colour and elongated shape where as the matured gonad become slight yellowish in colour and nearly spherical shaped (**Table 68**, **Figure 45**).

**Table 68. Different maturity stages of gonad of *C. nobilis***

| Stages of maturity | Male | Female |
|---|---|---|
| **Immature** | Ovaries transparent, thread like and translucent in appearance. Under microscope ova are irregular in shape and transparent but Ova are not visible in naked eyes. | Testes whitish in colour, small in size and thread like in appearance. |
| **Maturing** | Ovaries thread like and light yellowish in colour. Under microscope ova are almost spherical and partly opaque. Minute Ova are visible to naked eyes. | Whitish testes enlarged in size and weight. |
| **Matured** | Ovaries yellowish in colour. Ova are spherical in shape and opaque in appearance. It is relatively large in size. Ova are clearly visible to naked eyes. | Whitish testes enlarged in size and weight. |
| **Ripe** | Asymmetric ovaries are yellow in colour. Ova are spherical in shape and opaque. | Creamy white colour testes enlarged in size and weight |

Maturing Gonad

Ripe Gonad

**Figure 45. Different stages of gonad of female fish**

**(See colour photo in Plate No. X, Fig. 30)**

### 9.3.5. Gonadosomatic Index of the fish:

The breeding season of the fish extend from late July to September. The gonadosomatic index (G.S.I) fluctuated from 1.93 to 5.95. Lowest value of G.S.I. has been observed in the month of December; then it started to increase from January onwards and reached the first peak in May and then dropped down in June and then again reach highest peak in August; then dropped down in September and maintained the trend till October; then reach the lowest value again in December (**Figure 46**). Seasonal changes of mean GSI of *C. nobilis* was found in **Figure 47**.

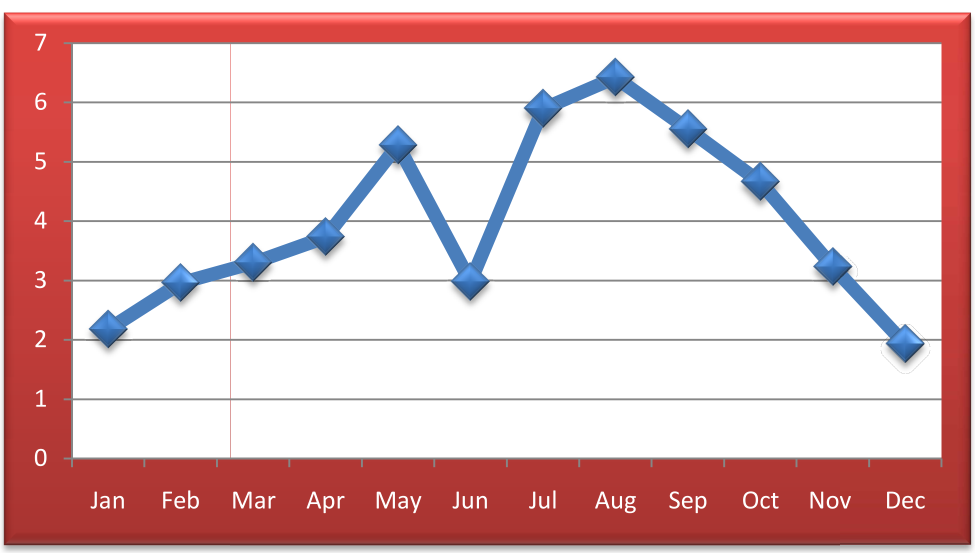


**Figure 46. Monthly changes of GSI**

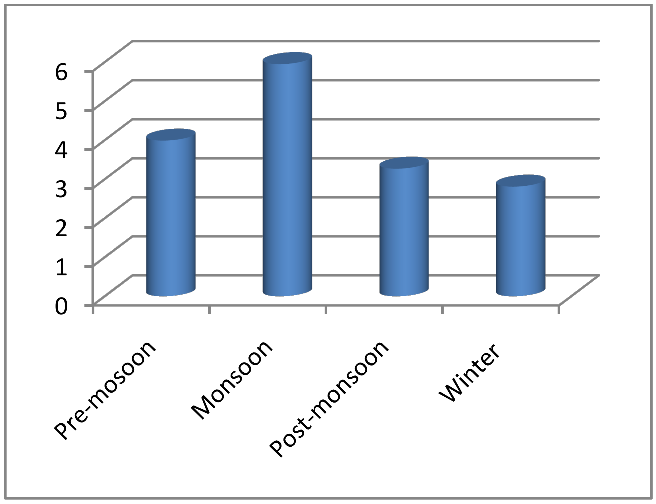


**Figure 47. Seasonal changes of GSI**

### 9.3.6. Ova diameter of matured gonad:

Seasonal fluctuation of weight of the gonad and ova diameter was recorded. The ripe ova (590-1055 µm) have been observed from April to October. The ova diameter (**Figure 48**) varied from 415µm to 1055µm.

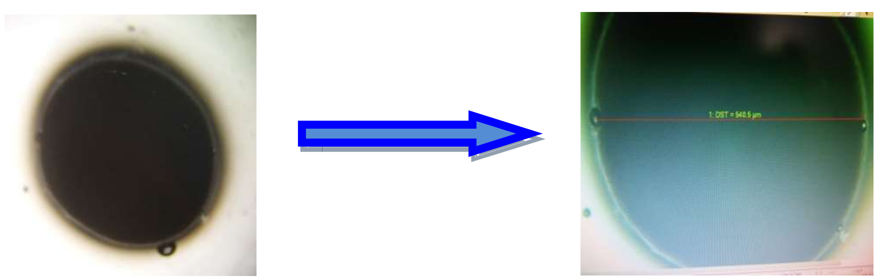

**Figure 48. Ova diameter of *C. nobilis***

### 9.3.7. Fecundity:

Ovaries were taken from individuals of known length and weight ranged from8 to 14 mm and 0.16 to 0.41 g respectively. Fecundity has been observed to vary between350 (for a fish of total length 76mm, body weight 5.55g, ovary weight 0.16g and ovary length 20mm) to 750 (for a fish of total length 85mm, body weight 6.45g, ovary weight 0.41g and ovary length 14 mm). The number of mature eggs per gram of body weight (fecundity factor) ranged from 63.07 to 116.28 with an average of 87.65 matured eggs.

**a) Relationship between fecundity (F) and fish length (TL)**

The scatter diagram revealed a linear (**Figure 49**) relationship between fecundity and fish length and the coefficient of correlation was significant at 1% level($p < 0.01$). The relationship between fecundity (F) and total length of the fish (TL) is expressed by the equation:**Log F = -7.799+5.534 Log TL**

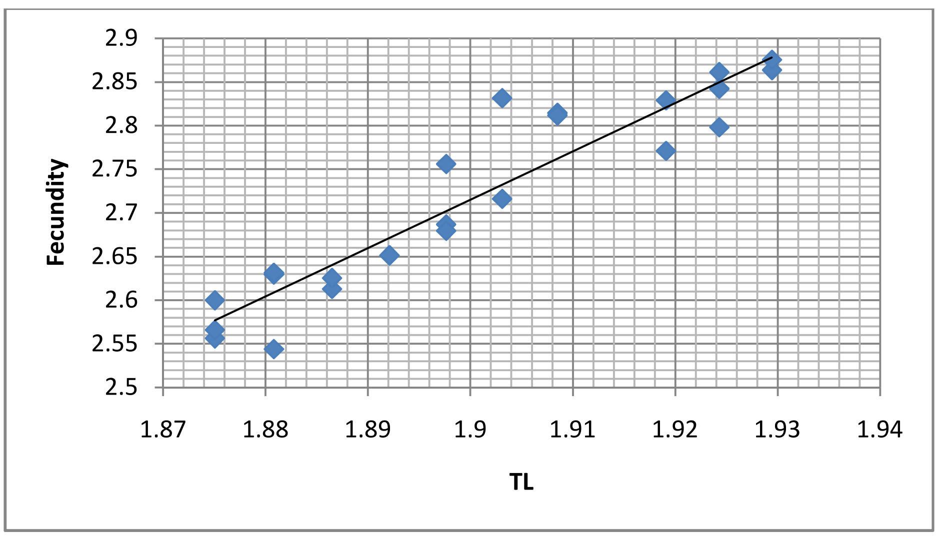


**Figure 49.Fecundity and Total length of the fish relationship in *C. nobilis***

**b) Relationship between fecundity (F) and Fish weight (FW)**

The scatter diagram revealed a linear (**Figure50**) relationship between fecundity and fish weight and the coefficient of correlation was significant at 1% level ($p < 0.01$). The relationship between fecundity (F) and Fish weight (FW)is expressed by the equation: **Log F = -1.089 + 4.915 Log TW**

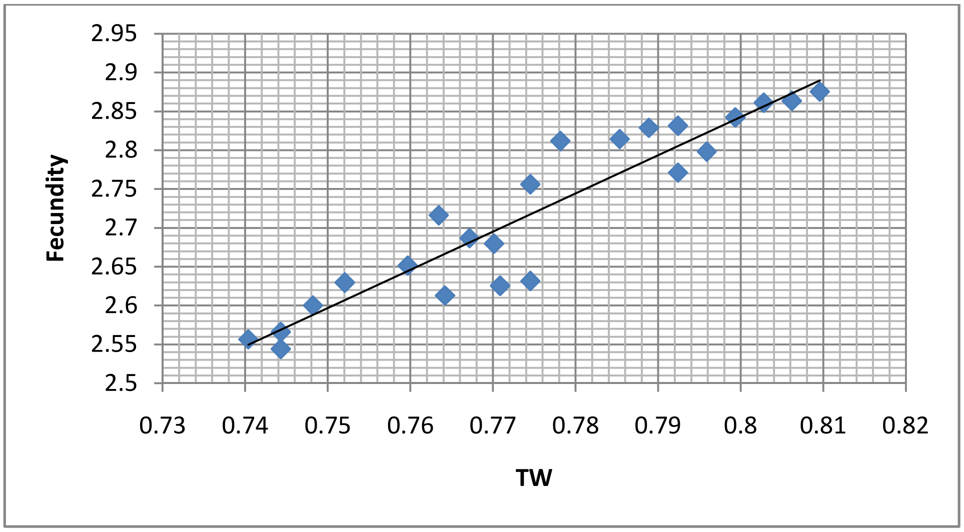


**Figure 50. Fecundity and total weight of the fish relationship in *C. nobilis***

**c) Relationship between fecundity (F) and ovary weight (OW)**

The scatter diagram revealed a linear (**Figure 51**) relationship between fecundity and ovary weight and the coefficient of correlation was significant at 1% level ($p < 0.01$). The relationship between fecundity (F) and ovary weight (OW)is expressed by the equation:**Log F = -2.446 + 1.179 Log OW**

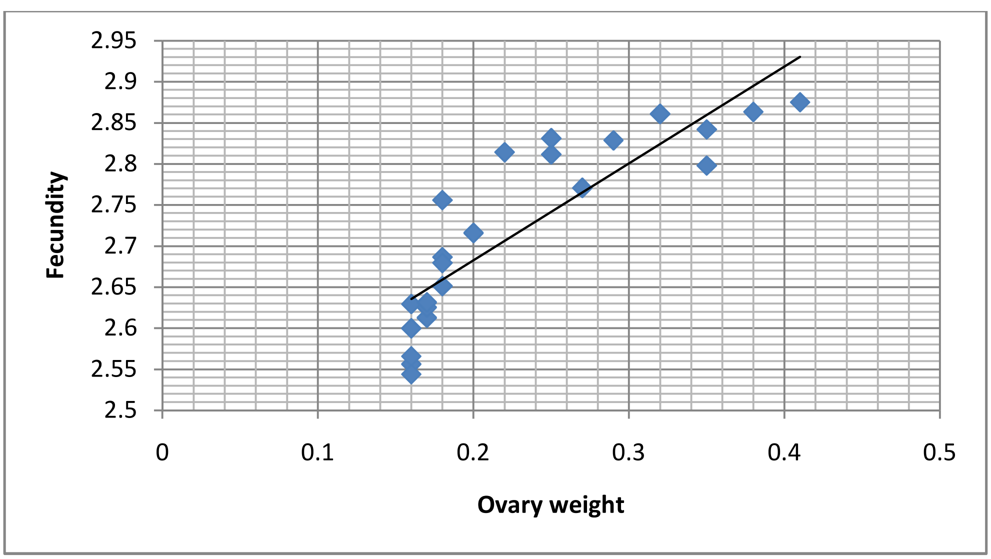


**Figure 51. Fecundity and ovary weight relationship in *C. nobilis***

**d) Relationship between fecundity (F) and ovary length (OL):**

The scatter diagram revealed a linear (**Figure 52**) relationship between fecundity and ovary weight and the coefficient of correlation was significant at 1% level ($p < 0.01$). The relationship between fecundity (F) and ovary weight (OL)is expressed by the equation:**Log F = -1.485 + 1.243 Log OL**

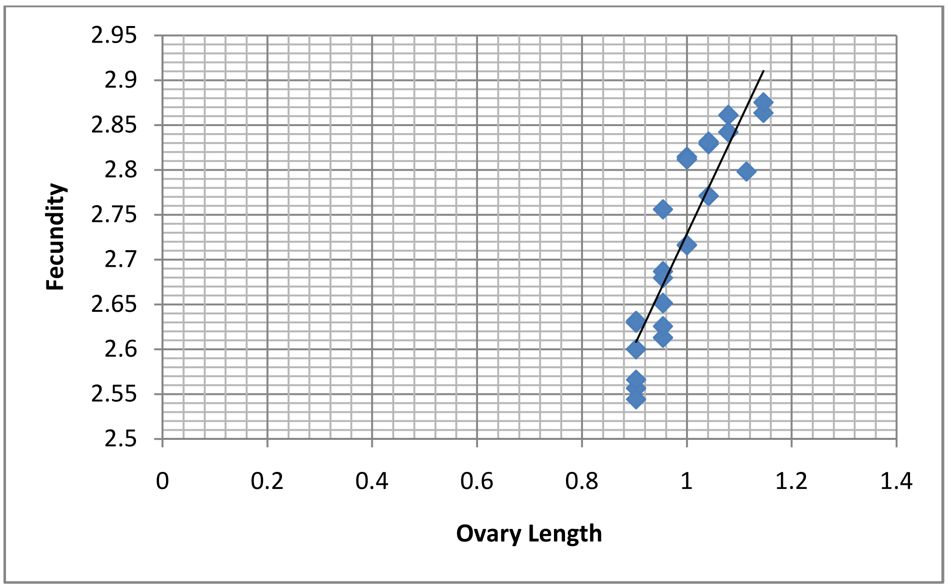


**Figure 52. Fecundity and ovary length relationship in *C. nobilis***

**e) Relationship between ovary length (OL)and total length (TL):**

The scatter diagram revealed a linear (**Figure 53**) relationship between fecundity and ovary weight and the coefficient of correlation was significant at 1% level ($p < 0.01$). The relationship between total length (TL) and ovary length (OL)is expressed by the equation:**Log OL = -6.767 + 4.028 Log TL**

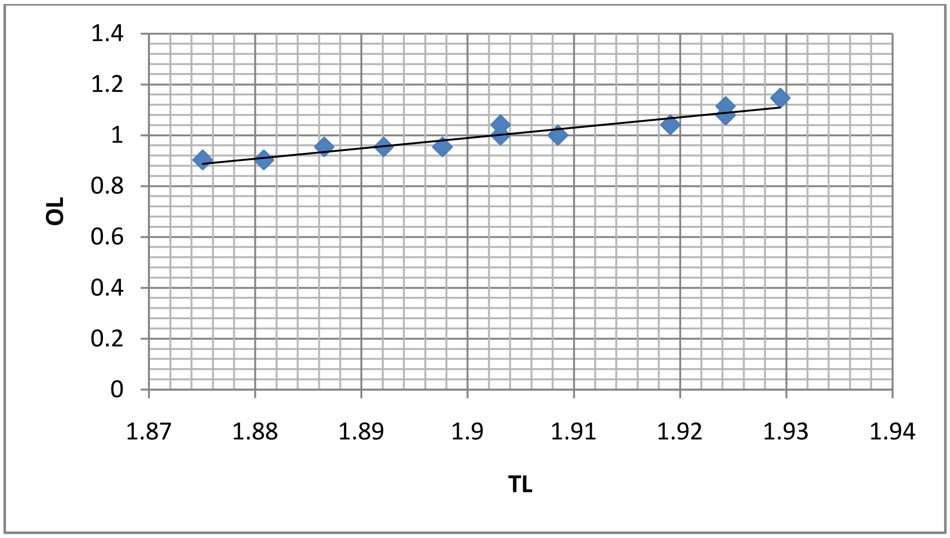


**Figure 53.Ovary length and fish length relationship in *C. nobilis***

**f) Relationship between ovary weight (OW) and total weight (WT):**

The scatter diagram revealed a linear (**Figure 54**) relationship between fecundity and ovary weight and the coefficient of correlation was significant at 1% level ($p < 0.01$). The relationship between total weight (TW) and ovary weight (OW)is expressed by the equation: **Log OW = -5.371 + 6.080 Log WT**

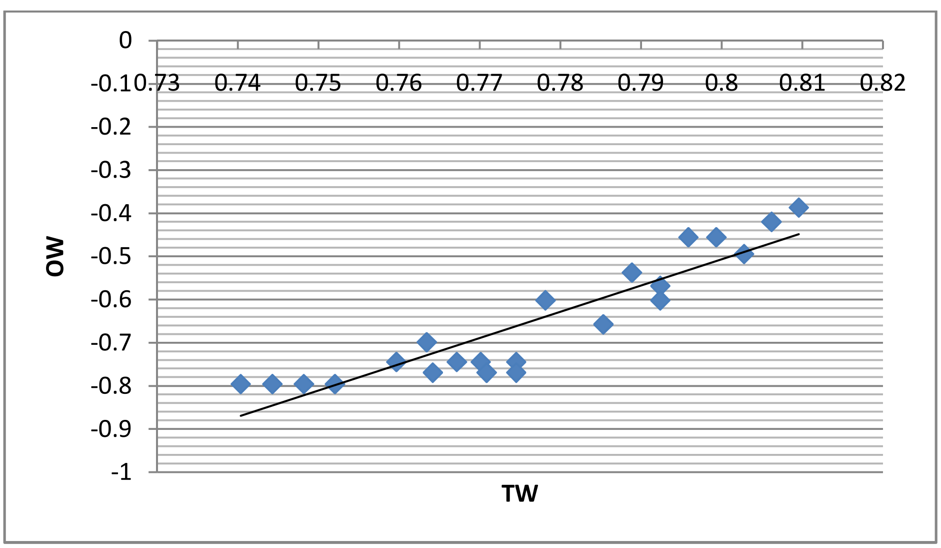


**Figure 54.Ovary weight and fish weight relationship in *C. nobilis***

## 9.4. DISCUSSION

Sexual dimorphism is one of the most important criteria for reproductive biological study of any organism. In early stages sexual differentiation of *C. nobilis* is very hard but adult male are clearly identified by broad and bigger throat and 'V' shaped white colouration at dorsal side. Rossman, 2008 was also observed broad throat area of male fish. Sex ratio of the fish proves there is a constant male domination over the female. In case of female first maturity observed at the length of 75-85 mm and weight of 5.50-6.45g where as in male maturity observed quite earlier at 68-72mm length and 4.75-5.82g weight. Female ovaries are small, yellowish in colour and asymmetric bi-lobbed. In matured gonad ova can observed in naked eye. The GSI ranges between 1.93 to 5.95. Highest value of GSI observed in August and lowest value of GSI has been observed in the month of December. Ova diameter of mature female varies between 590-1055 μm. Britz *et al*, 1995 also observed almost spherical eggs of diameter 1.9 to 2.1 mm. 350-750 fecundity range observed during the study period. There is a strong correlation observed ovary length and weight with total length and weight of fish. The exponential value of b was tested against '3' and was found to be significantly different at 1% level. The study also observed highest correlation between fecundity and fish length which is similar to the study by Behara *et al.,* 2005 on relationship between fecundity and total length and ovary weight of *T. fasciatus*. The breeding season of the fish extend from late July to September.