Fecundity and its role in racial studies of *Gudusia chapra* (Pisces: Clupeidae)

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Abstract. The fecundity study of 80 specimens of *G. chapra* from both the Keetham lake and the Ganga river system in and around Allahabad reveals that (i) the bigger-sized fish had relatively more ovarian eggs and the average fecundity value of different length and weight groups showed direct proportionate increase with the increase of the fish size. The number of eggs also proportionately increased with increase in the weight of the ovary, (ii) the two ovaries together accounted for 2.15 to 14.87% of the total weight of the fish, average being 5.67%, (iii) the average number of eggs per gm weight of fish and per 100 mg weight of the ovary were calculated to be as 947 and 1707 respectively, (iv) the various relationships involving fecundity—fish length,—fish weight and —ovary weight were found to be linear of the form \( y = a + bx \), the linearity showed significant at 1% level, and (v) the differences were found in the mean fecundity number and the egg size between the two populations, the Keetham fish had more number of eggs of relatively smaller size than the Ganga which had less number of larger-sized ones. The \( t \) test between the two mean fecundity showed significant difference at 5% level.

Keywords. Fish fecundity; *Gudusia chapra*; racial studies.

1. Introduction

The fecundity of a fish may be defined as the number of eggs that are likely to be laid during a spawning season. A knowledge of fecundity and its relation to the size of a fish makes it possible to estimate the number of eggs likely to be liberated. In fish cultural management programme, if the number of eggs likely to be obtained by spawning stock is known, it is easier to make arrangements for their successful hatching. In capture fisheries, however, the fecundity-size relationship is made use of in estimating the number of spawners in the fish-stock. The number of eggs produced may differ in different species with differences in size and age of fish as well as in the same species of different stock or race. Kesteven (1950) pointed out that variation in the composition of a population with regard to age and size and the dependence of fecundity upon the factors would mean variation from year to year in the total fecundity of the population, which when combined with wide differences in the favourability of the environment for the reception of the eggs, could cause changes

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in each year brood of the young stock. But Merriman (1941) held the view that changes in the numerical strength of the spawners had no significant effect on the strength of the comng brood. The fair differences observed in the number and the size of the eggs between the population of *G. chapra* of the Keetham lake of Agra (Chondar 1975) and the Ganga river system in and around Allahabad (Jhingran 1966), induced the author to take up this study as a part of the series of work on the biology and the raciation of the fish for both the populations.

2. Material and methods

80 (eighty) ovaries of the specimens from both the Keetham and the Ganga river system in and around Allahabad were utilised for this study. The specimens constituted all age groups and were of length ranging from 109·0 to 204·0 mm. The fishes of the above length range were selected keeping in view the minimum size on attainment of first maturity of the species from both the waters as recorded by Chondar (1975) and Jhingran (1968). The ovaries were collected intact very carefully. Its weight was taken in fresh condition, and then preserved in 2·5% formalin for about a week. At the time of work they were taken out of formalin and boiled in fresh water for about 10 min. This enabled the breakdown of the ovarian tissues considerably, and ova were freed from the covering membranes. The eggs were boiled again in freshwater for about 5 min, and they were completely liberated from the ovigerous lamellae after a few vigorous shakes with water in a tube. When the ova had settled down the supernatant water was decanted. The washed eggs were transferred on a blotting paper and air-dried for 15-30 min, when the remaining membranes and connecting tissues were removed by a forceps. The entire mass of the ova was weighed. Two samples of 100 mg each were taken from the mass, and the number of ova in each sample was counted separately under binocular microscope, and the total number of ovarian eggs was estimated by the formula,

\[ F = \frac{W}{W_1 + W_2} \frac{1}{N_1 + N_2}, \]

where \( F \) = fecundity, \( W \) = weight of total ova, \( W_1 \) and \( W_2 \) are weights of samples one and two, \( N_1 \) and \( N_2 \) the number of ova present in samples one and two. The advantages of this method as suggested by Antony Raja (1971) and Leeuwen (1972) are that the ova not only completely liberated from the ovary but the immature oocytes are also washed away during repeated decantings, keeping the yolked ova left behind. The immature ova below 200 micra diameter in size were not counted because the fecundity counts made on only the mature stock of eggs, which are alone shed during the ensuing spawning.

3. Observations and results

It is evident from the data computed that the fecundity of some individual specimens showed remarkable variations. This is likely because of the differences in the weight of the ovary and or maturity conditions of the individuals of same size. Moreover,
the number of ova of same weight of ovaries of similar stage at times showed a
difference, because the production capacity of eggs per individual may not be the
same. Further, the ova count of a sample of eggs taken at random from the ovary
for counting, gives only a rough estimate of the potential stock of the ovary. The
number of ova may vary in different samples obtained from the same ovary. This
is perhaps owing to the variations in the size of the ova, heterogeneous distribution of
various-sized eggs and for other reasons as pointed in the fecundity study of *Labeo
gonius* (Chondar 1970).

3.1. Fish size, gonad weight and average ova production

It is seen that not always but normally the bigger-sized fish had relatively more
ovarian eggs, although the maximum number of ova was estimated as 64,280 for a
fish measuring 129·0 mm and the minimum number as 9,119 in a specimen measuring
86·0 mm in standard length (within the size range recorded here). The fecundity
value of each 10 mm standard length-group has been computed in table 1. Although
the individual variability in the number of eggs in each length-group was very high,
the average fecundity value of the different length groups showed a direct proportion-
ate increase from 18,252 to 36,712 with the increase of the mean standard length
from 85·0 to 165·0 mm.

The number of eggs per gram weight of fish was calculated to be as 345 to 2077,
average being 947. The average egg production in each 10 gm group of fish-weight
as plotted in table 2 also indicated a clear upward trend of increase in the number of
ova from 20,925 at the mean weight of fish of 15·0 gm to 40,027 at 75·0 gm.

| Table 1. Average ova production on different standard-length groups of *Gudusia chapra*
<table>
<thead>
<tr>
<th>Standard length in mm</th>
<th>No. of fish examined</th>
<th>No. of eggs in the length group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td>80·1 — 90·0</td>
<td>85·0</td>
<td>8</td>
</tr>
<tr>
<td>90·1 — 100·0</td>
<td>95·0</td>
<td>7</td>
</tr>
<tr>
<td>100·1 — 110·0</td>
<td>105·0</td>
<td>11</td>
</tr>
<tr>
<td>110·1 — 120·0</td>
<td>115·0</td>
<td>10</td>
</tr>
<tr>
<td>120·1 — 130·0</td>
<td>125·0</td>
<td>12</td>
</tr>
<tr>
<td>130·1 — 140·0</td>
<td>135·0</td>
<td>10</td>
</tr>
<tr>
<td>140·1 — 150·0</td>
<td>145·0</td>
<td>7</td>
</tr>
<tr>
<td>150·1 — 160·0</td>
<td>155·0</td>
<td>10</td>
</tr>
<tr>
<td>160·1 — 170·0</td>
<td>165·0</td>
<td>5</td>
</tr>
</tbody>
</table>

| Table 2. Average ova production on different fish-weight groups of *Gudusia chapra*
<table>
<thead>
<tr>
<th>Total weight of fish in gm</th>
<th>No. of fish examined</th>
<th>No. of eggs in the weight group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>Mean</td>
<td></td>
</tr>
<tr>
<td>10·001 — 20·000</td>
<td>15·000</td>
<td>19</td>
</tr>
<tr>
<td>20·001 — 30·000</td>
<td>25·000</td>
<td>15</td>
</tr>
<tr>
<td>30·001 — 40·000</td>
<td>35·000</td>
<td>14</td>
</tr>
<tr>
<td>40·001 — 50·000</td>
<td>45·000</td>
<td>15</td>
</tr>
<tr>
<td>50·001 — 60·000</td>
<td>55·000</td>
<td>7</td>
</tr>
<tr>
<td>60·001 — 70·000</td>
<td>65·000</td>
<td>8</td>
</tr>
<tr>
<td>70·001 — 80·000</td>
<td>75·000</td>
<td>2</td>
</tr>
</tbody>
</table>
The two ovaries together of an individual fish ranged from 2.15 to 14.87% with an average of 5.67% of the total body weight. The number of ova per 100 mg weight of mature ovary was estimated at 902 to 2480, taking an average of 1707. The fecundity shows very clear proportionate increase in the average number of eggs from 14,367 to 64,280 with the increase of the mean weight of ovary from 750 to 4,250 mg (table 3).

3.2. Fecundity and its relation to fish size and ovary weight

3.2.1 Fecundity — Fish (standard) length

Kislevitch (1923), Clark (1934) and Schaefer (1936) expressed that the number of eggs released at a single spawning increases with the length of the fish. Although the relationship between fecundity and length was generally found to be curvilinear in fishes but the straight-line relationship of these two variants as described by various authors are not uncommon. According to Heidrich (1925) and Kesteven (1942), the number of ova holds some exponential relation with the length of the fish in the same manner as does the weight. Kesteven (1942) further stated that the gonad maintains a relationship with the remainder of the body of the organisms, and since the size of maturing and mature ova is constant in general, the number of eggs, being in effect a number of units of weight, will show an exponential relation with the length in the same way as dose the weight of the entire organisms. Length-fecundity relation has been expressed by an equation of the form \( F = a l^b \) (Raitt 1933; Katz 1945; Simpson 1951). Simpson (1951) and Bagenal (1957) stated that this relationship is normally non-linear. Mitchell (1913) assumed that the egg production is proportional to length cubed. Simpson (1951) and Pitt (1964) also hold this view and expressed that the fecundity is related nearly to the cube of the length for plaice; but Clark (1934) observed the value to be square of the length; while Farran (1938), Hickling (1940) and Nagasaki (1958) got the value to vary between 3 and 4.5. Raitt (1933) observed the value as 3-8, and Hodder (1963) as about 5 for haddock. Qasim and Qayyum (1963) have found that the number of ova is increased at a rate reaching 5.4 power of the length. Rounsefell (1957) stated that over the narrower range of length at first maturity found in *Onchorhynchus* sp., the straight line equation adequately describes the relationships, and this view was accepted by Foerster and Pritchard (1941). Hartman and Conkle (1960) fitted linear regression lines for *Onchorhynchus nerka*; Bhatnagar (1964) for certain Bhakra reservoir fishes; and Chondar (1970) for

**Table 3. Average ova production on different ovary-weight groups of Gudusia chapra**

<table>
<thead>
<tr>
<th>Ovary weight in mg</th>
<th>No. of ovary examined</th>
<th>Fecundity</th>
<th>Range</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500 — 1000</td>
<td>750</td>
<td>8</td>
<td>13,273 — 21,840</td>
<td>14,367</td>
</tr>
<tr>
<td>1001 — 1500</td>
<td>1250</td>
<td>23</td>
<td>9,119 — 32,210</td>
<td>23,689</td>
</tr>
<tr>
<td>1501 — 2000</td>
<td>1750</td>
<td>24</td>
<td>17,273 — 38,121</td>
<td>28,685</td>
</tr>
<tr>
<td>2001 — 2500</td>
<td>2250</td>
<td>16</td>
<td>22,311 — 49,320</td>
<td>36,001</td>
</tr>
<tr>
<td>2501 — 3000</td>
<td>2750</td>
<td>6</td>
<td>23,394 — 40,983</td>
<td>37,149</td>
</tr>
<tr>
<td>3001 — 3500</td>
<td>3250</td>
<td>2</td>
<td>49,000 — 50,103</td>
<td>49,551</td>
</tr>
<tr>
<td>3501 — 4000</td>
<td>3750</td>
<td>Nil</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4001 — 4500</td>
<td>4250</td>
<td>1</td>
<td>64,280 — 64,280</td>
<td>64,280</td>
</tr>
</tbody>
</table>
Racial studies of Gudusia chapra

In the present observation on Gudusia chapra, the relationship was found to be linear of the form $y = a + bx$, when the observed fecundity values were plotted against the standard length on a normal grid (figure 1), and the relationship was expressed by the equation:

$$F = 538.55 + 230.45 SL,$$

where $F$ is the fecundity and $SL$ the standard length of the fish. The test of linearity was applied and the relationship was found to be significantly linear at 1% level. The coefficient of correlation, $r$, was 0.5729, showing a fair positive degree of relationship between the fecundity and the standard length of the fish.

### 3.2.2. Fecundity—Fish weight

The fish weight and fecundity relation in haddock was found to be exponential (Raitt 1933). Smith (1947) found in Salvelinus fontinalis that fecundity was more related to the weight or volume of the fish than to the length. Simpson (1951) while studying the plaice indicated that fecundity is related nearly to the cube of the length and is thus directly proportional to fish weight. Yuen (1955) observed the relationship to be curvilinear. Allen (1951) got the curvilinear relationship between the number of ova and the fish weight in brown trout, but when he plotted the egg number against fork length it gave a straight line. Lehman (1953) has shown a direct proportional increase of egg number with the increase of fish-weight in the same manner as the length and the age of Hudson River Shad. In this study of G. chapra, a straight line relationship was obtained (figure 2) which is of the form:

$$F = 17535.84 + 321.77 W,$$

where $F$ and $W$ represent the number of ova and weight of fish in gram respectively. The linearity of the regression when tested was found to be highly significant at 1% level. The coefficient of correlation ($r = 0.5821$) declares a fair correlation between these two variables.
3.2.3. Fecundity—Ovary weight

Hickling (1940) indicated that since the egg production is the main function of the ovary, a close relation between the number of eggs and the weight of the ovary is expected. Saigal (1964) observed a close correlation between the weight of the ovary and the number of eggs in Mystus (Osteobagrus) aor. Bhatnagar (1964) showed a direct increase in number of eggs with the increase of the weight of ovary in Labeo dero and L. bata. Chondar (1970) determined a straight line relationship in L. gonius. The relationship between the ovary weight and the fecundity in G. chapra as observed here was found to be fairly close and linear in nature. The correlation coefficient, \( r \), being 0.8798, appears to be the highest amongst the three relationships studied here, and indicates that fecundity is more directly related to the weight of the ovary than the length and the weight of the fish. The fecundity-ovary weight relationship could be expressed as:

\[
F = 5051.934 + 13823.885 \times V,
\]

where \( F \) = fecundity and \( V \) = weight of ovary. The linearity of the regression (figure 3) was tested and was found to be significantly linear at 1% probability.

3.3. Fecundity in raciation

The fecundity study of 40 mature specimens each from the Keetham lake and the Ganga river system in and around Allahabad declared significant differences between them. The number of eggs of the same body length and weight of fish from Keetham was found to be higher than that of the Ganga. The maximum (64,280), minimum
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(15,104) and the average (31,291) egg numbers of the Keetham were higher than those of the Ganga, which had the fecundity as maximum 50,103; minimum 9,119 and the average 26,891. The *t* test on the mean values of the fecundity between the two stocks showed significant differences at 5% level (*t* = 2.12 for *t*0.05 = 1.99) (table 4), declaring them as two separate populations.

The observed differences in the fecundity (in mean egg number and size) between the Keetham and the Ganga *Gudusia* suspected to be genetical. The Keetham fish had more number of eggs of relatively smaller size as against the Ganga specimens which had less number of large sized eggs in the same body length and weight of fish. This finding holds good the opinion of Parrish and Saville (1965) who believed that fecundity and egg size are more likely to be genotypic than many other features used to characterise herring stock.

The prospects of fecundity characters in racial separation of fish have also been anticipated by many other authors with their different views. Reibisch (1899), Jenkins (1902), Franz (1910) and Farran (1938) suggested the possibility of fecundity differences being used for separating different stocks of flat-fish and herring. Hickling (1940), Katz (1945) and Baxter (1959) observed differences in fecundity number for herring spawners from different areas and seasons. Egg count differences in Salmon, studied by McGregor (1923), Gilbert and Rich (1927), Foerster and Pritchard (1941) and Aro and Broadbent (1950), have been taken as a means of separating

![Figure 3. Scatter diagram showing relation between fecundity and weight of ovary in *G. chapra*.](image)

**Table 4.** *t* test analysis to compare the mean egg number of Keetham *Gudusia* with that of Ganga

<table>
<thead>
<tr>
<th></th>
<th>Keetham</th>
<th>Ganga</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>$\bar{X}$</td>
<td>31291.17</td>
<td>26890.80</td>
</tr>
<tr>
<td>$\Sigma (X-\bar{X})^2$</td>
<td>4066080129</td>
<td>2630963518</td>
</tr>
<tr>
<td>$\Sigma (X-\bar{X})^3$</td>
<td>78</td>
<td>2071.97</td>
</tr>
<tr>
<td>$\sigma d$</td>
<td>2.12</td>
<td>2.12</td>
</tr>
</tbody>
</table>
races. Kandler and Dutt (1958) observed marked differences in the egg number between different stocks of Baltic herring, and ascribed that the reasons of differentiation being differences in the environmental conditions of the area where spawning took place. Nagasaki (1958) held that the differences in fecundity of Pacific herring, *Clupea pallasi*, followed a pattern to be expected from a series of intergrading populations. The view was confirmed by Tester (1937) and Stevenson (1955) in their studies on meristic characters and tag recovery methods on herring movement, respectively. The year-to-year fluctuations in the fecundity have been pointed for plaice (Simpson 1951), for *Hippoglossoides platessoides* (Bagenal 1957), for pink salmon (Rounsefell 1957), for haddock (Hodder 1963) and for *Sardinella longiceps* (Antony Raja 1971). They also proposed that the fecundity variations might be the results of environmental conditions and or for separate populations. Baxter (1959) further indicates that 'in the interpretation of differences in fecundity between spawners in two different areas, it is important to know whether the differences observed are due to genetical or environmental factors. If the differences between the fecundities of northern North sea and Southern Bight spawners shown here prove to be genetical, then it will provide useful evidence that these two groups of spawners are separate stocks'.

To further the view in support of the differences in the egg study to be of genetical, it could be mentioned here that the Keetham and the Ganga *Gudusia* also showed differences between them in the length-weight correlation factor (Chondar 1973). It could also be indicated that the Keetham species has been established and breeds in the lake (Chondar unpublished). Moreover, the topography and the ecological conditions of the two waters speak of a natural geographical separation between them, the Keetham lake being a piece of almost stagnant water with different environmental factors in relation to the Ganga river system, which is a lotic one. So the above study leads to the conclusion that the differences noted in the fecundity and in the egg size of the *chapra* between the Keetham lake and the Ganga populations possibly be owing to genetical causes, declaring them as two separate races.

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