J. Mar. biol. Ass. India, 1965, 7 (1): 89-101

BIOLOGICAL STUDIES ON THE GIZZARD SHAD, *ANODONTOSTOMA CHACUNDA* HAMILTON (FAM : CLUPEIDAE)

By M. Babu Rao*

Zoology Department, Andhra University, Waltair

Apart from descriptions by systematists (Hamilton 1822, Bleeker 1866-72, Day 1878, Weber & De Beaufort 1913 and Fowler 1941) and brief accounts of its distribution by Chaudhuri (1916), Jones & Sujansingani (1954) and Hardenberg (1931), very little biological work has been done on *Anodontostoma chacunda*. Delsman (1926) has given an account of the eggs and larvae from the Java Sea. Chacko (1949) has recorded the food preferences of this species in the Gulf of Mannar. Observations made on the biology of this species in the Godavari estuary are presented in the following brief account.

In the course of the present investigations, observations on this species were necessarily restricted, during each season, to November-June (i.e., the period during which the species forms a fishery in the estuary), because from July to September the estuary is flooded and country crafts do not do any fishing in the lower reaches of the river.

Material and Methods

Specimens of *Anodontostoma chacunda* were collected from the fishermen's catches from five fishing centres along the Gautami branch of the Godavari estuary and located 8 to 10 km. from one another (Fig. 1). Of the five centres, regular weekly samples were taken at Neellapalli, and monthly samples were taken from other stations.

The samples were analysed in fresh condition. Data on length, weight, sex and maturity stage were taken specimenwise. Total length was measured from the tip of snout up to the tip of the caudal fin. Sex and maturity stages were noted in each case after opening the body. Guts and mature ovaries were removed and preserved in 5% formalin.

(i) *Length frequency*: Length frequencies were obtained for each sample with one centimeter as class-interval. As there were only a few specimens in some samples, monthly length frequencies were obtained by pooling all the samples for the respective month.

(ii) *Length-weight relationship*: Averages of total lengths and total weights of the specimens for 0.5 cm. groups were plotted on a graph. From the trend of

*Present address: Zoological Survey of India, 27, Chowringhee Road, Calcutta-13.

distribution of the observations, various equations suitable for such a distribution were applied to the data. Among these equations, the one with a minimum sum of the squared differences between the observed and calculated weights was taken as the best fit.

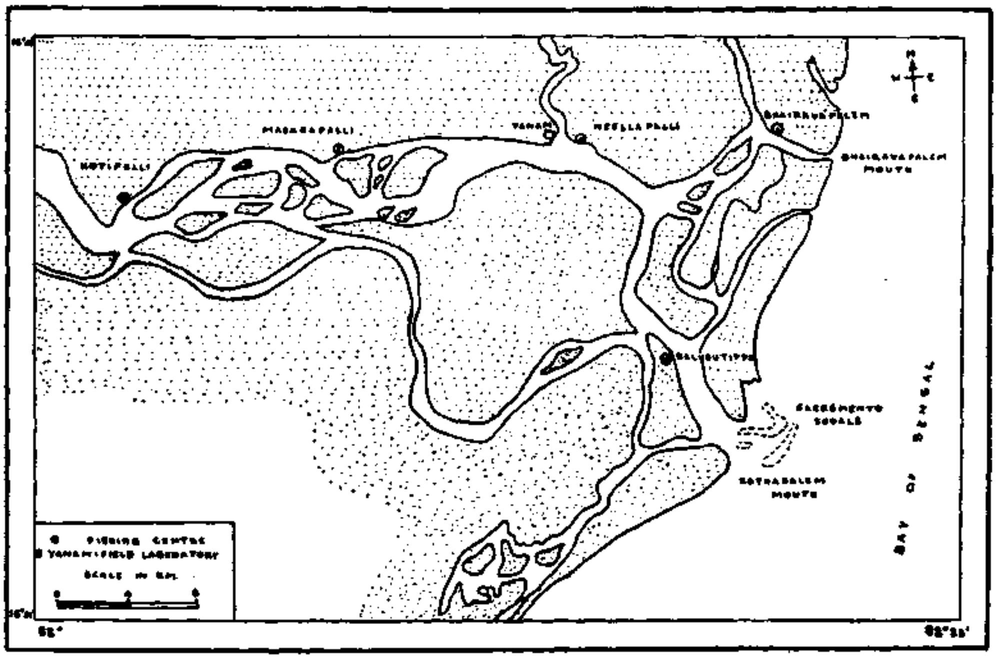

FIG. 1. Godavary estuary and the Gautami branch showing fishing centres

(iii) *Condition factor*: In the present studies 'relative condition' variations were studied, following Le Cren (1951).

(iv) *Fecundity*: After thorough cleaning and removal of extraneous tissues, the total volume of eggs was measured, by displacement, in a measuring cylinder. Four aliquots of 0.05 cc. each were taken, and from the average, the number of ova in the total volume was calculated. After the data were plotted as a scatter diagram, regression equations giving the best fit were selected to express the relationship of the number of eggs to the length or weight of the fish.

(v) *Food*: An attempt was made to study the food preference of this species using the 'occurrence method' (Pillay, 1952). The number of guts (expressed as percentage of total number examined) containing each item of food, was given for each month as well as for the whole season.

OBSERVATIONS

Length frequency distribution

The number of specimens occurring in different lengths during the various months for the 1960-61 seas on are presented in Table I. Percentage length frequency curves for this season are shown in Fig. 2. Adults were found to occur from the month of November to the month of February, juveniles made their appearance

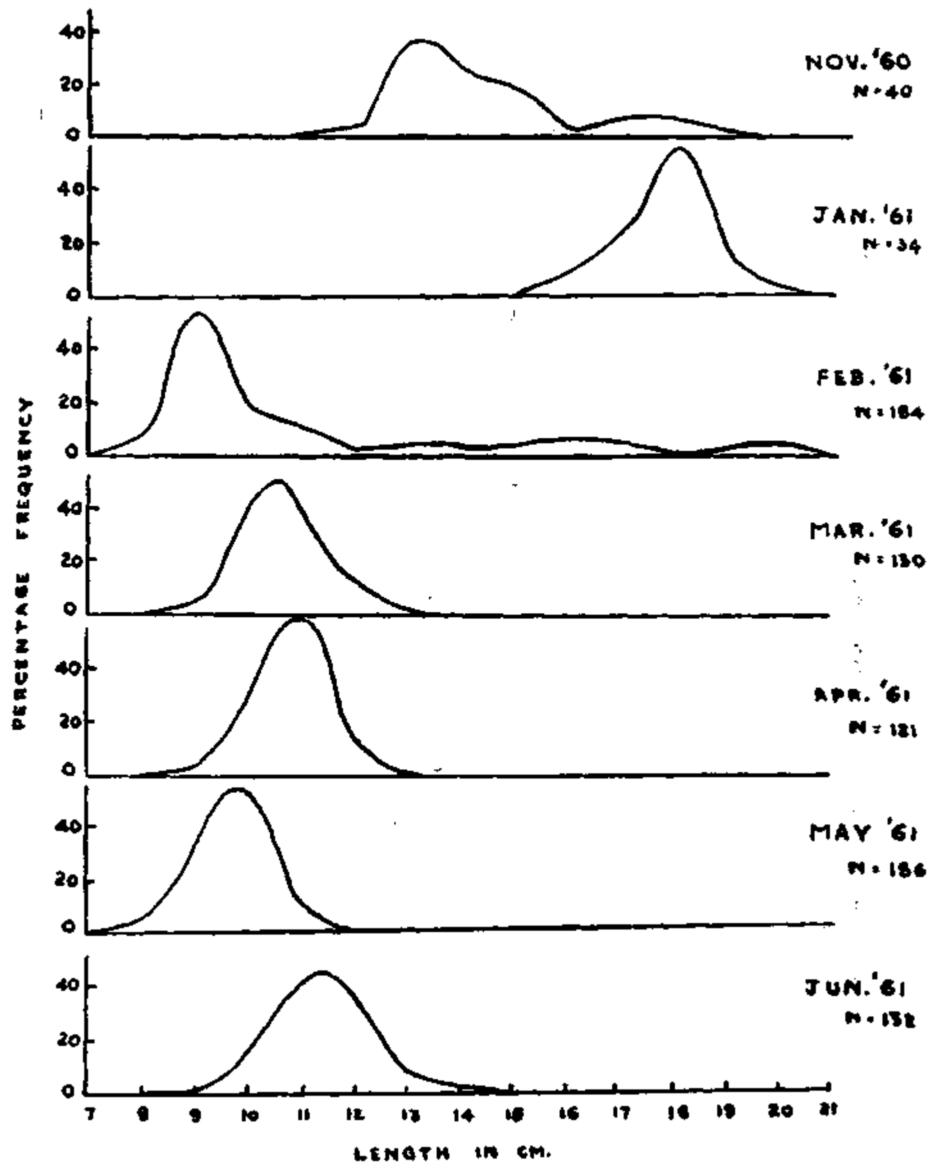

FIG. 2. Monthly percentage length frequency curves for 1960-'61 season

in the month of February and found to occur in the estuary upto the end of the season, i.e. June.

TABLE I

Centimeter length groups in different months of 1960-61 season

Length in Cm	Number of Specimens						
	Nov. '60	Jan. '61	Feb. '61	Mar. '61	Apr. '61	May '61	June '61
8	..	..	15	..	..	11	..
9	..	..	88	8	5	64	3
10	..	..	26	57	36	93	18
11	..	..	14	50	68	18	53
12	2	..	2	12	12	..	47
13	14	..	4	3	..	..	8
14	10	..	4	..	..	..	3
15	6	..	3	..	..	..	..
16	1	3	9	..	..	..	..
17	3	8	7	..	..	..	..
18	3	17	..	..	..	..	..
19	1	5	5	..	..	..	..
20	..	1	7	..	..	..	..

Length-weight relationship

In view of its low sum of the squared differences between the observed and calculated weights, the equation $W=a+b.L^3$ was found to be the best fit for the length-weight data. The equations for the pooled data and for different seasons along with the number of specimens and length range of the specimens are presented in Table II. Fig. 3 shows the observed average weights for 0.5 cm. length groups of the pooled specimens, and the calculated weights (forming the curves) obtained by applying different equations.

TABLE II

Equations of length-weight relationship for pooled data and different seasons

Season	n	Length range in Cm	Equation
Pooled	820	5-21	$W=0.19+0.01212.\ L^3$
1959-'60	231	5-20	$W=-0.45+0.01312.\ L^3$
1960-'61	166	9-20	$W=1.97+0.01195.\ L^3$
1961-'62	423	7-21	$W=0.47+0.01203.\ L^3$

To ascertain whether the length-weight relationship was similar in the three seasons, the data of the three seasons were subjected to analysis of covariance (V1) and the variance due to differences between regression coefficients (V2) gave a significant 'F' value (Table III A and B) indicating that real differences may exist between the regression coefficients of the length-weight relationship of the different seasons. The 't' test (Table IV) indicated that (i) 1959-60 season was significantly different from both 1960-61 and 1961-62 seasons but that (ii) between

1960-61 and 1961-62 seasons the difference was not significant. The high regression coefficient of the 1959-60 season indicates a greater rate of increase of weight, when compared to the other two seasons.

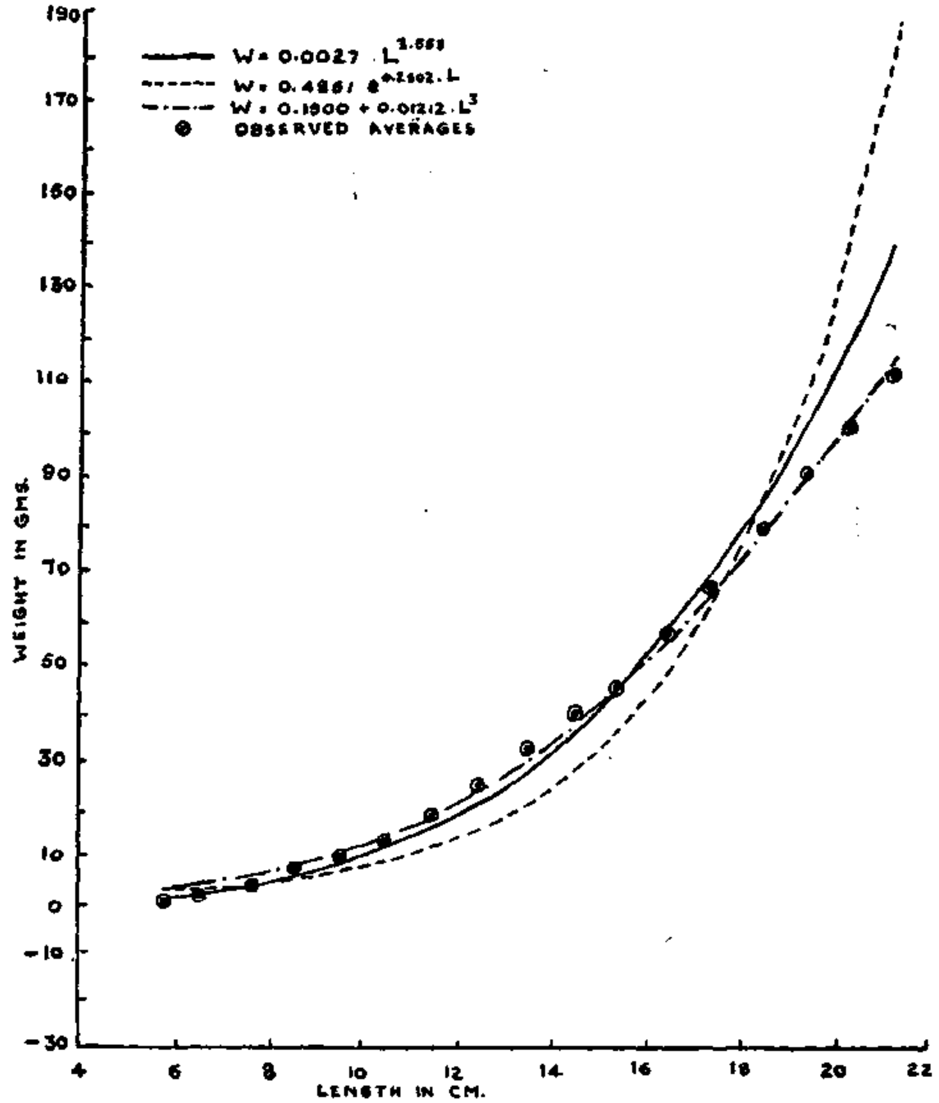

FIG. 3. Length-weight relationship of the pooled data

Relative condition (*Kn'*)

Variations in the condition of the fish (i) with length (ii) in different months of the 1960-61 season and (iii) at various maturity stages of females in the 1961-62 season were studied.

Table III (A)

Analysis of covariance applied to the length-weight data of the three seasons

	(1) D.F.	(2) $\Sigma(x-\bar{x})^2$	(3) $\Sigma(x-\bar{x})(y-\bar{y})$	(4) $\Sigma(y-\bar{y})^2$	(5) b	(6) $b.\Sigma(x-\bar{x})(y-\bar{y})$	(7) $\Sigma y'^2$	(8) D.F.
1959-'60	15	110,406,227	1,451,630.4	19,181.4	0.01312	19,100	81.34	14
1960-'61	11	65,634,014	782,011.4	9,363.6	0.01195	9,317	46.64	10
1961-'62	14	125,417,370	1,509,708.1	18,240.8	0.01203	18,190	50.76	13
Total	40	301,457,611	3,743,349.9	46,785.8	0.01242	46,480	306	39

(1) D.F. for unadjusted sums of squares
(2) S.S. of 'x' variate
(3) Sums of products
(4) S.S. of 'y' variate
(5) regression coefficients
(7) adjusted sums of squares
(8) D.F. for adjusted sums of squares

Table III (B)

Test of heterogeneity of regression between seasons

—	D.F.	Adjusted sums of squares	Variance	F	5% point	Significance
Total	(pq-1) 39	306.00	..	..	..	..
Within seasons	(pq-p) 37	178.74	4.84 (V_1)	13.15	3.26	Significant
Difference	(p-1) 2	127.26	63.63 (V_2)	..	..	..

The notation used is the same as that adopted by Goulden (1939 : 253-254).

TABLE IV

Test of significance of the difference between the regression coefficients of the three seasons in the length-weight data

—	Seasons compared		
	1959-'60 and 1960-'61	1960-'61 and 1961-'62	1959-'60 and 1961-'62
Standard error of difference	0.0003438	0.0003358	0.0003218
Difference in regression coefficients	0.00117	0.00008	0.00109
't'	3.404	0.238	3.388
P	<0.05	>0.05	<0.05
Significance	Significant	Not significant	Significant

During the three seasons the relative condition was low in the juveniles (Fig. 4); it gradually increased with growth until the fish attained a length of about 13 cm., after which the condition remained more or less steady with slight fluctuations that

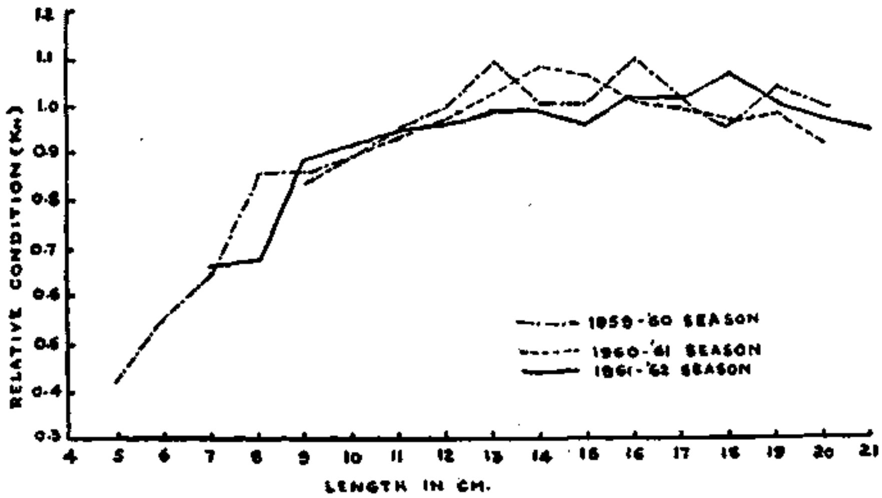

Fig. 4. Relative condition (Kn) variations with the length of fish during the three seasons

might be associated with maturity. This shows that in the juveniles the rate of increase in weight was less than the rate of increase in length.

In maturing females, the relative condition (Fig. 5A) was found to show a gradual slight increase from Stage II to Stage VI, obviously associated with the increasing weight of the ovary.

With regard to variations within a season during the 1959-60 season (Fig. 5B), the relative condition which during November was nearly unity, gradually increased, with a maximum in January. This increase was due to the development of the gonads, since mature forms were encountered during this period. In February there was a steep fall, which might be due to the cumulative effect of the occurrence of juveniles and spent adults. From March the relative condition was found to increase (associated with the growth of the individuals) and by April it came back to around unity, and was maintained at this level till the end of the season.

Fecundity

The relationship between fecundity, and length or weight of the fish was studied in samples from the 1961-62 season.

The relationship between the weight of the fish and fecundity was found to be best expressed by a linear regression equation (Fig. 6):

$$F = -18.17 + 0.9166.W$$

where 'F' is fecundity, expressed in thousands of eggs and 'W' is the total weight of the fish expressed in grams.

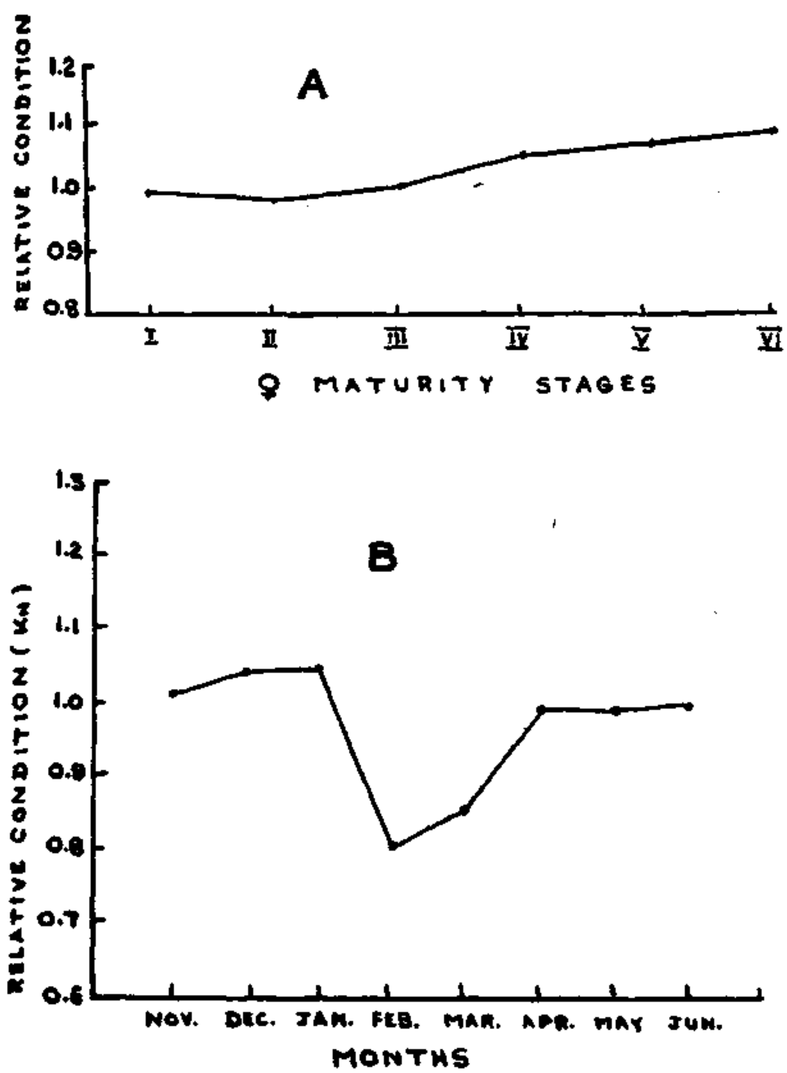

FIG. 5. Relative condition (Kn) variations

(A) 'Kn' variations in female maturity stages (1961-'62 season)

(B) Seasonal variations in 'Kn' (1959-'60 season)

The relationship between length of the fish and fecundity can be best expressed by a curvilinear equation, since the length-weight relationship was a cube relationship, and the weight and fecundity equation was linear (Fig. 7). The equation is

$$F=7.42+0.008093.\ L^3$$

where 'F' is fecundity, expressed in thousands of eggs and 'L' is total length of the fish expressed in centimeters.

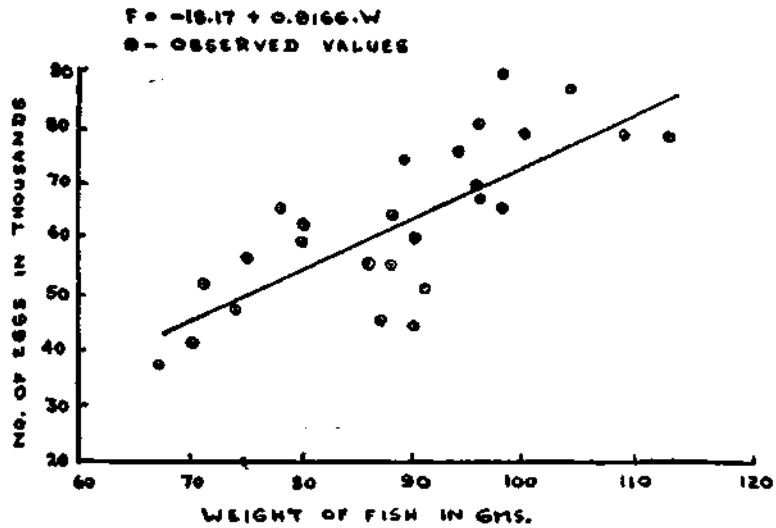

FIG. 6. Weight of the fish and fecundity relationship

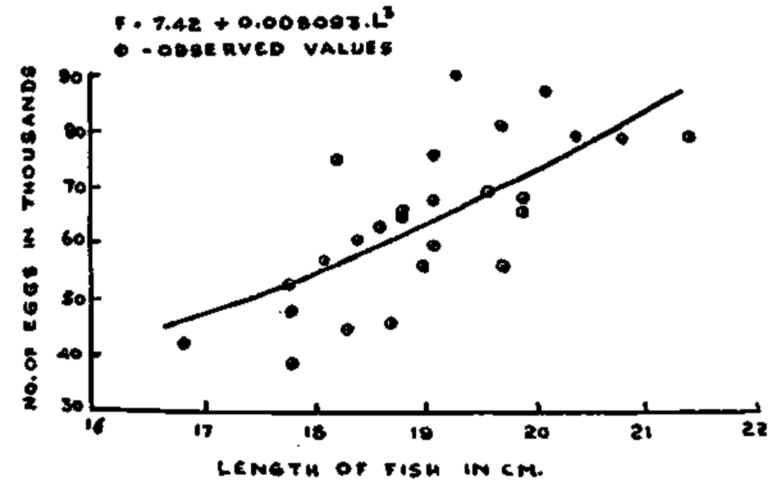

FIG. 7. Length of the fish and fecundity relationship

Food

The organisms that constitute the food of this species were, in the order of preference : diatoms, radiolarians, molluscs, copepods and crustaceans (Table V). The figures in the body of the table give the percentage of fish containing these various items. Diatoms were absent during December but from March onwards they were present in almost all the fish examined. A variety of diatoms were found in the gut contents (Table VI). The presence of radiolarians in the guts indicates that the fish feeds on plankton as well as on some of the bottom fauna.

Table V

Monthly percentage frequency of the guts containing the listed food items

Name of the food item	Nov. 1960 n=25	Dec. 1960 n=20	Jan. 1961 n=25	Feb. 1961 n=10	March 1961 n=25	April 1961 n=20	May 1961 n=20	June 1961 n=20	Average percentage for the season
Diatoms	96	..	52	40	100	100	100	100	36.1
Radiolarians	80	20	96	10	100	91	50	95	33.3
Molluscs	24	..	60	..	12	45	30	50	13.6
Copepods	12	..	32	10	36	55	25	10	11.1
Crustacean larvae ..	..	..	12	..	24	18	5	5	3.9
Cumaceans	4	..	16	..	12	..	..	..	2.0

Table VI

Monthly percentage frequency of the guts containing the listed diatoms

Name of Diatom	Nov. 1960	Dec. 1960	Jan. 1961	Feb. 1961	March 1961	April 1961	May 1961	June 1961	Average percentage for the season
Coscinodiscus	56	..	52	40	100	64	70	95	15.6
Nitzchia	48	..	36	..	36	91	95	60	12.0
Diploneis	68	..	4	10	56	65	100	40	11.2
Pleurosigma	12	..	40	..	80	73	90	10	10.0
Thallassionema	56	..	4	10	..	82	55	50	8.4
Leptocylindrus	12	..	40	..	36	55	80	10	7.6
Navicula ..	32	..	20	..	32	45	60	15	6.7
Amphora	12	..	16	..	4	9	80	30	4.9
Gyrosigma	56	..	40	..	20	9	5	5	4.4
Thallassiothrix	28	..	4	..	4	64	15	5	3.9
Surirella	..	..	..	..	4	36	60	..	3.3
Cyclotella	8	..	..	..	4	..	35	45	3.0
Mastogloia	12	..	12	..	8	9	5	5	1.7
Caloneis	..	..	..	..	4	18	25	..	1.5
Tropidoneis	12	..	4	..	4	..	15	5	1.3
Trachyneis	..	..	..	..	12	9	20	..	1.3
Synedra	12	..	..	..	..	..	15	10	1.2
Pinnularia	12	..	4	..	16	..	..	..	1.0
Rhizosolenia	4	..	..	..	4	9	..	..	0.5
Cymbella	12	..	..	..	..	..	5	..	0.5

The intestine is relatively long. The gill-rakers are numerous and arranged in a closely set manner.

Maturity and Spawning

Specimens (both males and females) were found to be maturing from 12 to 13 cm. onwards ; full maturity was found to be attained from 16 to 17 cm. onwards.

During 1960-61 season (Fig. 2) fully mature specimens were found to occur from November 1960 to January 1961.

Juveniles started appearing from Feb. 1961 onwards. In the percentage length frequencies of the juveniles, the occurrence of the mode at the same length in different months (for instance the occurrence of the mode at 10 cm. in the months of March and May 1961 and the occurrence of the mode at 11 cm. in the months of April and June 1961) may be due to the fact that the juveniles which were appearing earlier (10 cm. mode in March and 11 cm. mode in April) might be the offspring of the specimens spawning in November-December period and those that were appearing later (10 cm. mode in May and 11 cm. mode in June) might be the offspring of the specimens spawning in January-February period. This shows that spawning takes place from November to February, though maximum spent fish were recorded in the month of Feburary, indicating intensive spawning during that month.

The low values of the relative condition during the months of February and March might be mainly due to the occurrence of juveniles, more or less exclusively, than due to the effect of spawning, as in this species, the length of the fish has got much more effect on the relative condition (Fig. 4) than the weight of the gonads (Fig. 5A).

SUMMARY

Anodontostoma chacunda Hamilton was found to form a fishery in the Godavari estuary from November to June.

Length frequency distribution was found to show that the adults occur in the estuary from November to February and juveniles from February to June.

The equation $W=a+b.L^3$ was found to be the best fit for the length-weight data of the species. The length-weight relationship of 1959-60 season was found to be significantly different from 1960-61 and 1961-62 seasons.

Relative condition ('Kn ') (*i*) was found to increase steadily till the fish attained 13 cm. after which it remained fairly uniform, (ii) was low during February-March period, possibly associated with the occurrence of large numbers of juveniles (iii) increased gradually from stage II of maturity to stage VI in the females.

The relationship between fecundity on the one hand and length or weight of the fish on the other can best be expressed by the equations :

$F=7.42+0.008093.\ L^3$ and

$F=-18.17+0.9166.W$

The species was found to show the following order of food preference : diatoms, radiolarians, molluscs, copepods, crustacean larvae and cumaceans. The diatoms identified from the guts were listed.

Specimens were found to be fully mature from 16 to 17 cm. onwards. Spawning was found to take place from November to February, more intensively during the latter part of the period.

ACKNOWLEDGEMENTS

I am thankful to Dr. S. Dutt, Department of Zoology, Andhra University, Waltair, for his guidance and to Prof. P. N. Ganapati, Head of the Zoology Department, Andhra University, Waltair, for his interest and encouragement during the course of the present investigation. My thanks are also due to the authorities of Indian Council of Agricultural Research for awarding me Research Assistantship during the tenure of which the present investigation has been carried out.

REFERENCES

BLEEKER, P. 1866-1872. *Atlas Ichthyologique des Indes Orientales neerlandouses*. Tome 6. Amsterdam.

CHACKO, P. I. 1949. Food and feeding habits of the fishes of the Gulf of Manaar. *Proc. Indian Acad. Sci.*, **29B**, 83-97.

CHAUDHURI, B. L. 1916. Fauna of Chilka lake, Fish—Part I. *Mem. Indian Mus.*, 5(4) : 413-427.

DAY, F. 1878. *Fishes of India*. William Dawson & Sons Ltd., London.

DELSMAN, H. C. 1926. Fish eggs and larvae from the Java Sea. 8, *Dorosoma chacunda*—*Treubia*, **8** (3 & 4) : 389-394.

FISHER, R. A. 1950. *Statistical methods for research workers*—11th Ed. Oliver & Boyd : London.

FOWLER, H. W. 1941. Contributions to the biology of the Philippine Archipelago and adjacent regions. *Bull. U.S. Nat. Mus., Washington*, D.C., **100**(13) :

GOULDEN, C. H. 1939. *Methods of Statistical Analysis*. John Wiley & Sons Inc., New York.

HAMILTON, B. 1822. *An account of the fishes from the river Ganges and its branches*—Edinburgh.

HARDENBERG, J. D. F. 1931. The fish fauna of the Rokan mouth. *Treubia*, **13**(1) : 87-168.

JONES, S. & SUJANSINGANI, K. H. 1954. Fish and fisheries of the Chilka Lake with statistics of fish catches for the years 1948-1950. *Ind. J. Fish.*, **1** : 256-344.

LE CREN, E. D. 1961. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journ. Anim. Ecol.*, **20** : 201-210.

PILLAY, T. V. R. 1952. A critique of the methods of study of food of fishes. *J. zool. Soc. India*, **4**(2), 185-200.

WEBER, M. AND DE BEAUFORT, L. F. 1913. *The Fishes of the Indo-Australian Archipelago*, **2**, E. J. Brill Ltd., Leiden.