Relationships among Gonad Weight, Liver Weight and Body Weight of Major, Common and Some Chinese Carps under Composite Culture System with Special Reference to Pond Fertilization

Shahid Mahboob* and A. N. Sheri[1]
Department of Zoology, Government College, Faisalabad, Pakistan

ABSTRACT : The relationship of gonad weight and liver weight with body weight of six fish species viz; *Catla catla*, *Labeo rohita*, *Cirrhina mrigala*, *Hypophthlamichthys molitrix*, *Ctenopharyngodon idella* and *Cyprinus carpio* under the influence of artificial feed, broiler manure, buffalo manure, N:P:K (25:25:0) and a control pond were examined after a rearing period of one year. The positive relationship between gonad weight and body weight was significant which showed the dependence of gonadal development on body weight in all the six fish species. The currelation coefficients were higher in female fishes. However, the major carps had a much smaller proportional gonadal weight as compared with Chinese carps and a common carp due to their faster growth rate. The overall comparison of six fish species under different experimental treatments revealed that highest liver weight was observed for *C. idella* closely followed by *C. carpio*. The maximum correlation value was observed with *H. molitrix* under the broiler manure. The maximum Gonadosomatic Index (GSI) remained as 32.63 for *C. carpio* followed by *C. idella*. The maximum value for Hepatosomatic Index (HSI). remained 1.99 for *C. idella* followed by *C. mrigala*. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 5 : 740-744)***

Key Words : Gonad, Liver, GSI, HIS, Composite Culture System

INTRODUCTION

The condition of fish is affected by its gonad weight and visceral weight. However, in some fish species the gonad increases isometrically with body weight (LeCren, 1951). Dunham et al. (1985) mentioned that viscera percentage had phenotypic association with dressing percentage. They found that no traits could be measured from live fish that would predict viscera percentage. In most teleostean species gonadal weight depends, in part, on body weight (Mahboob and Sheri, 1997). One of the most common ways to account for the effect of body size on gonadal size has been to represent gonadal weight as a percentage of body weight, and the gonadosomatic index (GSI) introduced by Mein (1927) has often been used as an indicator of relative gonadal development or activity. GSI presumes a constant arithmetic relationship of gonadal weight over the range of fish weight being sampled.

Gonadal recrudescence in female fish involves an accumulation of lipid and protein stores within the developing oocytes (Mahboob et al., 1990). These stores may come from liver and may be inversely correlated with oocyte development in some species. Liver size in a given sample of fish is correlated with body weight minus liver weight and expressed as Hepatosomatic Index (HSI). This expression makes the same assumption as with GSI. Delahunty and DeVlaming (1980) reported ovary weight significantly increased relative to increasing body weight in the gold fish, *Carassius auratus*. The exact nature of this relationship changed from month to month. They further pointed out that larger fish were found to have proportionately larger ovaries than small fish at specific times of the year. The relationship of liver weight to body weight varies seasonally. Eliassen and Vahl (1982) reported that in mature cod the gonad was found to increase isometrically with fish weight suggesting that the relative energy demand for gonadal growth is independent of fish size.

The primary objective of this study was to establish relationships among gonad weight, liver weight and body weight and their meat bone ratios as influenced by fertilizers and artificial feed in composite culture of major, common and some Chinese carps.

MATERIALS AND METHODS

The experiment was started on November 30, 1997 under ambient conditions typical of Faisalabad and completed on November 25, 1998. Ground water of Faisalabad is somewhat salty. Fifteen newly dug earthen fish ponds of dimensions 15 m×8 m×2.5 m (length×width×depth) were used in three replicates in a factorial design for this experiment. Approximately four months old fingerlings of *Catla catla*, *Labeo rohita*, *Cirrhina mrigala*, silver carp (*Hypophthalmichthys molitrix*), grass carp (*Ctenopharyngodon idella*) and *Cyprinus carpio* were stocked in each of the ponds with the stocking density of 2.87 m^3/fish (Javed, 1988). The interspecies ratios were

* Corresponding Author: Shahid Mahboob. Tel: +92-41-728433, Fax: +92-41-634377, E-mail: rsmahboob1@hotmail.com
[1] Department of Zoology and Fisheries, University of Agriculture, Faisalabad, Pakistan.
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adopted according to Lakshmanan et al. (1971) (table 1). The percentage N, P and K in the four treatments materials in this study were obtained by A.O.A.C. (1984) methods as shown in table 2.

Feed supplementation of T_1 and fertilization of T_2, T_3 and T_4 was done with broiler manure, buffalo manure and N:P:K (25:25:0) based on their nitrogen contents at the rate of 0.15 gm nitrogen per 100 gm of wet fish weight daily for one year. However, control pond (T_5) remained without any additives.

Artificial feed was composed of sesame oil cake (32%), maize gluten meal 30% (20%), cotton seed meal decorticated 30% (40%) wheat bran (3.5%), rice polish (3.5%) and vitamin mineral mix (1%).

Physical analysis of fish meat

At the end of trial period on November 26, 1998 the seven fish of each species were randomly selected and were dressed and used for the analysis of meat/bone ratio. The big bones were separated by hand while the small bones were separated by suspending fish meat in a solution of 0.01 percent KOH with gentle heating (Javed, 1988). Precautionary measures were exercised to prevent the erosion of bones by successive bathing in distilled water; the moisture was allowed to absorb on blotting paper and weighed to obtain a final value for bones in fish.

Study of fish viscera

Fish viscera were analyzed at the end of experimental period for weight and the size of gonad and liver to study their possible relationship with fish weight. Seven fish of each species from each of the pond were randomly selected and killed the day after being received, which allowed 24 h starvation period. Correlation analysis among gonad weight, liver weight and body weight was worked out using the MSTAT package.

RESULTS AND DISCUSSIONS

Dressing losses and meat/bone ratios

The percentages losses in dressing and the meat/bone ratios are presented in table 3. In *Catla catla* the losses during dressing of fish were 29.23, 24.63, 32.02, 26.91 and 34.09 percent from T_1, T_2, T_3, T_4 and T_5, respectively. *L. rohita* showed the minimum and maximum losses as 21.25 and 32.36 under the effect of T_5 and T_4, respectively (table 3). In *C. mrigala* the dressing percentage losses were 26.98, 22.30, 30.75, 25.34 and 34.47 for T_1, T_2, T_3, T_4 and T_5, respectively. *H. molitrix* under T_2 showed minimum loss of 18.25 percent, while the maximum (31.03 percent) was under the influence of T_5. *C. carpio* placed on T_1, T_2, T_3, T_4 and T_5 showed the percentage losses as 43.49, 41.15, 44.40, 40.88 and 47.56, respectively, while in *C. idella* the minimum and maximum losses were 25.53 (under T_2) and 35.40 (under T_5) percent. In general, the percentage loss was inversely correlated with weight of fish i.e. the more healthy the fish, the lower the loss.

The percentage contributions of viscera towards losses during dressing for all the six fish species under all the five treatments are presented in table 3. The average total loss during the dressing of fish corresponded inversely to their live weight. Dressing percentage was always maximum for *C. carpio*, followed by *C. catla*, *C. idella*, *C. mrigala* and *H. molitrix* which was due to higher weights of viscera of *C. carpio* as compared to other fish species and correlated with body weight (table 3). This is a physiological rather than a genetic function since Bondari (1980) and Smitherman et al. (1983) found that progeny of catfish selected for body weight had dressing percentages similar to random controls. The results of the present study substantiate the findings of

Table 1. Interspecies ratio, initial weight, fork length and total length of six fish species

Fish species	Individual no.	Ratio (%)	Weight (gm)	Fork length (mm)	Total length (mm)
Catla catla	10	10	12.87±0.08	53.2±0.05	59.3±0.09
Labeo rohita	32	30	11.93±0.05	50.8±0.08	57.6±0.07
C. mrigala	13	12.5	16.80±0.05	51.9±0.06	61.2±0.07
H. molitrix	26	25	22.14±0.07	124.2±0.09	143.7±0.16
C. idella	10	10	19.57±0.09	93.2±0.07	97.8±0.08
C. carpio	13	12.5	18.49±0.10	81.3±0.07	101.4±0.23

Table 2. Percentage nitrogen and phosphorus contents of treatment materials

Treatment	Pond no.	Treatment material	% Nitrogen	% Phosphorus
T_1	1	Artificial feed (vegetable sources)	5.60±0.03	2.05±0.6
T_2	2	Broiler manure	4.62±0.12	1.66±0.14
T_3	3	Buffalo manure	1.02±0.05	0.96±0.02
T_4	4	N:P:K (25:25:0)	25.00±0.04	25.00±0.04
T_5	5	Control	No additive	No additives

Table 3. Average loss in finished fish meat, percentage of visceral weights with live body weight and bone:meat ratios of 6 fish species as influenced by different treatments

Fish species	Treatment	Avg.-live weight (gm)	Avg. dressed weight (gm)	Avg.-visceral weight (gm)	Visceral % of Avg. live body weight.	Avg.-fresh fish loss (gm)	% Loss	Avg.-bones in dressed fish (gm)	Avg.-bone free fillet (gm)	Bone: Meat at Ratio
		SE	SE							
Catla catla	T_1	870.1±2.03	615.8±1.56	84.2	9.68	254.4	29.2	25.3	590.5	1:23.4
	T_2	1339.7±3.14	1009.7±1.89	125.2	9.34	330.0	24.6	34.5	975.2	1:25.2
	T_3	590.2±1.94	401.2±1.71	61.0	10.33	189.0	32.0	18.6	382.6	1:20.5
	T_4	1002.4±2.69	732.6±1.67	97.4	9.72	269.8	26.9	28.3	704.2	1:24.8
	T_5	162.2±1.72	106.9±1.04	15.9	9.80	55.3	34.1	6.2	100.7	1:16.4
Labeo rohita	T_1	601.4±2.54	445.6±1.65	60.3	10.02	155.8	25.9	20.8	424.8	1:20.4
	T_2	822.6±3.81	620.1±1.97	82.4	10.01	202.6	24.6	25.6	594.5	1:23.2
	T_3	511.3±2.62	365.8±1.83	57.2	11.18	145.6	28.5	17.9	347.9	1:19.5
	T_4	987.2±3.93	777.4±2.16	111.5	14.30	209.8	21.2	29.8	747.7	1:25.1
	T_5	160.1±2.01	108.3±1.13	17.7	11.04	51.8	32.4	5.8	102.4	1:17.5
Cirrhina mrigala	T_1	428.6±2.14	312.9±1.61	60.3	14.06	115.6	27.0	13.8	299.1	1:21.7
	T_2	558.2±3.34	433.8±2.02	60.1	10.77	124.5	22.3	16.9	416.9	1:24.7
	T_3	381.9±2.12	264.5±1.52	36.1	9.44	117.4	30.8	12.7	251.8	1:19.9
	T_4	409.2±0.363	305.5±1.69	43.7	10.68	103.7	25.3	14.0	291.5	1:20.8
	T_5	156.9±1.66	102.7±1.07	20.1	12.79	54.1	34.5	5.9	96.9	1:16.4
H. molitrix	T_1	1136.8±3.09	908.4±2.22	93.7	8.24	228.4	20.1	35.8	872.6	1:24.4
	T_2	1438.2±4.23	1175.8±2.77	122.5	8.51	262.5	18.2	39.7	1136.0	1:28.6
	T_3	725.4±3.68	531.8±1.88	61.8	8.53	193.6	26.7	24.1	507.6	1:21.0
	T_4	998.6±3.02	767.2±1.94	86.3	8.64	231.4	23.2	38.8	734.4	1:22.4
	T_5	264.2±214	182.2±1.43	25.0	9.46	82.2	31.0	9.2	173.0	1:18.8
Cyprinus caprio	T_1	1566.8±4.14	885.4±2.76	477.6	30.48	681.4	43.5	35.7	849.7	1:23.8
	T_2	2777.8±6.09	1606.9±3.58	705.9	25.41	1170.8	41.2	50.6	1556.3	1:30.7
	T_3	1236.1±3.78	687.3±2.50	346.8	28.05	548.8	44.4	29.9	657.4	1:22.0
	T_4	1859.6±4.52	1099.4±2.95	519.5	27.93	760.2	40.9	38.6	1060.7	1:27.4
	T_5	475.6±3.67	248.8±2.11	97.4	20.47	226.2	47.6	12.8	236.1	1:18.4
C. idella	T_1	1167.8±3.79	859.5±2.42	175.0	14.99	308.3	26.4	31.8	827.8	1:26.0
	T_2	2372.7±4.78	1766.9±2.84	344.2	14.50	605.8	25.5	55.2	1711.7	1:31.0
	T_3	754.3±3.68	548.0±2.06	115.8	15.35	206.2	27.3	23.4	524.6	1:22.4
	T_4	1689.2±4.12	1238.5±2.14	240.1	14.22	450.7	26.7	42.8	1195.6	1:27.9
	T_5	327.5±2.52	211.9±1.76	32.1	9.81	115.5	35.4	10.1	201.8	1:20.0

Avg.: Average.

Dunham et al. (1985).

Viscera percentage was influenced by sexual differences and body weight of the fish. Viscera percentage to live body weight was maximum in *C. carpio*, followed by *C. idella*, *C. mrigala*, *L. rohita*, *C. catla* and *H. molitrix*. Viscera percentage increased with body weight more in females (*C. carpio* and *C. idella*) which related to egg development than males (*C. catla*, *L. rohita*, *C. mrigala* and *H. molitrix*). Viscera percentage seems to be the major variable explaining the dressing percentage. Dunham et al. (1985) reported viscera percentage was greater in young females than in young males.

The overall comparison of treatments showed broiler manure fertilization (T_2) to come up as the best treatment for meat/bone ratios of six fish species, followed by T_4, T_1, T_3 and T_5 as 24.73, 23.28, 20.88 and 17.93, respectively. Table 3 shows that meat/bone ratios were directly proportional to body weights.

The significant differences for meat/bone ratios of fish among both treatments and species were due to the effect of treatments on different final weights which were inversely correlated with the meat/bone ratios of fish (table 3). *C. idella* came up as the best fish species for overall meat/bone ratios under the influence of five treatments as compared to other fish species. This significantly high meat/bone ratio of *C. idella* could be due to its inherited quality characteristics as it contains less bones and higher muscle content as compared to *C. carpio*, *H. molitrix*, *C. catla*, *L. rohita* and *C. mrigala*. Sharma and Simolt (1971) reported that snakeheads had very little in the way of bony tissue but Javed (1988) mentioned *Labeo rohita* contained less bones as compared to *C. catla* and *C. mrigala*. This difference of opinion with the latter study was because of comparison among major carps, Chinese carps and common carp instead of among major carps only. No reference pertaining to meat/bone ratios of *H. molitrix*, *C. carpio*, *C. idella* could be found for comparison in Pakistan. These findings could be presumed as bench mark value in respect to the meat/bone ratios of fish under local conditions.

Study of visceral organs

The overall comparison of six fish species under all the five experimental treatments showed higher gonad weight in *C. carpio*, followed by *C. idella*, *H. molitrix*, *L. rohita*, *C. mrigala* and *C. catla*. It was observed that in male fish gonad weight was significantly less as compared to female fish (*C. carpio* and *C. idella*). The results of the present study are substantiated by the findings of Delahunty and DeVlaming (1980) who indicated that ovary weight in goldfish increases with increasing body weight.

In most teleostean species gonadal weight depends, in part, on body weight. One of the most common ways to account for the effect of body size on gonadal size has been to represent it as percentage of body weight. The gonadosomatic index introduced by Mein (1927) has been as an indicator of relative gonadal development or activity. GSI presumes a constant arithmetic relationship of gonadal weight to body weight over the range of fish weight being sampled.

Table 5 shows the gonadosomatic indices of the six fish species under all the five treatments. The maximum GSI value was 32.63 for *C. carpio* under the feed supplementation (T_1), followed by T_4. Thus, the fish developed proportionately larger gonad. It was noted the female *C. carpio* and *C. idella* showed the higher values of GSI which means that ovaries contributed more towards GSI than testis in male fishes.

The correlation coefficients were highly significant and positive under all the five treatments for the fish species. The maximum value of correlation coefficient (r=0.998) was observed with *H. molitrix* under the influence of T_2 (table 4). The hepatosomatic index, as a percentage of body weight, is shown in table 5. The maximum value for HSI remained 1.99 for *C. idella* followed by *C. mrigala* under the influence of T_1.

In studies on other species *Rutilus rutilus* (Mann, 1976a) and *Mastacembelus armatus* (Gupta, 1974), the relationship between GSI and body weight was constant over a range of fish weights, thus gonadosomatic index may be legitimate expression of gonadal activity. Mahboob and Sheri (1997) reported gonadosomatic index to increase with body weight in *C. idella* this explanation seem to be in line with the results of the present study. But these results contradict the findings of Mann (1976b) who found gonosomatic index not to increase with body weight. The relationship between gonad weight and body weight was positively significant which showed the dependence of gonadal development on the body weight or vice versa. The present results showed higher values of "r" for the female; this indicates that the females of both species gained more weight than the males. These results are in line with the findings of Okera (1974).

The overall comparison of six fish species under different experimental treatments revealed that highest liver weight was observed for *C. idella*, closely followed by *C.*

Table 4. Correlation coefficients among gonad weight, liver weight and body weight of six fish species

Treatment	Fish species	Gonad	Liver weight
T_1	*Catla catla*	0.988	0.973
	Labeo rohita	0.979	0.932
	Cirrhina mrigala	0.375	0.973
	H. molitrix	0.956	0.977
	C. carpio	0.891	0.935
	C. idella	0.970	0.977
T_2	*Catla catla*	0.973	0.961
	Labeo rohita	0.994	0.993
	Cirrhina mrigala	0.992	0.983
	H. molitrix	0.999	0.998
	C. carpio	0.982	0.906
	C. idella	0.950	0.959
T_3	*Catla catla*	0.973	0.916
	Labeo rohita	0.998	0.990
	Cirrhina mrigala	0.990	0.978
	H. molitrix	0.996	0.984
	C. carpio	0.829	0.807
	C. idella	0.993	0.958
T_4	*Catla catla*	0.986	0.978
	Labeo rohita	0.990	0.956
	Cirrhina mrigala	0.998	0.994
	H. molitrix	0.994	0.983
	C. carpio	0.986	0.993
	C. idella	0.994	0.984
T_5	*Catla catla*	0.995	0.990
	Labeo rohita	0.982	0.981
	Cirrhina mrigala	0.980	0.992
	H. molitrix	0.891	0.935
	C. carpio	0.915	0.880
	C. idella	0.987	0.993

Critical value (one tail 0.05) + or -=0.344.

Table 5. Gonadosomatic Index (GSI) and Hepatosomatic Index (HSI) of six fish species under various fertilization schemes

Fish species	Treatment	Gonadosomatic index	Hepatosomatic index
Catla catla	T_1	0.19	1.26
	T_2	0.50	1.22
	T_3	0.54	1.27
	T_4	0.51	1.23
	T_5	0.20	1.13
Labeo rohita	T_1	0.84	1.23
	T_2	0.83	1.21
	T_3	0.94	1.38
	T_4	0.91	1.45
	T_5	0.50	1.14
Cirrhina mrigala	T_1	1.18	1.74
	T_2	1.46	1.29
	T_3	1.27	1.57
	T_4	1.31	1.46
	T_5	0.13	1.45
H. molitrix	T_1	0.83	1.31
	T_2	1.17	1.32
	T_3	0.91	1.31
	T_4	1.21	1.28
	T_5	0.34	0.52
Cyprinus carpio	T_1	32.63	1.41
	T_2	26.23	1.32
	T_3	29.50	132
	T_4	30.27	1.37
	T_5	17.40	0.98
C. idella	T_1	7.67	1.99
	T_2	7.69	1.43
	T_3	8.20	1.47
	T_4	7.62	1.35
	T_5	1.99	1.20

carpio. Whereas, HSI remained highest in *C. idella* under T_1 (table 5). Delahunty and DeVlaming (1980) mentioned that HSI does not change over the range of body weight suggesting that HSI is an appropriate expression of liver size. The results of the present study were substantiated by the findings of the above mentioned workers. In the dab *Limanda limanda*, HSI values vary throughout the year in both male and female fish (Htun-Han, 1978). HSI values in the dab were lowest during the post spawning season, suggesting that liver reserves were not seriously depleted during yolk formation. Mahboob and Sheri (1997) found HSI to be highest in the pre-spawning season and lowest in the post spawning season period of grass carp (*Ctenopharyngodon idella*). The latter explanation is in line with the results of the present study because fishes were dissected prior to spawning period.

REFERENCES

AOAC. 1984. Official Methods of Analysis of the Association of Official Analytical Chemists (14th Ed.) Arlington, Virginia. p. 1141.

Bondari, K. 1980. Cage performance and quality comparison of tilapia and divergently selected channel catfish. Proc. Annu. Conf. Southeast.Assoc. Fish Wild. Ag. 34:88-98.

Delahunty, G. and V. L. DeVlaming. 1980. Seasonal relationships of ovary weight, liver weight and fat stores with body weight in the goldfish, *Carassius auratus* (L.) J. Fish. Biol. 16:5-13.

Dunham, R. A., J. A. Joyce, K. Bondari and S. P. Malvestuto. 1985. Evaluation of body conformation, and composition and density and traits for indirect selection for dressout percentage of channel catfish. Prog. Fish. Cult. 47:169-175.

Eliassen, J. E. and O. Vahl. 1982. Seasonal variations in the gonad size and the protein and water content of cod, *Gadus morhua* (L.) muscle from Northern Norway. J. Fish. Biol. 20:527-533.

Gupta, S. 1974. Observations on the reproductive biology of *Mastatacembelus armatus* (Lacepede). J. Fish. Biol. 6:13-21.

Htun-Han, M. 1978. The reproduction biology of the dab, *Limanda limanda* (L.) in the North Sea; gonadosomatic index, hepatosomatic index and condition factor. J. Fish. Biol. 13: 269-278.

Javed, M. 1988. Growth performance and meat quality of major carps as influenced by pond fertilization and feed supplementation. Ph.D., thesis, Dept. of Zoology and Fisheries, Agri. Univ., Faisalabad, p. 281.

Lakshmanan, M. A. V., K. K. Sukumaran, D. S. Murty, D. P. Chakraborty and M. T. Philipore. 1971. Preliminary observations on intensive fish farming in fresh water ponds by the composite culture of Indian and exotic species. J. Inland. Fish. Soc. India. 2:1-21.

LeCren, E. D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J. Anim. Ecol. 20:201-219.

Mahboob, S., A. N. Sheri and M. Javed. 1990. Observation on the biology of *Cyprinus carpio.* The 10th Congress of Zoology 26-27 May, Khanspur (Murree). Pak. J. Zool. Abstract, Series No. 10.

Mahboob, S. and A. N. Sheri. 1997. Relationships among ovary weight, liver weight and body weight in female grass carp *C. idella*. J. Aqua. Trop. 12:255-259.

Mann, R. H. K. 1976a. Observation on the age, growth, reproduction and food of the pike *Esox lucius* (L.) in two rivers in southern England. J. Fish Biol. 8:179-197.

Mann, R. H. K. 1976b. Observation on the age, growth, reproduction and food of the chub *Leuciscus cephalus (*L.) in the Rive Stour. Desert. J. Fish Biol. 8:265-288.

Meien, V. A. 1927. Observation on the yearly variations of the ovaries in the perch (*Perca fluvuiatilus*). Russk. Zool. Zh. 7, Vyp. 4.

Okera, W. 1979. Morphometrics, condition and gonad development of the East African *Sardinella gibbosa* (Bleeker) and *Sardinella albella* (Valenciennes). J. Fish Biol. 6:801-812.

Sharma, K. P. and M. M. Simolt. 1971. Chemical composition of some commercially important fishes of Jaisamand lake, Udalpur. J. Inland.Fish. Soc. India. 111:121-122.

Smitherman, R. O., R. A. Dunham and D. Tave. 1983. Review of catfish breeding research at Auburn University 1969-1981. Aquaculture 33:197-205.

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