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Length-Weight Relationship and Morphometric Analysis of *Crossocheilus diplochilus* (Heckel, 1838) from the Dal Lake of Kashmir Himalaya

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ABSTRACT

Background and Objective: *Crossocheilus diplochilus* (*C. diplochilus*) locally known as "Tether" is an endemic fish of Kashmir Valley. The length-weight relationship is one of the standard methods that yield authentic biological information and is of great importance in fishery assessments. Morphometric studies have been the primary source for taxonomic and evolutionary studies. To accurately manage fish populations, it is necessary to estimate their growth rates through the study of morphometric traits. This study was conducted in order to obtain information about the somatic growth of fish. **Materials and Methods:** Morphometric characters were measured by using fish measuring board and Vernier Calipers for accuracy to the nearest millimeter. The weight of the fish was measured using an electronic weighing balance. **Results:** The specimens examined in this study ranged in size from 81.9 to 119.7 mm in length and 5-13.5 g in weight. Length-weight relationship of *Crossocheilus diplochilus* revealed negative allometric growth with b value <3. The Log W = -4.8819+2.9072 Log L is the calculated and expressed form of the length-weight relationship equation. Standard length and fork length had the highest correlations with total length, at 0.853 and 0.842, respectively. Correlation analysis revealed that all morphometric characters changed proportionally as total length increased. **Conclusion:** The findings of this study, offer the fundamental details on the morphometric traits and length-weight parameters of Dal Lake's *Crossocheilus diplochilus*, which may aid in the straightforward identification of the fish species and could be used to study fish population dynamics and growth patterns.

KEYWORDS

Kashmir, Himalaya, *Crossocheilus diplochilus*, Dal Lake, length-weight relationship, morphometry

INTRODUCTION

The Dal Lake is located at an elevation of 1584 m above sea level between 34°5' and 34°6'N latitude and 74°8' and 74°12'E longitude[1]. Since ancient times, the lake, sometimes referred to as the "liquid heart" of Srinagar City, has been an indispensable fishery resource for the people of the valley, particularly

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Srinagar City[2]. Many native and exotic fish species, including schizothoracines, carps and trouts, as well as a number of small fish species, such as *Triplophysa*, *Crossocheilus* and *Gambusia*, have habitats in these water bodies[3,4]. The genus *Crossocheilus* belongs to the family Cyprinidae, which includes various carps and minnows. This fish can be found in a variety of habitats, but it is most frequently found in streams, reservoirs and rivers with swift currents and rocky bottoms[5]. Due to its small size, this fish has little commercial significance. It contributes significantly to the aquatic food chain and preserves ecological balance because it is preyed upon by large carnivorous fish. The fish has been designated as least concerned (LC) under the IUCN (2010) criteria. The freshwater benthopelagic fish *Crossocheilus diplochilus* (Heckel), also known as Kashmir latia, is widely distributed in Kashmiri waters. The fish grows to a maximum length of about 10-17 cm[6,7]. This fish can be found in a variety of habitats, but it typically prefers lakes and the banks of major rivers, it does not migrate up to cold water tributaries. It typically consumes epilithic growth, such as diatoms, filamentous algae and organic debris. This species has 36-38 lateral line scales, two pairs of barbells and an inferior mouth. Since this fish serves as a crucial food source for many commercially significant food fish species, studies of this species are required.

Shape, size, meristic counts and morphological measurements provide information that is helpful for taxonomic status[8]. In comparison to other vertebrates, fish typically exhibit greater variation in morphological traits both within and between populations and they are more highly susceptible to morphological changes brought on by the environment individual well-being and the potential differences between different unit stocks of the same species can be evaluated using the morphometric relationships between different fish body parts[9,10]. Fish are very sensitive to changes in their environment and they quickly adjust by changing the necessary morphometrics[11]. For taxonomic work, knowledge of fish morphometric measurements and research into their statistical relationships are crucial[12]. Morphometric characters can be used to identify the traits that are genetically controlled and those that are influenced by the environment[13,14]. Based on the difference in range, the various morphometric characters have been, numerous morphometric characteristics have been classified as genetically (limited range), intermediate (moderate range) and environmentally (wide range) regulated character[15]. To manage a fishery effectively, it is necessary to understand the relationship between length and weight[16]. The ability to estimate the average weight of fish in a given length group, evaluate the well-beingof individuals and identify potential variations between separate unit stocks of the same species make this relationship crucial to fisheries biology[17]. The standard method for quantifying growth in fisheries is to fit statistical models to data. Additionally, fisheries scientists can transform growth-in-length equations into growth-in-weight stock assessment models by using length-weight relationships. The goal of the current investigation was to gather information regarding the length weight and morphometric characteristics of the fish *Crossocheilus diplochilus* (Hamilton-Buchanan) found in Dal Lake, Srinagar, India.

MATERIALS AND METHODS

Collection of fish sample: The present study was conducted from August, 2022 to February, 2023. From the Dal Lake, a total of 40 *Crossocheilus diplochilus* specimens were obtained. A simple random sample that was representative of each length group was taken. The collected samples were brought to the Fish Genetics and Biotechnology Laboratory, Faculty of Fisheries, SKUAST-K in ice boxesfor Biological Analysis.

Length-weight relationship: The primary objective of length-weight data analysis is to mathematically describe the relationship between length and weight so that one can be converted to the other[18]. Additionally, it calculates a fish's deviation from its expected weight for its length. The conventional formula W = aLb, as described by Le Cren ED[18], was used to perform the calculations. Before the calculations, the equation (above mentioned) and data were logarithmically translated. As a result, the formula obtains Log W = log a+b log L. Where W and L represent total body weight in grams and length in millimeters, respectively and a and b are the functional regression coefficients between W and L.

Morphometric analysis: By using fish measuring board and Vernier Calipers, morphometric characters were measured for accuracy to the nearest millimeter as described by various authors. Morphometric characters were measured by using fish measuring board and Vernier Calipers for accuracy to the nearest millimeter as described by various scientists[19-22].

The 14 morphometric characteristics listed below were measured:

- **Total length (TL):** Measurement from the extreme tip of the snout to the tip of the caudal fin
- **Standard length (SL):** The length/distance between the tip of the snout and the base of the caudal fin
- **Fork length (FL):** Distance between the tip of the snout and the extreme end of the median caudal fin rays
- **Head length (HL):** Distance between the tip of the snout and the operculum's posterior border
- **Pre-dorsal length (PDL):** Distance between the tip of the snout and the anterior edge of the base of the dorsal fin
- **Pre-pectoral length (PPCL):** Distance from the tip of the snout to the anterior margin of the base of the pectoral fin
- **Pre-pelvic length (PPVL):** Distance from the tip of the snout to the anterior margin of the base of the pelvic fin
- **Pre-anal length (PAL):** Distance from the tip of the snout to the origin of the anal fin
- **Dorsal fin length (DFL):** Distance from the fin base of the dorsal fin to the tip of the dorsal fin
- **Pectoral fin length (PCFL):** Distance from the fin base of the pectoral fin to the tip of the pectoral fin
- **Pelvic fin length (PVFL):** Distance from the fin base of the pelvic fin to the tip of the pelvic fin
- **Anal fin length (AFL):** Distance from the fin base of the anal fin to the tip of the anal fin
- **Body depth (BD):** Overall maximum vertical length of the body (the deepest section of the body)
- **Maximum eye diameter (ED):** Distance separating the anterior and posterior margins of the eyes

Statistical analysis: The data was analyzed using MS Excel and SPSS Statistical Package for Social Science). The basis descriptive statistics were calculated for morphometric measurements. Correlation analysis was applied to see the linear and non-linear relationships between various parameters at a significance level of $p<0.05$.

RESULTS AND DISCUSSION

Length-weight relationship: A total of 40 specimens of *C. diplochilus* in length range 81.9 to 119.7 mm and weightrange 5 to 13.5 g were analyzed for length-weight relationship. The LWR was established logarithmically as

$$\text{Log } W = -4.8819+2.9072 \text{ Log } L \ (R^2 = 0.7036)$$

The scatter plot for this LWR is given in Fig. 1.

It is a universal truth that as an animal's body length increases, so does its ability to grow[23]. Therefore, it can be inferred that length and growth are related. If the fish maintains its shape and its specific gravity stays constant, it will exhibit isometric growth and the value of the exponent 'b' will be 3.0 precisely[24]. If the value is greater than 3.0 it indicated that the fish become heavier for a given length and less than 3.0 indicated that the opposite is true. In the present study, the b value was recorded at 2.9072, which indicateda negative allometric growth pattern. In other words, as length increases, *C. diplochilius* becomes less rotund (slender). Similar results were observed by other researchers in C. *diplochilius*[3,25]. *Labeo dyocheilus*[26], *Cyprinus carpio communis* and *Ctenophyryngodon idella*[27] and *Rasbora dani conius*[28] have all

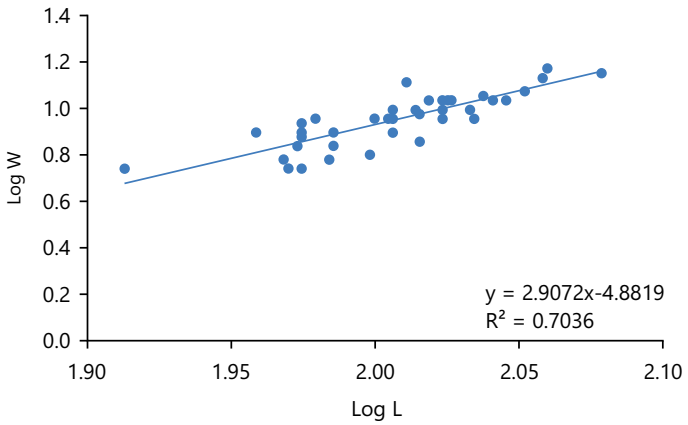

Fig. 1: Scatter diagram showing the length-weight relationship of *Crossocheilus diplochilus*

been reported to have regression lines with slope values less than 3. These reports concur with the current research on the length-weight relationship of *C. diplochilius*, which showed that there was a significant deviation of the "b" value from the isometric value of 3. The length-weight relationship of the majority of fish species may deviate from the cube law because the cube law only applies to species that maintain their form and specific gravity over the course of their lives[29]. However, because shape and form can change over time, this is not always the case.

Morphometry: Measurements of various morphometric characters of *Crossocheilus diplochilus*, their range, mean, median, standard error, standard deviation and coefficient of correlation were presented in Table 1. Table 2 demonstrated the relationship between different characters, including total length v/s FL, total length v/s HL, total length v/s SL, total length v/s PDL, total length v/s PPCL, total length v/s PPVL, total length v/s PAL, total length v/s DFL, total length v/s PVFL, total length v/s PCFL, total length v/s DFL, total length v/s PVFL, total length v/s BD, total length v/s AFL and total length v/s ED. The 'R2' values varied from 0.461 to 0.853 indicating that the compared characters had a high degree of correlation. While PVFL showed the lowest degree of correlation with total length (0.461) and standard length showed the highest degree of correlation (0.853), demonstrating a strong relationship between the characters compared. Table 2 illustrated the values of the constants "a" and "b" and the correlation "R^2" for the different morphometric relationships.

Fish morphometric analysis has been used extensively in fish identification[30] and is a key component in the study of fish biology[31]. In a study of *Schizothorax* spp. in the River Lidder of Kashmir, Maximum growth occurred in standard length (0.9080) and least growth occurred in maximum body depth (0.1730) with respect to the total length of the fish[32]. *Oncorhynchus mykiss* from Kashmir exhibits high levels of interdependence (0.8262-0.9979) between its fourteen morphometric characters[33]. When analyzing the morphometric and meristic traits of *Botia birdi* in the Indus Basin, Jammu and Kashmir, the association between total length and external body components was evaluated and a positive correlation with total length in all parameters[6]. The most significant correlation was found between fork length and total length (r = 0.999) with while postorbital length showed the lowest correlation (r = 0.776). Morphometry of *Crossocheilus diplochilus* from Dal Lake was reported with the highest correlation of total length with standard length (0.983) and fork length (0.989)[26].

The current study offers fundamental knowledge regarding the differentiation of *C. diplochilus* populations using morphometric parameters and recommends that morphometric variations seen in this species can be taken into account in its biodiversity pattern as well as be used as a first step towards fisheries

Table 1: Statistical estimates of morphometric characters of *Crossocheilus diplochilus*

	Range						
Morphometric character	Min	Max	Mean	Median	SD	SE	CV (%)
TL	81.9	119.7	101.885	102.15	7.615085	1.204051	7.474196
SL	72.1	102.6	84.8275	85.60	8.022468	1.268464	9.457391
FL	74.3	104.7	92.345	92.80	7.340019	1.160559	7.948474
HL	10.0	15.5	12.315	12.15	1.710683	0.270483	13.89105
PPCL	12.5	22.8	18.48	18.90	2.416312	0.382053	13.07528
PDL	32.1	45.2	39.47	40.25	3.515985	0.555926	8.907995
PPVL	37.0	69.4	45.255	44.70	5.687591	0.899287	12.56787
PAL	46.0	76.3	64.7675	64.90	6.455901	1.020768	9.96781
PCFL	11.3	19.5	16.0325	16.15	1.719777	0.271921	10.72682
DFL	11.8	23.4	18.9175	18.95	2.539623	0.40155	13.42473
PVFL	10.5	17.0	14.3175	14.40	1.38673	0.219261	9.685557
AFL	9.2	14.7	12.375	12.20	1.346363	0.212879	10.8797
BD	14.0	22.0	18.0325	18.65	2.048563	0.323906	11.36039
ED	4.8	5.9	5.3475	5.25	0.360191	0.056951	6.73568

TL: Total length, SL: Standard length, FL: Fork length, HL: Head length, PDL: Pre-dorsal length, PPCL: Pre-pectoral length, PPVL: Pre-pelvic length, PAL: Pre-anal length, DFL: Dorsal fin length, PCFL: Pectoral fin length, PVFL: Pelvic fin length, AFL: Anal fin length, BD: Body depth and ED: Eye diameter

Table 2: Length-length relationship of various morphometric characters of *Crossocheilus diplochilus*

Morphometric character	Intercept (a)	Slope (b)	Y =a+bX	Correlation coefficient (R^2)
SL	-14.300	0.973	SL = -14.30+0.973TL	0.853
FL	2.191	0.884	FL = 2.191+0.884TL	0.842
HL	-5.700	0.176	HL = -5.700+0.176TL	0.619
PPCL	-7.043	0.250	PPCL = -7.043+0.250TL	0.623
PDL	1.304	0.374	PDL = 1.304+0.374TL	0.658
PPVL	-9.845	0.540	PPVL = -9.845+0.540TL	0.524
PAL	-1.137	0.646	PAL = -1.137+0.646TL	0.582
PCFL	-1.678	0.173	PCFL = -1.678+0.173TL	0.592
DFL	-7.648	0.260	DFL = -7.648+0.260TL	0.611
PVFL	1.719	0.123	PVFL = 1.719+0.123TL	0.461
AFL	-2.210	0.143	y = -2.210+0.143TL	0.655
BD	-1.531	0.192	y = -1.531+0.192TL	0.509
ED	1.915	0.033	y = 1.915+0.033TL	0.507

TL: Total length, SL: Standard length, FL: Fork length, HL: Head length, PDL: Pre-dorsal length, PPCL: Pre-pectoral length, PPVL: Pre-pelvic length, PAL: Pre-anal length, DFL: Dorsal fin length, PCFL: Pectoral fin length, PVFL: Pelvic fin length, AFL: Anal fin length, BD: Body depth and ED: Eye diameter

management, commercial exploitation of this species and any stock enhancement program. Traditional morphometry has some drawbacks. In order to resolve the taxonomic ambiguity of morphologically similar species, additional studies are therefore required, including its integration with advanced morphometric techniques and genetic markers.

CONCLUSION

The results generated in the present study will provide baseline data on length-weight relationship and the findings of this study will offer baseline data on the length-weight relationship and morphometry of *C. diplochilus*, facilitating easier identification and contributing to the development of a conservation plan for the natural populations of *C. diplochilus* in Dal Lake. According to the findings of the current study, this fish exhibits negative allometric growth in accordance with the cube law. Total length has been found to positively correlate with a number of morphometric parameters. For more accurate results, a combined approach combining morphometry, genetics and other biological indicators (such as the growth pattern of scales and otoliths) must be taken into account.

SIGNIFICANCE STATEMENT

Morphometric differences among stocks of a species are recognized as an important method for evaluating the population structure and as a basis for identifying stocks. Morphometric measurements are widely used to identify differences between fish populations and such types of studies in this group of species are scanty. The manuscript will through light on the morphometric and meristic aspects of this fish species.

REFERENCES

1. Tabassum, S., A. Tiwari, M.F. Mir, R. Farooq and A.H. Shah *et al*., 2018. Dominance of *Limnodrilus hoffmeisteri* in oligochaete community of Dal Lake, Srinagar, Kashmir, India. SKUAST J. Res., 20: 203-207.
2. Shafi, S., F.A. Bhat, A.R. Yousuf and M. Parveen, 2012. Biology of *Cyprinus carpio communis* from Dal Lake, Kashmir with reference to food and feeding habits, length-weight relationship, and fecundity. Nat. Environ. Pollut. Technol., 11: 79-87.
3. Sidiq, M., I. Ahmed and Y. Bakhtiyar, 2021. Length-weight relationship, morphometric characters, and meristic counts of the coldwater fish *Crossocheilus diplochilus* (Heckel) from Dal Lake. Fish. Aquat. Life, 29: 29-34.
4. Raina, A.K., H. Jaffe, J.A. Klun, R.L. Ridgway and D.K. Hayes, 1987. Characteristics of a neurohormone that controls sex pheromone production in *Heliothis zea*. J. Insect Physiol., 33: 809-814.
5. Brraich, O.S. and S.K. Saini, 2019. Ichthyofaunal diversity of Ranjit Sagar Wetland situated in the Northwestern Himalayas. Eur. J. Environ. Sci., 9: 106-113.
6. Sharma, N.K., J.I. Mir, A.K. Dobriyal and R. Singh, 2015. Length-weight relationships of two cyprinid fish species, *Crossocheilus latius* (Hamilton, 1822) and *Garra gotyla gotyla* (Gray, 1830) from the Ganga River Basin, India. J. Appl. Ichthyol., 31: 1161-1162.
7. Talwar, P.K. and A.G. Jhingran, 1991. Inland Fishes of India and Adjacent Countries, Volume 2. CRC Press, USA., ISBN: 9789061911647, Pages: 1158.
8. Strauss, R.E., 1985. Evolutionary allometry and variation in body form in the South American catfish genus *Corydoras* (Callichthyidae). Syst. Zool., 34: 381-396.
9. Barlow, G.W., 1961. Causes and significance of morphological variation in fishes. Syst. Biol., 10: 105-117.
10. Brosset, P., J.M. Fromentin, F. Ménard, F. Pernet and J.H. Bourdeix *et al*., 2015. Measurement and analysis of small pelagic fish condition: A suitable method for rapid evaluation in the field. J. Exp. Mar. Biol. Ecol., 462: 90-97.
11. Hossain, M.A.R., M. Nahiduzzaman, D. Saha, M.U.H. Khanam and M.S. Alam, 2010. Landmark-based morphometric and meristic variations of the endangered carp, Kalibaus *Labeo calbasu*, from stocks of two isolated rivers, the Jamuna and Halda and a hatchery. Zool. Stud., 49: 556-563.
12. Narejo, N.T., A. Dayo, B.A. Dars, H. Mahesar, M.Y. Laghari and P.K. Lashari, 2010. Effect of stocking density on growth and survival rate of *Labeo rohita* (Hamilton) fed with formulated feed. Sindh Univ. Res. J. (Sci. Ser.), 42: 35-38.
13. Dujardin, J.P., 2008. Morphometrics applied to medical entomology. Infect. Genet. Evol., 8: 875-890.
14. Fagbuaro, O., J.A. Oso, M.B. Olurotimi and O. Akinyemi, 2015. Morphometric and meristic characteristics of *Clarias gariepinus* from controlled and uncontrolled population from Southwestern Nigeria. J. Agric. Ecol. Res. Int., 2: 39-45.
15. Johal, M.S. and A. Dua, 1994. SEM study of the scales of freshwater snakehead, *Channa punctatus* (bloch) upon exposure to endosulfan. Bull. Environ. Contam. Toxicol., 52: 718-721.
16. Shin, Y.J., M.J. Rochet, S. Jennings, J.G. Field and H. Gislason, 2005. Using size-based indicators to evaluate the ecosystem effects of fishing. ICES J. Mar. Sci., 62: 384-396.
17. Blackwell, B.G., M.L. Brown and D.W. Willis, 2000. Relative weight (Wr) status and current use in fisheries assessment and management. Rev. Fish. Sci., 8: 1-44.

18. Le Cren, 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.
19. Petrtýl, M., L. Kalous and D. Memiş, 2014. Comparison of manual measurements and computer-assisted image analysis in fish morphometry. Turk. J. Vet. Anim. Sci., 38: 88-94.
20. Shah, T.H., S.K. Chakraborty, A.K. Jaiswar, T. Kumar, K.M. Sandhya and R.K. Sadawarte, 2014. Biometric analysis of oil sardine *Sardinella longiceps* Valenceinnes, 1847 (Clupeiformes: Clupeidae) along Ratnagiri Coast of Maharashtra. Indian J. Geo-Mar. Sci., 43: 805-814.
21. Takács, P., Z. Vitál, Á. Ferincz and Á. Staszny, 2016. Repeatability, reproducibility, separative power and subjectivity of different fish morphometric analysis methods. PLoS ONE, Vol. 11. 10.1371/journal.pone.0157890.
22. Muñoz-Muñoz, F. and D. Perpiñán, 2010. Measurement error in morphometric studies: Comparison between manual and computerized methods. Ann. Zool. Fenn., 47: 46-56.
23. McCay, C.M., M.F. Crowell and L.A. Maynard, 1935. The effect of retarded growth upon the length of life span and upon the ultimate body size: One figure. J. Nutr., 10: 63-79.
24. Wootton, R.J., 1990. Ecology of Teleost Fishes. 1st Edn., Springer, Dordrecht, Netherlands, ISBN: 978-94-009-0829-1, Pages: 404.
25. Mushtaq, S.T., S.A. Mushtaq, M.U.H. Balkhi, F.A. Bhat and I. Farooq, 2016. Estimation of length-weight relationship and condition factor of *Crossocheilus diplochilus* (Heckel, 1838): A freshwater benthopelagic fish from Wular Lake in Kashmir Himalaya. Int. J. Fish. Aquat. Stud., 4: 522-525.
26. Malhotra, S.K. and R.S. Chauhan, 1984. Bionomics of hill-stream cyprinids. IV. Length-weight relationship of *Labeo dero* (Ham.) from India. Proc.: Anim. Sci., 93: 411-417.
27. Bhatt, D.M., K.J. Sarma, N.J. Thakkar and P.C. Mankodi, 2022. Length-weight relationship, condition factor, gonadosomatic index and gut-content analysis of *Planiliza planiceps* (Valenciennes 1836) (Actinopterygii, Mugiliformes, Mugilidae) from the four major estuaries of Gujarat, India. Thalassas, 38: 855-864.
28. Allen, K.R., 1938. Some observations on the biology of the trout (*Salmo trutta*) in Windermere. J. Anim. Ecol., 7: 333-349.
29. Cadrin, S.X. and K.D. Friedland, 1999. The utility of image processing techniques for morphometric analysis and stock identification. Fish. Res., 43: 129-139.
30. Ibañez, A.L., I.G. Cowx and P. O'Higgins, 2007. Geometric morphometric analysis of fish scales for identifying genera, species, and local populations within the Mugilidae. Can. J. Fish. Aquat. Sci., 64: 1091-1100.
31. Hussain, M.A., M.A. Khatun, M.A.B. Siddique, F.A. Flowra, M.M. Alam and S. Sultana, 2012. Morphometric characters of freshwater fish *Xenentodon cancila* collected from Rajshahi City, Bangladesh. J. Bio-Sci., 20: 171-177.
32. Arafat, M.Y. and Y. Bakhtiyar, 2020. Morphometric attributes and their controlling elements in himalayan snow trout, *Schizothorax labiatus* inhabiting Vishav Stream of South Kashmir, India. J. Ecophysiology Occup. Health, 20: 50-56.
33. Bazaz, A.I., T.H. Shah, F.A. Bhat, I. Ahmad and Nafhat-Ul-Arab *et al*., 2022. Assessment of spawning fecundity and its relationship with body parameters of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta* fario). Int. J. Bio-Resour. Stress Manage., 13: 1115-1123.