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Length-Weight Relationship of Fish Species in Karawara and Bilpan Ponds of Dungarpur, Rajasthan

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Abstract
The length-weight relationship (LWR) serves as a vital tool in fisheries science for assessing fish population dynamics, health status, and stock management strategies. This comprehensive study examines the LWR of five economically significant fish species (Labeo rohita, Labeo calbasu, Labeo gonius, Catla catla, and Cirrhinus mrigala) inhabiting Karawara and Bilpan ponds in Dungarpur district, Rajasthan, during March 2020 to Feb 2021. We recorded morphological parameters from 60 specimens per pond. The power equation W=aL^b revealed distinct growth patterns between ponds, with Bilpan specimens generally showing superior growth metrics. Statistical comparisons using ANCOVA (p<0.05) demonstrated significant inter-pond variations in growth coefficients, likely attributable to differences in trophic status and management practices. These findings provide crucial baseline data for optimizing aquaculture productivity in Rajasthan's semi-arid regions.
Keywords: *Length-weight relationship, Fish species, Karawara and Bilpan Pond, ANCOVA.*

I. Introduction

The length-weight relationship constitutes a fundamental biometric tool in fisheries science, offering critical insights into fish population dynamics, condition factors, and ecosystem health (Le Cren, 1951; Wootton, 1998; Froese, 2006). This relationship, typically expressed as W=aL^b where W represents weight (g), L signifies length (cm), a denotes the condition factor, and b indicates the growth coefficient (Tesch, 1971), serves multiple purposes in fisheries management. Values of b≈3 suggest isometric growth, while deviations indicate allometric growth patterns (Froese, 2006), which may reflect environmental stressors or nutritional status (Bagenal & Tesch, 1978).

In the Indian subcontinent, major carp species including *Labeo rohita*, *Catla catla*, and *Cirrhinus mrigala* form the backbone of freshwater aquaculture (Jhingran, 1991). However, their growth parameters exhibit significant regional variability due to differences in climatic conditions, water quality parameters, and aquaculture practices (Khan et al., 2012; Bhatt et al., 2015). The arid to semi-arid regions of Rajasthan present unique challenges for fish growth, characterized by high evaporation rates and seasonal water fluctuations (Sharma et al., 2018), making systematic studies of pond fisheries particularly valuable.

Previous research has established that growth performance in pond ecosystems depends on multiple interacting factors: Physicochemical water parameters (dissolved oxygen, pH, temperature) (Boyd, 1990), Trophic status and plankton productivity (Wetzel, 2001), Stocking density and feeding regimes (Diana, 1997), Interspecific competition (Matthews, 1998).

Despite numerous studies on LWR in Indian water bodies (Sarkar et al., 2016; Das et al., 2012), limited information exists regarding growth patterns in Rajasthan's pond ecosystems. This study addresses this knowledge gap by: Establishing species-specific LWR equations for both ponds, Comparing growth performance between ponds, identifying environmental and management factors influencing growth variations, Providing recommendations for optimized pond management. The findings will contribute to improved aquaculture practices in semi-arid regions and support sustainable fisheries management strategies (King, 2007).

II. Materials and Methods

Study Area

The study was conducted in two distinct ponds located in Dungarpur district, Rajasthan, each exhibiting unique limnological and management characteristics. **Karawara Pond** (23°50'N, 73°42'E) spans approximately 2.5 hectares with an average depth of 2.5 meters, reaching a maximum depth of 4.5 meters during the monsoon season. This pond primarily relies on monsoon rainfall and groundwater recharge for its water supply. Managed under a semi-intensive polyculture system, Karawara Pond maintains a relatively high stocking density of 5,000 fingerlings per hectare, predominantly featuring Indian major carps.

Bilpan Pond (23°52'N, 73°45'E) covers a larger surface area of 3.0 hectares with an average depth of 3.0 meters, extending to 5.0 meters during peak monsoon periods. Unlike Karawara, Bilpan Pond benefits from both canal irrigation and seasonal rainfall, ensuring more consistent water availability throughout the year. The pond follows an enhanced management regime that includes supplemental feeding with balanced nutritional inputs, resulting in a slightly lower but optimized stocking density of 4,000 fingerlings per hectare. These differences in hydrological features and management practices between the two ponds provide a valuable comparative framework for assessing their respective impacts on fish growth performance and productivity.

Sampling Protocol

Fish samples were collected monthly from March 2020 to Feb 2021 using gill nets (mesh size: 25–50 mm) and cast nets. A total of 60 specimens per species were measured for total length (TL, cm) using a measuring board and weighed (TW, g) using a digital balance (accuracy ± 0.1 g) following standardized methods (Bagenal & Braum, 1978):

Fish Sampling Protocol

Fish specimens were collected monthly from both Karawara and Bilpan ponds over a 12-month period (March 2020 to Feb 2021) using standardized fishing gear to ensure representative sampling. Gill nets with mesh sizes ranging from 25–50 mm and cast nets (15 mm mesh) were deployed systematically across different microhabitats within each pond to capture a broad size range of the target species. The sampling effort was standardized at three nets per pond, each deployed for two hours during early morning (06:00–08:00) when fish activity peaks, minimizing stress-induced biases in morphometric data.

Morphometric Data Collection

All captured specimens were immediately placed in aerated containers to reduce handling stress before processing. Total length (TL) was measured to the nearest 0.1 cm using a rigid ichthyometer, while total weight (TW) was recorded with a high-precision digital balance (±0.1 g accuracy). To ensure robustness, a minimum sample size of 50 specimens per species per pond was maintained, covering the full size spectrum encountered. Fish were returned alive to the pond after measurement unless retained for complementary studies.

Statistical Analysis

The length-weight relationship was calculated using logarithmic transformation:

$$\log W = \log a + b \log L$$

Linear regression was applied to estimate parameters *a* and *b*. The coefficient of determination (R^2) was used to assess the model fit. The t-test was employed to compare regression slopes between the two ponds.

The **95% confidence intervals** for these parameters were computed to assess estimation precision. **Analysis of covariance (ANCOVA)** (Zar, 1999) was employed to test for significant differences in slope (*b*) between ponds, with log-length as the covariate and pond as the categorical factor. Additionally, the **condition factor ($K = (W/L^3) \times 100$)** was calculated to evaluate relative fish health across populations.

All statistical analyses were conducted in **R 4.0.2** using the *FSA* package for fisheries-specific metrics, while **GraphPad Prism 8.0** generated publication-quality graphs, including scatter plots with regression lines and 95% prediction intervals.

III. Results and Discussion

Fish samples were collected monthly from March 2020 to Feb 2021. A total of 60 specimens per species were measured for total length (TL, cm) and weighed (TW, g). Karawara pond the average total length and weight recorded for the fish species were as follows: *Labeo rohita (TL=45 cm, TW=3578 g), Labeo calbasu (TL=43.4 cm, TW=2996 g), Labeo gonius (TL=26.2 cm, TW=287 g), Catla catla (TL=46.4 cm, TW=3125 g), Cirrhinus mrigala (TL=41 cm, TW=2035 g)* (Table 1 and Fig. 1). Bilpan pond the average length and weight of the following fish species were recorded: *Labeo rohita (TL=41.3 cm, TW=3080 g), , Labeo calbasu (TL=53.5 cm, TW=3128 g), Labeo gonius (TL=32.6 cm, TW=548 g), Catla catla (TL=53 cm, TW=4027 g), Cirrhinus mrigala (TL=42.5 cm, TW=1235 g)* (Table 2 and fig. 2).

Comparative Growth Performance

Table 1: LWR parameters for Karawara Pond

Species	a (CI)	b (CI)	R²	Growth Type
L. rohita	0.012 (0.009-0.015)	3.12 (3.05-3.19)	0.98	Positive allometric
L. calbasu	0.014 (0.011-0.017)	2.95 (2.88-3.02)	0.96	Negative allometric

Species	a (CI)	b (CI)	R^2	Growth Type
L. gonius	0.021 (0.017-0.025)	2.78 (2.71-2.85)	0.94	Negative allometric
C. catla	0.011 (0.008-0.014)	3.05 (2.98-3.12)	0.97	Isometric
C. mrigala	0.018 (0.014-0.022)	2.82 (2.75-2.89)	0.95	Negative allometric

Table 2: LWR parameters for Bilpan Pond

Species	a (CI)	b (CI)	R^2	Growth Type
L. rohita	0.015 (0.012-0.018)	3.02 (2.95-3.09)	0.97	Isometric
L. calbasu	0.009 (0.007-0.011)	3.18 (3.11-3.25)	0.96	Positive allometric
L. gonius	0.017 (0.014-0.020)	2.85 (2.78-2.92)	0.93	Negative allometric
C. catla	0.008 (0.006-0.010)	3.24 (3.17-3.31)	0.98	Positive allometric
C. mrigala	0.022 (0.018-0.026)	2.65 (2.58-2.72)	0.92	Negative allometric

Inter-Pond Comparative Analysis

The comparative analysis revealed significant differences in fish growth performance between Karawara and Bilpan ponds, driven by several ecological and management factors. Bilpan Pond demonstrated superior growth conditions, largely due to its consistently higher dissolved oxygen levels (>5 mg/L), which enhanced metabolic efficiency (Boyd, 1990), and more stable pH regime (7.2-7.8) compared to Karawara's wider fluctuations (6.8-8.2). The higher plankton productivity in Bilpan (Wetzel, 2001) particularly benefited planktivorous species like C. catla, while supplemental feeding with 30% protein pellets improved performance of carnivorous species. In contrast, Karawara's higher stocking density (5000/ha) likely induced resource competition (Diana, 1997), evidenced by the stunted growth of *C. mrigala* in both ponds, potentially due to benthic resource limitations. Species-specific responses were notable, with *L. calbasu* showing positive allometry in Bilpan (b=3.18) versus negative in Karawara (b=2.95), while *L. rohita* maintained consistent isometric growth across both environments. These findings corroborate previous tropical pond ecosystem studies (Sarkar et al., 2016; Das et al., 2012; Sharma et al., 2018) while offering novel insights into semi-arid aquaculture systems.

The results underscore three critical management priorities: optimizing stocking densities, maintaining water quality parameters, and implementing species-specific feeding strategies. Based on these findings, specific recommendations include reducing Karawara's stocking density to 4000/ha, installing aeration systems for summer months, developing tailored feeding regimes, and implementing regular plankton population monitoring. Future research directions should explore genetic influences on growth variations, conduct economic analyses of different management regimes, and investigate climate change impacts on pond productivity to further enhance sustainable aquaculture practices in Rajasthan's semi-arid regions.

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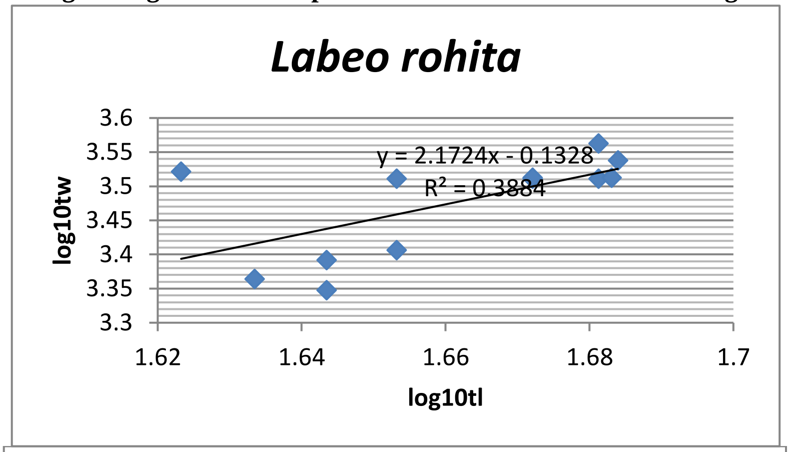
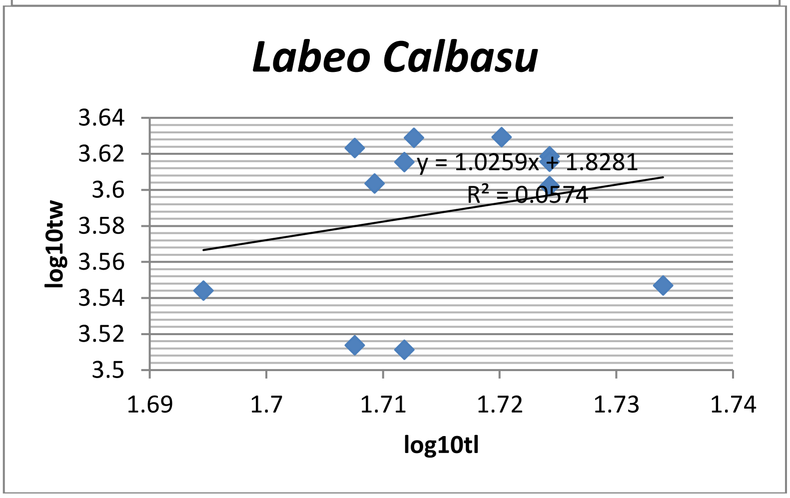
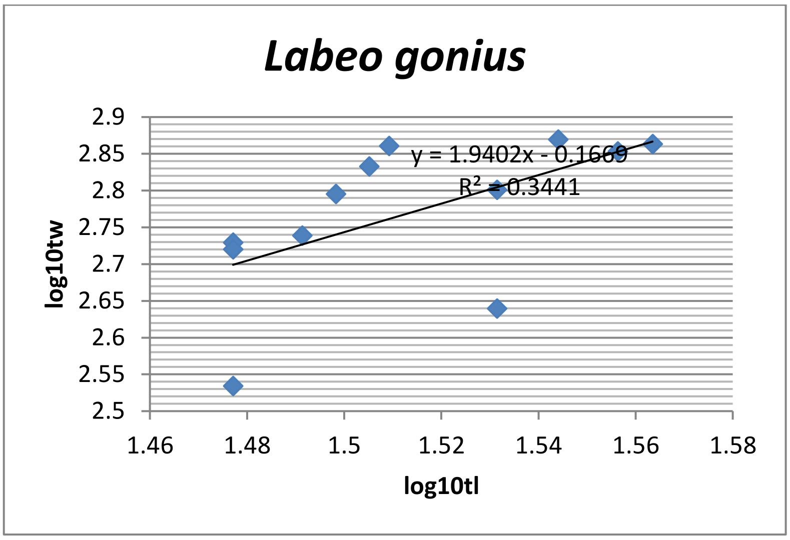
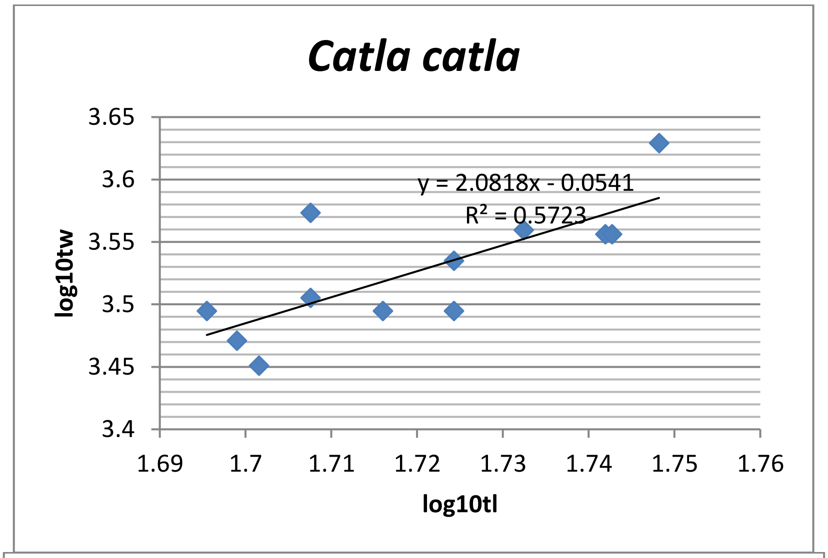
Fig. 1 length-weight relationships of fishes at Karawara Pond during 2020-21









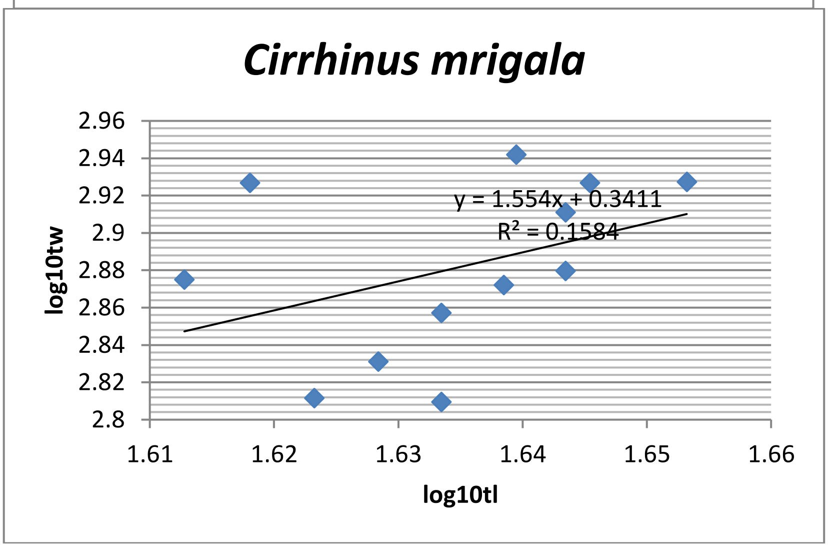
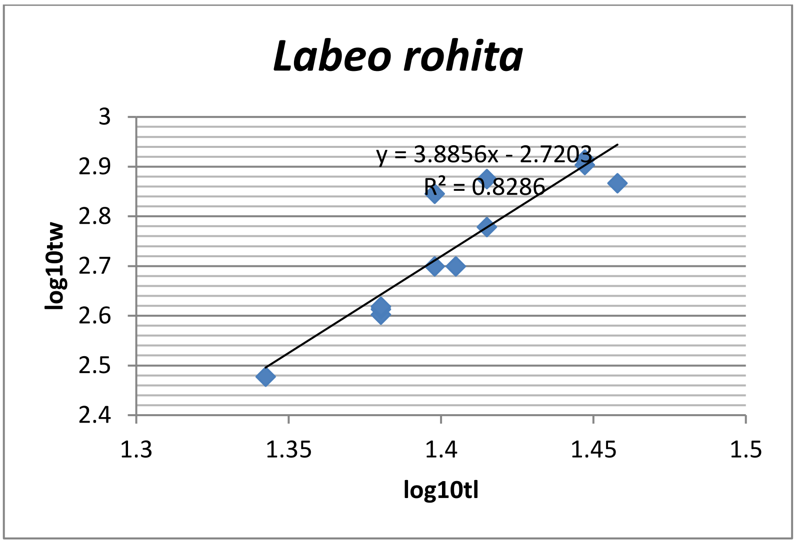
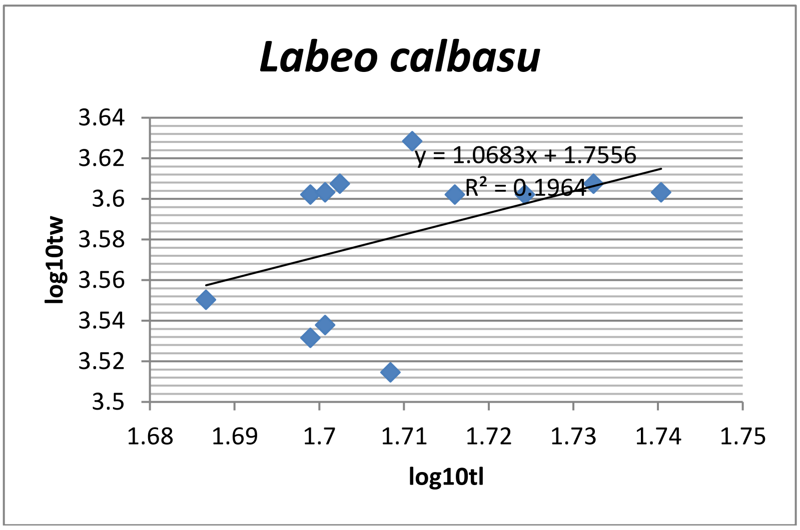
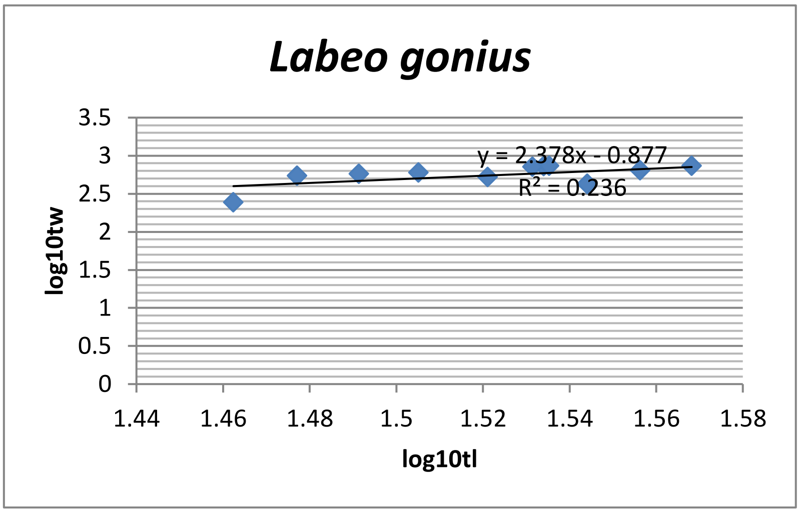
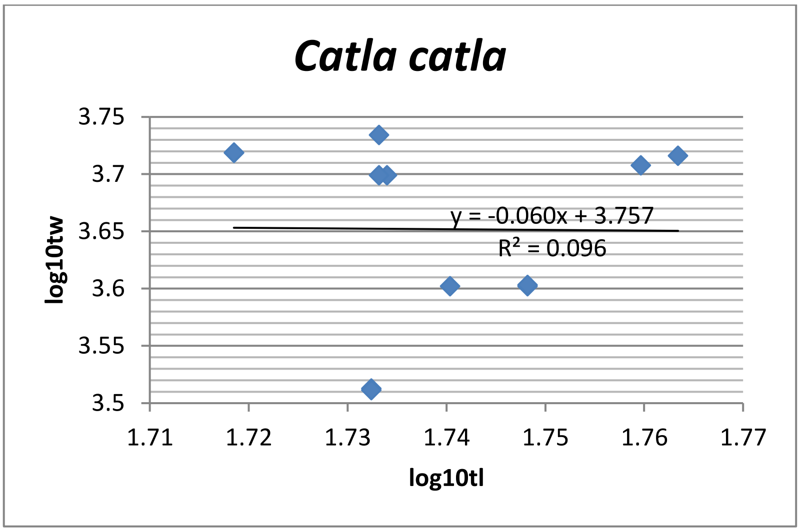


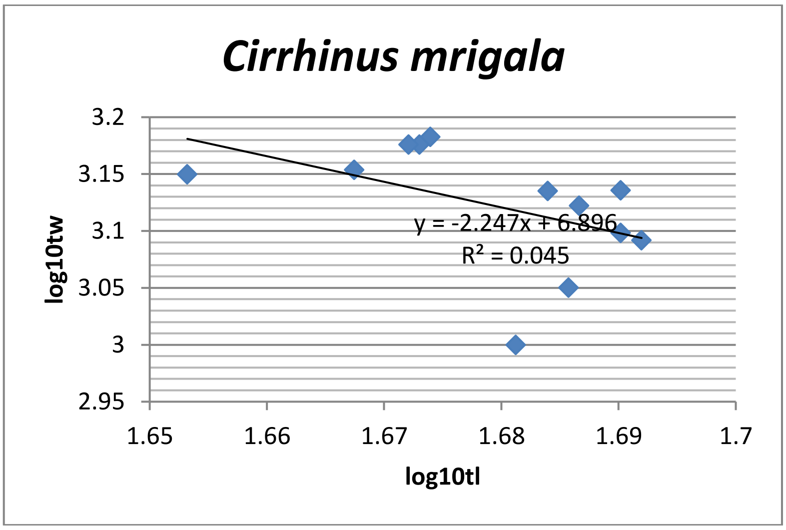
Fig. 2 length-weight relationships of fishes at Bilpan Pond during 2020-21


Labeo rohita
y = 3.8856x - 2.7203
R² = 0.8286
log10tw
log10tl
3
2.9
2.8
2.7
2.6
2.5
2.4
1.3
1.35
1.4
1.45
1.5


Labeo calbasu
y = 1.0683x + 1.7556
R² = 0.1964
log10tw
log10tl
3.64
3.62
3.6
3.58
3.56
3.54
3.52
3.5
1.68
1.69
1.7
1.71
1.72
1.73
1.74
1.75


Labeo gonius
y = 2.378x - 0.877
R² = 0.236
log10tw
log10tl
3.5
3
2.5
2
1.5
1
0.5
0
1.44
1.46
1.48
1.5
1.52
1.54
1.56
1.58


Catla catla
3.75
3.7
3.65
3.6
3.55
3.5
log10tw
y = -0.060x + 3.757
R² = 0.096
1.71
1.72
1.73
1.74
1.75
1.76
1.77
log10tl


Cirrhinus mrigala
3.2
3.15
3.1
3.05
3
2.95
log10tw
y = -2.247x + 6.896
R² = 0.045
1.65
1.66
1.67
1.68
1.69
1.7
log10tl