



Morphological Variation and Proximate Body Composition of the Freshwater Catfish *Wallago attu* (Bloch & Schneider, 1801): A Meta-Analysis

P. Ayodhya Reddy^{1*}, M. Madhusudhan Reddy²

¹Associate Professor of Zoology, Government Degree College (Autonomous), Siddipet

²Assistant Professor of Zoology; Government Degree College (Autonomous), Siddipet

Corresponding Author : P. Ayodhya Reddy*

Email: iamayodhya@gmail.com

Received: 14-09-2023

Accepted: 01-10-2023

Published: 29-10-2023

Abstract:

Wallago attu, commonly known as the freshwater shark, mulley, or boal, is a large silurid catfish of considerable commercial and nutritional importance across South and Southeast Asia. This paper brings together published studies on the morphology, growth pattern, and proximate body composition of *W. attu*, with the aim of comparing length-weight relationships, morphometric and meristic characters, and nutritional composition reported from different river systems, reservoirs, and lakes, mainly in Pakistan and India. The growth coefficient (b) obtained from the length-weight relationship varied from about 2.7 to 3.5 across different water bodies, with most populations showing isometric to slightly positive allometric growth, meaning that body weight increases at close to, or slightly faster than, the cube of body length as the fish grows. Morphometric studies consistently show that total length correlates most strongly with standard length and head length, while meristic counts of fin rays are relatively stable within the species and are useful for taxonomic confirmation. Proximate composition studies show that fresh *W. attu* muscle typically contains around 15 to 20 percent protein, 1 to 4 percent lipid, 75 to 82 percent moisture, and 1 to 2 percent ash, although these values change with body size, sex, season, and storage condition. Larger fish and fish in better body condition generally show higher percentage protein, fat, and ash content, while moisture content changes comparatively little with body size. Taken together, the evidence indicates that *W. attu* is a fast-growing, protein-rich food fish whose morphometric and nutritional profile is well documented in parts of its range but would benefit from more standardised, wider-ranging sampling to support fisheries management and aquaculture development.

Keywords: *Wallago attu*; morphometry; length-weight relationship; meristic characters; proximate composition; condition factor; freshwater catfish

1. Introduction

Wallago attu (Bloch & Schneider, 1801), popularly known as the freshwater shark, mulley, boal, or lanchi in different parts of its range, is one of the largest silurid catfishes found in the rivers, lakes, and reservoirs of South and Southeast Asia. It is distributed widely across Pakistan, India, Bangladesh, Nepal, Myanmar, Sri Lanka, Thailand, Vietnam, Cambodia, and parts of Indonesia (Yousaf, Salam, & Naeem, 2009). As a large, fast-growing, carnivorous fish that occupies a prominent place in local diets and fisheries, *W. attu* has attracted attention from fishery scientists for two related but distinct reasons: understanding its growth pattern through morphometric and length-weight studies, and evaluating its nutritional value through proximate composition analysis. Both lines of research are important for the same broader purpose, which is to support sustainable fisheries management, aquaculture development, and food-safety assessment of a fish that is both economically valuable and, in several parts of its range, of growing conservation concern (Hossain et al., 2008).

Length-weight relationships are one of the most basic and widely used tools in fishery biology. By fitting the equation $W = aL^b$ to samples of fish of different sizes, researchers can estimate how weight increases with length, and the value of the exponent b indicates whether growth is isometric, meaning that the fish keeps the same body shape as it grows and b is close to 3.0, or allometric, meaning that body proportions change with size. Yousaf, Salam, and Naeem (2009) examined *W. attu* and *Sperata sarwari* from the Indus River in southern Punjab, Pakistan, and reported a b value of 3.27 for *W. attu*, which is significantly higher than 3.0 and indicates that weight increases more rapidly than the cube of length as the fish grows, a pattern known as positive allometric growth. A separate study on *W. attu* from Manchar Lake in Sindh, Pakistan, examined 251 specimens and reported a combined b value of 3.08, which is close to isometric growth, with a slightly higher value for females than males (Achakzai, Baloch, Saddozai, & Memon, 2013). In India, Rufus, Eldho, Ali, Dahanukar, and Raghavan (2015) studied *W. attu* from three small westward-flowing rivers of central Kerala and found that the b value ranged from 2.7 to 3.5 across the different river populations, with condition factor values below unity, suggesting that fish in these rivers were, on average, in relatively poor body condition compared

with the ideal reference standard. These differences between water bodies show that although the general growth pattern of *W. attu* tends towards isometry, local environmental conditions, food availability, and sampling season can shift the growth coefficient noticeably in either direction.

Beyond the length-weight relationship itself, morphometric and meristic studies provide a more detailed picture of body shape and countable structures such as fin rays, which are useful both for basic biological description and for distinguishing populations or confirming species identity. Prasad, Desai, and Jogi (2020) carried out a detailed morphometric and meristic study of *W. attu* from the Bhadar reservoir in Gujarat, India, measuring total length, standard length, head length, and several fin lengths, together with counts of dorsal, pectoral, pelvic, anal, and caudal fin rays. Their results showed that total length correlated most strongly with standard length and head length, while fin length measurements such as caudal length and anal fin length showed weaker correlation with total length, and that most morphometric variables showed positive allometric growth relative to total length. A separate length-weight study by the same authors on the same reservoir population found that the maximum recorded size of *W. attu* was 109.5 centimetres, and that the length-weight relationship differed only slightly, and not significantly, between males and females, although the condition factor tended to be higher in females (Prasad & Desai, 2020). These morphometric details complement the length-weight studies by showing which body dimensions are most reliable for estimating overall size and by confirming the meristic counts, such as the typical number of dorsal, pectoral, and anal fin rays, that help characterise the species.

Alongside these morphological studies, a separate body of work has examined the proximate body composition of *W. attu*, meaning the percentage of protein, fat, moisture, and ash in its edible muscle tissue, since this information is directly relevant to its value as a food fish. Yousaf, Salam, and Naeem (2011) examined the relationship between body composition and body size, condition factor, and sex in wild *W. attu* from southern Punjab, Pakistan, and found that larger body size was associated with higher percentage ash, fat, and protein content on a wet-weight basis, while moisture content showed little relationship with body size. They also found that fish in better body condition, as measured by the condition factor, tended to have higher fat, ash, and protein content, and that sex had no significant influence on body composition. In a broader comparative study of eight freshwater fish species from the Indus River, Memon, Talpur, and Bhangar (2010) reported that moisture, ash, protein, and lipid content varied significantly between species, with moisture ranging from about 60 to 79 percent, protein from 17 to 20 percent, and lipid from under 1 percent to over 18 percent across the species examined, illustrating that *W. attu* sits within a wider group of Indus River fishes whose nutritional composition depends strongly on species-specific fat storage patterns. Working specifically with *W. attu* muscle, Gandotra, Gupta, Meenakshi, and Gupta (2013) reported that fresh, unfrozen muscle contained approximately 15.45 percent protein, 4.02 percent lipid, 81.66 percent moisture, and 1.48 percent ash, and that all four of these proximate parameters declined significantly over thirty days of frozen storage at minus twelve degrees Celsius, which has direct implications for how this fish should be handled and stored to preserve its nutritional value between catch and consumption.

Fatty acid composition, which is closely linked to proximate lipid content, has also received some attention in this species. Hossain et al. (2008), summarising the biology of *W. attu* as part of a wider review of threatened fish species, noted that fatty acid composition differed between small and large size groups of the fish, with saturated fatty acid content ranging from about 30 to 50 percent of total fatty acids depending on fish size and the tissue examined. A separate study by Bibi, Khan, Shah, Raziq, Muhammad, and Yousafzai (2016) examined cholesterol and fatty acid profiles in different tissues of *W. attu* of different sizes and confirmed that both cholesterol content and fatty acid profile vary significantly with fish size and with the tissue sampled, reinforcing the idea that a single average value for fat or fatty acid content can be misleading unless fish size and tissue type are specified.

Despite this useful body of work, the available studies on *W. attu* morphology and proximate composition are scattered across different countries, water bodies, and time periods, and they use somewhat different sampling designs, size ranges, and analytical methods. This makes it difficult, without a dedicated review, to see the overall pattern of how consistent the growth coefficient and body composition of this species really are across its range, and which factors, such as body size, sex, season, or storage condition, most reliably predict variation in these traits. The present review therefore brings together the available morphometric, meristic, and proximate composition data on *W. attu*, in order to compare growth patterns and nutritional composition across studies and to summarise what is currently known about the biology and food value of this commercially important catfish.

2. Methods

Published studies reporting original data on the morphology, growth, or proximate body composition of *Wallago attu* were identified through searches of standard bibliographic and full-text sources, including Scopus-indexed journals, Google Scholar, and the archives of relevant fisheries and food-science journals. Search terms included combinations of "*Wallago attu*", "length-weight relationship", "morphometric", "meristic", "condition factor", "proximate composition", "body composition", and "fatty acid". Studies were included if they reported original field or laboratory data on length-weight relationships, morphometric or meristic characters, or proximate and fatty acid composition of *W. attu*. Studies that mentioned the species only in passing, or that lacked extractable numerical data, were excluded. From each included study, information on the sampling location, sample size, and principal quantitative findings was extracted and organised for comparison.

3. Results

3.1 Length-Weight Relationship and Growth Pattern

The growth coefficient (b) obtained from the length-weight equation $W = aL^b$ has been estimated for *Wallago attu* in at least three separate water bodies. In the Indus River, southern Punjab, Pakistan, the b value was estimated at 3.27, indicating positive allometric growth, meaning the fish becomes proportionally heavier as it grows longer (Yousaf et al., 2009). In Manchar Lake, Sindh, Pakistan, the combined b value across 251 specimens was 3.08, close to isometric growth, with separate values of 3.12 for males and 3.01 for females (Achakzai et al., 2013). In three small rivers of central Kerala, India, the b value ranged more widely, from 2.7 to 3.5 depending on the specific river, with condition factor values generally below one, indicating relatively lean fish in those populations (Rufus et al., 2015). Figure 1 compares these reported b values, together with the reference line at $b = 3.0$ that marks the boundary between negative allometric, isometric, and positive allometric growth.

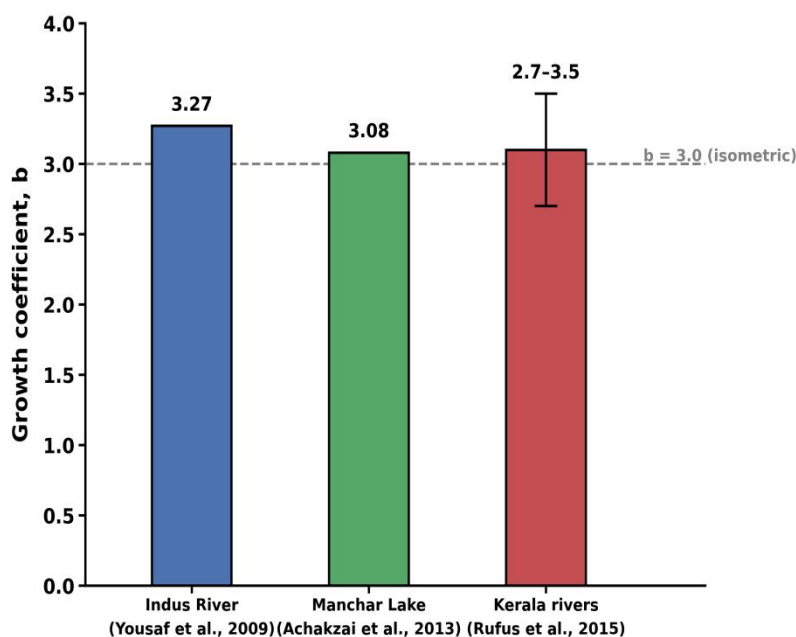


Figure 1. Growth coefficient (b) of the length-weight relationship of *Wallago attu* reported from different water bodies. The dashed reference line marks $b = 3.0$ (isometric growth); the Kerala rivers are shown as a range (2.7–3.5) with the midpoint marked (data from Yousaf et al., 2009; Achakzai et al., 2013; Rufus et al., 2015).

Maximum recorded body size also varies between water bodies, which may partly reflect fishing pressure and habitat differences rather than a true difference in the biological growth potential of the species. In the Bhadar reservoir of Gujarat, India, the largest specimen recorded measured 109.5 centimetres in total length, with a mean length of about 69 centimetres among landed fish, and the length-weight relationship did not differ significantly between males and females, although females tended to have a higher condition factor (Prasad & Desai, 2020). Table 1 summarises the principal length-weight and condition factor studies reviewed here.

Table 1. Summary of published length-weight and morphometric studies on *Wallago attu*.

Study	Location	Sample size	Key finding
Yousaf et al. (2009)	Indus River, Pakistan	n/a	$b = 3.27$ (positive allometric growth); $W = 0.001698 L^{3.27}$
Achakzai et al. (2013)	Manchar Lake, Pakistan	251	$b = 3.08$ combined; $b = 3.12$ (males), $b = 3.01$ (females); near-isometric growth
Rufus et al. (2015)	Three rivers, Kerala, India	n/a	b ranged 2.7–3.5 across rivers; condition factor (K) generally below unity
Prasad & Desai (2020)	Bhadar reservoir, Gujarat	n/a	Maximum size 109.5 cm; LWR not significantly different between sexes; K higher in females

Study	Location	Sample size	Key finding
Prasad, Desai, & Jogi (2020)	Bhadar reservoir, Gujarat	n/a	Total length correlated most strongly with standard length and head length; most variables showed positive allometric growth

3.2 Morphometric and Meristic Characters

Detailed morphometric analysis of *W. attu* from the Bhadar reservoir found a mean total length of 63.83 centimetres and mean standard length of 59.35 centimetres among sampled fish, and reported correlation coefficients between different body measurements and total length ranging from as low as 0.256 for caudal fin length to as high as 0.707 for standard length, showing that some body proportions track overall body size much more closely than others (Prasad et al., 2020). Meristic counts recorded in the same study included six dorsal fin rays, sixteen pectoral fin rays, ninety-three anal fin rays, twelve pelvic fin rays, eighteen caudal fin rays, and two pairs of barbels, values that are broadly consistent with the general taxonomic description of the species and can be used to help confirm species identity in field surveys.

3.3 Proximate Body Composition

Proximate composition data for *W. attu* muscle are reasonably consistent in showing that this species is a good source of dietary protein with a moderate fat content. Fresh, unfrozen *W. attu* muscle has been reported to contain approximately 15.45 percent protein, 4.02 percent lipid, 81.66 percent moisture, and 1.48 percent ash (Gandotra et al., 2013). Figure 2 presents these four proximate parameters together.

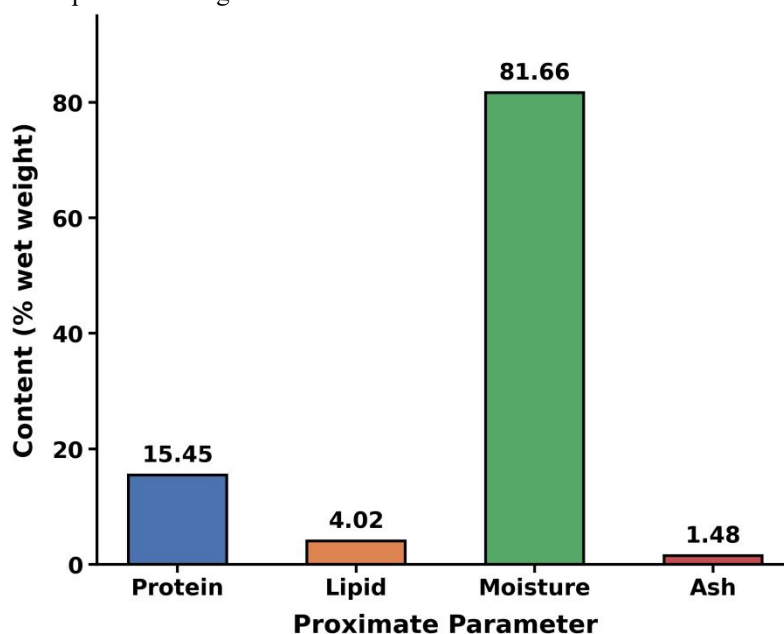


Figure 2. Proximate composition (percent wet weight) of fresh *Wallago attu* muscle (data from Gandotra et al., 2013).

Body size, condition, and storage all influence these values. Yousaf et al. (2011) found that larger *W. attu* individuals had higher percentage protein, fat, and ash content on a wet-weight basis than smaller individuals, while moisture content changed little with body size, and that fish with a higher condition factor similarly showed higher fat, ash, and protein content, with no significant difference between males and females. Gandotra et al. (2013) further showed that all four proximate parameters, protein, lipid, moisture, and ash, declined progressively over thirty days of frozen storage at minus twelve degrees Celsius, with protein declining by about 39 percent, lipid by about 61 percent, ash by about 14 percent, and moisture by about 9 percent by the end of the storage period, and that fish cutlets prepared from the muscle showed a smaller percentage decline than the raw muscle, most likely due to the added ingredients and processing used in cutlet preparation.

Comparative work across several Indus River fish species places *W. attu* within a wider range of nutritional profiles among freshwater fish. Memon et al. (2010) reported that across eight species, including *W. attu*, moisture content ranged from about 60 to 79 percent, ash from 0.05 to 4.95 percent, protein from 17 to 20 percent, and lipid from 0.85 to 18.32 percent, with monounsaturated fatty acids generally exceeding both saturated and polyunsaturated fatty acids across the species studied. Table 2 summarises the principal proximate composition studies reviewed here.

Table 2. Summary of published proximate and fatty acid composition studies on *Wallago attu*.

Study	Location / Setting	Key finding
Yousaf et al. (2011)	Southern Punjab, Pakistan (wild)	Body size positively related to percent ash, fat, and protein content; moisture largely unaffected; no sex effect.
Memon, Talpur, & Bhanger (2010)	Indus River, Pakistan (8 species incl. <i>W. attu</i>)	Moisture 60–79%, ash 0.05–4.95%, protein 17–20%, lipid 0.85–18.32% across species; MUFA > SFA > PUFA.
Gandotra et al. (2013)	Laboratory frozen-storage trial, India	Fresh muscle: 15.45% protein, 4.02% lipid, 81.66% moisture, 1.48% ash; all parameters declined over 30 days at –12°C.
Hossain et al. (2008)	Species review (multiple sources)	Fatty acid composition differs with fish size; saturated fatty acids ranged from about 30% to 50% of total fatty acids.
Bibi et al. (2016)	Pakistan (laboratory tissue analysis)	Cholesterol and fatty acid profile vary significantly with fish size and tissue type.

4. Discussion

The morphometric evidence reviewed here shows that *Wallago attu* generally grows close to isometrically, with the growth coefficient (b) clustering around 3.0 to 3.3 in most studies, although individual river populations in Kerala showed a wider range from 2.7 to 3.5. This spread is not unusual for a wide-ranging species sampled in different water bodies, since local food availability, water quality, fishing pressure, and the size range of fish actually captured can all shift the estimated b value. What is more striking is that condition factor values reported for river populations in Kerala were generally below unity, suggesting relatively poor body condition, while reservoir populations in Gujarat and lake populations in Sindh do not show the same pattern as clearly, which may reflect genuinely different feeding conditions between lotic river systems and larger standing water bodies such as reservoirs and lakes.

The morphometric correlation data further show that not all body measurements are equally useful for estimating the overall size of *W. attu*. Standard length and head length correlate strongly with total length, while measurements such as caudal fin length and anal fin length correlate more weakly, which makes sense given that fin length can be more easily damaged, worn, or measured inconsistently in older or larger fish. This has a practical implication for future field surveys of this species: total length and standard length are the more reliable single measurements to record when time or equipment limits the number of morphometric variables that can be measured.

On the nutritional side, the proximate composition data reviewed here place *W. attu* among the more protein-rich and moderately fatty freshwater food fishes of South Asia, with fresh muscle protein around 15 to 20 percent and lipid content in the low single digits under typical conditions, though this can rise somewhat in larger, well-conditioned fish. The finding that body size and condition factor, rather than sex, are the main predictors of proximate composition is a useful and consistent message across the studies reviewed, and it suggests that when comparing nutritional value between individual fish or between sampling occasions, researchers should control for or report fish size and condition rather than assuming that adult *W. attu* of any size will have a similar nutritional profile. The pronounced decline in protein, lipid, ash, and moisture during frozen storage reported by Gandotra et al. (2013) also carries a practical message for the fish trade, since it shows that the nutritional value of this species can decline measurably within a month of frozen storage, and that further processing, such as preparing cutlets, may help slow this decline slightly compared with raw muscle held under the same conditions.

As with any review of this kind, some caution is needed. The number of independent length-weight and proximate composition studies available for *W. attu*, while useful, is still limited compared with more heavily studied carp species, and almost all of the studies reviewed here come from Pakistan and India, so the picture presented may not extend evenly to populations in Myanmar, Thailand, Vietnam, or Indonesia, where the species is also found but appears to have received much less research attention. In addition, sample sizes, fish size ranges, and sampling seasons differ between studies, which can make direct numerical comparison between water bodies somewhat approximate rather than exact. Despite these limitations, the pattern that emerges is reasonably consistent and provides a useful baseline for future work on the growth and nutritional biology of this important catfish.

5. Conclusion

Wallago attu is a large, fast-growing, commercially important freshwater catfish whose length-weight relationship generally indicates isometric to mildly positive allometric growth across the water bodies studied so far, with the growth coefficient (b) mostly falling between about 3.0 and 3.3, although individual river populations can show somewhat wider

variation. Morphometric analysis shows that total length and standard length are the most reliable single predictors of overall body size, while meristic fin-ray counts remain fairly stable within the species and are useful for taxonomic verification. In terms of nutritional value, fresh *W. attu* muscle is a good source of protein, typically in the range of 15 to 20 percent, with a moderate and size-dependent fat content, and its proximate composition is influenced more strongly by body size and condition factor than by sex. Storage conditions, particularly frozen storage over several weeks, measurably reduce protein, lipid, ash, and moisture content, which has direct relevance for the handling and marketing of this species as food. Continued morphometric and nutritional monitoring of *W. attu* populations across a wider geographic range, together with more standardised sampling protocols, would help build a more complete picture of the growth and food value of this ecologically and economically significant catfish.

References

1. Achakzai, W. M., Baloch, W. A., Saddozai, S., & Memon, N. (2013). Length-weight relationships (LWRs) of *Wallago attu* (Bloch and Schneider) from Manchar Lake Jamshoro, Sindh, Pakistan. *Journal of Applied Ichthyology*, 29(5), 1172.
2. Bibi, C., Khan, A., Shah, N., Raziq, S., Muhammad, & Yousafzai, A. M. (2016). Size dependent variation in cholesterol and fatty acids profile of different tissues of carnivore freshwater catfish, *Wallago attu*. *Pakistan Journal of Zoology*, 48(4), 1017–1024.
3. Gandotra, R., Gupta, V., Meenakshi, K., & Gupta, S. (2013). Quality changes in the muscles of *Wallago attu* during frozen storage ($-12\pm 2^{\circ}\text{C}$) conditions. *Journal of Animal, Veterinary and Fishery Sciences*, 1(5), 16–20.
4. Hossain, M. Y., Ahmed, Z. F., Ohtomi, J., Ibrahim, A. H. M., El-kady, M. A. H., & Fulanda, B. (2008). Threatened fishes of the world: *Wallago attu* (Bloch and Schneider, 1801) (Siluriformes: Siluridae). *Environmental Biology of Fishes*, 82(3), 277–278.
5. Memon, N. N., Talpur, F. N., & Bhangar, M. I. (2010). A comparison of proximate composition and fatty acid profile of Indus River fish species. *Journal of Food Properties*, 13(2), 328–337. <https://doi.org/10.1080/10942910802398479>
6. Prasad, H., & Desai, A. Y. (2020). Length–weight relationship and condition factor of *Wallago attu* from Bhadar reservoir of Gujarat, India. *Journal of Experimental Zoology India*, 23(2), 1473–1479.
7. Prasad, H., Desai, A. Y., & Jogi, A. (2020). Morphometric and meristic characters of *Wallago attu* from Bhadar reservoir of Gujarat, India. *Journal of Entomology and Zoology Studies*, 8(2), 941–950.
8. Rufus, T., Eldho, P. S., Ali, A., Dahanukar, N., & Raghavan, R. (2015). Length-weight relationship and condition factor of a large predatory catfish, *Wallago attu* (Schneider, 1801) from the rivers of central Kerala, India. *Journal of Aquatic Biology and Fisheries*, 3, 105–110.
9. Yousaf, M. F., Salam, A., & Naeem, M. (2009). Length–weight relationships of *Wallago attu* and *Sperata sarwari* from the Indus River, southern Punjab, Pakistan. *Journal of Applied Ichthyology*, 25(5), 614–615.
10. Yousaf, M., Salam, A., & Naeem, M. (2011). Body composition of freshwater *Wallago attu* in relation to body size, condition factor and sex from southern Punjab, Pakistan. *African Journal of Biotechnology*, 10(20), 4265–4268.