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Colour variation in *Sperata sarwari* population inhabited in the indus drainage system

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Abstract

Fish has great tendency to adapt the environmental variations due to alteration in the physico-chemical quality of water. The colour variation indicates the phenotypic variations among and between the fish population found in different geographical regions. Therefore, this study was conducted to observe the colour variations among and between *Sperata (S.) sarwari* populations inhabited in the Indus drainage system. Fish samples (54 individuals) were collected from different geographical regions of four rivers (Chenab, Jhelum, Ravi and Indus). The body and adipose fin colour of all samples were observed and compared to investigate the colour variations among all individuals. The body colour of *S. sarwari* varied in different geographical regions due to predatory habit of fish. Body colour varied from dark grey colour to light grey colour on dorsal side while silver white colour on ventral side. Colour of fleshy adipose fin also varied from dark grey to light grey with and without black margin while position and colour of spot was the same in all individuals of *S. sarwari*. The 25% of total samples showed colour variation in adipose fin. The 50% individuals inhabited in the up and downstream of the River Indus and downstream of the River Jhelum showed the light grey colour of adipose fin with no dark grey margins, while individuals with black margin of adipose fin showed the lowest percentage (9.25%). It was concluded that the phenotypic colour variation of *S. sarwari was* influenced by environmental condition of rivers and predatory habit of fish.

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Introduction

Major anthropogenic alteration in aquatic system caused reduction in physical condition of habitat, flow and quality of water (Poff *et al.,* 1997; Xenopoulos and Lodge, 2006). Alteration in aquatic environmental conditions made freshwater fishes to adapt these changes and cause the phenotypic variations among fish populations (Langerhans *et al.,* 2003; Langerhans and De Witt, 2004; Sidlauskas *et al.,* 2006; Wagner *et al.,* 2009; Van Rijssel, 2013). Environmental, developmental (sexual dimorphism) and ontogenetic allometry factor caused intra and interspecific morphological differences (Langerhans *et al.,* 2003; Hendry *et al.,* 2006; Sidlauskas *et al.,* 2006; Webster *et al.,* 2011; Garcia- Alzate *et al.,*2010).

Morphological skin colour change in fish is often referred to in the sole context of background adaptation. It is becoming increasingly apparent that it is a broad phenomenon elicited by a variety of factors (Leclercq *et al.,* 2010). Factors such as genetic tendency and environmental variation caused major role in evolution of allopatric phenotypic variations. Natural landscape converts river into reservoir caused major physical modification in water.

Rapid change in colour may be due to aggressive and sexual behavior, ontogenetic evolution, defense from predators and prey recognition. The colour variation in fish population is related to the phenotypic malleability (Cheney *et al.,* 2017). The colour variation in both inter and intra population plays an important role in colour polymorphism evolution (Peter *et al.,* 2016).

The modifications in physical conditions associated with loss of water flow causes eco–evolutionary changes in inhabited species (Haas *et al.,* 2010). Water transparency was correlated with colouration among population of cichlid in Lake Victoria and it was noted that environment had major contribution causing variations in geographic colour pattern but pattern of colour variations was not dependent upon ecology of population (Seehausen *et al.,* 1997; Maan *et al.,* 2010; Castillo-Cajas *et al.,* 2012; Mattersdorfer *et al.,* 2012).

Two different colours were observed in *Channa argus* (snaked head) by Zhou *et al.* (2017) and revealed that colour variations in species were based exclusively on morphological characteristics but not dependent upon their genotype. Colour variation was not only observed in cichlid species but also observed within, between and among populations. Geographical, social and age triggered colour variations not only in populations but also in individuals (Maan and Sefc, 2013).

Environmental and geographical conditions mostly affect the phenotypic appearance like colour, shape, size of the freshwater fish population and also lead to speciation. Food availability, habitat and predator pressure caused phenotypic variations in fish. So, these phenotypic variations were extensively studied among the populations including fish (Rijssel and Witte, 2013; Henning *et al.,* 2013).

Physical condition of the Punjab Indus drainage system varies from river to river. The physical condition of River Ravi is different from the other rivers of the Punjab (Chenab, Jhelum and Indus). Water flow, transparency and physical environment of these rivers effected the colouration of inhabited *S. sarwari*. River Ravi is much fragmentized with head works and barrages, which isolated the fish population within the river. Therefore, the study was aimed to identify the colour variations among the population of *S. sarwari* inhabited in different rivers of the Punjab (Chenab, Jhelum, Ravi and Indus) caused by different environmental and geographical condition of local habitat.

Materials and methods

Sampling

The samples of *S. sarwari* (n=54) were collected during months of January, March, October and December 2014-2015 from upstream and downstream locations of four rivers of the Punjab (Chenab, Jhelum, Ravi and Indus). The specimens were transferred to the Research Laboratory of the Department of Zoology, Government college University Faisalabad and Pakistan for further analysis. All procedures performed in this study involving fish handling were in accordance with the research ethical standards with the approval of the Ethics Committee of the Government College University Faisalabad, Pakistan on Animal Experimentation.

Analysis

To observe the colour variations, body and adipose fin colour was noted and clearly photographed. Colour analysis was carried out by following Giery and Layman (2015) method. Adobe Photoshop was used by adjusting white balance and removed the background from each photo. Each fish was cropped including all body fins (dorsal, adipose fin and adipose fin spot, caudal fin, anal fin). The colour of each section was analyzed using Image J (http://imagej.nih.gov/ij/) followed by Selz *et al.* (2016). The average colour variation was simply calculated by using mean and grand mean formula.

Results

The body colour of *S. sarwari* was generally observed gray on the dorsal side and silver white on the belly or ventral side of the body. The black spot was present on the posterior side of adipose fin with the black margin. The body colour of *S. sarwari* varied from region to region. The body colour varied from dark to light gray in the upstream and the downstream of the River Chenab population.

Table 1. Colour variation (%) in adipose fin of *S. sarwari* collected from up and downstream of different Rivers (Chenab, Jhelum, Ravi and Indus) of Punjab, Pakistan.

Adipose fin colour	Rivers	No. of individual	%age
Light and dark with black margin	Upstream Chenab	5	27.77
	Up and downstream Ravi	10	
Dark grey with black margin	Downstream Chenab	5	9.25
Light grey with dark grey margin	Upstream Jhelum	7	12.96
Light grey with no definite margin	Downstream Jhelum	7	50.00
	Up and downstream Indus	20	
	Total	54	25

The adipose fin showed the light and dark gray colour, margin showed the black colour band and black spot was present on the extreme posterior side near the main body in the upstream population of *S. sarwari* (Fig. 1 A). Whereas, the specimens collected from the downstream of Head Tarimue (River Chenab) showed only light gray colour, the margin and the position of the black spot was the same as in the upstream population (Fig. 1 B). The specimens collected from the River Jhelum showed the light gray colour on the dorsal side and silver white on the belly or ventral side, and slight variation occurs in both colours between the upstream and the downstream populations. The colour of the adipose fin was white and light brown and margin of the adipose fin showed dark gray colouration rather than the black colour, and black spot was present in the margin (Fig. 2 A), while the light gray colour of adipose fin with nearly light gray margin and black spot on the posterior side of the fin was found in the downstream specimens of the River Jhelum (Head Rasul; Fig. 2 B). The colour of the body was dark gray on the dorsal side and the tail showed the gray colouration, while white on the belly. The body colour of both the upstream and the downstream of the River Ravi population was nearly similar to each other. Both showed dark and light colour on the dorsal side while the white colour on the belly. The colour of adipose fin was of gray colour with black margin and black spot was present on the posterior side of the fin in both specimens collected from the upstream and the downstream of the River Ravi at Head Bolki (Fig. 3 A and B). The body colour of specimens collected from the upstream and the downstream of Chashma Barrage (River Indus) was dark gray on the dorsal side and the tail also showed the gray colouration while white on belly (Fig 4 A and B). The colour of adipose fin was a light and dark shade of gray colour and no black margin was formed on the adipose fin, while black spot was present on the posterior side of the fin. Overall, the populations of *S. sarwari* collected from the river Chenab, Jhelum, Ravi and Indus showed variations in the body colour and adipose fin. The variation in the body colour could be due to the variable environment.

Fig. 1. The specimen of *S. sarwari* collected from the upstream (A) and downstream (B) of Head Tarimue (River Chenab) showing light and dark colour in upstream specimen and dark colour in both specimens (upstream A and downstream B) in adipose fin with black margin and black spot.

The 25% of total samples collected from up and down stream of rivers (Chenab, Jhelum, Ravi and Indus) of Punjab showed colour variation in adipose fin in *S. sarwari*. The 50% individuals inhabited in the up and downstream of the Indus and downstream of Jhelum showed the light grey colour of adipose fin with no margin while individuals with dark grey with black margin of adipose fin showed the lowest percentage (9.25%).

The percentage of colour variation with margin of adipose fin was found in order of light grey with no definite margin (Downstream Jhelum, Up and downstream Indus) > Light and dark with black margin (Upstream Chenab, Up and downstream Ravi)> light grey with dark grey margin (Upstream Jhelum) > dark grey with black margin (Downstream Chenab) as shown in Table 1.

Discussion

The body colour within the river population was similar but widely varied between the river populations. In the present study, body colour of *S. sarwari* was generally observed gray on the dorsal side and silver white on the belly or ventral side of the body while, the black spot was present on the posterior side of adipose fin with the black margin due to different environmental conditions of the four rivers. Variation in colour was strongly influenced by the environmental factors i.e., temperature, food and predation.

Fig. 2. The specimen of *S. sarwari* collected from the upstream (A) of Head Rasul (River Jhelum) showing brown and light gray colour in adipose fin with dark gray margin and black spot. While, in downstream (B) showing black spot and light gray colour in adipose fin with no definite light gray margin.

In this study we observed that physical environment like nutrition, temperature, water current, water depth and turbidity was encountered with adaptations of morphological characters causing colour variation in fish species, which is in good agreement with the previous studies (Wimberger, 1992; Turan *et al.,* 2005; Wringe *et al.,* 2015; Akbarzadeh *et al.,* 2009).

The body colour varied from dark to light gray in the upstream and the downstream of the River Chenab population. The adipose fin showed the light and dark gray colour, margin showed the black colour band and black spot was present on the extreme posterior side near to the main body in the upstream population of the *S. sarwari.* In the present study colour variations in *S. sarwari* (Shingaree) was primarily influenced by the environmental condition of the four rivers which is in line with the study of Leclercq *et al.,* 2010, who revealed that environmental factors directly influence the physiological variation in colour like light which affect migration of pigment in the skin of fish.

In this study, the body colour within the river population was similar but widely varied among the river populations, which is in line with the study of Hossein *et al.* (2013) who investigated that variation in colour was strongly influenced by the environmental factors i.e., temperature, food and predation of the habitat.

S. sarwari population inhabited in the River Jhelum showed light gray colour on dorsal side and silver white on belly or ventral side, and slight variation occured in both colours between the up and downstream populations. The colour of the adipose fin was white and light brown and margin of the adipose fin showed dark gray colouration rather than the black colour, and black spot was present in the margin, while the light gray colour of adipose fin with nearly light gray margin and black spot on the posterior side of the fin in the downstream specimens of the River Jhelum. In present study the colour variation in *S. sarwari* did not depend upon the sexual dimorphism of fish, rather it depend upon the physical environment of local habitat which is in agreement with the study of Reiss *et al.* (2012).They investigated that colour variantion of *Cichla temensis* was not dependent upon the sexual dimorphism, the colour differentiation is secondary sexual character which occurred periodically.

Fig. 3. The specimen of *S. sarwari* collected from the upstream (A) of Head Baloki (River Ravi) and downstream (B) both showing black spot and light gray colour in adipose fin with black margin.

S. sarwari collected from the upstream and the downstream of the River Ravi at Head Bolki showed adipose fin of gray colour with black margin and black spot on the posterior side of the fin. The body colour of *S. sarwari* collected from the upstream and the downstream of Chashma Barrage (River Indus) was dark gray on the dorsal side and the tail also showed the gray colouration while white colour on the belly. Geographical variations directly or indirectly affect the ecological conditions of fish population. Water flow, habitat and environment affect the ichthyofauna. The geographical condition of all Rivers in the present study varied from river to river. Factors like water flow, pH (Rodriguez and Lewis, 1997; Bartels *et al.*, 2012), conductivity, food and predator availability caused the variation in colour and body shape of fish (*S. sarwari*). Interaction between prey–predator strongly effected body colour which directly related to the efficiency of predator and similar was investigated in previous studies (Hori and Watanabe, 2000; Koblmueller *et al.*, 2009). *S. sarwari* is predatory fish, feed on zooplankton and small fish and adapt the colour which enhances their ability to access the prey.

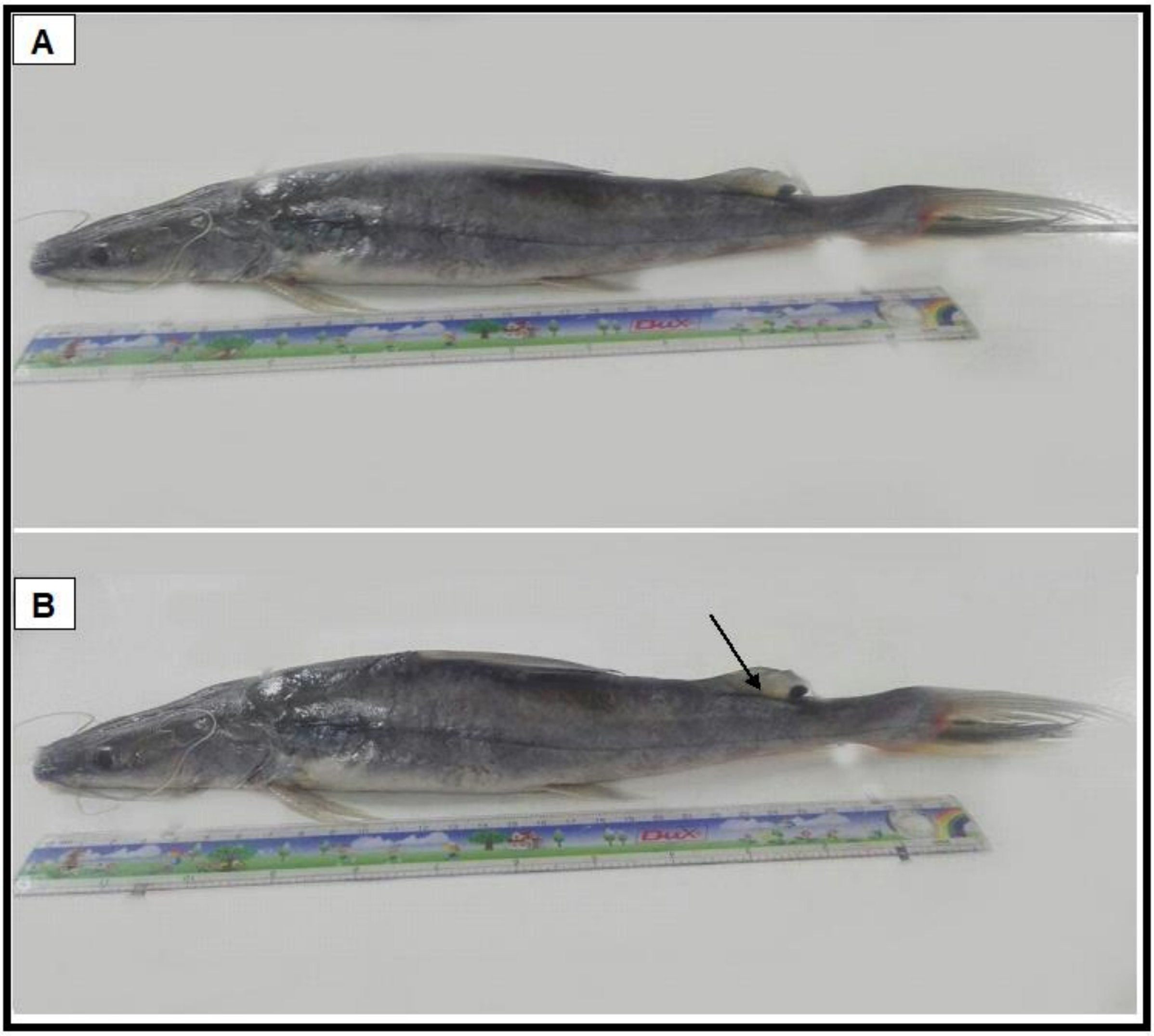

Fig. 4. The specimen of *S. sarwari* collected from the upstream (A) and downstream (B) of Chashma Barrage (River Indus) both showing black spot and light gray colour in adipose fin with no definite margin.

Both Chenab and Indus population of *S. sarwari* was elongated and similar findings were reported by Lazzarotto *et al.* (2017) in UN2, UN3 and UN5 of *Hemigrammus coeruleus*. Elongated body shape related to firmness and enhance the good swimming performance of *S. sarwari*, which is in good agreement with the study of Langerhans and Reznick (2010).

Conclusion

In present study the colour variation was observed in *S. sarwari* population inhabited in four rivers (Chenab, Jhelum, Ravi and Indus) of the Punjab Pakistan. The body colour and adipose fin colour varied from river to river. Phenotypic colour variation of *S. sarwari was* influenced by environmental condition of rivers and predatory habit of fish.

References

Akbarzadeh A, Farahmand H, Shabani AA, Karami M, Kaboli M, Abbasi K, Rafiee GR. 2009. Morphological variation of the pikeperch Sander lucioperca (L.) in the southern Caspian Sea, using a truss system. Journal of Applied Ichthyology **25**, 576-582.

Bartels P, Hirsch PE, Svanbäck R, Eklöv P. 2012. Water transparency drives intra-population divergence in Eurasian perch (Perca fluviatilis). Plo SONE **7(8),** e43641.

Castillo-Cajas RF, Selz O, Ripmeester EAP, Seehausen O, Maan ME. 2012. Species specific relationships between water transparency and male colouration within and between two closely related Lake Victoria cichlid species. International Journal of Evolutionary Biology **2012**, 1–12, http://dx.doi.org/10.1155/2012/161306.

Cheney LK, Cortesi F, Skold NH. 2017. Regulation,constraints and benefits of colour plasticity in a mimcry system. Biological Journal of Linnen Society **122(2),** 38-3893.

Garcia-Alzate CA, Román-Valencia C, Gonzalez MI. 2010.Morfogeometria de los pecesdelgenero Hyphessobrycon (Characiformes: Characidae), grupo heterorhabdus, en Venezuela. Revista de Biologia Tropical **58**(3), 801-811.

Giery ST, Layman CA. 2015. Interpopulation variation in a condition-dependent signal: predation regime affects signal intensity and reliability. American Society of Naturalist **186**, 187 –195. http://dx.doi.org/10.1086/682068

Haas TC, Blum JM, Heins CD. 2010. Morphological responses of a stream fish to water impoundment. Biological Letter **6**, 803–806. http://dx.doi.org/10.1098/rsbl.2010.0401

Hendry AP, Kelly ML, Kinnison MT, Reznick DN. 2006.Parallel evolution of the sexes? Effects of predation and habitat features on the size and shape of wild guppies. Journal of Evolution Biology **19(3),** 741-754.

Henning F, Julia CJ, Paolo F, Axel M, 2013. Transcriptomics of morphological colour change in polychromatic Midas cichlid. BMC Genomics **14**, 171.

Hori M, Watanabe K. 2000. Aggressive mimicry in the intra population colour variation of Tanganyikan scale eater Perissodus microlepis (Cichildae). Environmental Biology of Fishes **59**, 111-115.

Hossein AF, Farahmand H, Silva DM, Bastos RP, Khyabani A, Hassan AF. 2013. Fourteen years after the Shahid-Rajaei dam construction: an evaluation of morphometric and genetic differentiation between isolated up and downstream populations of Capoeta capoeta gracilis(Pisces: Cyprinidae) in the Tajan River of Iran. Genetic Molecular Research **12(3),** 3465-3478.

Koblmueller S, Egger B, Stumbauer C, Sefc KM. 2009. Sexual dimorphism and feed habit of scale eater Pleco dusstraeleni (Cichildae, Teleostei) in Lake Tanganyika. Molecular Phylogenetic Evolution **44**, 1295-1305.

Langerhans RB, DeWitt TJ. 2004. Shared and unique features of evolutionary diversification. American Society of Naturalists **164(3),** 335-349.

Langerhans RB, Layman CA, Langerhans AK, DeWitt TJ. 2003. Habitat-associated morphological divergence in two Neotropical fish species. Biological Journal of Linnaeus Society **80(4),** 689-698.

Langerhans RB, Reznick D. 2010. Ecology and evolution of swimming performances in fishes: predicting evolution with biomechanics. In: Domenici P, Kapoor BG, editors. Fish locomotion: an etho-ecological perspective. Enfield: Science Publishers; p. 200-248.

Lazzarotto H, Barros T, Louvise J, Caramaschi PE. 2017. Morphological variations among populations in a Negro River tributary, Brazilian Amazon. Neotropical Ichthyology **15(1).** http://dx.doi.org/10.1590/1982-0224-20160152

Leclercq E, Taylor JF, Migaud H. 2010. Morphological skin colour changes in teleosts. Fish **11**,159–193.

Maan ME, Seehausen O, Van Alphen JJM. 2010. Female mating preferences and male colourationc ovary with water transparency in a Lake

Victoria cichlid fish. Biological Journal of the Linnean Society **99**,398-406.

Maan ME, Sefc KM. 2013.Colour variation in cichlid fish: developmental mechanisms, selective pressures and evolutionary consequences, Seminars in Cell and Developmental Biology, http://dx.doi.org/10.1016/j.semcdb.2013.05.003.

Mattersdorfer K, Koblmüller S, Sefc KM. 2012. AFLP genome scans suggest divergent selection on colour patterning in allopatric colour morphs of a cichlid fish. Molecular Ecology **21**,3531-3544.

Poff NL, Allan JD, Bain MB, Karr JR, Prestegaard KL, Richter BD, Sparks RE, Stromberg JC. 1997. The natural flow regime. Bioscience **47**,769–84.

Richter BD, Braun DP, Mendelson MA, Master LL. 1997. Threats to imperiled freshwater fauna. Conservation Biology**11**, 1081–93.

Peter DD, Michele ERP, Ole S, Neil BM. 2016. Metabolism, Oxidative stress and territorial behavior in a female colour polymorphic cichlid fish. Behavioral Ecology and Sociobiology **70 (1)** 99-109.

Qchi H, Awata S. 2009. Resembling the juvenile colour of host cichlid facilitates access of the guest cichilid to host territory. Behavior **146**, 741-756.

Reiss P, Able KW, Nunes SM, Hrbek T. 2012. Colour pattern variation in Cichlatemensis (Perciformes: Cichlidae): Resolution based on morphological, molecular, and reproductive data. Neotropical Ichthyology **10**(1), 59-70.

Rijssel VJC, Witte F. 2013. Adaptive responses in resurgent Lake Victoria cichlids over the past 30 years. Evolution Ecology **27(2),** 253-267.

Rodriguez MA, Lewis-Jr WM. 1997. Structure of fish assemblages along environmental gradients in floodplain lakes of the Orinoco River. Ecological Monograph **67(1),**109-128.

Seehausen O, Bouton N. 1996. Polychromatism in rock dwelling Lake Victoria cichlids: types, distribution, and observation on their genetics. The Cichlids Yearbook **6**, 36-45.

Seehausen O, Van Alphen JJM, Witte F. 1997. Cichlid fish diversity threatened by eutrophication that curbs sexual selection. Science **277**, 1808-1811.

Selz OM, Thommen R, Pierotti ME, Anaya Rojas JM, Seehausen O. 2016. Differences in male colouration are predicted by divergent sexual selection between populations of a cichlid fish. Proceedings of the Royal Society B: Biological Sciences **283(1830),**20160172

Sidlauskas B, Chernoff B, Machado-Allison A. 2006. Geographic and environmental variation in Bryconops sp., melanurus (Ostariophysi: Characidae) from the Brazilian Pantanal. Ichthyology Research **53(1),** 24-33.

Turan C, Yalcin S, Turan F, Okur E, Akyurt II, Yalcin S. 2005. Morphometric comparisons of African catfish, Clarias gariepinus, populations in Turkey. Africa (Lond) **54**, 165-72.

Wagner CE, McIntyre PB, Buels KS, Gilbert DM, Michel E. 2009. Diet predicts intestine length in Tanganyika's cichlid fishes. Functional Ecology **23(6),** 1122-1131.

Webster MM, Atton N, Hart PJB, Ward AJW. 2011. Habitat-specific morphological variation among threespine sticklebacks (Gasterosteus aculeatus) within a drainage basin. PloS ONE **6(6),**e21060.

Wimberger PH. 1992. Plasticity of fish body shape. The effects of diet, development, family and age in two species of Geophagus (Pisces: Cichlidae). Biological Journal of Linneus Society **45(3),** 197-218.

Wringe BF, Fleming IA, Purchase CF. 2015. Rapid morphological divergence of cultured cod of the northwest Atlantic from their source population. Aquaculture and Environmental Interaction **9**, 167-177.

Xenopoulos MA, Lodge DM. 2006. Going with the flow: using species discharge relationships to forecast losses in fish biodiversity. Ecology **87**, 1907–14.

Zhou A, Xie S, Wang Z, Fan L, Wang C, Ye Q, Yanfeng Chen Y, Zou J. 2017. Molecular evidence of two colour morphs of northern snakehead (Channaargus) based on mitochondrial 12S rRNA MITOCHONDRIAL DNA PART B: Resources **2(1),** 283–286. https://doi.org/10.1080/23802359.2017.1325334