



Short Communication

Length-Weight Relationships of *Oreochromis niloticus* (Linnaeus, 1758) Around the World

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ABSTRACT

The *Oreochromis niloticus* (Linnaeus, 1758) has been introduced to various countries as a cultured species. Recently, it has been distributed on all continents except Antarctica and Australia, and has a high invasion risk. The invasion of *O. niloticus* has threatened the survival of native species, therefore, it is necessary to evaluate the condition and fitness of *O. niloticus* populations. Length-weight relationship (LWR) was one of the most effective and practical methods to assess fitness and condition and has been widely utilized in fisheries. Thus, the LWRs of this fish have been described in a number of publications. However, there are no systematic reports on LWRs of *O. niloticus* worldwide, especially comparing native and non-native populations. Therefore, the aim of this present research was to provide a systematic report of LWRs of *O. niloticus* on a global scale and to compare the LWRs of *O. niloticus* in native and non-native areas. The results indicated that *O. niloticus* showed negative allometric growth in native regions and the *O. niloticus* populations showed isometric growth in non-native regions. These results showed that *O. niloticus* was better adapted to the environment of the invasion regions and grew better. Given its potential for invasion, the hazards of this species should not be neglected. In addition, some preventive and management methods to eliminate or reduce the adverse effects of further expansion of this species have been provided in the present study.

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WS data curation, investigation, formal analysis, writing original draft. LP and CP methodology, writing review and editing. XS, GL, XC investigation, data curation. KAT data curation and writing original draft. CZ, YS, QZ, LS, XL, ZW data curation.

Key words

Oreochromis niloticus, Length-weight relationship (LWR), Native and non-native regions, invasive species, Condition and fitness of population, Evaluation

Oreochromis niloticus (Linnaeus, 1758), a freshwater Cichlid fish, which is native to Central and Western Africa (Senegal, Gambia, Volta, Niger, Benue and Chad river basins) (El-Sayed and Fitzsimmons, 2023). It has been widely cultured in aquaculture because of its fast growth, strong adaptability and wide feeding ability (Tsegay *et al.*, 2018). Thus, *O. niloticus* has been introduced outside its native range into many tropical, subtropical and temperate

regions (Geletu and Zhao, 2022). And *O. niloticus* is currently distributed on all continents except Australia and Antarctica (Stauffer *et al.*, 2022).

Invasive *O. niloticus* has posed a significant threat to native species through a range of mechanisms, including predatory behavior, resource competition, hybridization, and the transmission of disease (Arthur *et al.*, 2010; Xiong *et al.*, 2015). So, the invasion of *O. niloticus* in non-native sites further affected native fish diversity and fisheries (Xiong *et al.*, 2023). It has been shown that in some invaded regions, the number of native species decreased with the establishment of *O. niloticus* populations (Xiong *et al.*, 2023). The better fitness of invasive fish populations in an area, the greater threat to the existence of native species. Therefore, it is necessary to assess the condition and fitness of invasive *O. niloticus* populations in different areas.

Several parameters were used to assess the fitness

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and condition of the fish population in a given area, such as the length-weight relationship (LWR), population construction, and lipid accumulation (Schiemer, 2000; Verreycken *et al.*, 2011; Xiong *et al.*, 2020). Among all parameters, LWR was one of the most effective and practical methods to assess fitness and condition and has been widely utilized in fisheries (Froese, 2006). Thus, the LWRs of this fish have been described in a number of publications. However, most of the studies on the LWRs of *O. niloticus* results came from a single domain (Supplementary Table I). No systematic reports on the LWRs of *O. niloticus* have been recorded worldwide, particularly comparing native and non-native populations.

Thus, the purpose of this study was to provide a comparison of LWRs for the invasive *O. niloticus* between native and non-native regions worldwide and a systematic report of LWRs of *O. niloticus*. In this study, we want to answer the following question: Is there a significant difference in LWRs of *O. niloticus* between native and non-native regional populations or not?

Materials and methods

This study was based on Chinese and English databases such as China National Knowledge Infrastructure (<https://www.cnki.net>), Web of Science (<https://www.webofscience.com/wos>), Google Scholar (<https://scholar.google.com>), etc. A literature search was conducted on the topic “*Oreochromis niloticus*” “length-weight relationship”. All LWRs data on *O. niloticus* collected from published literature sources, such as peer-reviewed journals, conference minutes, and dissertations. All data on LWRs of *O. niloticus* were obtained from wild populations. Overall, data on LWRs of *O. niloticus* (233 total: 174 combined sexes, 30 males and 29 females) were acquired from literature published in 36 countries from 1987 to 2022 (Supplementary Table I). Of all the data, those with correlation coefficients greater than 0.8 were selected for this study, and these records were not flagged as abnormal due to potential errors or other factors (Froese, 2006). The following exclusion study for 214 populations will not include 19 of 233 data collected (Supplementary Table I) as the correlation coefficient is less than 0.8 (Froese, 2006). Among the 214 populations, 132 were native populations and 82 were invading populations (Supplementary Table I).

Length-weight relationship: The equation for the length-weight relationship was $W = aL^b$, where, W = wet body weight of fish in grams, L = total length of fish in centimeter, a is the intercept; and b is the slope (Froese, 2006). When the LWR was solely represented in logarithmic form (e.g., $\log W = \log a + b \log L$), and dependent on the exponent value and the units selected, parameter a was

acquired through the anti-logarithmic transformation (log is logarithm to base 10). As the majority of LWRs rated length in cm and described as TL, conversion factors $a_{\text{cm}} = a_{\text{mm}} 10^b$ and $a_{\text{TL}} = a_{\text{LS}} (\text{TL} / \text{LS})^b$ (where LS is length type in the original study by standard length (SL) or fork length (FL); $\text{TL} / \text{SL} = 1.25$, $\text{TL} / \text{FL} = 1.02$, as calculated from FishBase (Froese and Pauly, 2023) were applied for all studies reporting length in mm and/or LS (Supplementary Table I) (Froese, 2006). The meaning of the exponent, b , is straightforwardly physical and independent of the chosen system of units. According to the one-sample t-test, an ideal fish has a “ b ” value of 3 (Supplementary Fig. S1), which indicates isometric development. When the value of “ b ” is not 3, the weight increase is allometric (positive if “ b ” is greater than 3, negative if “ b ” is less than 3), which is a regularly used scale in the study of LWRs (Froese, 2006).

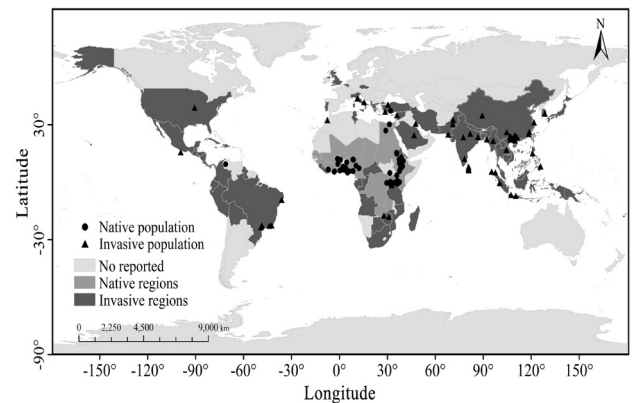


Fig. 1. The distribution was available on the FishBase website (Froese and Pauly, 2023), and *Oreochromis niloticus* (Linnaeus, 1758) was found in 92 countries. In the figure, the light gray sections were the native areas and the black sections were the invasive areas. In the 36 countries with the Length-weight relationships (LWRs) of *O. niloticus* data, the solid circles represented the native populations and the triangles indicated the invasive populations.

The figure of $\log(a')$ vs b was used in the LWRs data of *O. niloticus*. Using this technique, outliers that diverged from the regression line by more than two standard deviations were identified. And then the figure of $\log(a')$ vs b contained 14 outliers that were identified as problematic in Supplementary Table I and eliminated in subsequent research. After excluding outliers, a total of 200 data were available, of which 126 data were from the native region and 74 from the invaded region (Supplementary Table I).

In this study, IBM SPSS Statistics 23 was used to test if the data satisfied the normal distribution by Kolmogorov-

Smirnov test. And it also be used to test whether there were differences between invasive and native populations by Mann-Whitney test, and one-sample Wilcoxon test was used to compare the differences between invasive and native populations with 3, and all statistics were considered to be different at $p < 0.05$.

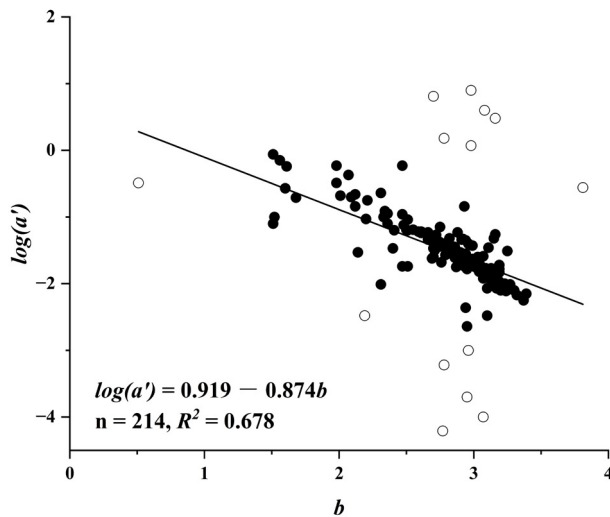


Fig. 2. The 214 length-weight relationships of *O. niloticus* were plotted in $\log(a')$ vs b . Fourteen outliers were marked in the graph with blank circles and were eliminated in subsequent analyses. Regression line: $\log(a') = 1.16 - 0.95b$, $n = 200$, $R^2 = 0.702$, $p < 0.05$.

Results and discussion

The range of values for b in the present study was from 1.51 in Wase Dam and Naivasha Lake (Kenya, Nigeria) to 3.39 in the Malewa Lake (Kenya). Generally, the b -values range from 2.5 to 3.5 (Tubb and Carlander, 1969). However, of 233 data collected, 44 were below 2.5. After correlation coefficient were less than 0.8 and $\log(a')$ vs b filtering, 28 were still below 2.5. We then reviewed the original literature and found that studies have shown that poor environmental conditions, lack of food, harsh climate and high population density can lead to low b -values (Vianny *et al.*, 2015; Batool *et al.*, 2017; Obayemi *et al.*, 2019; Yem *et al.*, 2020).

The Kolmogorov-Smirnov test rejected this distribution as normal (Fig. 3). In Figure 3, when compared with the normal distribution curve, all b -value distributions were lower than the normal curve except for 1.4-2.0 and 3.0-3.2. Among all LWRs data for *O. niloticus*, the median value of b was 2.94 ($SE = 0.02$). 90% of the values ranged from 2.07 to 3.21. As shown in Figure 3, the majority of b ($n = 121$, 60.5% of the total) was located to the left of the isometric line ($b > 3$). In addition, there was

a significant difference ($p < 0.05$) in median b between the native region ($b = 2.91$, $SE = 0.03$) and the invasive region ($b = 3.01$, $SE = 0.03$) (Supplementary Table II). Median value of b ($b = 2.91$, $SE = 0.03$) for native populations was less than 3 ($p < 0.05$) and median value of b ($b = 3.01$, $SE = 0.03$) and 3 for invasive populations was not different ($p > 0.05$) (Supplementary Table II). This suggested that the body shape of this species differed between the two regions.

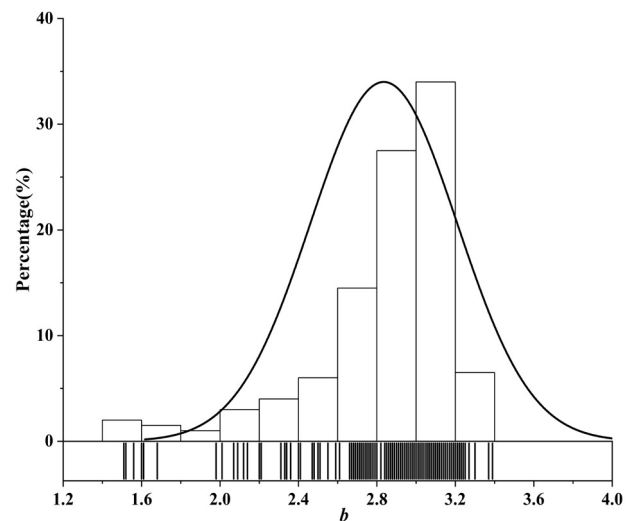


Fig. 3. Frequency distribution of index b based on 200 records for *O. niloticus*, 5th percentile = 2.07 and 95th percentile = 3.21. Gaussian distribution line was superimposed.

According to current research, *O. niloticus* was growing at negative allometric growth in native regions and at isometric growth in invasive regions. This showed that *O. niloticus* grew better in the invasion area than its origin. Further expansion of *O. niloticus* populations in invasive sites would compete with native species and destroy biodiversity (Stauffer *et al.*, 2022). Therefore, considering this potential threat, the harmfulness of this invasive species should not be ignored.

Some measures should be taken to suppress or mitigate further invasion of *O. niloticus* while maintaining economic benefits: (1) Improve the evaluation, early warning, identification and monitoring, management and eradication of invasive alien species, and establish appropriate rules and regulations; (2) For exotic farmed fish, the farming unit should strengthen the monitoring and management of the farming environment, take adequate anti-avoidance and isolation measures, and strictly control farmed species in a specific range of farmed waters; (3) If prevention methods fail, management of invasive

organisms should use a combination of biological, physical and chemical means to address this problem (Fletcher *et al.*, 2016; Dong *et al.*, 2020).

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Ethical statement and IRB approval

This study did not sacrifice fish, so institutional review board (IRB) approval was not required.

Supplementary material

There is supplementary material associated with this article. Access the material online at: <https://dx.doi.org/10.17582/journal.pjz/20230530080554>

Statement of conflict of interest

The authors have declared no conflict of interest.

References

- Arthur, R.I., Lorenzen, K., Homekingkeo, P., Sidavong, K., Sengvilaikham, B. and Garaway, C.J., 2010. *Aquaculture*, **299**: 81-88. <https://doi.org/10.1016/j.aquaculture.2009.11.022>
- Batool, A., Farooq, S., Muhammad, A. and Malik, A., 2017. *Sindh Univ. Res. J.*, **49**: 793-796. <https://doi.org/10.26692/Surj/2017.12.59>
- Dong, X., Ju, T., Grenouillet, G., Laffaille, P., Lek, S. and Liu, J., 2020. *Sci. Total Environ.*, **711**: 134661. <https://doi.org/10.1016/j.scitotenv.2019.134661>
- El-Sayed, A.F.M. and Fitzsimmons, K., 2023. *Rev. Fish. Sci.*, **15**: 6-21. <https://doi.org/10.1111/raq.12738>
- Fletcher, D., Gillingham, P., Britton, J., Blanchet, S. and Gozlan, R.E., 2016. *Sci. Rep.*, **6**: 1-8. <https://doi.org/10.1038/srep26316>
- Froese, R., 2006. *J. appl. Ichthyol.*, **22**: 241-253. <https://doi.org/10.1111/j.1439-0426.2006.00805.x>
- Geletu, T.T., and Zhao, J., 2022. *Hydrobiologia*, <https://doi.org/10.1007/s10750-022-04989-4>
- Obayemi, O.E., Komolafe, O.O., Okunola, O.V., Asafa, S.T. and Ayoade, M.A., 2019. *Not. Sci. Biol.*, **11**: 205-209. <https://doi.org/10.15835/nsb11210433>
- Schiemer, F., 2000. *Hydrobiologia*, **422**: 271-278. https://doi.org/10.1007/978-94-011-4164-2_22
- Stauffer, J.R., Chirwa, E.R., Jere, W., Konings, A.F., *Biol. Invasions*, **24**: 1585-1597. <https://doi.org/10.1007/s10530-022-02756-z>
- Tsegay, T., Haftom, Z. and Tesfay, M., 2018. *Int. J. Fish. Aquat. Stud.*, **10**: 86-94. <https://doi.org/10.5897/IJFA2017.0637>
- Verreycken, H., Van Thuyne, G. and Belpaire, C., 2011. *J. appl. Ichthyol.*, **27**: 1416-1421. <https://doi.org/10.1111/j.1439-0426.2011.01815.x>
- Vianny, N., Richard, O.O., Jackson, E., Fredrick, M., Dismas, M., Mark, O., Laban, M., Shamim, N. and Shaon, N., 2015. *Lakes Reservoirs Res. Manage.*, **20**: 101-119. <https://doi.org/10.1111/lre.12091>
- Xiong, W., Guo, C., Gozlan, R.E., and Liu, J., 2023. *Rev. Fish. Sci.*, **15**: 179-197. <https://doi.org/10.1111/raq.12710>
- Xiong, W., Sui, X., Liang, S.H. and Chen, Y., 2015. *Rev. Fish. Biol. Fisheries*, **25**: 651-687. <https://doi.org/10.1007/s11160-015-9396-8>
- Xiong, W., Zeng, Q., Gu, D. and Hu, Y., 2020. *Pakistan J. Zool.*, **52**: 1197-1200. <https://doi.org/10.17582/journal.pjz/20190422150443>
- Yem, I., Bankole, N., Umar, R., Ibrahim, A. and Ewutanure, S., 2020. *Int. J. Fish. aquat. Stud.*, pp. 257-260.