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Population parameters of *Mayaheros urophthalmus* (Günther, 1862) in the Malpaso dam, Chiapas, Mexico

Parámetros poblacionales de *Mayaheros urophthalmus* (Günther, 1862) en la presa Malpaso, Chiapas, México

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ABSTRACT

Mayaheros urophthalmus (Günther, 1862) had not previously been reported in commercial catches from the Malpaso Dam. A recent study shows that it is now common in landings and holds local economic importance. Size structure, average size at capture, sex ratio, gonadal stage, and condition factor were determined; these data were not previously available for this population. The size structure was analyzed using frequency histograms. Mean capture size was calculated using cumulative relative frequency and compared with size at sexual maturity and the minimum permissible size; Student's t-test was used to identify significant differences among these parameters. The sex ratio (M:F) was assessed with the chi-square test (X^2). A total of 131 specimens were examined, with a mean total length of 24.85 cm ± 1.99 cm (standard deviation). The mean catch size was 24.05 cm. Significant differences were observed between the mean size at capture and both the size at sexual maturity and the minimum permitted size ($p < 0.01$) in both cases. The commercial fishery of *M. urophthalmus* includes mature individuals. The Malpaso Dam supports its establishment and reproduction, indicating potential population growth and increased fishery activity in the coming years.

KEY WORDS: Nezahualcóyotl reservoir, fishing, mayan cichlid.

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RESUMEN

Mayaheros urophthalmus (Günther, 1862), no había sido reportada en las capturas comerciales en la presa Malpaso. Estudio reciente revela que ahora es frecuente en las capturas y de relevancia económica local. Se determinó la estructura de talla, talla media de captura, proporción sexual, estadio gonadal y factor de condición, datos no reportados para esta población. La estructura de tallas se analizó mediante histogramas de frecuencia. Se determinó la talla media de captura usando la frecuencia relativa acumulada, y se comparó con la talla de madurez sexual y la talla mínima permitida, se utilizó una prueba t de Student para identificar diferencias significativas entre estas. Se evaluó la proporción sexual (M:F), aplicando la prueba de Xi-cuadrada (X^2). Se analizaron 131 ejemplares con una longitud total promedio de 24.85 cm ± 1.99 cm de desviación estándar, la talla media de captura fue de 24.05 cm de longitud total. Se encontraron diferencias significativas entre la talla media de captura con la talla de madurez sexual y la talla mínima permitida ($p < 0.01$) para ambos casos. La captura comercial de *M. urophthalmus* incluye organismos maduros. La presa Malpaso favorece su establecimiento y reproducción, lo que proyecta un crecimiento poblacional y en la pesca en los próximos años.

PALABRAS CLAVE: Embalse Nezahualcóyotl, pesca, cíclido maya.

Introduction

Mayaheros urophthalmus (Günther, 1862), known in Mexico as mojarra castarrica, is native to the Atlantic region and is widely found in the lower hydrological basins of central and southern Veracruz, northern Oaxaca, Tabasco, Campeche, Quintana Roo, and Chiapas (Chávez-López *et al.,* 2005; Miller *et al.,* 2005). Its natural range is mainly in the coastal basins of the Mexican Caribbean and Central America, favoring warm, low-altitude environments with some connection to the sea (Barrientos-Villalobos & Schmitter-Soto, 2019; Fernández-Pérez, 2024; Froese & Pauly, 2025).

In Chiapas, the earliest records were from the northern zone, corresponding to the lower Grijalva River basin (Chávez-López *et al*., 2005; Miller *et al*., 2005). Since 2015, several researchers have documented the species in the Malpaso Dam, located in the middle basin of the Grijalva River within the Northern Mountains physiographic region (Gómez-González *et al*., 2015; Anzueto-Calvo *et al*., 2016; Velázquez-Velázquez *et al*., 2016; Gómez-Martínez *et al*., 2022). However, it had not been reported in studies of the Malpaso Dam's commercial fishery (Moreno-Moreno, 1995; Pérez-Castañeda, 2012; Rivera-Velázquez *et al*., 2015; Rivera-Velázquez *et al*., 2024). Gutiérrez Montejo (2023) determined that *M. urophthalmus* is now a common species in

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the fishery, with a relative importance of 16 %, and it is becoming increasingly significant in the commercial catch. This suggests that *M. urophthalmus* has expanded its distribution from the lower to the middle basin of the Grijalva River, a habitat altered by the construction of the Malpaso Dam; likewise, its abundance indicates the species' establishment in the reservoir's fishery.

In the Grijalva River, especially in the Malpaso area, important fisheries primarily developed for the catfish *Ictalurus meridionalis*, along with various native cichlid species (Velasco-Colin, 1976). The Malpaso Dam is part of the Grijalva River; however, it is an anthropogenic environment. The flooding caused by its construction had both positive and negative effects on native species: some disappeared, while others increased their populations. Nonetheless, fishing activity continued as a multispecies fishery, 14 species according to Pérez-Castañeda (2012), with catches mainly consisting of native species such as *I. meridionalis* and *Petenia splendida*. In the early 1970s, to exploit the impounded waters, supported by fisheries policies and the perception that the reservoir lacked species of fisheries importance, exotic species (the tilapia group, *Oreochromis spp*.) were introduced. By 1975, fishermen began organizing into cooperative societies to join Federación Regional de Sociedades Cooperativas de Introductores y Pescadores del Estado de Chiapas (located in Tonalá), and the Comité Promotor del Desarrollo Socioeconómico del Estado (CPDSE, 1979).

The system reached a new balance in species composition and temporal adaptation. In the case of *M. urophthalmus*, the increase in its catch in recent years has raised additional questions, mainly about which factors are promoting its demographic growth. This has altered the established relationship between native and introduced species. Therefore, the goal of this study is to provide initial data on some population parameters of *M. urophthalmus* in the Malpaso Reservoir, specifically size structure, mean size at capture (MSC), sex ratio, gonadal stages, and Fulton's condition factor (*K*), to establish reference parameters for future research and fisheries assessment of the resource.

Materials and Methods

Samples were obtained from the commercial fishery. Fishermen practice artisanal multispecies fishing, and the main fishing gear used is the gill net, 50-80 m long, 4 m deep, with a mesh size of 88.9 mm, which captures 16 species (Rivera-Velázquez *et al*., 2015). Some fishermen also use lines with Aberdeen-type hooks of different sizes, #13 for catfish (DOF, 2011; Rivera-Velázquez *et al*., 2015). Members of the Zoque Fishing Production Cooperative Society deliver all their catch to the cooperative collection center located in the town of Malpaso (Rivera-Velázquez *et al*., 2015), at coordinates 17°00′-17°15′ N and 93°45′20″ W (SAGARPA, 2015). During delivery, *M. urophthalmus* specimens are measured, weighed, and sexed.

For the size-structure analysis, the total length (TL) of each specimen, in cm, was measured using a standard ichthyometer (± 0.1 mm). A frequency histogram was created using Sturges' rule (1926) to determine the optimal number of classes. The mean size at capture (MSC) was calculated using the cumulative relative frequency of sizes; data were grouped monthly, and the

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logistic model by Sparre and Venema (1998) was applied. A Student's t-test was used to compare the MSC with the minimum permissible size (MPS = 20 cm TL; DOF, 2011) and with the size at sexual maturity (SSM = 12 cm TL; Álvarez-González *et al*., 2013) to assess whether the proportion of the population harvested by fishermen is mature and within the legal size range.

To evaluate the sex ratio (M:F), the chi-square test (X^2) was used to determine whether there was a significant difference between the observed and expected ratio (1:1) (Lorenzo-Nespereira & Gonzáles-Pajuelo, 1993). Sex and maturity were identified through macroscopic examination of the gonads. Since fish are eviscerated before being delivered to the cooperative collection center, the assessment was performed with intact gonads in some cases and with remnants in others. Gonadal stages were assigned only for females and were determined using Nikolsky (1963) macroscopic scale: I) virgin immature; II) incipient maturation/recovery; III) maturing; IV) mature; V) reproduction; VI) post-spawning.

To assess fish well-being or robustness, Fulton's condition factor (*K*) was calculated (Ricker, 1975): Equation 1: $k = 100(W/L^3)$, where W is the wet eviscerated body weight in grams and TL is in cm.

Results and Discussion

Samples were collected between January and May during the dry season to meet methodological assumptions and to generalize about the fraction of the population captured. During this period, no significant changes were observed among the samples. Fishermen mainly use gill nets and deliver their catch to the cooperative. A total of 131 organisms were obtained, ranging from 19.5 to 30 cm TL, with an average size of 24.85 ± 1.99 cm TL (SD). The size classes with the highest number of organisms were between 23 and 26 cm (Figure 1). MSC was 24.05 cm TL (Figure 2) and differed significantly from SSM ($p < 0.01$) and MPS ($p < 0.01$), indicating that the captured specimens are larger than both SSM and MPS.

The average size and MSC of *M. urophthalmus* in this study are larger than the mean size at capture reported by Argueta-Hernández *et al*. (2021) for the Usumacinta River basin, 22 ± 1 cm TL for organisms from San Pedro Balancán, Tabasco. In both cases, sizes exceed the MPS, mainly due to the selectivity of the fishing gear used. Both studies employed gill nets, which tend to catch a higher proportion of larger individuals with a minimum mesh size of 88.9 mm. The smallest recorded size was 19.5 cm, indicating that all organisms were part of the mature population during the sampling period, which aligns with the absence of stage I in the sample, based on previous reports of maturity sizes: 12 cm TL in Tabasco (Álvarez-González *et al*., 2013) and 17.1 cm TL for males and 15.7 cm TL for females in Lake Catemaco, Veracruz (Seba-Palacios, 2022). This suggests that some of the population manages to reproduce before being caught.

Regarding the sex ratio, a total of 38 males, 32 females, and 68 undetermined individuals were recorded, representing 29, 24.4, and 45.5 %, respectively. The sex ratio was M:F = 1.18:1 (excluding undetermined individuals), and no significant difference was found from the balanced

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ratio of 1:1 (X^2 = 0.51, p < 0.47). This ratio is similar to that reported by Poot-López *et al*. (2009) for *M. urophthalmus* in the Yucatán Peninsula and by Seba-Palacios (2022) for Lake Catemaco, Veracruz. However, it should be noted that 45 % of the organisms were not included in this analysis; therefore, it is advisable to increase sample size with confirmed sex identification in future studies, since sex ratio often varies among species and populations, and interannually within the same population (Nikolsky, 1963), due to differential growth between males and females and reproductive behavior (Vazzoler, 1996).

Stages II to VI were recorded (stage V was not observed in this study because fish are eviscerated before delivery to the cooperative), and stage IV was present in most months except May (Figure 3). The presence of gonadal stage IV in most months suggests that *M. urophthalmus* reproduces at least during the study months, which coincide with the spring-autumn reproductive season (Fernández-Pérez, 2024). The lack of a complete annual cycle and the sample size do not allow determination of reproductive peaks throughout the year, as reported by Poot-López *et al*. (2009) for populations from the Noh ts'ono'ot and Kan ts'ono'ot cenotes in Yucatán, where reproduction occurs during the dry, rainy, and northerly-wind seasons. Therefore, monthly or even biweekly monitoring of maturity stages is recommended, including analysis of the gonadosomatic index over an annual cycle, to identify reproductive periods for the *M. urophthalmus* population in the Malpaso Dam.

The average *K* for all organisms was 1.9 ± 0.1; monthly *K* values were similar across all months except May, when the average was 1.8 ± 0.1. According to Ujjania *et al*. (2012), a *K* factor > 1 indicates sufficient feeding and favorable environmental conditions for fish. In this study, *K* exceeded 1 in every month. This may be due to the dietary plasticity of *M. urophthalmus*, which can be considered carnivorous, omnivorous, or herbivorous depending on food availability and development stage (Villarreal *et al*., 2011). This suggests that the environmental conditions of the Malpaso Reservoir support its growth. The reservoir hosts various fish species that serve as prey for carnivorous species (e.g*., Dorosoma petenense*, *D. anale*; Rivera-Velázquez *et al*., 2015), and the diversity of vegetation encourages feeding, as rooted emergent, free-floating vegetation, and riparian shrubland are present along the reservoir shore (Rojas-García & Vidal-Rodríguez, 2008). These factors, combined with its high reproductive capacity and strong parental care (Martínez-Palacios, 1987), give *M. urophthalmus* an advantage in competition with native species, so an increase in its catch is anticipated.

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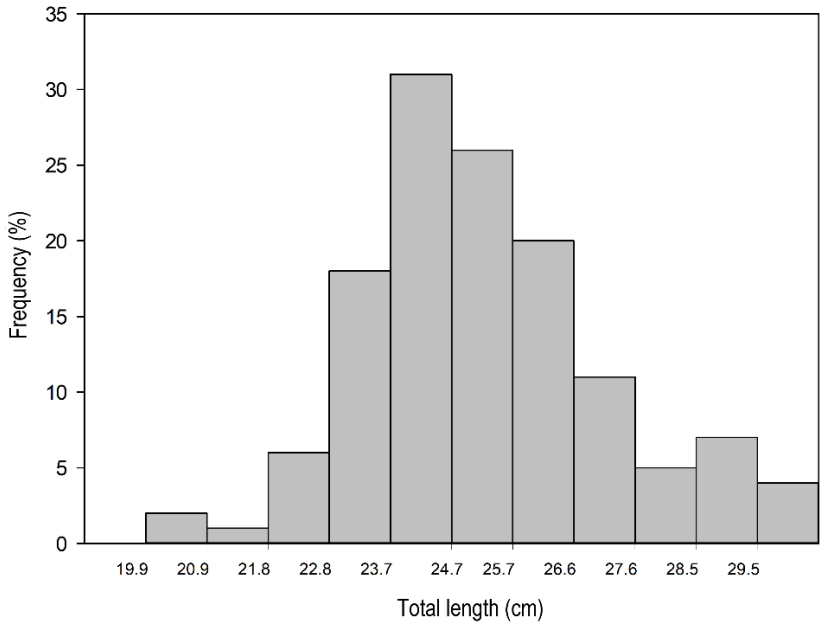

Figure 1. Size structure of *Mayaheros urophthalmus*.

Source: Prepared by the authors.

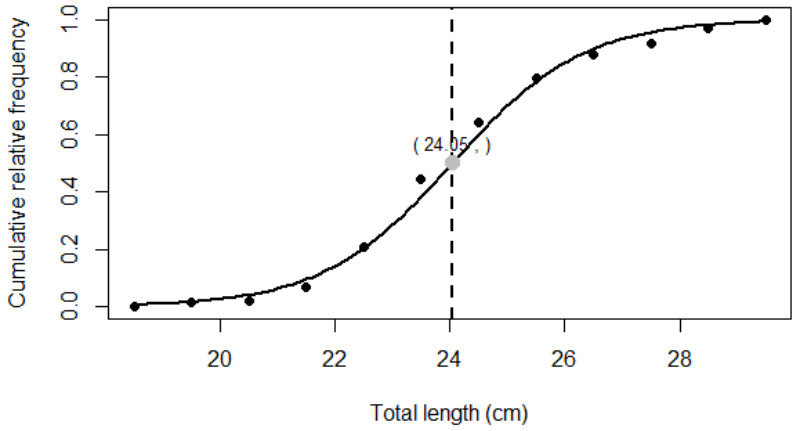

Figure 2. Mean capture size of *Mayaheros urophthalmus*.

Fuente: Prepared by the authors.

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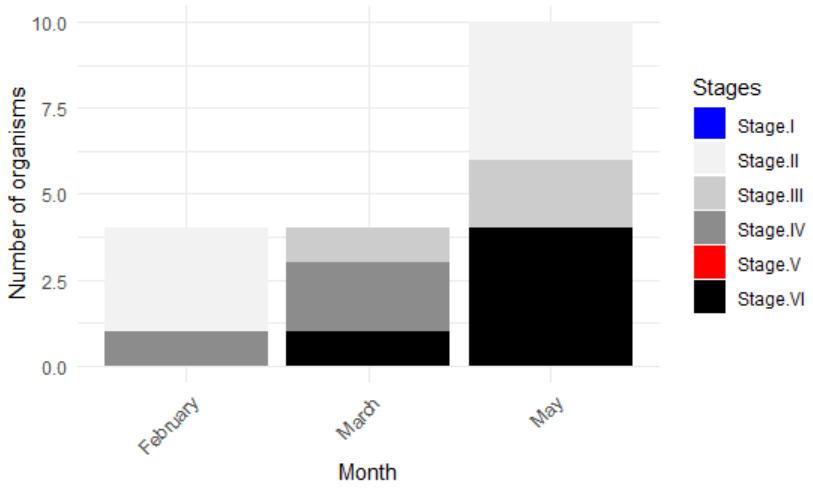

Figure 3. Gonadal stage of *Mayaheros urophthalmus*.

Fuente: Prepared by the authors.

Conclusions

The population of *M. urophthalmus* caught by the commercial fishery consists of mature organisms inhabiting environments that offer suitable conditions for growth and reproduction; therefore, an increase in its catch is anticipated in the coming years. Additionally, its high fecundity and well-developed parental care suggest that the commercially important species in the reservoir may face competition with *M. urophthalmus*. It is essential to establish a long-term routine monitoring system to track changes in the reservoir's fish community resulting from the establishment of the castarrica fish population.

Author Contributions

Conceptualization, GRV, JMAB, MAPM; Methodology, GRV, MAPM, WJGM; software, JMAB, WJGM; Data analysis, GRV, JMAB, MAPM; Data curation, JMAB, WJGM; Writing-original draft preparation, GRV, JMAB, MAPM, WJGM; Writing-review and editing, GRV, JMAB, MAPM, WJGM.

All authors have read and approved the final manuscript.

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Conflict of Interest

The authors declare no conflict of interest.

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