BIODIVERSITAS
Volume 25, Number 9, September 2024
Pages: 3095-3104

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d250931

Population dynamics of Eye-Spotted Barb (*Hampala dispar*: Cyprinidae) in Huai Kho Reservoir, Na Chueak District, Maha Sarakham Province, Thailand

SATIENPONG KHOWHIT[1,♥], TAWATCHAI TANEE[1], DOONNAPUT KHOWHIT[2], NATAPOL PUMIPUNTU[3], NARONGRIT MUAGMAI[4], PANNAWADEE MUSIRI[5]

[1]Faculty of Environment and Resource Studies, Mahasarakham University. Khamriang, Kantharawichai 44150, Maha Sarakham, Thailand. Tel./fax.: +66-4375-4435, ♥email: satienpong.k@msu.ac.th
[2]Faculty of Nursing, Mahasarakham University. Khamriang, Kantharawichai 44150, Maha Sarakham, Thailand
[3]Faculty of Veterinary Sciences, Mahasarakham University. Khamriang , Kantharawichai 44150, Maha Sarakham, Thailand
[4]Faculty of Fisheries, Kasetsart University. Chatuchak 10900, Bangkok, Thailand
[5]Lam Pao Reservoir Inland Fisheries Patrol Unite, Department of Fisheries. Sahatsakhan 46140, Kalasin, Thailand

Manuscript received: 14 May 2024. Revision accepted: 17 September 2024.

Abstract. *Khowhit S, Tanee T, Khowhit D, Pumipuntu N, Muagmai N, Musiri P. 2024. Population dynamics of Eye-Spotted Barb (*Hampala dispar*: Cyprinidae) in Huai Kho Reservoir, Na Chueak District, Maha Sarakham Province, Thailand. Biodiversitas 25: 3095-3104.* The study aims to analyze the population dynamics of the Eye-Spotted Barb (*Hampala dispar* (Smith, 1934)) in Huai Kao Reservoir, Thailand, focusing on age, growth, mortality, and other notable population characteristics. Fish specimens were collected monthly from January to December 2022 at six locations, selected based on information provided by local fishermen, using experimental gillnet fishing. A total of 1,060 individuals were analyzed with the FiSAT II program (FAO-ICLARM Stock Assessment Tools) to estimate population parameters. The study observed fish lengths ranging from 89 to 235 mm, with an average length of 148.47±25.83 mm. Fish weights varied between 13.0 and 191.0 g, averaging 46.04±27.48 g. The length-weight relationship was described by the equation LWR = $0.0000135L^{4.86723}$ ($r^2 = 0.98$), modeled the length-weight relationship, indicating a positive allometric growth with an allometric coefficient (b) greater than 3.00 for the *H. dispar* population. Key growth parameters included a growth performance index (ϕ) of 4.11 years^{-1}, an asymptotic length (L_∞) of 246.75 mm, and a growth coefficient (K) of 0.21 years^{-1}. The probabilities of capture at various lengths were L25% = 108.99 mm, L50% = 186.52 mm, and L75% = 191.44 mm. Instantaneous mortality rates were calculated as M = 0.37 year^{-1} for natural mortality, F = 0.60 year^{-1} for fishing mortality, and Z = 0.97 year^{-1} for total mortality. Recruitment was continuous throughout the year, peaking between February and June, with rates ranging from 11.19% to 16.41%. Virtual Population Analysis (VPA) showed that most *H. dispar* were caught at lengths between 130 mm and 160 mm, with maximum Fishing mortality (F) occurring at a mid-length of 220 mm, where F reached 0.60 year^{-1}. An estimated total steady-state biomass of 8.46 tons was found, and with a maximum exploitation rate (E_{max}) of 0.954 and Exploitation rate (E) of 0.62, it indicates high fishing pressure (E>0.50) on *H. dispar* in the Huai Kho Reservoir, Thailand. Thus, the environmental conditions of Huai Kho Reservoir are favorable for the growth of the *H. dispar* and can support an increase in their population.

Keywords: Fishing pressure, habitat conditions, *Hampala dispar*

INTRODUCTION

The Eye-Spotted Barb belongs to the phylum Chordata, class Actinopterygii, order Cypriniformes, family Cyprinidae, and genus *Hampala*. This genus is a key representative of freshwater cyprinid fish in Thailand. The species is highly sensitive to water quality and is found only in unpolluted rivers. It has a broad distribution across Southeast and South Asia, including countries such as Malaysia, Myanmar, Thailand, Laos, Cambodia, Brunei, Indonesia, Vietnam, India, Nepal, and Bangladesh. Hampala species are typically abundant and grow to a significant size (up to approximately 700 mm in total length), making them an important source of food (Herawati et al. 2023; Fishbase 2024). One notable feature that draws attention to this genus is the geographical variation in coloration and morphological traits. Currently, seven species of Hampala are recognized in Southeast Asia: *Hampala lopezi* (Herre, 1924) from the Philippines; *Hampala macrolepidota* (Valenciennes, 1824); *Hampala sabana* (Inger and Chin, 1962) from North Borneo; *Hampala ampalong* (Bleeker, 1852) from Brunei and Indonesia; *Hampala bimaculata* (Popta, 1905) from Borneo; *Hampala salweenensis* (Doi and Taki 1994) from Thailand; and *Hampala dispar* (Smith, 1934) from Cambodia (Suryaningsih et al. 2021). The Hampala diet consists primarily of food sources, including fish, shrimp, crabs, insects, mollusks, and aquatic plants. Shrimp are the most common and prominent objects in their stomachs (Makmur et al. 2014). Importantly, Hampala plays a significant indicator of water quality conditions. Their presence or absence can provide crucial insights into the health of aquatic ecosystems. They are known to inhabit areas where different types of water bodies meet, such as the transition between rivers and lakes or reservoirs. They can be found in different depth zones of water bodies, from shallower to moderately deep sections.

It's important to note that these characteristics are commonly associated with Hampala (Suryaningsih et al. 2021; Afriansyah et al. 2023). Water quality is crucial for determining fish food availability, directly affecting fish growth, health, and population. Poor water quality can reduce food availability, leading to stunted growth, poor health, and potentially causing declines in fish populations or even extinction (Islami et al. 2022; Afriansyah et al. 2023). However, only three Hampala species are currently described in Thailand: *H. dispar*, *H. macrolepidota*, and *H. salweenensis*.

Huai Kho Reservoir is an artificial water system in Thailand, built in 1968, and has an important role as a multifunctional resource, including controlling floods, supporting agriculture through irrigation, encouraging aquaculture and fisheries, and serving as a tourist attraction (CMARE 2020). One of the most frequently found fish species in this reservoir is *H. dispar* as much as 28.72% (Khowhit et al. 2023). The catch in the Huai Kho watershed reservoir, thanks to the favorable environmental conditions and the presence of prey species such as *Parambassis siamensis* (Fowler, 1937), *Henicorhynchus siamensis* (Sauvage, 1881), and *Labiobarbus lineata* (Sauvage, 1878). Its adaptability to various aquatic environments, including upland and lowland areas, both stagnant and flowing waters, contributes to its significance as a vital food source for communities around the Huai Kho Reservoir. The *H. dispar* holds significant economic value for local communities due to its year-round availability. It is widely consumed both fresh and processed into products like fermented fish paste (Pla-Ra) and fish sauce (Pattaravivat and Ittipong 2023).

Effective freshwater management of fish resources in reservoirs requires understanding various population parameters, Exploitation levels (E), and the conservation status of the fish population. Research on the population dynamics of *H. macrolepidota* in reservoirs is exceedingly rare, with the latest study conducted in Lao PDR in 2019. (Samuel and Nuryati 2014; Tessier et al. 2019) This study on the population dynamics of *H. dispar* is the first of its kind in Thailand and Southeast. The study aims to analyze the population dynamics of *H. dispar*, evaluate the stock status of the species in the Huai Kho Reservoir, and generate essential data for the conservation and management of *H. dispar* resources. This information will be valuable for comparisons with or adaptations to other reservoirs, adding to the novelty and excitement of this study. In addition, the biological parameters available in the existing literature are limited.

MATERIALS AND METHODS

Ethical statement

The research project has been carefully reviewed and approved according to the Ethical Principles and Guidelines for the Use of Animals (No. 36/2023) provided by Mahasarakham University, Thailand.

The study site and sampling methods

Over one year, from January to December 2022, fishermen collected *H. dispar* samples every month. The samples were gathered from six locations, each sampled six times throughout the year (Table 1). Gill nets with mesh sizes ranging from 3.0 to 6.0 cm captured the fish)Figure 1(. Once collected, all the fish were carefully weighed in grams (g) and measured in millimeters (mm) to ensure precise data collection). The Bronze featherback species was identified in 2024 using a modified comparison method with the online Fishbase (2024).

Table 1. Sampling Stations (ST) in Huai Kho Reservoir, Thailand

Sampling stations	Site code	Latitude	Longitude
Ban Kao Kwang	ST1	15°83'59.38"N	103°02'47.81"E
Ban Sumsang	ST2	15°84'72.21"N	103°02'72.71"E
Koh Nonkha	ST3	15°84'75.05"N	103°03'64.11"E
Pattaya Na Chauk 2	ST4	15°84'15.43"N	103°04'12.46"E
Pattaya Na Chauk 1	ST5	15°83'25.43"N	103°03'99.59"E
Huai Kho Reservoir	ST6	15°83'26.98"N	103°03'26.62"E

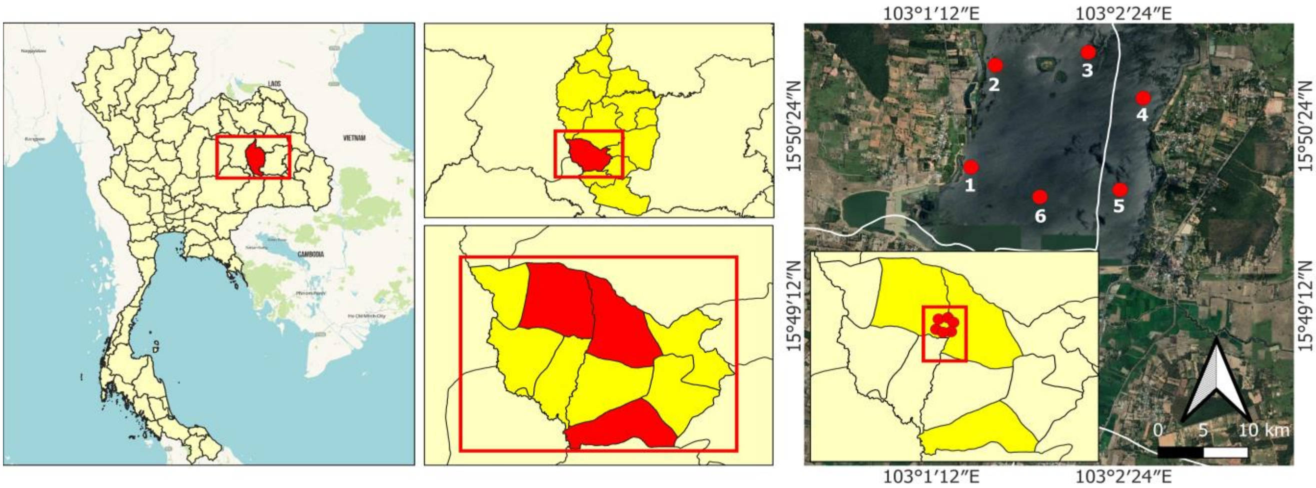

Figure 1. The six sampling stations (red dots) are positioned within the Huai Kho Reservoir, located in Na Chueak District, Maha Sarakham Province, Thailand. Note: No. 1-6 indicate station 1 to station 6

Population dynamics parameters of calculation

1,060 Eye-Spotted Barb (*H. dispar*) specimens were collected for biometric analysis, involving precise measurements of their lengths and weights. The data were then stratified into 0.5 mm length intervals for detailed statistical analysis (Bahtiar et al. 2022a). The analysis was performed using FiSAT II software in conjunction with Microsoft Excel 2021, following the methodologies described by the Gayanilo method (Fazli et al. 2019; Beaune et al. 2020; Johnson et al. 2020; Muhtadi et al. 2022; Achmad et al. 2024).

Length-Weight Relationship (LWR)

The mathematical expressions of Le Cren's empirical equation (Nur et al. 2023) were used to compute the length-weight relationship:

$$LWR = aL^{b.}$$

Where:
W : Total fish weight in grams
L : Total fish length in millimeters (mm).

The parameters a and b define this relationship, with a being a coefficient associated with body form, and b being an exponent that reflects isometric growth when it equals 3. This relationship was determined using the formula. (Herwaty et al. 2023):

$$Log_{10}\ LWR = log_{10}\ a+b\ log_{10}\ L$$

Where in the logarithmic form of the Length-Weight Relationship (LWR), log W represents the logarithm of the fish weight in grams, log a is the logarithmic coefficient, b is the logarithm of the exponent, and log L denotes the logarithm of the total fish length in centimeters. This logarithmic transformation was used to assess the significance level of r^2 through linear regression analysis

Asymptotic length (L_∞) and growth coefficient (K)

The empirical formula of Pauly (Achmad et al. 2024) was used to estimate the theoretical age at birth (t_0) with the formula:

$$log_{10}(-t_0) = -0.3922-0.275\times log_{10}\ L_\infty\ -1.038\ \times log_{10}K$$

Where:
t_0 : Hypothetical age corresponding to a length of zero (in years)
L_∞ : Asymptotic length in centimeters (cm)
K : Growth constant with units of year^{-1}.

The growth performance index is determined using Munro and Pauly's formula (Achmad et al. 2024) as follows:

$$\phi = 2\ log10\ L_\infty + log10K$$

Where:
ϕ : The growth performance index
L_∞ : The asymptotic length measured in millimeters (mm)
K : The curvature of the growth constant in the Von Bertalanffy Growth Function (VBGF)

Using the adjusted length-frequency data, the parameters L_∞ and K were fitted to the classical Von Bertalanffy Growth Function (VBGF). Pauly's formula was applied within the VBGF fitting routine in ELEFANT-I in FiSAT_II to calculate the growth constant (K) and asymptotic length (L_∞). (Achmad et al. 2024) as follows:

$$L_t = L_\infty\ (1-e^{-K(t-to)})$$

Where:
L_t : The average length at age t
L_∞ : The maximum length the fish can achieve
K : The growth coefficient
t : The age of *H. dispar*
t_0 : The assumed age at which the fish's length would be zero

Age

Age analysis was conducted using the Bhattacharya method (Osman et al. 2024); this method involves dividing fish into various length classes. The frequency of each length class is then converted into a logarithm, and the difference between the logarithm of each class and the previous class is calculated.

Mortality rates (M)

To estimate total mortality (Z), we utilized the Ricker method implemented in ELEFAN I (Achmad et al. 2024) with a length-converted catch curve. The formula applied is:

$$Z = K\frac{(TL_\infty - L)}{(L - L^/)}$$

Using Pauly's empirical equation (Bahtiar et al. 2022b), the natural mortality coefficient (M) was calculated as:

$$log_{10}\ M = -0.0066-0.279\ log_{10}\ L_\infty +0.6543\ log_{10}K+0.4634\ log_{10}T$$

The annual average surface water temperature in the Huai Kho Reservoir was used to determine the Fishing mortality rate (F), F = Z-M (Herwaty et al. 2023). The level of Exploitation (E) was calculated using Pauly's empirical equation (Bahtiar et al. 2022b) as follows:

$$E = \frac{F}{Z}$$

Recruitment pattern and probability of capture

The length-converted catch curve routine provides a way to quantify the probability of capture, estimating the capture lengths at L25, L50, and L75, where 25%, 50%, and 75% of the fish are captured, according to the Gayanilo method (Diaby et al. 2022). The recruitment pattern over a one period was estimated based on the monthly length measurements of the Bronze Featherback fish and the consistency of their length distribution, using the Von Bertalanffy growth function as described by the Moreau and Cuende method (Achmad et al. 2024)

Virtual Population Analysis (VPA)

Using length-structured Virtual Population Analysis (VPA), the population sizes and fishing mortality for each length group were calculated. This was done by inputting parameters such as a, b, M, F, L_∞, and K into the FiSAT_II software, following the Pauly method (Ghosh et al. 2024).

Relative Yield per Recruit (Y'/R) and Biomass per Recruit (B'/R)

Y'/R and B'/R were approximated in FiSAT_II software by applying Beverton and Holt's formula (Doinsing and Ransangan 2024):

$$Y'/R = EU^{M/K}\left\{1 - \frac{3U}{(1+m)} + \frac{3U^2}{(1+2m)} - \frac{U^3}{(1+3m)}\right\}$$

Where: $U = 1 - \frac{L_c}{L_\infty}$; $m = \frac{(1-E)}{\left(\frac{M}{K}\right)} = \frac{K}{Z}$; $E = \frac{F}{Z}$

B'/R is estimated using the relationship: (Y'/R)/F.

RESULTS AND DISCUSSION

Size structure

The Frequency distribution of the size of 1.060 *H. dispar* samples from six locations in the Huai Kho Reservoir for 12 months (January-December 2022) weighed 13.0 to 191.0 grams, an average weight of 46.04±27.48 grams. The total length with an interval of 5.0 millimeters ranged from 90 to 235 millimeters with an average length of 148.47±25.83 millimeters. Most of the sampled population was 135 to 140-millimeter class, comprising 126 individuals (11.88%). The most prominent size class occurred between 130 and 160 millimeters (Figure 2).

Age and growth parameters

The initial extreme length value was applied in ELEFAN-I, within the FiSAT II package, to create the most accurate growth curve for *H. dispar*. The observed extreme length was 235.00 millimeters, while the predicted extreme length was 240.29 millimeters. The length range of the 95% confidence interval was between 228.76 and 251.81 millimeters. This analysis provided a robust estimate of the growth parameters essential for understanding the population dynamics of *H. dispar* in the Huai Kho Reservoir.

The growth performance indices (phi prime; Ø') for *H. dispar* in the Huai Kho Reservoir, Thailand, were determined, with a phi prime (Ø') value of 4.17. This index serves as a crucial metric for comparing the growth rates of different fish populations. Monthly analyses of the length frequency distribution revealed specific growth parameters for *H. dispar*. The growth performance index (ϕ) was calculated to be 4.11 year-1 (Figure 4), indicating a moderate growth rate for the species in this environment. Additionally, the asymptotic length (L_∞) was estimated at 246.75 millimeters, suggesting the maximum length *H. dispar* could achieve under optimal conditions. The growth coefficient (K) was 0.21 per year, and the t_0 value, which represents the theoretical age when the fish would have a length of zero, was -0.34 months (Figure 5).

The growth equation for *H. dispar*, based on the VBGF, was derived as follows: Length-Weight Relationship (LWR) = $0.0000135L^{4.86723}$ (r^2= 0.98). The specific growth model for *H. dispar* is $Lt = 246.75*(1-e^{-0.21}(^{t+0.34}))$, here Lt represents the length at age t. This equation provides a predictive model for estimating the length of *H. dispar* at various ages, facilitating better resource management and conservation strategies (Figure 3).

According to the growth model, the sizes attained by *H. dispar* at different ages were estimated. At 2 months, the fish reached a length of 87 millimeters; at 4 months, 142 millimeters; at 6 months, 177 millimeters; at 8 months, 202 millimeters; at 10 months, 217 millimeters; and at 12 months, 227 millimeters. These estimates highlight the rapid initial growth phase of *H. dispar*, followed by a gradual decrease in growth rate as the fish age (Figure 5).

Mortality (Z) and exploitation (E)

Using the VBGF growth parameters (L_∞ and K) in length, total mortality (Z) was estimated at 0.97 $year^{-1}$, with a 95% confidence interval ranging from 0.62 to 1.31 (r^2 = 0.99). (Figure 7) The natural mortality (M) was 0.37 $year^{-1}$. Consequently, the fishing mortality (F), expressed as F=Z-M, with a calculated value of F equals 0.60 $year^{-1}$ The exploitation (E) ratio is expressed as E= F/Z, with a calculated value of E equals 0.62 (Figure 6).

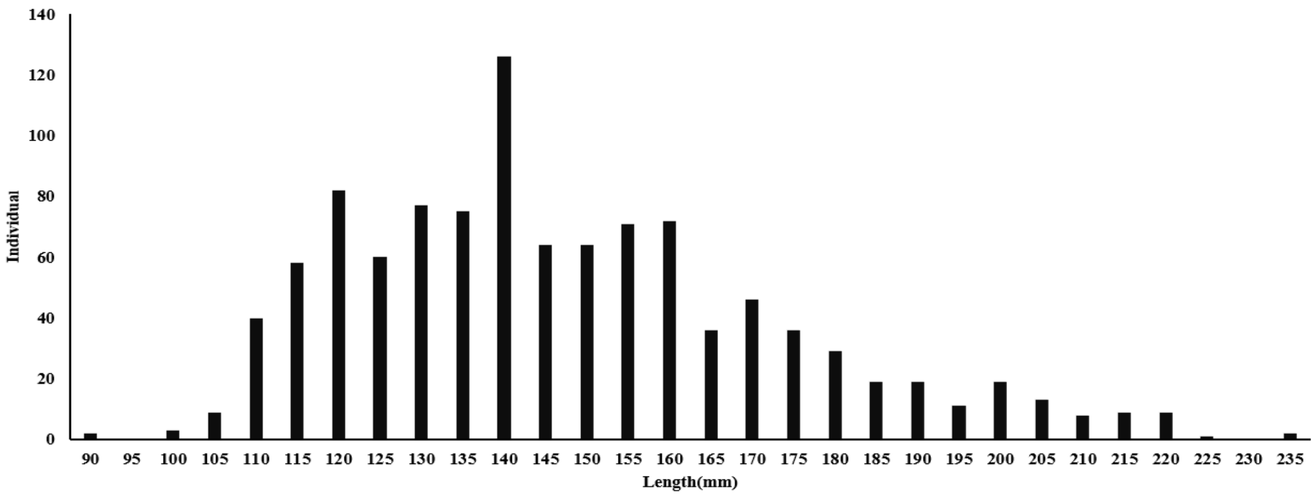

Figure 2. Length frequency distribution ranging between 90 and 235 millimeters (TL) for both sexes of *Hampala dispar* (n = 1060) using the landing data from Huai Kho Reservoir, Na Chueak District, Maha Sarakham Province, Thailand, during January-December 2022

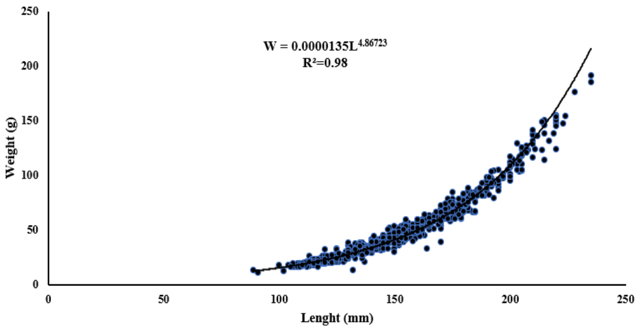

Figure 3. Length-Weight Relationship (LWR) of) *H. dispar* (n = 1060) in the Huai Kho Reservoir, Na Chueak District, Maha Sarakham Province, Thailand

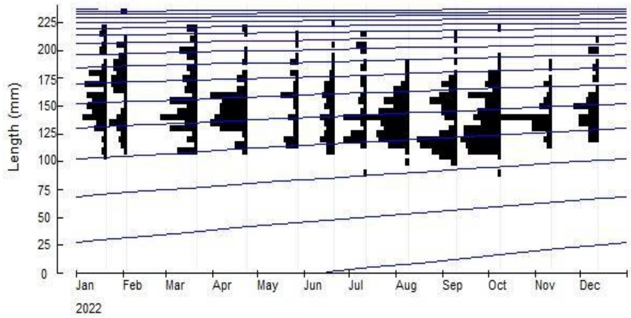

Figure 4. Restructured length-frequency distribution of *H. dispar* samples (n = 1060) from trawl catches in the Huai Kho Reservoir, Na Chueak District, Maha Sarakham Province, Thailand, superimposed with growth curves analyzed using ELEFAN-1 from K-scan of FiSAT_II (The parameters = L_∞ equals 246.75 mm and K = 0.21 year^{-1})

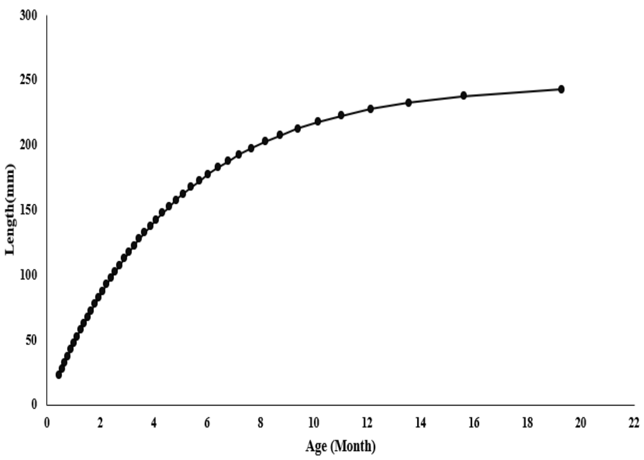

Figure 5. The graph shows the relationship between age and length of *H. dispar* (n = 1060), using data from the computed growth parameters of *H. dispar* (L_∞ = 246.75 mm and K = 0.21 year^{-1})

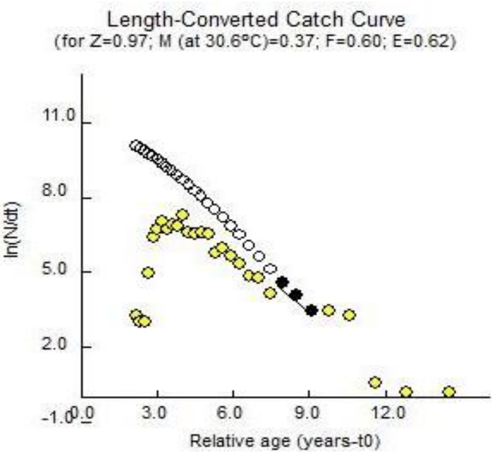

Figure 6. Length-converted catch curve for *H. dispar* (n = 1060; r^2 = 0.99) in the Huai Kho Reservoir, Na Chueak District, Maha Sarakham Province, Thailand, utilizing the equation used to estimate different mortality and exploitation rates

Probability of capture and recruitment pattern

The probability of capture for *H. dispar* was calculated in fork length as follows: L25% equals 165.00 millimeters, L50% equals 184.84 millimeters, and L75% equals 204.69 millimeters (Figure 7). The recruitment pattern indicates a single annual peak for *H. dispar*, with a replacement rate ranging from 0.00% to 16.41%. The highest replacement rates occur between February and Jun, peaking at 16.41% in April, while the lowest replacement rates are recorded in December, reaching 0.00% (Figure 8).

Virtual population analysis (LVPA)

FiSAT_II analyzed output graphics for LVPA. Throughout 2022, 33,511.93 individuals of *H. dispar* were observed, while individuals of *H. dispar* ranged from 3.23 to 3425.31. The highest numbers of *H. dispar* were caught between 130 millimeters and 160 millimeters. The total steady-state biomass was 8.46 tons, while steady-state biomass ranged from 0.02 to 0.42 tons. The overall mortality rate ranged from 0.00 to 0.60 year^{-1} while the maximum value occurred at 220 millimeters, totaling 24.44 individuals (0.60 year^{-1}), repeatedly indicating high fishing mortality in juvenile *H. dispar* (Figure 9).

Yield per recruit (Y/R) and biomass per Recruit (B/R)

The knife-edge analysis method was employed to estimate the relative yield per recruit (Y/R) and relative biomass per recruit (B/R) for *H. dispar.* The input parameters for this analysis were L_c50/L_∞ set at 0.75 and M/K at 1.76. The estimated relative Y/R was 0.091 grams per recruit, whereas the actual B/R was 0.280 grams per recruit. In comparison, while the values of the exploitation rate at E10, E50, and Emax were found to be 0.810, 0.398, and 0.954, respectively (Figure 10).

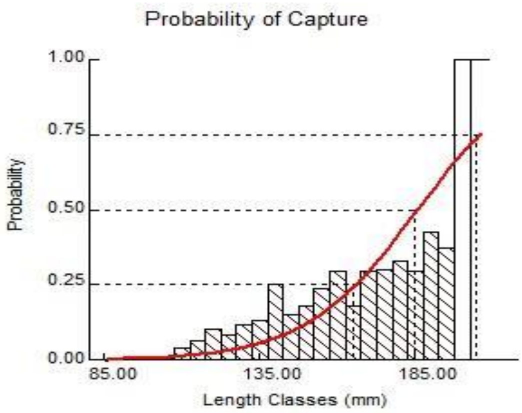

Figure 7. Selectivity curve for *H. dispar* (n = 1060), depicting the mean size at first capture at probabilities of 0.25 (L25%), 0.5 (L50%), and 0.75 (L75%) in Huai Kho Reservoir, Na Chueak District, Maha Sarakham Province, Thailand

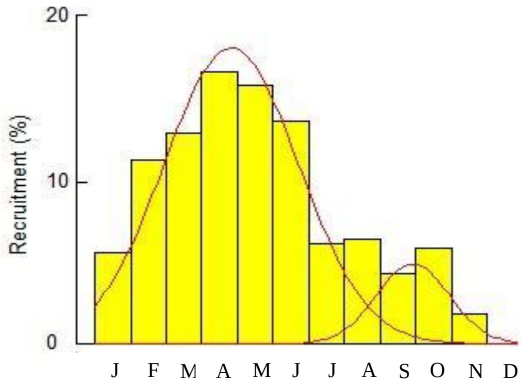

Figure 8. Recruitment pattern of *H. dispar* (n = 1060) in the Huai Kho Reservoir, Na Chueak District, Maha Sarakham Province, Thailand, from January to December 2022

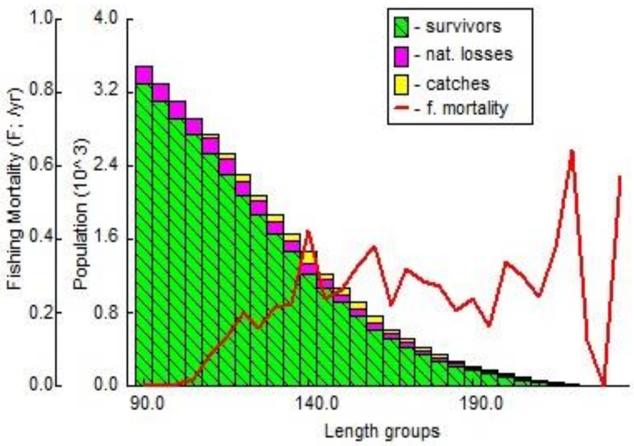

Figure 9. The population size and mortality characteristics of *H. dispar* (n = 1060) in the Huai Kho Reservoir, Na Chueak District, Maha Sarakham Province, Thailand, were evaluated using length-structured Virtual Population Analysis (VPA)

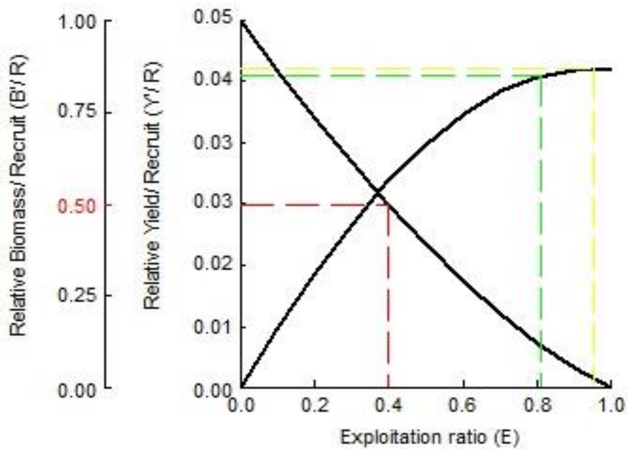

Figure 10. The relative yield per recruit and biomass per recruit for *H. dispar* (n = 1060) in the Huai Kho Reservoir, Na Chueak District, Maha Sarakham Province, Thailand, were analyzed using Beverton and Holt's relative Y'/R method with a knife-edge approach. Note: The dash-lines: red (--) green (--) and yellow (--) indicate the exploitation rates at $E_{0.1}$, $E_{0.5}$, and E_{max}, respectively

Discussion

The average total length of *H. dispar* was 148.47±25.83 millimeters. The majority of the sample population was in the size class of 135 to 140 millimeters, which included 126 individuals (11.88%). The peak sample size was collected in October, with 150 individuals (14.24%). The size distribution of *H. dispar* in this study varied compared to other locations. For instance, in Lake Kerinci, Jambi, Indonesia, *H. macrolepidota* had a total length ranging from 85 to 425 millimeters, with the largest group, 1,253 individuals (30.60%), between 225 and 275 millimeters (Figure 2). Similarly, a study by Samuel and Nuryati (2014) studied Nam Theun 2 Reservoir in Lao and found, reported *H. macrolepidota* lengths from 40 to 379 millimeters, with the predominant size class being 140 to 159 millimeters, comprising 54 individuals (15.12%) (Tessier et al. 2019). In contrast, in Lake Singkarak, West Sumatera, Indonesia, *H. macrolepidota* ranged from 54 to 590 millimeters in total length, with 371 individuals (44.22%) falling within the 104 to 153 millimeter range. The peak sample size was recorded in August, with 150 individuals, accounting for 23.24% of the total (Risdawati et al. 2020). The differences in the size of *H. macrolepidota* depend on the fishing gear used, the migration patterns of the fish, the availability of food, the water capacity in the area, and the period during which the nets are set (Tirtadanu et al. 2018; Herwaty et al. 2023). These factors collectively influence the fish size structure, fishing pressure, the extent of the fishing area, and the timing of fish sampling. The analysis of length frequency distribution in each month revealed growth parameters for *H. dispar* in the study area, with a growth performance index (ϕ) value

= 4.11 year^{-1}, asymptotic length (L_∞ = 246.75 millimeters), growth coefficient (K = 0.21 year^{-1}) and t0 = -0.3467 months. Figure 4 shows that a negative t0 suggests that juveniles grow faster than adults' anticipated growth curve. According to Paujiah et al. (2023), a value of K equal to 1.0 signifies rapid growth, 0.5 indicates moderate growth, and 0.2 suggests slow growth. The estimated value of K, which equals 0.21 for *H. dispar* in this study, indicates slow growth. Food scarcity in this oligotrophic reservoir could also contribute to the observed low growth rate (Descloux et al. 2016; Martinet et al. 2016). These values indicate lower growth than of *H. dispar* from the Huai Kao reservoir. When compared with the reference area, the growth of *H. macrolepidota* parameters was found to be lower, with a Growth performance index (ϕ) value = 3.09 year^{-1}, asymptotic length (L_∞) = 430 millimeters, and a growth coefficient (K) = 0.66 year^{-1} with an asymptotic length (L_∞) = 295 millimeters (Table 2) (Samuel and Nuryati 2014) and a growth coefficient (K) = 0.24 year^{-1} (Tessier et al. 2019). Various factors influence aquatic organisms' growth patterns. These include changes in body shape at different life stages, growth phases, seasonal variations, food availability, stomach fullness, the breeding period, gonad maturity, sex, geographical location, temperature, water quality, and the length range of analyzed fish (Makmur et al. 2014; Soetignya et al. 2016; Risdawati et al. 2020; Herawati et al. 2022). Tessier et al. (2019) suggest that variations in the growth of *H. macrolepidota* among different populations may be attributed to environmental factors (water temperature and nutrient), human impacts (including fisheries and pollution), species plasticity, or the presence of diseases. Thus, the growth coefficient (K) serves as an indicator of the growth rate of aquatic organisms. A higher growth coefficient (K) signifies faster and more favorable growth, while a lower growth coefficient (K) indicates slower and less optimal growth.

The assessment of Length-Weight Relationships (LWR) is vital for promoting sustainable fisheries conservation in aquatic systems and is fundamental in creating guidelines for the management of aquatic resources (Afriansyah et al. 2023). Length-Weight Relationship (LWR) of *H. dispar* is detailed as follows: LWR = $0.0000135L^{4.86723}$ (r^2 = 0.98); Lt = 246.75*(1-e $^{-0.21}$($^{t+0.34}$)) (Figure 3). Compared with the reference area, the Length-Weight Relationship (LWR) of *H. macrolepidota* was found to be LWR = $0.0122L^{2.9552}$ (r^2 = 0.98); Lt = 443.00*(1-e $^{-0.66}$($^{t+0.22}$)) (Table 2) (Samuel and Nuryati 2014). The disparities in the values of variables 'a' and 'b' can be attributed to alterations in fish physiology, sex, gonadal development, species diversity, seasonal variations, spawning periods, feeding behaviors, gear selectivity, water levels, water quality, nutritional intake, as well as geographical and geopolitical disparities (Warsa et al. 2019; Risdawati et al. 2020; Makmur et al. 2021; Suryaningsih et al. 2021; Herawati et al. 2022; Muhtadi et al. 2022; Afriansyah et al. 2023). This preliminary study on *H. dispar* from Huai Kho Reservoir shows a positive allometric growth pattern as indicated by a value of ‘b’. The growth coefficient, b, generally lies between 2.5 and 3.5, and the relation is isometric when it equals 3. Hence, indicating a large number of fish, as reported for most fish species (Hasim et al. 2021). In the present case, estimated b (4.86723) is higher than the values mentioned by Risdawati et al. (2020) and significantly higher than the isometric value (3), so the indication of the growth pattern of length is faster than the weight growth. The *H. dispar* is a carnivorous and predatory fish hunting for food. The stomach contents of *H. dispar* were found to consist of small fishes (40%), remains (26.22%), freshwater prawn (25.31%), insect larvae (4.23%), weeds (3.59%), phytoplankton (0.51%), and zooplankton (0.13%) (Udonkarn et al. 2024). Therefore, the Length-Weight Relationship (LWR), which establishes the relationship between the length and weight of the fish, is crucial for understanding the feeding ecology of *H. dispar*.

Table 2. Compared to other regions, the population dynamics parameters of *Hampala dispar* in Huai Kho Reservoir, Thailand

Population dynamics parameters	**Huai Kho Reservoir**	**Kerinci Lake)Indonesia(**
Species of fish	*Hampala dispar*	*Hampala macrolepidota*
Intercept (a)	0.0000135	0.0122
Exponent (b)	4.86723	2.9552
Coefficient of determination (R^2)	0.98	0.9859
Growth performance indices (ϕ) (year^{-1})	4.11	3.086
Asymptotic length (L_∞) (mm)	246.75	430
Growth coefficient (K) (year^{-1})	0.21	0.66
Theoretically age(t) at zero length (t_0) (year^{-1})	-0.34	-0.22
Total mortality (Z) (year^{-1})	-	1.93
Natural mortality (M) (year^{-1})	0.37	1.15
Fishing mortality (F) F = Z-M (year^{-1})	0.60	0.78
Exploitation ratio (E) E = F/Z	0.62	0.40
Peak recruitment (%)	February-June (16.41%)	-
Dominant length range (mm)	135-140 (11.88%)	225-275 (30.60%)
Sample size (n)	1,060	3,590
Reference	Present study	Samuel and Nuryati (2014)

The total mortality rate (Z) of 0.97 $year^{-1}$ shows that fish mortality from fishing (F = 0.60 $year^{-1}$) exceeds natural mortality (M = 0.37 $year^{-1}$). This aligns with the findings of Khowhit et al. (2024), which confirmed that the water quality in the Huai Kho Reservoir is good and does not negatively affect aquatic life. Therefore, *H. dispar* in the Huai Kho Reservoir is primarily subjected to Fishing mortality (F) (Figure 6). The observed condition indicates a high level of exploitation, likely due to increased fishing activities. Differences in these values may be due to size-specific selectivity of different fishing methods and seasonal migrations (Warsa et al. 2019). Small fluctuations in growth parameters can still significantly affect the estimated mortality rates (Bam et al. 2022). When comparing the total mortality in the study area with the reference data, it was found that for *H. macrolepidota*, the total mortality (Z), natural mortality (M), and fishing mortality (F) were 1.93 $year^{-1}$, 1.15 $year^{-1}$, and 0.78 $year^{-1}$, respectively (Table 2) (Samuel and Nuryati 2014). By contrast, Tessier et al. (2019) documented Z, M, and F values of 1.13 $year^{-1}$, 0.15 $year^{-1}$, and 0.98 $year^{-1}$, respectively. This indicates that *H. dispar* in the studied area is primarily affected by higher fishing mortality (F) than natural mortality (M). The observed high fishing mortality suggests an elevated fishing pressure, potentially attributed to the abundance and presence of large individuals at this sampling site. According to Afriansyah et al. (2023), the stock is steady if Z/K equals 1.0, collapses if it is above 1.0, and overexploits if the proportion is greater than 2.0. The Z/K value in this research reached 4.61, which is higher than 2.0; hence, the current stock is considered over-exploited.

The current exploitation rate of E = 0.62 is lower than the maximum sustainable exploitation rate of Emax = 0.954, suggesting that the fish in the Huai Kho Reservoir is over-exploited. Overall, the study concludes that the level of exploitation is approaching the optimal level of E = 0.50. (Risdawati et al. 2020). Bahtiar et al. (2022b) stated that an E value above 0.5 indicates the height level of exploitation rates of *H. dispar* from this Huai Kho Reservoir. The utilization of aquatic organisms has exceeded the sustainable production capacity. When comparing with the reference values, the Exploitation rate (E) of *H. macrolepidota* was determined to be E = 0.40 (Samuel and Nuryati 2014). The Exploitation rate (E) of *H. macrolepidota* was determined to be E = 0.87 was higher than the E_{max} was 0.559 (Tessier et al. 2019) which is relatively higher than the optimum fishing level (0.5). This indicates higher levels of exploitation rates for *H. macrolepidota* in this reservoir. The height exploitation rates suggest that the utilization of aquatic resources in this reservoir is high at the sustainable production threshold.

The probability of capture analysis revealed that approximately 75% of *H. dispar* are captured at 204.69 mm long, indicating a higher likelihood of catching juvenile fish before reaching reproductive maturity. Consequently, there is a potential risk of overexploitation of *H. dispar* resources in the Huai Kho Reservoir area, leading to inadequate replenishment due to a shortage of breeding adults. This could result in a decrease in the future recruitment of *H. dispar* offspring (Figure 7). This underscores the importance of fishing gear selectivity as a crucial tool for fisheries management to minimize bycatch and mitigate the impact on fish populations. Warsa et al. (2019) emphasize that fishing gear selectivity plays a pivotal role in reducing non-target catches. The exploitation pattern and its effects on fish populations are influenced by multiple factors, such as the type of fishing gear, the size of the net, and the length and depth of the fishing nets (Ginzel et al. 2022). This relationship is related to the size of the fish and the selectivity of the gear concerning the available fish size.

The recruitment pattern for *H. dispar* shows a single annual peak, with the highest replacement rates occurring between February and June, reaching 16.41% in April (Figure 8). This pattern reflects an increase in the gonadosomatic index from January to March, peaking in April and decreasing in June. Tropical fish studies suggest that intense sunlight and high surface water temperatures during the dry season, as well as just before the rainy season, may induce stress that triggers reproductive activity (Tessier et al. 2019). Compared with the reference area, the recruitment pattern for *H. macrolepidota* of the highest replacement rates occurs between January and April, with a peak in June (Tessier et al. 2019). According to Makmur et al. (2021), *H. macrolepidota* shows its highest replacement rates between March and April for the first peak and in November for the second peak. Although this species can reproduce throughout the year, several studies have documented a peak in spawning at the start of the rainy season (Liu et al. 2015). According to Ratanachamnong and Karkkaew (2022), Thailand's location within a tropical zone significantly influences the replacement patterns throughout the year. Two continuous patterns of fish replacement can be observed in Thailand. It is reported that most of the Thailand fish stocks exhibit two pulse of recruitment each year such as Red-tailed Barb (*Barbonymus altus*, Gunther, 1868) Nile Tilapia (*Oreochromis niloticus*, Linnaeus, 1758), Siamese Mud Carp (*H. siamensis*) and fish stocks exhibit one pulses of recruitment each year such as Soldier River Barb (*Cyclocheilichthys enoplos*, Bleeker, 1850), Thai Silver Barb (*Barbonymus gonionotus*, Bleeker, 1849), Yellow Mystus (*Hemibagrus nemurus*, Valenciennes, 1840), and Smith Barb (*Puntioplites proctozysron*, Bleeker, 1865).

The relative $Y^{/}/R$ is 0.091 grams per recruit, while the actual $B^{/}/R$ is 0.280 grams per recruit, showing that the actual $Y^{/}/R$ is lower than the relative B/R. This points to inefficient stock replenishment, thought to be caused by heavy fishing pressure from multiple gears, leading to excessive strain on the fish population (Mehanna et al. 2017). While the total steady-state biomass of *H. dispar* was found to be 8.11 tons (Figure 9). The values of the exploitation rate at E_{10}, E_{50}, and E_{max} were found to be 810, 0.398, and 0.954, respectively (Figure 10). When comparing with the reference values, the exploitation rates for *H. macrolepidota* at $E_{0.1}$, $E_{0.5}$ and E_{max} were found to be 0.467, 0.312, and 0.559, respectively (Tessier et al. 2019). In the present study, the optimum biomass of *H. dispar* can be maintained at E0.5 of 0.398, slightly smaller than the current E of 0.62. From the point of fisheries management, E0.5 is considered a target reference point to conserve the spawning stock biomass. Suppose E_{max} is higher than the current Exploitation rate (E) of 0.954 per year. This this indicates significant potential for further exploitation of *H. dispar* in the Huai Kho Reservoir. This is echoed by the study by Khowhit et al. (2023), which examined the types and quantities of fish in the Huai Kho Reservoir and found that *H. dispar* was the most abundant in every month and throughout the study period because The Huai Kho Reservoir offers a unique habitat for the species. To fully understand this environment, it is important to consider factors such as high water quality and the presence of vegetation like *Hydrilla verticillata* (L.f.) Royle, *Utricularia aurea* Lour., *Spirogyra* sp., and *Azolla pinnata* R.Br. Therefore, the utilization of *H. dispar* in the Huai Kho Reservoir has yet to exceed its capacity.

In conclusion, the study on the population dynamics of *H. dispar* revealed a growth performance index (ϕ) of 4.11 year^{-1}, an asymptotic length (L_∞) of 246.75 mm, and a growth coefficient (K) of 0.20 years^{-1}. These findings suggest that *H. dispar* is a slow-growing species with a short lifespan, early sexual maturity, and consistent recruitment. Recruitment patterns indicate a single annual peak, with the highest replacement rates between February and June, peaking at 16.41% in April. The spawning season extends from January to March, aligning with the egg-laying period. The maximum exploitation rate (E_{max}) reached 0.954, highlighting significant fishing pressure. because Huai Kho Reservoir, provides a specific habitat for the species. Understanding the environmental conditions of this reservoir, such as good water quality, and vegetation. The observed fishing mortality (F = 0.60 year^{-1}) exceeds the natural mortality (M = 0.37 year^{-1}), with an overall Exploitation rate (E) of 0.62. This indicates that *H. dispar* in the Huai Kho Reservoir is under high fishing pressure, surpassing the sustainable level (E<0.50). If the current high level of exploitation continues unchecked, the future population of *H. dispar* in the reservoir will likely decline. Based on the findings from your study on the *H. dispar* and its overexploitation, here are some recommended conservation measures for sustainable management: i) Fishing gear regulations: Implement restrictions on the types and sizes of fishing gear used to reduce bycatch and prevent the capture of juvenile or spawning individuals. For example, using larger mesh sizes can help reduce the capture of smaller fish. ii) Seasonal fishing bans: Introduce fishing bans during critical periods such as spawning seasons to protect breeding populations and ensure successful reproduction. For the Eye-Spotted Barb, this might be during specific months when peak recruitment occurs. iii) This includes setting appropriate legal size limits for fishing gear and avoiding fishing during the breeding, spawning seasons and establishing conservation zones for the marble goby by designating the area along the rim of Huai Kho Reservoir, extending 1 kilometer inland and 100 meters into the water, as a protected area. 4) Habitat restoration: Invest in restoring and maintaining the aquatic habitat within the reservoir. This includes managing water quality, controlling pollution, and preserving aquatic vegetation that provides important habitat for fish. Such measures will help to sustain the *H. dispar* population and protect its future in the Huai Kho Reservoir.

ACKNOWLEDGEMENTS

This research project was financially supported by Mahasarakham University, Thailand.

REFERENCES

Achmad DS, Nurdin MS, Tilome AA, Moore AM. 2024. Population dynamics of *Variola albimarginata* Baissac, 1953 and *Variola louti* Fabricius, 1775 (Perciformes: Serranidae) in Sulawesi Sea, Indonesia. Biodiversitas 25 (3): 978-989. DOI: 10.13057/biodiv/d250310.

Afriansyah A, Muslim M, Irawan R. 2023. Sexual dimorphism, length-weight relationship, and condition factor of *Hampala ampalong* (Bleeker, 1852) from Kalong Floodplain, Ogan Komering Ilir Regency. Intl J Sci Res Arch 10 (1): 666-674. DOI: 10.30574/ijsra.2023.10.1.0800.

Bahtiar B, Purnama MF, Kasim M, Ishak E. 2022a. Population dynamics of blood clams *Tegillarca granosa* (Linnaeus, 1758) in Kendari Bay, Southeast Sulawesi, Indonesia. Biodiversitas 23 (10): 5084-5092. DOI: 10.13057/biodiv/d231015.

Bahtiar B, Purnama MF, Muis, Ishak E, Kasim M. 2022b. The size structure, growth, and exploitation rate of freshwater clam (*Batissa violacea* var. *celebensis*) from Southeast Sulawesi, Indonesia. J Shellfish Res 41 (1): 145-152. DOI: 10.2983/035.041.0112.

Bam GR, Kamrani E, Kaymaram F, Jamili S, Fatemi MR. 2022. Population dynamic parameters of the Malabar trevally *Carangoides malabaricus* (Bloch and Schneider, 1801) in the Persian Gulf and Oman Sea. Iran J Fish Sci 21 (2): 516-525. DOI: 10.22092/ijfs.2022.126511.

Beaune D, Guillard J, Cottet M, Kue K, Lae R, Chanudet V, Descloux S, Tessier A. 2020. Investigating key biological parameters of Nile tilapia (*Oreochromis niloticus* L.) in a large Asian reservoir to better develop sustainable fisheries. Hydroecol Appl 21: 157-179. DOI: 10.1051/hydro/2020001.

Climate Change Mitigation and Adaptation Research Unit (CMARE). 2020. Climate Change Adaptation for Nachueakpittayasan School, Nachuak Sub-District, Nachueak District, Mahasakham Province. Climate Change Mitigation and Adaptation Research Unit; CMARE, Faculty of Environment and Resources Studies, Mahasakham University, Thailand. [Thailand]

Descloux S, Guedant P, Phommachanh D, Luthi R. 2016. Main features of the Nam Theun 2 hydroelectric project (Lao PDR) and the associated environmental monitoring programmes. Hydroecol Appl 19: 5-25. DOI:10.1051/hydro/2014005.

Diaby M, N'dri KM, Kouassi KD, N'da K. 2022. Angling at lavononkaha reservoir)Department of Korhogo, Côte D'Ivoire(: Ichthyological composition of catches and exploitation parameters of *Oreochromis Niloticus*)Linnaeus, 1758(. Res Agric Livest Fish 9 (2): 229-238. DOI: 10.3329/ralf.v9i2.61628.

Doinsing JW, Ransangan J. 2024. Population dynamics of the tropical oyster *Magallana bilineata* (Mollusca, Bivalvia, Ostreidae) in Bengkabong Bay, Tuaran, Malaysia. Aquac Fish 9 (2): 295-305. DOI: 10.1016/j.aaf.2022.04.005.

Fazli H, Daryanabard GR, Janbaz A, Jolodar MN, Mirzaei R, Hosseinpour H, Vahedi N. 2019. Age and growth of *Alburnus mossulensis* Heckel, 1843 in Azad Dam Reservoir and Komasi River in Kordestan Province, Iran. Iran J Fish Sci 18 (4): 672-683. DOI: 10.22092/ijfs.2018.117745.

Fishbase. 2024. Scientific Name. http://www. Fishbase.org.

Ghosh M, Dutta S, Dutta M, Homechaudhuri S. 2024. Assessing the population dynamics of *Cirrhinus reba* (Hamilton, 1822) in River Atrai, India, for its conservation and sustainability as natural stock. J Fish Environ 48 (1): 51-67. DOI: 10.34044/j.jfe.2024.48.1.05.

Ginzel FI, Wijayanti DP, Subagiyo, Sabdono A. 2022. Growth and mortality, recruitment and exploitation rate of fringescale sardinella *Sardinella fimbriata* (Valenciennes 1847) in Rote Island in the Savu Sea. Croat J Fish 80 (4): 189-196. DOI: 10.2478/cjf-2022-0019.

Hasim H, Tuheteru J, Fazrin DN. 2021. Comparison of growth pattern, condition factor, gonadosomatic index of Manggabai (*Glosogobius giuris*) and Payangka (*Ophieleotris aporos*) in Limboto Lake, Gorontalo, Indonesia. Biodiversitas 22 (6): 3389-3393. DOI: 10.13057/biodiv/d220646.

Herawati T, Agung MUA, Yustiati A, Suwartapradja OS, Sukono. 2023. Characteristics of meristics, morphometrics, and analysis of cytochrome oxidase gen fragmen subunit 1)CO1(Hampala Barb)*Hampala* sp.(from Jatigede Reservoir, Sumedang, West Java, Indonesia. J Surv Fish Sci 10)1(: 2396-2406. DOI: 10.53555/sfs.v10i1.916.

Herawati T, Yustiatia A, Nurhayatia A. 2022. Growth patterns and reproduction of Hampala Barb (*Hampala macrolepidota*) Kuhl and Van Hasselt 1823 in Jatigede Reservoir, West Java Indonesia. Indones J Limnol 3 (2): 66-75. DOI: 10.51264/inajl.v3i2.33.

Herwaty S, Mallawa A, Najamuddin, Zainuddin M. 2023. Age, growth, mortality and population characteristics of the red snapper (*Lutjanus malabaricus*) in the Timor Sea waters, Indonesia. Biodiversitas 24 (4): 2217-2224. DOI: 10.13057/biodiv/d240434.

Islami NI, Herman RG, Herawati T, Sunarto. 2022. Food habits of Hampala fish (*Hampala macrolepidota*, Kuhl & Van Hasselt 1823) in Jatigede Reservoir Sumedang Regency, West Java Province. IJARIIE 8 (5): 2103-2109.

Johnson C, Sarkar UK, Koushlesh SK, Das AK, Das BK, Naskar BK. 2020. Population structure of Nile tilapia and its impact on fisheries of a tropical impacted reservoir, Central India. Environ Sci Pollut Res Intl 27 (23): 29091-29099. DOI: 10.1007/s11356-020-09234-w.

Khowhit S, Tanee T, Khowhit D, Pumipuntu N, Muangmai N, Musiri P. 2024. Population dynamics and exploitation rate of Bronze Featherback (*Notopterus notopterus*, Pallas, 1769) for sustainable management in Huai Kho Reservoir, Na Chueak District, Maha Sarakham Province, Thailand. Egypt J Aquat Biol Fish 28 (5): 219-237. DOI: 10.21608/ejabf.2024.377650.

Khowhit S, Tanee T, Khowhit D. 2023. Species diversity and distribution of fish in Huai Kao Reservoir, Na Chauk District, Maha Sarakham Province, Thailand. J Surv Fish Sci 10 (1): 2363-2377. DOI: 10.53555/sfs.v10i1.214.

Liu MD, Huang FJ, Zhu JZ, Liu RC, Liu SP. 2015. Reproductive biology of *Hampala macrolepidota*. Chin J Zoo 50 (3): 405-414.

Makmur S, Arfiati D, Bintoro G, Ekawati AW. 2014. Food habit of hampala (*Hampala macrolepidota* Kuhl & Van Hasselt 1823) and its position in food web, food pyramid and population equilibrium of Ranau Lake, Indonesia. J Biodivers Environ Sci 4 (6): 167-177.

Makmur S, Muthmainnah D, Subagdja, Arfiati D, Bintoro G, Ekawati AW. 2021. Reproductive biology of hampala barb (*Hampala macrolepidota* Kuhl & Van Hasselt 1823) in Ranau Lake, Indonesia. IOP Conf Ser: Earth Environ Sci 744: 012042. DOI: 10.1088/1755-1315/744/1/012042.

Martinet J, Guédant P, Descloux S. 2016. Phytoplankton community and trophic status assessment of a newly impounded sub-tropical reservoir: Case study of the Nam Theun 2 Reservoir (Lao PDR, Southeast Asia). Hydroecol Appl 19: 173-195. DOI: 10.1051/hydro/2015006.

Mehanna SF, Baker TS, Soliman FM, Soliman HA. 2017. Some biological aspects and population dynamics of the five-lined snapper, *Lutjanus quinquelineatus* (Family: Lutjanidae) from Red Sea off Hurghada, Egypt. Intl J Fish Aquat Stud 5 (5): 321-326.

Muhtadi A, Nur M, Latuconsina H, Hidayat T. 2022. Population dynamics and feeding habit of *Oreochromis niloticus* and *O. mossambicus* in Siombak Tropical Coastal Lake, North Sumatra, Indonesia. Biodiversitas 23 (1): 151-160. DOI: 10.13057/biodiv/d230119.

Nur M, Tenriware, Nasyrah AFA. 2023. Length-weight relationship and condition factor of bullet tuna (*Auxis rochei* Risso, 1810) in the waters of Mamuju District, West Sulawesi Province, Indonesia. Biodiversitas 24 (10): 5253-5259. DOI: 10.13057/biodiv/d241005.

Osman HM, El-Ganainy AA, Shalloof KAS, El-Betar TA. 2024. Length-based estimates of growth parameters and population structure of *Siganus rivulatus* (Forsskål, 1775) from the Gulf of Suez, Red Sea, Egypt. Egypt J Aquat Biol Fish 28 (1): 339-351. DOI: 10.21608/ejabf.2024.338215.

Pattaravivat J, Ittipong B. 2023. Pla-Ra. Fisheries Industrial Technology Research and Development Division (FTDD), Department of Fisheries, Ministry of Agriculture and Cooperative, Thailand. [Thailand]

Paujiah E, Dhahiyat Y, Herawati T, Iskandar, Haryono, Zulfahmi I, Fahri. 2023. Length-weight relationships and condition factors of brackish water catfish, *Mystus gulio* (Hamilton, 1822) from three different estuaries, West Java, Indonesia. Biodiversitas 24 (5): 2855-2864. DOI: 10.13057/biodiv/d240540.

Ratanachamnong D, Karkkaew M. 2022. Fish population dynamics in Pasak Jolasid reservoir. Inland Fisheries Research and Development Division, Department of Fisheries, Ministry of Agriculture and Cooperative, Thailand. [Thailand]

Risdawati R, Dahelmi D, Nurdin J, Syandri H. 2020. Bioecological aspects of *Hampala macrolepidota* in Lake Singkarak, West Sumatera, Indonesia. AACL Bioflux 13 (2): 893-901.

Samuel, Suryati NK. 2014. Population parameters of Barau fish)*Hampala macrolepidota* Kuhl & Van Hasselt 1923(in Kerinci Lake, Jambi. Jurnal Penelitian Perikanan Indonesia 20)4(: 191-198. DOI: 10.15578/jppi.20.4.2014.191-198. [Indonesian]

Soetignya WP, Suryobroto B, Kamal MM, Boediono A. 2016. Sex ratio, size structure and fecundity in *Hampala bimaculata* (Cyprinidae) from Betung Kerihun National Park, West Kalimantan Province, Indonesia. AACL Bioflux 9 (3): 713-721.

Suryaningsih S, Sukmaningrum S, Amurwanto A, Rofiqoh AA. 2021. Reproductive characters of hampala fish (*Hampala macrolepidota* kuhl & Van Hasselt, 1823), correlation with body length. IOP Conf Ser: Earth Environ Sci 819: 012013. DOI: 10.1088/1755-1315/819/1/012013.

Tessier A, Beaune D, Guillard J, Kue K, Cottet M, Chanudet V, Descloux S, Panfili J. 2019. Life history traits and exploitation of Hampala barb (*Hampala macrolepidota* -Cyprinidae) in a subtropical reservoir (Lao PDR). Cybium 43 (4): 351-365. DOI: 10.26028/cybium/2019-434-005.

Tirtadanu, Wagiyo K, Sadhotomo B. 2018. Growth, yield per recruit and spawning potential ratio of red snapper)*Lutjanus malabaricus* Schneider, 1801(in Sinjai and adjacent waters. Jurnal Penelitian Perikanan Indonesia 24)1(: 1-10. DOI: 10.15578/jppi.1.1.2018.1-10. [Indonesian]

Udonkarn C, Ruekaewma P, Sutti-arj S, Nitsupap R. 2024. Some biological aspects of *Hampala dispa* Smith, 1934 in Nonng Han, Sakon Nakhon Province. Sakon Nakhon Inland Fisheries Research and Development Center, Muang District, Sakon Nakhon Province. [Thailand]

Warsa A, Tjahjo DWH, Astuti LP. 2019. Monofilament gillnet selectivity for Hampala Barb (*Hampala macrolepidota*) management at Ir. H. Djuanda Reservoir-West Java. Omni-Akuatika 15 (1): 66-74. DOI: 10.20884/1.oa.2019.15.1.638.