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Bioecology and Distribution of Dwarf Snakehead (*Channa limbata,* Cuvier 1831) Based on Geographic Information System in Progo River, Magelang, Central Java

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Abstract

This research was a database collection process to determine the resources of dwarf snakehead *C. limbata* and found the potential fish resources in the Progo River forming a zonation map, so it was very necessary to determine the next step in the management of fish resources (domestication efforts) of potential commodities in Magelang. The research was conducted from May to November 2021. Parameters observed were morphometric, length-weight relationship, gonad maturity level, feed, condition factor, and water quality. The tools used in this research were GPS for determining sampling points, nets for catching fish, etc. The results showed that dwarf snakehead was a demersal fish that lived in freshwater with an environmental condition with muddy sand and rocky gravel as its natural habitat. The morphology was rounded tail shape, protocercal tail type, and ctenoid scales. The growth pattern was allometric negative. Gonad maturity stage of male (GMS 1) and female (second development/GMS 4). The GSI value for males was 0.0875 and for females was 0.729. The GI value for males was 0.06 and for females was 0.551. Plankton found in the stomach include *Leptocylindrus* sp., *Cylindrospermopsis* sp., *Rotaria neptunia*, *Dipleuchlanis propatula*, and *Conochilus hippocrepis.*

INTRODUCTION

The Progo River is one of the rivers in Central Java and Yogyakarta Provinces. Upstream on Mount Sindoro with a main river of 138 km and a watershed area of 243,833,086 hectares. The Progo River has tributaries that have upstream in a number of mountains, one of which was Mount Merapi (Syamsu, 2016). The influencing factor is the number of fish (a lot or a little) in freshwater waters, one of which is the rate of water flow (Fauziah *et al.,* 2017), it can affect the quality of river waters on the organisms that live in it, especially the impact on fish (Pranata *et al.,* 2016). The status of freshwater commodity resources in Indonesia has been reported by Hubert *et al.* (2015) were 1,218 species consisting of 84 families including 1,172 species, which are native species from 79 families and 630 endemic species.

Based on LIPI data (2015), it was estimated that there were as many as 4000 -

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6000 species of fish in all Indonesian waters. Dwarf Snakehead *C. limbata* is a fish from the Channidae family also known as the red-tailed snakehead which is considered rare and only found in shallow rivers (near the forest) and waterfalls (near mountains) (Khoomsab dan Wannasri, 2017). Even though it is widely distributed in Asia, it has declined drastically (vulnerable) in India (CAMP, 1998) and is endangered in some Asian countries like Singapore (Alfred, 1966). Until now, there is still a lack of information related to the bio-ecological aspects of *C. limbata* species in Indonesia, especially in Magelang. Therefore, knowledge and research must continue to develop to be able to present the latest data on potential freshwater fish.

This study aimed to study the bio-ecology of dwarf snakehead in the Progo River in determining the status of fish resources based on the Geographic Information System. The urgency of this research was to obtain the latest information on snakehead resources *C. limbata* and find the potential of fish resources in the Progo River in the form of a zoning map so it was very necessary to determine the next step, namely the management of fish resources in an effort to domesticate or cultivate potential commodities that were in Magelang.

METHODOLOGY

Ethical Approval

Not applicable.

Place and Time

This research was carried out from May to November 2021 in 4 places including sampling in the Progo River, identification of snakehead *C. limbata* at the Laboratory of the Faculty of Agriculture, Tidar University, making histological preparations at the LPPT (Integrated Research and Testing Laboratory) Gadjah Mada University and testing of water quality samples in Akatirta (Tirta Wiyata Technical Academy) Magelang.

Research Materials

The tools used in this research were GPS (Global Positioning System) for determining sampling points, nets for catching fish, a sectio set for dissecting fish, a cool box and jars for fish containers, pH meter, thermometer, DO meter, wooden ruler, digital scale, black-white plate (Secchi disk) and film bottle. The materials needed in this study were five specimens, 10% formalin, 70% alcohol, and latex for preserving specimens.

Work Procedure

Parameter Measurement

Morphological characters in snakehead adults were measured individually: total length (TL), standard length (SL), head length (HL), head width (HW), head depth (HD), eye diameter (ED), snout length (SNL), interorbital width (IW), pre anal length (PAL), body depth (BD), body width (BW), ventral length (PVL), caudal peduncle depth (CPD), caudal peduncle length (CPL), dorsal basic length (DBL), dorsal fin height (DFH), pre caudal length (PCL), pre pelvic length (PPL), anal basic length (ABL), pre dorsal length (PDL), upper caudal length (LUCL), middle caudal length (LMCL), and lower caudal length (LCLL) (Ansyari and Slamat, 2022). Meristically such as scales, gills, teeth, and fins specifically and the color of the external organs.

Length - Weight Relationship

Dwarf snakehead was weighed using a 10^{-2} digital scale and measured using a 10^{-1} cm ruler. The formula for the relationship between length and weight according to Jin *et al.* (2015), is as follows:

$W = aL^b$

$\log W = \log \log a + b \log \log L$

Where:

W = weight (g)
L = length (cm)
a and b = constant

The isometric growth regression coefficient was 3 and the allometric was less or more than 3. Growth analysis used the

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von-Bertalanfy method (Haryono *et al.,* 2014).

Gonadal Maturity Stage

Determination of the gonadal maturity stage is compared based on morphological characteristics comparison by Bagenal (1968). Dwarf snakehead was dissected and the gonads were taken and then weighed. The Gonado Somatic Index (GSI) calculation followed the method by Sadekarpawar and Parikh (2013):

$$GSI\ (\%) = \frac{\text{gonad weight (g)}}{\text{body weight (g)}} \times 100\%$$

Type of Food

Dwarf snakehead was dissected to remove the intestines and stomach. Intestines were measured in comparison to body length. The stomach was taken intact and weighed. The whole hull was cut in part and then weighed. After that, the part of the stomach was chopped and diluted in a measuring cup. Take 1 ml placed on the slide and observe using a microscope to identify the type of phytoplankton or zooplankton eaten.

Condition Factor

Calculation of condition factor used the method by Jin *et al.* (2015):

$K = 100\ (W/L^3)$

Where:

K = condition factor
W = weight (g)
L = length (cm)
100 = factor used to approach the value of 1 in K

Water Quality

The water quality parameters measured in the morning included: temperature, pH, DO, TSS, COD, ammonia, phosphate brightness, depth, substrate, and current. The sampling point survey aimed to determine the research location based on regional boundaries and the physical condition of the waters that represent each sampling station. These observations were also used to determine the distribution and relationship of habitat characteristics (Eduardo *et al.,* 2018).

Sample Identification

The morphological characters analysis of dwarf snakeheads was carried out based on Weber and de Beaufort (1922). The dwarf snakeheads caught were placed in a cool box and then recorded and the number of individuals counted. The organ was stored in 96% alcohol to be used as specimens and then observed morphometrically and meristically (Hasan and Tamam, 2019).

Data Analysis

Data processing based on Geographic Information System. The data processing used in the form of hardware, namely: Personal Computer (PC), color printer, and scan tool, while the software was ArcGIS 9.x, Ms. Excel, and Ms. Word (Jailani *et al.,* 2021).

The method in this research used a GIS approach with spatial analysis techniques where techniques were used in the analysis of spatial studies. Map overlay or tumpeng stacking (superimposed) map was used to determine constraints, boundaries, and developments in compiling a zoning map of dwarf snakehead in the Progo River, Magelang. Buffering and querying were used in displaying, converting, and analyzing data. Spatial query plays a very important role and is tailored to the needs of the user.

RESULTS AND DISCUSSION

Water Quality

The habitat characteristics of dwarf snakehead in the Progo River Magelang were in the depth range of 18-47 cm and the average from 5 stations was 30 cm; the brightness of 18-40 cm and the average were 26.4 cm; the current was 5-7 sec/m and the average was 6.6 sec/m. The environment used as a habitat for these fish was close to dense vegetation (Figure 1).

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Figure 1. Progo River, Magelang.

Table 1. Measurement results of water quality in Progo River.

Parameter	Unit	Mean (during research)
Temperature	°C	24,6
pH	-	7,9
Dissolved Oxygen	mg/l	7,7
Chemical Oxygen Demand	mg/l	6,016
TSS	mg/l	12
Ammonia	mg/l	0,03312
Phosphate	mg/l	0,086
Depth	Cm	30
Brightness	Cm	26,4
Current	sec/m	6,6

Based on the results of the analysis of water quality in the Progo River (Table 1), showed that the water conditions were still classified as normal which has an average parameter including a temperature value of 24.6°C; pH 7.9; DO 7.7 mg/l; COD 6.016 mg/l; TSS 12 mg/l; ammonia 0.03312 mg/l and phosphate 0.086 mg/l. According to Pujiastuti *et al.* (2013) and Syamiazi *et al.* (2015), waters with a temperature range of 25-32 °C were best for aquaculture activities of fish and other living organisms. Supratno (2016) explained that the increase in temperature was in line with the increase in the growth rate of fish. The increase in temperature causes the metabolic activity of aquatic organisms to also increase so that the dissolved gas in the waters is reduced which is important for the life of aquatic organisms.

Measurement of pH at all sampling stations in the Progo River was still classified as normal, namely 7.7-7.9. Domestic activities and fish farming as well as the entry of organic and inorganic compounds into the waters can affect the pH value (Tobing, 2014). Low productivity of aquatic ecosystems occurs if the pH value of the water is < 5.0 (Rahman, 2016). Dissolved oxygen (DO) levels in the Progo River ranged from 7.13-8.85 mg/l, DO in the waters was an important factor for the survival of dwarf snakehead. The increase in dissolved oxygen demand was caused by an increase in aquatic metabolic activity in the waters. The phosphate value at the data collection station in the Progo River was 0.04-0.1 mg/l, although it looks close to the quality standard value, this value was still relatively low so it can be said that the water conditions are good. The high value of phosphate was caused by the entry of agricultural fertilizers into the waters through rain drainage (Fazrin *et al.,* 2020).

The increased growth of algae can also be caused by the presence of excessive phosphorus accompanied by the presence of nitrogen so that it can form a surface layer of water that is able to inhibit the penetration of oxygen and sunlight it affects the life of aquatic ecosystems

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(Lihawa and Mahmud, 2017). The environmental conditions of the Progo River are included in the range of water quality which can be said to be good because it was appropriate and didn't exceed the water quality standard threshold.

Distribution

Dwarf Snakehead *C. limbata* was a fish that lived in fresh waters. The distribution map below shows that it was distributed along the Progo River, Magelang, Central Java (Figure 2). The distribution of dwarf snakehead *C. limbata* was strongly influenced by the contour, substrate, river water flow, and river depth. It was indicated by the large number of fish distribution which was dominated at points with a depth of 10-20 cm. The characteristics of *C. limbata* prefer environmental conditions with muddy sand and rocky gravel as a substrate. More details can be seen in Table 2 below.

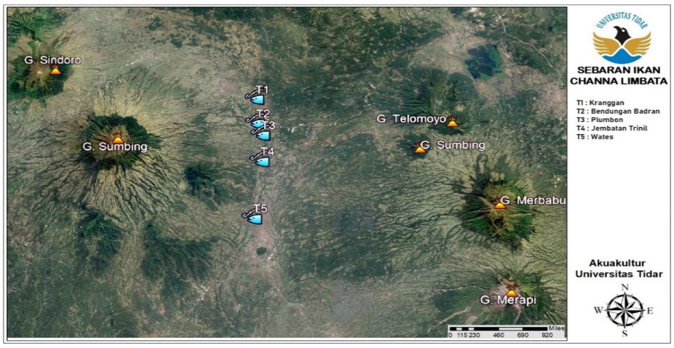

Figure 2. Distribution map of dwarf snakehead *C. limbata* in Progo River, Magelang.

Table 2. Sampling point.

Station	Description
Kranggan (St.1)	Sandy mud (there was many big rock) Depth 3 m Slowly flow Found < 10 fish
Bendungan Badran (St.2)	Rocky Gravel Heavy flow Depth 50 cm Found >15 fish
Jembatan Bengkal (St.3)	Muddy sand There was litter of leaves and twigs Heavy flow Depth 10 cm Found >10 fish
Jembatan Trinil (St.4)	Gravel Sand Heavy flow Depth 15-20 cm Found >10 fish
Gelangan (St.5)	Gravel Sand Slowly flow Leaf litter Depth 20 cm Found >15 fish

Dwarf snakehead *C. limbata* preferred shallow waters, river flow velocity, and twig litter, this was because almost all fish samples found were in locations with the above characteristics. Besides being used as a hiding place, it was also used for

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hunting prey. When breeding the *C. limbata* prefers rocky areas, where the sidelines were used as a nursery ground.

Morphology

Morphological measurements of the average lengths of dwarf snakehead (*C. limbata*) specimens collected are shown in Table 3.

Table 3. Morphological measurements of average lengths of *C. limbata*.

Morphometric characteristics	Result (cm)	Literature*
Body standard length	10.5	10.97
Body depth	2.3	1.62
Caudal peduncle minimal depth	1.4	1.28
Caudal fin depth	1.3	1.12
Caudal fin surface	1.1	0.82
Distance from insertion of pectoral fin to bottom of body	1.5	1.41
Body depth at level of pectoral fin insertion	1.6	1.67
Pectoral fin length	1.9	1.90
Pectoral fin surface	1.3	1.35
Head depth along vertical axis of eye	1.3	1.23
Eye diameter	0.5	0.41
Body width	2.1	2.35

* Khoomsab and Wannasri (2017).

Meristically, the results showed that the formula for the radius of the fins in females included dorsal fins: xvii, 16; ventral fin: 8; caudal fin: 26; pectoral fins: 14; and anal fin: xxiii. While males included the dorsal fin: xxiii; ventral fin: 7; caudal fin: 29; pectoral fin: 13; and anal fin: xiv,1.

Dwarf snakehead *C. limbata* had a rounded tail, protocercal tail type, and ctenoid scales. This fish belongs to the category of demersal fish where these fish live and forage on the bottom of the waters (demersal zone).

Length-Weight Relationship

The results of measurements of the total length and total body weight of *C. limbata* in the Progo River showed that the average length was 11.80 cm and weight was 12.50 g. The results of the analysis of the relationship between length and weight (Figure 3).

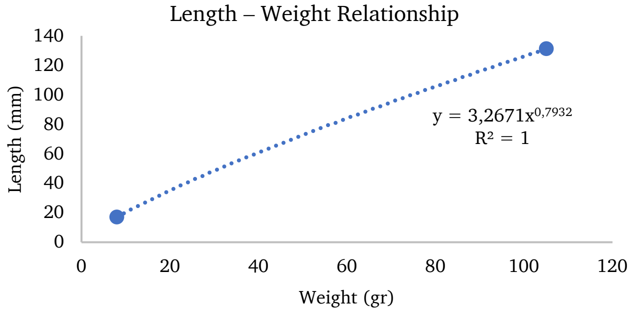

Figure 3. Length–weight relationship of dwarf snakehead.

The results of the analysis of the relationship between total length and body weight of dwarf snakehead *C. limbata* obtained a constant value of a = 3.2671 and a constant value of b = 0.7932 so that the relationship between length and body weight of fish W = 0.084957. These results indicate that the value of b < 3 means that *C. limbata* in the Progo River

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has an allometric (negative) growth pattern. Negative allometric growth of *C. limbata* was indicated by the increase in body weight that was faster than the increase in length. According to Fazrin *et al.* (2020), The existence of different values in the relationship between length and weight of fish was also influenced by sex and gonad maturity of fish. In addition, the calculation of growth in length and body weight of fish was influenced by several factors including fish species, water conditions, species, season, and time of catching.

Condition Factor

The results of the calculation of the condition factor of *C. limbata* obtained a value of 0.6910701 in males while in females it was 0.7561971. The condition factor also reflects changes in food reserves so that it can be interpreted as the condition of fish in general (Datta *et al.,* 2013; Islam *et al.,* 2013).

Identification of Plankton Types in Stomach

The condition of the aquatic environment and the availability of food were one of the factors for the presence of fish in the water. It was in line with the statement of Effendie (1997) that feed was an important factor in fish breeding because food determines the population, growth, and condition of fish in the waters. Types of plankton include *Leptocylindrus* sp., *Cylindrispermopsis* sp., *Rotaria neptunia*, *Dipleuchlanis propatula,* and *Conochilus hippocrepis* (Table 4). This showed that dwarf snakehead *C. limbata* was a type of fish that ate all types of plankton (phytoplankton and zooplankton) in the waters but tended to be dominated by zooplankton.

The identified food types of snakehead (*C. striata*) larvae and fry from Danau Bangkau were *Chlorella* sp., *Chara* sp., *Spirulina* sp., *Anabaenopsis* sp., *Nitzschia* sp., *Synedra* sp., *Melanosira* sp., *Navicula* sp., *Diatoms, Daphnia, Rotifers, Copepod, Spirostomum, Euglena deses* (Ansyari and Slamat, 2022).

Table 4. Identification of plankton in *C. limbate* stomach.

Image	Plankton Types	Classification
	Phytoplankton	Kingdom : Chromista Phylum : Heterokontophyta Class : Coscinodiscophyceae Order : Leptocylindrales Family : Leptocylindraceae Genus : Leptocylindrus Species : *Leptocylindrus* sp.
	Phytoplankton	Kingdom : Cyanobacteria Class : Cyanophyceae Order : Nostocales Family : Aphanizomenonaceae Genus : Cylindrospermopsis Species : *Cylindrospermopsis* sp.

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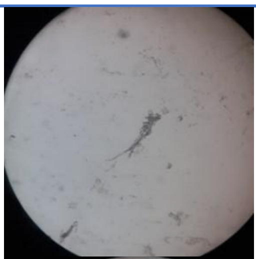
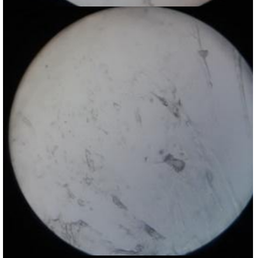
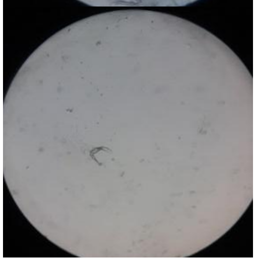
	Zooplankton	Kingdom : Rotifera Class : Bdelluidea Order : Bdelloida Family : Philodinidae Genus : Rotaria Species : *Rotaria neptunia*
	Zooplankton	Family : Euehlanidae Genus : Dipleuchlanis Species : *Dipleuchlanis propatula*
	Zooplankton	Phylum : Rotifera Family : Conochilus remane Genus : Conochilus Species : *Conochilus hippocrepis*

Gonad Maturity

Based on the classification of Gonad Maturity Stage (GMS) according to Kesteven (1960), the male dwarf snakehead was at the wench (GMS 1), while the female was at the second development level (GMS 4). The results of observations showed that the GSI (Gonad Somatic Index) value in the form of a percent (%) obtained in males was 0.0875, while for females it was 0.729. The GSI value indicates that the snakehead caught from the wild was still in the developmental stage. The heavier the body weight, the maturity level of the gonads would also increase. The greater the GMS value, the greater the percentage of gonads occupying the abdominal cavity, in other words, the greater the GSI value. The results of the observation of the GI (Gonad Index) of male fish were 0.06 and 0.551 for females. It can be seen in Figure 4 below.

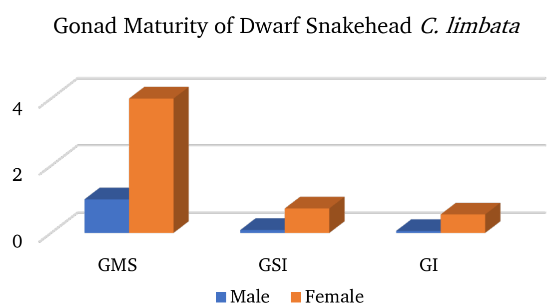


Figure 4. Gonad maturity of dwarf snakehead.

CONCLUSION

Based on the results of the study, it was concluded that the snakehead (*C. limbata*) was a demersal fish that lived in

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fresh waters and preferred environmental conditions with muddy sand and rocky gravel as their natural habitat. Its distribution was found along the Progo River, Magelang. Rounded tail shape, protocercal tail type, and ctenoid scales. The growth pattern was allometric negative. Gonad maturity level of male (wench/GMS 1) and female (second development/GMS 4). The GSI value for males was 0.0875 and for females was 0.729. The GI value for males was 0.06 and for females was 0.551. Plankton found in the stomach include *Leptocylindrus* sp., *Cylindrospermopsis* sp., *Rotaria neptunia*, *Dipleuchlanis propatula* dan *Conochilus hippocrepis*.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest among all authors upon writing and publishing the manuscript.

AUTHOR CONTRIBUTION

Each author contributes equally to this paper.

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