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Length-weight relationship and condition factor of Japanese Weather Loach (*Misgurnus anguillicaudatus*, Cantor, 1842) in selected Municipalities of Mountain Province, Philippines

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Abstract

The length-weight relationship and condition factor of fishes is a great importance in fishery assessment studies since it provides information about their growth, general wellbeing and fitness in their habitat. This study was conducted to determine the sex ratio, length-weight relationship, condition factor and size distribution of *Misgurnus anguillicaudatus* (Japanese weather loach) collected in selected municipalities of Mountain Province. A total of 308 *M. anguillicaudatus* from December 2022 to February 2023 were studied. There were 124 males and 184 females. Female loach dominated the male (1:1.48) with 5.99 level of significance. Length-weight relationships of male *M angillicaudatus* showed negative allometry ($W=1.11\ L^{2.48}$) indicating that length increases faster than weight. Female also showed negative allometry ($W=0.16\ L^{2.48}$) Combined sex showed negative allometry with value of $W=0.12\ L^{2.72}$ Combined data from the three stations revealed that females have higher K value than males with a mean K value of 0.43 in males and 0.46 in females. Size distribution analysis showed that female loaches have 7-8cm in length ranging from 8-9cm and a common weight of 4-5 grams. Meanwhile, male loaches have 7-8cm in length and 1-2 grams in weight. Tus female loaches are longer and heavier than male loaches.

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Introduction

Aquaculture is one of the fastest-growing forms of food production worldwide. It has been on steady growth due to the increasing demand for protein from the increasing population (Sexton, 2020). Global aquaculture production in 2020 reached a record of 122.6 million tons, including 87.5 million tons of aquatic animals worth USD 264.8 billion and 35.1 million tons of algae worth USD 16.5 billion. Around 54.4 million tons were farmed in inland waters and 68.1 million tons came from marine and coastal aquaculture. This leads to the contribution of aquaculture to the global production of aquatic animals which reached a record 49.2 percent in 2020 (Food and Agriculture Organization, 2022). Furthermore, National Oceanic and Atmospheric Administration (2021) stated that global aquaculture production is dominated by Asia where China accounts for the highest rating having 57.8 percent of production. The Philippines is among the top fisheries and aquaculture producers globally ranking 11th in aquaculture production in 2019 (Southeast Asian Fisheries Development Center, 2022).

According to Philippine Statistic Authority (2021), the volume of harvests from aquaculture farms during the second quarter of 2021 was 585.48 thousand metric tons while in the previous year's second quarter, 2020 registered 566.94 thousand metric tons. Additionally, the latest data from FAO (2022) stated that the total harvests from aquaculture farms reported 536.55 thousand metric tons in the first quarter of 2022, from 522.96 thousand metric tons in the same quarter of the previous year which is equivalent to 2.6 percent increase during the quarter. The aquaculture subsector constituted 55.2 percent of total fisheries production. In other words, there is a decline in aquaculture production, but it increases this year 2022 (Jewel *et al.*, 2019).

Cordillera Administrative Region (CAR), registered an aquaculture production of 2,760.0 MT with an estimated area harvested of 535.6 hectares. Aquaculture dominated the region's fisheries accounting for 75.4% of the total fish production. Ifugao Province is the aquaculture fishery carrier of the region which posted the highest production with 1,825.6 MT from an area harvested of 210.5 hectares. Abra was second with 395.4 MT with an area harvested of 150.0 hectares while Mountain Province has 12.6 MT and an area harvested of 5.5 hectares. Hence, Mountain Province is one of the contributors to aquaculture production in the Cordillera Region even though it contributed the smallest share in the fishery of the region (PSA, 2021). Mountain Province is a landlocked province of the Philippines in the Cordillera Administrative Region in Luzon. It has an area of 215, 738 hectares with 83% mountainous while 17% consist of hills and levels. It has many rivers, waterfalls, mountains, and caves (Provincial Government of Mountain Province, n.d.).

A study conducted by Lawagey (n.d.) entitled "Inventory of Fish and Shell Species with Aquaculture Potential in Mountain Province" showed that many aquatic species are existing in different water bodies of the freshwater ecosystem (lakes, ponds, rivers, creeks, and rice fields). These include crustaceans and shells such as Luso (*Melanoides spp*), Bennek/tik- am (*Mugil dussumieri*), Kumpiyas, Ket-an (*Brotia insolita*), lesdeg (*Bellamya angularis*), Sup-sup or Bessukol (*Viviparus angularis*), Ginga (*Melanoides granifera*) Udchila and Kuhol(*Pomacea canaliculata*), other aquatic life like Udang (*Macrobachium rosenbergii*), Bakbak (*Rana species*) and Gakki (*Carcinedes maenas*), as well as fish like Igat (*Anguilla rostrata*), Wading (*Pseudogobius javanicus),* Bunog (*Gobius criniger),* Gurgurami gold (*Redigobius chrysosoma*), Gurgurami black (*Oryzias luzonensis),* Ayungin (*Leiopotherapon plumbeus*), Turuchok (*Anguilla japonica*), Carpa (*Cyprinus carpio*) tilapia (*Oreochromis niloticus*) and Dojo *(Misgurnus anguillicaudatus)*. These aquatic species have long been one of the major sources of protein for the people of Mountain Province. These species were found to be wild except for tilapia and carp which were raised through aquaculture production. However, other fish species such as dojo or the Japanese Weather Loach and "Turuchok" have great potential for pond production.

Japanese Weather Loach *(Misgurnus anguillicaudatus)* is a benthic freshwater fish species belonging to the family Cobitidae that is subjected to a considerable decline in many regions across its original distribution range (Schreiber, 2017). They live in shallow rivers, paddies, and even in ditches. This species is adaptable to almost any conditions, but they prefer cold temperatures (Sharpe, 2022). The species can survive in oxygen-depleted waters, and out of the water, by gulping air and absorbing the oxygen through the hindgut. Also tolerates temperatures of 2-30°C (Gomon & Bray, 2020). The normal lifespan of a Dojo Loach is between 7 and 10 years (Yang, 2022).

Japanese weather loach is a brownish to yellowish eel-like fish with darker marbling and spots, a pale silvery underside, and usually a small dark blotch on the upper part of the tail base. The species has a cylindrical body, rounded fins, thick fleshy lips, five pairs of barbells around the mouth, and a short-based dorsal fin positioned far back on the body above the pelvic fins (Gomon & Bray, 2020). Sex identification of Japanese weather loach can be identified through their body size wherein females are generally larger and fuller than males (Sharpe, 2022). The Dojo Loach can grow to 12 inches or about 30 centimeters (Morgan, 2021).

Other names like oriental weather fish, dojo, dojo loach, weather loach, Japanese weather fish, and Amur weather fish are also used in other parts of the world (Nico, *et al.*, 2022) Accordingly, they are very active right before a thunderstorm when the barometric pressure drops. This drop in barometric pressure causes a pressure change in their swim bladder. One reason that loaches can survive in poor conditions is that they could swallow atmospheric air and pass it through the gut, extracting oxygen internally, and excess air is expelled via the anus. It is why they can be often found in muddy ponds and even intended to borrow themselves in paddies (Brand, 2014). Weather loaches are native to most places in Asia such as Australia, Canada, China, Japan, Korea, Northern Vietnam, Sakhalin Island, and Siberia. They have been introduced into locations across the world and wild populations can now be found in Germany, Italy, Kazakhstan, Spain, the U.S., Turkmenistan, Uzbekistan, and the Philippines (Sharpe, 2022).

The introduction of Japanese Weather Loach in the Philippines was during World War II by the Japanese in the Cordillera Region (Domoguen, 2019). Loaches have high tolerance in marginal habitats and extreme conditions (Nico *et al.*, 2022), and the species adapted to the weather conditions in the Cordilleran Region. Moreover, an article published by PSA, Republic of The Philippines-Philippine Statistic Office- Cordillera Administrative Region (2020) proved that CAR has an undeniably low temperature due to its high elevation. Located in the mountainous region, its geographical and geological characteristics make it very suitable for rice paddies, rivers, watersheds, and different water sources. It is a perfect place for Japanese Weather Loach to survive. Fish terracing is a kind of rice production management system where it incorporates aspects of aquaculture into other aspects of agricultural activity and tourism. This system allows a more intensive culture of fish with the inclusion of appropriate activities and management of resources to augment the required food supply of small farmers or communities and increase production (Aquino, 2008).

This type of loach was a common sight during market days in the province. Interviews with farmers reveal that “yu-yu” played a significant role in supplying nutrition for the people in the upland areas being the major source of protein; until the tremendous decline of catch in recent years (Valcobero, 2020).

The exotic fish increased in rice paddies in Cordillera, not until the Golden Snail Infestation. The application of inorganic fertilizer and changing farming practices contributed to the decline and eventual disappearance of their usual Habitat (Guisdan, 2019). In the past few years, studies about culturing loach in a controlled environment have evolved to support the restoration of Japanese Weather Loach Production in

Mountain Province. La Trinidad Regional Fish Farm (LTRFF) Located at Balili La Trinidad Fish farm has started using induced spawning for production. In addition, the Special Area for Agricultural Development Program provided financial support to aquaculture projects in Mountain Province which include loach production (Valcobero, 2020).

However, despite the improvement in cultured production, there is still not enough production to sustain the overall demand, especially since fish (Ramirez, 2014) is very popular in Japan and Korea where it can command a price as high as P6,000 per kilo and P1,500 to P1,800 per kilogram in the local market which helped the fisher folk generate income for their daily essentials (Valcobero, 2020).

The length and weight relationship are an important parameter that helps to understand the growth pattern of the fish population (Kumar & Ghoshal, 2022). According to Getso *et al.* (2018), condition factor in fisheries science is used to compare the "condition", fatness or well-being of fish that comes up with the hypothesis, heavier fish of a particular length are in better physiology condition (Getso *et al.*, 2017). Condition factor under the study by Ujjania *et al.*, (2012) cited in the study of Getso *et al.*, (2018) is a useful index to monitor the feeding intensity, age, and growth rates of fish. Length-weight relationship and relative condition factor are useful in fishery assessment studies because it provides information about the growth of fish, general wellbeing, and fitness in a marine habitat (Jisr *et al.*, 2018).

According to the study of Radhi *et al.*, (2018), the researchers stated some importance of LWR where the following are cited; Length-weight analysis is a useful analysis in estimating the average weight of fish caught from samples of lengths of fish caught (Hilborn & Walters, 2001; Adaka *et al.*, 2015). The length-weight relationship (LWR) of fish is important in fisheries and fish biology studies to provide information regarding growth patterns and the condition of fish species (Bagenal & Tesch, 1978). The study of LWRs is also important for the conservation and management of fish in aquatic systems, including freshwater systems (Lawson, 2011), which are the most plausible area of efficacious pollutant sources due to the frequency, duration, and magnitude of anthropogenic influences (Rahel, 2007; Francis, 2012).

Therefore, through assessment of the length and weight relationship and condition factor, the results of the study will provide baseline information on the distribution and general wellbeing of Japanese Weather Loach including the identification of which part is good sources of breeders for organizations conducting induce spawning. In addition to the study that was previously conducted by Reyes *et al.* (2019), regarding the length-weight relationship and condition factor of male and female Japanese Weather Loach grown in Ponds in Bauko, Mountain Province, the results of the study will serve as a guide information to the fishery students or researchers who will be conducting Loach related studies in the future. It will serve as a reference to further studies which will be helpful for the sustainable production of loach in the region.

Materials and methods

Research Design

The study utilized descriptive research design which aims to accurately and systematically describe a population, circumstance or phenomena. The effect of the independent variables (station) on the dependent variable (sex ratio, length weight, condition factor, and size distribution) was determined. It was also conducted in a natural setting and no changes were made in the environment.

Materials and Procedures

Before sampling collection and identification of sampling location, coordination with the Provincial Fisheries Office (PFO) and Local Government Unit Mountain Province Farmers and Fisher folk Association and Loach Throng (LGU MPFFaLT) and local farmers from each municipality was conducted. This is to seek suggestions, guidance, and assistance for site selection and sampling collection.

Sampling Station

Sampling stations were established in Bauko (16°59' N, 120°52' E), Bontoc (17°5' N, 120°59' E), and Tadian (17° N, 120°49' E) Mountain Province, Cordillera administrative Region, Philippines. Specific barangay and rice paddies were based on suggestions from the PFO and local farmers.

Station 1, Balew Rice Terraces is located at Bagnen Oriente, Bauko, Mountain Province. Bagnen Oriente can be found at coordinates approximately 17° 01' 09.85" North, 120° 53' 37.15" East. Elevation at these coordinates is estimated at 1,620.5 meters or 5,316.5 feet above mean sea level. It was observed that the substrate of the rice paddies where the study was conducted is loamy. Station 2, Kavat-tang rice field is located at Mainit, Bontoc, Mountain Province. Mainit can be found at approximately 17° 10'13.36" North, 120° 57'46.10" East. Elevation at these coordinates is estimated at 1,228.7 meters or 4,031.1 feet above mean sea level. It can be observed that the soil texture of the rice paddies where sampling was conducted is loamy. Station 3 is located in Abungo, Tadian Mountain Province based on coordinates, it is located at approximately 17°2'8.73" North and 120° 51' 9.68" East. The estimated terrain elevation above sea level is 1,313 meters. It was observed that the soil texture is sandy-loamy.

Sample Collection

Preparation of gears was done before proceeding to the sampling area to set up the gear (ugat). Weekly sampling collection started on the last week of December 2022 and ended on the last week of February 2023 which was in time with the field preparation up to the planting season of rice. Setting up of fifteen (15) eel weir baskets or the "ugat" in each station was done between 5:00 to 6:00 and hauled early in the morning at around 5:00 to 6:00AM. The gear was set by digging the mud about 1-foot-deep forming a V-shape. The higher the water level, the wider the area where the "ugat" was placed. Then, the tail part of the "ugat" was slightly buried on the tip of the v-shaped excavated mud, while its mouth faced downwards on the wider part of the v-shaped structure where the water accumulated. The gear was covered with dried leaves to warm the inside of the "ugat". Signage was placed to keep others from mistakenly collecting the samples. During collection, basins were prepared containing dried leaves to keep the collected samples warm and lessen stress during the whole process of collection. The tail part of the gear was twisted to collect to trapped loach. The samples were then placed in bottles with water enough to keep them from scratching and bruising each other and to keep them from being stressed throughout the journey to the school laboratory. Samples in each station were documented. Other materials like bottles used for transportation, labeled bottles, chopping board, dissecting kit and compound microscope were prepared prior to the laboratory activities.

Length (cm) and weight (g) of the collected samples in each area was measured after transporting them to the Don Mariano Marcos Memorial State University-South La Union Campus (DMMMSU-SLUC), College of Fisheries Aquaculture laboratory. Sex determination was done both through ocular observation and dissection process in the DMMMSU laboratory collecting the eggs and testicles and preserving the collected gonads in a Gilson's fluid to keep their natural quality for further analysis and future reference. Dissected samples in Station 1, Station 2, and Station 3 were documented for future reference and to keep evidence as important data.

Measurement of Samples

The total length (TL) and body weight (BW) of the fish samples were measured to the nearest 0.1 centimeter (cm) and to the nearest 0.1 gram (g) respectively. A measuring board was used to measure the fish length from the tip of the snout to the tip of the caudal fin. The weight of the samples was determined using a digital weighing scale.

Data Analysis

Sex Ratio

Sex identification was bases on ocular observation and dissecting the sample with proper documentation and was examined visually by comparing their fins. The sex ratio is given as male to female (M:F), was

calculated by dividing the total number of males over the total number of females. The Chi-Square (X^2) was used to determine the existence of differences between the sex ratio of the samples and the commonly expected 1:1 sex ratio (Oliveira, 2021). Samples with identified sexes will only be used in the analysis (Urquhat & Koetsier, 2011).

The pectoral fins of males are enlarged with a thickened second ray forming a structure known as the lamina circularis while female *M. anguillicaudatus* has a rounded pectoral fin with a smooth posterior edge.

Length-weight Relationship

The relationship between length and weight was calculated using the least square method for male and female Japanese Weather Loach separately, and combined sex was estimated using the equation of Fulton (Pauly, 1984):

where: (KF) $W=aL^b$.

W- weight of the loach sample in gram L- total length of the loach sample incm a- intercept b- slope

The parameters a and b of the length-weight relationship was estimated by the least-squares method based on logarithms.

$$\text{Log } (W) = \log a + b^* \log L$$

where the value of b is nearly between 2 and 4 and often close to 3 and when:

b = 3; fish growth is isometric (length and weight increase proportionally) b > 3; fish growth is in positively allometric (weight increases faster than length) b <3; fish growth is in negatively allometric (length increases faster than weight)

3. Condition Factor (K). Fulton's Condition Factor was used to compare the length and weight of a particular sample. The Fulton's condition factor showing the degree of the well-being of the loach sample was determined by calculating the value of K following Froese (2006): $K=100\ W/L^3$

Where,

K- Fulton condition factor

W- The weight of the loach sample in grams

L- Total length of the loach sample in cm

Regression analysis and Chi-square were used in the study to analyze the result of the length-weight relationship and sex ratio respectively. Descriptive analysis using mean, percentages, and ranges was also used.

Results and discussion

Sex Ratio

The sex ratio indicates both the proportionate survival of females and males as well as the population's future breeding potential (Sapir *et al.*, 2008). Results of this objective provide baseline information on the sex ratio of *M. anguillicaudatus* which is useful for brood stock management and enables the development of appropriate breeding scheme.

Table 1 presents the sex ratio of *M. anguillicaudatus* collected from the different stations during the study. In station 1, there are 101 female *M. anguillicaudatus* and 44 male *M. anguillicaudatus*. The computed sex ratio (1:2.30) implies that female *M. anguillicaudatus* are dominant in this station.

There are 50 female *M. anguillicaudatus* and 43 male *M. anguillicaudatus* in station 2 while the completed sex ratio (1:2.30) which is also in favor of female samples. Meanwhile, 33 females and 37 male *M. anguillicaudatus* were collected from station 3. The computed sex ratio (1:0.89) implies that male *M. anguillicaudatus* are more dominant than female *M. anguillicaudatus*. However, in terms of overall population female *M. anguillicaudatus* is dominant than that of the male with a sex ratio of 1:1.48.

Table 1. Sex ratio of *M. anguillicaudatus* from the different stations during the study period.

			Sex Ratio		
Station	Male	Female	Total	Sex Ratio (M:F)	Chi Square Value (df=2)
1	44	101	145	1:2.30	
2	43	50	93	1:1.16	5.99*
3	37	33	70	1:0.89	
Total	124	184	308	1:1.48	

*Significant at 0.05 level

Chi-square revealed that the female and male sex ratio has a significant difference at 0.05 levels with a value of 5.99*. The ideal sex ratio for a particular individual in a particular population depends on both the population's current sex composition and the respective costs and advantages of raising offspring of each gender. The quality and stability of the immediate habitat, as well as life-history features, competition, and dispersal, which affect local competition for males and resources, may have an impact on patterns of natural selection on sex ratio.

The excess production of sex that is easier to produce under unfavorable environmental conditions might result in a biased sex ratio due to environmental impacts, both temporal and spatial. Sex ratio is measured as the ratio of an individual's one's sex to the other sex. Male and female ratio that is generally the most common evolutionary stable strategy (ESS) is 1:1 which was led by frequency dependent natural selection due to the competition for mates among individuals of the same sex. Natural selection often determines the differences within the population and among the sex ratio of the species (Sapir *et al*., 2008).

A study conducted in on the comparison of age and growth performance of diploid and tetraploid loach *M. anguillicaudatus* in the Yangtze River basin by Feng *et al.* (2017), showed a result that female *M. anguillicaudatus* are dominant in both diploid and tetraploid with a computed sex ratio of 1:2.17 and 1:1.92, respectively. Another study on the growth and reproductive biology of loaches (Cobitis sp.) in Lake Lucien, Poland conducted by Kostrzewa *et al.* (2003), showed completed sex ratio of 1:1.27 in favor of female.

Length-Weight Relationship

Length-weight relationships (LWRs) are important in fishery science and fishery assessment studies since it provides information about the growth of any organisms, their general well-being, and fitness to their habitat (Jisr *et al*, 2018). In this study, the length-weight relationship of *M. anguillicaudatus* was studied to determine the correlation of the length and weight of the samples per station. The length-weight parameters presented in Tables 2 on page 15 shows the minimum and the maximum values of the length and weight of *M. anguillicaudatus* while Tables 3 on page 15 presents the a and b values of the form $W= aL^b$, pertaining to 308 *M. anguillicaudatus* species.

Male samples ranged from 6.2-11.8cm (8.22±1.12) in TL with 0.8-7.1 g (2.4614 ±1.3304) in BW in station 1, whereas in station 2, its recorded TL and BW were 6.5-11.2cm (9.27±1.21) and 1.2-6.4 g (3.39±1.23). Station 3 recorded a TL ranging from 4.4-12.5cm (6.93±2.28) and BW of 0.312 g (2.04±2.45).

Total length (TL) of the female *M. anguillicaudatus* from station 1 ranges from 3.3-15.5cm (9.37±1.57), with body weight (BW) of 1.3-17.5 g (3.71±2.35). In station 2, total length (TL) and body weight (BW) of female fall on the range of 7.7-14cm (11.10±1.47) and 2.1-11.1 g (5.95±2.41). Recorded TL and BW of female *M. anguillicaudatus* in Station 3 were 5.8-13.5cm (9.12±2.20) and 1-12 g (3.99±2.79).

Combined samples of *M. anguillicaudatus* (Table 2) in station 1 range from 3.3- 15.5cm (9.02±1.54) in TL and 0.8-17.5 g (3.33±2.17) in BW. Combined TL and BW of station 2, on the other hand, range from 6.5-14cm (10.25±1.63) and 1.2-11.1 g (4.76±2.33). Recorded combined TL of station 3 ranged from 4.4-12.5cm (7.96±2.49) with BW of 0.3- 12 g (2.96±2.77).

Table 2 presents the regression analysis on the length and weight of *M. anguillicaudatus* collected from the three sampling stations during the sampling period in the three (3) sampling stations from December 2022 to February 2023.

Table 2. Length and Weight Parameters of Combined *M. anguillicaudatus* Collected in Different Sampling Stations.

Sampling Station	Length (cm) Min-Max	Mean (SD)	Weight (g) Min-Max	Mean (SD)
1	3.3-15.50	9.02 ±1.54	0.8-17.5	3.33 ±2.17
2	6.5-14	10.25 ±1.63	1.2-11.1	4.76 ±2.33
3	4.4-12.50	7.96 ±2.49	0.3-12	2.96 ±2.77

Regression analysis revealed negative allometry (b3) in station 2. The analysis also showed variable estimates of the parameter b with 2.00 for station 1, 3.02 for station 2 and 2.82 for station 3. Results presented in Table 3 revealed that combined female *M. anguillicaudatus* in all the sampling stations which is 2.48 exhibited negatively allometric (b<3). Variable estimate of parameter *b* for the whole sampling station for males presents 2.71 for station 1, 3.00 for station 2, and 2.94 for station 3. Results showed that male *M. anguillicaudatus* exhibited negatively allometric (b<3) in all the sampling stations which is 2.84.

Table 3. Parameter Estimates of the Length-Weight Relationship of *M. anguillicaudatus*

Sex	a	b	r^2	r	N	Growth type
Male	0.11	2.84	0.91	0.95	124	Allometric -
Female	0.16	2.48	0.81	0.90	184	Allometric -
Combined	0.12	2.72	0.88	0.94	308	Allometric -

Regression analysis of combined and separate sexes revealed negatively allometric (b<3) relationship which implies that length increases faster than weight. Fish becomes slimmer with increasing length if it presents negatively allometric (b<3). On the other hand, b>3 mean that the fish becomes heavier showing a positive allometric growth and reflecting optimum condition for growth (Jisr *et al.*, 2018).

The correlation coefficient values of female, male, and combined sex revealed that the observed and calculated length and weight relationship of *M. anguillicaudatus* with the combined r values of 0.94 showed a very strong correlation. It coincides with the study of Reyes (2019), based upon the computed r, very strong association existed between the length and weight of male (r = 0.95) and female (r = 0.90) loach.

The calculated data showed some outliers. Based on the researchers' ocular observation, two outliers were identified from the combined three (3) stations where the sample has a measurement of 15.5cm in length and 17.5 g in weight indicating that the sample is at its peak sexual maturity, and a sample with 3.3cm in length and 3 g in weight, which is considered as the smallest catch.

According to Yang (2022), loaches in the wild are capable of growing to almost 12 inches (30.5cm) in length especially if it has a spacious environment and with good condition. It was also added by Nico *et al.* (2022) that loaches have a standard length of 28cm and an average length of 10-12cm. From the study cited in the study of Reyes *et al.*, (2019), it was stated that the common size for male loach ranges from 9 to 10cm and 1 to 12 for the female. In addition, Luo *et al.*, (2021), stated that female loach is considered fast-growing because it has higher levels of energy metabolism and lower steroid hormone synthesis and fatty acid degradation abilities than slow-growing loaches (males). Length-weight relationship in fish species can be affected by various factors which include the season, habitat, gonadal maturity, sex, diet, stomach fullness, health and preservation techniques, and the differences in the length ranges of the specimen caught. Factors that influence the growth of fish include the quantity of available food, the number of fish utilizing the same food source, temperature, oxygen, and other water quality factors besides the size, age, and sexual maturity of the fish (Kuriakose, 2014).

Condition Factor

The condition factor (K) reflects to physical and biological circumstances and fluctuations by the interaction among feeding conditions, parasitic infections, and physiological factors (Mokhtar *et al.*, 2015). This also indicates the changes in food reserves and therefore an indicator of the general fish condition. It is an index reflecting interactions between biotic and abiotic factors in the physiological condition of fishes (Jewel *et al.*, 2019).

The condition factors of Japanese Weather Loach in different municipalities of Mountain Province presented in Table 4 on page 18 revealed that

combined data from the three stations has a mean K value of 0.43 in males and 0.46 in females. Comparing the condition factor of males and females from different stations revealed that male samples in station 1 have a k value of 0.44; females is 0.49, station 2, male and female have the same k value of 0.41; and in station 3, they have the same k value of 0.46. Female in all station has a higher k value than male.

Table 4. Condition Factor of Collected *M. anguillicaudatus* from Three Stations.

Station	Male		Female		Combined	
	r value	K value	r value	K value	r value	K value
1	0.78	0.44	0.79	0.49	0.81	0.47
2	0.97	0.41	0.94	0.41	0.97	0.41
3	0.97	0.46	0.98	0.46	0.98	0.46
Combined	0.95	0.43	0.90	0.46	0.94	0.45

Combined male and female in station 1 have a k value of 0.47, station 2 has 0.41 and station 3 has 0.46. Comparing the three stations, station 1 ended up having the highest mean value of condition factor. This indicates that Japanese weather loach caught in the first station has a good physical condition since its condition factor mean value is nearly equivalent to 1 compared to the other 2 stations.

According to Angelescu *et al.* (1958) as cited in the study of Abdullahi *et al.*, (2017), the highest k-values are attained in this loach species when viewed from a reproductive perspective if the fish is fully matured and have higher reproductive potentiality. This indicates that female loach is naturally having a good K factor since they are always bigger in size than male. Additionally, according to study of Maguire and Mace (1993) cited in the study of Abdullahi *et al.*, (2017), from a nutritional point of view, an increase in k values indicates the accumulation of fat and sometimes gonadal development. This coincides with the observations of eggs during the dissection of the female loach samples. However, this contradicts the result of the study conducted by Reyes *et al.* (2019) wherein the condition factor of a male is slightly higher than female loach collected in fishponds. This might be caused due to environmental factors where the species were being caught. In this study, there were three stations namely Bauko, Bontoc and Tadian and each sampling station have different geographical features, samples were caught in the wild. On the other hand, the study of Reyes *et al.* (2019) focused on cultured loach species in one sampling station which is in Bauko. Kuriakose (2014) stated that the length and weight of a fish species can be affected by the season, habitat, gonadal maturity, sex, diet, stomach fullness, health and preservation techniques, and the differences in the length ranges of the specimen caught. Factors that influence the growth of fish also include the quantity of available food, the number of fish utilizing the same food source, temperature, oxygen, and other water quality factors besides the size, age, and sexual maturity of the fish (Kuriakose, 2014).

Size Distribution

A total of 308 Japanese weather loaches were caught and sampled from three different areas. Station 1 has 44 males and 101 females for a total of 145; Station 2 has 43 males and 50 females for a total of 93; and Station 3 has 37 males and 33 females for a total of 70. Based on the total catch per station, Station 1 has the most fish caught, followed by station 2 and 3 respectively. This could imply that the municipality of station 1 is more abundant with Japanese weather loach. In station 1, most caught samples have a length frequency that is between 8 and 9cm. The highest length is 15.5cm, and the lowest is 3.3cm. Data also showed that the most common weight caught in Bauko is 3-5 grams. The highest weight is 17.5 g, and the lowest is 0.8 g.

Based on the analysis of the size distribution, the length frequency of combined male and female Japanese weather loach *(Misgurnus anguillicaudatus)* samples that were most commonly

caught in Station 2 is between 10 and 11cm. The highest length was 14cm, while the lowest dropped to 6.5cm. In terms of combined loach size distribution in weight data, the majority caught are at sizes ranging from 4-5 g. The highest weight was at 11 g, and the lowest was at 1.2 g.

In station 3, the most commonly caught measurement was 5–6cm. The highest length falls at 13.5cm, and the lowest is at 4.4cm. In terms of weight frequency, the combined data showed that the samples most commonly caught were between 0 and 1 g. The highest weight is 12 g, and the lowest is of 0.3 g. According to an interview to the locals, the Loach Organization in Tadian (TAFFIA) gets their breeders in their barangay. Farmers overfish the bigger sizes and sell them leaving the smallest size in the field. Based also on the researcher's observation, some farmers do not remove the gubo/ugat after they collected their catch. Other batch of loaches that entered the "Ugat" cannot escape the gear and they eventually die.

Based on the data gathered, the result is similar to an article published on the Global Invasive Species Database (2010) showing that the common size (total length) of weather loach is around 15cm in length. Among the three sampling stations, Station 2 showed the closest length size with a mean of 10.2548, followed by Station 1, which has a total mean of 9.0221, and station 3, with a mean of 7.9629.

Combined data showed that female loaches caught at three sampling sites have a common total length ranging from 8–9cm and a common weight of 4-5 grams. The male loaches have a total length of around 7-8cm and a total weight of 1-2 grams. This result is identical to the study conducted by Reyes *et al.* (2019), which proves that female loach is longer and heavier than male loach. It was also added that 9 to 10cm is the common size for males and 11 to 12cm for females, which are grown in ponds at Bauko and are still comparable to the result of this study. According to the study of Kessel *et al.* (2013, April 27). The age at first maturity in *M. anguillicaudatus* is 1–2 years for females and 1 year for males, and in intensive culture, they reach a length of over 11cm at two years of age. This proves that most samples caught in station 2 are sexually mature and suitable for spawning. This is a good indication that it is a good source of breeders.

Conclusions and recommendations

Based on the salient findings of the study, the following conclusions were drawn. The chi-square of the sex ratio of male and female *Misgurnus anguillicaudatus* showed significant difference at 0.05 level with a value of 5.99. Hence, the sex ratio was 1:1.48 in favor of females. The male population of *M. anguillicaudatus* is enough to support the female population in terms of pairing to breed. The length-weight relationship showed negative allometry ($b<3$) and thus suggested that the length of the *M. anguillicaudatus* increases faster than the weight. The condition factor of the combined sexes in each station showed that station 1 has the highest mean value of 0.47 which is an indication that the Japanese weather loach caught in this station has a good physical condition. Station 1 is a suitable source of breeders for it has the highest k value. The size distribution showed that female loach is longer and heavier than male loach. Therefore, it can be concluded that the size range of the samples are in lined to the common sizes of loach and in normal measurement. Further study will be conducted to determine the sex ratio of loach by temporal distribution, to increase the sampling period to identify the Length-Weight Relationship of Japanese Weather Loach per month, to determine the factors affecting the conditions of male, female and between different municipalities, to assess the existence of loach in all municipalities of Mountain Province and to compare their size distribution.

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