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Pergeseran ontogenetik dalam preferensi umpan dan perilaku makan ikan invasif *Pterygoplichthys* spp.
[Ontogenetic shifts in bait preference and foraging behavior of invasive *Pterygoplichthys* spp.]

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ABSTRACT | The invasive suckermouth catfish (*Pterygoplichthys* spp.), native to South America, poses ecological threats in non-native freshwater systems. However, effective natural baits for its control remain understudied. This study evaluated the behavioral responses of three size classes (<10 cm, 25 cm, >35 cm) to two baits—*Lumbricus rubellus* (earthworm) and *Loligo* sp. (squid) and assessed bait durability via protein and fat leaching over 15 hours. Using 32 CCTV-monitored trials, significant ontogenetic differences were observed ($p < 0.05$): juveniles responded most actively (10 and 9 approaches), adults avoided earthworms but approached squid moderately (5 times), and larvae showed intermediate responses. Though earthworms induced a faster mean response time (20:19 min), it was not statistically different from squid ($p = 0.79$). Biochemical analysis revealed superior nutrient retention in *L. rubellus* (protein: 10.78%, lipid: 9.90%) compared to rapid leaching in squid. The findings suggest that *L. rubellus* is a highly effective bait for catfish due to its strong chemosensory attraction and nutrient stability, supporting size-specific baiting strategies for targeted management of this invasive species.

Key words | Invasive species, fisheries, foraging behavior

ABSTRAK | Ikan sapu-sapu invasif (*Pterygoplichthys* spp.) yang berasal dari Amerika Selatan menjadi ancaman ekologis di perairan tawar non-habitat aslinya. Namun, umpan alami yang efektif untuk pengendaliannya masih diteliti. Penelitian ini mengevaluasi respons perilaku tiga kelas ukuran (<10 cm, 25 cm, >35 cm) terhadap dua jenis umpan *Lumbricus rubellus* (cacing tanah) dan *Loligo* sp. (cumi-cumi) serta menilai daya tahan umpan melalui analisis protein dan lemak selama 15 jam. Dalam 32 uji coba yang dipantau dengan CCTV, ditemukan perbedaan signifikan secara ontogenetik ($p < 0,05$): juvenil menunjukkan respons tertinggi (10 dan 9 pendekatan), ikan dewasa menghindari cacing tanah namun merespons cumi-cumi secara moderat (5 kali), sementara larva menunjukkan respons menengah. Meskipun cacing tanah menghasilkan waktu respons rata-rata lebih cepat (20:19 menit), perbedaannya tidak signifikan secara statistik dibanding cumi-cumi ($p = 0,79$). Analisis biokimia menunjukkan *L. rubellus* memiliki retensi nutrisi yang lebih baik (protein: 10,78%; lemak: 9,90%) dibanding *Loligo* sp. yang cepat meluruh. Hasil ini menunjukkan bahwa *L. rubellus* merupakan umpan yang sangat efektif bagi sapu-sapu karena daya tarik kimianya yang kuat dan kestabilan nutrisinya, mendukung strategi umpan berbasis ukuran untuk pengendalian spesies invasif ini secara lebih efisien.

Kata kunci | Spesies invasif, perilaku mencari makan, perikanan

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PENDAHULUAN

The suckermouth catfish (*Pterygoplichthys* spp.) is a freshwater invasive species of the Loricariidae family, originating from South America's Amazon River Basin, particularly Brazil and Peru (Rao *et al*., 2017). Characterized by a dorsoventrally flattened body covered in flexible armored plates (Armbruster & Page, 2006), this species exhibits distinct meristic features including XII dorsal fin spines, I+3 anal fin rays, 16 caudal fin rays, and I+5 rays in both pectoral and pelvic fins (Rao & Sunchu, 2017). These morphological adaptations facilitate its benthic lifestyle in diverse freshwater ecosystems where it has become established outside its native range. The species' hard, overlapping scales and depressed cephalic morphology represent specialized evolutionary traits for substrate attachment and herbivorous feeding strategies in turbulent riverine environments.

Pterygoplichthys spp has a distinctive behavior that other fishes of the *Loricariidae* family do not share. The distinctive ability of this fish is to hold a solid substrate using the mouth (suction mouth), which is reinforced by the movement of pelvic fins and spines found on its body, as well pectoral fins (Hoover *et al*., 2014). It can clean algae from submerged surfaces and has excellent environmental adaptability (Hoover *et al*., 2004; Nico *et al*., 2012; Wu *et al*., 2010).

Pterygoplichthys spp food consists of *Dinoflagellata* (0,68%), *Amoebozoa* (0,28%), *Euglenophyta* (1,19%), *Cyanophyta* (3,74%), *Chlorophyta* (12,7%), dan *Bacillariophyta* (82,03%)" (Elfidasari, 2020; Tisasari *et al*., 2016), as well as invertebrates such as snails, detritus, and bottom food (Mazzoni *et al*., 2010; Pound *et al*., 2011). In general, the *Loricariidae* family feeds on a diet consisting of plant fragments, *zooplankton*, *arthropoda*, *chlorophytes*, dan *cyanobacteria* (Mazzoni *et al*., 2010; Tisasari *et al*., 2016; Manna *et al*., 2020).

These distinctive feeding habits lead to food competition among *herbivorous and omnivorous* fish (Stolbunov *et al*., 2021). Such food competition is likely to be won by *Pterygoplichthys* spp as these fish can grasp solid substrates using their mouths and have fast growth rates. *Pterygoplichthys* spp can live between 15 and 20 years and adapt quickly and well to environmental changes (Nico, 2010; Gibbs *et al*., 2013).

Efforts to reduce the impact of the development and spread of this fish in the waters include catching it using fishing gear. The process of catching *Pterygoplichthys* spp can be strengthened by adding natural bait to the fishing gear used. This natural bait serves as an amplifier to increase the effectiveness of passive fishing.

Algae are a natural food that can be used as bait for *Pterygoplichthys* spp. This type of food can also be used as a base material for making pellets for *Pterygoplichthys* spp. However, if algae that grow naturally are exploited on a large scale, this could negatively impact the sustainability of other algae-eating fish. Such impacts will be felt by *herbivorous* fish, such as tawes (*Barbonymus gonionotus*) (Pratiwi *et al*., 2021; Tugiyono *et al*., 2022).

These impacts can be avoided if appropriate, cheap, and alternative natural foods are available. However, the type of alternative natural food is not yet known. Research conducted in Tempe Lake includes study of fish feeding habits in Tempe Lake (Hatta *et al*., 2019), utilization as fish feed (Yuniar, 2023), chemical analysis of *Pterygoplichthys* spp (Hasnidar *et al*., 2021; Sumaidi *et al*., 2023), quality characteristics of shredded *Pterygoplichthys pardalis* (Kasmiati *et al*., 2023), and feeding behavior of sangkuriang catfish (*Clarias gariepinus* var. sangkuriang) towards several types of fingerlings (Widodo *et al*., 2009). Apart from that, there is also the use of natural food in farmed fish such as in climbing perch (Putra *et al*., 2016), maggots in catfish (Putra *et al*., 2022), and the use of several plants and algae as feed for fish (Baleta *et al*., 2013; Putra *et al*., 2019; Putra *et al*., 2020; Putra *et al*., 2019; Putra *et al*., 2022). Based on the information collected from previous research, no research has been found that discusses natural bait for *Pterygoplichthys* spp; therefore, this study is necessary. The objectives of this study were to describe the behavior pattern of *Pterygoplichthys* spp approaching natural bait and to determine the best type of natural bait for *Pterygoplichthys* spp.

BAHAN DAN METODE

Location and Time of Research

This study was conducted through controlled laboratory experiments at Pangkep State Polytechnic of Agriculture, with observational periods in October 2023 and April 2024 comprising 32 replicates (16 for *Lumbricus rubellus* and 16 for *Loligo* sp.). To evaluate ontogenetic behavioral responses to natural bait, 45 *Pterygoplichthys* spp. specimens were collected from Tempe Lake and categorized into three size classes (n=15 per group: 10 cm, 25 cm, and 35 cm). The experimental system featured two glass aquaria (200×60×70 cm and 150×60×70 cm) and two tarpaulin-lined acclimatization pools (300×100×100 cm), structurally reinforced with 20 wooden beams and fastened using 5 cm and 12 cm nails (1 kg each). Ecologically relevant baits (*L. rubellus* and *Loligo* sp.) were presented in standardized 20g portions, with behavioral responses quantified using a digital CCTV system (HK Vision) under controlled photoperiods. Life support systems maintained dissolved oxygen at >5 mg/L through continuous aeration, while construction tools facilitated apparatus modifications. All experimental procedures followed a completely randomized design with systematic documentation protocols to ensure replicability and ecological relevance of the observed foraging behaviors.

This study employed a laboratory-scale experimental approach, with data analyzed through both statistical and descriptive methods. The experimental protocol commenced with the preparation of acclimatization infrastructure, consisting of two glass aquariums (200 × 60 × 70 cm and 150 × 60 × 70 cm) and two tarpaulin-lined ponds (300 × 100 × 100 cm) to facilitate gradual environmental adaptation. All aquatic systems were equipped with integrated aeration and filtration systems to maintain dissolved oxygen levels >5 mg/L, pH 6.5-7.5, and water temperatures of 27-30°C, thereby simulating natural limnological conditions. The experimental design incorporated controlled acclimatization periods to minimize stress-induced behavioral artifacts, with water quality parameters monitored daily using multiparameter probes to ensure stability throughout the observation period. This standardized approach enabled precise quantification of behavioral responses while maintaining ecological validity in the experimental setting.

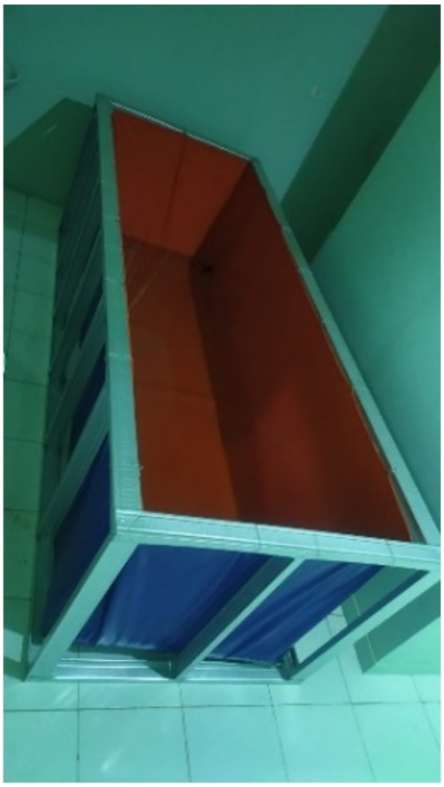


Figure 1. Tarpaulin pool for acclimatization process.

The bait preparation involved the use of natural attractants, specifically *Lumbricus rubellus* (earthworms) and *Loligo* sp. (squid). These baits were carefully placed in designated containers, with each portion standardized to approximately 20 grams to ensure consistency. Once measured, the bait containers were securely sealed to prevent premature dispersal and maintain controlled experimental conditions. This standardized approach ensured that the behavioral responses of *Pterygoplichthys* spp. could be accurately assessed under uniform bait exposure.

Protein analysis was conducted on both *Lumbricus rubellus* and *Loligo* sp. samples. *Lumbricus rubellus* was collected from natural habitats, while *Loligo* sp. was sourced from local fishermen at Paotere Port in Makassar. For the analysis, 100 grams of live *Lumbricus rubellus* were first soaked in freshwater to remove impurities. Subsequently, a subsample of 0.2–0.5 grams was weighed and transferred into a Kjeldahl flask. A catalyst mixture containing selenium was added along with 10 mL of concentrated sulfuric acid (H_2SO_4) to homogenize and initiate digestion. The mixture was then heated in a fume hood for approximately two hours until the solution turned clear, after which it was allowed to cool. Following digestion, 30 mL of distilled water and 50 mL of 40% sodium hydroxide (NaOH) were introduced to alkalize the solution. The sample was then subjected to distillation for about seven minutes or until the distillate volume reached 75 mL. Finally, the liberated ammonia was quantified via titration using a standardized 0.1 M hydrochloric acid (HCl) or sulfuric acid (H_2SO_4) solution to determine the crude protein content. This method ensured accurate and reproducible protein measurements for comparative analysis.

The fat analysis was conducted using a Soxhlet extraction method. First, the fat flask was dried in an oven at 105°C for 30 minutes, cooled in a desiccator for 15 minutes, and then weighed (A). A 5 g (S) sample was weighed, wrapped in filter paper, and placed inside a fat sleeve, which was then covered with fat-free cotton to prevent sample loss. The sleeve was inserted into the extractor chamber of a Soxhlet apparatus, and the system was doused with a fat solvent (hexanes) before being assembled for distillation. The prepared fat flask was attached to the distillation apparatus and heated at approximately 80°C using an electric heater. Reflux was carried out for a minimum of 5 hours, continuing until the solvent returning to the flask appeared clear, indicating complete lipid extraction. The solvent was then distilled off, and the flask containing the extracted fat was dried in an oven at 105°C for 60 minutes or until a constant weight was achieved. Finally, the flask was cooled in a desiccator for 20–30 minutes and reweighed (B) to determine the fat content through gravimetric analysis. This standardized procedure ensured accurate and reproducible quantification of lipid content in the samples.

The transportation and experimental preparation of *Pterygoplichthys* spp. samples involved a structured protocol to ensure sample viability and behavioral accuracy. A total of 45 fish were randomly collected from Tempe Lake, stratified into three size classes (15 individuals each <10 cm, 25 cm, and 35 cm), and transported to the laboratory in Pangkep by vehicle. Upon arrival, specimens were transferred to tarpaulin acclimatization ponds, where they were maintained at 27–30°C and fed a diet of moss, food waste, and species-specific pellets twice daily (04:00 and 20:00 WITA) to promote physiological stability (Elfidasari *et al*., 2020; FishBase, 2024; Santika *et al*., 2022). Following a 6-day acclimatization period (Arianto *et al*., 2018), six fish—comprising two larvae (<10 cm), two juveniles (25 cm), and two adults (35 cm)—were selected based on established ontogenetic size thresholds (Santika *et al*., 2022) and transferred to a 150 cm × 60 cm × 70 cm observation aquarium. To standardize hunger-driven responses, fish were fasted for 24 hours for gut clearance (Akbar *et al*., 2020). Behavioral trials were conducted at 23:00 WITA to align with their nocturnal activity patterns (Nico, 2010). A 20 g portion of natural bait, secured in a mesh bag, was suspended 20 cm from each aquarium side. After a 10–15 minute equilibration period following bait introduction, the approach behavior of *Pterygoplichthys* spp. was recorded for one hour, with movement trajectories and latency metrics documented. Water, bait, and test subjects were replaced between experimental replicates to mitigate residual effects. This protocol ensured controlled assessment of chemosensory-driven foraging behavior across ontogenetic stages.

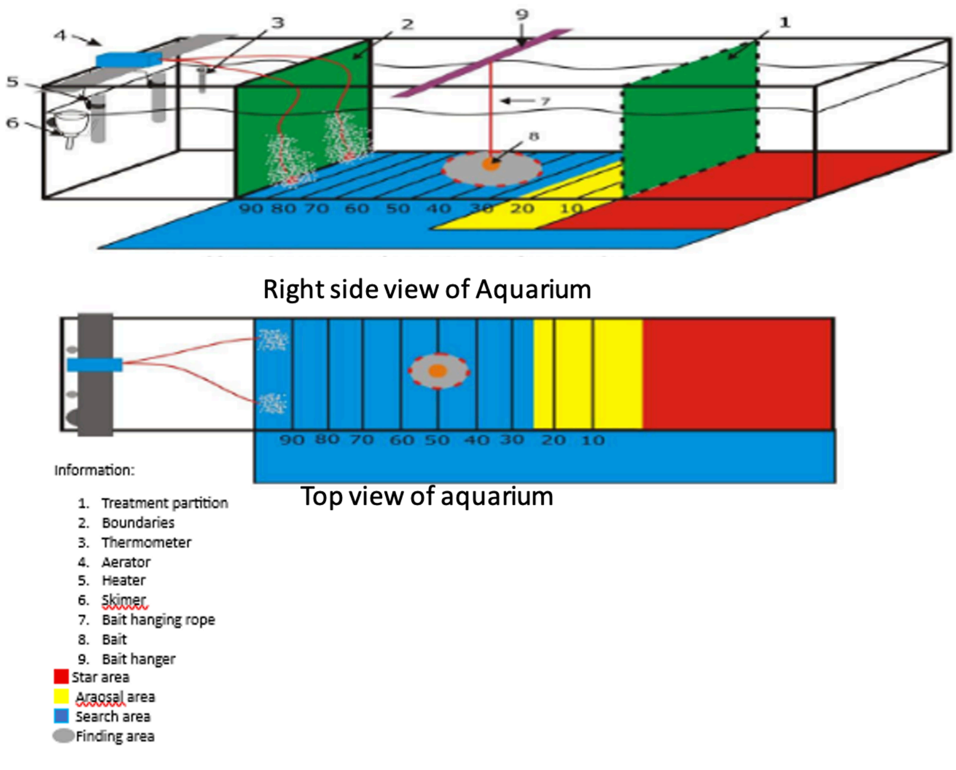


Figure 2. Experimental containers design (Riyanto, 2020).

Data Analysis

The results of the observations were tabulated according to the study's objectives the frequency of *Pterygoplichthys* spp. Approaching the bait was analyzed using crosstabulation, and then further analysis was performed using the *Chi-square* test to assess the relationship between the two parameters. The relationship between the size of *Pterygoplichthys* spp and the response time of approaching natural bait was analyzed using Analysis of Variance (ANOVA) and the correlation of the duration of *Pterygoplichthys* spp. Response time to the presence of two natural baits was analyzed using a t-test. Analysis of the protein and fat content of the natural baits was performed using the AOAC (2005) formula as follows.

Protein level=(HCL volume 0,01 N (V1)-HCL volume 0,01(V2)x Normality HCL(N)x 0,014 x Convertion factor (6,25)(fk)x Diluent factor(fp))/W x 100%

Where; W: Sample weigth (g), V1 : HCL volume 0,01 N, V2 : HCL volume 0,01, N NHCL: Normality HCL, Fk : Convertion factor (6,25), Fp : Diluent factor

Analysis of fat content of bait using the following formula; Fat faktor= W1/W x 100%

HASIL

The study revealed size-dependent variations in *Pterygoplichthys* spp.'s foraging response to natural baits (Figure 3). Juvenile specimens (25 cm) exhibited the highest attraction frequency, approaching *Lumbricus rubellus* 10 times and *Loligo* sp. 9 times. Larval-stage individuals (<10 cm) showed intermediate activity with 6 approaches to *L. rubellus* and only 2 to *Loligo* sp., while adults (>35 cm) displayed complete avoidance of earthworm bait (0 approaches) and moderate interest in squid (5 approaches). These behavioral patterns demonstrate an ontogenetic shift in feeding preferences, with peak bait responsiveness occurring during the juvenile growth phase when metabolic demands are highest for both somatic growth and reproductive development. The complete absence of adult approaches toward *L. rubellus* suggests either dietary specialization or reduced chemosensory sensitivity to annelid-derived stimuli in mature specimens.

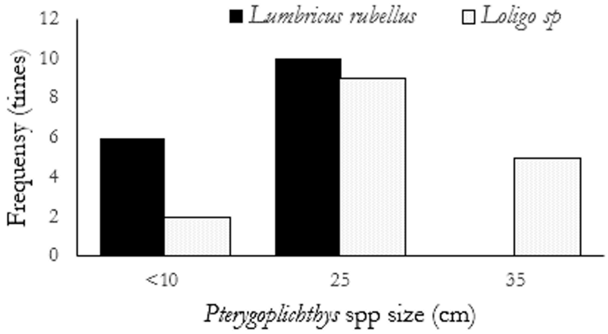


Figure 3. Frequency *Pterygoplicbtbys* spp Approaches Natural Bait.

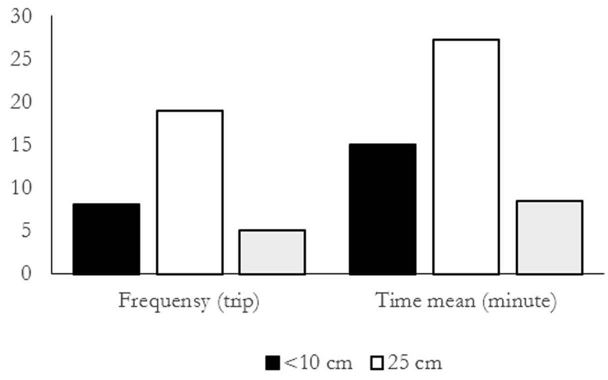
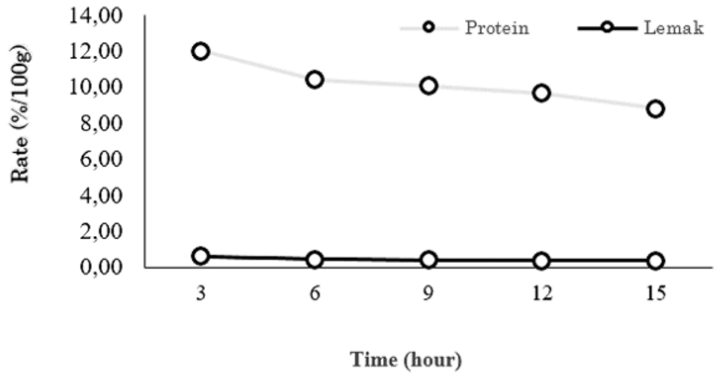
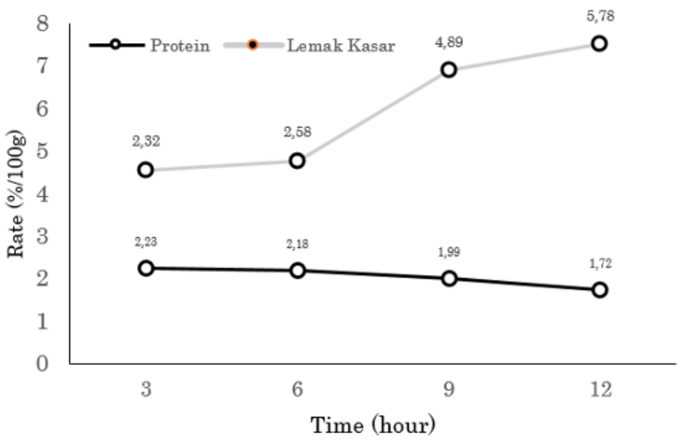


Figure 4. Total Frequency (trip) of Pterygoplicbtbys Near Natural Baits Andaverage Response Time (Minutes) of Fish Approaching Natural Bait.

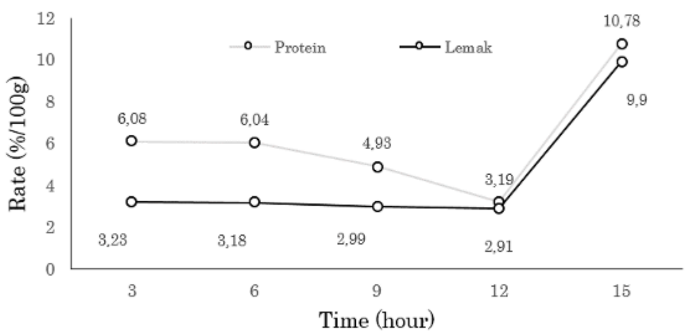
Statistical analysis using Pearson's Chi-square test (32 replicates: 16 *Lumbricus rubellus*, 16 *Loligo* sp.) revealed a significant ontogenetic influence on bait attraction ($\chi^2 = 0.029$, $p < 0.05$), leading to rejection of the null hypothesis (H_0) and acceptance of the alternative (H_1) that *Pterygoplichthys* spp. body size affects foraging frequency. Larval specimens (<10 cm) demonstrated the fastest chemosensory response (mean = 15 minutes), while juveniles (25 cm) showed delayed but more frequent approaches (mean = 27 minutes 13 seconds). Adults (>35 cm) exhibited selective behavior, responding only to squid bait (mean = 18 minutes 24 seconds), yielding an overall mean approach time of 23 minutes 18 seconds across size classes (Figure 4). These temporal patterns suggest an inverse relationship between body size and foraging urgency, potentially reflecting developmental shifts in metabolic demand, with larvae prioritizing rapid energy acquisition and adults displaying more deliberate, prey-specific hunting strategies. The statistically confirmed size-dependent behavioral differences underscore the importance of ontogenetic considerations in bait-based management strategies for this invasive species.



(a)



(b)



(c)

Figure 5. Changes in protein and fat content in *Loligo* during 15 hour soaking (a), decrease in protein and fat content in *Lumbricus rubellus* alive upon freshwater immersion for 15 h (b), and decrease in protein and increase in fat in *Lumbricus rubellus* died after 15 h of freshwater immersion (c).

Statistical analysis of *Pterygoplichthys* spp. foraging behavior revealed distinct patterns in response to natural baits. ANOVA results (p=0.2 > α=0.05) indicated no significant correlation between fish size and mean response time to bait presence, suggesting ontogenetic stage does not systematically influence detection latency. However, bait-type comparisons showed differential responsiveness, with faster mean approach times for *Lumbricus rubellus* (20 minutes 19 seconds) compared to *Loligo* sp. (25 minutes 15 seconds). An Independent Samples t-test confirmed this variation was not statistically significant (F=0.72, p=0.79), indicating equivalent overall attractiveness despite temporal differences in response. Parallel biochemical monitoring (Figure 5) documented progressive nutrient leaching patterns during 15-hour freshwater immersion, with *L. rubellus* demonstrating greater protein and fat retention (initial 10.78% protein, 9.90% fat) compared to *Loligo* sp., potentially explaining its slightly enhanced chemosensory profile. These collective findings suggest that while bait composition affects nominal response times, the biological significance of these differences may be marginal for practical fishing applications, as neither size class nor bait type produced statistically distinct approach latencies under experimental conditions.

PEMBAHASAN

Statistical analysis revealed a significant correlation between *Pterygoplichthys* spp. body size and bait approach frequency ($p<0.05$), demonstrating the potential for natural baits to enhance capture efficiency in targeted fishing operations. Juvenile specimens (25 cm) exhibited the strongest behavioral response, approaching *Lumbricus rubellus* and *Loligo* sp. baits <10 and 9 times respectively, followed by larval-stage individuals (<10 cm) with 6 and 2 approaches. In contrast, adult fish (>35 cm) showed minimal attraction to *L. rubellus* (near-zero approaches) and moderate response to *Loligo* sp. (5 approaches). These findings support the strategic use of size-specific natural baits as catch boosters in fishing gear, corroborating previous studies (Fitri *et al*., 2010; Zulkarnain *et al*., 2011; Puspito *et al*., 2020; Rahawarin *et al*., 2022) that documented increased capture rates with bait supplementation. The ontogenetic variation in feeding behavior suggests optimal bait deployment should prioritize juvenile-sized specimens, which demonstrated the highest foraging motivation under experimental conditions.

The study revealed that *Pterygoplichthys* spp. exhibited peak bait attraction during their juvenile stage (25 cm total length), likely due to heightened nutritional demands associated with rapid somatic growth and initial gonad maturation (Pinem et al., 2016; Wei et al., 2017). This ontogenetic pattern aligns with the increased protein requirements characteristic of developing fish (Nugraha, 2020) and corresponds to findings by Dewi *et al*. (2020), who reported maximum foraging activity in medium-sized *P. multiradiatus* (248-318 mm), followed by smaller (177-247 mm) and larger (319-389 mm) individuals. The observed size-specific feeding intensity suggests that juvenile *Pterygoplichthys* optimize resource acquisition during critical life history stages when metabolic demands are greatest for both growth and reproductive development, while mature individuals may exhibit more selective feeding behaviors or reduced metabolic requirements.

The study revealed significant ontogenetic differences in behavioral responses *of Pterygoplichthys spp.* to natural baits, with distinct mean approach times across size classes. Larval specimens (<10 cm) demonstrated the fastest response (mean = 15 minutes), reflecting their characteristically active benthic movement patterns, as documented in unpublished laboratory observations. Juvenile fish (25 cm) exhibited intermediate latency (mean = 27 minutes 21 seconds), while adults (>35 cm) showed response only to squid bait (mean = 18 minutes 24 seconds). This size-dependent activity gradient mirrors the locomotor patterns observed in other benthic species like snapper, where juveniles display greater mobility than adults (Hidayat *et al*., 2022). Statistical analysis ($p=0.2 > \alpha=0.05$) confirmed no significant correlation between approach duration and body size, suggesting that while response times vary developmentally, these differences do not follow a linear size-dependent relationship. The observed behavioral patterns likely reflect complex interactions between metabolic demands, foraging strategies, and life history stages in this invasive loricariid species.

Pterygoplichthys spp showed a time response to two different natural baits. It responded faster to *Lumbricus rubellus*, at 20 minutes 31 second, compared to *Loligo* sp., with a response time of 25 minutes 25 second. This fish was 4 minutes 27 second quicker to approach *Lumbricus rubellus* bait than *Loligo* sp. because *Lumbricus rubellus* has a high nutritional content consisting of protein and fat, especially its high protein content (64-76%) and higher than other protein sources, including mammals and fish. In addition, *Lumbricus rubellus* has the highest amino acid content, consisting of alanine, glycine, proline, tyrosine, phenylalanine, lysine, histidine, tryptophan, and valine. Baits containing fat, protein, chitin, and pungent odor are excellent attractors to lure lobsters (Fielder, 1965; Phillips *et al*., 1980; Moosa and Aswandy, 1984).

Based on the analysis of protein and fat content (%) in 100 g of *Lumbricus rubellus* and *Loligo* sp during 15 hour of immersion in freshwater (Figure 5). There were changes in protein and fat levels in *Lumbricus rubellus* from alive to dead: *Lumbricus rubellus* had fat and protein levels reduced per three hours of freshwater immersion. In the first three hours, the protein and fat contents were 6.08% and 3.23%, respectively; in the second three hours, the protein and fat contents. Were 6.04% and 3.18%, respectively. At the 12th hour, the protein and fat contents were 3.19% and 2.91 %, respectively at the 15th hour (beginning of death), there was an increase in protein and fat release, which was 10.78% (protein) and 9.90% (fat).

Biochemical analysis revealed dynamic changes in the nutritional composition of *Lumbricus rubellus* during 15 hours of freshwater immersion (Figure 5). The bait exhibited a progressive decline in protein (6.08% to 3.19%) and fat content (3.23% to 2.91%) during the initial 12 hours of submersion, with consistent 3-hour interval reductions. Notably, a significant biochemical shift occurred at the 15-hour mark (onset of mortality), characterized by a substantial release of nutrients - protein content surged to 10.78% (Δ+7.59%) while fat concentration increased to 9.90% (Δ+6.99%). This terminal release phase suggests cellular autolysis and membrane degradation processes, potentially enhancing the bait's chemosensory attractiveness to benthic feeders. The differential leaching rates between protein and fat fractions during the immersion period (3.89% vs 0.32% cumulative loss respectively prior to death) indicate selective preservation of lipid components during the initial 12 hours, followed by synchronized nutrient liberation upon organismal death.

The post-mortem biochemical analysis of *Lumbricus rubellus* revealed significant temporal changes in nutritional composition during freshwater immersion. Initial protein (10.78%) and fat (9.90%) levels underwent progressive degradation, declining to 2.23% and 2.32% respectively after three hours, with further reduction to 1.57% (protein) and 6.62% (fat) by the 15th hour. Comparative analysis demonstrated that *Loligo* sp. exhibited faster nutrient leaching rates, indicating *L. rubellus* possesses superior biochemical stability in aquatic environments. These findings align with previous research by Zulkarnain *et al*. (2011), who reported *L. rubellus* maintained 67.3% of initial protein content after 12 hours seawater immersion (18.45% to

12.41%), while fish bait showed 48.2% greater protein loss (11.67% to 5.63%) over the same duration. The differential degradation kinetics between taxa suggest *L. rubellus* possesses structural or compositional adaptations that enhance nutrient retention, making it a more durable biological attractant for extended fishing operations. This durability profile supports its utility as a preferred bait source in both freshwater and marine applications.

KESIMPULAN

This study reveals that foraging behavior in *Pterygoplichthys spp.* varies ontogenetically. Juveniles showed the highest attraction to *Lumbricus rubellus* and *Loligo sp.*, while adults only responded to squid. Body size significantly influenced bait attraction frequency ($p < 0.05$), though not response time. *L. rubellus* retained nutrients better, possibly enhancing chemosensory appeal. Findings suggest juvenile-targeted baiting may be most effective for controlling this invasive species, highlighting the role of developmental stage, nutrient dynamics, and behavior.

Ucapan Terima Kasih

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