Traditional fishing gear for sarasin's goby (*Mugilogobius sarasinorum*), endemic to lake Poso, Sulawesi, Indonesia

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Abstract. Lake Poso is one of the world's ancient lakes and is home to several endemic fish. One of these is the Sarasin's goby *Mugilogobius sarasinorum*, local name *bungu masiwu*. For a long time, the community around Lake Poso, predominantly of the Pamona ethnic group, have used a traditional fishing gear called *inanco*. The objective of this study was to describe *inanco* fishing gear and evaluate the catch composition. The research location in Bo'e Village River (inlet Lake Poso). Research was conducted in March-June 2020. The result showed *inanco* is made from *Arenga pinnata* leaves, with 20 leaves used for each unit. The *inanco* is weighted with stones so the leaves won't drift away. The fish will hide between the leaves in the *inanco* structure, and can be harvested on the following day. The *inanco* is highly selective with minimal environmental impact and has potential as a conservation and sustainable fishing gear.

1 Introduction

Ancient lakes are evolutionary "hotspots" for ichthyofauna, as limited founder populations millions of years ago have since adjusted to changing habitat conditions and ecological niches [1]. In Southeast Asia four lakes or lake systems are considered as ancient lakes: Lake Inlé in Burma, Lake Lanao in Mindanao, Philippines, and Lake Poso and the Malili lakes on Sulawesi, Indonesia [2]. Lake Poso, a freshwater tectonic lake formed around 2 million years ago, is famous as one of the ancient lakes in Indonesia; it has an area of 323 km^2 and a maximum depth of around 450 m [3,4,5]. Geological, geographical and ecological isolation have caused the evolution of unique aquatic biota in Lake Poso [4]. The endemic fauna include several endemic fish species including *Adrianichthys kruyti*, *A. oophorus*, *A. poptae* *A. roseni*, *Mugilogobius amadi*, *M. sarasinorum*, *Nomorhamphus celebensis*, *Oryzias nebulosus*, *O. nigrimas*, and *O. orthognathus* [6-12].

In recent decades, the abundance of endemic fish populations has declined, due to similar threats to those faced by fish in many other lakes such as eutrophication, intensive fishing,

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invasive non-native species, and pollution [12,13]. One of the endemic fish affected was *A. roseni*; this fish was collected in September 1978, but until now there have been no further reports [7-9,12]. In addition, the status of Sarasin's goby *M. sarasinorum* in the International Union for Conservation of Nature (IUCN) Red List was changed from Vulnerable to Endangered in 2019 [8,9,14]. This goby is known to be traded as ornamental fish [13, 15], although the impacts of this trade have not been quantified [14,15]. The Sarasin's goby is also known as the Black Toraja goby in the ornamental fish trade, and in the area surrounding it's native (endemic) habitat (Lake Poso) it is known and sold on local markets as *bungu masiwu*. This fish exhibits sexual dimorphism, similar to other species in this genus [16]; adult male *M. sarasinorum* in breeding condition appear very dark brown to jet black, while the fuller-bodied females are paler and retain a brownish coloration with some mottling. *M. sarasinorum* is a medium-sized benthic fish typically found in rocky and sandy areas; it tends to be active in shallow areas at night but is rarely seen during the day [9, 16].

In 2013 Lake Poso was assessed as Key Biodiversity Area (KBA) by Burung Indonesia [14] and Participatory Conservation Planning (PCP) has been carried out in 4 villages (Meko, Salukaia, Owini, and Uranosari) since 2017 [17]. Clearly the conservation of endemic fish in Lake Poso is important, including through addressing identified threats such as pollution and the introduction of non-native (alien) invasive species [12]. Conservation actions have been implemented in the area, including raising public awareness and reducing the use of chemical herbicides and pesticides in the surrounding watershed [14]. With regards to fishing intensity and sustainability, the Pamona ethnic community has been using traditional wisdom which can be considered as a conservation effort since the earliest times, using a traditional fishing trap known as *inanco* or *nanco* [17]. The Pamona ethnic group is one of the indigenous peoples in the Poso area, and they are known to have a lot of local wisdom [18]. The use of this fishing trap, specifically used for catching Sarasin's goby, has been considered environmentally friendly [17]. The objective of this study was to describe *inanco* fishing gear and evaluate the catch composition.

2 Materials and methods

2.1 Study site and sample collection

This study was conducted in Bo'e Village River (inlet Lake Poso), Central Sulawesi Province, Indonesia in March-June 2020. The site coordinates were -2º2'45.561''N and 120º42'36.094''E. Sampling was carried out several times over one day. In this study we used eight *inanco* fish traps, placed separately at a distance from one another. Each *inanco* was placed close to the edge of a Lake Poso river inlet at a depth of approximately 33 cm.

Ecological parameters measured at each *inanco* experimental fishing site were temperature, pH, substrate, clarity, and the presence of aquatic plants. All fish caught from each *inanco* were collected. The fish samples obtained from each catch were separated by species and the specimens were then preserved in a 1000 mL sample bottle containing 70% alcohol, labeled with the name of the fish species, station, date of collection, collector's name, and other information required [9]. The samples were then taken to the laboratory for further analysis.

2.3 Data analysis

Fishing gear is described based on how it is used and the dimensions of the fishing gear. Selectivity evaluation is carried out based on the number of target fish caught. All fish caught were identified using standard taxonomic keys [16, 19]. The sex of each Sarasin's goby specimen was noted, as male and female fish can be distinguished based on their morphology

(Figure 1). Specimens were analyzed at the Animal Biosystematics and Evolution Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Tadulako University, Palu, Indonesia.

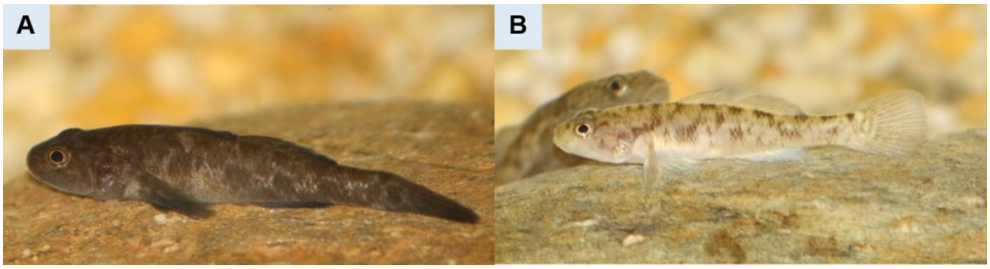

Fig. 1. Live color of *Mugilogobius sarasinorum* male (A) and female (B).

3 Results and discussion

3.1 Background and description of *inanco* fishing method

The Pamona ethnic is an indigenous ethnic group living in the areas around Lake Poso [18]. They have developed and retained a varied body of local wisdom, including the use of local plants in traditional medicines [20]. In addition, this ethnic group is famous for the traditional ceremony known as "Padungku". Padungku is a harvest ceremony as a thanksgiving to God in the area [17,21]. To prepare for the ceremony, the community usually process their rice harvest, and also catch fish using traditional fishing gears such as *inanco*. *Inanco* is traditionally used to catch the gobies *Mugilogobius amadi* and *M. sarasinorum*. These fish are caught as a popular food fish during the wet season, comprising the transition and east monsoon (March to August), but not during the dry season because the rivers dry out then. However, based on Bandjolu et al., research [9], there is currently only *M. sarasinorum* because *M. amadi* has not been caught since 1987 in Lake Poso.

The Pamona ethnic community generally install the *inanco* fish traps in the afternoon and then collect the catch on the next day. Although in general fish are collected every morning and afternoon, the best catches are most often in the morning, considering that *M. sarasinorum* is mostly active at night. The *inanco* are typically placed in unshaded areas where the sunlight can penetrate the riverbed to a depth of 3-5 meters, as previously reported by [17]. Each *inanco* is made from sugar palm (*Arenga pinnata*) leaves which are placed horizontally with the ribs aligned in the direction of the flow of water in the slow-flowing part of the river. One *inanco* unit was made from 20 sugar palm leaves, which were cut into several parts. The middle part of the leaves were bundled and bound using strips of the rotan cane *Calamus minahassae* (Indonesian names rotan tikus or rotan patani). Each *inanco* unit measures less than one meter in width and has a cross-section of approximately 20 cm × 20 cm (Figure 2).

Fig. 2. *Inanco* made with palm leaves (*Arenga pinnata*).

The *inanco* are ballasted with round stones, so that they will not be washed away. The fish are then attracted to the trap, and come to hide in the leaves as a shelter. Fishermen will harvest fish for household consumption by inserting a fishnet at the bottom end of the *inanco*, so that when the ballast is removed, the fishnet can be moved towards the top end as the *inanco* rises up. The fish hiding in the *inanco* will then enter completely into the net. In effect, the *inanco* functions similarly to the bamboo fish traps called *bubu*. It has been proposed that the *inanco* can be used as a model of modern environmentally friendly fishing gear that can be adopted for conservation purposes through the development of local wisdom [17].

3.2 Ecological parameters and catch composition

The water quality parameters measured at the study site were pH 8.3 and temperature 26ºC. Visibility could not be measured because it exceeded the water depth due to the high water clarity at the sampling locations. The waters tend to be clear and transparent, most likely due to the generally oligotrophic conditions [12] and because turbidity does not last long in the streams flowing into the lake [9,19]. The substrate at the study site was dominated by coarse sand, pebbles, and rounded stones, and aquatic plants were absent.

The *inanco* catches comprised four species with a total volume of 510 individuals (Table 1). The target species, *M. sarasinorum*, comprised nearly 95% of the catch with 483 individuals, demonstrating the high selectivity of the *inanco* fishing gear. The other fish caught included a small proportion of one other endemic species, the endangered *anasa* (vernacular name) *N. celebensis* (1.37%). A few individuals from two introduced species were also caught: *kepala timah* (vernacular name) *Aplocheilus panchax* (1.76%) and or *nilem* (vernacular name) *Osteochilus vittatus* (2.16%). Both introduced species are of low-value locally. Furthermore, *O. vittatus* is considered invasive [12], such as in Lake Talaga, Lake Rano, and Lake Lindu, Central Sulawesi [8].

Table 1. Fish caught using *inanco* in Bo'e Village River, Lake Poso

Species	Family	n	Common name	IUCN Red List status	Human uses
Aplocheilus panchax	Aplocheilidae	9	Blue Panchax	Least concern	OF
Nomorhamphus celebensis	Zenarchopteridae	7	Poso Halfbeak	Data deficient	OF
*Mugilogobius sarasinorum**	Gobiidae	483	Sarasin's Goby	Endangered	OF & FF
Osteochilus vittatus	Cyprinidae	11	Bonylip barb	Least concern	FF

*: target species, OF: ornamental fish, FF: food fish

The total catch of 483 *M. sarasinorum* in this study comprised 140 males and 343 females. More males than females were caught in each *inanco*. The number of males is 6.83-14.49%, while the number of females is 2.48-5.59% (Figure 3).

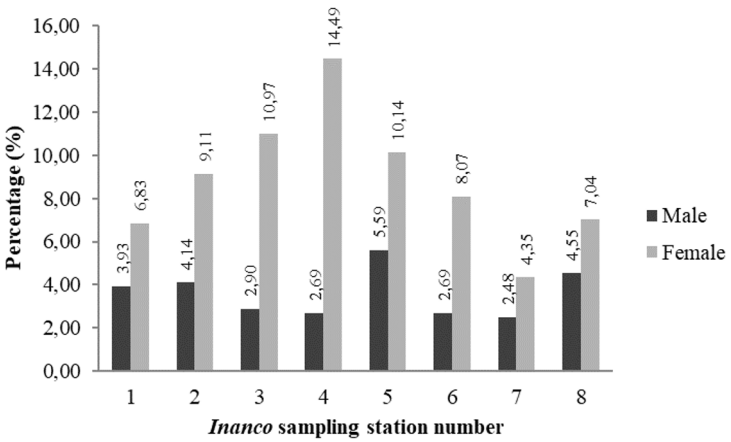

Fig. 3. Percentage of male and female *M. sarasinorum* caught using *inanco* fishing gear.

According to [16], *M. sarasinorum* can mostly be found in open areas on mud and gravel substrates with some aquatic plants, but also on steep gravel slopes and among large limestone rocks. In this study we only found *inanco* being used in Bo'e Village. According to [17], this gear is also used in the rivers of Meko and Salukaia villages, but the coordinates were not provided. Based on a gut content study, the feeding habit of *M. sarasinorum* is predominantly carnivorous with prey dominated by small fish and insect larvae [16].

The *inanco* fishing gear is highly selective, which means that it is unlikely to be a threat to the non-target fish in Lake Poso. This is important for the conservation of the other native fish living in the lake, especially the other endemic species in IUCN Red List at risk categories, several of which tend to be caught in other fisheries [12]. With respect to the introduced species, especially those considered invasive, it is unlikely that *inanco* can contribute to the control of these alien fish populations. With respect to the target species, *M. sarasinorum* is itself considered endangered [14], raising the question as to whether this fish should be targeted for human consumption or indeed for the aquarium trade.

In this respect, the *inanco* can be considered as a potentially sustainable approach to the exploitation of *M. sarasinorum* for several reasons. Firstly, the *inanco* gear used readily available, renewable and non-polluting materials and does not damage the habitat. Secondly, the fish are caught alive and in good condition, thereby potentially allowing further selectivity such as the release of juveniles or fish in breeding condition. Furthermore, in addition to using *inanco* traps as an ephemeral structure to harvest *M. sarasinorum* with minimal adverse side-effects, the *inanco* itself can also be used to help maintain *M. sarasinorum* and other fish populations. As explained by [17], *inanco* structures can be placed to provide protective habitat, resulting in increased *M. sarasinorum* abundance.

4 Conclusion

The *inanco* is a traditional fishing gear for Sarasin's goby *Mugilogobius sarasinorum* (local name *bungu masiwu*), made from sugar palm (*Arenga pinnata*) leaves. One *inanco* unit is made from 20 palm leaves and weighted with stones. The fish taking refuge in the *inanco* can be readily harvested. The gear was highly selective (≈ 95% target species), and the *M. sarasinorum* was male-dominated. The *inanco* shows promise for a sustainable *M. sarasinorum* fishery and, with some modification, for supporting conservation of this endangered species in Poso Lake.

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