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Short Communication: Invasive mollusks *Melanoides tuberculata*, and *Achatina fulica* in Southeast Sulawesi, Indonesia

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Abstract. *Purnama MF, Salwiyah. 2022. Short Communication: Invasive mollusks* Melanoides tuberculata, *and* Achatina fulica *in Southeast Sulawesi, Indonesia. Biodiversitas 23: 4770-4774.* Southeast Sulawesi Province has natural/artificial inland waters for various usages. For example, freshwater has supported various activities such as agriculture, plantations, inland fisheries, and ecotourism. This study reports the presence of invasive mollusk in freshwater (*Melanoides tuberculata*) and terrestrial (*Achatina fulica*) habitats. This study is the first report regarding the spatial distribution of the three invasive mollusk species in the inland waters of Southeast Sulawesi, Indonesia. All administrative areas (17 districts/cities) in Southeast Sulawesi province were invaded by *A. fulica* and 16 districts/cities by *M. tuberculata*. These invasive mollusks species are a severe threat to the preservation of native species and human health because they are an intermediate host for several types of parasites, such as the trematode group. The spreading and rapid development of these invasive mollusks is caused by their reproductive ability and resistance to poor environmental quality and airborne dispersal factors by birds, water flow, and commercial activities. This invasive species can directly cause huge economic losses as they become a pest in agricultural activities, plantations, and freshwater fisheries (aquaculture). They also can transmit pathogens and displacement of native species. Therefore, it is recommended to have a preventive effort to tackle the expansion of IAS in Southeast Sulawesi.

Keywords: Freshwater species, gastropods, spatial distribution, terrestrial mollusks

INTRODUCTION

The presence of invasive alien species (IAS) in the freshwater and terrestrial habitat of Southeast Sulawesi Province has become one of the leading causes that can shift and get rid of indigenous or native water species. The presence of IAS has invaded the freshwater waters of Southeast Sulawesi (Purnama et al. 2020, 2021; Sirza et al. 2020; Oetama and Purnama 2022; Purnama et al. 2022a, 2022b; Salwiyah et al. 2022), including other areas in Indonesia (Afkar and Aldyza 2017; Assuyuti et al. 2017; Purbasari 2017; Syaifudin et al. 2017; Rustiasih et al. 2018; Viza 2018; Safa'ah and Primiani 2018; Athifah et al. 2019) and it has been a global concern hitting several major countries in the world.

The invasive species can cause a systemic impact on the ecology, economy, and human health of its affected area (Mooney and Cleland 2001; Stohlgren and Schnase 2006). Ecologically, the IAS can cause the loss and migration of native species as they can dominate an aquatic environment, causing damage to that environment. In addition, they are predatory competitors and can hybridize with native species generating their genetic characteristics. Also, these invasive species are disturbingly persistent due to their high adaptability to environmental conditions, consuming anything, and faster growth (FQIA 2017). Economically, invasive exotic/foreign species can cause major losses, such as agriculture, plantations, fisheries, and other commercial activities (Lovell et al. 2006). In addition, the invasive species are intermediate hosts for several trematodes parasites, making them very dangerous to human health (Żbikowska and Nowak 2009; McKoy et al. 2011; Chuboon et al. 2013; Veeravechsukij et al. 2018; Lopes et al. 2021; Nguyen et al. 2021).

There are several regulations to control non-indigenous species and mitigate their risks. According to the list of invasive mollusks mentioned in the policy of the head of FQIA (2017), the presence of alien species in Indonesia is generally due to the import activities to increase production and control the weeds and species stocking. Also, it is because of the trade activities of ornamental species intentionally disposed into the waters. Moreover, this introduction also encompasses research activities, for example, the exchange of genetic material, biological specimens, microbial culture collections and laboratory equipment. Several invasive mollusk species have been identified, such as *Melanoides tuberculata* (Purnama et al. 2019, 2022a, 2022b; Barros et al. 2020; Khanam et al. 2020; Lopes et al. 2020; Okumura and Rocha 2020; Alfaro et al. 2021; Lopes et al. 2021; McClure 2021), and *Achatina fulica* (Gregoric et al. 2011; Purnama et al. 2019; Barbosa et al. 2020; Oliveira et al. 2020; Song et al. 2020; Cano-Pérez et al. 2021; Dumidae et al. 2021) Their biological properties are highly resistant to water quality change, making them quickly colonize new environments. These two invasive mollusks have been a major concern in many parts of the world.

Melanoides tuberculata, commonly known as "red-rim Melania" and "quitted Melania", has polymorphic forms and it is a native species of South Asia and tropical Africa (Abbott 1952). While the snail, *A. fulica*, is a native species of East Africa. This terrestrial gastropod can quickly reproduce, enabling it to spread relatively fast. These snails are found in the islands of Mauritius, India, Malaysia, and Indonesia. Since 1933, the snails have been around the city of Jakarta, with other sources stating that the *Achatina fulica* snail entered Indonesia in 1942 (during the Japanese occupation). These invasive species have widely spread in Indonesia, especially in Southeast Sulawesi Province (Purnama et al. 2019; Oetama and Purnama 2022; Purnama et al. 2022a, 2022b; Salwiyah et al. 2022). Therefore, an empirical study related to the spatial distribution of the three invasive alien species is required primarily related to their distribution in the inland waters of Southeast Sulawesi Province. This research is expected to provide the latest scientific database and reference information to control the invasive alien species in Southeast Sulawesi Province. The present study indicated a severe effort required to protect the preservation of native shellfish and gastropod species and other freshwater and terrestrial germplasms in Southeast Sulawesi that have been affected by the presence of these three invasive species.

MATERIALS AND METHODS

This research was conducted for five years (2017-2021) in 17 Districts/Cities of Southeast Sulawesi Province, including Kendari City, Konawe District, South Konawe District, North Konawe District, East Kolaka District, Kolaka District, Kolaka District. Utara, Bombana District, Konawe Kepulauan District, Muna District, West Muna District, Baubau City, Central Buton District, South Buton District, North Buton District, Buton District, and Wakatobi District. This research focused on natural and artificial inland waters such as rivers, swamps, lakes, rice fields/irrigation canals, dams, embankments, drainages, reservoirs, and particular terrestrial areas that become snails' habitats and niches. This study used the descriptive qualitative method. The sampling locations were determined by purposive sampling or based on the presence of inland waters (natural/artificial) in the district/city of the destination. Meanwhile, invasive mollusks of *M. tuberculata* and *A. fulica* were observed and collected using a handpicking method with gloves and hand scoops. The images were taken by camera Canon Powershot A3350. Furthermore, the existing areas of the three invasive alien species were marked (GPS-Garmin 60) to determine their distribution coordinates.

The species of gastropods indicated (morphologically based) on the two invasive species (IAS) were then identified to ensure their species using several specific identification keys for freshwater gastropods that were credible in malacology, such as Eichhorst (2016a, 2016b); General Shell Portal Version 3 (2020). Apart from textbooks, several reputable journals were also used to strengthen the identification results (double checklist), such as Global Invasive Species Database (2005); Gregoric et al. (2011); Harding et al. (2019); Purnama et al. (2019); Barbosa et al. (2020); Barros et al. (2020); Khanam et al. (2020); Lopes et al. (2020); Okumura and Rocha (2020); Oliveira et al. (2020) Song et al. (2020); Alfaro et al. (2021); Cano-Pérez et al. (2021); Dumidae et al. (2021); Harahap et al. (2021); Lopes et al. (2021); McClure (2021).

RESULTS AND DISCUSSION

Results

The study is the first investigation on the presence and absence of the invasive mollusks species *M. tuberculata* (Figure 1A) and *A. fulica* (Figure 1B) in the inland waters of Southeast Sulawesi Province, Indonesia. It is also the second study on the invasive alien species (Mollusca: Gastropoda) after *Tarebia granifera* (Purnama et al. 2020, 2021). River waters and a land area of Southeast Sulawesi Province have become the habitat of invasive mollusk species *M. tuberculata* and *A. fulica*. *Achatina fulica* and *M. tuberculata* had a massive invasive impact as they were distributed in all districts/cities. These two species of gastropod have their typical distribution and are cosmopolitan. For example, *M. tuberculata* snails occupied every type of inland water (natural/artificial), such as rivers, swamps, lakes, rice fields (irrigation canals), dams, embankments, drainage, and reservoirs. Similarly, in inland areas, *A. fulica* snails were widely observed, either crawling on the ground and grass or climbing trees or house walls. *Achatina fulica* is a common invasive gastropod with which the civilization became familiar. Apart from being a plant pest, *A. fulica* can be found in residential areas, especially on moist substrates or soil. Their presence has impacted agricultural and plantation activities.

Figure 1. Freshwater invasive molluscs. (A) *Melanoides tuberculata* from rice fields and irrigation channels/embankments; (B) *Achatina fulica* climbing on the trunk of tree. Photographs by MFP

This study provided extensive scientific evidence regarding the existence of several invasive alien species, in addition to *T. granifera*, in Southeast Sulawesi (Purnama et al. 2020, 2021). The wide and even distribution in this area indicates the high persistence of the three invasive species. Also, they might have high potential effects on the environmental quality as they have physiological adaptivity systems in terms of reproduction that can trigger an uncontrolled population explosion. The distribution of the invasive mollusks *M. tuberculata* and *A. fulica* in Southeast Sulawesi, Indonesia is presented in Figure 2.

Figure 2 shows that *M. tuberculata* snails were distributed in 16 districts/cities, and *A. fulica* snails were found in 17 districts/cities. The distribution describes the massive invasion and the wide range of habitats of these two invasive species in their respective ecological spaces. Details of the number and location of the District/City distribution of the two invasive mollusks are presented in Table 1.

Discussion

The invasive snail, *M. tuberculata*, is a freshwater gastropod generally found living in association with the invasive snail, *Tarebia granifera* (Purnama et al. 2019, 2020, 2021). Meanwhile, *A. fulica* snails have different habitat characteristics than other invasive alien species. *A. fulica* snails generally occupy habitats with moist land areas with many vegetations and are very close to human activities. The large population of *A. fulica* causes this invasive snail to be found everywhere. The distributions of the invasive species *M. tuberculata* and *A. fulica* are massive in Southeast Sulawesi. The invasive gastropod species *M. tuberculata* has spread in all districts except Wakatobi and invaded various natural and artificial land water such as rivers, swamps, lakes, rice fields, irrigation canals, dams, embankments, reservoirs, and drainage. Meanwhile, *A. fulica* is found in all districts/cities and invades the mainland as a plant pest.

Many studies indicated that the existence of invasive species could be attributed to their resistance to water quality fluctuations, high adaptability, and rapid reproduction and development rate. These aspects set the two species of invasive mollusks (*M. tuberculata* and *A. fulica*) as "cosmopolitan" organisms. Other important things were also related to the magnitude of the impacts of the invasions of these two alien species, including the threat to the survival or preservation of local and endemic aquatic and inland species. Therefore, interventions are needed to control their population in the nature of Southeast Sulawesi.

Table 1. Checklist of existing location invasive molluscs *Melanoides tuberculata*, and *Achatina fulica* in Southeast Sulawesi

District/city (Southeast Sulawesi)	Cecklist invasive molluscs	
	M. tuberculata	***A. fulica***
Kendari	√	√
Konawe	√	√
South Konawe	√	√
North Konawe	√	√
Kolaka	√	√
East Kolaka	√	√
North Kolaka	√	√
Bombana	√	√
Muna	√	√
West Muna	√	√
Central Buton	√	√
North Buton	√	√
South Buton	√	√
Buton	√	√
Baubau	√	√
Konawe Islands	√	√
Wakatobi	X	√
Amount	16 R/C	17 R/C

*Note: (x): Not exist; (√): Exist; R/C: District/City

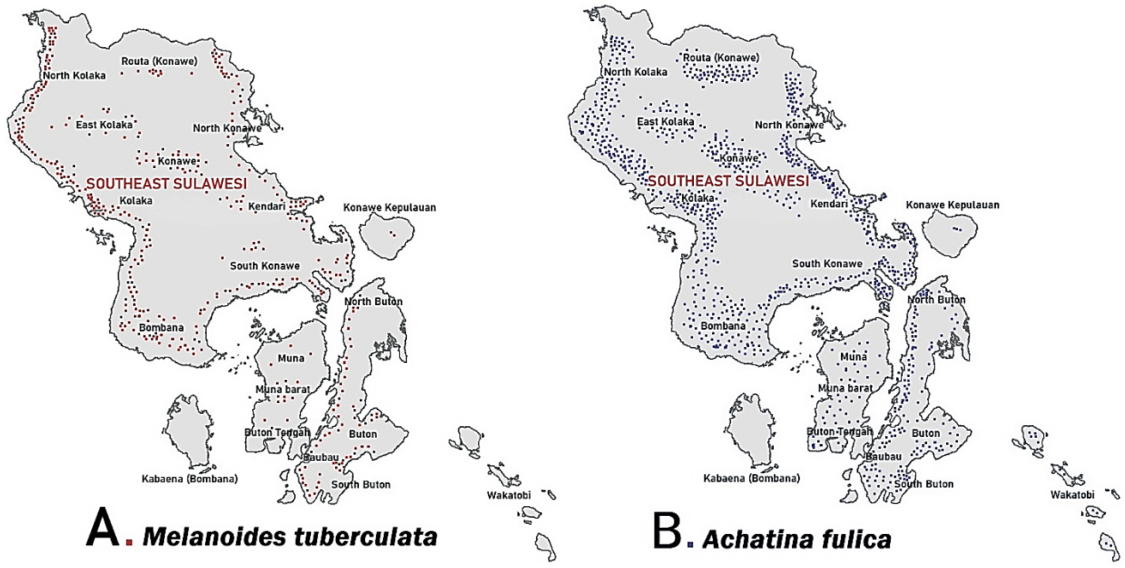

Figure 2. Distribution points of invasive molluscs. (A) *M. Melanoides tuberculata*; (B) *Achatina fulica* in Southeast Sulawesi, Indonesia

Another important aspect is related to the water's physical conditions. *Melanoides tuberculata* could not invade the freshwater habitat with a depth of 1 m, as observed in the district/city in Southeast Sulawesi. These findings are similar to a previous study by Purnama et al. (2019), which also explored the invasive species *M. tuberculata* also, it applies to the invasive *T. granifera* snails, which they cannot live in waters with depths of >1 m, both natural and artificial inland waters. On the other hand, the water depth of > 1 m (in freshwaters of Southeast Sulawesi) presents a favorable habitat for the mussel (*Anodonta woodiana*) and pokea (*Batissa violacea*) bivalves (Purnama et al. 2020, 2021).

In conclusion, Spatial distribution of aquatic invasive alien species (IAS) *T. granifera* and invasive terrestrial snail *A. fulica*, massively found in inland waters of Southeast Sulawesi province. The existence of these two IAS needs to be evaluated because they can threaten the endemic mollusk species of Sulawesi, so their spreading should be prevented by concerted management action to minimize the harm they cause.

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