

Specific characteristics of niche and spatial distribution of invasive alien species *Tarebia granifera* in Buton Island, Indonesia

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Abstract. This research was conducted for a year, starting from August 2019 to August 2020, located in the river waters of Buton Island, in 5 district/city administrative areas. Objective of this study was to determine the typical characteristics of niche and spatial distribution of the invasive alien species *Tarebia granifera* in river waters of the island. Outcomes of this study are the standard data of bioecological aspect; it will be used as the scientific basis to set a management strategy of invasive alien species particularly in Buton Island and generally in Indonesia. Based on preliminary survey, sampling location of *T. granifera* was determined by a purposive sampling method. Meanwhile, a simple random sampling method was used to sample this invasive alien species. *T. granifera* was collected manually using gloves, because this snail lives on the surface of substrate (epifauna) and sticks to rocks and other hard objects in the river, so it was relatively easy to collect. *T. granifera* spread massively throughout the administrative region of Buton Island: in Buton Regency, South Buton Regency, North Buton Regency, Muna Regency and Baubau City. They occupies natural and artificial inland waterways, with various morphological characteristics such as, waterfalls, calm currents rivers, fast flowing rivers, muddy rivers, rocky rivers, sandy and gravel rivers as well as rice substrate, embankments/drainage and dams.

Key Words: IAS, *T. granifera*, dispersion, type of niche, invasive status.

Introduction. Buton Island is a terrestrial area, it is surrounded by oceans and located in the administrative area of Southeast Sulawesi Province. Buton Island consists of 5 municipal districts which are connected by land, among others Buton Regency, South Buton Regency, North Buton Regency, Muna Regency and Baubau City. The total land area of Buton Island is 4,408 km², it is 1/8 of the total land area of Southeast Sulawesi (38,140 km²). Therefore, these five administrative regions in Buton Island have a huge potential in inland fisheries resources. Buton Island mainland is have various types of rivers, both natural and artificial stationery water bodies, such as dam, lake, embankment and retention basin. Extensive land waters make Buton Island as a source of germplasm or mega-biodiversity for a typical freshwater commodity (BPS 2019).

One of the important economic commodities in freshwater that are widely used by the community of Buton Island, are gastropods (molluscs). There are many common and endemic gastropods in Buton Island river waters; however the presence of invasive alien species *Tarebia granifera* has ecologically succeeded in invading the local gastropods. It can be seen from the dominance of this species, found in river areas. Referring to the results of recent research conducted by Purnama et al (2020) in mainland cluster of Southeast Sulawesi (North Kolaka Regency, Kolaka Regency, East Kolaka Regency, Bombana Regency, Konawe Regency, North Konawe Regency, South Konawe Regency and Kendari City) showed that *T. granifera* is found in all these districts/city and its

population always dominated the habitats and niches of local gastropods and bivalves. The rapid reproductive ability and resistance or high adaptability to environmental changes are the main causes of this invasive alien species dominance (Purnama et al 2020).

Several findings from previous research explained that the *T. granifera* thiaridae snail is an invasive alien species (IAS) or exotic species, whose existence can disrupt the ecosystem balance, especially if the area provides environmental conditions that is suitable to its habitat preferences or its niche. In addition, parthenogenetic reproduction makes *T. granifera* snails able to reproduce fast, even without prior copulation with the opposite sex, because this reproductive system allows females to produce developing eggs without fertilization process (Purnama et al 2020; Purnama et al 2019; Rustiasih et al 2018; Didham et al 2007; Charles & Dukes 2007; Moslemi et al 2012; Rangel et al 2011). Therefore, to find out in detail the distribution of *T. granifera* in Buton Island and its domination to local gastropods, research on spatial distribution and specific characteristics of niche is a first step to do in efforts to manage and control thiaridae snails, invasive *T. granifera* in Southeast Sulawesi river waters in general and Buton Island in particular.

The present study aims to determine the characteristics of the niche and the spatial distribution of invasive alien species *T. granifera* in Buton Island.

Material and Method. This research was conducted for a year (from August 2019 to August 2020) located in the river waters of Buton Island, specifically in five regencies/city namely in Buton Regency, South Buton Regency, North Buton Regency, Muna Regency and Baubau City (Figure 1).

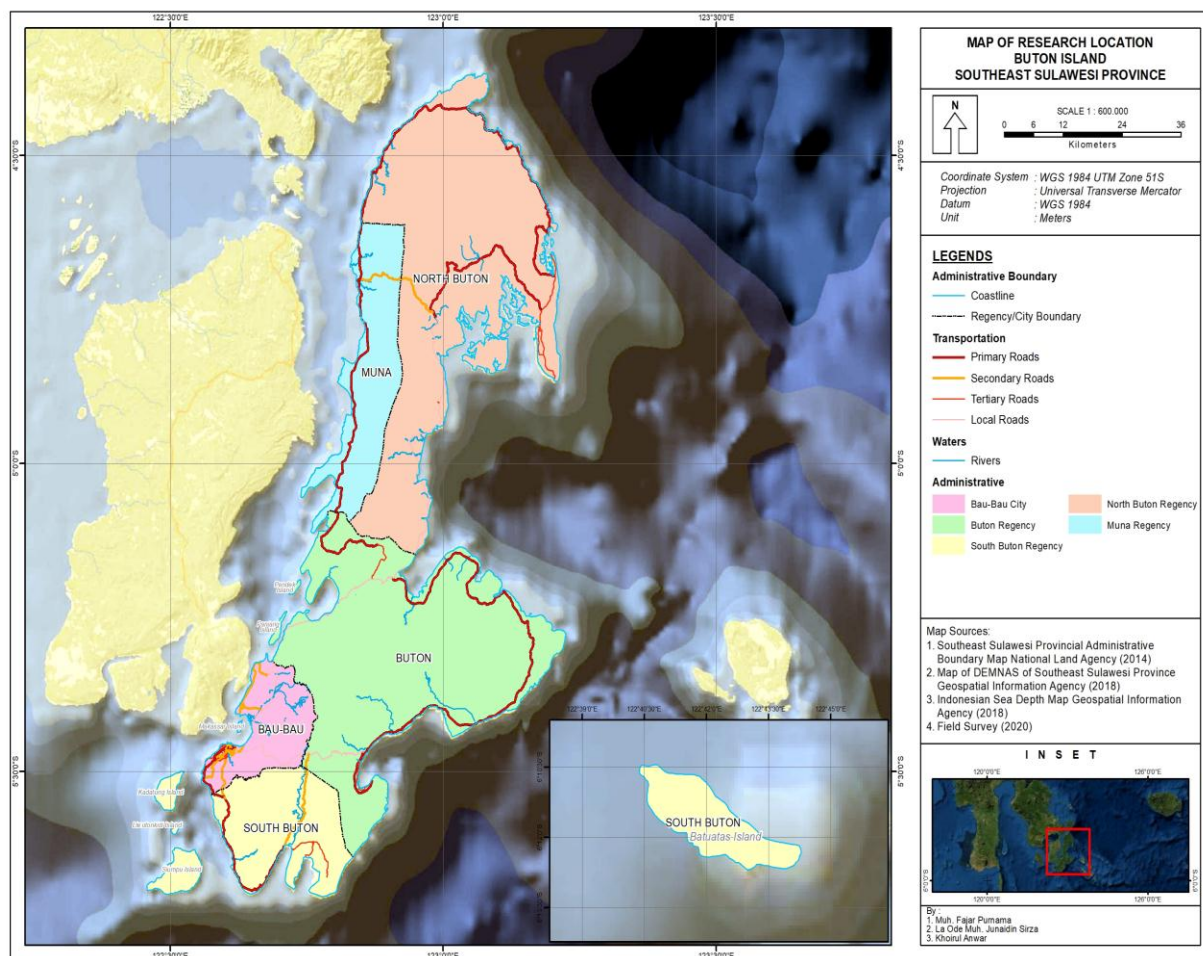


Figure 1. Research location: Buton Island, Southeast Sulawesi Province.

Determination of study site or sampling locations was started by preliminary survey or field observation. Sampling location of *T. granifera* was determined by a method of

purposive sampling (non-probability sampling), while collection of *T. granifera* was done by a simple random sampling (probability sampling) method. *T. granifera* (epifauna) found in the sampling locations were collected by a manual method using gloves. This exotic species exploration was relatively easy, because it lives on the surface of substrate and rocks or on other hard objects in river at a depth of $\pm 10-30$ cm, so it did not require a special fishing gear to collect samples. Specific characteristics of niche and spatial distribution of invasive alien species *T. granifera* were analyzed by a descriptive qualitative analysis, which was interpreted using a distribution map based on the coordinates of the existing locations and a detailed of physical description of the niches of invasive thiaridae commodity was done. The following figure is a map of the research location (Buton Island, Southeast Sulawesi Province).

Results. *T. granifera* (Figure 2) was found in almost all natural and artificial inland waters of Buton Island. This exotic thiaridae species occupies a variety of typical habitats and niches in Buton Regency, South Buton Regency, North Buton Regency, Muna Regency and Baubau City. In other words, the inland waters of 5 regencies/cities in Buton Island have been invaded massively by *T. granifera*. It can be seen by the dominance of *T. granifera* against local gastropods, with a density of 21-43 ind m^{-2} . Native species only occupy the edges or walls of the river with a maximum density of 3-5 ind m^{-2} .



Figure 2. Invasive alien species *Tarebia granifera*.

T. granifera occupies natural and artificial inland waterways with various morphological characteristics, such as, waterfalls, calm currents rivers, fast flowing rivers, mud-substrate rivers, rock, sand and gravel as well as rice substrate, embankments/drainage and dams. Figures 3-7 presents the detailed habitat and niches of *T. granifera* on Buton Island.



Figure 3. Habitat and niche of *Tarebia granifera* in the Mainland of Baubau City.



Figure 4. Habitat and Niche of *Tarebia granifera* in the Mainland of North Buton Regency.

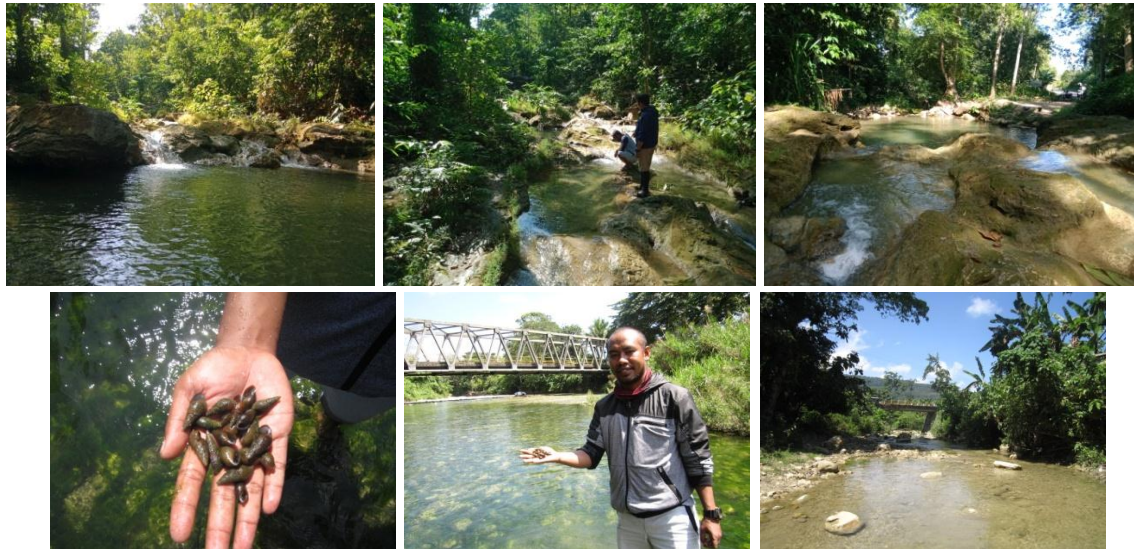


Figure 5. Habitat and niche of *Tarebia granifera* in the Mainland of South Buton Regency.



Figure 6. Habitat and Niche of *Tarebia Granifera* in the Mainland of Buton Regency.

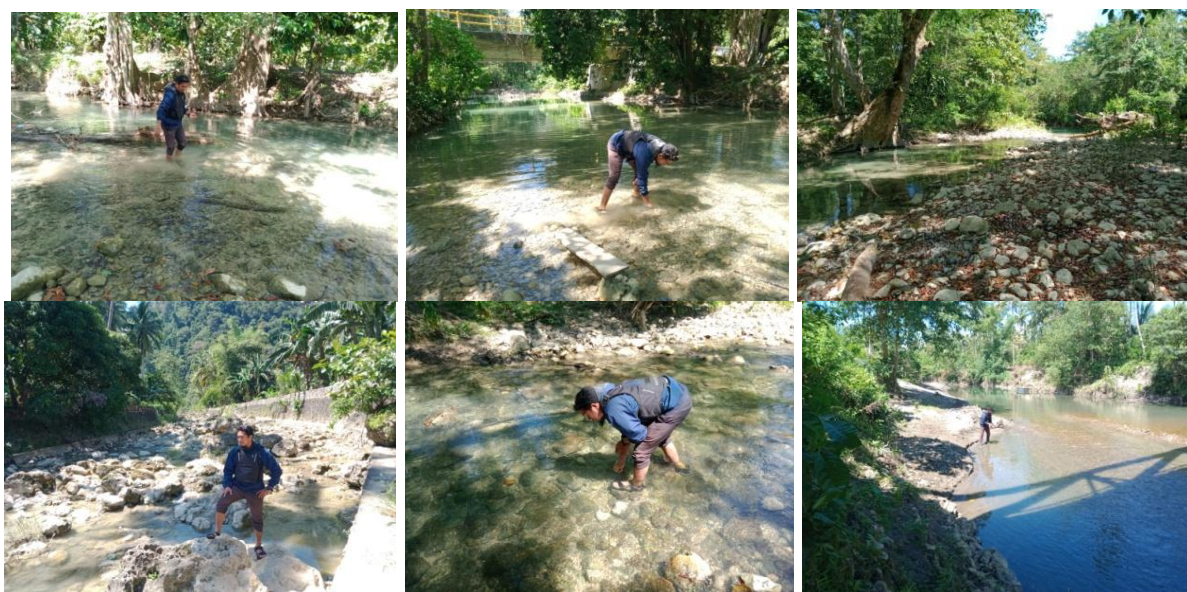


Figure 7. Habitat and niche of *Tarebia granifera* in the Mainland of Muna Regency.

The area covered by *T. granifera* infestation in Buton Island is presented in Table 1.

Table 1

The invasive alien species *Tarebia granifera* coverage in Buton Island

No.	Sampling location	Type of inland waters	Coordinates	Invasive status
Baubau City				
1	Wisata Permandian Bungi, Lakologau Sub-district, Kokalukuna District	River (Dam)	-5.4186413,122.6532229	Present (Dominant)
	Rice field/Embankment at Waliabuku Sub-district, Bungi District	Rice Field/Embankment	-5.3891978,122.6811073	Present (Dominant)
	Rice Field, Embankment and River at Ngkari-ngkari Sub-district, Bungi District	Rice field, Embankment and River	-5.3819613,122.6850279	Present (Dominant)
Buton Selatan Regency				
2	Batuan Waterfall (Flat) at Bola Village, Batauga District	Waterfall	-5.6832426,122.6295445	Present (Dominant)
	Watershed at Katilombu Sub-district, Sampolawa District	Rocky river	-5.648162,122.6914696	Present (Dominant)
	TPI Watershed at Katilombu Sub-district, Sampolawa District	River	-5.6459146,122.692435	Present (Dominant)
	Wandoke Watershed at Gunung Sejuk Village, Sampolawa District	Rocky river	-5.5817969,122.7369227	Present (Dominant)
Buton Regency				
3	Wakoko Watershed at Wakoko Sub-district, Pasar Wajo District	Rocky river	-5.4663136,122.8597785	Present (Dominant)
	Kaongkea Watershed, Kaongkea Village, Pasar Wajo District	Rocky river	-5.4771894,122.7418421	Present (Dominant)
	Watershed at Wakalambe Village, Kapontori District	Sand/Gravel substrate-river	-5.2569881,122.7471174	Present (Dominant)
	Drainage at Bukit Asri Village, Kapontori District	Drainage	-5.1268598,122.8445677	Present
	Watershed at Tumada Village, Kapontori District	Sand/Gravel substrate-river	-5.1306287,122.7779594	Present (Dominant)

No.	Sampling location	Type of inland waters	Coordinates	Invasive status
Muna Regency				
4	River at Kamosope Village, Pasir Putih District	Rocky river	-5.0423026,122.8141782	Present
	Watershed at Kamosope Village, Pasir Putih District	Rocky river	-5.039747,122.8124467	Present
	Watershed at Bumbu Village, Pasir Putih District	Rocky river	-5.0145936,122.8157215	Present (Dominant)
	Watershed at Wakorumba Village, Wakorumba Selatan District	Rocky river	-4.9378853,122.8399234	Present (Dominant)
	Watershed at Pure Sub-district, Wakorumba Selatan District	Sand/Gravel substrate-river	-4.9045159,122.8383363	Present (Dominant)
	Watershed at Wambona Village, Wakorumba Selatan District	Sand/Gravel substrate-river	-4.851451,122.8325438	Present (Dominant)
	Watershed at Moolo Village, Batukara District	Sand/Gravel substrate-river	-4.8132803,122.8623753	Present
	Watershed at Moolo Village, Batukara District	Sand/Gravel substrate-river	-4.8000399,122.8607919	Present
	Watershed at Lanobake Village, Batukara District	Sand/Gravel substrate-river	-4.7799715,122.8585829	Present (Dominant)
	Watershed at Desa Pohorua Kecamatan Maligano	Sand/Gravel substrate-river	-4.7365631,122.8481865	Present (Dominant)
5	Watershed at Maligano Village, Maligano District	Sand/Gravel substrate-river	-4.7048198,122.8446271	Present
	Watershed at Latompa Village, Maligano District	Muddy river	-4.6769688,122.8467225	Present (Dominant)
	Watershed at Langkoroni Village, Maligano District	Sand/Gravel substrate-river	-4.6681353,122.8461626	Present
	Kabupaten Buton Utara			
	Watershed at Matalagi Village, Wakorumba Utara District	Sand/Gravel substrate-river	-4.5924071,122.8524992	Present (Dominant)
	Watershed at Matalagi Village, Wakorumba Utara District	Sand/Gravel substrate-river	-4.5767612,122.8562651	Present (Dominant)
	Watershed at Matalagi Village, Wakorumba Utara District	Sand/Gravel substrate-river	-4.5761046,122.8564783	Present
	Watershed at Desa Labuan Bajo Kecamatan Wakorumba Utara	Sand/Gravel substrate-river	-4.4770369,122.90418	Present (Dominant)
	River at Labuan Bajo Village, Wakorumba Utara District	Sand/Gravel substrate-river	-4.4724857,122.9071467	Present (Dominant)
	Watershed at Labuan Bajo Village, Wakorumba Utara District	Muddy sandy river	-4.4700202,122.9078342	Present (Dominant)

In detail and systematically, the spatial distribution of the invasive alien species *T. granifera* in Buton Island was interpreted qualitatively using the existing area maps (Figures 8-13):

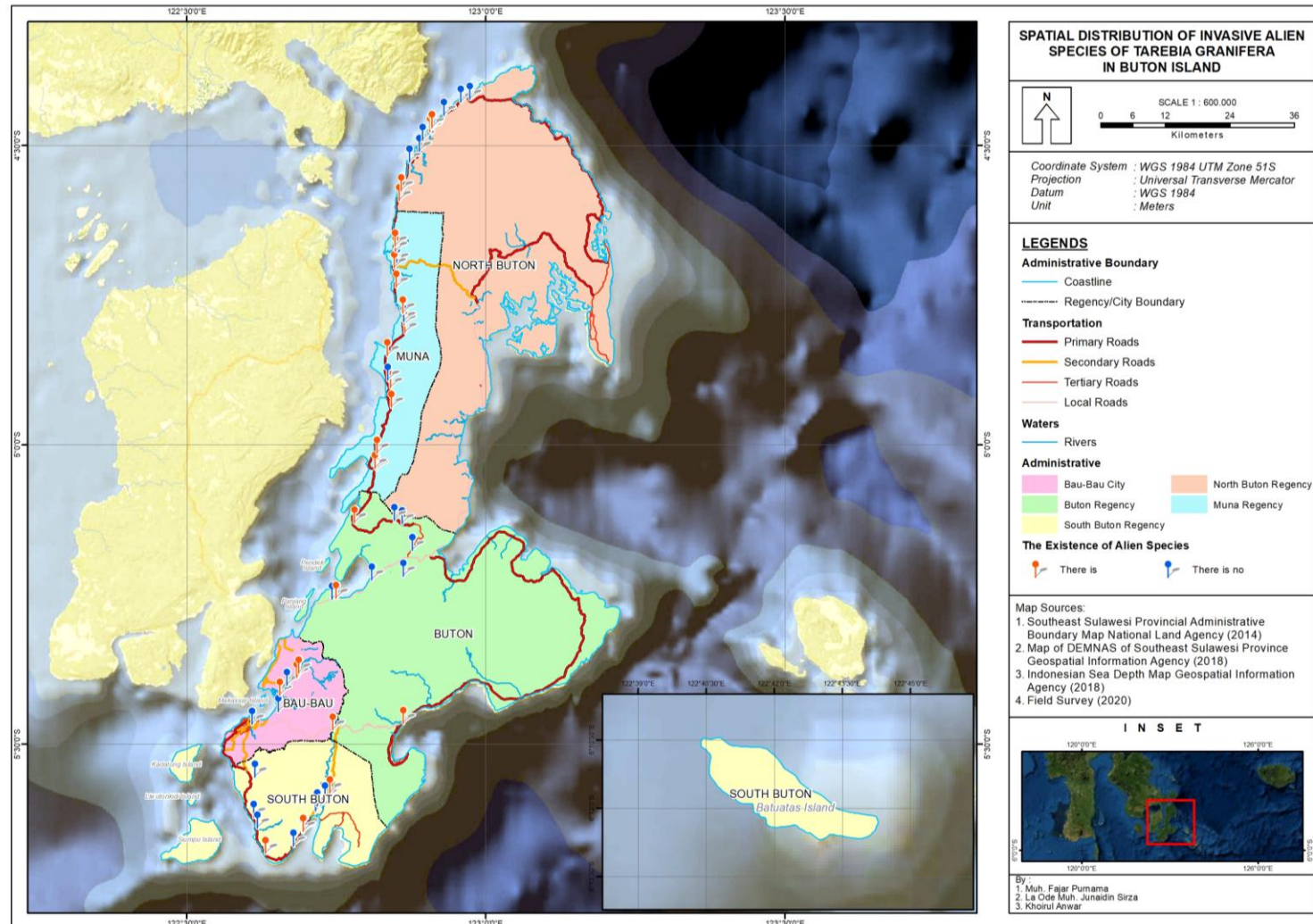


Figure 8. Presence of *Tarebia granifera* in Buton Island.

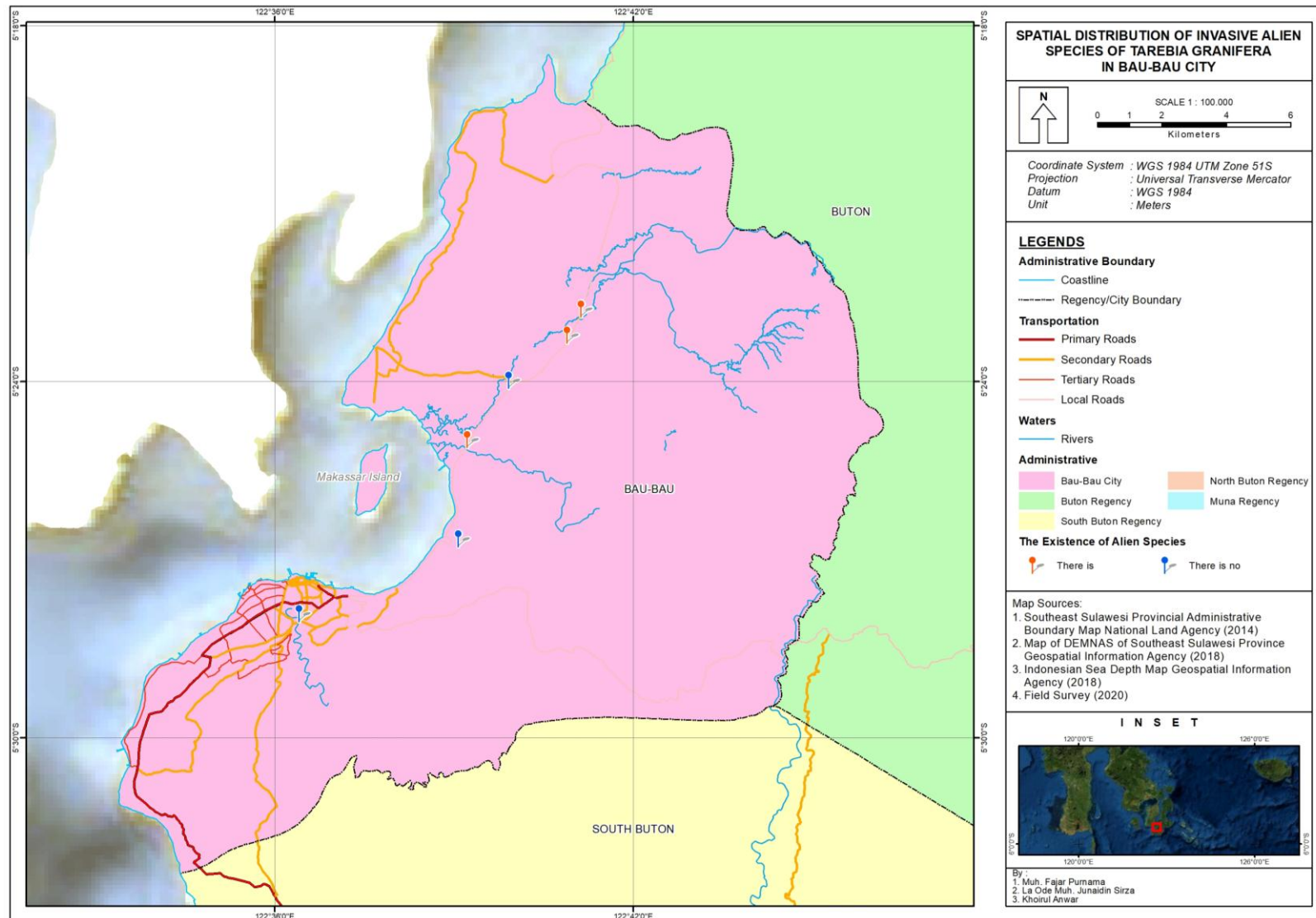


Figure 9. Presence of *Tarebia granifera* in Baubau City.

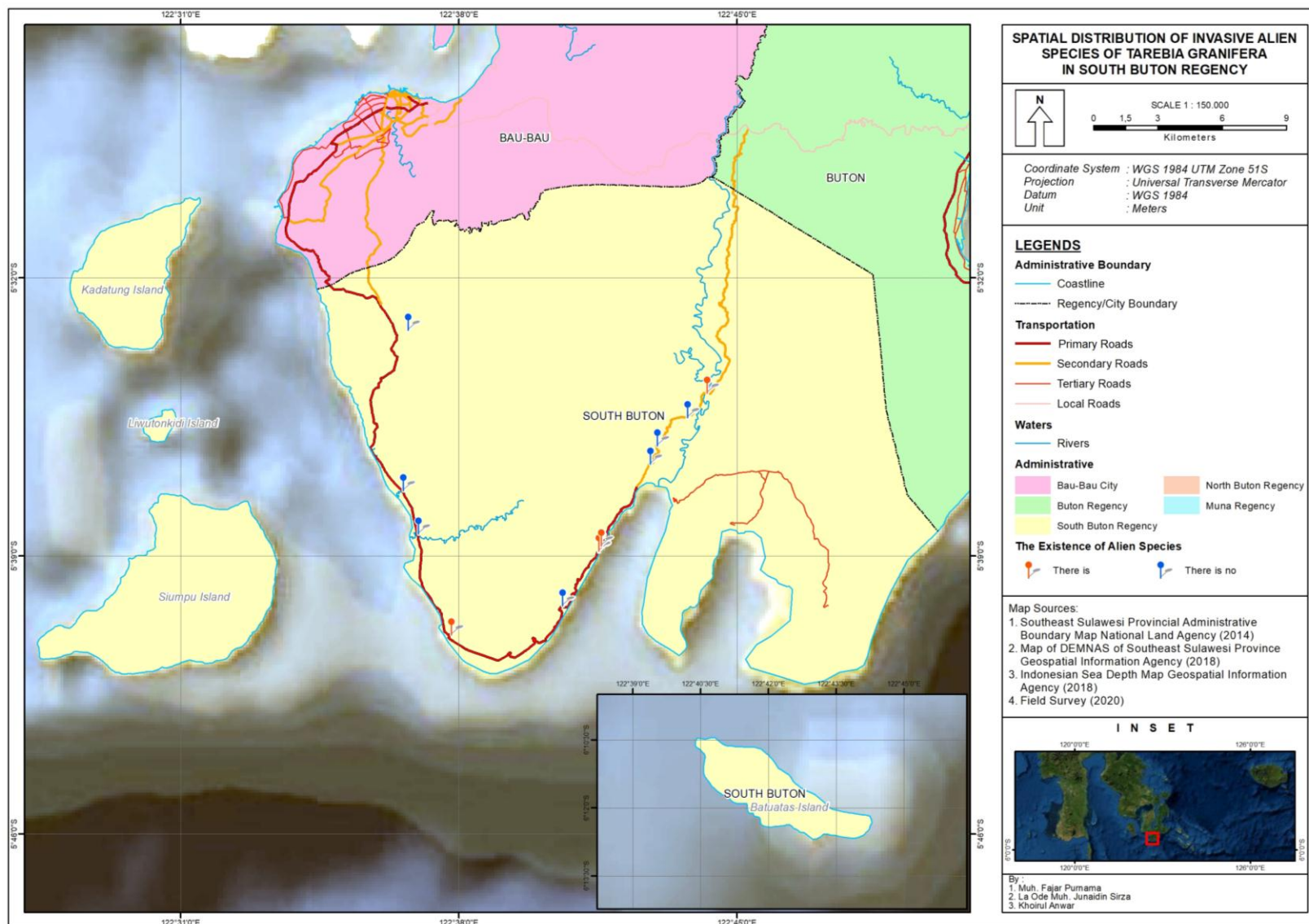


Figure 10. Presence of *Tarebia granifera* in South Buton Regency.

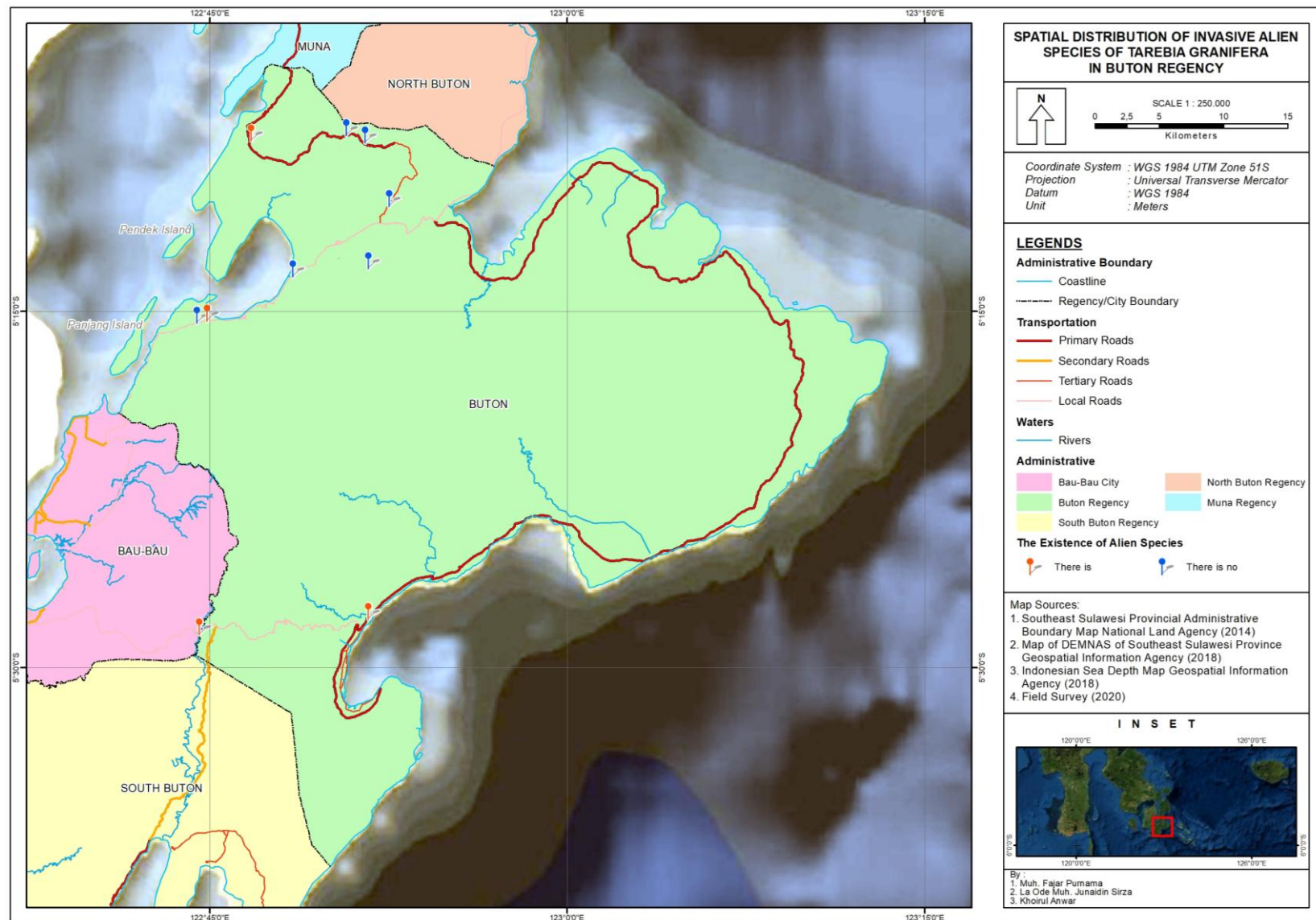


Figure 11. Presence of *Tarebia granifera* in Buton Regency.

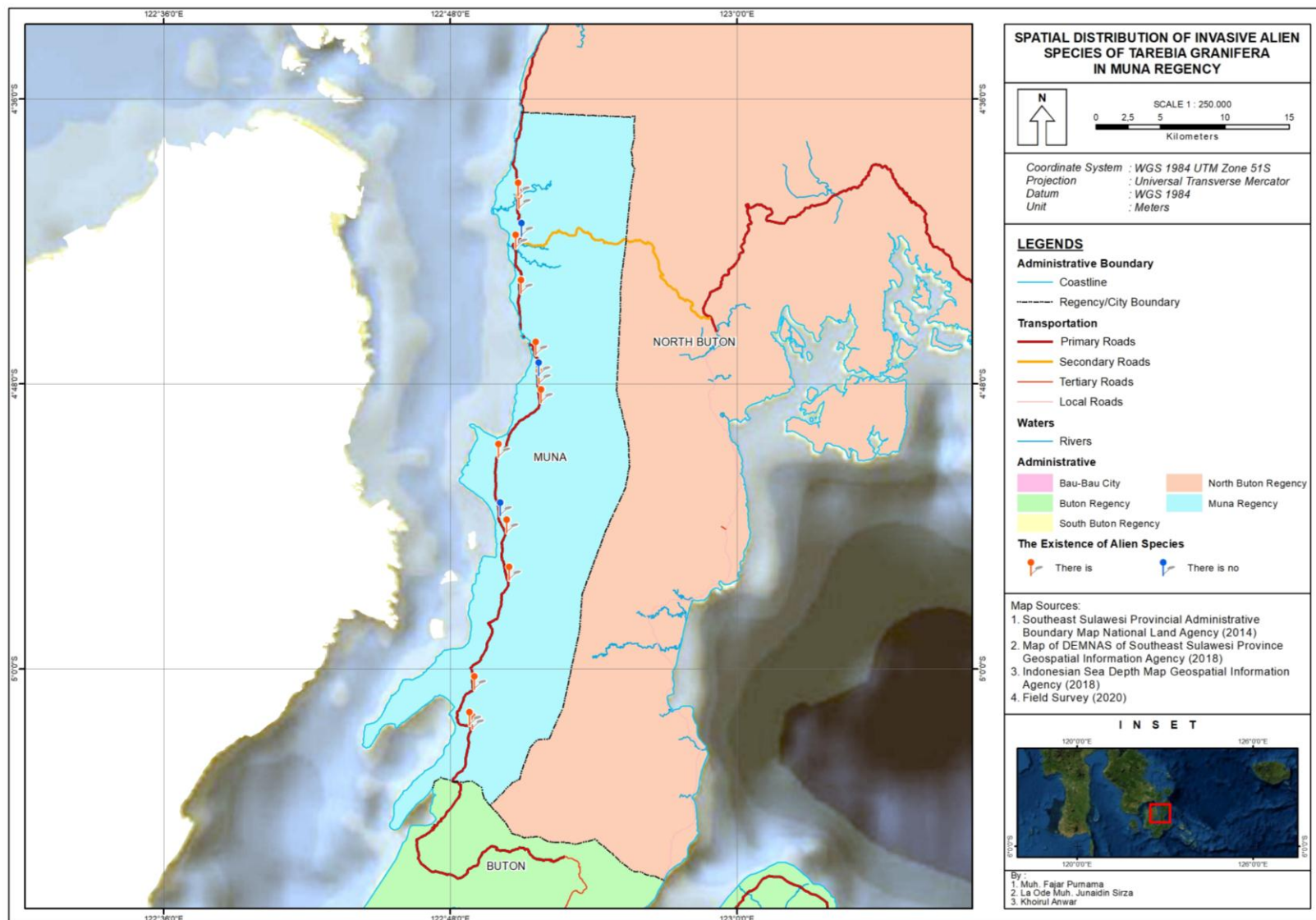


Figure 12. Presence of *Tarebia granifera* in Muna Regency.

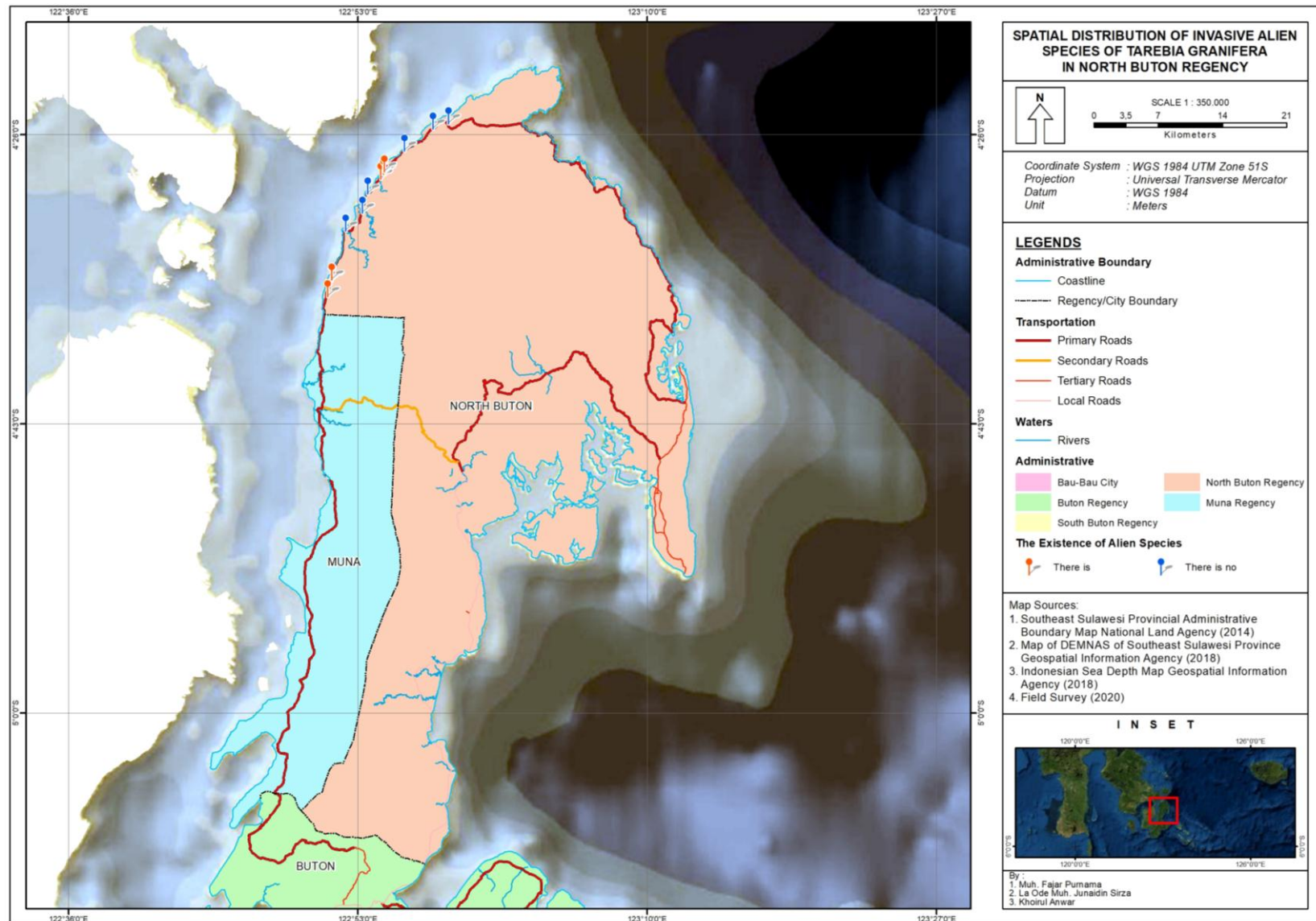


Figure 13. Presence of *Tarebia granifera* in North Buton Regency.

Discussion. The main habitat and niche of *T. granifera* in Buton Island was at fast-flowing river with rock, gravel and sand substrate. In addition, Inland waters also became the existing areas of *T. granifera*, such as a flat rock substrate waterfalls, calm rivers, embankments/drainage, rice fields and dams. These habitats and niches provide optimal living requirements for *T. granifera* population. High adaptability to various water quality parameters (physico-chemical) and to inland water morphology were a cause of the dominance of *T. granifera* in every niche, where the species population was found. In addition, rocky rivers were a media for macroalgae attaching such as moss and other types, so that they became the area of thiaridae gastropod grazing. *T. granifera* is a herbivore gastropod, and strongly dominant in the ecological spaces of land-based waters in Buton Island. A high-density of *T. granifera* population resulted in the inability of native species to compete in space and for food, which in turn the dominance scale increased and slowly degraded the existence of native species. This invasive alien species is also found in other areas, with various type of habitat, such as, Lur Tawar Aceh Besar Lake (Arita et al 2019), rivers with rock, sand and gravel substrate, Dam of TPA Kebon Pongok has the highest population abundance compared to other species (Athifah et al 2019) and also present in Rokan Kiri River, Rokan Hulu Regency (Purwanti et al 2015). Miranda & Perissinotto (2014), Appleton & Nadasan (2002) stated that *T. granifera* had succeeded in invading various typical inland waters in South Africa, especially in Durban Reservoir, Kwazulu-Natal and Isimangaliso Wetland Park, which can be seen from the aspect of high density and abundance of *T. granifera* populations. High resistance of *T. granifera* to physico-chemical fluctuation is one of many determinants of the presence of this species. Another vital factor that causes the biological dominance of *T. granifera* in nature is the reproductive system "Parthenogenesis" or a reproduction without the process of copulation or mating, in other words, *T. granifera* females can produce as many eggs as possible, and develop without fertilization by male individuals. This is the cause of explosion of uncontrolled population of *T. granifera* in nature. Purnama et al (2020) and Moslemi et al (2012) stated that several factors caused the high dominance of *T. granifera* in natural and artificial land waters in the mainland clusters area of Southeast Sulawesi and Trinidad (West Indies), such as parthenogenesis reproduction system and high adaptability to water physico-chemical parameters. Spatial distribution of *T. granifera* in inland waters of Buton Island was considered as cosmopolitan; indicated by the discovery of the invasive alien species in 5 administrative regions (Buton Regency, South Buton Regency, North Buton Regency, Muna Regency, and Baubau City) on various type of natural and artificial inland waters. Previous research by Purnama et al (2019, 2020) and Rustiasih et al (2018) confirmed that *T. granifera* is an invasive alien species that has a high adaptability, capable of living in various typical of inland waters, among others rivers, lakes, swamps, drainage, embankment, and dam. This condition has an ecological impact to the existence of native species populations. Dominance of invasive alien species in the inland waters of Buton Island was very high and massive, as well as generally in Southeast Sulawesi waters. So, it is necessary to control and manage the invasive alien species *T. granifera*, to ensure the preservation and sustainability of native species populations. Previous studies showed that every organism, naturally, has its own geographic distribution area which is commonly known as indigenous species (Prabowo & Ardli 2010). Native species is defined as a species that is within the range of its natural habitat and does not depend on human activities (Lymbery et al 2014). A foreign species is a new/immigrant species from another area or ecosystem. Foreign or alien species (exotic, non-indigenous) species are species that are transported by human activities to an area beyond their natural range (Lymbery et al 2014). Foreign fish or commonly known as introduced is a type of fish that does not come from the original habitat or its zoogeographic distribution area or can also be referred to as fish whose natural habitat does not come from Indonesia (Dewantoro & Rachmatika 2016). Invasive species are one of the biggest threats to biodiversity (Loveridge et al 2016), because they are a major component in global environmental change (Vitousek et al 1997; Hulme et al 2009), a threat to biodiversity and local species (Gordon 1998; Jose et al 2009), are the causes of changes in structure, ecosystem function, nutrient cycle, fire cycle, hydrological cycle, and energy cycle (Mack et al 2000), as well as for loss of biodiversity

(Charles & Dukes 2007). Invasive alien species is defined as non-native species that are generally introduced by humans and then threaten the ecosystems, habitats or other species and cause significant changes in the environment (Pejchar & Mooney 2009). Another impact caused by invasive alien species is the health sector. Many foreign invasive species cause health problems. Nearly 100 species (6%) of foreign invertebrates in Europe have affected human and animal health (Roques et al 2009). Several researchers have reported the impact of invasive species on native species and their community structure (Williamson 1996; Parker et al 1999; Sala et al 2000; Stein et al 2000). In the end, invasive species aggravate the entire ecosystem, because due to the higher amount of non-native species (exotic, alien), will occupy the specific space of a water. Some of negative impacts of invasive alien species are: (1) Change in native habitat (2) Damage to ecosystems (3) Breakdown of food chains (4) Decrease in native fish populations (5) Decrease in endemic fish populations (6) Loss of genetic variability (7) Decrease in native population due to competition (8) Decreasing local resources such as fish. More than half of the 12 nematodes introduced were endoparasites to humans or caused zoonoses (Bangladesh) in livestock or to animals obtained directly from nature (Samad 2011). The impact of invasive species on native species, communities, and ecosystems has been widely recognized for decades (Lodge 1993; Simberloff 2009), and invasive species are now viewed as a significant component of world change (Vitousek et al 1997). The most obvious impacts of this species is visible in economic perspective; the cost of invasive species are estimated to range from millions to billions of dollars per year (Pimentel et al 2000). Based on an economic approach, the direct costs of managing invasive alien species are very high. Actions to control invasive alien species before they spread can be more cost-effective and more successful than actions after they have spread. Although only a small proportion of alien species become invasive, the effects can be devastating (Mc Neely et al 2001). Several studies have reported that the economic losses incurred by a country due to invasive species, can reach 375 million dollars per year, even in Europe between 1988 and 2000 the losses reached 5 billion dollars (Purwono et al 2002).

Conclusions. Invasive alien species *T. granifera* spread massively throughout the administrative region of Buton Island: Buton Regency, South Buton Regency, North Buton Regency, Muna Regency and Baubau City. *T. granifera* occupies natural and artificial inland waterways with various morphological characteristics such as, waterfalls, calm currents rivers, fast flowing rivers, muddy rivers, rocky rivers, sandy and gravel rivers as well as rice substrate, embankments/drainage and dams.

Acknowledgements. Authors deliver profusely thank to all fellow researchers namely Alfi Kusuma Atmaja, LM. Junaidin Sirza, Aksa Julianto and Muh. Arjuna RA for the willingness to help and facilitate activities during the field research.

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Received: 16 November 2020. Accepted: 11 February 2021. Published online: 18 February 2021.

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How to cite this article:

Purnama M. F., Sari S. F., Oetama D., Sirza L. O. M. J., Admaja A. K., Anwar K., Salwiyah, Abdullah, Findra M. N., 2021 Specific characteristics of niche and spatial distribution of invasive alien species *Tarebia granifera* in Buton Island, Indonesia. *AACL Bioflux* 14(1):233-248.