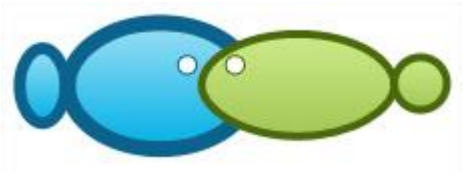

Spatial distribution of invasive alien species *Tarebia granifera* in Southeast Sulawesi, Indonesia

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Abstract. The present research was performed for a year (from January 2018 to January 2019). A purposive random sampling method was implemented to choose 17 regencies/cities in Southeast Sulawesi as sampling sites. The aim of this research was to determine the distribution of invasive *Tarebia granifera* in Southeast Sulawesi Province. Results of this research are expected to be a cutting-edge reference for further research, as well as scientific and empirical recommendations to maintain biological resources, especially shellfish commodities (Pelecypoda) and endemic or native gastropods in Southeast Sulawesi. Samples of *T. granifera* were collected by using transect square method, small transect of 1x1 m in 3 random plots placed within a 5x5 m transect. Spatial distribution of Invasive Alien Species (IAS) *T. granifera* was analyzed descriptively qualitative, interpreted by its distribution map based on coordinates of its existence. Distribution of IAS *T. granifera* in Southeast Sulawesi Province wasfound in eight regencies/cities (Status: Mainland), among others: Kendari City, South Konawe Regency, Bombana Regency, Kolaka Regency, North Kolaka Regency, East Kolaka Regency, Konawe Regency and Konawe Utara Regency. Meanwhile, *T. granifera* (Gastropod: Thiaridae) were absence at regencies/cities located in the islands of Southeast Sulawesi Province.

Key Words: invasive freshwater snail, gastropod, Thiaridae, *T. granifera*, aquatic fauna.

Introduction. Currently, diversity of aquatic fauna in Indonesia has decreased dramatically. It is caused by various environmental stresses, such as; excessive resource exploitation (over exploited) and land conversion due to the concept of regional spatial planning which is not environmentally friendly. Environmental stress is a result of changes in environmental order, while environmental change is a result of environmental degradation. Meyerson & Mooney (2007) and Didham et al (2007) stated that environmental degradation was basically caused by land conversion, while land conversion generally was the major cause of environmental changes that specifically accelerating the invasive alien species (IAS) expansion. Furthermore, Alaydrus (2013) identified that the decline of biodiversity is caused by many aspects, such as land conservation, exploitation, and introduction of alien species (especially IAS).

One of main components of environmental change is introduction of IAS, where its distribution is a threat to local aquatic fauna (endemic) biodiversity. Wittenberg & Cock (2001) stated that IAS will threaten biodiversity, while also having an enormous impact on fisheries activities. In addition, Convention on Biodiversity (CBD 2015), more specifically stated that IAS has been suspected to be the direct cause of biodiversity loss in the world. Introductions of alien species can affect the balance of ecological system. Indonesia is located in an important position in the map of biodiversity in the world because it is in the top ten countries with high biodiversity (Alaydrus 2013).

Southeast Sulawesi is one of provinces in Indonesia which has a high diversity of freshwater aquatic fauna, particularly concerning the commodity of "Nonfish" (invertebrate: Mollusca: Gastropod), among others *Lymnae rubiginosa, Indoplanorbis exustus*, *Belamya javanica*, *Melanoides tuberculata*, *Achatina fulica*, *Filopaludina javanica*, *Pila ampullacea*, *Pila polita*, *Pila scutata*, *Pomacea canaliculata*, *Melanoides torulosa*, *Neritina pulligera*, *Thiara scabra*, *Thiara winteri*, *Clithon squarrosus*, *Clithon oualaniensis* and *Tarebia granifera* (Purnama et al 2019). One of these several species identified is an IAS, namely *T. granifera* (Gastropod: Thiaridae). Morphological characteristics of *T. granifera* are: medium-sized shell, with a conical elongated shape and rather thick, while the shell color is yellowish or light brown to dark brown, there are invisible spirals and axials lines that forming nodules, the shell has 6-8 circles with a high spire, and mouth of the shell (aperture) is curved (Takdim & Annawaty 2019).

T. granifera is an IAS that is currently found throughout the world, both in tropics and subtropics region. Effects of ecological invasion of *T. granifera* are largely unknown (Moslemi et al 2012; Rangel Ruiz et al 2011; López-López et al 2009). Moslemi et al (2012) stated that *T. granifera* is a class of snails with asexual reproduction by parthenogenesis system or form of asexual reproduction in which females produce eggs that develop without fertilization. This was thought as the main cause of uncontrolled population of *T. granifera* in nature. Some research on invasion of Thiaridae family snail has been previously carried out by Moslemi et al (2012), Rangel Ruiz et al (2011) and López-López et al 2009.

Some studies mentioned above could be a basic reference on the status of invasive *T. granifera* in Indonesia, especially in Southeast Sulawesi. Existence of *T. granifera* in freshwater waters of Southeast Sulawesi must be controlled, especially if it cause of various disturbances of local ecosystem. Therefore research on spatial distribution of IAS *T. granifera* in Southeast Sulawesi is important. The purpose of this study was to determine the distribution of *T. granifera* IAS in Southeast Sulawesi. Results of this study are expected to be a reference edge for further research, as well as scientific and empirical recommendations to protect biological resources, especially shellfish resources (Mollusca: Peleycipoda) and endemic Gastropod in Southeast Sulawesi.

Material and Method. The present study was conducted from January 2018 to January 2019, located in 17 regencies in Southeast Sulawesi. It consisted of 8 regencies on land region including: Kendari City, South Konawe, Bombana, Kolaka, North Kolaka, East Kolaka, Konawe, North Konawe, and 9 regencies on island region, among others: Muna, West Muna, Konawe Islands, Buton, North Buton, South Buton, Central Buton, Baubau City, and Wakatobi (Figure 1).

Tools and materials used in this study were GPS Garmin 60, digital camera, calipers (mm), labeling paper, plastics bags, transect (5x5 m and 1x1 m squares), Identification book (Mollusca: Gastropoda) and *T. granifera* as research objects (Figure 2). A purposive random sampling was applied to determine the sampling station, especially. Sampling of *T. granifera* snails was carried out using 5x5 m quadratic transect, while 3 plots of 1x1 m transects randomly were assigned inside that 5x5 m quadratic transect. Spatial distribution of *T. granifera* was analyzed descriptively qualitative, in which it was interpreted using a distribution map based on the coordinates of *T. granifera* location.

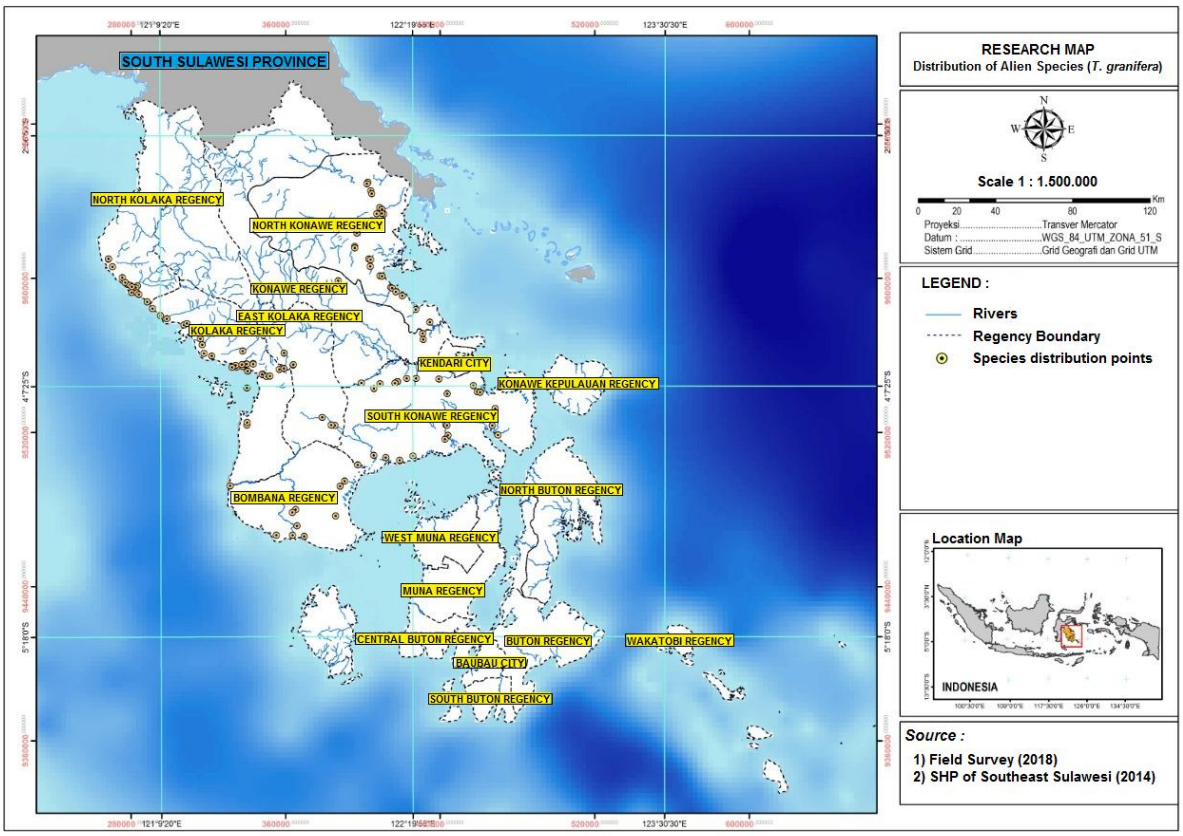

Figure 1. Map of research sites in 17 regencies in Southeast Sulawesi.

Figure 2. Invasive Alien Species (IAS), *Tarebia granifera* (Purnama et al 2019).

Results. Spatial distribution of IAS *T. granifera* in the river of Southeast Sulawesi; was only found in inland clusters, among others: Kendari City, South Konawe, Bombana, Kolaka, North Kolaka, East Kolaka, Konawe and North Konawe. As for the regencies and city located in the islands, there were no such invasive Thiaridae snails. Spatial distribution of IAS *T. granifera* is presented systematically and descriptively using qualitative interpretations of the maps below (Figures 3-10):

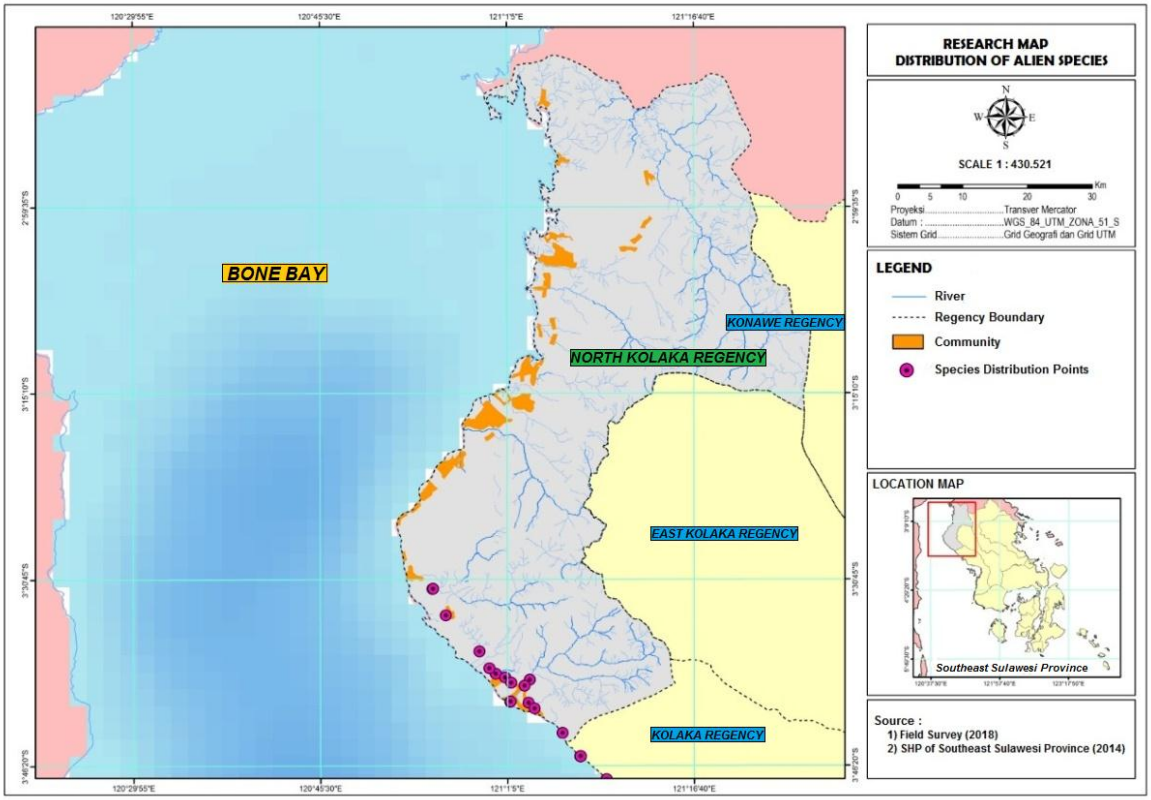

Figure 3. Map of *Tarebia granifera* distribution in North Kolaka.

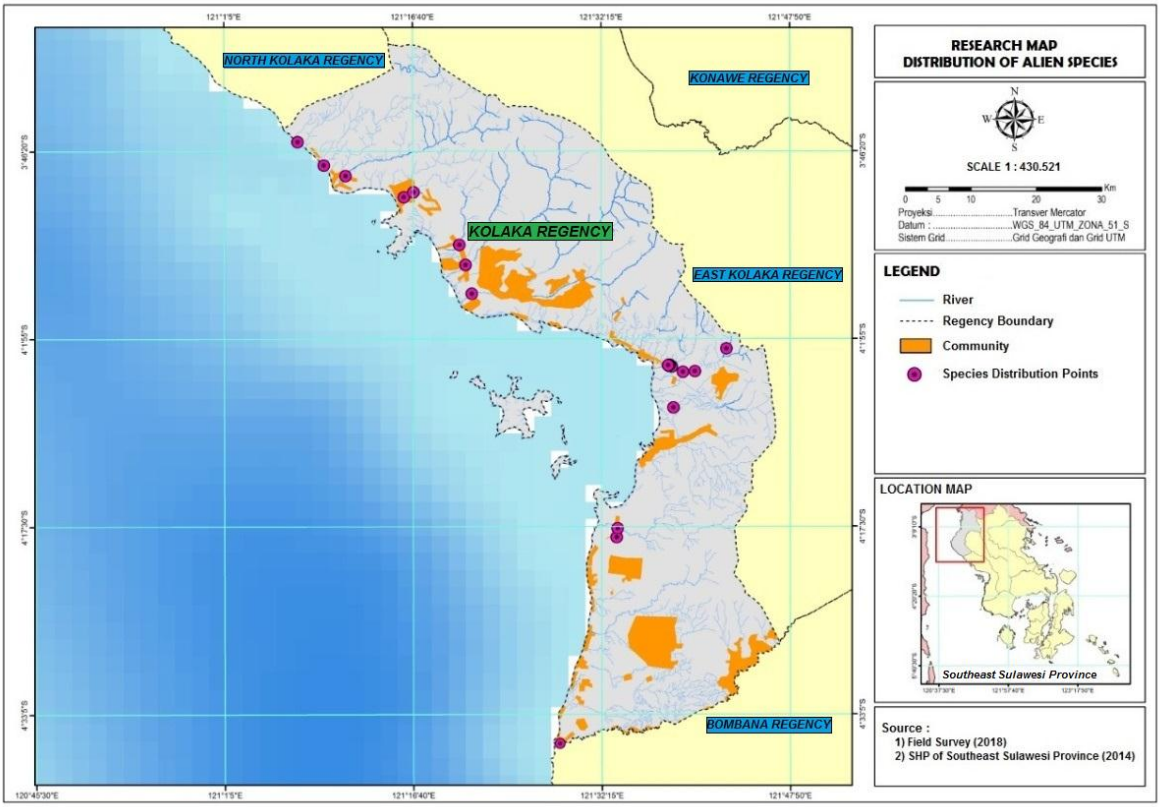

Figure 4. Map of *Tarebia granifera* distribution in Kolaka.

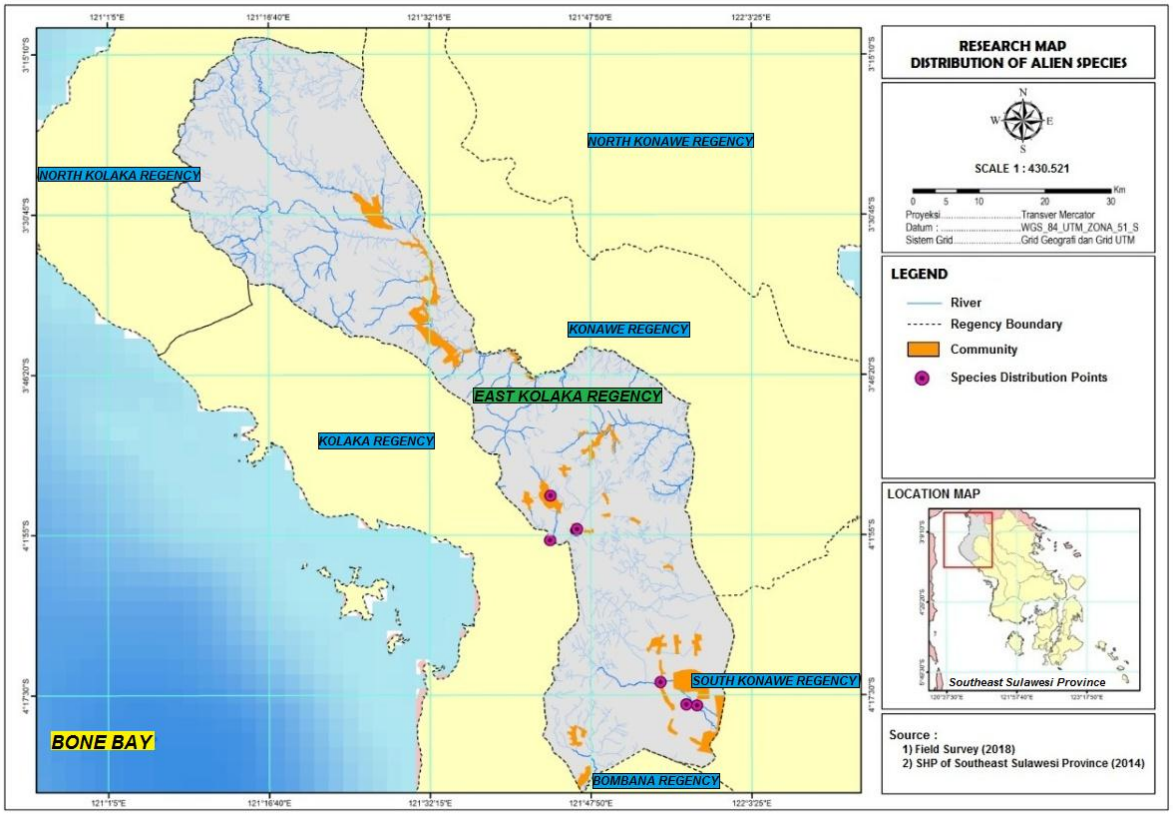

Figure 5. Map of distribution of *Terabia granifera* in East Kolaka.

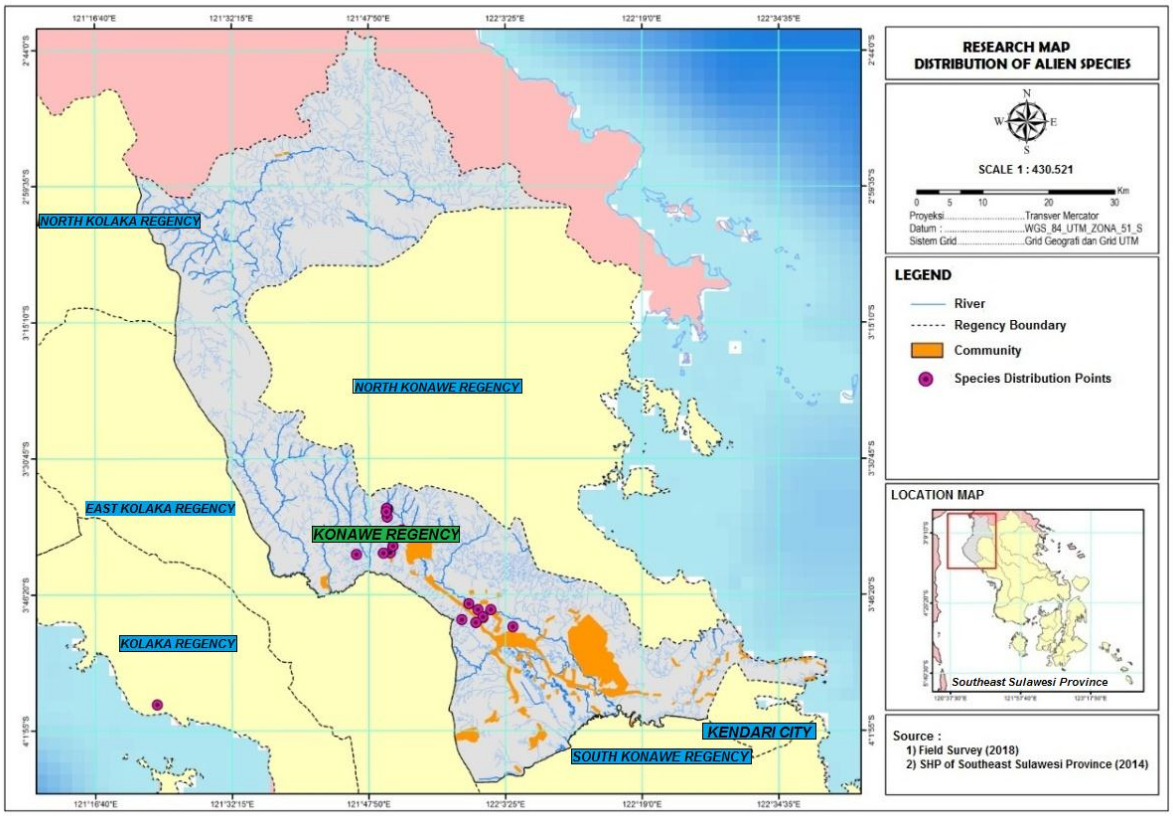

Figure 6. Map of *Tarebia granifera* distribution in Konawe.

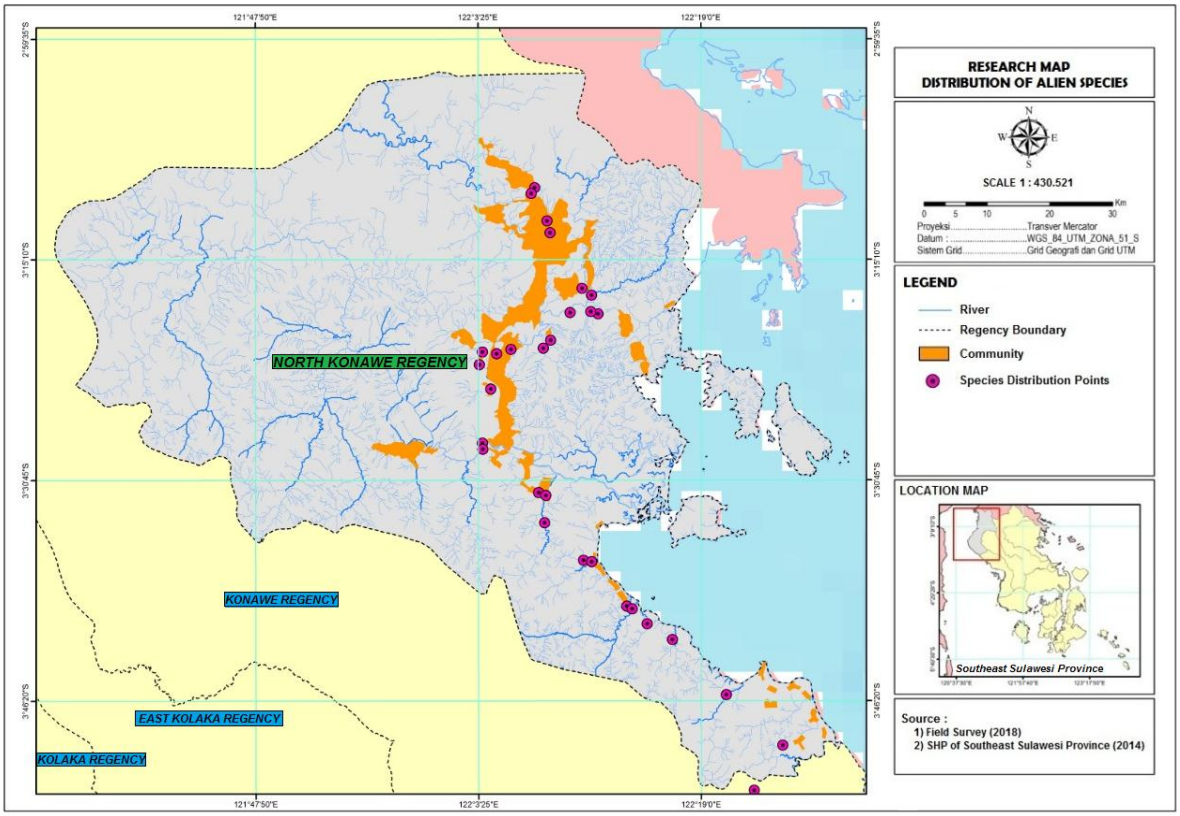

Figure 7. Map of *Tarebia granifera* distribution in North Konawe.

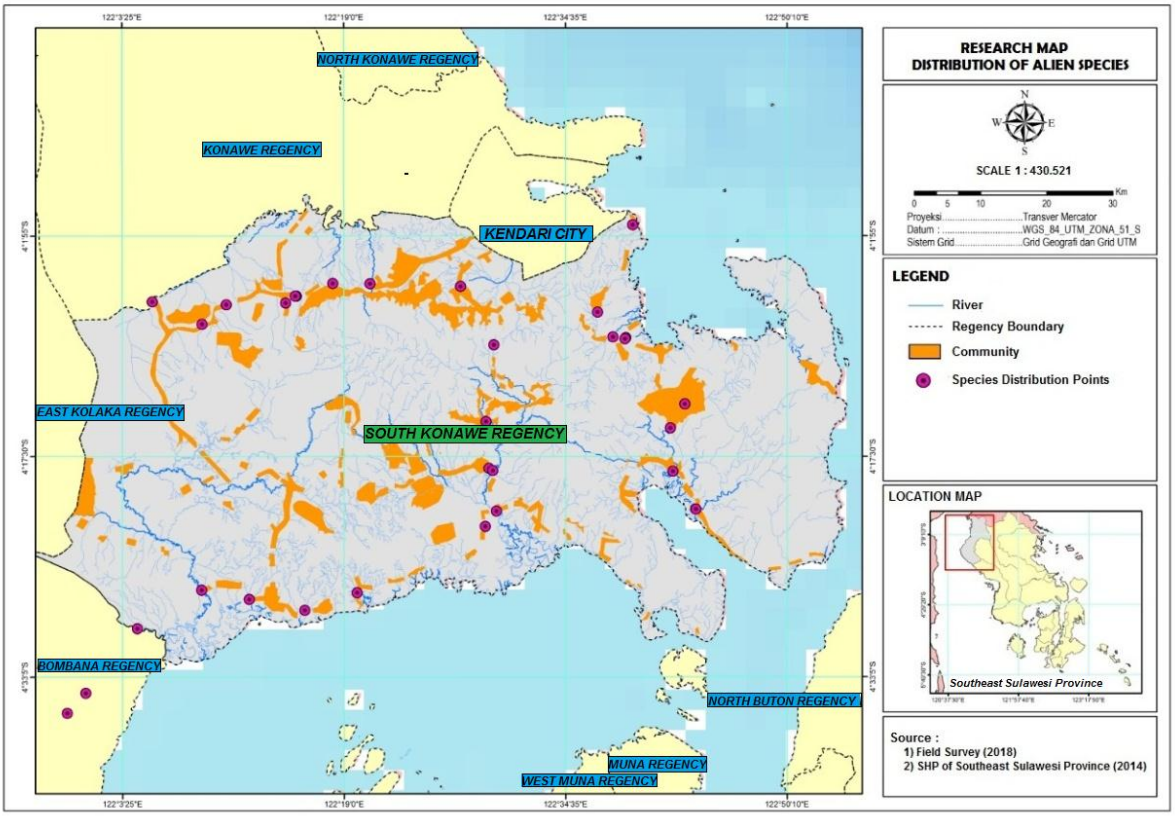

Figure 8. Map of *Tarebia granifera* distribution in South Konawe.

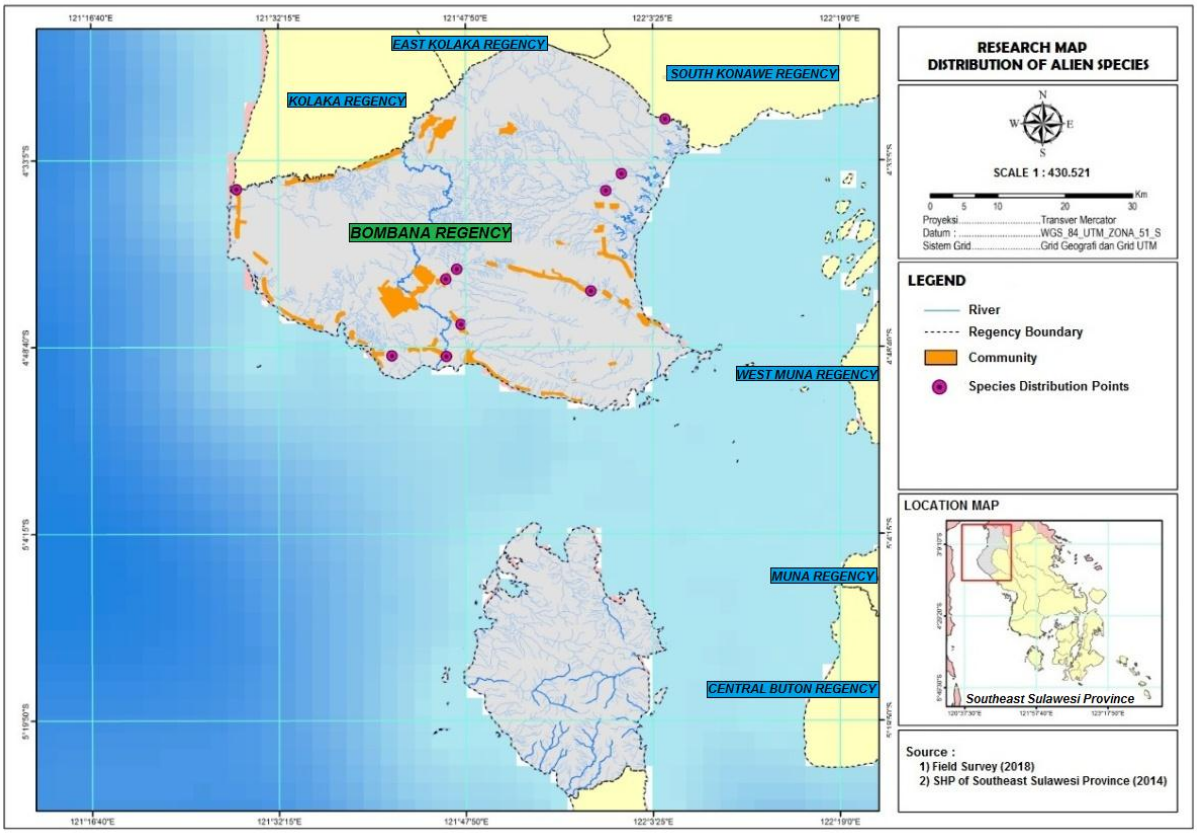

Figure 9. Map of distribution of *Tarebia granifera* in Bombana.

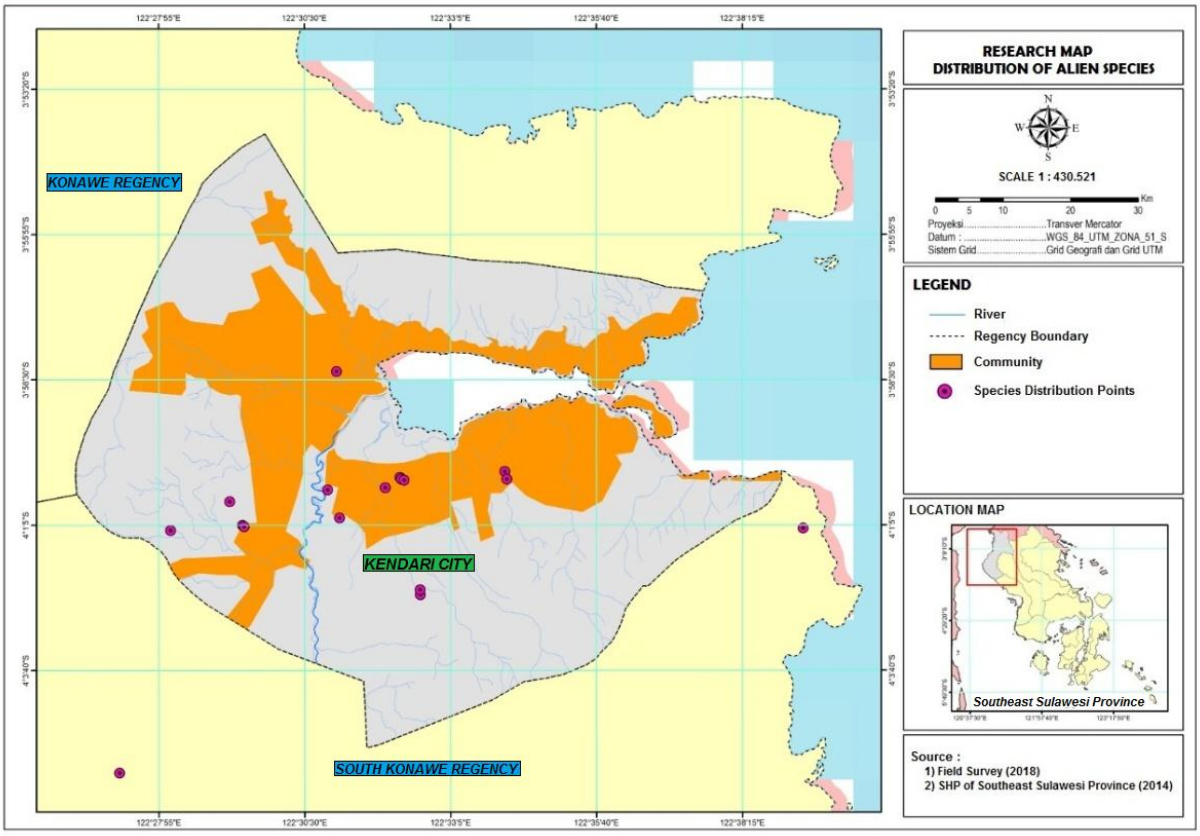

Figure 10. Map of *Tarebia granifera* distribution in Kendari.

Discussion. Distribution of *T. granifera* in North Kolaka was found in watersheds, with physical characteristics of calm currents, shallow waters (10-30 cm), in diameter of ±3 m. *T. granifera* was found in the following Districts: Wawo District (Walasiho Village, Latawe Village, Salurengko Village), Lambai District (Lambai Village and Woise Village), Ranteangin District (Ranteangin Village) and Lasusua District (Rante Limbong Village) (Figure 3). While in Kolaka Regency *T. granifera* was also found in watersheds, rice fields and canals of the following Districts: Toari District (Toari Village), Tangetada District (Lamedai Village, Kolaka District (Sabilambo Village, Balandete Village, Lalombaa Village) Wundulako District (19 November Village), Samaturu District (Konaweha Village, Samaturu Village, Amamotu Village) Wolo District (Ulu Wolo Village, Wolo Village) and Iwoimendaa District (Iwoimendaa Village, Tambambangan Village) (Figure 4).

Similar to Kolaka Regency, in East Kolaka *T. granifera* wa also found in watersheds, rice fields and canals. This IAS is also spread evenly in some districts: Mowewe District (Inebenggi Village, Horodopi Village, Woitombo Village, Polewali and Watupute Village), Tinondo District (Tinondo Village, Lamunde Village, Talata and Tawarombadaka Village) and Lambandia District (Penanggo Jaya Village, Penanggoosi and Penanggootu Village) (Figure 5). Furthermore, in Konawe Regency, *T. granifera* was found in the following districts: Puriala District (Puriala and Sonai Village), Lambuya District, Uepai District (Uepai Village), Unaaha District (Wawonggole, Puasaa, and Tuoy Village), Wonggeduku District (Lambangi, Lahotutu, Lalohao, and Wawoone Village), Amonggedo District (Amonggedo Baru Village) and Sampara District (Sampara Village) (Figure 6). Meanwhile, in North Komawe, this IAS was found in ±3 m diameter of watershed (calm current and shallow waters: 10-30 cm), in water fall, and in canal, all over the districts in North Konawe Regency, among others: Sawa District, Lembo District, Lasolo District, Molawe District, Oheo District, Asera District, Langgikima District and Wiwirano District. Spatial distributin of *T. granifera* is indicated in Figure 7.

In South Konawe Regency, a calm and shallow current (10-30 cm) river, was also suitable place for the survival of *T. granifera*. Invasive exotic species was distributed in several sub-districts in South Konawe, including: Moramo District (Moramo Village, Sumber Sari Village and Lapuko Village), Kolono District (Awunio Village and Roda Village), Laeya District (Punggaluku Village, Laeya Village), Konda Subdistrict, Ranomeeto Subdistrict, Landono Subdistrict, Tinanggea Subdistrict and Mowila Subdistrict. Spatial distribution of *T. granifera* in South Konawe Regency is indicated in Figure 8. The distribution of IAS *T. granifera* in Bombana Regency is in the watershed of Lantari Jaya District (Rarongkeu Village), Rarowatu District (Ladumpi Village), North Poleang District (Toburi Village), Poleang Timur District (Meambo Village, Bambaea Village), South Poleang District (Waemputang Village) West Poleang District (Toari Buton Village). Map of the spatial distribution of *T. granifera* in Bombana Regency is shown in Figure 9. Meanwhile, IAS *T. granifera* in Kendari City was found in watersheds and of Abeli District (Tobimeita Village), Poasia District (Anduonohu Village), Baruga District (Baruga Village), West Kendari District (Kemaraya Village), Puuwatu District (Puuwatu Village). The spatial distribution of *T. granifera* in Kendari City is displayed in Figure 10.

IAS *T. granifera* were spatially scattered in natural and artificial inland waters (rivers, dams, paddy fields, embankments and canals) in all regencies/cities in Southeast Sulawesi Province. This type of Thiaridae gastropods dominates in every ecological niche occupied. This condition was found in regencies/cities of mainland clusters, where in an area of 1 m^2 exists 55-87 individuals and the rest are individuals of Thiaridae snails of other types. High density of *T. granifera* (55-87 ind/m^2) indicates the ability of these organisms to adapt well to environmental changes. In addition, the reproductive cycle is short, so this species can grow and develop quickly. This snail's reproductive system basically does not require the presence of males to copulate. This type of reproduction was known as parthenogenesis, so that with its broad tolerance of water quality and short reproduction cycle, this species is able to invade the habitat of local/endemic snails.

Moreover, presence of *T. granifera* in rivers is generally characterized by ecological characteristics such as calm current, depth of 10-30 cm (litoral zone) and types of sandy clay substrate, and watersheds which were dominantly covered by canopy of river vegetation. This statement is in line with the study of Takdim & Annawaty

(2019), that *T. granifera* snail was an abundant species downstream of Pomua Palandu river, Poso with 85.3%. This is basically related to very slow current conditions and sandy mud-type substrates. According to Fajri & Kasry (2013) mud substrate is a substrate that contains a lot of organic matter. Gastropods and bivalves are found of mud or sandy mud habitats in the form of gathering and spreading (Indria et al 2017). This statement is confirmed by the results of Husnayati et al (2012), namely that a slow speed of flow in waters causes the waters to be dominated by muddy substrates that contain high amount of organic material. This creates a habitat which is very supportive to survival of freshwater snails. In addition, Athifah et al (2019) stated that *T. granifera* species from the family Thiaridae was the snail species that was most widely found at each station (127, 92 and 47 individuals) in fresh waters of Kebon Kongok, West Lombok landfill area. High density of *T. granifera* found is thought to be related to the substrate, the place where they live and feed and also their tolerance to extreme environments.

According to Syaifudin et al (2017) *T. granifera* is a type of Mollusca that is widespread in the whole Indonesian region and is found every day in rice fields and rivers. Furthermore, Rustiasih et al (2018) stated that the magnitude of *T. granifera* abundance in waters of Tukad Badung - Bali, was caused by conditions of water quality and ecological character that is very optimal for the survival of Thiaridae snails. The results of a recent research of Rustiasih et al (2018) further reinforce the alleged massive level of invasion of exotic species or alien species of *T. granifera* in Indonesia. In addition, there are also the latest researches that reported the presence of *T. granifera* in almost all Indonesian freshwater waters (Viza 2018; Safa'ah & Primiani 2018; Afkar & Aldyza 2017; Purbasari 2017; Assuyuti et al 2017). Studies on *T. granifera* generally described the same environmental conditions, where the Thiaridae family snails were found, thus indicating this species has a special preference for several parameters of the aquatic environment.

Several previous studies explained that Thiaridae snail (Mollusca: Gastropoda) type *T. granifera* was an IAS or exotic species, whose existence in ecosystem can disrupt the equilibrium of ecological system, especially if an aquatic region provides environmental conditions that are in accordance with its habitat or niche preferences. In addition, the parthenogenesis reproduction makes *T. granifera* snails to quickly reproduce without copulating with the opposite sex, because this reproductive system allows females to produce eggs that develop without undergoing fertilization (Didham et al 2007; Charles & Dukes 2007; López-López et al 2009; Moslemi et al 2012; Rangel Ruiz et al 2011). The substance of this research focuses on the sustainable management of invasive *T. granifera* species as a preventive measure in preserving local/endemic gastropods and bivalves resources in Southeast Sulawesi Province. Empirical information related to the spatial distribution of *T. granifera* in Southeast Sulawesi is a scientific reference in the management of local endemic species and as a form of control of ecological dominance of IAS in regency/city (land cluster) of Southeast Sulawesi.

Conclusions. Distribution of IAS *T. granifera* in Southeast Sulawesi is increasingly massive and its existence dominates the ecological system in which Thiaridae family snail grows and develops. Moreover, the existence of *T. granifera* gastropods is a threat to sustainability of freshwater commodity of Southeast Sulawesi. From 17 regencies (as survey sites), *T. granifera* was only found in 8 regencies, which are located in land area of Southeast Sulawesi, among others: Kendari City, South Konawe Regency, Bombana Regency, Kolaka Regency, North Kolaka Regency, East Kolaka Regency, Konawe Regency and North Konawe Regency. Meanwhile, in the archipelago of Southeast Sulawesi, *T. granifera* was not found at all.

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