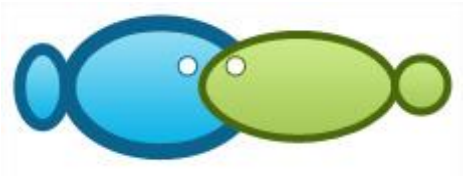

Preliminary study on the domestication of giant freshwater prawn, *Macrobrachium rosenbergii* (De Man, 1879) from North Kalimantan, Indonesia

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Abstract. The massive exploitation of giant freshwater prawn (GFP) (*Macrobrachium rosenbergii*) and the use of illegal catching methods have caused great threats to GFP populations, including in North Kalimantan. Therefore, domestication and farming of the origin prawn population is urgent. The purpose of this study was to analyze the domestication method of GFP in North Kalimantan waters. The research used a purposive sampling approach testing ecological parameters and the development of domestication, cultivation, and survival model methods as well as the level of osmotic work of the prawns. The prawns were collected from the estuarine area in the Bulungan (BL), Nunukan (NN), and Tana Tidung (TT) regencies. The success of domestication and cultivation of the prawns was highest in the NN district, while the highest mortality in domestication and cultivation was in BL District. The prawns survival rate during rearing in several salinities water (2±1 ppt, 5±1 ppt, 8±1 ppt, and 11±1 ppt) showed that the prawns from BL are weaker than the others. The successful domestication and cultivation data showed that the Nunukan giant freshwater prawn population has a higher level of adaptation to the culture environment than the Bulungan and Tana Tidung populations. Based on the survival rate and a number of moulting prawns we can state that the salinity of 8 ppt is more suitable to domesticate the local population of giant freshwater prawn of North Kalimantan.
Key Words: adaptation, local population, prawn, salinity, survival.

Introduction. The vast area of Indonesian water bodies that house diverse aquatic resources can potentially be developed to support the country's economy. The diverse aquatic flora and fauna have not been utilized optimally for the welfare of the Indonesian people. The giant freshwater prawn is a leading commodity among crustaceans due to its large size and high economic value in both on domestic and international markets. The giant freshwater prawn (*Macrobrachium rosenbergii*) is popular in many countries in Asia.

The largest producer of giant prawn in 2009-2018 was China, followed by Taiwan, and Thailand (Pillai et al 2022), India (Ray & Mukhopadhyay 2012; Sarkar et al 2017), Bangladesh (Alam & Alam 2014), and Vietnam (Thanh & Mather 2017). This commodity is also produced in small quantities in Costa Rica, Ecuador, Brazil, Malaysia (Pillai et al 2022), Indonesia (Khasani & Sopian 2021). The prawn's ecological preference is in tropical and subtropical climates,and it can adapt to freshwaters (Banu et al 2015; Paul et al 2016; Thanh & Mather 2017) and brackish waters (Alam & Alam 2014; Rebecca & Bhavan 2014; Indarjo et al 2021b).

Currently, the reported production of giant prawns in Indonesia relies on capture fishery, and they are captured with various fishing gears (Indarjo et al 2021a). In the North Kalimantan region, particularly in Salimbatu village, part of the Bulungan Regency, giant prawns are usually captured with traps, whereas in Sembakung Village, Nunukan, and Tana Tidung Regencies, the prawns are caught with fishing nets. Indarjo et al (2021a) report that the prawn price in Kalimantan varies greatly, depending on their size and season, with a price range of 2.69–7.4 USD per kg. The range size of the consumption prawns in the local market is between 10.3–50 cm, with larger prawns sold at a higher price (Indarjo et al 2020d; Indarjo et al 2020e).

Previous studies stated that the captured giant freshwater prawns in the estuaries of North Kalimantan province vary in size depending on the fishing gear (Indarjo et al 2021a). Several capture methods are adopted in these area, and occasionally, illegal fishing gears are also used. The most popular involves the application of poison, being reported to be widely used in Salimbatu village (Bulungan Regency) and Sesayap village (Nunukan Regency). The fishing method is the most simple way of getting abundant prawn catches, despite being detrimental to the environment and to other animals. Furthermore, Salim et al (2021b) reported that the degradation of natural habitats, reclamation of mangroves, water pollution and the use of illegal methods for catching prawn have caused great threats to freshwater prawn and fish populations in Kalimantan, and adversely affects the economy of local fishermen. Considering the sustainability of the local population of giant prawns in Kalimantan, hard efforts to domesticate and develop the cultivation technology of prawn must be carried out. Indarjo et al (2021b) reported that domestication is generally directed at aquatic biota that can survive and thrive in an environment provided by humans. However, to achieve this aim, there is a need to acquire relevant scientific data helpful in developing techniques for the successful domestication of giant prawns in captivity. According to Wyban (2007), Thanh & Mather (2017), and Sarkar et al (2017), domestication was developed to enrich the population, prevent degradation, restock aquatic biota, and increase the quality and quantity of fish production.

In Indonesia, giant freshwater prawns can be found widely in rivers, streams, estuaries, and mangrove areas. *M. rosenbergii* can tolerate a wide range of temperatures (14–35°C) and salinities (0–25 ppt) (New 1995; Indarjo et al 2020). Therefore, domestication of these species at several salinity levels is important to be conducted. The objective of the present study was to analyze the domestication method of giant prawns from North Kalimantan in the several water salinity levels.

Material and Method

Sample collection. The present study was conducted in March – September 2021 in three different districts, namely: Bulungan Regency (Salimbatu Village), Nunukan Regency (Sembakung Village), and Tana Tidung Regency (Sesayap Village) (Figure 1). The live giant prawn specimens from Nunukan (called Nunukan population) and Bulungan regencies (called Bulungan population) were caught using fishing nets, whereas the specimens from the Tana Tidung district (Tana Tidung population) were caught using prawn traps, locally known as "bubu" (Indarjo et al 2021a; Indarjo et al 2020d; Indarjo et al 2020e). The live prawns were transported to a small prawn hatchery at the Faculty of Fisheries and Marine Sciences, University of Borneo, Tarakan. The average of total length and body weight of the collected prawns are presented in Table 1. The total length (TL), body weight (BW) and sexes of all specimens of the giant prawns were recorded

and determined. Sex determination of the prawns was based on the presence of the petasma at the 1st pleopod for males and the thelicum between 4th and 5th pereopods for females (Brown et al 2010). Samples of hemolymph were collected from prawn specimens and sent to the Laboratory of the Faculty of Fisheries and Marine Sciences, Diponegoro University, Semarang, Central Java, for osmolarity analysis using the atomic absorption spectrophotometry (AAS) method (SOP Shimadzu AA-680).

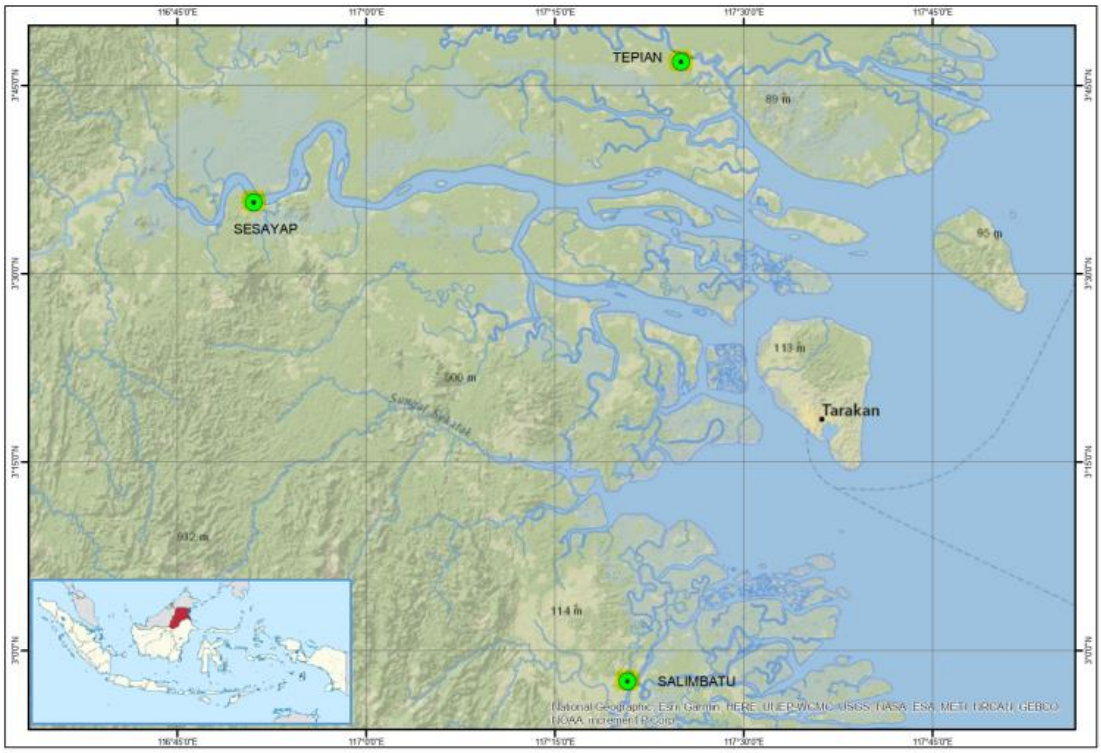

Figure 1. Map of the domestication research locations of giant freshwater prawn (*Macrobrachium rosenbergii*); Salimbatu village of Bulungan Regency; Sembakung village of Nunukan Regency; Sesayap village of Tana Tidung Regency; and Borneo University, Tarakan, North Kalimantan.

Table 1

The total length and body weight of collected prawns from three locations of North Kalimantan

Population	*Sex*	*Total length (mm)*	*Body weight (g)*
Bulungan	Male	14.55±4	31.76±10.47
	Female	12.13±4.12	20.37±12.26
Nunukan	Male	11.77±4.69	37.31±43.65
	Female	8.62±1.57	9.33±7.14
Tanah Tidung	Male	10.37±3.1	20.13±24.37
	Female	8.9±2.42	12.18±9.77

Experimental design and data collection. The present research was conducted based on a descriptive quantitative research method. The domestication and cultivation of the giant prawn specimens was carried out in a wet laboratory. The domestication of prawns was carried out randomly in 100 L glass tanks. A recirculation system was used to maintain the water quality. The prawns were fed fresh potatoes, 10% of their biomass in the morning. The remaining feed was removed from the rearing tanks every early morning before feeding. PVC pipes (10 cm diameter, 30 cm length) were used as shelter to minimize cannibalism. The domestication phase was conducted for 7 days using water

from estuaries (2±1 ppt salinity) where the prawns are present. The cultivation phase was done for 60 days. In this second phase, the prawns were reared at four salinity levels, namely S1 (2±1 ppt), S2 (5±1 ppt), S3 (8±1 ppt) and S4 (11±1 ppt) with four replications for each treatment. The osmotic work rate (TKO) of the prawns was estimated by the difference of osmotic pressure between the hemolymph of the prawns and the culture media. Finally, the domestication success and cultivation success rates were estimated based on the total number of prawns that survived at the end of domestication and cultivation. The number of molting prawns from different water resources (Nunukan, Bulungan Regency, and Tana Tidung populations) in different water salinities were counted and analyzed. Water quality parameters (pH, salinity, temperature, dissolved oxygen) were monitored daily using a water quality checker (Horiba) and a refractometer.

Data analysis

Osmotic work rate (TKO). The TKO was calculated based on Anggoro et al (2018):

TKO = [P osmo hemolymph - P osmo medium]

Where: TKO - osmotic work rate, mOsm/H_2O; P osmotic hemolymph - hemolymph osmotic pressure, mOsm/H_2O; P osmo-medium - osmotic pressure of the treatment medium, mOsm/H_2O; [] - absolute value. The TKO value was grouped according to Anggoro et al (2018) and Salim et al (2021b). The values were iso-osmotic (=0), hyperosmotic (>0), and hypoosmotic (<0).

Domestication success (DSc). The percentage of successful domestication was determined by the ratio between the prawn number at the end of domestication (TenD) and the total number of prawns (live and dead) at the early domestication (TeaD) stage. The DSc was calculated based on Salim et al (2021a):

DSc = TenD/TeaD x 100

Where: DSc - domestication success; TeaD - total number of prawns in early domestication; TenD - total number of prawns at the end of the domestication. The percentage of domestication success was interpreted as: perfectly adapting (100%), very well adapting (99.9-80%), well adapting (79.9-75%), moderately adapting (74.9-50%), poorly adapting (49.9-0.1%), and fail to adapt (0%).

Cultivation success. The percentage of cultivation success was estimated using the total number of prawns at the initial cultivation (end time of domestication) and the ratio of the number of live prawns at the end of the domestication stage, referring to Salim et al (2021a):

CSc = TenC/TeaC x 100

Where: CSc - cultivation success; TeaC - total number of prawns in the initial cultivation experiment (end of domestication); TenC - total number of prawns at the end of the cultivation experiment. The interpretation of the CSc follows Salim et al (2021a): perfect survival (100%), very good survival (99.9-80%), good survival (79.9-75%), moderate survival (74.9-50%), poor survival (49.9-0.1%), and complete mortality (0%).

Survival rate. The survival rate was calculated using the ratio between the number of the prawns at the end of the treatment (Nt) in different culture media and the number of live prawns at the beginning of the treatments regarding water salinity. The survival rate was calculated based on Effendie (1979):

SR = Nt/No x 100

Where: SR - survival rate; No - total number of prawns at the early stage of the experiment (S1, S2, S3, S4); Nt - total number of prawns at the end of treatment (S1, S2, S3, S4). SR was interpreted following Salim et al (2021a): perfect condition (100%), very good condition (99.9-80%), good condition (79.9-75%), moderately good (74.9-50%), poor condition (49.9-0.1%), and very bad condition (0%).

Results and Discussion

Domestication and cultivation success. The domestication and the cultivation success of the Nunukan population of giant freshwater prawn (88.57% and 59.68%, respectively) was higher than that of prawns from Tana Tidung population (67.74% and 57.14%, respectively) and of prawns from Bulungan population (66.6% and 30%, respectively). The domestication and cultivation success rates are illustrated in Table 2.

Table 2

The domestication and cultivation success level of giant freshwater prawn (*Macrobrachium rosenbergii*) from North Kalimantan

Location (Regency)	*Domestication*				*Cultivation*			
	Captured prawns	*Death*	*Survival*	*Success (%)*	*Initial number*	*Death*	*Survival*	*Success (%)*
Bulungan	30	10	20	66.67	20	14	6	30.00
Nunukan	70	8	62	88.57	62	25	37	59.68
Tana Tidung	62	20	42	67.74	42	18	24	57.14

Based on the domestication experiment, we can state that the prawns from Tana Tidung and Bulungan adapt well to rearing conditions, whereas prawns from Nunukan are adapting very well to the culture conditions. The prawns of Tana Tidung and Nunukan seemed to have good survival in all salinity treatments (2±1 ppt, 5±1 ppt, 8±±1 ppt, and 11±1 ppt). The SR of prawns from Bulungan in the cultivation phase was relatively low, between 20-40% (Table 3).

Table 3

The survival rate of giant freshwater prawn (*Macrobrachium rosenbergii*) in several salinities

Origin	*Survival (%) in the rearing water salinity (ppt)*			
	2	*5*	*8*	*11*
Bulungan	20	40	40	20
Nunukan	56	67	36	70
Tana Tidung	69	68	33	58

The domestication and cultivation success rates of male and female prawns were different. The domestication success of male prawns from the three locations was relatively similar (40–46.4%). Meanwhile, in the female population, the domestication success of Nunukan prawns was higher (89%) than others (62.9% and 66.7%). In the cultivation phase, the male prawns from Tana Tidung and the female prawns from Nunukan have a higher cultivation success (Table 4).

Table 4

The domestication and cultivation success of male and female giant freshwater prawn (*Macrobrachium rosenbergii*)

Population	*Domestication (%)*		*Cultivation (%)*	
	Male	*Female*	*Male*	*Female*
Bulungan	40.0	66.7	37.5	25.0
Nunukan	46.4	89.1	46.2	63.3
Tana Tidung	42.6	62.9	75.0	40.9

Osmolarity. Molting is a regular physiological process in the growth of crustaceans, including freshwater prawn (Silva et al 2019). The number of molting prawns in the treatments with different water salinity was different. The highest number of molting prawns was recorded in the water salinity of 8 ppt (9 prawns), followed by 5 ppt salinity (8 prawns), 11 ppt (5 prawns), and 2 ppt (3 prawns). Some prawns from Bulungan were observed to completely molt (7 prawns), while a fewer number (4 prawns) from Nunukan was observed to partially molt (Table 5).

Table 5

The number of molting giant freshwater prawns (*Macrobrachium rosenbergii*) in different salinity treatments

Origin	*Molting*	*The number of molting prawns*			
		Salinity (ppt)			
		2	*5*	*8*	*11*
Bulungan	Partial	0	1	3	0
	Complete	2	2	2	1
Nunukan	Partial	0	2	1	1
	Complete	0	2	1	1
Tana Tidung	Partial	1	0	1	1
	Complete	0	1	1	1

The osmolarity value of the prawns was affected by the water salinity. The osmolarity of the prawn hemolymph consistently increased with increasing salinity of the rearing water (Table 6). Hyperosmotic condition was observed in the higher water salinity treatments, 54-55 mgOsm L^{-1} and 139-140 mgOsm L^{-1} for 8 ppt and 11 ppt, respectively. On the contrary, the hypoosmotic condition was observed in the lower salinity treatments, -117-116 mgOsm L^{-1} and -32-30 mgOsm L^{-1} for 2 ppt and 5 ppt, respectively.

Table 6

The osmolarity and osmotic working level (TKO) of the prawns and prawn rearing water in the different salinity treatments

Population	*Osmolarity*	*Water salinity (ppt)*			
		2	*5*	*8*	*11*
Bulungan	Water sample	58	146	234	322
	Haemolymph samples	174	176	179	182
	TKO	-116	-30	55	140
Nunukan	Water sample	59	147	235	323
	Haemolymph samples	175	178	180	184
	TKO	-116	-31	55	139
Tana Tidung	Water sample	57	145	234	323
	Haemolymph samples	174	177	180	183
	TKO	-117	-32	54	140

The strong increase in aquaculture production has relied mainly on the domestication of an increasing number of fish species. Domestication is classified into five levels. The first level is the first trial of acclimatization to the captive environment, and the top level is using a selective breeding program focusing on specific goals (Teletchea 2019). Therefore, the domestication effort in this study was categorized in the first level.

In this study, the domestication of giant freshwater prawns from North Kalimantan was carried out to anticipate a population decline because of overexploitation and ecosystem damage. The successful cultivation of the prawn, both for males and females was carried out using the domestication success (KbD) method to compare the total catches and stocked prawns to the domesticated prawns. Based on the KbD of the three populations, we observed a difference in adaptability levels between the sexes and

among the populations. In the male prawn population, 40.0-46.4% of the prawns had low adaptability, with KbD values of 0.1 to 49.9%. Meanwhile, 50.0-74.49% of the female prawns collected from Bulungan and Tana Tidung have fairly good adaptability, with a KbD value between 62.9-66.7%. The collected prawns from Nunukan have excellent adaptability (KbD=80-99.9%). These differences in adaptability levels are caused by several factors, including size, sexes, environment characters of the water resource, and transportation. Mohanta (2000) stated that transportation of wild broodstock of giant freshwater prawn causes stress to the animal resulting in high mortality.

In this study, the higher adaptability level (lower mortality) of the female prawns compared to males is in line with previous research. Cavalli et al (2001) reported that the mortality of male giant freshwater prawns from the wild populations during the acclimation period was higher than that of females. The SR of males in the rearing period was only 16.7%, less than the SR of females, of 83.3%. They explained that the high mortality of collected prawns is commonly caused by epibiont fouling on the prawn carapace. Moreover, Khasani (2010) noted that the mortality of male prawns in the spawning period is higher (50%) than that of females (25%).

In the prawn domestication process, environmental changes between natural conditions and cultivation conditions must be kept to a minimum level. According to Indarjo et al (2021b), domestication success is affected by the adaptability level of the prawns to the environmental changes. Therefore, several salinities were used in this study. Environmental factors such as temperature and salinity play important roles in the development and growth of decapod crustaceans. *M. rosenbergii* can tolerate a wide range of salinities (0–25 ppt) (Habashy & Hassan 2010; Chand et al 2015). In the salinity treatments, all of the three prawn populations had hypoosmotic conditions at salinities of 2 ppt and 5 ppt, with an osmotic working level ranging from -117 to 116 mgOsm L^{-1} and -32 to 30 mgOsm L^{-1}. Based on the data in Table 6, an ideal osmolarity was detected at a salinity of 8 ppt. In these salinity levels, the osmotic working level is close to zero, with a positive value (hyperosmotic) within 54 to 55 mgOsm L^{-1}. The molting process (Table 5) shows that the number of molted prawns in the salinity of 8 ppt was higher than in the other salinities. In addition to be partially caused by salinity, the high number of molting prawns is also influenced by the optimum level of other water parameters, including temperature (27 to 28^{o}C), pH (5.5-5.8), and DO (5.3 to 5.6 mg L^{-1}). According to Anggoro & Nakamura (1996), the factors that influence prawn molting were stress caused by environmental changes (salinity, light intensity, temperature, pH, and DO), feeding activity, and prawn age. Indarjo et al (2021b) explained that the molting process under stress conditions will cause the imperfection (partial molting) of the process. In sub-optimal conditions, the energy obtained is not optimally used for growth due to part of the energy being used for adaptation and survival. Salim et al (2021a) stated that partial molting is due to insufficient energy and interference from other prawns. Moreover, the effect on the prawns of sub-optimal conditions, such as high salinity, was reported by Sahri et al (2014), with osmotic disturbances causing mortality, especially in the embryo and larvae phases.

Conclusions. The successful domestication and cultivation showed that the Nunukan giant prawn population has a higher level of adaptation to the conditions of the cultivation environment than the Bulungan and Tana Tidung populations. Based on the survival rate and the number of molting prawns, we can state that the salinity of 8 ppt is sufficient to domesticate the local giant freshwater prawn from North Kalimantan. The development of giant freshwater prawn farming using a local domesticated population of the North Kalimantan must be established as a first step in providing prawn juveniles for the conservation of the prawns in nature.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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