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Growth patterns of captive painted terrapins *Batagur borneoensis* in the Aceh Province, Indonesia

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Abstract. *Mawardi AL, Atmaja THW, Sarjani TM, Khalil M, Sarong MA, Yusriono. 2022. Growth patterns of captive painted terrapins* Batagur borneoensis *in the Aceh Province, Indonesia. Biodiversitas 23: 4872-4878.* Painted terrapin is one of the endemic animal species found only in Indonesia and Malaysia. These animals live in very wide waters, which include rivers, mangroves and coastal areas. The purpose of this study was to determine the growth pattern of *Batagur borneoensis* at the Marine Tuntong Education and Conservation Center, *Satucita Lestari Indonesia Foundation*, Aceh Province. The study used a survey method with data collection techniques by direct observation to the location of the captive *B. borneoensis* to obtain comprehensive data. The sample used in this study was the captive-bred *B. borneoensis* at the Marine Tuntong Education and Conservation Center *Satucita Lestari Indonesia Foundation* with different age variations, including 2 months, 2 years, 3 years and 4 years, with a total sample 3 individuals per age category. Parameters measured in this study included the total weight of *B. borneoensis*, carapace arch length and carapace arch width. In general, the growth pattern of *B. borneoensis* found in the education and conservation center at YSCLI is classified as negative allometric, this growth indicates that length growth is faster than overall body weight gain. When viewed based on the age difference, the growth pattern of *B. borneoensis* aged 2 months to 2 years is still classified as positive allometric, but when it is 3 to 4 years old, it only changes to negative allometric. It can be concluded that for the age of 2 years and under, the captive process of *B. borneoensis* is still suitable, but when it is over 2 years old, it is no longer suitable for captivity, considering that the animal's growth pattern is not balanced between carapace length and total body weight. It is recommended that if the animal is over 2 years old, it should be immediately released into its natural habitat in the wild so that it can live and develop naturally in order to preserve the aquatic biota.

Keywords: Captivity policy, conservation, endangered species

INTRODUCTION

Batagur borneoensis is one species of painted terrapin that is classified as an endemic animal species. This animal is only found in certain areas in river waters to coastal areas. This painted terrapin is a rare species, the population is only found in the coastal areas of Southeast Asia, which includes Indonesia and Malaysia (Andersen et al. 2021; Tan et al. 2022). Based on the results of research that has been carried out in Indonesia, this painted terrapin is only found in Sumatra and Kalimantan (Hernawan et al. 2019; Rahayu et al. 2021). Based on data from the IUCN Red List of Threatened Species, *B. borneoensis* is one of the animals that has been classified as an endangered species. The results of the population trend assessment show that the population of this animal species has decreased from year to year (Shepherd et al. 2021). This is due to the condition of the declining population in their habitat and the condition of the painted terrapin's habitat, which is increasingly being eroded due to illegal logging of mangrove forest vegetation. Mangrove vegetation is one of the areas for the survival of these animals (Saputra et al. 2021).

The original habitat of this painted terrapin is in a very wide water area, including watersheds, mangrove ecosystem areas and coastal areas. Immature painted terrapins are often found in river flows and in mangrove areas, while adults are often found in mangrove areas and the coast (Behera et al. 2019; Jualaong et al. 2019). These animals are more active in the afternoon until the evening to find food, mate, and to lay eggs. In the afternoon, painted terrapins are often found in their natural habitat to bask on tree branches and branches and look for food. These animals are very sensitive to noisy environments, so they need a relatively quiet habitat. According to information from local coastal communities, painted terrapins lay eggs in coastal areas at night when the environment is quiet (Mallick et al. 2021; Mim et al. 2022).

These animals are omnivores, plant vegetation found in river waters and mangrove plant vegetation are the main food sources in addition to various species of shrimp and fish found around the environment where these animals live (Arceo-Carranza et al. 2021; Lovich and Whit 2022). For stable survival in their habitat, the plant vegetation must be available in sufficient conditions (Nagy 2021). Food is one of the main factors needed by every individual

to be able to survive optimally in a habitat. If the availability of food in an environment has begun to decline, there will usually be competition for food, so the growth and condition of the animal population will also be disrupted. Even if there is a food shortage, some animal species will migrate to other places with more available food sources in the environment (Nagy 2021; Pillans et al. 2021).

Due to illegal hunting carried out by the community and taking eggs for consumption, the population of *B. borneoensis* is increasingly decreasing in its natural habitat (Saputra et al. 2021). This is because painted terrapin eggs are believed by the coastal community of Seruway to have high nutritional content and good properties to increase stamina. Based on the public's belief in the efficacy of this animal's eggs, the price of eggs is in great demand by the public for consumption, thus causing the price of painted terrapin eggs to be very expensive (Marshall et al. 2020). This is what causes coastal communities to engage in poaching painted terrapin eggs increasingly, given the increasingly high market demand (Mardiastuti et al. 2021; Tshewang et al. 2021).

The occurrence of uncontrolled poaching of painted terrapin eggs by the coastal community of Seruway caused concern by some people who still care about the sustainability of this animal population, so a foundation was formed to conserve painted terrapins. YSCLI has a role in monitoring and taking eggs in the habitat to be hatched ex-situ to avoid poaching and predation from predatory animals. After hatching, these painted terrapin hatchlings are in the form of hatchlings, then they are conserved in captivity until the carapace grows hard, so they are able to live independently in their natural habitat. If they can live independently, these animals, which are still in the form of hatchlings, are then released back into their habitat to live and develop naturally. This research needs to be done to see the growth pattern of *B. borneoensis* at the Marine Tuntong Education and Conservation Center of the Satucita Lestari Indonesia Foundation (YSCLI).

MATERIALS AND METHODS

Study area

This research was conducted from May to June 2022. The study was conducted at the Marine Tuntong Education and Conservation Center of the Satucita Lestari Indonesia Foundation (YSCLI), located in Seruway, Aceh Tamiang District, Aceh Province, Indonesia (Figure 1). The YSCLI Marine Tuntong Education and Conservation Center is a place of education for the community, students and university students in an effort to educate the general public in efforts to conserve the painted terrapin so that this animal species is maintained and sustainable in its natural habitat.

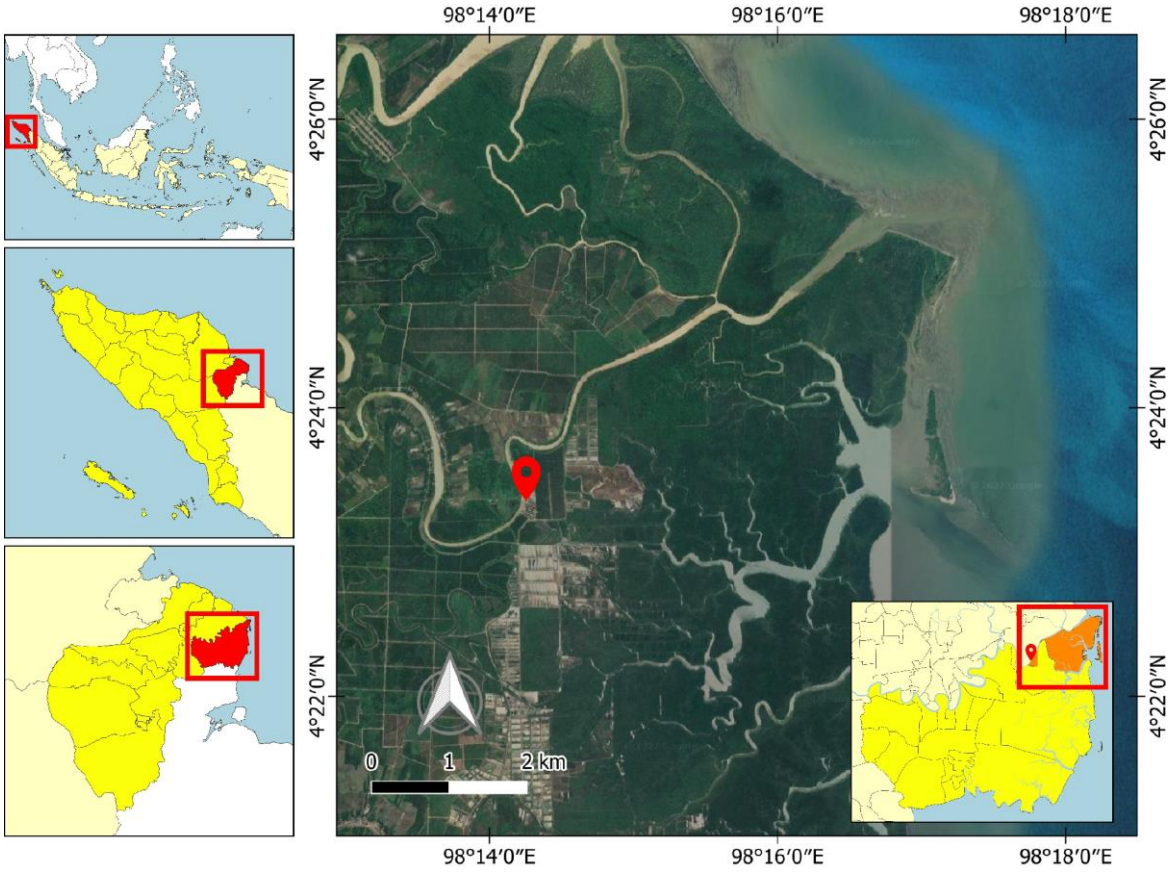


Figure 1. Map of research locations on growth patterns of *Batagur borneoensis* in Seruway, Aceh Tamiang, Indonesia

Procedures

Research methods

The study used a survey method with data collection techniques by direct observation to the location of the *B. borneoensis* captivity to obtain comprehensive data.

Sample selection

The sample used in this study was captive-bred *B. borneoensis* at the Marine Tuntong Education and Conservation Center Satucita Lestari Indonesia Foundation with different age variations, including 2 months, 2 years, 3 years and the age of *B. borneoensis* 4 years, with a total sample of each age 3 individuals. The sample of *B. borneoensis* in this study is the eggs taken when the species lay eggs at night on the Seruway beach. The egg hatching process is carried out ex-situ at YSCLI. Newly hatched hatchlings are kept together in captivity with a size of 5x5 m. This captivity has included a pond, sundeck, and shelter as a hiding place to be similar to its natural habitat. The feed given is in the form of pellets and vegetables, which are given routinely 2 times a day, in the morning and evening.

Sample parameter measurement

The measurements were conducted at the location of the captivity. Parameters measured in this study included the total weight of *B. borneoensis*, carapace arch length and carapace arch width. The measurement of the length of the carapace arch and the width of the carapace arch used a centimeter, while the measurement of the total weight of *B. borneoensis* using a digital scale (0.1 g accuracy) can be seen in Figure 2. The measurement of all parameters needed in this study was carried out in direct captivity to minimize stress levels. *Batagur borneoensis* species, considering this animal is a biota that is very sensitive to noise and new environmental changes.

Data analysis

Analysis of the data used to determine the relationship between carapace arch length and the total weight of *B. borneoensis* used the following formula:

$$\text{Log } W = \log a + b \log L$$

Where, W: Total weight (g); L: Carapace arch width (cm); a and b: Constant

To find out Constants a and b use the following formula:

$$\text{Log } a = \frac{\Sigma \log W \times \Sigma(\log L)^2 - \Sigma \log L \times \Sigma(\log L \times \log W)}{n \times \Sigma(\log L^2) - (\Sigma \log L)}$$

$$\text{Log } b = \frac{\Sigma \log W - (n \times \log a)}{\Sigma \log L}$$

To see the growth pattern that occurs in *B. borneoensis* in captivity YSLI with the formula used:

$$W = {}_aL^b$$

Where, W: Total weight (g); L: Carapace length (cm)

Figure 2. The process of measuring weight and carapace length of *Batagur borneoensis*

The growth of the length of the carapace of *B. borneoensis* is balanced with the increase in total weight, it is said to be isometric (b: 3), whereas if the value of b is greater than or less than 3, the growth is said to be allometric, assuming that if the value of b<3, the increase in the length of the carapace of *B. borneoensis* is faster than the weight gain, whereas if the value of b>3 the weight gain was faster than the increase in carapace arch length. Further regression analysis was used to study the relationship between carapace curvature length-width, body weight-carapace curvature length, and carapace curvature width-body weight (Talukdar et al. 2021; Yusup et al. 2021).

RESULTS AND DISCUSSION

Morphometric *Batagur borneoensis*

Measurement of morphometric parameters that have been carried out on 12 individuals of *B. borneoensis* with different age variations consisting of 2 months to 4 years of age found at the Marine Tuntong Education and Conservation Center, Satu Cita Lestari Indonesia Foundation, Aceh Tamiang District, Aceh Province. Body weight ranged from 48 g to 1470 g, the highest body weight was at the age of 4 years, while the lowest body weight was at the age of 2 months. Likewise, the length of the carapace arch ranged from 7 cm to 22 cm, this parameter was also similar to the body weight of *B. borneoensis*, the highest carapace arch length was found at the age of 4 years while the lowest carapace arch length was found at the age of 2 months (Table 1). In general, the growth of carapace arch length, carapace arch width and body weight was influenced by age, the higher the age of *B. borneoensis*, the increase in length, width and body weight was directly proportional.

Table 1. Maximum and minimum morphometric measurement of *Batagur borneoensis* at YSCLI Aceh Tamiang District, Aceh Province (N: 12 Individuals)

Age group	LCC (cm)	CCW (cm)	Weight
2 months	7-8	7-8	48-93
2 years	14-14.5	14-14.5	319-378
3 years	16-17	16-17	717-812
4 years	21-22	21-22	1297-1470

Note: LCC: Length of Curved Carapace; CCW: Carapace Curve Width

The relationship between length and width of carapace arch and body weight

Regression analysis determines several parameters of the relationship between carapace arch length, carapace arch width and body weight of *B. borneoensis*. Positive linear relationship between carapace length and body weight, and carapace width and body weight. A positive linear relationship can be seen as the carapace length increases, it is followed by an increase in body weight and carapace width. A positive linear relationship was also seen that the increase in carapace length was directly proportional to the increase in the width of the carapace arch of *B. borneoensis*. This shows that when there is an increase in the age of this aquatic biota species, it is also followed by an increase in carapace length, carapace width and overall body weight (Figure 3).

Growth pattern of *Batagur borneoensis*

The results of the analysis of growth patterns of *B. borneoensis* as a whole showed that growth occurred in a negative allometric manner (Table 2). Negative allometric growth indicates that there is poor growth of these aquatic biotas, where growth in length of *B. borneoensis* is faster than growth in total body weight.

Based on the age difference, which varies greatly from the growth pattern of *B. borneoensis* found in the Marine Tuntong Education and Conservation Center, Satu Cita Lestari Indonesia Foundation, Aceh Tamiang District, Aceh Province, it is found that the growth pattern is very varied. Positive allometric growth patterns were found at the age of 2 months to 2 years, but there was a different growth pattern when they were 3 to 4 years old with negative allometric growth patterns (Table 3). The positive allometric growth pattern found at the age of 2 months to 2 years explains that *B. borneoensis* in captivity YSCLI body weight growth is faster than carapace length growth. But it's different when it's 3 years old to 4 years old, where the growth in length occurs faster than the growth in body weight, so this animal looks slimmer and looks a bit thin.

Discussion

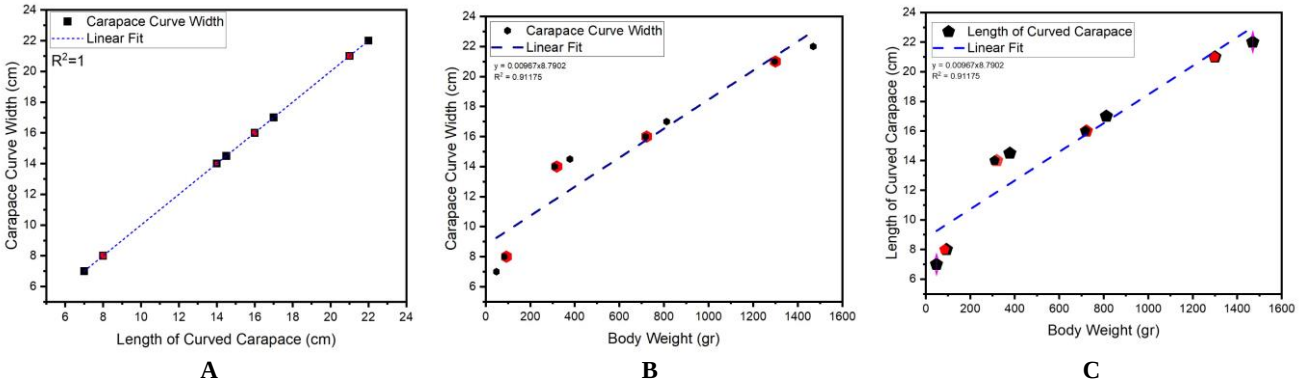
The population of reptiles belonging to the *Batagur* genus in various parts of the world at this time is very alarming. This condition occurs due to human activities that continuously utilize plant vegetation in the mangrove ecosystem to meet the needs of a better life (Estoque et al. 2018; Rudianto et al. 2020; Bhowmik et al. 2022). Various human activities continue to exploit natural resources uncontrollably, which is the habitat of various biota that live in it, including the *Batagur* habitat. For now, this animal is only found in several countries, including Malaysia, Thailand and Cambodia, in these three countries *B. affinis* is found, this animal is also in very poor condition, so a conservation process has been carried out (Moll et al. 2015; Çilingir et al. 2019; Jualaong et al. 2020; Camara and Jamil 2021). Likewise, with *B. borneoensis*, this animal is now only found in Indonesia and also neighboring Malaysia. The current population condition is also not much different from that of *B. affinis*, which has begun to decline in its population found in its original habitat in Seruway, Aceh province (Mardiastuti et al. 2021; Saputra et al. 2021).

Table 2. Growth Pattern of *Batagur borneoensis* in YSCLI Aceh Tamiang District, Aceh Province, Indonesia

Equation relationship of length and weight	R^2	A	B	Growth pattern
$_{0.7366}L^{2,9134}$	0.9807	0.7366	2.9134	Negative allometric

Table 3. Growth Pattern of *Batagur borneoensis* by Age at YSCLI Aceh Tamiang District, Aceh Province, Indonesia

Age group	Equation relationship of length and weight	R^2	A	B	Growth pattern
2 months	$_{2.1826}L^{4.572}$	0.9796	2.1826	4.572	Positive allometric
2 years	$_{3.566}L^{5.2899}$	0.9784	3.566	5.2899	Positive allometric
3 years	$_{0.4547}L^{1.995}$	0.9975	0.4547	1.995	Negative allometric
4 years	$_{0.4125}L^{2.6667}$	0.9997	0.4125	2.6667	Negative allometric



A **B** **C**

Figure 3. Analysis of the Relationship (A) Carapace Curvature Length-Width; (B) Body Weight-Carapace Curvature Width; (C) Lenghr Carapace Curvature- Body Weight

The cause of the decline in the population of *B. borneoensis* found in the waters of Seruway, Aceh Province, is the high level of illegal hunting carried out by the community, both for their parents to be traded illegally and illegal hunting of their eggs for consumption. Habitat conditions that are increasingly being eroded due to illegal logging of mangrove forests in coastal areas, which are habitats for these animals, also have an impact on the decline in the population of these animals (Arifanti et al. 2022; Savari et al. 2022). Mangrove plants, both leaves and fruit, are one of the main food sources for these aquatic species, as well as various species of shrimp and fish, so these animals are omnivores (Bhupathy and Mathur 2013; Hairul and Shahrul 2014). Trunks and branches of mangrove vegetation are often found as a place for sunbathing and resting in the afternoon in a quiet and stable environmental condition.

As a result of the disruption of the habitat of *B. borneoensis* in Seruway, Aceh Province, the idea arose from the surrounding community who still cared about the existence of this species, so YSCLI was formed as an effort to educate the public about the role of ecosystems as habitat for this endemic animal so that it is maintained and sustainable. By conserving eggs and hatchlings, after the hatchlings are independent, they are then released back into their natural habitat. The captive process is one solution that must be done for the conservation of animal species that have begun to be threatened from extinction in their natural habitat in aquatic areas (Mim et al. 2022). If breeding activities for eggs and hatchlings of *B. borneoensis* are not carried out, it is feared that the eggs and hatchlings of these animals have a very high chance of being preyed on by predatory animals and hunted by the public for sale and collection as pets (Stanford et al. 2020). *B. borneoensis* hatchlings that are still unstable with very slow mobilization capabilities in coastal waters and with soft carapace conditions will certainly become food for various predatory animals if conservation is not carried out in captivity.

In general, the growth pattern of *B. borneoensis* found in the education and conservation center at YSCLI is classified as negative allometric, this growth indicates that length growth is faster than overall body weight gain. Negative allometric growth indicates that the growth that occurs in this animal species is not good. This is, of course, caused by several factors, including environmental and food factors (Saputra et al. 2020). Food is one of the factors that has a very large influence on the growth and development of an organism, including painted terrapin. Food that is routinely given by YSCLI to *B. borneoensis* species as the main food is in the form of pellets and vegetables such as kale, spinach and water hyacinth. Of course, this feed certainly does not fulfill the nutritional elements needed by aquatic animal species due to the lack of variety in the food provided. Pellet feed also certainly does not meet the nutritional needs of aquatic omnivorous animals, so when they are older, the growth of these animals does not occur ideally and tends to be thin. If the availability of the amount of food, both in quality and quantity, of course, the animal will grow normally, but if the food, both in quality and quantity, is not available optimally, of course, the growth of the animal will not be good (Mourniaty et al. 2019; Arceo-Carranza et al. 2021).

If you look at the age difference, the growth pattern of *B. borneoensis* found in the education and conservation center at YSCLI at the age of 2 months to 2 years is still classified as positive allometric, but when it is 3 to 4 years old, it only changes to negative allometric. This indicates that the growth pattern of these animals at the age of 2 years and under is still good, where the growth of body weight is faster than the growth of length. This kind of growth is certainly very good for biota that lives in captivity locations because these animals look fat and healthy (Puteri et al. 2019; Mughni et al. 2022). However, it is different when the animal is over 2 years old in captivity, where the growth pattern has begun to be unbalanced and tends to be thin and lean. It is suspected that the narrow and noisy environment of captivity caused by human activities causes these animals to not be able to grow normally. *Batagur borneoensis* is an animal species that is very sensitive to the environment, if the environment tends to be noisy and unsupportive, these animals often hide in the water rather than come to land either to find food, lay eggs, or to sunbathe. It is suspected that the growth of *B. borneoensis*, which is over 2 years old, has begun to be disturbed if its activities are still conserved at the captive location. When the animal begins to grow into adulthood, of course, the aquatic animal has begun to form its instincts so that it has begun to appear sensitive to environmental noise, this is what causes the growth of the animal to increase in carapace length faster than the growth of total body weight.

The process of conservation of animals that have been categorized as endangered species is one of the most appropriate efforts to do, including the conservation of the *B. borneoensis* species found on the coast of Serway, Aceh Province. This conservation activity is carried out as an effort to maintain and preserve endemic animal species that are categorized as endangered animals that are only found in certain areas. This animal certainly has very specific habitat characteristics, so the conservation process is carried out only at the age phase, which is still in the hatchling phase, if it is of adult age and productive age, it must be immediately released to its original habitat so that mating and egg-laying processes occur. The process of conserving these animals is still feasible, from eggs to neonates of these animals up to 2 years old, because these animals are still normal and ideal plants. When the hatchlings are over 2 years old, they should be immediately released into their natural habitat, considering that when they are over 2 years old, the animal is not growing ideally. This is because when it reaches adulthood, the animal has begun to appear its original nature, which is very sensitive to environmental noise, so that it has an impact on diet and activity patterns which will eventually have an impact on the growth and development of the animal is disturbed. The findings in this study can be used as recommendations for captive management in *B. borneoensis* conservation efforts (Fagundes et al. 2018)

Based on the study's results, it can be concluded that the growth pattern of *B. borneoensis* found in the Marine Tuntong Education and Conservation Center of the Satu Cita Lestari Indonesia Foundation, Aceh Province is generally allometrically negative. If viewed based on age, the positive allometric growth pattern was found in *B. borneoensis* aged 2 months to 2 years, but if the age was over 2 years, the growth pattern had led to a negative allometric. Conservation efforts against *B. borneoensis* are very suitable to be used to prevent the extinction of these animals, but it is recommended until the animals are under 2 years old. When it is over 2 years old, it should be immediately released to its natural habitat, considering that at that age, *B. borneoensis* is no longer suitable to live in captivity because its growth pattern is not ideal.

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