Growth, food efficiency, and survivorship of several fish species treated with artificial feed enriched with *Alstonia acuminata*

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Abstract. This study aims to determine the growth rate of rabbitfish *Siganus guttatus*, snapper *Lates calcarifer,* tiger grouper *Mycteroperca tigris* and humpback grouper *Cromileptes altivelis* using artificial feed enriched with *Alstonia acuminata*. It was carried out in seawater of Kelanit village, southeast Mallucas district. This experiment used fish with a total length of 13-14 cm (35-37 g) for *C. altivelis*, 11-12 cm (32-34 g) for *S. guttatus*, 14-15 cm (43-45 g) for *M. tigris*, and 21-23 cm (127-130 g) for *L. calcarifer,* respectively. Experimental fish were kept in floating net cages with 100 individuals of each species. The feed used was pellet feed with the addition of *A. acuminata* plant which was given twice a day as much as 5% of the fish biomass. The experimental design used was a randomized block design with 3 replications for 60 days of observation. Each species was stocked at a density of 25 ind plot^{-1}, so that there were 16 experimental units. The results showed that there were significant differences between the treatment of fish species by using *A. acuminata* in absolute growth, daily growth rate, daily feed consumption, feed efficiency and feed conversion ratio. The highest absolute growth, daily growth rate, feed efficiency, and the lowest feed conversion ratio were achieved in the treatment of *L. calcarifer* species.

Key Words: consumption rate, feed conversion, *S. guttatus*, *L. calcarifer*, *M. tigris*, *C. altivelis*.

Introduction. Feed is an input component in fish culture that covers the largest proportion of the production cost, and its contribution can reach 70% of total production costs (Harris 2006). In intensive aquaculture, artificial feed plays very important role to meet the fish need for their growth. Good nutritive artificial feed is one of the determining factors for fish growth, and therefore good artificial feed supply in aquaculture becomes more important to maximize feed consumption level (Hermawan et al 2015).

According to Laheng et al (2016), the use of plant material in fish feed begins to get more attention in order to increase the health status of the organisms and the feed utilization efficiency. One of the plants with potential to increase feed utilization efficiency is *Alstonia acuminata*. The use of *A. acuminata* as feed material is intended to raise the fish growth and the feed digestive efficiency, beside resistance to diseases (Syahailatua et al 2017).

Dangeubun et al (2013) found that application of coarse extract of *A. acuminata* skin at a dose of 200 ppm gave the highest mean response to the development of total leukocytes, monocytes, lymphocytes, and neutrophils that makes the survival of tiger grouper increase up to 94.44%. The number of lymphocytes that was 75.5% rose to 82.35% after treated with 200 ppm of *A. acuminata*. It indicates that fish humoral immune response is in good condition so that defense mechanism to alien material and antibody formation occur. Based on previous study (Dangeubun et al 2013), pure isolate of ethyl acetate extract of *A. acuminata* skin contains compound structure of methyl-hydroxy-2-methoxy-3(2-oxohexyl) benzoate, while LC-MS revealed that coarse methanol extract of *A. acuminata* skin held dominant compound of coumaric acid indicated by a spectrum with a molecular mass of 339.0468 m/z. This compound is supposed to be p-

coumaroyl quinic acid ($C_{16}H_{18}O_8$) belonging to phenolic compound group (Dangeubun 2012).

Studies on addition of *A. acuminata* plant in animal feed were conducted by Syahailatua et al (2017) and Serang et al (2018) to humpback grouper *Cromileptes altivelis*. Both studies found that addition of *A. acuminata* plant as much as 0.2 g/100 g feed can increase the absolute growth, daily growth rate, food consumption, food efficiency, and the survivorship of *C. altivelis*. While research on adding *A. acuminata* as much as 0.2 g/100 g of feed on various fish species has not been done. This study was conducted to know the growth level of rabbitfish *Siganus guttatus*, white snapper *Lates calcalifer*, tiger grouper *Mycteroperca tigris*, and humpback grouper *C. altivelis* by benefitting of the addition of *A. acuminata* plant in the artificial feed.

Material and Method. This study was carried out for 30 days, from May 12th to July 10th, 2018, in the seawater of Kelanit village, southeast Mallucas (Figure 1).

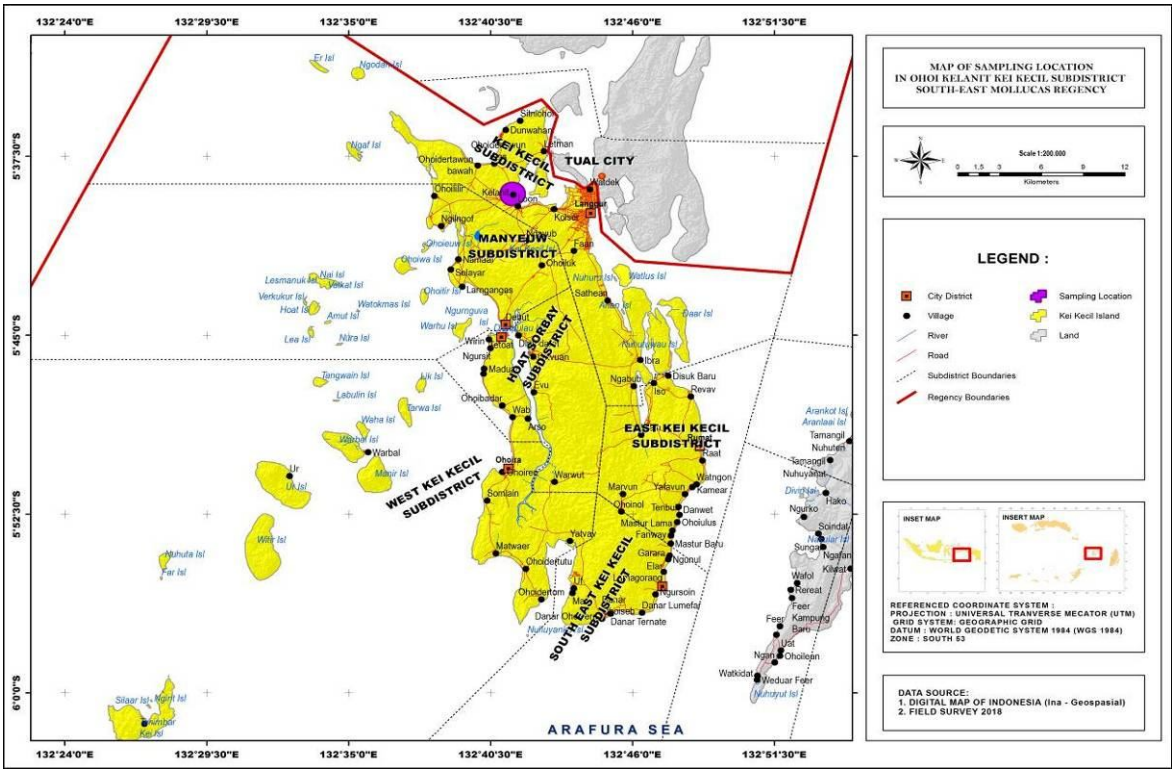

Figure 1. The map of the study site.

Fish used in the experiment were *C. altivelis* with a total length of 13-14 cm (35-37 g), *S. gutatus* with a total length of 12-13 cm (32-34 g), *M. tigris* with a total length of 14-15 cm (43-45 g), and *L. calcarifer* with a total length of 21-23 cm (127-130 g), respectively. The test fishes were reared in 16 floating net cages of 1 x 1 x 2 m at a density of 25 ind plot^{-1} with 3 replications for each species so that there were 400 individuals of each species used. The experiment used artificial feed with addition of 0.2 g of *A. acuminata* per 100 g feed (Table 1). Protein content of the feed was 45%. Feeding was carried out twice a day, at 06.00-07.00 am and 17.00-18.00 pm as much as 5% of fish biomass. The fish were taken from Marine Fish Hatchery in Ambon.

Table 1

Materials used in feed composition

No.	*Feed materials*	*Amount (g)*
1	*A. acuminata* meal	0.2
2	Fish meal	39.5
3	Shrimp meal	11.7
4	Cow's blood meal	10
5	Moringa leaf flour	3.4
6	Bran flour	9.6
7	Fish oil	9
8	Mineral mix	8.3
9	Vitamin mix	8.3
	Total	100

Parameters measured were absolute length growth, daily growth rate, feed efficiency, daily feed consumption, and feed conversion ratio. To obtain growth data of each species group, total body length (TL) and weight were recorded. The measurements were done once a week. For the body weight measurement we used a 0.1 g-table balance and the total body length was measured using a digital stainless steel Sigmat vernier caliper.

Absolute length growth was calculated following Jobling (2003):

$$L_m = L_t - L_0$$

where: L_m = absolute length growth (cm);
L_t = mean length at the end of the study (cm);
L_0 = mean length at the beginning of the study (cm).

Absolute weight growth was calculated based upon Jobling (2003):

$$AG = W_t - W_0$$

where: AG = absolute weight growth (g);
Wt = mean weigth at the end of study (g);
Wo = mean weigth at the end of study (g).

Daily growth rate in length was calculated based upon Jobling (2003):

$$DGRl = \frac{L_t - L_0}{t}$$

where: DGRl = daily growth rate (cm);
Lt = length at the end of study (cm);
Lo = length at the beginning of study (cm);
t = culture duration (day).

Daily growth rate in weight was calculated based upon Effendie (1997):

$$DGRw = \frac{W_t - W_0}{t}$$

where: DGRw = daily growth rate (g);
W_t = mean weight at the end of study (g);
W_0 = mean weight at the beginning of study (g);
t = culture duration (day).

Feed efficiency was calculated as follows (Watanabe 1988):

$$FE = \frac{(B_t + B_0) - B_0}{F} \times 100$$

where: FE = feed efficiency (%);
B_t = fish weight at the end of the study (g);
B_0 = fish weight at the beginning of the study (g);
B_d = dead fish weight during the study (g);
F = amount of feed consumed during the study (g)

Fish survival rate was estimated following Talpur & Ikhwanudin (2012) as follows:

$$SR = \frac{N_t}{N_0} \times 100$$

where: SR = survival rate (%);
N_t = number of fish alive at the end of the study (ind);
N_0 = number of fish at the beginning of the study (ind).

Parameters statistically tested were daily growth rate, absolute growth rate, and feed efficiency. ANOVA was applied to see the feed effect on the measured variables. If there is a significant difference ($p < 0.005$) between treatments, Honest Significant Difference (HSD) test was applied (Steel & Torrie 1993).

Results and Discussion

Absolute growth. The present study found that each fish group had growth in both weight and length. The highest mean absolute weight growth was found in *L. calcarifer*, 123.35±11.45 g, followed by *C. altivelis*, *M. tigris*, and the lowest was recorded in *S. guttatus*, 63.19±1.21 g. The highest mean daily weight growth rate was recorded in *L. calcarifer* group, 4.11±0.38 g d^{-1}, followed by *C. altivelis*, *M. tigris*, and the lowest in *S. guttatus*, 2.11±0.041 g d^{-1} (Figure 2).

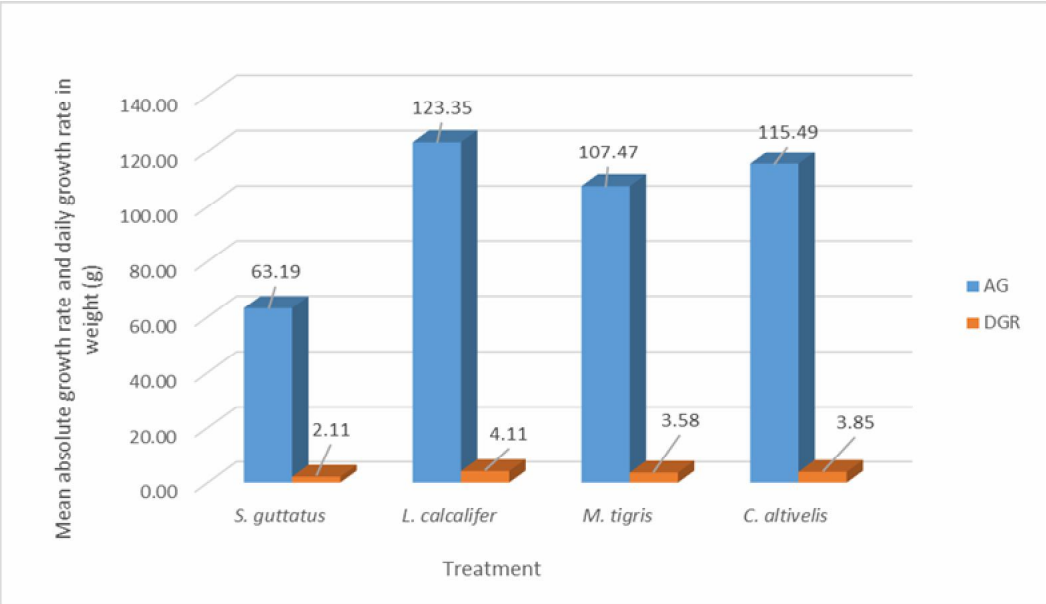

Figure 2. Mean absolute weight growth and daily growth rate in weight during the study.

Figure 3 shows that the highest mean absolute length growth was recorded in *L. calcarifer* 6.91 cm, followed by *M. tigris,* then *C. altivelis*, and the lowest in *S. guttatus,* 5.72 cm, while the highest mean daily length growth rate was found in *L. calcarifer* and *M. tigris*, 0.23 cm, followed by *L. altivelis*, 0.22 cm, and the lowest in *S. guttatus,* 0.10 cm.

It could result from application of feed with addition of 0.2 g of *A. acuminata* per 100 g feed as optimum level of *A. acuminata* for *C. altivelis* and *L. calcarifer* so that the feed is digested faster and yields better growth. *L. calcarifer* and *C. altivelis* digested more feed for weight growth. Syahailatua et al (2017) revealed that addition of *A. acuminata* as much as 0.2 g/100 g feed could increase the growth of *C. altivelis* better than control feed.

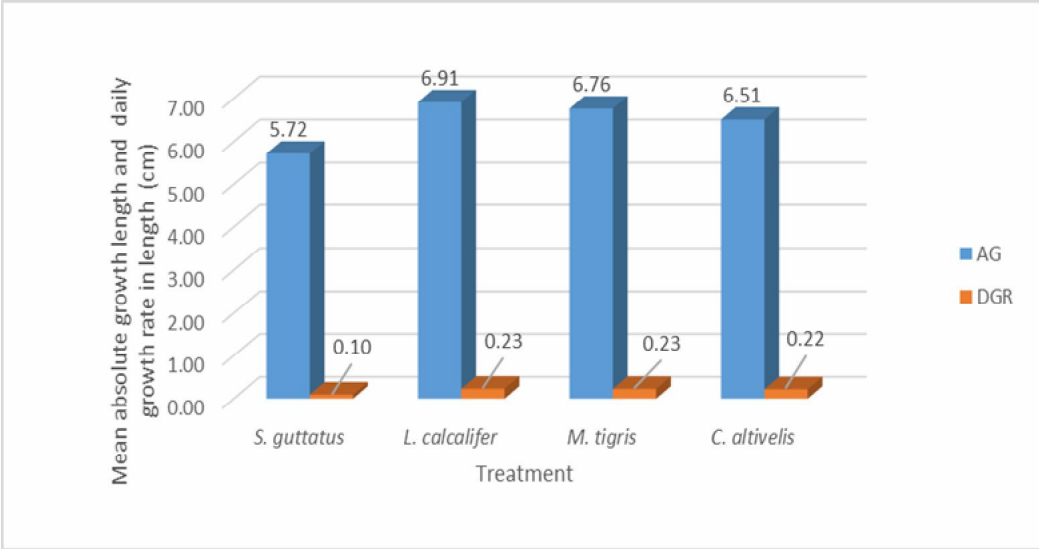

Figure 3. Mean absolute growth and daily growth rate in length during the study.

According to Serang et al (2018), addition of *A. acuminata* at the same ratio gave the highest mean daily weight growth rate of humpback grouper *C. altivelis* at day 28th, 4.00%, and the highest mean daily length growth rate 0.011%. Setiawati et al (2017) obtained daily growth rate of *Pangasius* sp. as much as 1.13 % after fed with addition of 0.1% of cinnamon leaf extract.

Maulidin et al (2016) also found that addition of papain enzyme in the artificial feed gave significant effect on growth and food efficiency, but snakehead seed *Channa striata* has the best growth at the treatment of 3.0% papain/kg feed. Talpur & Ikhwanudin (2012) reported that there is significant weight growth and feed conversion of *L. calcalifer* fed with feed added with garlic.

High mean absolute growth and daily growth rate of *C. altivelis* and *L. calcarifer* could result from 45% protein contained in the feed. Growth could only occur if the energy need for other living needs is fulfilled. Anil et al (2010) reported that *L. calcalifer* seeds which were kept in floating cages experienced daily weight growth from 0.2 g in December 2008 to 7.71 g in May 2009, while SGR decreased from 5.88 to 2.47. *Mentha piperita* diet in feed seems to reduce mortalities and significantly improve survival, weight gain and feed conversion ratio for treated groups over the control (Talpur 2014).

Feed efficiency and survival rate. Table 2 demonstrates that feeding with addition of 0.2 g of *A. acuminata* per 100 g feed for 60 days yields the highest mean feed efficiency in *L. calcarifer* group, 77.42%, followed by *C. altivelis* and *M. tigris,* and the lowest in *S. guttatus*, 55.97%. All fish groups have high survivorship, 100%.

Table 2

Mean food efficiency and survival rate for each fish group

No	*Species*	*Feed efficiency (%)*	*Survivival rate (%)*
1	*Siganus guttatus*	55.97	100
2	*Lates calcarifer*	77.42	100
3	*Mycteroperca tigris*	68.26	100
4	*Cromileptes altivelis*	71.81	100

Feed efficiency is gained from the ratio between fish weight increment and amount of feed consumed during the rearing period. Higher feed efficiency indicates more efficient feed consumption for growth (Iskandar & Elrifadah 2015). Improving feed efficiency means reducing feed consumption per kg of fish produced, or increasing fish production from the same amount of feed. It is important to note that feed efficiency will vary from one species to another, with rearing environment (i.e. temperature, salinity, pH and feed

composition (Árnasson et al 2009) and the developmental stage of the fish (Henryon et al 2002; Árnasson et al 2009). The efficiency value obtained in this study is higher than that reported by Setiawati et al (2017) in *Pangasius* sp. fed with addition of 0.1% cinnamon extract, 41.89%.

Table 2 demonstrates that feed with addition of 0.2 g of *A. acuminata* could yield 100% survivorship in all tested fish species. It could result from that *A. acuminata* could raise the fish resistance to disease infection. However, Talpur & Ikhwanudin (2012) found that *L. calcarifer* fed with feed added with garlic had only 83.35% survivorship, but the garlic could increase the immune and the resistance to *V. harveyi* infection.

Table 3 shows that feeding with addition of *A. acuminata* gives significant difference of mean absolute growth, mean daily growth rate, and mean feed efficiency among the fish groups ($p < 0.05$). Similar effects were also found in Nile tilapia *O. niloticus* using feed with addition of water cabbage *Pistia stratiotes* under different density (Iskandar & Elrifadah 2015). Shapawi et al (2011) reported that not all marine fish feeds are of equal quality but when correctly formulated to meet the requirements of humpback grouper, pelleted feeds consistently give better performance compared to a diet of trash fish. Therefore, switching from trash fish to pelleted feeds is highly recommended for grouper farmers.

Table 3

Absolute growth (AG), daily growth rate (DGRw), and feed efficiency (FE)

Parameter	*Treatment*			
	S. guttatus	*L. calcarifer*	*M. tigris*	*C. altivelis*
AG	63.19 ± 1.210^{b}	123.35 ± 11.448^{a}	107.47 ± 5.997^{a}	115.49 ± 4.931^{a}
DGRw (g)	2.11 ± 0.041^{b}	4.11 ± 0.382^{a}	$3.58 \pm .0.200^{a}$	3.85 ± 0.164^{a}
FE (%)	55.97 ± 0.942^{b}	77.42 ± 7.411^{a}	68.26 ± 3.783^{a}	71.81 ± 3.211^{a}

Note: different letters in the same row indicate sigificant differences ($p < 0.05$).

Conclusions. Feeding with the addition of *A. acuminata* 0.2 g can increase the absolute growth and daily growth rate. The best feed efficiency was found in *L. calcalifer* and the lowest in *S guttatus*. All fish groups had high survival rate, 100%, and feeding with addition of *A. acuminata* gave significantly different mean absolute growth, mean daily growth rate, and mean feed efficiency among the fish groups. Therefore, feed formulation with addition of 0.2 g *A. Acuminata* could give future expectation for marine fish culture development.

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