OPEN ACCESS Freely available online

Journal of
Aquaculture Research & Development

Research Article

The Effects of Rabbitfish Existence in Polyculture System and Feed Type against the Growth Performance of Bigeye Trevally in Floating Net Cage

Carolus P. Paruntu[1]*, Suria Darwisito[1], Antonius P. Rumengan[1], Defny S. Wewengkang[2], Henki Rotinsulu[2]

[1]Faculty of Fisheries and Marine Science, Sam Ratulangi University, Manado 95115, Indonesia; [2]Faculty of Mathematic and Natural Science, Sam Ratulangi University, Manado 95115, Indonesia

ABSTRACT

The objective of this research is to investigate the effects of rabbitfish (*Siganus canaliculatus*) existence in polyculture system and feed type against the growth performance of bigeye trevally (*Caranx sexfasciatus*) in floating net cage. Study on polyculture of bigeye trevally and rabbitfish and monoculture of bigeye trevally in the cage were conducted at the coastal of South Bolaang Mongondow, North Sulawesi, Indonesia in 2018. The experiment was designed with three treatments for bigeye trevally, namely: monoculture of bigeye trevally fed with fresh trash fish + corn oil 4% (Treatment A), polyculture of bigeye trevally and rabbitfish fed with fresh trash fish + corn oil 4% (Treatment B), polyculture of bigeye trevally and rabbitfish fed only fresh trash fish (Treatment C); On the other hand, 2 treatments for rabbitfish, namely: polyculture of rabbitfish and bigeye trevally which are fed with only carp pellets + fresh trash fish (1:1) (Treatment D) and polyculture of rabbitfish and bigeye trevally which are fed with carp pellets + fresh trash fish (1:1) + corn oil 4% (Treatment E). Each treatment consisted of 3 replications. The results show that the daily growth rates of bigeye trevally from treatment A, B, and C are 0.67%, 1% and 0.68% of body weight per day, while the daily growth rates of rabbitfish from treatment D and E are 0.56% and 0.81% of body weight per day, respectively. Feed conversion ratios of bigeye trevally from treatment A, B and C are 6.69, 4.86 and 6, while feed conversion ratios of rabbitfish from treatment D and E are 4.57 and 4.16, respectively. Rabbitfish existence in polyculture system and feed type gave a faster growth of bigeye trevally in the cage compared to the absence of both.

Keywords: Feed type; KJA; Polyculture; *Caranx sexfasciatus*; *Siganus canaliculatus*

INTRODUCTION

Monoculture and polyculture are two systems of aquaculture, which are commonly used in economic ventures in the fisheries sector to be efficient and facilitate land use. Monoculture system is an aquaculture system using one type of commodity, which is running once, or several times in a year depending on the type of commodity. The polyculture system is an aquaculture which cultivating two or more commodities on one cage at the same time. Polyculture is an aquaculture method used to maintain many fish commodities in one cage. With the use of that system in the same area, the community can increase their income from harvesting other products. This of course greatly helps increase the income of fish farmers. The existence of this polyculture system is expected to be able to boost the welfare of fish farmers since they get income from two different commodities without having to increase the amount of cultivating area [1]. The effects of the polyculture system of tiger grouper and rabbitfish against the growth rate of tiger grouper in floating net cages have been investigated by Paruntu et al. [2].

Bigeye trevally (*Caranx sexfasciatus*) is one type of associated reef fish that is very potential to be developed because it has several comparative advantages such as being able to live in conditions of high density, has a high growth rate, is very responsive to the addition of feed from trash fish, feed conversion is quite efficient and favored by consumers [3].

Rabbitfish (*Siganus canaliculatus*), naturally feed on green algae and benthic plants, but also receive other types of provided food [4]. Seed and adult of rabbitfish are diurnal, meaning they eat almost continuously during the daytime [5]. Rabbitfish that are bred in floating net cages can utilize moss or plants that are retained in the net as food, so these fish are referred to as cleaning fishes in aquaculture containers [2]. Rabbitfish have characteristics to form a large group, so they can be cultivated in limited places with high density [6].

Correspondence to: Carolus P. Paruntu, Faculty of Fisheries and Marine Science, Sam Ratulangi University, Manado 95115. Indonesia, Tel: 82187204678; E-mail: carolusparuntu@unsrat.ac.id

Received: November 21, 2020, **Accepted:** February 15, 2020, **Published:** February 22, 2020

Citation: Paruntu CP, Darwisito S, Rumengan AP, Wewengkang DS, Rotinsulu H (2020) The Effects of Rabbitfish Existence in Polyculture System and Feed Type against the Growth Performance of Bigeye Trevally in Floating Net Cage. 11: 581. doi: 10.35248/2155-9546.19.10.581

Based on the behavior of bigeye trevally and rabbitfish in nature and the potential of both types of fish in the development of the mariculture industry, and which have important economic value, these two types of fishes provide prospects to be raised together with polyculture techniques and feed types added with corn oil in floating net cages, which can have a special effect on the growth rate of both bigeye trevally and rabbitfish. As stated above, the effect of the use of polyculture techniques and the type of feed added by corn oil against the growth of bigeye trevally which is kept together with rabbitfish is an alternative technique for mariculture that can increase the quantity and quality of fish growth, as well as the economic value of fish farmers.

MATERIAL AND METHODS

Polyculture of bigeye trevally together with rabbitfish and monoculture of bigeye trevally in floating net cage (= KJA = keramba jaring apung in Indonesia) with different feeding patterns were conducted in May to August 2018 during 70 days period of maintenance on the coast of South Motandoi, South Bolaang Mongondow Regency, North Sulawesi Province, Indonesia (Figure 1).

The fishes used are bigeye trevally (*C. sexfasciatus*) and rabbitfish (*S. canaliculatus*) obtained from local fish farmers. Young bigeye trevally measuring between 18.29 ± 2.63 - 19.67 ± 2.81 cm with body weight ranging from 104.78 ± 40.06 - 105.11 ± 48 grams and young rabbitfish measuring 14.79 ± 1.46 - 15.00 ± 1.74 cm with body weight ranging from 45.87 ± 18.24 - 46.22 ± 19.43 grams, which was first adapted for 3 weeks in the KJA that has been installed at sea.

The type of feed used is fresh trash fish (*Stolephorus* spp.) containing 20% protein added by 4% corn oil for monoculture bigeye trevally, and fresh trash fish containing 20% protein added by and without adding 4% corn oil for polyculture bigeye trevally, then pellets commercially drowned carp (commercial comfeed ISO 9001: 2008, Indonesia) containing 25% protein mixed with fresh trash fish containing 20% protein with a ratio of 1:1 added by and without adding 4% corn oil for rabbitfish in polyculture. Feed given for big-eye trevally was 10-15% of total body weight per day and for rabbitfish 5-10% of total body weight per day. The frequency of feeding was twice a day, namely 07: 30-08: 30 a.m. and 4: 30-05: 30 p.m. However the feeding of the test fishes is carried out until they do not want to eat anymore [7].

This research was conducted using a container in the form of KJA measuring 2 × 2 × 2 m totaling 9 cages, each of cage had a water volume of about 6 m^3 (2 × 2 × 1.5 m) filled with bigeye trevally and rabbitfish, each of KJA with a density of 3 individual/m^3/species. The construction KJA as a raft is made of wood (*Homalium foetidum*) beams, wood rep, boards and nails, and buoys of styrofoam tied with nylon rope, while the cage net of polyethylene with a mesh size of 1 inch. The rectangular raft, which is 6 × 6 meters, is divided into 4 squares and each measuring 3 × 3 meters. The number of rafts was 3 units and on top of it a 2 × 2 m guardhouse was built made of wood, beams, boards, wood rep, nails, zinc roof and paint. The maintenance container is equipped with a rabbitfish food container, which is a plastic tray measuring 40 × 40 cm with several small holes made at the bottom of the tray for water circulation to be easily submerged, then hung 50-100 cm from the bottom of the cage (Figure 2).

The experiment was designed with three treatments for bigeye trevally, namely treatment A (control): monoculture of bigeye trevally fed with fresh trash fish (*Stolephorus* spp.) containing 20% protein mixed with 4% corn oil; treatment B: polyculture bigeye trevally reared with rabbitfish fed with fresh trash fish (*Stolephorus* spp.) containing 20% protein mixed with 4% corn oil; treatment C: polyculture of bigeye trevally reared with rabbitfish fed with fresh trash fish (*Stolephorus* spp.) containing 20% protein without added with corn oil; In contrast, 2 treatments for rabbitfish were treatment D (control): polyculture fish were kept together with bigeye trevally fed with commercial drowned carp pellets (commercial comfeed ISO 9001: 2008, Indonesia) containing 25% protein mixed with fresh trash fish (*Stolephorus* spp.) containing 20% protein with a ratio of 1: 1 without added corn oil, and treatment E: polyculture of fish kept with bigeye trevally fed with commercially drowned pellet (commercial comfeed ISO 9001: 2008, Indonesia) containing 25% protein mixed with trash fish fresh (*Stolephorus* spp.) contains 20% protein in a ratio of 1:1 added by 4% corn oil. Each treatment consisted of 3 replications.

Observation parameters include daily growth rate (body weight and length of fish), mortality, and feed conversion measured every 2 weeks (14 days) and water quality supporting data were also observed 2 weeks when measuring fish body weight and length, including salinity (%), pH, dissolved oxygen (ppm), current velocity (cms^{-1}), depth (m), temperature (°C), brightness (m) using Horiba U-50 Series. Fish body length was measured from the tip of the

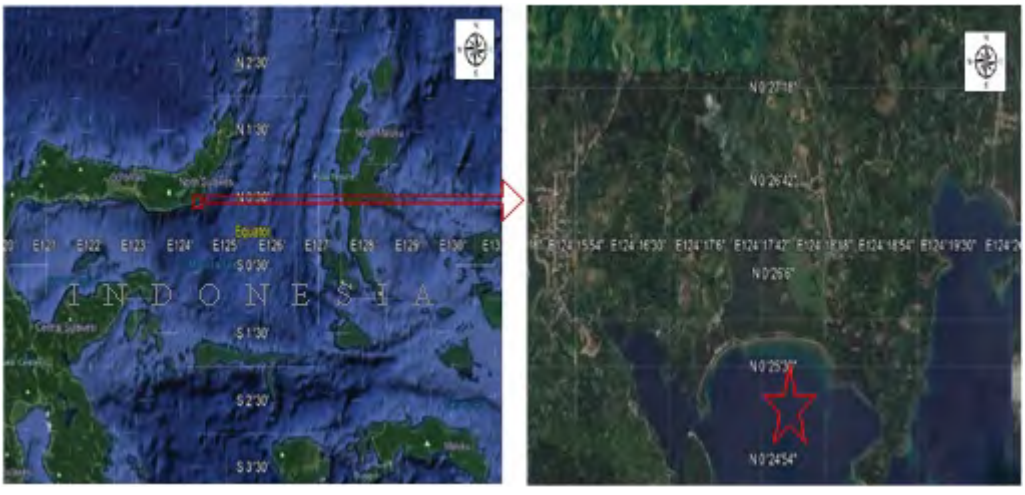

Figure 1: Study site at the coastal of South Motandoi in the South Bolaang Mongondow, North Sulawesi Province, Indonesia.

mouth to the tip of the tail fin as the total body length using a regular rule with a level of accuracy of 1 mm, while for observing the daily growth rate of weighing the test fish using a regular scale 1 kg capacity of Nagata type with a level of accuracy of 5 grams. Data obtained during the study were used to calculate daily growth rate (%), feed conversion ratio, and mortality (%) of the test fishes using the formula from Yamaguchi [8,9].

Statistical analysis

Three average values of the test fish population were analyzed using the Anova single factor to state whether there were differences between the three treatments, whereas to find out which treatment was significantly different, it was continued with the LSD test (Excell program); Next to test the two average values of the test fish population using the t-test statistical test (Excell program). Water quality analysis is done descriptively.

RESULTS AND DISCUSSION

The increase in average body length (cm) and average body weight (g) of bigeye trevally and rabbitfish during maintenance for 70 days are shown in Table 1. Growth of the total length and body weight of bigeye trevally and rabbitfish observed every 2 weeks for 70 maintenance days are presented in Figure 3. Furthermore, the daily growth rate, food conversion ratio and mortality of test fishes on polyculture and monoculture systems in KJA are listed in Table 2.

Table 1 shows that the length or body weight of the bigeye trevally at the beginning of the maintenance period was not significantly different ($p>0.05$), then towards the end of the 70 days maintenance period, especially in the body weight of the bigeye trevally weight showed significantly different growth results between treatments A, C and B ($p<0.001$), but not significantly different between treatments A and C ($p>0.05$). At the end of the study, the highest average body weight was achieved by treatment B, which was 219.78 ± 39.84 (gr), and the lowest was achieved by treatment A (control), which was 169.22 ± 45.18 (gr). In addition, the daily growth rate of the bigeye trevally in treatment B of 1% was greater than that of treatment A (control) of 0.67% and treatment C of 0.68% (Table 2). The effects of polyculture and the addition of corn oil in the feed appeared to have a significant effect ($p<0.001$) on fish growth, especially the body weight of the bigeye trevally. The low growth rate in treatment A (control) is thought due to the monoculture maintenance system, while the low growth rate from treatment C is due to the lack of nutrient content in the feed given and both of these, both the monoculture maintenance system

Figure 2: Construction of KJA.

Table 1: The average length and body weight of the test fish measured once every 2 weeks were kept in floating net cages with polyculture and monoculture techniques and feeding with different types of feed.

Rearing period (days)	Species	Treatment			Average body length (cm)	Statistics	Average body weight (g)	Statistics
		Type	KJA system	Feed type				
0	Bigeye trevally	A (Control)	Monoculture	Fresh trash fish mixed with corn oil	18,29 ± 2,63 (3) *a*	Single Factor Anova & BNT test: 3.42, P<0.05, df = 132	104,78 ± 40,06 (3)	Single Factor Anova: 2.83, P>0.05, df = 132
		B	Polyculture with rabbit fish	Fresh trash fish mixed with corn oil	19,38 ± 2,47 (3) *a*		105,11 ± 48 (3)	
		C		Fresh trash fish without corn oil mixture	19,67 ± 2,81 (3) *b*		123,56 ± 39,91 (3)	
	Rabbit fish	D (Control)	Polyculture with bigeye trevally	Pellet + trash fish (1:1) without corn oil mixture	14,79 ± 1,46 (3) *a*	t-Test: 0.74, P> 0.05, df = 44	45,87 ± 18,24 (3) *a*	t-Test: -0.02, P> 0.05, df = 44
		E		Pellet + trash fish (1:1) mixed with corn oil	15,00 ± 1,74 (3) *a*		46,22 ± 19,43 (3) *a*	

14	Bigeye trevally	A (Control)	Monoculture	Fresh trash fish mixed with corn oil	19,11 ± 3.20 (3)	Single Factor Anova: 2.92, P>0.05, df = 132	109,78 ± 35,66 (3) *a*	Single Factor Anova & BNT test: 6.73, P<0.05, df = 132
		B	tPolyculture with rabbit fish	Fresh trash fish mixed with corn oil	20,39 ± 2,51 (3)		139,22 ± 40,01 (3) *b*	
		C		Fresh trash fish without corn oil mixture	20,28 ± 2,56 (3)		132,78 ± 43,93 (3) *b*	
	Rabbit fish	D (Control)	Polyculture with bigeye trevally	Pellet + trash fish (1:1) without corn oil mixture	15,04 ± 1,60 (3) *a*	t-Test: 1.34, P> 0.05, df = 44	50,56 ± 10.93 (3) *a*	t-Test: 2.19, P< 0.05, df = 44
		E		Pellet + trash fish (1:1) mixed with corn oil	15,46 ± 1,11 (3) *a*		54,78 ± 12,61 (3) *b*	
28	Bigeye trevally	A (Control)	Monoculture	Fresh trash fish mixed with corn oil	19,16 ± 2.65 (3) *a*	Single Factor Anova & BNT test: 10.90, P<0.0001, df = 132	126,67 ±38,35 (3) *a*	Single Factor Anova & BNT test: 9.39, P<0.001, df = 132
		B	Polyculture with rabbit fish	Fresh trash fish mixed with corn oil	20,99 ± 2,4 (3) *a*		167,00 ± 48,77 (3) *b*	
		C		Fresh trash fish without corn oil mixture	21,34 ± 2,07 (3) *b*		156,23 ± 49,19 (3) *a*	
	Rabbit fish	D (Control)	Polyculture with bigeye trevally	Pellet + trash fish (1:1) without corn oil mixture	15,31 ± 1,36 (3) *a*	t-Test: 1.73, P> 0.05, df = 44	57,33 ± 11,80 (3) *a*	t-Test: 2.14, P< 0.05, df = 44
		E		Pellet + trash fish (1:1) mixed with corn oil	15,78 ± 1,08 (3) *a*		62,56± 10.42 (3) *b*	
42	Bigeye trevally	A (Control)	Monoculture	Fresh trash fish mixed with corn oil	20,32 ± 2,75 (3) *a*	Single Factor Anova & BNT test: 8.29, P<0.001, df = 132	143,33 ± 46,43 (3) *a*	Single Factor Anova & BNT test: 11.83, P<0.0001, df = 132
		B	Polyculture with rabbit fish	Fresh trash fish mixed with corn oil	22,21 ± 2,09 (3) *b*		190,89 ± 51,73 (3) *b*	
		C		Fresh trash fish without corn oil mixture	21,97 ± 2,29 (3) *a*		178,44 ± 45,9 (3) *a*	
	Rabbit fish	D (Control)	Polyculture with bigeye trevally	Pellet + trash fish (1:1) without corn oil mixture	15,42 ± 1,12 (3) *a*	t-Test: 5.55, P< 0.0001, df = 44	59,56 ± 10,81 (3) *a*	t-Test: 4.27, P< 0.0001, df = 44
		E		Pellet + trash fish (1:1) mixed with corn oil	16,53 ± 0.88 (3) *b*		69,56 ± 12,56 (3) *b*	
56	Bigeye trevally	A (Control)	Monoculture	Fresh trash fish mixed with corn oil	21,14 ± 2,23 (3) *a*	Single Factor Anova & BNT test: 7.35, P<0.001, df = 132	152,11 ± 39.15 (3) *a*	Single Factor Anova & BNT test: 11.30, P<0.0001, df = 132
		B	Polyculture with rabbit fish	Fresh trash fish mixed with corn oil	22,74 ± 1,97 (3) *b*		194,56 ± 49,96 (3) *b*	
		C		Fresh trash fish without corn oil mixture	22,36 ± 1,98 (3) *a*		181,67 ± 40,75 (3) *a*	
	Rabbit fish	D (Control)	Polyculture with bigeye trevally	Pellet + trash fish (1:1) without corn oil mixture	15,52 ± 1,25 (3) *a*	t-Test: 4.04, P< 0.001, df = 44	63,60 ± 11,49 (3) *a*	t-Test: 5.03, P< 0.0001, df = 44
		E		Pellet + trash fish (1:1) mixed with corn oil	16,70 ± 1,09 (3) *b*		76,33 ± 11,5 (3) *b*	
70	Bigeye trevally	A (Control)	Monoculture	Fresh trash fish mixed with corn oil	21,23 ± 2,17 (3) *a*	Single Factor Anova & BNT test: 9.16, P<0.001, df = 132	169,22 ± 45,18 (3) *a*	Single Factor Anova & BNT test: 15.83 P<0.0001, df = 132
		B	Polyculture with rabbit fish	Fresh trash fish mixed with corn oil	22,78 ± 1,89 (3) *b*		219,78 ± 39,84 (3) *b*	
		C		Fresh trash fish without corn oil mixture	22,80 ± 1,90 (3) *b*		200,33 ± 43,8 (3) *a*	
	Rabbit fish	D (Control)	Polyculture with bigeye trevally	Pellet + trash fish (1:1) without corn oil mixture	16,17 ± 1,04 (3) *a*	t-Test: 3.99, P< 0.05, df = 44	68,44 ± 12,61 (3) *a*	t-Test: 6.44, P< 0.0001, df = 44
		E		Pellet + trash fish (1:1) mixed with corn oil	16,9 ± 1,04 (3) *b*		82,56 ± 11.11 (3) *b*	

Note: The number in the parentheses represents the replications number of each treatments of the test. Fifteen Trevallies of monoculture, and fifteen Trevallies and fifteen Rabbit fishes of polyculture were measured to calculate average values for each replication. Body growth comparisons of the test fishes are based on statistical test. Values are not significantly different at the 0.05 level share the same characters for each test.

and nutrient deficiencies will affect the fish's appetite. Paruntu et al. [2] stated that monoculture systems can cause cage nets look more dirty and water circulation is less smooth, and fish appetite is decreased, this condition will affect the growth of fish, whereas in polyculture culture it appears that cage nets are cleaner due to rabbitfish use or clean the moss that sticks to the net, so that the water quality is better and the water circulation is smoother, and the impact on fish appetite increases. The use of corn oil as an enrichment material for egg yolk emulsions is used because corn oil contains linoleic acid of 56.3% [10], and has a low melting point of 17.0 - 20.6°C [11]. Corn oil contains essential fatty acids (oleic fatty acids, linoleic fatty acids and linolenic fatty acids), which can

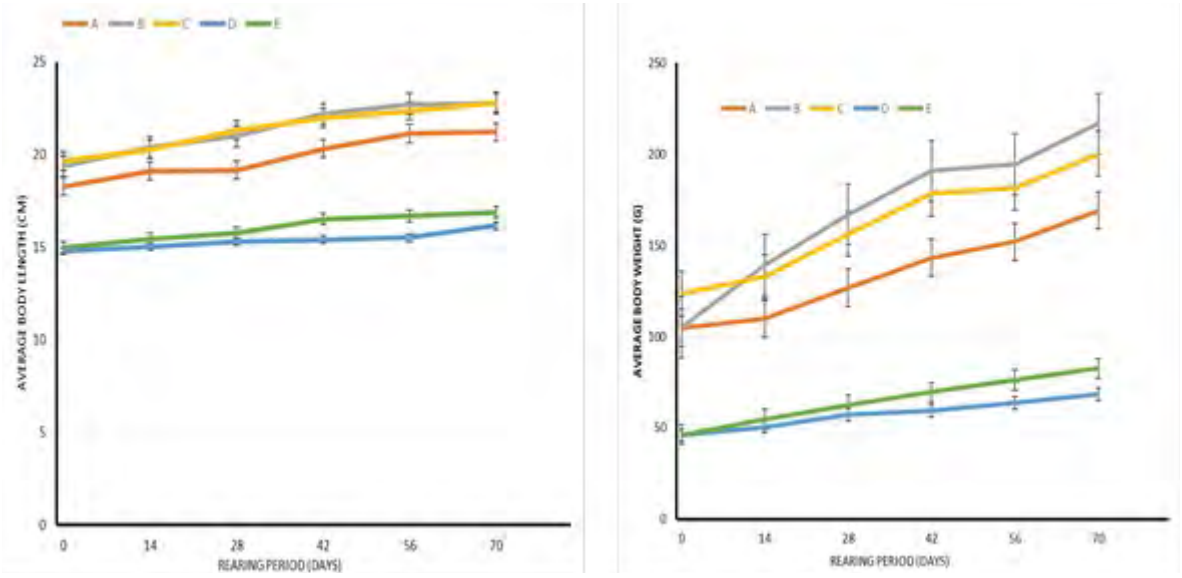

Figure 3: The increase in average body length (cm) and average body weight (g) of bigeye trevally and rabbitfish that observed every 2 weeks during maintenance for 70 days. (*Notes*: A=Bigeye trevally+monoculture+fresh trash fish feed mixed with corn oil; B=Bigeye trevally+polyculture with rabbit fish+fresh trash fish feed mixed with corn oil; C=Bigeye trevally +polyculture with rabbit fish+fresh trash fish feed without corn oil mixture; D=Rabbitfish+polyculture with bigeye trevally+ feed (pellet+trash fish (1:1)) without corn oil mixture; E=Rabbitfish+polyculture with bigeye trevally+ feed (pellet+trash fish (1:1)) mixed with corn oil).

Table 2: Data of daily growth rate, food conversion ratio and mortality of test fishes on polyculture and monoculture systems with different feed types feeding in KJA.

No	Growth Parameters	Bigeye Trevally			Rabbit fish	
		Treatment type			Treatment type	
		A (Control)	B	C	D (Control)	E
		KJA system			KJA system	
		Monoculture	Polyculture with rabbitfish		Polyculture with bigeye trevally	
		Feed type			Feed type	
		Fresh trash fish mixed corn oil	Fresh trash fish mixed with corn oil	Fresh trash fish without corn oil mixture	Pellet + trash fish (1:1) without corn oil mixture	Pellet + trash fish (1:1) mixed with corn oil
1	Daily growth rate (%)	0.67	1	0.68	0.56	0.81
2	Food conversion ratio	6.69	4.86	6	4.57	4.16
3	Mortality (%)	0	0	0	0	0
4	Fish density (individuals/m^3)	3	3	3	3	3
5	Rearing time (days)	70	70	70	70	70
6	Fish initial amount (individuals)	45	45	45	45	45
7	Fish final amount (individuals)	45	45	45	45	45
8	Initial average body length (cm)	18.29	19.38	19.67	14.79	15
9	Final average body length (cm)	21.23	22.8	22.78	16.17	16.9
10	Initial average body weight (gr)	104.78	105.11	123.56	45.87	46.22
11	Final average body weight (gr)	169.22	219.78	200.33	68.44	82.56
12	Initial body weight total (gr)	4715	4730	5360	2064	2055
13	Final body weight total (gr)	7615	9890	8870	3080	3615
14	Total body weight increasement (gr)	2298	5160	3510	1016	1560
15	Feeding food total (gr)	15375	25098	21094	4647	6498

increase fish growth through the formation of growth hormones [12]. Therefore, the addition of corn oil to fish feed could be considered in feeding bigeye trevally and rabbitfish in the floating net cage aquaculture system.

Table 1 also shows that the length or body weight of rabbitfish at the beginning of the rearing period is not significantly different ($p > 0.05$), then towards the end of the 70 days maintenance period shows significantly different growth results between treatments D (control) and E ($p<0.001$). At the end of the study, the average length and body weight achieved by treatment E, which was 16.9 ± 1.04 (cm) and 82.56 ± 11.11 (g) higher than the treatment D (control), i.e., 16.17 ± 1.04 (cm) and 68.44 ± 12.61 (g). Besides that, the daily growth rate value of rabbitfish in treatment E (0.81%) is greater than in treatment D (control) (0.56%) (Table 2). The effect of cultivation with the addition of corn oil in feed seems

Table 3: The range of water quality parameters values were observed every 2 weeks for 70 days of the study. (Note: 1. Antoro et al. [1]; 2. Boyd [2]; 3. Chua and Teng and Yoshimitsu et al. [3]; 4. Kepmen LH No 51 Tahun [4]. 5. Mansyur et al. [5]; 6. SNI [6])

Water quality parameters	Bigeye trevally			Rabbit fish		Standard
	Treatment type			Treatment type		
	A (Control)	B	C	A (Control)	B	
Salinity (%)	29.2-32.3	29.1-32.8	29.4-33.0	29.4-33.0	29.1-32.8	15-35[5]; 30-33[3]; 28-35[6]
pH	7.2-8.0	7.4-8.0	7.3-8.1	7.3-8.1	7.4-8.0	6.8-8.5[1]; 7.8-8.0[3]; 7-8.5[4]; 7,8-8,3[6]
Dissolved oxygen (ppm)	4.71-5.89	5.49-6.75	5.51-6.72	5.51-6.72	5.49-6.75	>3.0[2]; >3.5[3]; >5[4,6]
Current velocity (cm/s)	15.2-30.5	16.1-32.1	16.2-31.0	16.2-31.0	16.1-32.1	Normal[4]
Depth (m)	8.0-8.5	7.5-8.0	7.3-7.9	7.3-7.9	7.5-8.0	Normal[4]
Temperature (°C)	29.93-30.40	29.78-30.5	29.82-30.2	29.82-30.2	29.78-30.5	24-31[3], 28-30[4]; 28-32[6]
Brightness (m)	5.2-6.6	5.5-7.0	5.7-7.1	5.7-7.1	5.5-7.0	>5[4]

to have a significant effect ($p<0.05$) on the growth of body length and body weight of rabbitfish. The low growth rate in treatment D (control) is suspected that the nutritional content of the feed given is insufficient and besides that the appetite of fish is reduced. As reported before that the addition of corn oil to fish feed could increase growth of the fish [12].

Polyculture of bigeye trevally in treatment B uses 4.86 grams of feed to increase body weight of 1 gram, polyculture bigeye trevally in treatment C uses 6 grams of feed to increase body weight of 1 gram, and monoculture bigeye trevally in treatment A (control) uses 6.69 grams of feed to increase same body weight. Furthermore, for polyculture fish in treatment E using 4.14 grams of feed to increase body weight of 1 gram, while polyculture fish in treatment D (control) use 4.57 grams to increase the same body weight. The lowest value of feed conversion ratio in the growth of bigeye trevally is achieved by treatment B and the highest is by treatment A (control). While the value of the ratio of feed conversion to the lowest growth of rabbitfish was achieved by treatment E and the highest by treatment D (control) (Table 2). High feed conversion ratio shows that the treatment given is inefficient, it is suspected that fish feed that is not mixed with corn oil is more difficult to digest, this is in line with Agustono et al. that the higher feed conversion ratio shows that the food consumed has quality poor quality and poor feed efficiency [13].

The difference in daily growth rate and feed conversion ratio in each treatment in this study is thought to be caused by a combination of differences in composition or type of feed and sea fish culture techniques in KJA, namely feed with a mixture of corn oil accompanied by polyculture techniques with rabbitfish giving growth effect which is better, especially in the growth of bigeye trevally compared to the absence of both.

During 70 days of maintenance, no fish died, this was presumed because the fish density was very low for all treatments and the amount of feed provided was sufficient for all fish being farmed. Lilis [14] stated that the optimal fish density value for marine fish culture is 60 fish/m^3, while the density of fish in this study is only about 3 individuals/m^3/species [15].

Water quality parameters measured during the study were salinity, dissolved oxygen (DO), acidity (pH), temperature, flow velocity, depth and brightness. Boyd [16] stated that water quality is a variable in the fish's life media influencing growth and survival, because water is a means of transporting oxygen and the results of metabolism in the fish's body. The results of water quality measurements during the study as well as the feasibility values based on the literature are presented in Table 3. However, especially dissolved oxygen shows a tendency to be greater in the KJA polyculture compared with the monoculture KJA. This is thought to be caused by the activity of rabbitfish in the KJA polyculture which always graze on the net, resulting in the net KJA polyculture to be cleaner and water circulation smoothly impacting the appetite and increases the growth of bigeye trevally. The condition of dissolved oxygen which is high enough can play a role in increasing the metabolic process of fish [17]. The results of this study are in line with research conducted by Paruntu et al. [2] concerning the effects of monoculture or polyculture of tiger groupers (*Epinephelus fuscoguttatus*) [18] and rabbit fish (*S. canaliculatus*) on the growth performance of tiger groups in floating net cage [19,20].

CONCLUSION

The type of feed mixed with corn oil and polyculture technique with rabbitfish in floating net cages provided a better daily growth rate and feed conversion ratio of bigeye trevally compared to the absence of both.

ACKNOWLEDGMENT

The authors are conveyed with respect to the Government of the Republic of Indonesia, the Ministry of Research and Technology of Higher Education as the support of PTUPT research scheme funding for 3 years (2017-2019), the Government of South Bolaang Mongondow Regency as a research collaboration partner, and all related parties that have contributed to completing this research.

REFERENCES

1. Husain TK, Mulyo JH. Comparative analysis of benefits and risks of fisheries business with monoculture and polyculture systems in Pangkep Regency. Agro Ekonomi. 2016; 27: 138-149.

2. Paruntu CP, Darwisito S, Rumengan AP, Sinjal JH. The effects of monoculture or polyculture of tiger grouper (*Epinephelus fuscoguttatus*) and rabbitfish (*Siganus canaliculatus*) on the growth performance of tiger grouper in floating net cage. AACL Bioflux. 2018; 11: 635-644.

3. Irianto B, Zubaidi T, Hasan N, Harwanti S, Suwarda R. Potential development of trevally fish (*Caranx* spp.) culture with floating net cage systems. Balai Penelitian Perikanan Budidaya Pantai Maros. 2002; p.49.

4. Wiryawan SB, Taurusman AA, Santoso J, Riyanto M. Variations in size and catch distribution of white spotted rabbit fish (*Siganus canaliculatus*) on bio- FADs from spatially and temporary point of view, at Luwu District, South Sulawesi, Indonesia. AACL Bioflux. 2016; 9: 1220-1232.

5. Armando AJ, Afonso M, Luiz S. Some aspects of the biology of three fish species from the seagrass beds at Inhaca Island, Mozambique. Cybium. 1999; 23: 369376.

6. Lam TJ. Siganid, their biology and mariculture potential. Aquaculture. 1974; 3:324-354.

7. Chua TE, Teng SK. Effect of feeding frequency on the growth of young estuary grouper. *Ephinephelus tauvina* (Fosskal) cultured in floating net-cage, Aquaculture. 1979; 14: 31-57.

8. Mansyur A, Rosjid UF. Maintenance of mud grouper (*Epinephelus tauvina* Forskal) at several levels of salinity and laboratory conditions. Jurnal Penelitian Perikanan, Indonesia. 1995; 1: 100-105.

9. Yamaguchi M. Practical and culture method of Read Sea-Bream. Koseikoku. Japan. 1978; 301.

10. Stickney RR. Principle of warm water aquaculture. John Willey and Sons, New York, USA. 1979.

11. Djajasewaka H. Fish feed. Cetakan I. Penerbit Yasaguna, Jakarta. 1990.

12. Syakirin MB, Darmono B. The effect of differences in the percentage of corn oil addition in egg yolk emulsions on larval growth of African catfish (*Clarias gariepinus* Burchell). PENA Akuatika. 2008; 1: 46-51.

13. Agustono M, Cahyoko HY. Provision of fermented shrimp waste flour in artificial feed rations on growth rate, feed conversion ratio and survival of tilapia (*Oreochomis niloticus*) seeds. Jurnal Ilmiah Perikanan dan Kelautan. 2013; 1: 157–162.

14. Lilis. Aquaculture of marine fishes and plankton at Sub Research Institute for Coastal Aquaculture (SBPBP) Bojonegoro, Serang, West Java. Faculty of Fisheries IPB, Bogor. 1988; 56.

15. Yoshimitsu TH, Hiramatsu EK. Groupers final report marineculture research and development in Indonesia. ATA 192, JICA. 1986; 103-129.

16. Boyd CE. Calcium water quality in ponds for aquaculture. Department of Fisheries and Allied Aquacultures. Alabama Agricultural Experiment Station, Auburn University, USA. 2000; 143.

17. Davis JC. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species. J Fish Res Board Can. 1975; 32: 2296-2332.

18. Antoro S, Widiastuti E, Hartono P. Biology of tiger grouper in tiger grouper (*Epinephelus fuscoguttatus*) hatchery techniques. Balai Budidaya Laut Lampung. Bandar Lampung. 1999.

19. Indonesian Ministry of Environment. Decree of the Minister of Environment Number 51 Year of 2004. Concerning Sea Water Quality Standards. 2004.

20. Indonesian National Standard (SNI). The production of tiger grouper (*Epinephelus fuscoguttatus*) seed: Class of Spread Seed. SNI-01-6488.3-2000. Jakarta, SNI. 2000; 1: 1-9.