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EFFECT OF ARTIFICIAL FEED ON THE GROWTH AND SURVIVAL OF WHITE SHRIMP (*Litopenaeus vannamei*) AND MILKFISH (*Chanos chanos*) IN APPLICATION OF INNOVATIVE POLYCULTURE TECHNOLOGY

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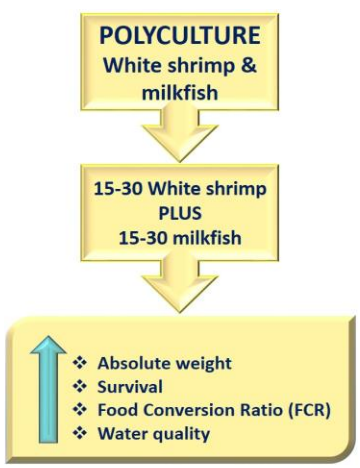
Graphical abstract



Abstract

The objective of this research was to investigate growth and survival of white shrimp (*Litopenaeus vannamei*) and milkfish (*Chanos chanos*) in the application of innovative polyculture technology. The material in this study was white shrimp with initial weight of (1.25 ± 0.025) g and milkfish of (3.25 ± 0.075) g, respectively and artificial feed containing 35 % of protein enriched with vitamin C (3 % biomass d^{-1}). Completely Randomized Design was used with four treatments and three replications, i.e. T1 (15 individuals of white shrimp per m^2 and 15 individuals of milkfish per m^2), T2 (30 individuals of white shrimp and 15 individuals of milkfish per m^2), T3 (15 individuals of white shrimp and 30 indviduals of milkfish per m^2), T4 (30 individuals of white shrimp per m^2 and 30 indviduals of milkfish per m^2). Absolute weight of growth, survival, FCR, and water quality data (temperature, salinity, pH, O_2, NO_2, NH_3) were analyzed by analysis of variance (F test) and descriptive analysis. The results elucidated significant effect ($P < 0.05$) on the growth and survival rate of white shrimp and milkfish. The highest absolute growth weight of white shrimp and milkfish were obtained from T4 treatment i.e (19.25 ± 1.015) g for white shrimp), for milkfish (185.71 ± 1.025) g. Survival rate of white shrimp was 95 % ± 2.5 % and for milkfish was 75 % ± 2.75 %.

Keywords: White shrimp [*Litopenaeus vannamei*(Boone, 1931)], milkfish [*Chanos chanos* (Forsskal, 1775)], growth, survival, polyculture

1.0 INTRODUCTION

Recently, aquaculture production has grown enormously, and among that penaeid shrimps are one of the most important cultured species worldwide especially in Asia due to their high economic value and export [1]. White shrimp (*Litopenaeus vannamei*) and milkfish (*Chanos chanos*) are annually produced but the current global demand for both the wild and farmed shrimp and milkfish are approximately more than 339 000 t [2].

Currently, problem of aquaculture in Indonesia that often arises is declining fishery products, with a high mortality of 60 % to 90 %, not to mention other problems, such as, bacteria, fungi, lack of nutrition food, poor environmental water quality. Conventional farming techniques and monocultures will still cause a decrease in quality and production of white shrimp and fish.

Central Java is very potential for production of tiger prawn, milkfish and polyculture system for seaweed cultivation, because they have a source of good fresh water and sea water, aquaculture pond, ponds in fallow land and open area for fish and seaweed (*Gracylaria* sp.) cultivation. This was in accordance to previous report in which Fisheries Sub-Sector includes the business activities of Marine Fisheries and Inland Fisheries. Production on Inland Fisheries activities from the fisheries activities in 2003 in Central Java reached 339 × 10^3 t [3]. Fishery production was dominated by marine fisheries for about 236.24 × 10^3 t (approximately 74 % of total fishery production) with a value of IDR 0.77 trillion (trillion = 10^{12}). In 2003, aquaculture and fisheries businesses in public waters of Central Java, both production and value of production, was higher than the previous year. The production of aquaculture and fisheries businesses in public waters reached, each for 75 to 88 thousand ton and 14.33 thousand ton with production value reached IDR 0.88 billion and IDR 91.90 billion (billion = 10^9). So that was currently cultivating the farmers on the northern coast Central Java, particularly the city of Semarang stil conducted monoculture conventionally, thus, the production is low. One effort was the polyculture of white shrimp and milkfish maintained simultaneously, so that production increases.

Innovation of polyculture technology of white shrimp and milkfish includes the use of low or zero water exchanged recirculating system, adoption of alternative feed ingredients and feeding strategies, polyculture rotation techniques and the use of natural feed [1, 4, 5]. Polyculture technology improvement of white shrimp, milkfish and seaweed involves biological filter increased production of white shrimp and milkfish [6-8].

Investigation on the production of polyculture was performed using combination of white shrimp and milkfish. This design showed that culture can be implemented successfully using polyculture technology due to its ability to increase production of white shrimp and milkfish [6, 7].

Polyculture technology was performed simultaneously to obtain proper growth and high survival rate and production. This technology is better than monoculture cultivation in which single species is cultivated. By simultaneous maintanence in polyculture technology of white shrimp and milkfish, result of analysis will be more likely showing improvement in growth and survival rate compared to monoculture system (one species). Currently, white shrimp has high economic value and is available in all across Indonesia, especially in northern coast of Central Java, Indonesia. On the other hand, milkfish is a native species, has high nutrient content and economic value [3].

The objective of this research was to investigate effect of different density on the growth and survival of white shrimp [*Litopenaeus vannamei* (Boone, 1931)] and milkfish [*Chanos chanos* (Forsskal, 1775)] in the application of innovative polyculture (white shrimp and milkfish) technology, to determine food conversion ratio of white shrimp and milkfish and to examine the effect of food conversion ratio on the white shrimp and milkfish.

2.0 EXPERIMENTAL

2.1 Material

The material in this study were seed of white shrimp *Litopenaeus vannamei* with average initial weight of (1.25 ± 0.025) g and milkfish (*Chanos chanos*) with average initial weight of (3.25 ± 0.075) g. Artificial feed containing 35 % of protein enriched with vitamin C (3 % biomass d^{-1}) was also used. Feed ingredients and proximate analysis can be seen in Table 1.

Table 1 Feed ingredients formulation for white shrimp and milkfish

Material (g)	Composition
Vitamin C (mg)	0.08
Fish meal	34.5
Soybean	35
Corn meal	8.7
Rice bran	8.1
Dekstrin	10
Corn oil	1.42
Fish oil	1.1
CMC	1.1
Total	100
Energy (kkal)	300.02
Ratio E/P	8.7

The experimental was conducted in the brackishwater pond using Randomized Complete Design (RCD) with four treatments and three replications namely T1 (15 individuals of white shrimp per m^2 and 15 individuals of milkfish per m^2), T2 (30 individuals of white shrimp per m^2 and 15 individuals of milkfish per m^2), T3 (15 individuals of white shrimp per m^2 and 30 individuals of milkfishper m^2), T4 (30 individuals of white shrimp per m^2 and 30 individuals of milksfish per m^2).

The study was conducted in polyculture media with dimension of approximately 1 200 m^2, with each plot of 100 m^2 breadth of research. Inovation of polyculture could improve biofilter system using seaweed *Gracilaria* sp. closed system. For polyculture technology of white shrimp and milkfish, the seeds were purchased from a BBPAP Jepara and were stocked at a different density, i.e. 15 to 30 individuals of white shrimp and 15 to 30 individuals of milkfish. This study was conducted in 120 d and the animal growth was examined every week. Biological variables examination included absolute weight, survival rate, while variables of the water quality included temperature, salinity, pH, O_2, ammonia (NH_3). Data were analyzed by analysis of variance (F test) and descriptive analysis.

Table 2 Absolute growth based on weight (g) on a variety of treatments and replications

Parameter	Treatments in Polyculture			
	T1 (15 W/15 M)	**T2 (30 W/15 M)**	**T3 (15 W/30 M)**	**T4 (30 W/30 M)**
Absolute growth of white shrimp (g)	17.14 ± 0.17[b]	17.96 ± 0.81[b]	18.64 ± 0.97[a]	19.25 ± 0.99[c]
Absolute growth of milkfish (g)	179.53 ± 2.48[b]	183.81 ± 0.90[b]	186.45 ± 0.89[a]	187.26 ± 1.02[c]
Survival rate of white shrimp (%)	88.98 ± 2.10[c]	93.47 ± 0.45[b]	94.07 ± 2.17[a]	95.00 ± 0.33[c]
Survival rate of milkfish (%)	69.75 ± 1.82[c]	72.27 ± 0.1[b]	73.84 ± 0.62[a]	75.25 ± 0.13[c]
FCR of white shrimp and milkfish	3.51 ± 0.54[c]	2.89 ± 0.23[b]	2 ± 0.15[a]	1.25 ± 0.02[c]

Note:
W = white shrimp
M = milkfish
Different superscript letters in the same column indicate significant differences between samples at the level of ($P < 0.01$)

3.1 Absolute Growth of *White* Shrimp

Table 2 shows that the highest rate of absolute growth weight in treatment T4 (30 individuals per m^2 for white shrimp and 30 individuals per m^2 for milkfish) was (19.25 ± 0.99) g reared in ponds Muara Tegal Reja. Effect of the difference in the density of white shrimp and milkfish on the absolute growth of white shrimp (g) in polyculture systems highly significant ($P < 0.01$) (Figure 1).

Artificial feed was given with a protein content of 35 % to 40 %, thus, led in FCR (Food Conversion Ratio) of 1.1. This value means that to produce 1 kg of vannamei shrimp needed pellets 1.1 kg of pellets was needed with survival after was 95 % to 97 %. In addition, the cultivation of polyculture system by simultaneous maintainaning the density of white shrimp and milkfish (30 individuals per m^2 white shrimp and 30 individuals per m^2 milkfish) was able to provide the highest absolute growth weight, because the amount of feed and its density level was appropriate and feasible for life and better growth. The growth indicator was the change in length and weight in a given period. Individual growth due to the addition of tissue mitotic cell division that causes changes in size [6, 9–17] is a growth factor that affects the feed ratio and the weight of the fish, while other factors are external and internal factors. External factors include water and environmental conditions while the internal factors are the species, sex, genetic and physiological status of fish.

Indicator of physical growth includes number or size of the cells that build up the body tissue and morphologically visible growth of body shape changes. Growth will occur when the energy needed for the metabolism and tissue maintenance fulfill the needs of the fish [18]; when the amount of consumed feed was greater than the amount needed for body maintenance; and when it is used as an energy source for the fish [1, 4, 19], thus, the highest value was obtained from T4 (30 individu of white shrimp and 30 individu of milkfish per m^2) which used polyculture system because of the source of the formulated feed for the testing was made from artificial feed with 35 % of protein content enriched with vitamine C (3 % biomass · d^{-1}). Fish meal is the source of protein and contain the whole essential amino acid. Furthermore, polyculture technology application in fish, black tiger shrimp, seaweed with biofilter seaweed and without science program IbM results could increase production by 200 % [6, 10–12].

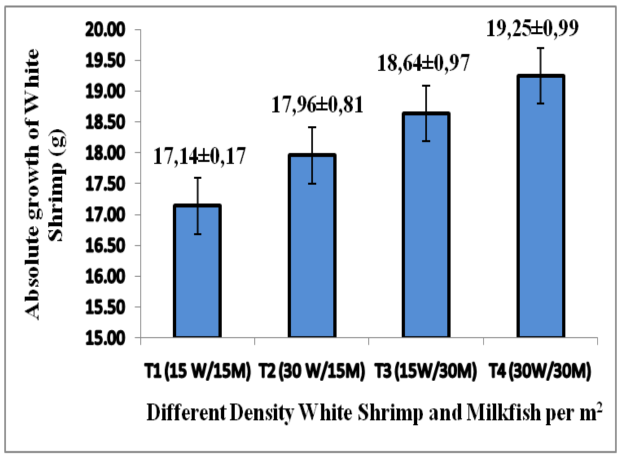


Figure 1 Effect of the difference in the density of white shrimp and milkfish on the absolute growth of white shrimp (g) in polyculture systems

3.2 Absolute Weight Growth of Milkfish

The results showed that the highest growth based on absolute weight in milkfish and white shrimp was treatment T4 with polyculture system (30 individuals per m^2 of white shrimp and 30 individuals per m^2 of milkfish which was (187.26 ± 1.02) g (Table 2). Effect of the difference in the density of white shrimp and milkfish based on the absolute growth of milkfish (g) in polyculture systems (Figure 2).

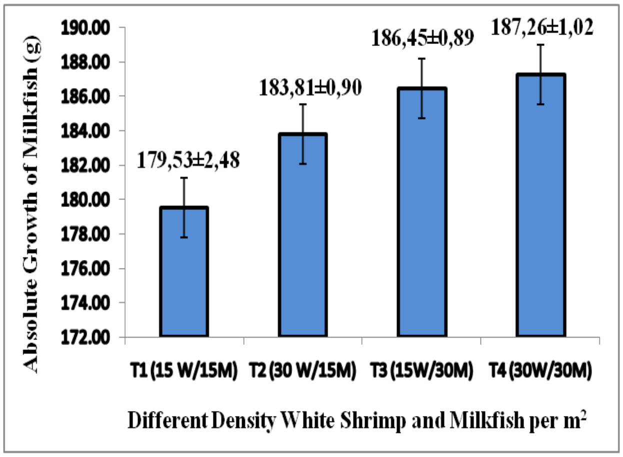


Figure 2 Absolute growth based on weight of milkfish

The highest growth based on absolute weight was treatment T4 (30 individuals per m^2 of white shrimp and 30 individuals per m^2 of milkfish). The number of density and the amount of artificial feed was in accordance with the growth of the absolute weight of fish (185.71 ± 1.025) g and was able to increase the highest growth, compared to other treatments (T1, T2, and T3) (Figure 2). Analysis of variance showed a significant influence ($P < 0.01$). The highest weight based on absolute growth was obtained from T4 because protein content in the feed affected the absolute weight of milkfish. Protein is useful for growth in which it highly affected the growth of white shrimp and milkfish size, protein quality in energy content of feed, and also balanced the nutrient and feeding rate [5, 20]. Protein deficiency could decrease the absolute weight of shrimp and milkfish followed by muscle loss due to lack of protein in the muscle and vital organ [21]. Similar with previous research, he artificial feeding with a protein content of 35 % enriched with vitamin C for milkfish was able to increase the growth of the absolute weight of milkfish for 179.5 g to 185.25 g [6, 10–13], thus, this research gave a better result in absolute weight. Moreover, the use of artificial feed with a protein content of 35 % enriched vitamin C can also increase the absolute growth of milkfish [6, 8, 12]. This was likely because vitamin C was useful to maintain body condition, hence, contributes also in the growth. Vitamin C is needed by fish even in small amounts because the body can not synthesize vitamin, thus, it should get extra vitamin C from artificial feeds [6, 22, 23]. Therefore, complete and balance nutrient content of the formulated feed is necessary for the white shrimp and milkfish polyculture system. Moreover, polyculture system is one of the important system to increase growth and survival rate of white shrimp and milkfish [24, 25].

3.3 Survival of White Shrimp

The results showed that the highest survival rate at white shrimp reared in polyculture system was obtained from T4 (30 individuals of whitei shrimp per m^2 and 30 individuals of milkfish per m^2) with value of (95 ± 0.33) % (Table 2, Figure 3).

Furthermore, based on Figure 3, effect of the difference in the density of white shrimp and milkfish on the survival rate of white shrimp in polyculture systems, and the analysis of variance showed a significant influence ($P < 0.01$) in survival of white shrimp. The survival rate was relatively high at T4. This is more likely due to several factors. The application of biofilter system contributed to a better environmetal condition. Artificial feed with a high protein content of 35 % enriched with vitamine C also contributed to proper tissue maintainance.

Moreover, the number of stocking density of white shrimp and milkfish in this polyculture system was relatively sufficient, thus, contributing in high survival rate (95 % ± 0.33 %) for T4. This is consistent with previous research [6, 26, 27]. Good water quality is essential in the fish cultivation. Water quality affects the survival of white shrimp and milkfish which led to better growth rate [25]. Furthermore, maintaining water quality using biofilter system and seaweed application towards white shrimp and milkfish polyculture could increase the survival rate up to 80 % to 90 % [28, 30–35], thus, improved production and economic returns of white shrimp and milkfish reared in polyculture system which were higher than those in the crop rotation polyculture system. Furthermore, previous research on polyculture of tilapia shrimp showed an improvement on water quality in white shrimp and milkfish cultivation ponds by reducing diseases and chemicals.

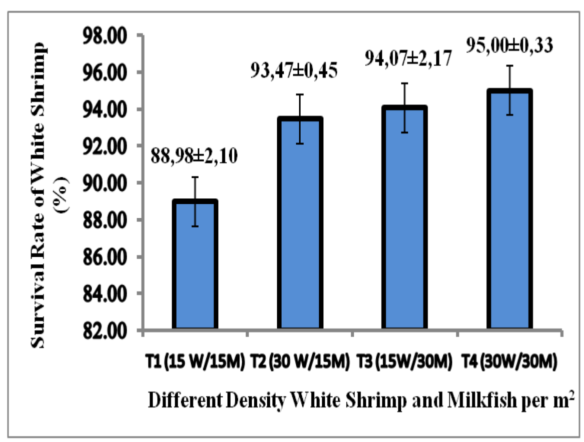


Figure 3 Survival rete of white shrimp in a variety of treatments and replication

3.4 Survival Rate of Milkfish

The results showed that the highest survival rate in fish was obtained from T4 polyculture (30 individuals of white shrimp per m2 and 30 individuals of milkfish per m2) which was 75 % ± 0.13 % (Table 2). Effect of the difference in the density of white shrimp *L. vannamei* and milkfish on the survival rate of milkfish in polyculture system is shown in Figure 4).

Based on Table 2, analysis of variance showed a high significance (P < 0.01) on the survival of the milkfish. This is likely because inovation polyculture uses recirculation system and biofilter system from seaweed. Other factors also contributed, such as administration of artificial feed containing 35 % of protein enriched with vitamine C, good environmental media, and proper number of stocking density, thus, increasing survival rate, i.e. 75 % ± 0.13 %.

This was in accordance with the opinion of reference [6], Good water quality in polyculture milkfish farming with white shrimp can increase the survival rate up to 80 % to 90 % [36–38]. Good water quality is an essential requirement in the cultivation of milkfish. Water quality affects the survival, proliferation and growth. Water quality can be maintained by biofilter system using seaweed application to polyculture of white shrimp and milkfish which was able to improve the survival rate up to 80 % to 90 % [6, 8, 11, 12, 34, 35, 39, 40]. It was reported that polyculture of *Gracilaria* sp. and milkfish showed that amount of stocking density of *Gracilaria* sp. which was good for the survival and growth of milkfish in the polyculture system was 500 kg of *Gracilaria* sp. because it was able to provide high survival for milksfish up to 100 % and growth rate for 9.26 g for absolute weight.

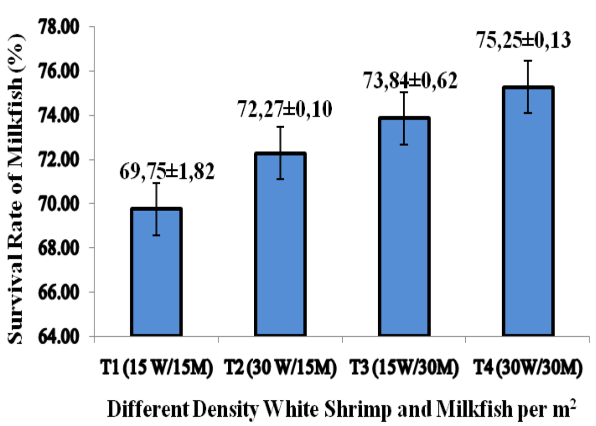


Figure 4 Survival rate of milkfish reared in polyculture on a variety of treatments and replications

3.5 Food Conversion Ratio (FCR)

The feed conversion ratio was a very important parameter to examine whether the feed was able to increase the growth of white shrimp and milkfish. The feed conversion values are also useful to see how far the feed was converted further into meat of milkfish or white shrimp. Treatment 4 (Figure 5) shows relatively low value of FCR (1.25 ± 0.02), although, highest growth was obtained from this treatment as well. This means that administration of feed was well conducted, thus, was efficient enough.

Based on Table 2, analysis of variance showed a high significance (P < 0.01) on the Food Conversion Ratio (FCR) on the white shrimp and milkfish reared in polyculture system. This is likely because the feed was proper for the pollyculture system, thus, increase growth rate better [41–44] and was able to be converted into white shrimp and milkfish. FCR lower value means more efficient feed administration [6, 10–12, 45, 46].

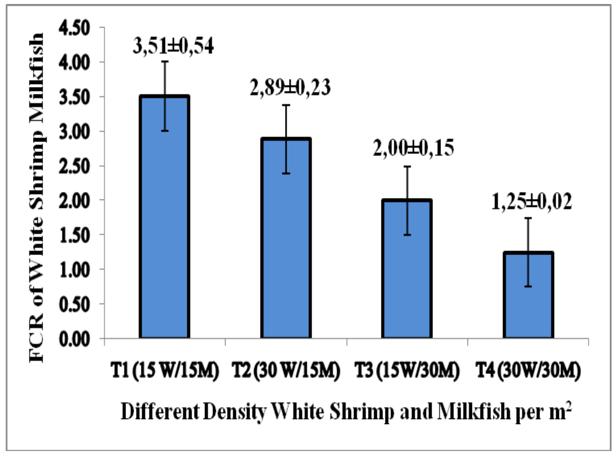


Figure 5 Food Conversion Ratio (FCR) on the white shrimp and milkfish reared in polyculture system

Other research reported that feed conversion ratio defined how many grams of a given amount of feed to produce one gram of body weight of milkfish and white shrimp [46]. FCR could also mean a value between the weight of feed consumed by the milkfish and the achieved weight (known as feed efficiency) [14, 18, 19, 30]. Good quality feed was determined from low value of feed conversion ratio [27–29], in which the value was expressed as food conversion ratio index of the total feed for growth. Low value of FCR means better conversion because the administration of the feed is efficient. Feed conversion values are still efficient when the value is less than 3 [27–29, 49].

3.6 Inovation of Polyculture Using Biofilter Systems Improved Water Quality Maintenance Farming

Water quality maintenance in polyculture technology of white shrimp and milkfish during the study showed feasibility for the second life cultivan. This is more likely due to the inovation in polyculture which used recirculation systems and biofilter system from seaweed and the difference in the density of white shrimp and milkfish (Table 3).

Table 3 Water quality maintenance media polyculture system vanamei shrimp and milkfish used biofilter system

Water Quality Parameter	Range	Literature
Dissolved oxygene (mg · L⁻¹)	4.75 – 5.95	> 4 [31,33]
Temperature (°C)	28.2 – 30.75	26.5 – 35 [25,32]
Salinity (ng · L⁻¹)	19 – 25.4	15 – 30 [25,32]
pH	7.5 – 8.5	7,5 – 8,7 [25,32]
Ammonia (mg · L⁻¹)	0.02– 0.295	< 1 [25,32,48]

Table 3 shows value of some parameter, i.e. the dissolved oxygen content (4.75 mg L^{-1} to 5.95 mg L^{-1}), temperature (28.2 °C to 30.75 °C), salinity (19 ng L^{-1} to 25.4 ng L^{-1}), pH (7.5 to 8.5), and ammonia (0.02 mg L^{-1} to 0.295 mg L^{-1}), all of which are still in the range of viable and capable support for the life of white shrimp and milkfish which were reared in polyculture system [25, 31–33, 48]. Several other research reported the application of closed polyculture system of tilapia shrimp combined with tagelus could increase productivity up to 28 %, which was higher than polyculture system for shrimp and tagelus. Moreover, the efficiency of nitrogen utilization increased up to 85 % [48–51]. This closed polyculture system reduced the nitrogen discharge ratio up to 6 % to 8 %, instead of 40 % to 90 % in the usual open culture systems.

4.0 CONCLUSION

The results showed that the density different on the white shrimp and milkfish gave significant effect ($P < 0.01$) on the growth and survival of white shrimp and milkfish. The highest growth in absolute weight of white shrimp and milkfish were obtained from treatment T4 (19.25 g ± 1.015 g) for white shrimp and 185.71 g ± 1.025 g for milkfish. Survival rate of white shrimp was 95 % ± 2.5 % for white shrimp and 75 % ± 2.75 % for milkfish. While for FCR (food conversion ratio), it was 1.25 ± 0.02. The inovation of polyculture technology by using biofilter systems and different stocking density of white shrimp and milkfish improved water quality which was still feasible to the life of white shrimp and milkfish.

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