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Crown of Thorns Starfish (*Achantaster planci*) Meal in Formulated Diets on the Growth of Whiteleg Prawn (*Penaeus vannamei* Boone, 1931)

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Abstract

The study investigated the growth of juvenile whiteleg prawn (*Penaeus vannamei*) fed with different doses of the crown of thorns starfish (*Acanthaster planci*) meal in formulated diets. The study was designed using a completely randomized design consisting of four treatments and three replications. The treatments were the dosages of *A. planci* meal in a formulated diet, namely A: 0% (control); B: 9%; C: 18%; and D: 27%. Juveniles of *P. vannamei* were reared in a 40 × 25 × 25 cm aquarium (15 Liter water volume) for 28 days. The results showed that the Individual Weight Gain (IWG) of juveniles ranged from 2.68 to 2.94 g, Specific Growth Rate (SGR) ranged from 2.82 to 2.93% day^{-1}, feed conversion ratio ranged from 3.03-3.22, feed efficiency was 31.31-33.17%, and survival rate was 96.67-100%. The analysis of variance revealed that the use of *A. planci* meal in a formulated diet did not have a significant effect ($p>0.05$) on growth performance (IWG and SGR), feed conversion ratio, feed efficiency and survival rate of juveniles of whiteleg prawn during 28 days of culture. The utilization of *A. planci* meal up to a dose of 27% can be used as a substitute for fishmeal as a feed protein source for cultured whiteleg prawns.

INTRODUCTION

Whiteleg prawn (*Penaeus vannamei* Boone, 1931) currently dominates the global prawn aquaculture to meet the increasing demand for prawn products. This species has several advantages including it can be cultured in a high stocking density, which reaches 400-500 PL per m^3 (da Silveira *et al*., 2020), has a relatively fast growth, thus the rearing period to reach market size (82 prawns kg^{-1}) is short, which is around 77-126 days cycle^{-1} (da Silveira *et al*., 2020; Purnamasari *et al*., 2017), and can tolerate a wide salinity range of 5-49 ppt (Bray *et al*., 1994; Sadek and Nabawi, 2021). However, a common problem that often occurs in whiteleg prawn farming is the price of feed

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which increases along with the increase in protein content of feed (Van *et al*., 2017).

The most expensive component in aquafeed is protein, and the main source of protein in whiteleg prawn feed generally comes from fishmeal and it is quite expensive. The use of fishmeal has yet to be fully replaced by plant-based ingredients. This is because the content of essential amino acids in the form of methionine and lysine from vegetable materials is relatively low compared to fishmeal (Andri *et al*., 2020; Daniel, 2018; Yang *et al*., 2012). Therefore, low-cost feeds that still meet nutrient quality and quantity can be produced by utilizing non-economic animal raw materials that have amino acid content and profiles similar to fishmeal.

Crown of thorns starfish (*Acanthaster planci*) has the potential to be used as a raw material for animal protein sources in aquafeed. This species is undergoing a population explosion and becoming a significant threat to coral reef biodiversity around the world. Several methods such as capturing, drying, and landfilling can be applied to control their population explosion (Kayal *et al*., 2012; Rotjan and Lewis, 2008; Stella *et al*., 2011; Suharsono, 1991). Until now, the crown of thorns starfish (COTS) has not been utilized by the community, thus it can be categorized as having no economic value. In addition, COTS meal has a high nutrient content and amino acid profile resembling fishmeal (Luo *et al*., 2011; Safir *et al*., 2022b). The utilization of COTS meal in the formulated diet at 210 g kg^{-1} feed produced the same growth performance of tilapia as the control, 280 g fishmeal kg^{-1} feed (Safir *et al*., 2022a). However, a report on the utilization of *A. planci* meal in prawn culture is not sufficiently available. Therefore, this study aimed to assess the growth performance of whiteleg prawn juveniles fed with formulated diets containing COTS meals.

METHODOLOGY

Ethical Approval

The use of the experimental animals has been approved by the Animal Ethics Commission of the Faculty of Animal Husbandry and Fisheries, Tadulako University based on certificate number 89/UN28.1.31/KP/2022, January 05, 2022.

Place and Time

The entire series of research was carried out from December 2021 to June 2022. Juveniles of whiteleg prawn were reared at the Mamboro Fish Seedstock Center (BBI), Mamboro, Palu, Central Sulawesi. Proximate analysis of the formulated diets was conducted at the Animal Nutrition Laboratory, Faculty of Animal Husbandry and Fisheries, Tadulako University.

Research Materials

Some devices were used in this study including ovens (Eyela-NDO-410, China), desiccators (Pyrex-CLS3121150, Indonesia), automatic rapid extraction system/Soxtherm (Gerhardt Sox-412/13-005, Germany, and Eyela-CCA/1111, China), distillation system (Gerhardt VAPE 45s (12-0035), Germany), automatic digestion system (Gerhardt KBL8S-12-0059, Germany), Turbosog (Gerhard ZKE-12-0361, Germany), furnace (Nabertherm LE14-11P300, Germany), fish pellet machine (MKS-PLT10, Indonesia), analytical balances (Kern 572-32, Germany), analytical scales (Newtech-NT-A-300, China), beaker glass (Gerhardt-SEBMA-13-0050, Germany), graduated cylinder (IWAKI-CTE33, Indonesia), volumetric flasks (Iwaki, Indonesia), rack sox (Gerhardt-EGMA-13-0073), aerator (Resun LP100, China), dissolved oxygen DO Meter (Lutron DO-5510, Taiwan), pH meter (Hanna-HI 9813-5, Romania), and refractometer (Atago, EG PG 2930, Japan).

The materials used included n-hexane pro analysis (Supelco-Emsure-MTA-171026907, Germany), acetone pro analysis (Merck, EMSURE-S1734, Germany), Kjeldahl tablets (Supelco 118348, Germany)

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H_2SO_4 95-97% (Merck, EMSURE, Germany), NaOH 30% (Supelco, 105589, Germany), HBO_3 2% (Supelco, EMSURE-105589, Germany), HCL 0.1 N (Merck, EMSURE, Germany), filter paper, and distilled water.

Research Design

The study was designed with a completely randomized design consisting of four treatments and three replicates. The treatments were the dosages of *A. planci* meal in a formulated diet, namely A: 0% (control); B: 9%; C: 18%; and D: 27% (Table 1).

Work Procedure

Experimental Animals

Whiteleg prawn juveniles with a mean body weight of 2.25±0.09 g were sourced from Mamboro Coastal Seedstock Center, Palu, Central Sulawesi. Prawns were acclimated in a bin (65 × 33 × 25 cm), containing 40 L of water with a salinity of 30 ppt. Acclimation was carried out for 2 days before the animals were distributed to each rearing bin. During acclimation, prawns were fed with commercial prawn pellets (containing 35% crude protein) of 5% of total body weight divided into three daily feedings.

Formulation and Nutritional Contents of Feed

Feed was formulated with a target crude protein content of 35% and energy ranging from 3700-3900 kcal (Table 1). COTS meal is used to substitute fishmeal as a source of animal protein in feed. The fish meal used decreased as the dose of *A. planci* meal used as a raw material in the formulated diet increased. The percentage of plant protein sources (soybean meal, bran meal, and corn meal) used was adjusted to the shortage of feed protein content due to the reduction of fishmeal to meet the target crude protein of 35% (Table 1 and 2). Feed formulation and processing were carried out following a method used by Safir *et al.* (2022a) and the nutritional content of the feed was confirmed by proximate analysis following methods used by Safir *et al.* (2020). The nutritional content of the formulated diets based on proximate analysis is presented in Table 2.

Table 1. Feed formulation used in the study.

Ingredient Composition	Protein Content (%)*	*Achantaster planci* meal in feed (%)			
		0 (A)	9 (B)	18 (C)	27 (D)
Fishmeal (*Sardinella* sp.)	51.30	41.00	32.00	23.00	14.00
Achantaster planci meal	26.02	0.00	9.00	18.00	27.00
Shrimp head meal	46.12	3.00	3.00	3.00	3.00
Soybean meal	33.18	9.00	18.00	29.00	41.00
Bran meal	14.24	19.00	13.00	7.00	3.00
Corn meal	14.06	20.00	17.00	12.00	4.00
Vegetable oil		1.75	1.75	1.75	1.75
Fish oil		1.75	1.75	1.75	1.75
Tapioca powder		2.50	2.50	2.50	2.50
Vitamin & mineral mix		2.00	2.00	2.00	2.00
Total		100.00	100.00	100.00	100.00
GE target (kcal/kg)**		3770.31	3808.87	3867.88	3909.75
C/P***		12.24	12.58	12.85	12.97

*Protein content of ingredients based on proximate analysis at the Nutrition Laboratory, Faculty of Animal Husbandry and Fisheries, Tadulako University; **GE= Gross energy; ***C/P= Calorie per protein ratio

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Table 2. Nutritional content of formulated diets used in the study.

Nutritional content	*Achantaster planci* meal in feed (%)			
	0 (A)	9 (B)	18 (C)	27 (D)
Dry ingredients	94.05	94.15	94.37	95.10
Crude fat	8.50	10.39	12.43	13.41
Crude protein	35.45	35.30	35.21	35.79
Crude fiber	5.14	3.73	3.75	3.10
Ash content	26.33	24.94	27.03	27.41
NFE*	18.63	19.79	15.97	15.39

**NFE = Nitrogen Free Extract.

Culture and Sampling of Experimental Animals

Juveniles of *P. vannamei* were stocked at a density of 10 prawns 15 L^{-1} of water in glass aquaria (40 × 25 × 25 cm) connected with aeration. Experimental animals were fed at 10-4% of body weight (Lee and Lee, 2018) divided into five daily feedings. The body weights of experimental animals were measured weekly until the end of the experiment (28 days of culture). The weights of consumed feed and dead prawns were recorded throughout the experiment. Water quality was monitored regularly and maintained at a suitable range for *P. vannamei* juveniles including temperature 25-30 °C, pH 6-8.5, dissolved oxygen ≥4 ppm, and salinity 30-33 ppt (Rusydi *et al*., 2021; Saoud *et al*., 2003).

Data Analysis

To examine the effect of each treatment on individual weight gain, specific growth rate, (Safir *et al*., 2022d; Sanudin *et al*., 2014)), feed conversion ratio (Madani *et al*., 2018), feed consumption (Dini *et al*., 2019), and survival rate (Madani *et al*., 2018), the data was analyzed using analysis of variance (One Way ANOVA) at an accuracy level of 95%. Differences between each treatment were determined using Duncan's test.

RESULTS AND DISCUSSIONS

Juveniles of *P. vannamei* fed with different doses of COTS in formulated diets had no significant effect on individual weight gain (IWG) and specific growth rate (SGR) ($p>0.05$) of *P. vannamei* (Table 3). Similar results have been reported by Safir *et al*. (2022a) where tilapia fed a diet containing COTS meal up to a dose of 21% for 40 days of culture showed no significant effect on the growth performance of tilapia ($p>0.05$).

The growth that did not differ significantly between all treatments and the control in this study is thought to be related to the protein content of COTS meal which can improve the protein composition, especially amino acids in feed, due to the reduced use of fishmeal and increased use of soy meal in feed. Fishmeal is a source of animal protein with a complete amino acid profile, while soybean is a source of plant protein in feed that is rich in essential amino acids except for methionine and lysine, which are quite limited (Andri *et al*., 2020; Daniel, 2018). The increased use of soybean meal in feed will certainly have an impact on the unbalanced amino acid profile, especially methionine and lysine.

A. planci meal has a fairly high protein content and amino acid profile that resembles fishmeal (Luo *et al*., 2011; Safir *et al*., 2022a; Safir *et al*., 2022b). Therefore, the absence of significant differences in growth performance for all treatments including the control proved that the reduced supply of animal protein from fishmeal in this study could be substituted by *A. planci* meal as a feed ingredient up to a dose of 27%.

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Table 3. Individual weight gain (IWG), specific growth rate (SGR), feed consumption (FC), feed conversion ratio (FCR), and survival rate of *Penaeus vannamei* juveniles fed with *Achantaster planci* meal in formulated diets.

Test parameters	*Achantaster planci* meal in feed (%)			
	A (0)	B (9)	C (18)	D (27)
IWG (g)	2.68 ± 0.30	2.92 ± 0.11	2.80 ± 0.27	2.94 ± 0.36
SGR (%/day)	2.84 ± 0.25	2.93 ± 0.14	2.82 ± 0.13	2.92 ± 0.20
FC (g)	85.01 ± 0.72	85.95 ± 6.45	85.20 ± 4.78	86.30 ± 5.14
FCR	3.22 ± 0.40	3.05 ± 0.34	3.07 ± 0.42	3.03 ± 0.21
SR (%)	96.77 ± 5.77	90.00 ± 0.00	100 ± 0.00	96.67 ± 5.77

The feed consumption ratio indicates the amount of feed consumed by *P. vannamei* juveniles. Analysis of variance showed that COTS meal in formulated diets had no significant effect (p>0.05) on feed consumption rate between all treatments, including the control (Table 3). These results illustrate that the experimental diets can be responded to well by *P. vannamei* juveniles as well as control feed. Wirtz *et al*. (2022) suggested that the rate of feed consumption is influenced by the rate of gastric emptying and the appetite of the organism. *Penaeus vannamei* is an organism that actively seeks food by using its sensory organs (antennae and antennules). The aroma produced from the feed will make it easier for shrimp to find and consume the feed given until their body needs are met. The addition of *A. planci* meal can improve the aroma of the feed as well as fishmeal (Safir *et al*., 2022c). The amount of feed consumed and properly utilized by the experimental animals will directly have a positive impact on the feed conversion ratio (Table 3).

The feed conversion ratio obtained in this study is relatively higher than the results reported by several researchers, 1.81-2.63 (Aalimahmoudi *et al*., 2016), 1.76-2.21 (Madani *et al*., 2018), and 1.32-1.43 (Chi *et al*., 2009) in *P. vannamei*. The high FCR may be related to the ash content of the experimental feed, which ranged from 24.94-27.03% (Table 2). High ash content in feed will limit the absorption of nutrients by shrimp, causing the FCR value to increase. Several published articles showed that the ash content of *P. vannamei* feed ranging from 5.13 to 5.33 resulted in an FCR of 1.32-2.76 (Lee and Lee, 2018), and ash content in the feed of 9.88% resulted in an FCR of 1.59-2.06 (Sadek and Nabawi, 2021). High ash content in feed generally comes from animal raw materials used in feed manufacturing (Hua *et al*., 2019; Chi *et al*., 2009), including the COTS meal used in this study (Safir *et al*., 2022a; Safir *et al*., 2022b).

The survival rate of *P. vannamei* juveniles at the end of culture for all treatments ranged from 96.67 to 100%. The statistical analysis showed that the use of *A. planci* meal as a substitute for fishmeal with different doses in formulated diets did not have a significant effect (p>0.05) on the survival of *P. vannamei* juveniles. The non-different survival rates in all treatments indicate that the toxins in the thorns of *A. planci* did not cause mortality to the experimental animals that consumed them, especially in the form of meal. This is because the raw material for *A. planci* meal has gone through a drying and grinding process before being used as feed ingredients.

Furthermore, the toxic substance in the thorns of *A. planci*, phospholipase-A2 (Shiomi *et al*., 1998), functions as an antibacterial and antiviral (Wijanarko *et al*., 2018) and plays an important role in the fat metabolism process (Savitri *et al*., 2012). Survival rates did not reach 100% for all treatments due to cannibalism in the experimental animals shortly after molting. This is due to a relatively high stocking density of 10 prawns per 15 L of water or ± 600 prawns per m^3.

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CONCLUSION

The use of *Acanthaster planci* meal as a substitute for fishmeal in the feed up to a dose of 27% did not have a significant effect on the growth performance, feed consumption, feed conversion ratio, and survival rate of whiteleg prawn juveniles. *A. planci* meal can be utilized as a raw material for animal protein sources to substitute fishmeal in reducing high prices of feed in *Penaeus vannamei* culture.

CONFLICT OF INTEREST

No conflict of interest among all authors upon writing and publishing the manuscript.

AUTHOR CONTRIBUTION

Muhammad Safir (Conceptualization, and Project administration), Seftina Fifi Mangitung (Data curation), Izhar (Investigation), Novalina Serdiati (Methodology), Nur'aidah (Formal analysis).

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