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Growth performance and survival rate of vannamei shrimp (*Litopenaeus vannamei*) post-larva stages in a super intensive cultivation system with varied densities

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ABSTRACT

Vannamei shrimp (*Litopenaeus vannamei*) holds significant economic importance in Shrimponesia as a prominent shrimp commodity. The post-larval stage often encounters challenges, primarily due to the shrimp's limited ability to adapt and survive in a new environment. Stocking density is a crucial factor influencing the growth and production performance of vannamei shrimp culture. This study aims to assess the optimal stocking density for achieving optimal growth and survival in *L. vannamei.* A 40-day maintenance trial was conducted at UD Mina Rahayu Kalianda to investigate the impact of different stocking densities on water quality in the maintenance media. The study utilized containers with varying stocking densities: treatment A (1 shrimp/L), treatment B (1.5 shrimp/L), and treatment C (2 shrimp/L), each with three replications. The findings revealed survival rates (SR) of 83.33% for treatment A, 62.78% for treatment B, and 58.33% for treatment C. Mean Body Weight (MBW) values were recorded as 1.2592 g/shrimp for treatment A, 1.1216 g/shrimp for treatment B, and 0.7728 g/shrimp for treatment C. Average Daily Growth (ADG) results showed 0.0313 g/shrimp for treatment A, 0.0279 g/shrimp for treatment B, and 0.0192 g/shrimp for treatment C. Based on the study, the recommended stocking density for white vannamei shrimp is 40 shrimp/L, demonstrating improved growth and survival rates for this species.

Introduction

Litopenaeus vannamei, commonly known as vannamei shrimp, stands out among shrimp species due to its significant economic value, earning the status of a national superior species (Danya and Naik, 2014). The aquaculture production of vannamei shrimp exhibited a positive trend from 2016 to 2018, with figures reaching 40,381 tons in 2016, 457,793 tons in 2017, and 498,174 tons in 2018 (KKP, 2019). In comparison with tiger prawns, vannamei shrimp offers several advantages, such as adaptability to a wide salinity range (0.5-45 ppt), the ability to thrive at high density exceeding 150 shrimp/m^2, increased resistance to suboptimal environmental conditions, and shorter maintenance cycle of approximately 90-100 days per cycle (Hudi *et al.*, 2005). Classified within the Penaeid genus of the Crustacean class, vannamei demonstrates execeptional productivity with white shrimp production reaching 13,600 kg/ha (Boyd and Clay, 2002). Research by Samocha *et al.* (2013b), utilizing a super intensive-raceway system, reported white shrimp production at 9.2 kg/m^3 (92,000 kg/ha), while Salas and Rendon (2013) documented white shrimp production reaching 4.5 kg/m^3 (45,000 kg/ha) under a hyper-intensive system within a controlled environment.

The cultivation of Vannamei shrimp is driven by the growing market demand. Various approaches are employed for the maintenance of Vannamei shrimp larvae, and one notable method is the application intensive system cultivation technology. This

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technique involves utilizing high stocking density treatment and optimal feeding practices. Vannamei shrimp exhibits robust growt under high stocking densities, ranging 60 to 150 shrimp/m^2 (Briggs *et al*., 2004), with a growth rate of 1-1.5 g/week. According to Wyban and Sweeney (1991), a stocking density of 100 shrimp/m^2 remains suitable for white shrimp growth. Cultivation of Vannamei shrimp at high stocking densities has been implemented through various systems, including a raceway system (271 m^2) with stocking densities of 300-810 shrimp/m^2 (Venero *et al*., 2009); 658-1602 shrimp/m^3 (Lawrence, 2010); a raceway system (40 m^3) with stocking densities of 530 shrimp/m^3 (Samocha *et al*., 2010); a raceway system (40-100 m^3) with stocking densities of 390-500 shrimp/m^3 (Samocha *et al*., 2012); and a biofloc raceway system of 100 m^3 with a stocking density of 500 shrimp/m^3 (Samocha *et al*., 2013a). The cultivation of Vannamei shrimp under high stocking density has been conducted in smaller containers (<100 m^3) utilizing an indoor system. Since 2011, Indonesia has pioneered the development of super-intensive Vannamei shrimp culture in 1,000 m^2 ponds with a stocking density ranging 312 to 1,000 shrimps/m^2 (Atjo, 2013). The intensive cultivation system represents a shrimp cultivation technology characterized by a higher seed stocking rate than the semi-intensive system, incorporating natural and artificial feed alongside other production inputs (Nugroho *et al.,* 2016).

The implementation of high stocking densities in super-intensive cultivation systems is geared towards enhancing production, as indicated by the varying number of larvae stocked, namely 1000, 1500 and 2000 shrimp/m^3. However, a critical threshold exists where the carrying capacity of the pond can no longer sustain the well-being of the shrimp. The stocking density of Vannamei shrimp plays a pivotal role in determining the applied shrimp cultivation management system (Tahe & Makmur, 2016). Consequently, it becomes imperative to ascertain the optimal stocking density to minimize production costs and enhance profits, ensuring the creation of sustainable and highly competitive products. Excessive stocking density can cause lead to heightened competition among for space, feed and oxygen, resulting in uneven growth (Rakhfid *et al*., 2017; Akbar and Fazli, 2023). Mangampa *et al.* (2014) recommend stocking densities for extensive cultivation techniques of white vannamei shrimp to be <5 shrimp/m^2 and for extensive-plus stocking densities to range from 6 to 8 shrimp/m^2. Vannamei shrimp exhibits favorable growth even at stocking densities exceeding 100 shrimp/m^2, a notable contrast to tiger shrimp, which has a maximum stocking density of 40 shrimp/m^2 (Supono *et al*., 2014). In line with this, Nababan *et al.* (2015) emphasize that shrimp in ponds commonly adopt intensive and supra-intensive technologies, enabling them to achieve high stocking densities ranging from 100 to 400 shrimp/m^2.

The elevated stocking density contributes to an increase in organic matter content, including ammonia derived from feed residues and shrimp. The accumulation of excess feed leads to an elevation in ammonia levels, posing toxicity risks to shrimp. Consequently, it is imperative to conduct a study addressing the optimal stocking density in shrimp cultivation, particularly during the post larval stages ranging from post-larva 10 to post larva 50. The aim of this study was to assess the suitable stocking density that promotes optimal growth and survival in *L. vannamei.*

Materials and Methods

Research Location

This study was conducted at UD Mina Rahayu, Merak Belantung District, Haringin Village, South Lampung, Lampung, Indonesia.

Materials and Tools

The utilized various equipment including tanks containers, concrete tubs, dippers, hoses, buckets, basins, blowers, and aeration stones. Additionally, it involved the use of leads, brushes, mugs, digital scales, feed sieves, tarpaulins, water pumps, filter bags, foam, cotton, and plastic packing. The equipment list also comprised oxygen hoses and oxygen tube,s thermometers, DO meters, pH meters, and NH_3/NH_4 test kits. The materials used included post-larva, artificial feed, virqon, and EDTA.

Preparation of Tub and Maintenance of Larval Media

The initial step involves cleaning the tub by scrubbing its walls and bottom uniformly using a sponge, along with the application of a disinfectant solution dissolved in water. Subsequently, the tub is left to dry in sunlight for a period of 3-4 days. This same procedure is replicated for the containers used as maintenance media. Once the tub is thoroughly dried, the containers are placed and arranged within the tub.

The subsequent procedure involves the installation of aeration. Prior to usage, both the aeration stone and hose are immersed in a chlorine solution for a duration of 3-4 days. Following this, the aeration system is set up, with each container

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being equipped with two aeration hoses. The subsequent step involves water filling. Reservoir water, which has undergone physical filtration and has been treated with 20 g/m^3 of Virkon brand disinfectant, along with 100-150 g of Ethlene Diamine Tetra Acid (EDTA), is utilized. The water is then subjected to additional filtration through cotton, foam, and abalone. This process serves the purpose of filtering carrier organisms that may harbor viruses, act as competitors and sterilizing the incoming water. Each container is subsequently filled with 40 liters of sea water.

Naupli Acclimatization and Stocking

Temperature acclimatization was carried out by submerging the naupli bag containing seawater under circulating conditions for approximately 30 minutes. Once the water temperature inside the naupli bag equaled the water temperature in the acclimatization tank, the naupli was delicately transferred from the plastic bag to a container for subsequent salinity acclimatization. The acclimatization process in the container lasted approximately 20 minutes without water circulation, accompanied by aeration. A total of 540 post larvae were utilized for stocking, referencing previous researc (Supono, 2006).

Maintenance

To maintain water quality, siphoning is carried out to eliminate debris and residual feed settled at the bottom of the aquarium. This procedure is undertaken when the water conditions deteriorate, using 0,5-inch diameter siphon hose.

Feed Management

The maintenance was carried out for 40 days, involving the administration of Prima Feed brand shrimp feed in granule form, containing 39% protein with a size ranging from 0.5 to 0.7 mm. Blind feeding was adopted, with feeding occurring four times daily at specific intervals: 07.00 WIB, 11.00 WIB, 15.00 WIB, 19.00 WIB

The initial step was to weigh the feed following the predetermined blind feeding guidelines. Adjustments were made based on considerations such as the larvae's number/density, appetite, tub water conditions, and larvae status. Subsequently, the feed underwent filtration using a 100-mesh feed filter with fresh water until fully dissolved (feeding with fresh water). Finally, the feed was evenly distributed across each larval rearing container at multiple points.

Research parameters

The parameters observed in the vannamei shrimp larvae rearing activities were as follows:

a. Mean Body Weight (MBW)

Mean body weight (MBW) represents the average weight of the shrimp based on the sampling results. MBW calculations are performed to assess shrimp growth over specific time intervals. In this final project, MBW is calculated every 14 days during the maintenance period. The calculation of MBW can be done using formula provided by Hermawan (2012).

$$\text{MBW} = \frac{\text{Total sample weight}}{\text{number of sample}}$$

b. Average Daily Growth (ADG)

Average Daily Growth (ADG) signifies the average daily weight gain of shrimp over a specific time frame, enabling determination of the shrimp's growth rate. ADG can be calculated using the formula provided by (Haliman and Adijaya, 2005).

$$ADG = \frac{Current\ ABW - previous\ ABW}{maintenance\ period}$$

All acquired data underwent analysis using the SPSS program to derive average values and standard deviations. Subsequently, the data was presented in the form of tables and figures.

c. Survival Rate (SR)

The measurement of survival rate can be accomplished using the formula provided by Haliman and Adiwijaya (2005). The formula for calculating survival rate (SR) is as follows:

$$SR = \frac{Nt}{No} x\ 100$$

Description:
SR = Survival Rate (%)
Nt = Number of shrimps at harvest
No = Number of initial stockings of shrimp

Experimental design

This research employed a completely randomized design consisting of three treatments, each with three replications. The treatments were as follows:

- Treatment A : Stocking density of 1 shrimp/L
- Treatment B : Stocking density of 1.5 shrimp/L
- Treatment C : Stocking density of 2 shrimp/L

Results

Mean Body Weight (MBW)

Observations on the average weight of shrimp were conducted at 10-day intervals over a 40-day maintenance period. The outcomes of these observations regarding the growth of the average weight of shrimp are illustrated in Figure 1.

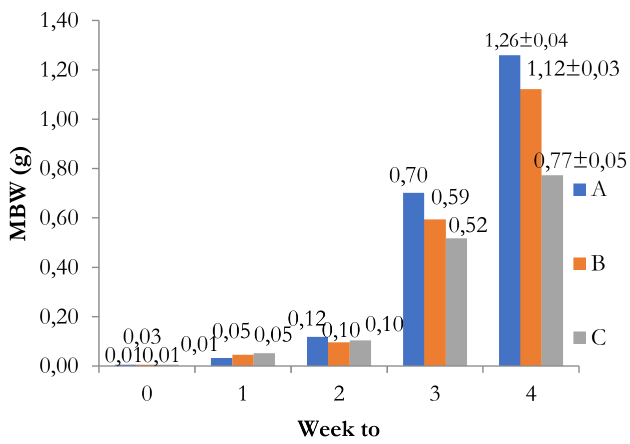

Figure 1. Mean Body Weight (MBW) of vannamei shrimp reared for 40 days

The initial average weight of white vannamei shrimp, stocked at a density of 1 shrimp per liter, was 0.0054 g. By the 40th day of rearing, the weight had increased to 1.2592 g. Notably, the weight growth of white vannamei shrimp at this stocking density did not exhibit a decrease throughout 40-day period, resulting in absolute weight growth of 1.2538 g. Similarly, at a stocking density of 1.5 shrimp per liter, the average initial weight was 0.0054 g. On the 40th day, the growth led to an average weight of 1.1216 g. Furthermore, for a stocking density of 2 shrimp per liter, the initial weight was 0.0054 g, which increased to 0.7728 g by the 40th day. The absolute weight growth during this period of maintenance was 0.7674 g.

Average Daily Growth (ADG)

Observation of the daily average growth rate of white vannamei shrimp was carried out at intervals of 10 days. The outcomes of these observations are depicted in Figure 2.

The Average Daily Growth (ADG) in this study yielded distinct outcomes among treatments A, B, and C. Treatment A exhibited the highest growth rate, with an ADG value of 0.0313 g/shrimp, surpassing the growth rates observed in the other treatments. Notably, during the period from Day of Culture (DOC) 0 to DOC 10, there was a variation in the growth rate among the three treatments, with treatment C demonstrating the highest growth rate at 0.0057 g/shrimp.

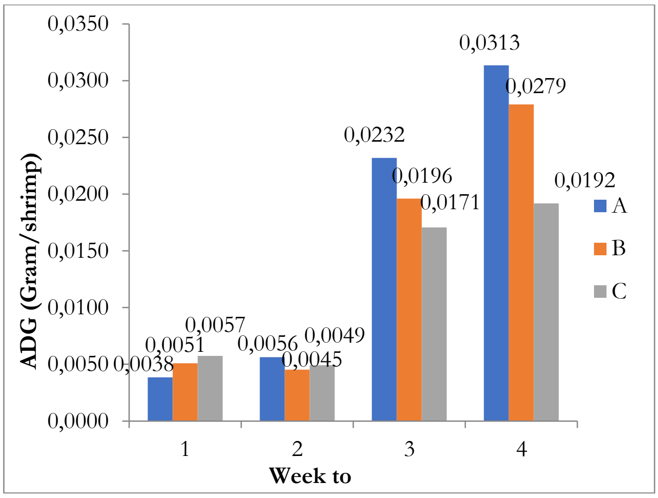

Figure 2. Average Daily Growth (ADG) of vannamei shrimp reared for 40 days

Survival Rate (SR)

Survival rate (SR) is defined as the percentage ratio between the number of organisms that service at the end of the maintenance period and the number of organisms that were alive at the beginning of the rearing period (Cholik *et al.,* 2005). The survival rate of vannamei shrimp over the 40-day rearing period is illustrated in Figure 3.

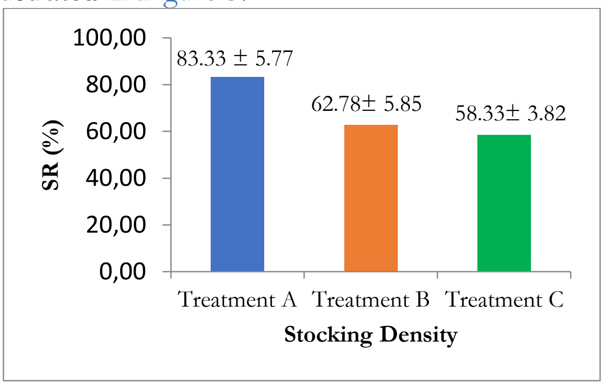

Figure 3. Survival Rate (SR) during maintenance

According to the provided illustration, it is evident that Treatment A exhibits the highest survival rate at 83.33%, whereas the lowest survival rate is observed in Treatment B at 58.33%.

Water Quality

The findings of observations pertaining to water quality parameters are presented in Table 1. According to the observational findings, it is evident that the water quality parameters, particularly temperature, fluctuated in treatments B and C, surpassing the optimal range for elevated temperatures. Additionally, the pH values in treatments B and C were below the optimal range.

Conversely, the salinity parameters for all three treatments remained within the optimal value range. However, the ammonia parameters in treatments B and C exceeded the optimal values.

Table 1. Water Quality Parameters

Parameters	A	B	C	Optimum values
Temperature (°C)	28	27 - 29	27 - 29	26 – 28 (Supono, 2017)
pH	7.7 - 8.3	6.8 - 6.9	6.8 - 8.5	7.5 – 8.5 (SNI7311:2009)
DO (mg/l)	5.0 - 5.7	5.5 - 6.2	5.2 – 62	>4 (Supono, 2017)
Salinity (ppt)	25	25	25	10-30 (Suprapto, 2005)
Amonia (mg/L)	0 - 0.1	0.25 - 1.5	0.25 - 3.0	<0,1 (SNI8037.1:2014)

Discussion

The results of the average final weight of vannamei shrimp indicate that the stocking density of 1 shrimp/L exhibits superior weight growth compared to the stocking densities of 1.5 shrimp/L and 2 shrimp/L. This implies that the stocking density of 1 shrimp/L demonstrates better growth. This finding aligns with the assertion by Li *et al.* (2020), which suggests that vannamei shrimp can achieve robust growth with a rate of 1-1.5 g/week. The lower stocking density results in reduced competition for feed, a more expansive space for prawns to move, and improved environmental conditions due to fewer accumulated by-product at the bottom of the rearing media. Consequently, shrimp in rearing media with a stocking density of 1 shrimp/L exhibit superior growth and development compared to those in stocking densities of 1.5 shrimp/L and 2 shrimp/L. This observation concurs with Li *et al.* (2020), statement that the stocking density influences competition for space, dietary requirements, and environmental conditions.

The Average Daily Growth (ADG) in this study exhibited different results among treatments A, B and C. Treatment A recorded the highest growth rate, with an ADG value of 0.0313 g/shrimp, surpassing the other treatments. From Day of Culture (DOC) 0 to DOC 10, there was a divergent growth rate increase among the three treatments, with treatment C achieving the highest rate at 0.0057 g/shrimp. It is hypothesized that shrimp adaptation varies based on their immune condition. A compromised immune state can lead to a reduced appetite, as observed in treatments A and B, whereas treatment C demonstrated better adaptability after 10 days of maintenance. However, during the maintenance period from DOC 10 to DOC 40, the Mean Body Weight of white vannamei shrimp in treatment A, with a stocking density of 1 shrimp/L, exhibited a higher daily growth of 0.0313 g/shrimp. This is attributed to the low stocking density in treatment A, eliminating food competition and enabling cultured organisms to efficiently utilize the energy obtained from the provided feed for growth.

The average daily growth of shrimp has not met the target, as evident from the ADG target (BSN, 2006), which is set at 0.2 g/shrimp per day. This suboptimal daily growth rate may be attributed to water quality within the aquaculture system, having undergone various phases, including sedimentation, oxygenation, and biological processes. Through these phases, the incoming water quality is consistently maintained to optimize absorption by cultivated organisms. Growth is influenced by several factors, categorized as internal and external. Internal factors, such as genetics and physiology, including health levels, impact growth. External factors encompass feed, stocking density and water quality (Watanabe, 1988).

Based on the provided data, it is evident that the treatment A exhibits the highest survival rate at 83.33%, while the lowest is recorded at 58.33%. The enhanced survival rate in treatment A, compared to other treatments, is likely attributed both the lower density and the broader range of movement, minimizing competition for space and optimizing food accessibility. Consequently, nutrients from the feed can be efficiently absorbed, supporting growth and maintaining biomass. This aligns with the Juarez *et al.* (2014) assertion that stocking density influences competition for space, food requirements, and environmental conditions. High stocking density fosters competition among shrimp for space, leading to increased energy expenditure on adapting to environmental conditions, with only a small portion allocated to growth. This concurs with the findings of Ding *et al.* (2018); Li *et al.* (2020), indicating that shrimp growth is indeed influenced by shrimp density.

High stocking densities create conditions conducive to shrimp interactions, fostering cannibalism and intense competition for food resources. This aligns with Ding *et al.* (2018) assertion that elevated stocking densities lead to decreased shrimp survival rates, intensifying competition for food, space, habitat, and oxygen. Shrimp, exhibiting cannibalistic tendencies, prey on conspecifics (Gao *et al.*, 2019), particularly under conditions of stress induced by high ammonia levels and moulting. The weakened state of molting shrimp emits an aroma triggering cannibalistic behavior, often observed in the remains of deceased shrimp in specific areas.

Cahyono (2009) highlights that factors influencing survival rates in aquaculture encompass both abiotic and biotic components. Abiotic factors, such as water quality, play a crucial role, with optimal conditions supporting physiological processes and overall biota growth and survival. Deviations from optimal conditions can disrupt ecological stability in the cultivation site (Wafi *et al*., 2021).

Observations reveal fluctuating temperature values in water quality parameters, notably in treatments B and C, surpassing the optimum range for the highest temperature. pH values in these treatments also fall below the optimum range, with Makmur *et al.* (2018) recommending a suitable pH range of 7.4-8.9 for intensive vaname shrimp cultivation. Elevated daily pH fluctuations, beyond 0.5, can induce stress in shrimp, potentially impacting their well-being (Yunarty *et al*., 2022). Additionally, ammonia levels in treatments B and C exceed optimal values, indicating suboptimal water quality.

The link between high stocking densities, cannibalism, and heightened competition for resources is reinforced by Muzaki (2004), emphasizing the negative impact of increased stocking density on shrimp survival rates and competition for food, space, habitat, and oxygen. The cannibalistic behavior of shrimp, particularly directed at conspecifics of the same sex (Hidayat *et al*., 2013), is exacerbated under stress induced by high ammonia content and moulting. Cannibalism is often observed in decreased shrimp, especially in specific body parts.

The observed variations in growth are attributed to intensified competition for food and limited space for movement at higher stocking densities. As stocking density increases, so does the competition for essential resources. Purba (2012) emphasizes that factors influencing organismal growth include heredity, sex, age, water quality, feed, density, parasites and disease.

Conclusion

The optimal stocking density for vannamei shrimp was determined to be 1 shrimp/L, resulting in a mean body weight (MBW) of 1.2592 grams, an average daily growth of 0.0313 g, and a survival rate of 83.33%.

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References

Akbar, S.A., and R.R Fazli, R. R. 2023. Meta-Analysis: The effectiveness of artificial diets to increase on survival rate of vannamei shrimp (Litopenaeus vannamei). In IOP Conference Series: Earth and Environmental Science (Vol. 1221, No. 1, p. 012066). IOP Publishing.

Atjo, H. 2013. Keberlanjutan budidaya udang vannamei supra-intensif Indonesia. Dipresentasikan pada Workshop Keberlanjutan Budidaya Vannamei Supra-Intensif. Makassar, 23-24 Oktober 2013, 42 hlm

Badan Standarisasi Nasional [BSN]. SNI. No. 01. 7246. 2006. Produksi Udang Vannamei (Litopanaus vannamei) di Tambak Dengan Teknologi Intensif.

Baloi, M., R. Arantes, R. Schveitzer, C. Magnotti, and L. Vinatea. 2013. Performance of pacific white shrimp *Litopenaeus vannamei* raised in biofloc systems with varying levels of light exposure. Aquacultural Engineering, 52 : 39–44

Boyd, C.E. & J.W. Clay. 2002. Evaluation of Belize Aquaculture, Ltd: A Superintensive Shrimp Aquac-ulture Systems. Report prepared under the WorldBank, NACA, WWF and FAO Consortium Programon Shrimp Farming and the Environment. Workin Progress for Public Discussion. Published bythe Consortium, 17 pp.

Briggs, M., F.F. Smith, R. Subasinghe, and M. Phillips. 2004. Introduction and Movement of *Penaeus vannamei* and *Penaeus stylirostris* in Asia and The Pacific. RAP Publication 2004/10.

Cahyono, B. 2009. *Budidaya Biota Air Tawar*. Kanisius. Yogyakarta. Diponegoro Journal Of Maquares. Hal. 155-162.

Cholik, F., A.G. Jagatraya, R.P. Poernomo, dan A. Jauzi. 2005. Akuakultur: Tumpuan Harapan Masa Depan Bangsa. Kerjasama Masyarakat Perikanan Nusantara dengan Taman Aquarium Air Tawar TMII.PT. Victoria Kreasi Mandiri. 415 hlm.

Danya B.R, N.M. Jagadish. 2014. Effect of density on growth and production of Litopenaeus vannamei of brackish water culture system in summer season with artificial diet in Prakasam District, India. American International Journal of Research in Formal, Applied, & Natural Sciences 5: 10-13.

Haliman, R.W., S.D. Adijaya. 2005. Udang Vannamei, Penebar Swadaya, Jakarta.

Hasan B.M.A., B. Guha, and S. Datta. 2012. Optimization of Feeding Efficiency for Cost Effective Production of Penaeus monodon Fabricius in SemiIntensive Pond Culture System. Aquaculture research & development, 3(6) : 1-7.

Hermawan, D. 2012. Teknik Pemeliharaan Larva Udang Windu (Penaeus monodon) di HSRT. Proposal Praktek Kerja Lapangan II Jurusan Teknologi Budidaya Perikanan. Jawa Timur; Akademi Perikanan Sidoarjo

Hidayat, D., A.D. Sasanti, dan Yulisman. 2013. Kelangsungan Hidup, Pertumbuhan dan Efisiensi Pakan Ikan Gabus (Channa striata) yang Diberi Pakan Berbahan Baku Tepung Keong Mas (Pomacea sp). Jurnal Akuakultur Rawa Indonesia, 1(2) :161-172 2013 ISSN : 2303-2960.

Hudaedah, S. & Supono. 2007. Laporan Akhir Penelitian Dosen Muda Studi Tentang Pertumbuhan dan Tingkat Kelulusanhidup Udang Vannamei (Litopenaeus vannamei) di Tambak Plastik. Fakultas Pertanian. Universitas Lampung.

Hudi L, A. Shahab. 2005. Optimasi Produktifitas Budidaya Udang Vannamei Litopenaeus vannamei dengan menggunakan Metode

Respon Surface Non Linier Programming. Institut Teknologi Sepuluh Nopember, Surabaya.
Kementerian Kelautan Perikanan [KKP]. 2019. Laporan Tahunan KKP Tahun 2019. https://kkp.go.id/artikel/22215-laporan-tahunan-kkp-2019. Diakses 10 Maret 2022.
Kureshy N. and D.A. Davis, 2002. Protein Requirement for Maintenance and Maximum Weight Gain for the Pacific White Shrimp, Litopenaeus vannamei. Aquaculture 204 : 125-143.
Lama, H.A.W. 2019. Optimasi Padat Tebar Terhadap Pertumbuhan dan Kelangsungan Hidup Udang Vannamei (Litopenaeus vannamei) dengan Sistem Resirkulasi. Skripsi. Program Studi Budidaya Perairan. Fakultas Pertanian Universitas Muhammadiyah Makassar.
Lawrence, A.L. 2010. Super-intensive raceway shrimpproduction. The road to sustainability. Tahiti Aquaculture 2010. Papeete, Tahiti, December 07,2010, 15 pp.
Mangampa, M. Burhanuddin, S.H. Suwoyo, A.E. Hendradjat, S. Tahe. 2014. Budidaya udang Vannamei (Litopenaeus vannamei) Pola Ekstensif Plus Melalui Aplikasi Probiotik dan Pergiliran Pakan. Pelayanan Teknis Balai Penelitian dan Pengembangan Budidaya Air Payau Dipa No. 032.11.2.230894/2014.
Makmur, H.S. Suwoyo, M. Fahrur, R. Syah. 2018. Pengaruh jumlah titik aerasi pada budidaya udang vaname Litopenaeus vannamei. Jurnal Ilmu dan Teknologi Kelautan 10: 727-738.
Muzaki, Ahmad. 2004. Produksi udang vannamei (Litopenaeus vannamei) Pada Padat Penebaran Berbeda di Tambak Biorete. Skripsi. Program Studi Teknologi dan Manajemen Akuakultur. FPIK Institut Pertanian Bogor.
Nababan, E., I. Putra, dan Rusliadi, 2015. Pemeliharaan Udang Vannamei (Litopenaeus Vannamei) Dengan Persentase Pemberian Pakan Yang Berbeda. Jurnal Ilmiah Perikanan dan Kelautan, 3(2).
Nugroho R.L, Sukardi, B. Triyatmo. 2016. Penerapan cara budidaya ikan yang baik pada pembesaran udang vaname (Litopenaeus vannamei) di Pesisir Daerah Istimewa Yogyakarta. Jurnal Perikanan Universitas Gadjah Mada 18: 47-53
Purba C.Y. 2012. Performa Pertumbuhan, Kelulushidupan, dan Kandungan Nutrisi Larva Udang Vannameii (*Litopenaeus vannamei*) Melalui Pemberian Pakan Artemia Produk Lokal yang Diperkaya dengan Sel Diatom. Journal of Aquaculture Management and Technology. 1(1):102–115.
Rakhfid, A., N. Baya, M. Bakri, and F. Fendi. 2017. Growth and Survival Rate of White Shrimp (Litopenaeus Vannamei) at Different Density. Akuatikisle: Jurnal Akuakultur, Pesisir dan Pulau-Pulau Kecil, 1(2):1–6.
Saha, S. 2011. Innate Immune Source and Functional Machinery in Decapods of Crustacea. Indian J. of Fundamental and Appl. Life Sciences,1(3) : 311-24.
Salas, A.O., L.A.M. Rendon. 2013. Hyper-intensive Farming White Shrimp *Litopenaeus vannamei* (Decapoda: Penaeidae) in a Seawater Tank Under Semi-Controlled Conditions. UNED Resesarch Journal, 5(1) : 69-74. DO-10.22458/urj.v5i1.249
Samocha, T.M., J.S. Wilkenfeld, T.C. Morris, E.S. Correia, and T. Hanson. 2010. Intensive racewayswithout water exchange analyzed for white shrimpculture. Global Aquaculture, July/August 2010, p. 22-24.
Samocha, T.M., R. Schveitzer, D. Krummenauer, and T.C. Morris. 2012. Recent advance in super-in-tensive, zero-exchange shrimp raceway systems.Global Aquaculture November/December 2012, p.70-71.
Samocha, T.M., A. Braga, V. Magalhaes, B. Advent, and T.C. Morris. 2013a. On going studies advance intensive shrimp culture in zero-exchange bioflocraceway. Global Aquaculture March/April 2013, p.38-40 Studies Advance Intensive Shrimp Culture In Zero.
Samocha, T., T.C. Morris, A. Braga, V. Magalhaes, R. Schveizer, D. Krummenauer, D. Correia, Kim J.S, J.J. Austin, J.K. Mishra, J. Burger, B. Ad-vent, & T. Hanson. 2013b. Shrimp productionin greenhouse-enclosed superintensive biofocsystems at the Texac A&M AgriLife Research Mari-culture Lab:2003-2012. Aquaculture 2013 Nashville,Tennessee, USA. February 21-25, 2013, 37 pp Exchange Biofloc Raceways. Global Aquaculture Advocate.March/April (38-41).
Setiawati, J.E., Y.T. Tarsim, Adiputra dan S. Hudaidah. 2013. Pengaruh Penambahan Bakteri *Rhodopseudomonas* sp., Lactobacillus sp., *Actinomycetes* sp., ragi/yeast (*Saccharmyces cerevisiae*) dan *Aspergillus* sp. pada Pakan dengan Dosis Berbeda Terhadap Pertumbuhan, Kelulushidupan, Efisiensi Pakan dan Retensi Protein Ikan Patin (*Pangasius hypophthalmus*). Jurnal Rekayasa dan Teknologi Budidaya Perairan. Vol 1 (2) : 151-162.
Supono. 2006. Produktivitas Udang Putih pada Tambak Intensif di Tulang Bawang Lampung. Jurnal Saintek Perikanan, 2 (1) : 48-53.
Supono, J., S.B. Hutabarat, Prayitno, dan Y.S. Darmanto. 2014. White Shrimp (*Litopenaeus vannamei*) Culture Using Heterotrophic aquaculture System on Nursery Phase. International Journal of waste Resources 4 (2):1000142.
Tahe dan Makmur. 2016. Pengaruh Padat Penebaran Terhadap Produksi Udang Vaname (Litopenaeus vannamei) Superintensif Skala Kecil. Prosiding Forum Inovasi Teknologi Akuakultur.
Venero, J.A., B. McAbee, A. Lawson, B.L. Lewis, J.W. Leffler, & C.L. Browdy. 2009. Greenhouse-Enclosed superintensive shrimp production: Al-ternative to traditional ponds in U.S. Global Aquac-ulture Advocate, January/February, 2009, p. 61- 64
Wafi A, Ariadi H, Muqsith A, Mahmudi M, Fadjar M. 2021. Oxygen consumption of Litopenaeus vannamei in intensive ponds based on the dynamic modeling system. Journal of Aquaculture and Fish Health 10: 17-24.
Watanabe, T. 1988. Shrimp Nutrition and Mariculture. JICA Texbook The General Aquaculture Course. Kanagawa International Shrimperies Training Centre Japang International Coopertion Agency, 348 p.
Wyban, J.A. 2007. Domestication of Pacific White Shrimp Revolutionizes Aquaculture. Global Aquaculture AdvocateJuly/August : 42-44.
Wyban, J.A. dan J.N. Sweeney. 1991. Intensive Shrimp Production Technology. The Oceanic Institute: Hawai. USA.
Yunarty, A. Kurniaji, Budiyati, D.P. Renitasari, M. Resa. 2022. Karakteristik kualitas air dan performa pertumbuhan budidaya udang vaname (Litopenaeus vananmei) pola intensif. PENA Akuatika: Jurnal Ilmiah Perikanan dan Kelautan 21: 75-88.

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