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Hatchery Performance of Barramundi (*Lates calcarifer*) in the Integrated Pond Systems

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ABSTRACT

The barramundi, also known as Asian sea bass, has the ability to adapt to various environmental conditions. Indonesia has introduced barramundi from different regions, including Australia, which is known to have a faster growth rate and larger body size. At the same time, the Indonesian strain demonstrates greater resilience to local conditions but grows more slowly. This study evaluates the hatchery performance of Australian and Indonesian strains of barramundi (*Lates calcarifer*) in a controlled environment using circular concrete ponds. The research examines water quality, spawning productivity, and larval development. The results indicate that the Australian strain produces more eggs than the Indonesian strain, with a hatching rate of 62%. Key water quality parameters, including temperature (28.3–28.6°C), pH (8.26–8.29), and salinity (33–35 ppt), were generally favorable for successful spawning and larval development. Additionally, providing live feed, such as rotifers and Artemia, improved larval growth up to the early juvenile stage. The significant differences in productivity between the two strains highlight the importance of genetic selection and nutritional management in optimizing barramundi hatchery production. This study underscores the need for superior strain selection and the application of science-based aquaculture strategies to enhance the sustainability of barramundi production in Indonesia.

INTRODUCTION

The barramundi (*Lates calcarifer*), also known as Asian sea bass, is a highly valuable species in aquaculture. Its ability to adapt to various environmental conditions, combined with increasing market demand, has driven extensive research to optimize hatchery practices and improve productivity (Astuti *et al*., 2023). As a leading aquaculture producer, Indonesia has introduced barramundi from different regions, including Australia, to enhance genetic diversity and performance in local farming systems.

Despite significant progress, challenges remain in comparing reproductive performance, growth rates, and environmental adaptation between local and imported strains. The Australian strain is known for its faster growth rate and larger body size, while the Indonesian strain demonstrates greater resilience to local conditions but grows slower (Pietoyo *et al*., 2022). These differences raise critical questions about optimizing hatchery strategies to maximize productivity while ensuring the sustainability of barramundi farming (Ulfani *et al*., 2018).

This study uses circular concrete ponds to evaluate the hatchery performance and larval development of Australian and Indonesian barramundi strains under controlled conditions. The research focuses on water quality management and egg production parameters to identify each strain's specific advantages. Through this study, we hope to provide practical insights for aquaculture stakeholders in selecting and managing barramundi strains for optimal and sustainable production in tropical environments.

METHODS

The study was conducted at the Center for Marine Aquaculture Research and Fisheries Extension (BBRBLPP) Gondol, located in Dusun Gondol, Desa Penyabangan, Gerokgak District, Buleleng Regency, Bali Province. It was carried out from July 8 to August 16, 2024. Geographically, the site is situated at coordinates 144°–115° E and 7°–8° S, with an elevation of approximately 2 meters above sea level (Figure 1.a).

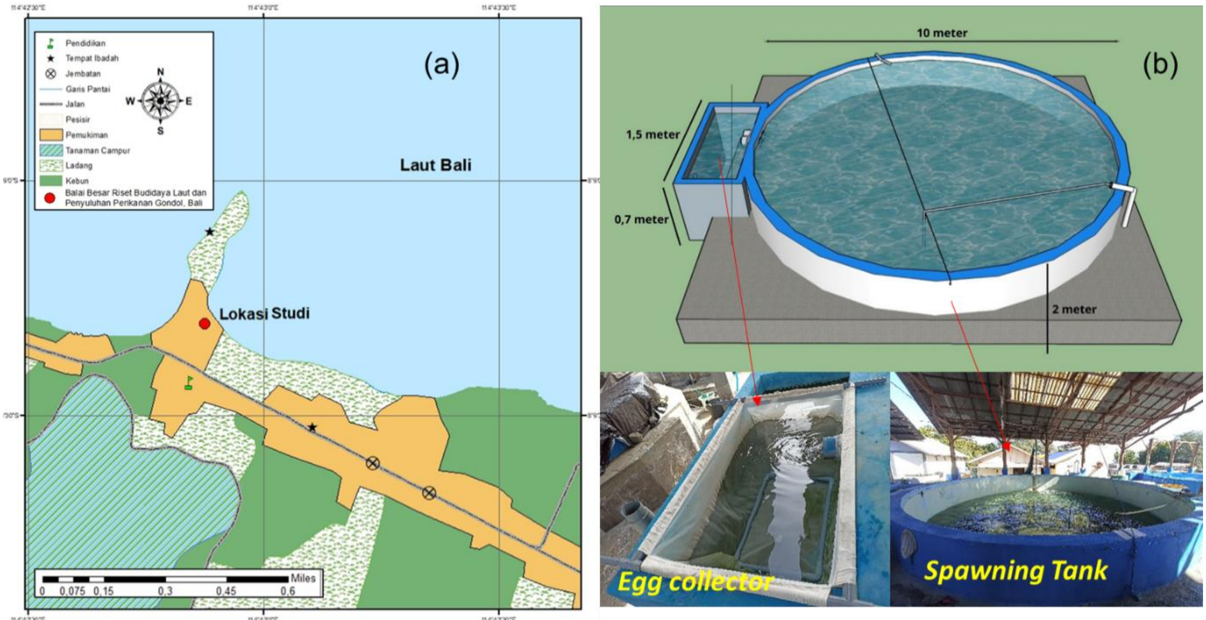


Figure 1. (a) Barramundi Hatchery Location, (b) Concrete Pond Used for Hatchery

Broodstock Preparation

Barramundi broodstock was obtained from BBRBLPP and consisted of Indonesian and Australian strains. The Indonesian strain originated from wild-caught fish from the coastal waters of Bali, which were reared until they reached spawning maturity. In contrast, the Australian strain was acquired through collaboration with a private company and raised from juveniles. Short, rounded fins characterize the local strain, while the Australian strain has long, sharp fins. The male-to-female ratio used was 1:3, with an average weight of 7 kg, and the rearing period until spawning maturity was approximately 4–5 years (Supryady *et al*., 2022). High-quality broodstock must be disease-free without spots, wounds, or swelling (Prajayanti *et al*., 2023). Morphological observations of males included the shape, color, and size of the testes and the presence of milt. Female gonad observations focused on the ovaries and eggs, assessing their shape, size, color, and texture smoothness (Ridho & Patriono, 2016).

Broodstock Rearing Pond

Barramundi broodstock was reared in a 10-meter diameter concrete tank containing 21 fish, with an egg collector measuring 1.5 × 1 meters (Figure 1b). Although concrete tanks are more expensive, they offer advantages such as high durability, resistance to damage, and an efficient water management system that supports circulation, drainage, and optimal maintenance (Paksi *et al*., 2023). The tank floor was sloped at a 5% gradient towards the center to facilitate drainage and was equipped with inlet and outlet channels and an egg collector. Water was continuously circulated at a flow rate of 0.278 m^3/s, creating a clockwise current to maintain water quality. Tank preparation included scrubbing the walls, floor, and drainage pipes and disinfection with a 1 kg chlorine solution. After disinfection, the tank was thoroughly rinsed with seawater before being refilled and stocked with broodstock.

Feeding Management

Barramundi broodstock was fed fresh tuna (*Euthynnus* spp.), which is rich in protein (22.6–26.2 g/100 g), fat (0.2–2.7 g/100 g), minerals, and vitamins A and B (Hafilludin, 2011). The feed was stored in cold storage at -20°C and provided once daily at 09:00 at 1–2% of the total biomass (1–2 kg/day) using the ad libitum method. Fresh feed is essential to prevent bloating and improve egg quality (Izzah *et al*., 2019). The feeding schedule consisted of fresh tuna six days a week, with vitamin C and E supplements (0.5 g each) added on Mondays and Thursdays. Sunday was designated as a fasting day to maintain appetite regulation. Vitamin E plays a crucial role in cell membrane formation, acting as an antioxidant and supporting reproductive hormones, while vitamin C enhances immunity, egg quality, and testosterone levels. These supplements improve egg hatchability and larval survival rates (Iskandar *et al*., 2023).

Water Quality Monitoring

Water exchange in the barramundi broodstock tanks was conducted daily from 07:30 to 15:00 using a flow-through circulation system with a renewal rate of 200–300%, replacing 50–70% of the tank volume. Lowering the water level was used as a spawning stimulus. The primary purpose of water exchange was to remove toxic substances and maintain an environment similar to the fish's natural habitat (Rahardjo & Shih ,2023). Water quality parameters, including salinity, pH, and temperature, were measured twice a week due to the relative stability of the water conditions (Marie *et al*., 2018). The optimal ranges for successful spawning were pH of 7.5–8.5, temperature of 25–30°C, and salinity of 28–35 ppt (Putri & Kurniawan, 2023).

Disease Management and Biosecurity

Barramundi broodstock is regularly monitored to prevent diseases and parasites. Initial treatment involves immersing the broodfish in freshwater mixed with Elbayou (10 g) for 5 minutes to detect diseases or parasites and cleaning the concrete tanks monthly using chlorine (50 g/ton) to prevent contamination. Disease prevention is done by soaking the broodfish in freshwater while gently scrubbing their bodies. If wounds are found, the fish are treated with Elbayou (3 g) (Mubarrak *et al*., 2024). Biosecurity measures include the weekly application of hydrogen peroxide (H_2O_2) on Sundays during fasting days, using a dose of 1 L for a 10 x 2 m tank or 500 ml for an 8 x 2 m tank. The H_2O_2 is added to the aeration point and left for 10 minutes to ensure even distribution, and then the inlet channels are reopened. Hydrogen peroxide is more environmentally friendly than formalin, effectively controls ectoparasites, and improves water quality (Arini *et al*., 2018). A net (paranet) is installed to prevent fish from jumping out and injuring themselves.

Spawning

Spawning involves manipulating natural environmental conditions to reduce broodstock stress and produce high-quality eggs. This technique is carried out by lowering the water level in the rearing tanks by 50–70% and raising it again daily to trigger spawning through temperature changes. This manipulation supports regular gonadal maturation, quick recovery of the broodstock, and optimal egg quality (Abduh & Fatahudin, 2016). Spawning occurs at night (21:00–03:00), following the lunar phases (new and full moon), twice a month. Each spawning period lasts 5–6 days, with the quantity and quality of eggs being influenced by environmental factors, feed, water quality, and weather conditions (Adnan *et al*., 2022). The current carries the eggs to the egg collector and is harvested at 04:00.

Egg Harvesting and Selection

Barramundi eggs are buoyant, so the spawning tanks are designed with a surface water drainage system. A soft mesh egg collector (with a mesh size of 300 µm) is used to harvest eggs at 04:00. The eggs are then transferred to a 400 L incubation tank with aeration for counting and separation. Fertilized eggs float, are transparent, and spherical, while unfertilized eggs sink to the bottom (Adnan *et al*., 2022). Egg counting is done volumetrically using a 10-egg sample. Hatchability is calculated as the percentage of eggs that hatch into larvae. Egg spreading occurs between 09:00 and 10:00 the morning after tank preparation, with a 6–8 8-hour hatching period. Larvae are reared in fiber tanks with filter bags to prevent unwanted particles from entering. Starting on day D12, water is exchanged, and aeration is carried out every 2 days when the larvae reach day D13. The percentage of egg hatching obtained from the research results was analyzed using an analysis of variance (F-test). If the F-test results show a significant effect, further study is conducted using the BNJ test with a 95% confidence interval. Meanwhile, water quality data is analyzed descriptively. The data for statistical analysis is the number of eggs produced by the Australian strain and the Indonesian strain that was observed two times over 5 days of observation.

RESULTS

Water Quality

Based on the water quality data analyzed in Table 1, the environmental conditions generally support barramundi breeding. The pH parameter ranged from 8.26 to 8.29, which is ideal for the spawning, fertilization, and larval development processes, as it falls within the optimum range of 7.5 to 8.5. The stability of the pH values also indicates that the environment did not experience significant fluctuations, minimizing the risk of stress for both broodstock and larvae (Shubhi *et al*., 2017; Rahardjo & Shih, 2024). Water temperature remained stable, ranging from 28.3°C to 28.6°C, which aligns with the optimal temperature range for barramundi spawning at 28–30°C. This temperature stability is crucial, as sharp fluctuations can affect the fish's metabolism and the successful development of eggs (Mudiarti, 2023; Rahardjo & Shih, 2023).

Salinity was recorded between 33 and 35 ppt. Most of the salinity values remained within the tolerance range for spawning, which is 28–34 ppt, although there were a few days when the salinity reached 35 ppt. Salinity approaching the upper limit may affect fertilization success and increase osmotic stress on both broodstock and larvae (Mulyono & Ritonga, 2019; Sholichin *et al*., 2024). Therefore, stricter salinity management is recommended to keep it below 34 ppt. Overall, the water quality data supports barramundi breeding, but greater attention to salinity control is needed to optimize spawning success (Rahardjo & Shih, 2022).

Table 1. Water Measurement Data

Parameters	Measurement	Standard	References
Temperature	26,6 - 28°C	28 - 32°C	Standar SNI (2014)
pH	7,4 – 8,2	7,5 – 8,5	Standar SNI (2014)
Salinity	33 – 35 ppt	28 – 34 ppt	Standard SNI (2014)
DO	4 – 6 ppm	≥4 ppm	Standar SNI (2014)

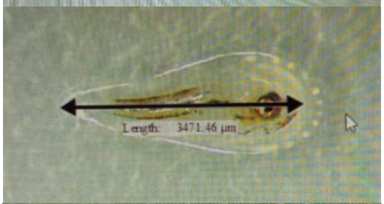
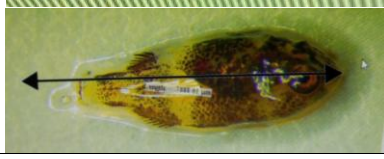
Egg Hatching

Based on the observation data in Table 2, the growth of barramundi larvae in terms of body length strongly correlates with their biological phases. On the first day, the eggs hatch, and the larvae are less than 0.2 cm long, still carrying the yolk sac, their primary nutrition source (Thépot & Jerry, 2015). On the second day, the larvae begin absorbing nutrients from the yolk sac to support the development of vital organs, although there is no significant growth in body size yet. By the fourth day, the larvae have absorbed the yolk sac and start consuming external food sources, such as rotifers (*Brachionus* sp.), reaching a length of 0.25 cm. This marks the successful transition from relying on internal nutritional reserves to external feed sources. During the early larval phase, recorded on day nine, the larvae's length increased to 0.34 cm. The larvae develop body structures, such as fins and the digestive tract, and show more active swimming abilities. By day 14 (mid-larval phase), the larvae's length reaches 0.47 cm, with complete organ development, including fins and directed swimming patterns. Artemia is introduced as an additional feed to support their high protein needs (Rahardjo *et al*., 2024).

In the late larval phase, occurring on day 19, the larvae's length increases to 0.55 cm. Their body structure becomes more similar to adult fish, developing pigmentation and fins. The larvae also begin adapting to a combination of live and artificial feeds. On day 25, the larvae enter the early juvenile phase, with a body length of 0.88 cm. At this stage, the larvae transform into juveniles with nearly perfect body structures, exhibiting active swimming abilities and better environmental adaptation. Artificial feed (small pellets) replaced most live feed, indicating a successful nutritional transition.

The data shows that feed quality and stable environmental parameters, such as pH, temperature, and salinity, have supported consistent growth at each stage. However, to optimize success, it is recommended that feed quality be maintained, the stability of water parameters be ensured, and routine monitoring of larval development be conducted. The data also indicates that the growth of barramundi larvae in terms of body length aligns with their biological phases, reflecting consistent growth. This suggests that feed and water quality during the breeding process have been well-managed. To further optimize growth, maintaining the quality of live feed, such as rotifers and artemia, is essential to ensure they remain highly nutritious (Nuswantoro & Rahardjo, 2018). Additionally, the stability of water parameters, including pH in the range of 7.5–8.5, temperature at 28–30°C, and salinity between 28–34 ppt, must be maintained throughout the developmental stages. Regular monitoring is also necessary to detect any potential stress or growth retardation in the larvae so that corrective actions can be taken promptly when needed.

Table 2. Barramundi Larval Development Stages

Phase	Size (cm)	Microscopic investigation
Day 1 Hatching of Eggs	-	
Day 2 Yolk Sac Absorption	-	
Day 4 Initial Feeding	0.25	
Day 9 Early Larval Stage	0.34	
Day 14 Mid-Larval Stage	0.47	
Day 19 Advanced Larval Stage	0.55	
Day 25 Early Juvenile Stage	0.88	

Egg Calculation

The spawning process of barramundi occurs from 9:00 p.m. to 03:00. Spawning follows the lunar cycle, occurring twice a month during the new moon and complete moon phases. The spawning season of barramundi is influenced by their habitat and the current lunar phase. Barramundi spawns for 5-6 days during each cycle. The eggs produced during spawning are carried by the current and collected in a tank equipped with an egg collector, where they are harvested at 04:00. The egg harvesting continues throughout the spawning period. Fertilized eggs float on the water surface, are transparent, and are round, while unfertilized eggs sink, are white, and are damaged (Hasibuan *et al*., 2018).

Based on the observation data, there is a significant difference in the number of eggs produced by the Australian strain (Figure 2a) and the Indonesian strain (Figure 2b). On the first day, the Australian strain produced an average of 5,362,100 ± 2,188,000 eggs, while the Indonesian strain only produced 2,655,000 ± 1,214,000 eggs. The number of eggs produced by the Australian strain continued to increase consistently, reaching 15,747,000 ± 2,755,000 on the second day, compared to 7,399,000 ± 2,540,000 for the Indonesian strain. The difference became more pronounced on the third day, where the Australian strain produced 29,975,000 ± 987,000 eggs, while the Indonesian strain only produced 13,518,000 ± 3,710,000 eggs.

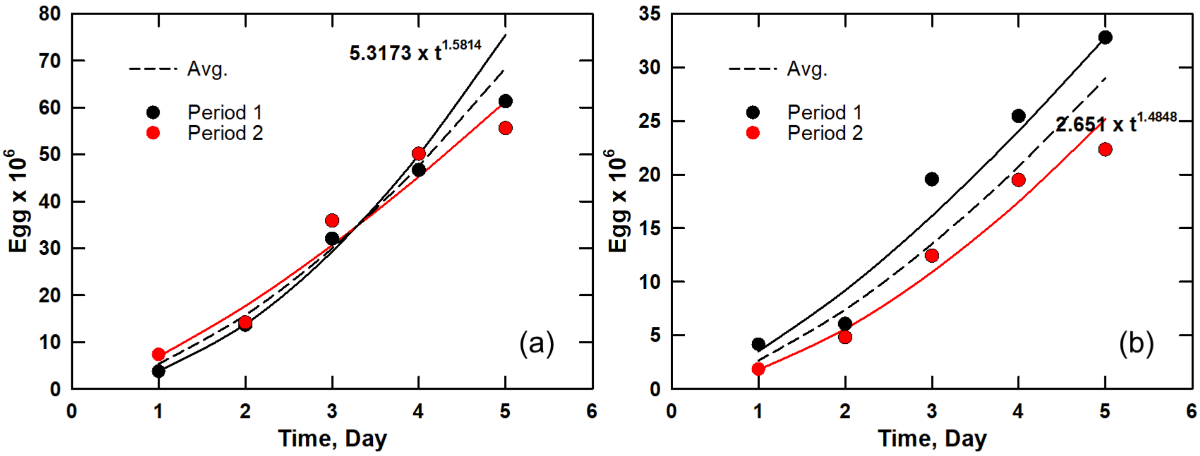


Figure 2. Egg Count from Barramundi Spawning of (a) Australian Strain and (b) Indonesian Strain for Two Spawning Periods

On the fourth day, the egg production of the Australian strain surged to 47,621,000 ± 3,256,000, while the Indonesian strain reached 20,762,000 ± 4,666,000. The peak difference occurred on the fifth day, with the Australian strain producing 68,433,000 ± 10,028,000 eggs, nearly three times more than the Indonesian strain, which only produced 28,987,000 ± 5,385,000 eggs. The reproductive advantage of the Australian strain may be attributed to genetic selection that supports better reproductive performance and optimal adaptation to aquaculture management. On the other hand, although the Indonesian strain shows good potential, the number of eggs produced is consistently lower. This suggests the need for genetic selection, environmental management, and nutritional optimization improvements to enhance the Indonesian strain's reproductive performance (Rey & Sahetapy, 2024).

Table 3. Statistical Analysis of Barramundi Eggs

Day	Strain Barramundi x 10^6		F test	T Test
	Australia	Indonesia	Fcrit = 6.388	Tcrit = 2.776
1	5.3621 ± 2.188	2.655 ± 1.214	5.762	2.853
2	15.747 ± 2.755	7.399 ± 2.54		Significantly
3	29.975 ± 0.987	13.518 ± 3.71		Different
4	47.621 ± 3.256	20.762 ± 4.666		
5	68.433 ± 10.028	28.987 ± 5.385		

The statistical tests show significant differences, with the Australian strain proving superior in egg production during the observation period. The F and T-tests (Table 3) indicate a significant statistical difference, with the T value of 2.853 being higher than the critical T value of 2.776 ($P < 0.05$). The Hatching Rate (HR) was calculated using the subsampling method with a breaker glass volume of 100 ml. Samples were taken from three different locations while aeration remained active. The hatching rate of the barramundi eggs obtained was 62% for the Australian strain and 58% for the Indonesian strain. If the hatching rate of fish eggs exceeds 50%, it can be considered optimal (Putra *et al*., 2017).

DISCUSSION

The results of this study show a significant difference in seed production productivity between the Australian and Indonesian Barramundi strains. The Australian strain produced more eggs on each spawning day, supported by genetic advantages and optimal adaptation to the farming environment. In contrast, the Indonesian strain showed lower productivity despite its potential for resilience to local conditions. These findings emphasize the importance of enhancing genetic selection and optimizing nutrition management to support the reproduction of the local strain.

The water quality throughout the study supported successful spawning, with temperature (28.3–28.6°C), pH (8.26–8.29), and salinity (33–35 ppt) within nearly optimal ranges. However, salinity approaching the upper tolerance limit could increase osmotic stress on broodstock and larvae, requiring stricter salinity management. Additionally, live feed such as rotifers and Artemia proved effective in supporting the development of larvae from the early to mid-stages. However, the quality of this feed needs to be consistently maintained to ensure optimal nutrition throughout the larval stages.

The Australian strain also exhibited a higher hatching rate (62%), reflecting the effectiveness of broodstock nutrition management and environmental quality. Thus, this research highlights the importance of selecting superior strains and implementing scientifically based breeding management to enhance productivity. Genetic optimization and sustainable ecological management are essential to ensuring the success of Barramundi aquaculture in Indonesia.

CONCLUSION

This study shows that the Australian Barramundi strain has a significant advantage over the Indonesian strain in seed production productivity, with higher egg production, a hatching rate of 62%, and more optimal larval development. The water quality during the study was within ranges that supported successful breeding, although more stringent salinity management is needed to minimize the risk of stress. The provision of live feed, such as rotifers and Artemia, proved effective in supporting larval growth, but maintaining the stability of nutritional quality remains a key factor. The Indonesian strain has good potential but requires genetic selection and nutrition management improvements to enhance its reproductive performance. These results emphasize the importance of selecting superior strains, optimal environmental quality management, and implementing scientifically-based aquaculture technologies to support the sustainability of Barramundi aquaculture in Indonesia.

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REFERENCES

Abduh, M., & Fatahudin, F. (2016). Pemijahan alami ikan kakap putih (*Lates calcarifer*) di keramba jaring apung. *Buletin Teknik Litkayasa Akuakultur*, 10(2), 85-89.

Adnan, N., Amrullah, S. H., & Hamka, H. (2022). Teknik Pemeliharaan Induk Ikan Kakap Putih (*Lates calcarifer*) di Balai Perikanan Budidaya Air Payau (BPBAP) Takalar, Sulawesi Selatan. *Filogeni: Jurnal Mahasiswa Biologi*, 2(3), 69-75.

Arini, P. D., Muhammad, F., Baskoro, K., & Fahris, N. (2018). Pengaruh Pemberian Hidrogen Peroksida (H_2O_2) Dalam Pengendalian Ektoparasit, Dan Kelangsungan Hidup Benih Ikan Nila Salin (*Oreochromis niloticus*) di Balai Besar Perikanan Budidaya Air Payau Jepara. *Bioma: Berkala Ilmiah Biologi*, 20(1), 59-65.

Astuti, E. P., A'yun, Q., Vitasari, A., & Sari, P. D. W. (2023). Kajian Teknis Budidaya Ikan Kakap Putih (*Lates calcarifer*) di Balai Perikanan Budidaya Air Payau (BPBAP) Situbondo, Kabupaten Situbondo, Jawa Timur. *Jurnal Perikanan Pantura* (JPP), 6(1), 269-280.

Hafiludin, H. (2011). Karakteristik Proksimat dan Kandungan Senyawa Kimia Daging Putih dan Daging Merah Ikan Tongkol (*Euthynnus affinis*). *Jurnal Kelautan: Indonesian Journal of Marine Science and Technology*, 4(1), 1-10.

Hasibuan, R. B., Irawan, H., & Yulianto, T. (2018). Pengaruh Suhu Terhadap Daya Tetas Telur Ikan Kakap Putih (*Lates calcarifer*). *Intek Akuakultur*, 2(2), 49-57.

Iskandar, A., Carman, O., AM, N. F. A., & Ruliaty, L. (2023). Kaji Terap Pengkayaan Pakan Induk Ikan Bandeng *Chanos chanos* forsskall untuk Meningkatkan Performa Hasil Pembenihan. *JURNAL LEMURU*, 5(2), 265-279.

Izzah, N., Ihkwantaka, A. S., Nurcahyono, E., & Rahardjo, S. S. P. (2019). The Effect of Micro Feed on the Growth of Rajungan Larva (*Portunus pelagicus*).

Marie, R., Syukron, M. A., & Rahardjo, S. S. P. (2018). Teknik Pembesaran Ikan Nila (*Oreochromis niloticus*) Dengan Pemberian Pakan Limbah Roti. *Jurnal Sumberdaya Alam dan Lingkungan*, 5(1), 1-6.

Mubarrak, M. D. F., Kusumanti, I., Wiyoto, W., & Muzaki, A. (2024). Manipulation of the Aquatic Environment to Optimize the Natural Spawning of Sunu Grouper (*Plectropomus leopardus*) in Controlled Tanks. *Depik*, 13(1), 85-91.

Mudiarti, I. L. (2023). *Pengantar Budidaya Laut*. Unisnu Press.

Mulyono, M., & Ritonga, L. B. (2019). *Kamus Akuakultur (Budidaya Perikanan)*. Stp Press.

Nuswantoro, S., & Rahardjo, S. S. P. (2018). Effect of Using Silkworm (*Tubifex* sp.) Living on the Survival Rate and Growth of the Catfish Larvae (*Clarias* sp.). *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 1(2), 42-46.

Paksi, A. K., Silawa, K., & Nabilazka, C. R. (2023). Peningkatan Kemandirian Ekonomi Pondok Pesantren Ahmad Dahlan, Kriyan Melalui Usaha Ternak Ikan Nila dan Ikan Gurami. *Jurnal Surya Masyarakat*, 6(1), 80-90.

Pietoyo, A., Tarigan, R. R., Astiyani, W. P., Febriani, V. T., & Syah, I. F. (2022). Performa Hasil Pemijahan Ikan Kakap Putih (*Lates calcarifer*) Strain Lokal dan Australia. *Journal of Aquaculture Science*, 7(2).

Prajayanti, V. T. F., Prama, E. A., Arif, G. N. M., & Pietoyo, A. (2023). Pengaruh Pasang Surut pada Pembenihan Ikan Kakap Putih (*Lates calcarifer*) Secara Alami. *Marlin: Marine and Fisheries Science Technology Journal*, 4(1), 57-64.

Putra, H. F. E., Rahardjo, S. S. P., & Permana, A. (2017). Pemijahan Ikan Hias Botia (*Chromobotia macracanthus* Bleeker) Secara Buatan Dengan Injeksi Hormon HCG (*Human Chorionic Gonadotrophin*) dan LHRH-a (*Luteinizing Hormone Releasing Hormone-analog*). *Journal of Aquacultur and Fish Health*, 6(3), 101-109.

Putri, M. N., & Kurniawan, R. (2023). Kualitas Air pada Media Pemeliharaan Larva Ikan Kakap Putih (*Lates calcarifer*). South East Asian Aquaculture, 1(1), 1-4.

Rahardjo, S. S. P., & Shih, Y. J. (2022). Electrocatalytic Ammonia Oxidation Mediated by Nickel and Copper Crystallites Decorated with Platinum Nanoparticle (PtM/G, M= Cu, Ni). *ACS Sustainable Chemistry & Engineering*, 10(15), 5043-5054.

Rahardjo, S. S. P., & Shih, Y. J. (2023). Electrochemical Characteristics of Silver/Nickel Oxide (Ag/Ni) for Direct Ammonia Oxidation and Nitrogen Selectivity in Paired Electrode System. Chemical Engineering Journal, 452, 139370.

Rahardjo, S. S. P., & Shih, Y. J. (2023). In-situ Phase Transformation of Silver Oxide Nanoparticles Encapsulated in Reduced Graphene Oxide (Ag/rGO) for Direct Electrochemical Ammonia Oxidation. *Chemical Engineering Journal*, 473, 145396.

Rahardjo, S. S. P., Kurniawan, H. A., Oktaviani, E. D., Wibawa, G. S., Widyawati, Y., & Mahariawan, I. M. D. (2024). Performance of Amino Acid Supplementation in Feed on the Production of Cantang Grouper (*Epinephelus lanceolatus* x *Epinephelus fuscoguttatus*) in the Nursery Phase. *Jurnal Akuakultura Universitas Teuku Umar*, 8(2), 51-54.

Rahardjo, S. S. P., Shih, Y. J., & Fan, C. S. (2024). Ammonia Oxidation by In-Situ Chloride Electrolysis in Etching Wastewater of Semiconductor Manufacturing Using RuSnOx/Ti Electrode: Effect of Plating Mode and Metal Ratio. *Journal of Hazardous Materials,* 469, 134042.

Rey, J., & Sahetapy, J. M. (2024). The Effect of Incubation Temperature on Hatching Period, Hatching Rate, and Embryonic Development of Barramundi (*Lates calcarifer*, Bloch 1790). *Aquaculture Studies*, 25(1).

Ridho, M. R., & Patriono, E. (2016). Aspek Reproduksi Ikan Kakap Putih (*Lates calcarifer* Block) di Perairan Terusan dalam Kawasan Taman Nasional Sembilang Pesisir Kabupaten Banyuasin. *Jurnal Penelitian Sains*, 18(1), 1-7.

Sholichin, M., Prayogo, T. B., Wicaksono, K. S., Hidayati, A. S., & Rahardjo, S. S. P. (2024). Examining Water Quality Indices Method in Varied Climatic Regions–Sutami Reservoir Case Study. Ecological Engineering & Environmental Technology, 25.

Shubhi, M. Z. A., Kusumadewi, Y. S., & Suswati, D. (2017). Study of Suitability and Environmental Carrying Capacity for Barramundi (*Lates calcarifer*. Bloch) Culture in Waters of Lemukutan Island and Penata Besar Island, Bengkayang Region, West Kalimantan. Aquasains, 5(2), 495-508.

Supryady, S., Kurniaji, A., Syahrir, M., Budiyati, B., & Hikmah, N. (2022). Derajat Pembuahan dan Penetasan Telur, Pertumbuhan dan Kelangsungan Hidup Larva Ikan Kakap (*Lates calcarifer*). Jurnal Salamata, 3(1), 7-12.

Thépot, V., & Jerry, D. R. (2015). The Effect of Temperature on the Embryonic Development of Barramundi, the Australian Strain of Lates Calcarifer (Bloch) Using Current Hatchery Practices. Aquaculture Reports, 2, 132-138.

Ulfani, R., Defira, C. N., Kuala, S., Aceh, B., Perikanan, B., Air, B., & Besar, K. A. (2018). Inkubasi Telur Ikan Kakap Putih (*Lates calcarifer*) menggunakan Sistem Corong dengan Padat Tebar yang Berbeda. *Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah*, 3, 135–142.