Abundance, Diversity, and Distribution of Fish Larvae in The Bali Strait

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Abstract

Larva represents the initial phase of a fish's life after hatching from the egg. Studies on fish larvae aim to provide seasonal information, as well as identify spawning and nursery areas, especially economically important fish species, to support the sustainability of fishery resources. This study aimed to gather information on the abundance, diversity, and distribution of fish larvae in the waters of the Bali Strait. Sampling was carried out from August to November 2024, using a trawl net at five observation stations. The larval samples were preserved with 4% formalin and subsequently identified and counted using a microscope at the Capture Fisheries Laboratory of Marine and Fisheries Polytechnic of Jembrana. This study found 22 families of fish larvae, with abundance ranging from 38 to 433 individuals per 1000 m^3. Spatially, the highest abundance was recorded at the Perancak station, followed by Tuwed, Sumbersari, Cupel, and Jimbaran. Temporarily, fish larvae with high abundance were found from September to November. The larval composition was dominated by the families Clupeidae, Gobiidae, Bramidae, and Carangidae. Shannon-Wiener Index (H') of fish larvae ranged from 0.64 to 2.18, indicating that the level of diversity and stability of the community was at a low–moderate level. The highest diversity was found at Tuwed station. The distribution of fish larvae is influenced by oceanographic characteristics, fish behavior, and the availability of natural food sources, such as plankton.

Keywords: *Clupeidae, fish larvae, nursery area, spawning area, spawning season*

Introduction

Larvae mark the initial phase of a fish's life. At this stage, its morphology is underdeveloped; it lacks the complete body organs found in the adult fish. During this phase, larvae are grouped as meroplankton, which later transition into free-swimming organisms in the water column, known as nekton. The development phase of fish is divided into four phases: the yolk-sac stage, which is the newly hatched larva phase, where the yolk sac is still present; the larval phase, which includes the pre-flexion, flexion, and post-flexion stages; the transformation phase, where larvae undergo significant morphological changes, and the juvenile stage. Research on fish larvae is essential for predicting fishery resource stocks, supporting conservation efforts, and ensuring optimal utilization of these resources. The purpose of studying fish larvae is to obtain information on spawning seasons and nursery areas, especially for economically important fish species, to maintain the sustainability of fishery resources (Mazaheri *et al.,* 2020).

The waters of the Bali Strait are part of the State Fisheries Management Area (FMA) 573 of the Republic of Indonesia, with the primary fishery commodity being Lemuru (*Sardinella lemuru*). Lemuru is one of the important economic fish species that belongs to the Clupeidae Family. Based on the results of the study of *lemuru* fisheries in the waters of the Bali Strait, the catch has been very volatile and has shown a declining trend over the past 10 years (Natsir *et al*., 2021; Satyawan *et al*., 2023).

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The potential fishery resources in the waters of the Bali Strait are not limited to *lemuru*. Pertami *et al*. (2022) reported 43 species of fish belonging to 24 families, with dominance by *Sardinella gibossa*, *Decapterus macrosoma*, *Sardinella lemuru*, and *Auxis rochei*. These fishery resources are the main commodities that support livelihoods of fishers around the Bali Strait. In addition, these commodities are also important for fish processing industries, which provide significant employment in the Pengambengan area and its surroundings (Satyawan *et al*., 2023).

The status of the utilization of fishery resources, especially *lemuru* in the waters of the Bali Strait, indicates overfishing (Warren and Steenbergen, 2021; Satyawan *et al*., 2023; Sari *et al*., 2024). The utilization of *lemuru* fishery resources must prioritize sustainability. This sustainability is determined by the existence of protected areas that limit fishing activities in these locations. Protections should include seasonal closures and the designation areas suspected to be spawning and nursery grounds to ensure successful recruitment. The goal of these protections is to maintain the stock of fishery resources in the waters of the Bali Strait.

Wujdi *et al*. (2013) explained the habitat suspected to be suitable for *lemuru* spawning is found in zone VI (Bukit, Benoa, Jimbaran, and Pemancar), while the nursery area is suspected to be in zone II in the northern part and zone III around Pangpang Bay. These findings were based on research that examined fishery resources from fishermen's catches. As few studies have focused on fish resources in their larval stages in the waters of the Bali Strait, this research aims to obtain more actual and accurate information about the abundance, diversity, and distribution of fish larvae, to serve as a basis for the development of marine protected areas in the waters of the Bali Strait.

Materials and Methods

The research data collection was carried out in the waters of the Bali Strait. The sampling period represents the eastern season (August), the second transitional season (September), and the western season (November). Data were collected from five stations (Figure 1). Fish larval sampling was carried out horizontally to provide an overview of the distribution of fish larvae in the waters.

Sample collection and observation

Sampling of fish larvae carried out using the purposive sampling method at each observation station. First, the coordinates of the sampling location were recorded using GPS, and then samples of fish larvae were collected using a trawl net with a mouth diameter of 100 cm, a net length of 300 cm, and a mesh size of 500 μm (0.5 mm). The trawl net was lowered to the position, ready to be towed by the motorized boat at a speed of approximately 1 knot. Once the sample was obtained, the filtered sample volume was separated from the waste and other abiotic material, then placed into a 500 ml sample bottle containing 4% Formalin and labeled. The separation of samples from other organisms was carried out at the Capture Fisheries Laboratory of the Marine and Fisheries Polytechnic of Jembrana.

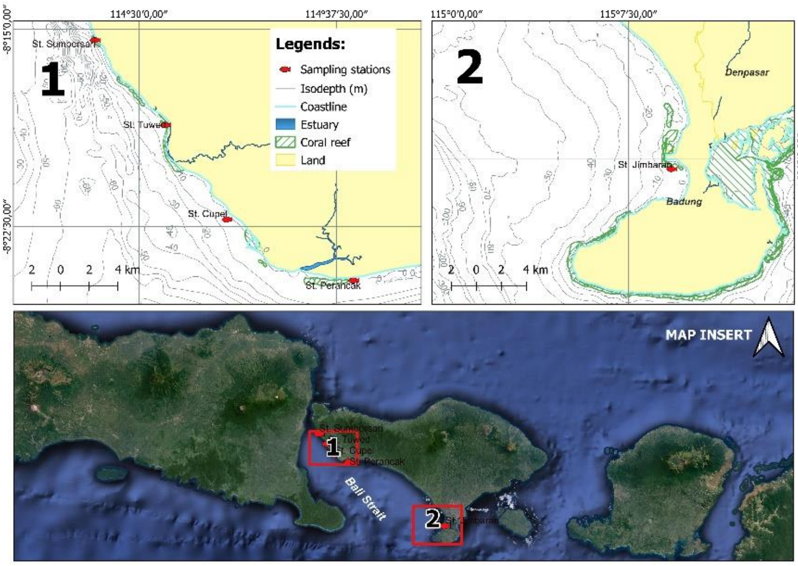

Figure 1. Research/samping sites

Identification, observation, and morphometric measurements of fish larvae were carried out at the Capture Fisheries Laboratory of the Marine and Fisheries Polytechnic of Jembrana. Morphometric measurements of fish larvae were performed using a stereo microscope. Fish larval identification was carried out based on the identification books *The Larvae of Indo-Pacific Coastal Fishes* (Leis and Carson-Ewart 2000) and *Larval Fish Identification for The South China Sea and Gulf of Thailand* (Konishi *et al*., 2008). The criteria for identifying fish larvae were based on snout length (SnL), eye diameter (ED), head length (HL), body length (BL), length from the ventral anal to the juvenile fin (VAFL), anterior anal fin length (PAL), anterior dorsal fin length (PDL) and body width (BD). Morphometric parameter analysis can be used for fish larval identification by observing the number of myomeres and characteristics that appear to be pigmentation patterns (Mazaheri *et al.,* 2020).

Observation of fish larval habitat characteristics included the measurement of ecological parameters (physical, chemical, and biological). Measurement of physico-chemical parameters included water clarity, depth, temperature, pH, salinity, and dissolved oxygen (DO). Measurement of biological parameters involved the abundance of plankton: phytoplankton were collected using a net with a 30 cm ring diameter, 100 cm net length, and 40 µm mesh size, while zooplankton were collected using a net with a 30 cm ring diameter, 100 cm net length and, 300 µm mesh size. Identification of plankton and enumeration were carried out at the Capture Fisheries Laboratory of the Marine and Fisheries Polytechnic of Jembrana. Plankton species were identified based on identification books by Yamaji (1976), Bold and Wynne (1978), and Inaba *et al*. (2020). After identifying the phytoplankton, the number of each type of plankton found was enumerated.

Data analysis

Fish larval abundance is defined as the number of fish larvae per unit of water volume, calculated using the following formula:

$$N = \frac{n}{V_{fil}}$$

Note: *N*= abundance of fish larvae (ind.m^{-3}); *n*= number of fish larvae (individuals); V_{fil} = filtered water volume (m^3)

Plankton abundance is calculated to determine the number of individual plankton per liter of seawater. The abundance calculation is carried out based on the following formula:

$$N = n\, x\, \frac{Vr}{Vo}\, x \frac{1}{Vs}$$

Note: *N*= plankton abundance (ind.L^{-1}); *n*= number of plankton observed; *Vr*= sample volume (ml); *Vo*= observed water volume (ml); *Vs*= volume of filtered water (ml)

The diversity index refers to the Shannon-Wiener Diversity Index:

$$H' = -\sum p_i \ln p_i$$

Note: *H'* = Shannon-Wiener Diversity Index; $p_i = \frac{n_i}{N}$; n_i = number of individuals of the type-*i;* *N*= total number of individuals

with the following criteria: *H'*<1: Low community stability; 1<*H'*<3: Community stability is moderate; *H'*>3: High community stability

Results and Discussion

Abundance of fish larvae

Based on the results of the study, the abundance of fish larvae varied both spatially and temporally (Figure 2). The abundance of fish larvae ranged from 38 to 433 ind.1000 m^{-3}. The highest abundance was found at Perancak station (433 ind.1000 m^{-3}), followed by Tuwed (255 ind.1000 m^{-3}), Sumbersari (115 ind.1000 m^{-3}), Cupel (64 ind.1000 m^{-3}), and Jimbaran (38 ind.1000 m^{-3}).

The abundance of fish larvae relatively found in this study was higher than the results of other studies in Indonesia (Table 1). Jatmiko *et al*. (2018) reported that the abundance of fish larvae in the waters of the Alas Strait, West Nusa Tenggara, ranged from 8 to 120 ind.1000 m^{-3}. Similarly, Hadi *et al*. (2013) reported the abundance of fish larvae in the coral reef waters of the western region of Karimunjawa ranged from 1 to 366 ind.1000 m^{-3}. However, the abundance of fish larvae in the waters of the Bali Strait was relatively higher compared to the abundance in Sulawesi waters, which ranged from 9 to 834 ind.1000 m^{-3} (Amri *et al*., 2015). In the Natuna waters, the abundance of fish larvae ranged from 16 to 2342 ind.1000 m^{-3} (Taufik *et al*., 2022).

Fish larval abundance is influenced by aquatic environmental factors, fish behavior, and the availability of food sources (plankton) in their habitat. It is also closely related to temperature (Dodson *et al.,* 2019), chlorophyll-*a*, and zooplankton diversity (Tarimo, 2022a). Fish larvae migrate to the surface at midnight, while during the day (Shima *et al.,* 2021), they concentrate at a depth of 5–15 m, following the abundance of *nauplius* copepods. Stations with high fish larval abundance in the waters of the Bali Strait are typically located near river estuaries and mangrove vegetation.

Temporally, the abundance of fish larvae varies from month to month with an increasing trend (Figure 3). At Perancak station, an increase was observed each month, with the highest abundance recorded in September–November. A similar pattern was observed at Sumbersari station, where fish larval abundance peaked in November. In contrast, Cupel, Tuwed, and Jimbaran stations indicated the highest fish larval abundance in September.

This finding aligns with the report of Wujdi *et al*. (2013), which stated that the spawning season of *lemuru* fish starts in September and continues for one or two months (October–November). Pata *et al.* (2021) predicted that the spawning period of *Sardinella lemuru* in the Sulu Sea occurs during November-February. This is because the availability of natural food sources is relatively high during the rainy season, providing essential nourishment for fish larvae. The spawning period is also closely related to

Table 1. Abundance (Ind.1000 m^{-3}) of fish larvae at each station

No	Family	Perancak			Cupel			Tuwed			Sumbersari			Jimbaran		
		Aug	Sep	Nov	Aug	Sep	Nov	Aug	Sep	Nov	Aug	Sep	Nov	Aug	Sep	Nov
1	*Acanthuridae*	-	-	-	-	-	-	-	-	-	-	13	-	-	-	-
2	*Ambassidae*	-	-	-	-	13	-	-	-	-	-	-	-	-	-	-
3	*Apogonidae*	-	-	-	-	-	-	-	-	-	13	-	-	-	-	-
4	*Blennidae*	-	-	25	-	-	-	-	-	-	-	-	-	-	25	-
5	*Bramidae*	-	64	-	-	-	-	-	25	-	-	-	-	-	-	-
6	*Carangidae*	-	-	-	-	-	-	-	38	13	-	-	25	-	-	-
7	*Chaetodontidae*	-	-	-	-	-	-	-	13	-	-	-	-	-	-	-
8	*Clupeidae*	-	89	25	-	13	-	-	51	-	-	-	-	-	-	-
9	*Cynoglossidae*	-	-	-	-	-	-	-	13	-	-	-	-	-	-	-
10	*Gereidae*	-	-	-	-	-	-	13	-	-	-	-	-	-	-	-
11	*Gobiidae*	-	-	140	-	38	-	-	-	-	-	-	-	-	-	13
12	*Haemulidae*	13	-	13	-	-	-	-	13	-	-	-	-	-	-	-
13	*Labridae*	-	-	-	-	-	-	25	-	-	-	-	-	-	-	-
14	*Leiognathidae*	-	-	-	-	-	-	-	-	-	-	13	-	-	-	-
15	*Monacanthidae*	-	-	-	-	-	-	-	13	-	-	-	-	-	-	-
16	*Mullidae*	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	*Nemipteridae*	-	-	13	-	-	-	-	-	13	-	-	38	-	-	-
18	*Pomacentridae*	-	-	-	-	-	-	13	-	-	-	-	-	-	-	-
19	*Scaridae*	-	-	-	-	-	-	-	-	-	13	-	-	-	-	-
20	*Sciaenidae*	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-
21	*Scombridae*	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	*Serranidae*	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TOTAL	51	166	217	-	64	-	51	166	25	25	25	64	-	25	13

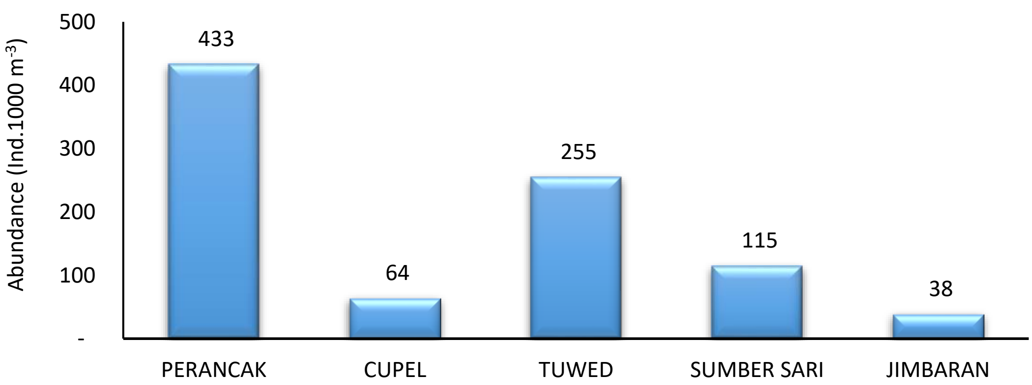

Figure 2. Abundance of fish larvae at each station

the occurrence of upwelling phenomena in the Bali Strait during the eastern monsoon season, which triggers an increase in phytoplankton abundance as food for fish larvae (Setyohadi *et al*., 2021). Specifically, Ramírez-Martínez *et al.* (2022) mentioned that the abundance of reef fish larvae species is greater at night. This is also supported by the findings of Yeakub *et al.* (2023), which state that spawning events occur during the full lunar phase.

The presence of natural food in the waters is influenced by the phenomenon of upwelling. Upwelling typically leads to increased productivity, characterized by low Sea Surface Temperatures (SST) and high concentrations of chlorophyll-a (Kunarso *et al.,* 2020). In the Bali Strait, upwelling occurs from April to November, peaking in July and August (Supriato *et al.,* 2021).

Sartimbul *et al*. (2023a) explained that in the southeast monsoon season (April–October), southeast winds from Australia cause upwelling, making the water cooler and bringing nutrients to the surface along the southern coasts of Java, Bali, and Sumatera. The conditions differ from the southwest monsoon season (October–April). The southeast monsoon season is indicated by a high concentration of chlorophyll-*a* and low SST, while the southwest monsoon wind season is characterized by a low concentration of chlorophyll-*a* and a high SST. A high concentration of chlorophyll-*a* indicates a high abundance of plankton (phytoplankton and zooplankton) in water. The existence of plankton as a natural feed is an important factor in the survival of fish larvae. The distribution of larvae in the Bali Strait is influenced by the Indonesian Throughflow (Winata *et al.,* 2022; Sartimbul *et al.,* 2023a).

The fluctuating abundance of fluctuating fish larvae is influenced by physical, chemical and biological factors. Fish larvae have underdeveloped locomotory organs, which cause larvae in the yolk-sac and preflexion stages to be carried by currents to shallower waters, such as seagrass beds and mangroves. In addition, the migration patterns of fish larvae, both vertical and horizontal, also affect their distribution in a water body. Fish larvae tend to move toward the bottom or mangrove areas during the day to avoid predators and search for food (Tarimo *et al.,* 2022b). These factors are suspected to strongly contribute to the relatively low abundance at several sampling points.

Fish larval diversity

The total of 71 fish larvae specimens were found during the study, representing 22 families (Figure 4). The dominant families included *Clupeidae* (21%), *Gobiidae* (21%), *Bramidae* (10%), *Carangidae* (8%), *Nemipteridae* (7%), *Blenniidae* (6%), *Haemulidae* (4%), *Labridae* (3%), and other families, each contributing 1%. The larval figures of dominant fish families are presented in Figure 5. Spatially, the highest number of fish larval families was found at Tuwed station (11), followed by those at Perancak (10), Sumbersari (6), Cupel (3), and Jimbaran (2).

The total number of fish larval families found in the waters of the Bali Strait is relatively higher than that the 17 families reported by Romdon *et al*. (2023) in Ambon Bay, where the dominant families were *Engraulidae*, *Gobiidae*, and *Myctophidae.* Purnomo *et al*. (2020) reported 13 genera of fish larvae in the west coast estuary of Demak, Indonesia dominated by the families *Ambassidae* and *Carangidae*. Mocuba *et al*. (2023) reported 22 taxa (families, genera and species) dominated by the Gobiidae family in the Bons Sinais estuary, Mozambique. However, the number of larval families found in the Bali Strait was relatively smaller than the 26 families reported by

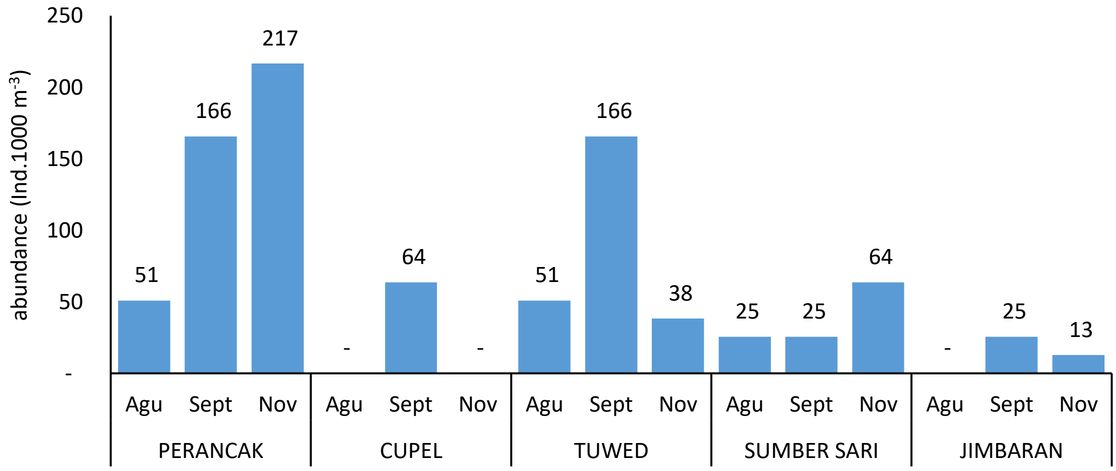

Figure 3. Fish larvae abundance

Jatmiko *et al*. (2018) in the waters of the Alas Strait, where *Scombridae*, *Carangidae*, and *Blennidae* were dominant. Taufik *et al.* (2022) reported a significantly higher diversity in Natuna waters, with 47 fish larval families dominated by *Engraulidae*, *Nemipteridae*, *Scaridae*, and *Pomacentridae*. Li *et al*. (2023) using DNA barcoding successfully reported 44 families consisting of 147 species of fish larvae in the Luzon Strait, China.

Fish larvae from *Clupeidae* were the most dominant during the observation. One species of Clupeidae commonly caught in the waters of the Bali Strait is *Sardinella lemuru* (Jatisworo *et al*., 2022). The distribution of *lemuru* is influenced by environmental factors such as temperature (Dodson *et al.,* 2019), chlorophyll-*a* concentration, currents, and salinity (Sartimbul *et al*., 2023b; Satyawan *et al*., 2023). The *lemuru* fish larvae found in the waters of Perancak may have been carried by currents from the spawning site. Wujdi *et al*. (2013) identified the spawning area of *lemuru* fish in zone VI (Bukit, Benoa, Jimbaran, and Pemancar). *Lemuru* is a filter feeder, which primarily consumes plankton (phytoplankton and zooplankton) as its food source (Hunnam, 2021; Sartimbul *et al.,* 2023a). Phytoplankton is the most dominant food for *Clupeidae* larvae (Smit *et al.,* 2023).

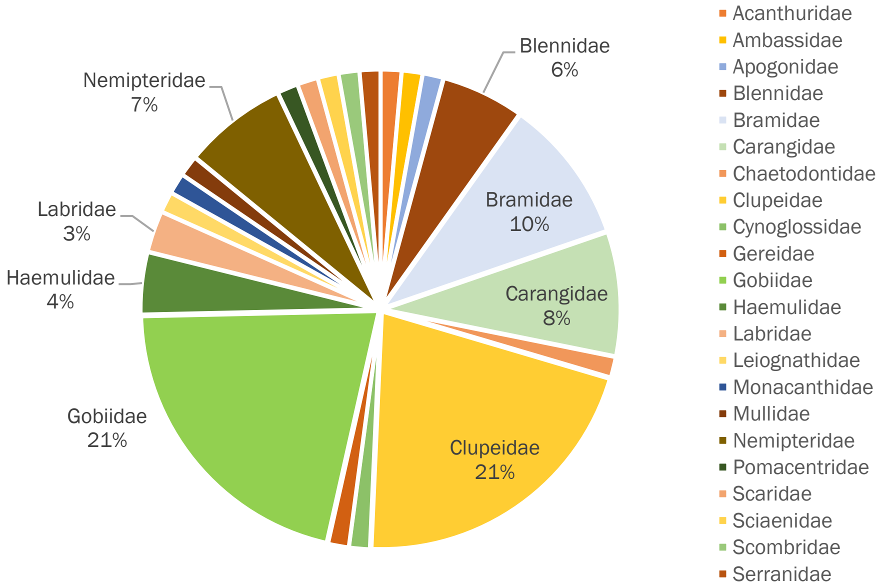

Figure 4. Composition of Fish Larval Families found in the waters of the Bali Strait

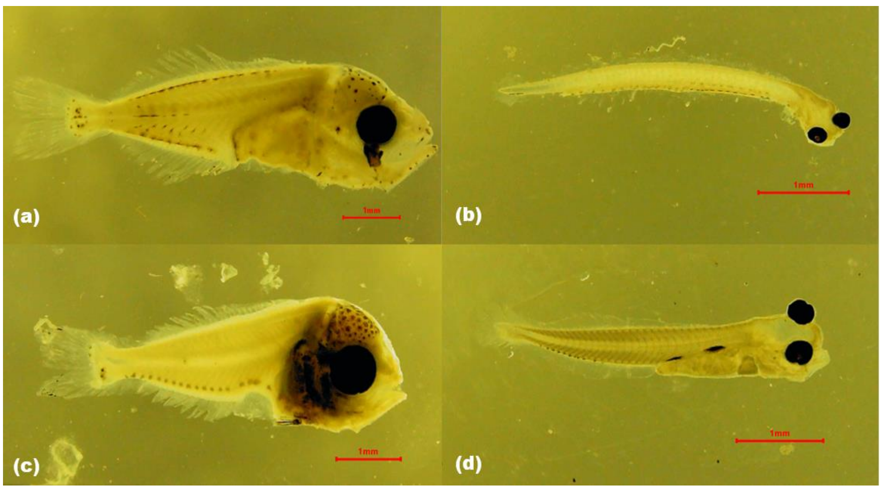

Figure 5. The dominant fish larval families (a. *Carangidae*; b. *Clupeidae*; c. *Bramidae*; d. *Gobiidae*)

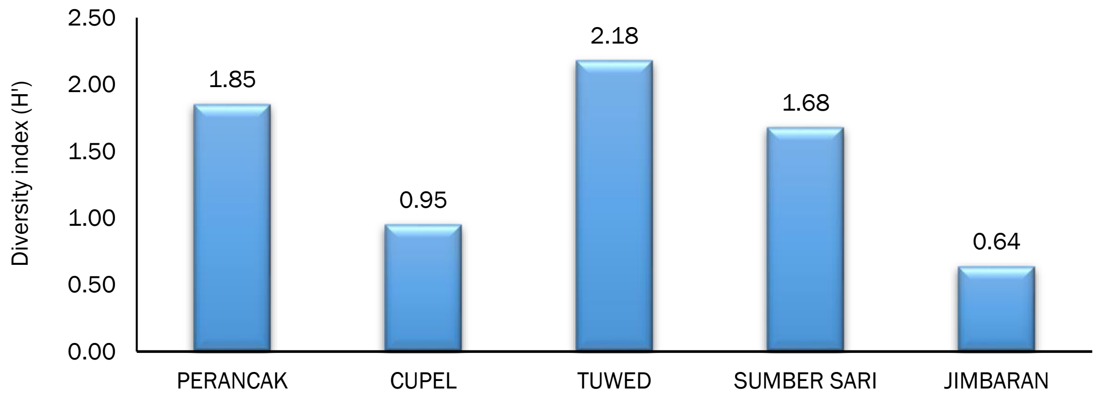

Figure 6. Shannon-Wiener Diversity Index (*H*') at each station

Another dominant family of fish larvae in this study was *Gobiidae*. *Gobiidae* is typically predominant in estuary waters due to its good adaptability to environmental conditions (Zhai *et al*., 2023). It is a family of fish with a wide distribution across various habitats in tropical and subtropical waters and is amphidromic (Donaldson *et al.,* 2023). Temperature and turbidity are abiotic factors that affect the presence of *Gobiidae* larvae in an aquatic environment (Baihaqi *et al*., 2022).

Bramidae was also found to be quite dominant in the waters of the Bali Strait. One type of fish from *Bramidae* caught in the waters of the Bali Strait is *Brama dussumieri* (Pertami *et al*., 2022). The spawning season for *Bramidae* usually occurs in March-November (Mahé *et al.,* 2024). It has been further explained that fish from *Bramidae* usually feed on plankton, small fish, and groups of cephalopods (Pan *et al*., 2022).

Fish larvae from *Carangidae* were also found to be quite dominant. Pertami *et al*. (2022) reported that the most widely identified fish species in the southwestern waters of Bali Island were of *Carangidae*. It was further explained that one of the species from *Carangidae* that is widely caught in the waters of the Bali Strait is the shortfin scad (*Decapterus macrosoma*). Some members of *Carangidae* spawn close to the coast, with spawning generally occurring in the dry season. The eggs hatch approximately 24–48 hours after spawning, depending on the size of the eggs and the temperature of the waters (Réalis-Doyelle *et al.,* 2022).

The value of the Shannon-Wiener Diversity Index (*H*') of fish larvae ranged from 0.64 to 2.18 (Figure 6), indicating that the level of diversity and stability of the community was at a low–moderate level. The highest index value was found at Tuwed station with an *H'* value of 2.18 (moderate), followed by Perancak station with a value of 1.85 (moderate), Sumbersari 1.68 (moderate), Cupel 0.95 (low), and Jimbaran 0.64 (low). The diversity index value shows its relationship with aquatic environmental conditions, spawning seasons, or other oceanographic factors at each station. The composition and dominant species of larval fish reflect the different spawning strategies of adult fish (Harith *et al.,* 2021).

Fish larvae distribution

The distribution of fish larvae was uneven across the stations (Table 2). Fish larval families that have the highest frequency of encounters were *Clupeidae*, *Gobiidae*, and *Nemipteridae*. *Clupeidae* were found at three stations (Perancak, Cupel, and Tuwed), *Gobiidae* were found at three stations (Perancak, Cupel, and Jimbaran), and *Nemipteridae* were observed at three stations (Perancak, Tuwed, and Sumbersari). The distribution of fish larvae is influenced by oceanographic factors, fish behavior, and the availability of food sources (plankton). Fish larvae actively select the optimal size of prey (plankton) for their growth (Landaeta *et al.,* 2019; Hauss *et al.,* 2023). Behavioral differences between individuals and taxa, especially in the ability to catch prey related to body and mouth size, may be an important element contributing to the larvae's success in obtaining food (Pepin, 2023).

Table 3 presents the oceanographic characteristics of the waters at each sampling station. These characteristics include various physical, chemical, and biological aspects of the waters, which are crucial in determining the suitability of an environment for fish breeding. Factors such as water temperature, salinity, currents, underwater topography, water clarity, primary productivity, and nutrient availability play crucial roles in creating an ideal habitat for young fish. Areas with supportive oceanographic characteristics not only help young fish survive but also support the growth of healthy and sustainable marine ecosystems.

Temperature is one of the key environmental factors that affect the presence of fish larvae in the water (Dodson *et al.,* 2019; Sambah *et al.,* 2021). The average temperature at each station ranges from 27 ºC to 28.5ºC. The highest average temperature was found at Perancak station (26.6–31.4 ºC), followed by Jimbaran (25.5–32ºC), Cupel (26.1–30.7ºC), Sumbersari (26.2–29.2ºC), and Tuwed (27.0–29.2 ºC). Temperature affects the growth rate of fish larvae, as it is related to the rate of egg yolk absorption. The optimal temperature for egg yolk absorption is 27–29ºC (Srithongthum *et al*., 2020). Amri *et al*. (2015) reported that fish larvae were found in higher abundance in waters with warm temperatures (28–29ºC). Warmer water temperatures decrease microbial abundance and potentially lead to a decline in fish larval health which ultimately contributes to a decline in fish recruitment (Sardi *et al*., 2023; Franke *et al.,* 2024).

Table 2. Distribution of fish larvae in the waters of the Bali Strait

No.	Family	Perancak	Cupel	Tuwed	Sumbersari	Jimbaran
1	*Acanthuridae*	-	-	-	+	-
2	*Ambassidae*	-	+	-	-	-
3	*Apogonidae*	-	-	-	+	-
4	*Blennidae*	+	-	-	-	+
5	*Bramidae*	+	-	+	-	-
6	*Carangidae*	-	-	+	+	-
7	*Chaetodontidae*	-	-	+	-	-
8	*Clupeidae*	+	+	+	-	-
9	*Cynoglossidae*	-	-	+	-	-
10	*Gereidae*	-	-	+	-	-
11	*Gobiidae*	+	+	-	-	+
12	*Haemulidae*	+	-	+	-	-
13	*Labridae*	-	-	+	-	-
14	*Leiognathidae*	-	-	-	+	-
15	*Monacanthidae*	-	-	+	-	-
16	*Mullidae*	+	-	-	-	-
17	*Nemipteridae*	+	-	+	+	-
18	*Pomacentridae*	-	-	+	-	-
19	*Scaridae*	-	-	-	+	-
20	*Sciaenidae*	+	-	-	-	-
21	*Scombridae*	+	-	-	-	-
22	*Serranidae*	+	-	-	-	-

note: (+) found; (-) not found

Table 3. Oceanographic conditions of the waters of the Bali Strait

Parameters	Unit	Perancak		Cupel		Tuwed		Sumbersari		Jimbaran	
		Range	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*
Temperature	ºC	26.6–3 1.4	28.5	26.1–30.7	27.9	27.0–29.2	27.0	26.2–29.2	27.1	25.5–32.0	28.4
Water clarity	m	5 - 6	5.3	4–5	4.2	3–6	4.8	7–9	7.7	2–4	3.0
Depth	m	5 - 9	6.3	4–8	5.3	3–7	5.1	7–9	8.0	6–8	6.7
DO	$mg.L^{-1}$	7.1 - 8.3	7.6	7.1–7.9	7.4	6.9–7.5	7.3	5.9– 6.7	6.1	6.5–7.8	7.3
pH		6.5–8.09	7.5	6.5–8.03	7.1	6.5–8.08	7.2	6.5–8.15	7.5	6.8–8.11	8.1
Salinity	‰	33–35	34.2	32–34	33.7	32–35	33.0	31–34	33.0	30–35	32.3
Phytoplankton abundance	$Ind.L^{-1}$		435		357		232		207		222
Zooplankton abundance	$Ind.L^{-1}$		215		51		105		21		36
Substrate		Coral		Coral		Coral		Coral		Sand	

In addition to temperature, another oceanographic factor that affects the presence of fish larvae in water is salinity (Restiangsih *et al.,* 2021). The average salinity at each station ranged from 32.3‰ to 34.2‰. The highest average salinity was found at Perancak station (34.2‰), followed by Cupel station (33.7‰), Tuwed (33‰), Sumbersari (33‰), and Jimbaran (32.3‰). A higher abundance of fish larvae was found in waters with moderate salinity (34–36‰) (Amri *et al*., 2015).

Acidity (pH) is a determining factor in the productivity of waters that directly or indirectly affects marine life, including larvae. The average pH at each station ranged from 7.1 to 8.1. The highest average pH was found at Jimbaran station (8.1), followed by Sumbersari and Perancak stations (7.5), Cupel (7.1), and Tuwed (7.2). A higher abundance of fish larvae was found in waters with a pH range of 7 (normal) compared to waters with a pH >8 (Amri *et al*., 2015).

The survival of aquatic biota, including fish larvae, is also greatly influenced by the level of dissolved oxygen (DO) in the water. The concentration of dissolved oxygen affects the metabolism of fish larvae. The average dissolved oxygen level at each station ranged from 6.1 to 7.6 $mg.L^{-1}$. This average value is still above the threshold needed for the survival of aquatic biota. Amri *et al*. (2015) reported that a higher abundance of fish larvae was found in waters with dissolved oxygen levels of >8 $mg.L^{-1}$.

Conclusion

Based on the results of observation and discussion, it can be concluded that 22 fish larvae families were identified, with abundance ranging from 38 to 433 individuals per 1000 m^3. Spatially, the highest abundance was found at Perancak station, followed by Tuwed, Sumbersari, Cupel, and Jimbaran stations. Temporarily, the peak abundance of fish larvae occurred between September and November. The composition of fish larvae was dominated by the families *Clupeidae*, *Gobiidae*, *Bramidae*, and *Carangidae*. The level of diversity and stability of the community was at a low–moderate level with the highest diversity found at Tuwed station. The distribution of fish larvae was influenced by oceanographic characteristics, fish behavior, and the availability of natural food sources such as plankton.

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