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REPRODUCTIVE BIOLOGY OF FIVE SPECIES OF ANCHOVIES (ENGRAULIDAE) FROM BIMA BAY, SUMBAWA, NUSA TENGGARA

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ABSTRACT

The reproductive biology of five species of anchovies (*Encrasicholina* and *Stolephorus*) in Bima Bay, Nusa Tenggara, Indonesia was examined and compared with previous studies of the same species in Bacan, Maluku and other parts of Indonesia. Fish and plankton sampling was conducted in February and April 2000. The length and weight relationship of five species of anchovies had a slope (b) that ranged from 2.71 to 3.74. These values were less than those found in Bacan for the same species. All species were multiple spawner and the mean batch fecundity ranged between 1226 (*Encrasicholina devisi*) and 2470 (*E. punctifer*). Relative fecundity varied among the species inversely with size, being lower in the larger species. Age at first spawning varied from 67 to 141 days for all five species and was higher in *Stolephorus* species. Lifetime egg production was less than that found in Bacan for the same species, but similar to that found in similar habitats elsewhere in the tropical Indo-Pacific. These results suggest that anchovy egg production is higher, but more variable in open oceanic environments compared with the more stable, coastal bays.

[*Keywords*: Anchovies; fertility; oviposition; Nusa Tenggara]

INTRODUCTION

Anchovies (Engraulidae) are small pelagic fish that are important throughout the tropical Indo-Pacific region for human consumption and as tuna baitfish. They are the main component of the live bait used by the pole-and-line tuna fishery. The fish are also highly priced as food in many Asian countries. These fish were caught by light fishing/lift net (*bagan*) and beach seine *redi* during the night or nearly in the morning, depending on the brightness of the moon.

Tuna fishery relies on a regular supply of anchovies for live bait. In eastern Indonesia, the large pole-and-line tuna fishery catches over 70,000 tonnes of fish a year and requires about 16,000 tonnes of anchovies (Naamin and Gafa, 1998; Rawlinson *et al.* 1998). However, in many areas of eastern Indonesia, anchovies are also valuable as human food. This can lead to competing demand and periods of short supply for the pole-and-line fishery.

Until recently, the shortage of anchovies for baitfish was thought to result from over-exploitation in some areas. However, Milton *et al.* (1998) showed that in Bacan (North Maluku), the shortage was probably due to natural fluctuations in the abundance of anchovies that are a response to variation in their zooplankton food. This variation in zooplankton is mostly driven by natural fluctuations in primary productivity.

Tropical anchovies have a reproductive strategy that is adapted to high natural mortality. The most abundant species of anchovies in baitfish catches in North Maluku (*Encrasicholina heterolobus* and *E. devisi*) reach sexual maturity within three months and spawn continuously thereafter (Andamari and Milton 1998). Females can spawn batches of eggs daily under favourable conditions (Milton *et al.* 1995; Andamari and Milton, 1998). Batch fecundity varies widely, both seasonally and between site conditions (Milton *et al.,* 1995), probably in response to prey intake (Milton and Blaber, 1993).

To gain a better understanding of the anchovy productivity in eastern Indonesia, studies of their reproductive biology is needed. Previous studies in Indonesia (Sumadhiharga, 1995; Andamari and Milton, 1998; Andamari *et al.* 1998; Maack and George, 1999) have examined the reproductive biology of anchovies in open, oceanic embayments. In this study, we contrast aspects of the reproduction of five species of anchovies (*Stolephorus* and *Encrasicholina* species) from Bima Bay, and compare our results with those of previous studies in more open habitats.

Bima Bay (Fig. 1) is a small enclosed bay on the north coast of Sumbawa, Nusa Tenggara (8° 32' 47"N 118° 42' 27" E). It is approximately 20 km long and 4.5 km wide at its widest point. The survey period

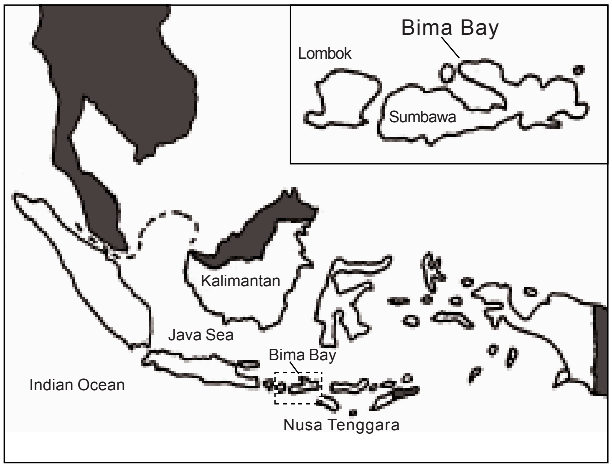

Fig. 1. Map of Nusa Tenggara, Indonesia showing the location of the study.

corresponded to the main wet season in eastern Sumbawa. However, there are few rivers flowing into Bima Bay and the salinity varied between 30 and $34^{0}/_{00}$ throughout the study. Tidal range in Bima Bay was approximately 1.5 m during the study and there apears to be limited water exchange with the Flores Sea as the mouth of the bay is narrow (< 300 m wide) and the water in the bay was highly turbid compared to the adjacent seas.

MATERIALS AND METHODS

Random subsamples of anchovies were collected from *bagan* catches in Bima Bay, northeastern Sumbawa during two periods, February and April 2000. During each month, a sample of at least 100 anchovies was collected daily for three days from *bagan*. All fish in each sample were then fixed in 10% formalin and stored in labelled jars. At the end of each survey, all samples were taken to the laboratory of the Research Institute for Mariculture, Gondol, Bali for analysis.

In the laboratory, fish were sorted and identified to species and up to 150 were dissected for sex identity and histology. The fish and their gonads were removed and weighed (+ 0.001 g). Ovaries were embedded in paraffin and sectioned with a microtome at 5 µ. Sections were stained with haematoxylin and eosin by the methods of Luna (1968) and staged with the criteria of Andamari *et al*. (1998). Fish that had ripe eggs stage 4 (Fig. 2) were used to estimate fecundity and relative fecundity following the approach of Andamari and Milton (1998).

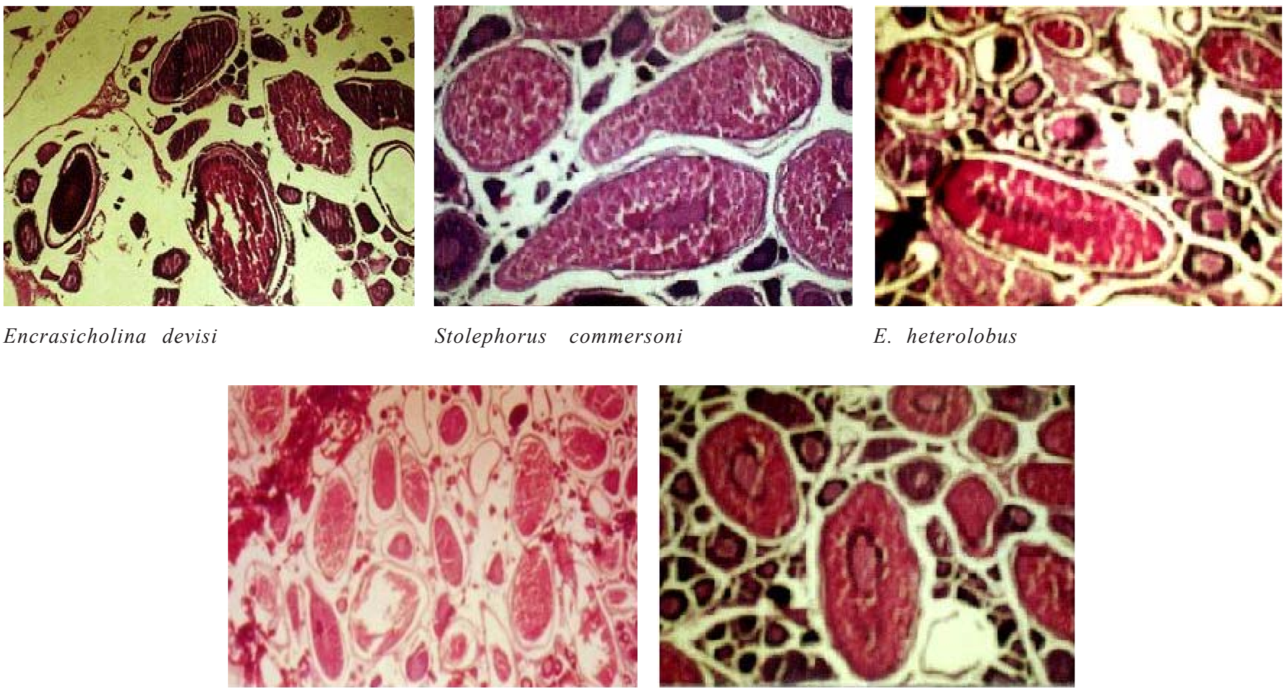

Fig. 2. Histological sections of the gonads of five species of anchovies from Bima Bay showing the stage 4 of maturity (H&E 100 x).

The age of each fish was estimated from the von Bertalanffy growth equations for *E. devisi* and *E. punctifer* from Fiji (Milton and Blaber, 1993), for *E. heterolobus* in Solomon Islands (Milton, unpubl.), and for *Stolephorus commersoni* and *S. indicus* in northern Australia (Hoedt, 2000). Ages were back-calculated from the length of each fish and corresponded to the mean age at that length. These ages were then used to estimate the mean age at sexual maturity (gonads contain stage 4 eggs) and their reproductive life-span. Spawning was defined as those fish that had post-ovulatory follicles (spent). Then the days between spawning could be estimated as the inverse of the proportion spawning (Milton *et al.,* 1995).

RESULTS AND DISCUSSION

A total of 1077 fish of five species were measured the length and the weight and 471 fish were examined histologically. The length-weight relationship at Bima (Fig. 3) and other sites in Indonesia (Table 1) shows that the slope varies widely between samples. In

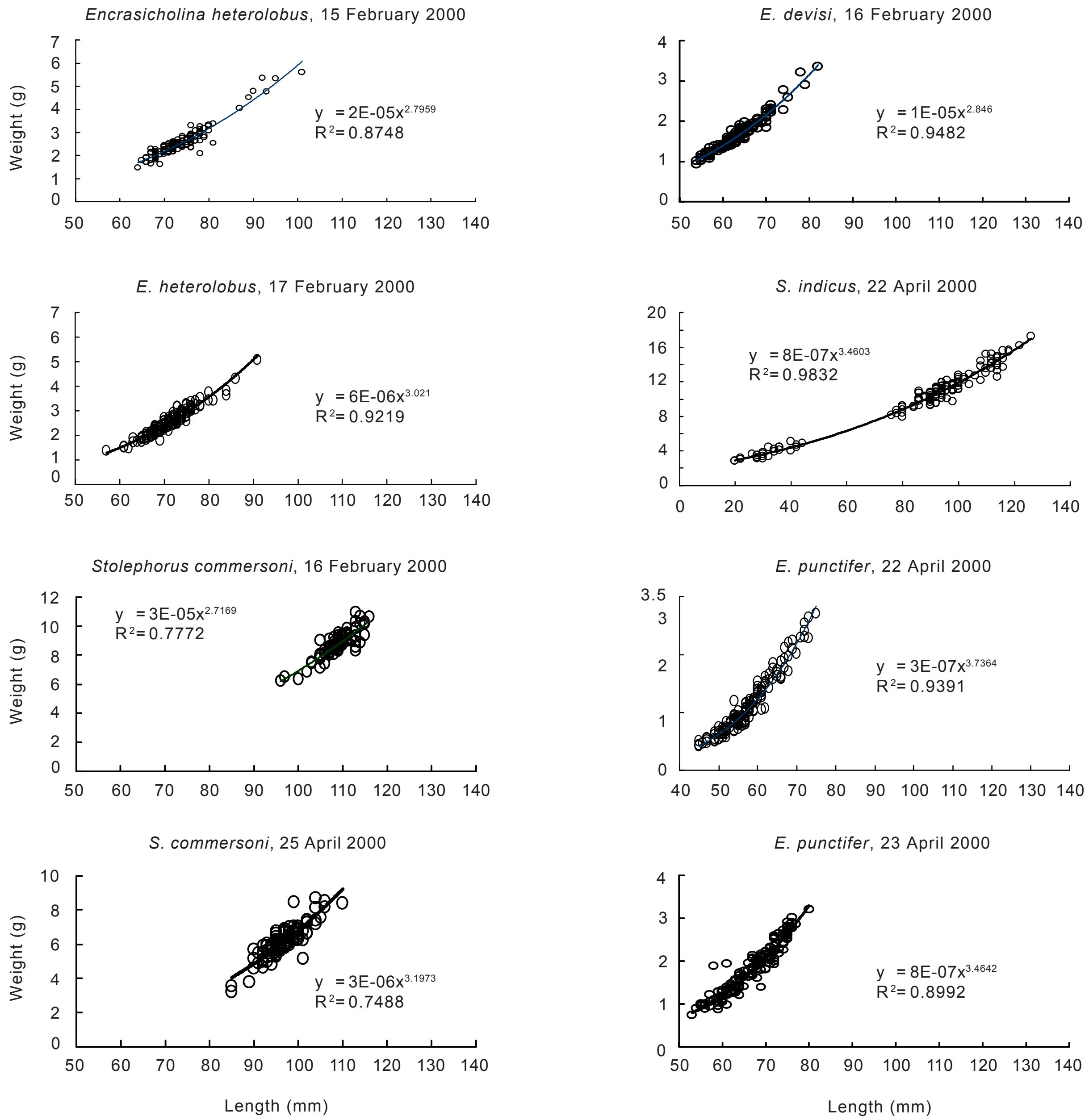

Fig. 3. Length-weight relationship of five species of anchovies from Bima Bay, Nusa Tenggara.

most samples from Bima Bay, the slope was less than that found for the same species in Bacan, suggesting that the fish were in poorer condition.

The fecundity of *Encrasicholina* species was lower in Bima Bay than that from other sites in Indonesia (Table 2). The mean size of spawning adults was also lower than that from Bacan. Fish that spawn earlier and have lower fecundity usually do so because of increased unpredictability of their environment. However, Bima Bay is a relatively stable environment, so the data suggest that mortality may be high in Bima Bay, causing the mean size of fish caught decreases. We found a similar pattern in *Encrasicholina* species in Bacan and this was related

Table 1. Length-weight relationship of anchovies from Bima Bay, Nusa Tenggara ($W = aL^b$) compared to those from Bacan and Ambon Bays.

Sites	Date	Species	a	b	r^2	n
Bima Bay	15 February 2000	*E. heterolobus*	2×10^{-5}	2.80	0.87	150
	17 February 2000	*E. heterolobus*	6×10^{-6}	3.02	0.92	150
Bacan[1]	September 1996	*E. heterolobus*	5.4×10^{-6}	3.38	0.95	230
	November 1996	*E. heterolobus*	5.4×10^{-6}	3.36	0.97	434
	April 1997	*E. heterolobus*	1.6×10^{-5}	3.09	0.85	1391
	July 1997	*E. heterolobus*	1.6×10^{-5}	3.08	0.90	1107
Bima Bay	16 February 2000	*E. devisi*	1×10^{-5}	2.85	0.95	150
Bacan[1]	September 1996	*E. devisi*	8.1×10^{-6}	3.29	0.95	412
Ambon[2]	September-January 1993	*E. devisi*	7×10^{-6}	2.97	0.95	700
Bima Bay	22 April 2000	*E. punctifer*	3×10^{-7}	3.74	0.94	150
	23 April 2000	*E. punctifer*	1×10^{-6}	3.40	0.89	150
Ambon[2]	September-January 1993	*S. buccaneri*	2×10^{-6}	3.25	0.94	300
Bima Bay	22 April 2000	*S. indicus*	8×10^{-7}	3.46	0.98	139
	16 February 2000	*S. commersoni*	3×10^{-5}	2.71	0.78	82
	25 April 2000	*S. commersoni*	3×10^{-6}	3.19	0.75	106

W = weight (g), L = length (mm); a, b = constants
Sources: [1]Andamari and Milton (1998); [2]Sumadhiharga (1995)

Table 2. The mean total length, weight, fecundity, and relative fecundity of five species of anchovies from Bima Bay, Nusa Tenggara, compared to those from Bacan (North Maluku), Jepara (Central Java), and Padang (West Sumatra).

Species/site	Period	Length (mm)	Weight (g)	Fecundity	Relative fecundity	n
Enchrasicholina devisi						
Bima Bay	16 February 2000	63.4 + 3.6	1.7 + 0.3	1226 + 675	382 +184	2
Bacan[1]	September 1996	68.2 + 0.9	3.5 + 0.1	6959 +663	1578 + 85	26
E. heterolobus						
Bima Bay	February 2000	73.6 + 2.8	2.6 + 0.5	1698 + 104	451 + 47	4
Bacan[1]	November 1996	77.0 + 0.7	5.1 + 0.1	5775 +221	1138 + 33	123
	April 1997	91.9 + 1.1	3.4 + 0.2	3441 + 307	1029 + 79	31
	July 1997	78.5 + 0.8	4.0 + 0.1	1809 + 147	472 + 39	49
Jepara[2]	June 1984-July 1985	69.3 + 5.9	2.4 + 0.1	422 + 32	180 + 10	22
E. punctifer						
Bima Bay	22 April 2000	57.7 + 2.3	1.1 + 0.2	2470 + 372	1632 +221	8
	23 April 2000	66.7 + 1.4	1.80 + 0.1	1986 +197	844 + 74	18
Padang[3]	April-July 1994	-	-	-	985 + 61	35
Stolephorus commersoni						
Bima Bay	16 February 2000	109.9 + 0.5	8.9 + 2.4	2055 + 152	231 + 17	14
	25 April 2000	95.2 + 1.3	5.9 + 0.3	1914 + 222	291 + 32	21
S. indicus						
Bima Bay	22 April 2000	1080 +16.0	9.7 + 4.7	1573 + 421	186 + 48	2

Sources: [1]Andamari and Milton (1998); [2]Wright (1992); [3]Maack and George (1999) to seasonal density of zooplankton (Milton *et al.,* 1998). There were at least 25 *bagan* catching anchovies in Bima Bay during February-April 2000. If zooplankton production was low at that time, the *bagan* may have reduced the populations, causing the fish to spawn at a smaller size.

The fecundity of the two species of *Stolephorus* (*S. commersoni* and *S. indicus*) in Bima Bay was similar to that of the smaller *Encrasicholina* species. However, since they were larger species, their relative fecundity was lower than that the other species. The largest species, *S. indicus*, had the lowest relative fecundity of all the species examined (Table 2). This suggest that *S. indicus* may be less productive than the other species in Bima Bay.

There are few data available on the reproductive biology of *Stolephorus* species. Our limited data from Bima Bay suggest that they take longer time to reach sexual maturity, have similar fecundity and reproductive life-span to the smaller species, but produce larger eggs than the smaller species. This may compensate for their lower relative fecundity as egg mortality inversely correlated with egg size (Bagarinao and Chua, 1986).

The mean age at first spawning and the reproductive life-span of *E. devisi* were longer in Bima than those in Bacan (Table 3). The spawning frequency was usually higher in Bacan. This led to a higher lifetime egg production for *E. heterolobus* compared to *E. devisi* and the pattern appears to be similar in Bima Bay.

The oceanic anchovy, *E. punctifer*, spawned earlier than the other species, but had a short reproductive life-span and long interval between spawnings in Bima Bay (Table 3). This resulted in the lowest estimated lifetime egg production of the five species studied. The larger *Stolephorus* species took longer time to reach sexual maturity, but had similar length reproductive life-span and overall lifetime egg production to the smaller *Encrasicholina* species (Table 3).

The reproductive biology of *E. devisi* and *E. heterolobus* in Bima Bay differed from that found previously in Bacan by Andamari and Milton (1998). Relative fecundity varied seasonally in Bacan, but was generally higher than that in Bima. This resulted in a higher estimated lifetime egg production. The results from Bima are more consistent with those found by Milton *et al.* (1995) in the Solomon Islands. The habitats at the study sites in the Solomon Islands were more similar to Bima Bay, having narrow entrances and limited exchange of water.

Table 3. The estimated age at first spawning, mean reproductive life-span, and mean lifetime egg production of five species of anchovies at Bima Bay during 2000 compared with those from Bacan, North Maluku.

Species/site	Date	First spawning (d)	Reproductive life-span (d)	Range (d)	Days between spawning	Lifetime egg production (eggs)
Encrasicholina devisi						
Bima Bay	16 February 2000	108.5	47.2	4-203	4.6	12,260
Bacan[1]	September 1996	88.8	25.8	3-69	34.0	4680
	July 1997	103.9	41.0	10-103	6.5	41,754
E. heterolobus						
Bima Bay	15 February 2000	90.1	19.8	4-101	4.0	8490
	16 February 2000	94.9	16.5	4-70	4.0	6792
	17 February 2000	67.4	34.8	4-109	4.0	15,282
Bacan[1]	September 1996	137.6	54.7	0-125	8.2	40,425
	November 1996	142.6	59.8	0-248	1.3	265,650
	April 1997	111.3	28.3	0-115	2.1	44,733
	July 1997	143.8	60.9	0-310	2.5	43,416
E. punctifer						
Bima Bay	22 April 2000	65.5	17.1	7-42	6.5	7410
	23 April 2000	75.7	22.2	9-46	8.7	5958
Stolephorus commersoni						
Bima Bay	16 February 2000	141.8	19.6	1-29	1.0	40,278
	25 April 2000	115.8	26.7	12-41	12.3	4110
S. indicus						
Bima Bay	22 April 2000	115.8	47.2	7-81	7.0	11,011

Source: [1]Andamari and Milton (1998)

Milton and Blaber (1993) and Rawlinson (1993) found that the oceanic anchovy (*E. punctifer*) spawned periodically in coastal bays and lagoons in Fiji. Our data from Bima suggest that their productivity may be lower in this habitat, compared with that in more open ocean environments. The estimated egg production in Bima was the lowest of the five species examined and the proportion of fish spawning was also the least for the species that were present at the same time. This suggests that enclosed bays may be less productive for *E. punctifer* or they are being outcompeted by other anchovies

The results of this study add to the increasing weight of data that show that tropical anchovies have extremely plastic reproductive biology that varies widely in response to local conditions. Andamari and Milton (1998) suggested that the higher, more variable egg production of *E. devisi* and *E. heterolobus* from Bacan had resulted from the proximity of productive, upwelling water that supported the high tuna catches in that area.

CONCLUSION

Encrasicholina populations in more protected habitats such as Bima Bay may be less productive than those from some oceanic regions, but egg production should be more stable. The results from Bima Bay were similar to those found previously in similar habitats elsewhere.

The stolephoried anchovies in Bima Bay produced fewer, larger eggs than the *Encrasicholina* species. However, the larger egg size may compensate for their fecundity and egg production by having lower mortality.

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REFERENCES

Andamari, R. and D.A. Milton. 1998. Reproductive biology of anchovies (*Encrasicholina heterolobus* and *Encrasicholina devisi*) from Bacan Island. Indon. Fish. Res. J. 4 (2): 40-45.

Andamari, R., M. Farmer, U. Khodriyah, and A.N. Susanto. 1998. Gonad maturity stages of anchovies (*Encrasicholina heterolobus*) from Bacan Island. Indon. Fish. Res. J. 4 (2): 46-50.

Bagarinao, T. and T. Chua. 1986. Egg size and larval size among teleots: Implications to survival potential. p. 651-656. *In* J.L. Maclean, L.B. Dizon, and L.V. Hosillos (Eds). The First Asian Fisheries Forum, Asian Fisheries Society, Philippines.

Hoedt, F.E. 2000. Growth in eight species of tropical anchovies determined from primary growth increments. Marine Freshwater Research 52 (in press)

Luna, L.G. 1968. Manual of Histological Staining Methods of the Armd Forces. Third ed. Institute of Pathology. McGraw-Hill, New York.

Maack, G. and M.R. George. 1999. Contribution to the reproductive biology of *Encrasicholina punctifer* (Engraulidae) from West Sumatra, Indonesia. Fish. Res. 44: 113-120.

Milton, D.A. and S.J.M. Blaber. 1993. Aspects of growth and reproduction relevant to managing tuna baitfish stocks in Fiji. *In* S.J.M. Blaber, D.A. Milton, and N.J.F. Rawlinson (Eds.). Tuna Baitfish in Fiji and Solomon Islands. ACIAR Proc. 52: 79-92.

Milton, D.A., S.J.M. Blaber, and N.J.F. Rawlinson. 1995. Fecundity and egg production of four species of short-lived clupeoid from Solomon Islands, tropical South Pacific. ICES J. Marine Sci. 52: 111-125.

Milton, D.A., R. Andamari, and N.J.F. Rawlinson. 1998. The biomass of tropical anchovies (*Encrasicholina* species) at Bacan, Eastern Indonesia, estimated by the daily egg production method. Indon. Fish. Res. J. 4 (2): 58-65.

Naamin, N. and B. Gafa. 1998. Tuna baitfish and the pole-and-line fishery in Eastern Indonesia, an overview. Indon. Fish. Res. J. 4 (2): 16-24.

Rawlinson, N.J.F. 1993. A review of previous baitfish studies and report in Fiji. *In* S.J.M. Blaber, D.A. Milton, and NJ.F. Rawlinson, (Eds.). Tuna Baitfish in Fiji and Solomon Islands. ACIAR Proc. 52: 8-25.

Rawlinson, N.J.F., B. Iskandar, D.A. Milton, and B. Gafa. 1998. Changes in fishing efficiency of the pole and line skipjack tuna fleet based at Sorong, Irian Jaya, Indonesia. Indon. Fish. Res. J. 4 (2): 25-40.

Sumadhiharga, O.K. 1995. Anchovy fisheries and ecology with special reference to the reproductive biology of *Stolephorus* spp. in Ambon Bay, Indonesia. PhD Thesis. University of Tokyo, Japan. 143 pp.

Wright, P.J. 1992. Ovarian development, spawning frequency and batch fecundity in *Encrasicholina heteroloba* (Ruppell, 1958). J. Fish. Biol. 40: 833-844.