REPRODUCTIVE BIOLOGY OF ANCHOVIES (*Encrasicholina heterolobus* AND *Encrasicholina devisi*) FROM BACAN, MALUKU

Retno Andamari*) and David Milton**)

ABSTRACT

The reproductive biology of the anchovies, *Encrasicholina heterolobus* and *E. devisi* at Bacan were compared with published data from other parts of their geographic range. Sampling was carried out in April, September and November 1996 and April and July 1997. The length-weight relationship for both species has a *b* value greater than 3 suggesting that the environment is favourable for these species. Both species are multiple spawners and the batch fecundity ranged between 1573 and 7090 for *E. heterolobus* and up to 6959 for *E. devisi*. This is much higher than recorded elsewhere for these species, but is partly due to larger fish size. Age at first spawning varied from 111 to 180 days for *E. heterolobus*, which is later than that estimated for fish from sites in the Solomon Islands. The age of *E. devisi* at first spawning varied between 81 and 106 days and was less than that found in the Solomon Islands. Both species live longer at Bacan than in the Solomon Islands and so the reproductive life span is also longer than found elsewhere. This means that the lifetime egg production of *E. heterolobus* and *E. devisi* at Bacan is higher than in the Solomon Islands. It suggests that populations of *E. heterolobus* and *E. devisi* in Bacan should be able to sustain higher long-term exploitation and be able to recover more rapidly from short periods of overexploitation.

KEYWORDS: **tropical anchovies, length-weight, fecundity, age at first spawning, sustainability**

INTRODUCTION

The anchovies, *Encrasicholina* and *Stolephorus* species, play an important role as live-bait fish for the skipjack tuna *Katsuwonus pelamis* fisheries in Maluku. In Bacan and elsewhere in Maluku Province, these anchovies are caught using "bagan" (light-fishing), "redi" (beach seine) and "bouke-ami" (the stick-held dipnet) at night. An understanding of the reproduction of these anchovies is important for determining the sustainability of the baitfish supply to the fishery. Previous research has been conducted elsewhere on the reproductive biology of the stolephorid anchovies (Sumadhiharga, 1995; Milton *et al.* 1990; Milton *et al.* 1995).

The present study was carried out in Bacan, north Maluku and the objectives were: (1) to determine length-weight relationships, batch fecundity, age at first spawning, and egg production of *Encrasicholina heterolobus* and *Encrasicholina devisi* at Bacan; and (2) to compare the results with other studies from the tropical Pacific in order to assess the relative sustainability of the Bacan anchovy populations.

MATERIALS AND METHODS

Sampling

Random sub-samples of *E. heterolobus* and *E. devisi* were collected from bagans in the main baitgrounds at Bacan in September and November 1996 and April and July 1997. During each sampling trip, 200 fish were collected from at least two bagans each night for at least three consecutive nights. All samples were preserved in 10% formalin and taken back to the laboratory in Ambon for analysis.

Laboratory Analyses

Fish were measured (standard length mm), weighed (± 0.001 g) and then dissected. Gonads were removed and sex and gonad weights were recorded for all of the samples. Gonads were ex-

* Ambon Assessment Institute for Agricultural Technology, Agency for Agriculture Research and Development, Ministry of Agriculture, Indonesia.
** CSIRO Marine Research, PO Box 120, Cleveland, Qld. 4163, Australia

amined histologically to identify their stage of development (Andamari *et al.*, this issue). Fish that had ripe eggs (> Stage 4 of Milton and Blaber, 1991) were used to estimate fecundity.

Batch fecundity was estimated by weighing a sub-sample of gonad and counting the number of eggs (Bagenal, 1978) and batch fecundity was estimated from the equation:

$$F = (Wg / Ws).n$$

where F = batch fecundity

Wg = gonad weight (g)

Ws = weight gonad of sub sample (g)

n = number of eggs in sub sample

Fish were given an estimated age based on the growth equation of Wright (1989) for *E. heterolobus* in Java and by counting daily growth rings of *E. devisi*. The age at first spawning was estimated from the age of fish with mature gonads. Age at sexual maturity was defined as the age at which fish first developed ripe eggs (Stage 4). This occurred at 83 days for *E. heterolobus* and 63 days for *E. devisi*. The reproductive life span for each species on each day was estimated by subtracting the age at maturity from the estimated age of the largest fish. Lifetime egg production was estimated by the method of Milton *et al.* (1995) and was the product of length-specific fecundity and days between spawning.

RESULTS AND DISCUSSION

A summary of the length and weight of the samples collected is given in Table 1. The length-weight relationships are shown in Table 2. The value of b in Bacan of each species was compared with other sites. In Bacan, it was always greater than 3, which means that the fish grow allometrically.

The batch and relative fecundity of *E. heterolobus* and *E. devisi* differed between trips. The batch fecundities of *E. heterolobus* and *E. devisi* in Bacan are higher than at other sites except for Ambon Bay (Table 3). The fecundity of *E. heterolobus* was much lower in July 1997 compared with other sampling periods. The single estimate of fecundity of *E. devisi* in September 1996 was higher than at other sites in the Solomon Islands or Papua New Guinea.

The age at first spawning and reproductive life span of *E. heterolobus* and *E. devisi* varied between sampling periods (Table 4). In Bacan, female *E. heterolobus* were older at first spawning than *E. devisi*, and older than those estimated in the Solomon Islands. In contrast, *E. devisi* spawned first at a younger age than in the Solomon Islands. The mean reproductive life span of *E. heterolobus* varied from 27 to 97 days, and from 18 days to 43 days for *E. devisi*. In the Solomon Islands, the mean reproductive life span of *E. devisi* was longer than in Bacan.

These results have implications for the sustainability of anchovies in Bacan. Mean total lifetime egg production of *E. heterolobus* was 3 to 20 times that estimated for Solomon Islands fish. The total egg production of *E. devisi* also appears to be higher, but the difference is not as great. The higher fecundity of female anchovies in Bacan indicates that these species are more likely to be resilient to higher levels of exploitation at Bacan than in the Solomon Islands. The larger mean

Table 1. The mean and range in length (mm) and weight (g) of anchovies collected from Bacan between September 1996 and July 1997.

Date	Species	Length (mm)			Weight (g)			n
		min	max	mean ± SE	min	max	ean ± S	
Sep. 96	*E. heterolobus*	54	88	73.6 ± 0.5	1.17	6.63	3.7 ± 0.08	230
	E. devisi	38	76	59.5 ± 0.03	0.56	4.98	2.2 ± 0.04	412
Nov. 96	*E. heterolobus*	30	93	73.7 ± 0.5	0.19	8.83	4.4 ± 0.08	434
Apr. 97	*E. heterolobus*	49	86	69.3 ± 0.2	0.78	5.91	3.1 ± 0.02	1,391
Jul. 97	*E. heterolobus*	46	94	75.9 ± 0.2	0.75	6.85	3.7 ± 0.03	1,107
	E. devisi	55	82	67.8 ± 0.2	1.26	5.0	2.7 ± 0.03	496

Table 2. Length-weight relationship of anchovies from Bacan and other areas in the Indo-Pacific region. Equation is of the form $W = aL^b$.

Sites	Date	Species	A	b	r^2	n
Bacan	Sep-96	*E. heterolobus*	5.4×10^{-6}	3.38	0.95	230
		E. devisi	8.1×10^{-6}	3.29	0.95	412
	November 1996	*E. heterolobus*	5.4×10^{-6}	3.36	0.97	434
	Apr-97	*E. heterolobus*	1.6×10^{-5}	3.09	0.85	1391
	July 1997	*E. heterolobus*	1.6×10^{-5}	3.08	0.9	1107
		E. devisi	1.3×10^{-5}	3.11	0.85	496
Munda[1]	1987-1989	*E. heterolobus*	1.9×10^{-5}	2.82	0.79	3419
Vona Vona[1]	1987-1989	*E. heterolobus*	8.4×10^{-5}	2.46	0.74	2465
Tulagi[1]	1987-1989	*E. heterolobus*	6.4×10^{-5}	2.50	0.69	2400
Munda[1]	1987-1989	*E. devisi*	3.2×10^{-5}	2.71	0.70	2870
Vona Vona[1]	1987-1989	*E. devisi*	2.2×10^{-5}	2.22	0.54	3643
Tulagi[1]	1987-1989	*E. devisi*	2.5×10^{-5}	2.78	0.73	2922
Ambon bay[2]	1992	*E. heterolobus*	7.9×10^{-5}	2.97	0.96	700
	1992	*E. devisi*	8.3×10^{-6}	3.44	0.94	500
Maldives[3]	1987-1989	*E. heterolobus*	2.1×10^{-6}	3.36	0.92	1289
Ysabel, PNG[4]	1982	*E. heterolobus*	2.4×10^{-6}	3.35	0.98	737
Singapore[5]	-	*E. heterolobus*	3.7×10^{-6}	3.59	-	-
Palau[6]	1976	*E. heterolobus*	7.6×10^{-6}	3.09	-	-
New Caledonia[7]	1986	*E. heterolobus*	1.2×10^{-6}	3.38	0.99	140

[1] Milton *et al.* (1995), [2] Sumadhiharga (1995), [3] Milton *et al.* (1990), [4] Dalzell (1985), [5] Tham (1966), [6] Muller (1976), [7] Conand (1988)

size at Bacan also indicates that the populations are probably not heavily exploited at present. Allometric growth in weight with length suggests that Bacan is a favourable environment for anchovies with plenty of food available. The combination of these population characteristics suggests that anchovy populations in Bacan should be able to sustain higher long-term levels of exploitation than anchovies in the Solomon Islands and be more resilient to short-term over-exploitation or poor recruitment.

Acknowledgements

We thank Mr. M. Syarif for helping collect the fish samples and Andriko Noto Susanto for laboratory analysis and entering the data. This work was part of the ACIAR-funded Baitfish Research Project and involved collaboration between Research Institute for Marine Fisheries, Agency of Agricultural Research and Development, Ministry of Agriculture, Indonesia and CSIRO Marine Research, Cleveland, Australia.

REFERENCES

Bagenal, T.B. 1978. *Methods for Assessment of Fish Production in Fresh Water*. IBP. Handbook (3) Blackwell Scientific Publications, Oxford. 253 pp.

Conand, F. 1988. *Biology and Ecology of Small Pelagic Fish from the Lagoon of New Caledonia Usable as Bait for Tuna Fishing*. PhD Thesis, ORSTOM Paris.

Dalzell, P. 1985. Some aspects of the reproductive biology of *Spratelloides gracilis* in the Ysabel Passage, Papua New Guinea. *J. Fish Biol.* 27: 229-237.

Dalzell, P. 1987. Some aspects of the reproductive biology of stolephorid anchovies from northern New Guinea. *Asian Fish. Sci.* 1: 91-106.

Milton, D.A. 1992. *Ecology of Five Species of Clupeoid Used as Tuna Baitfish in the Solomon Islands*. Ph D Thesis. University of Queensland, Brisbane. 145 pp.

Table 3. Mean length and weight and batch fecundity of *E. heterolobus* and *E. devisi* from Bacan, northern Maluku and other areas in the Indo-Pacific region (SE = standard error; n = sample size; SI = Solomon Islands; PNG = Papua New Guinea; AUS = Australia)

Species	Sites	Date	Length (mm) ± SE	Weight (g) ± SE	Fecundity ± SE	Relative Fecundity ± SE	n
E. devisi	Bacan	14-Sep-96	68.2 ± 0.9	3.47 ± 0.13	6959 ± 663	1578 ± 85	26
E. heterolobus	Bacan	3 Nov 1996	83.1 ± 0.6	6.44 ± 0.15	7098 ± 287	1160 ± 35	51
		7 Nov 1996	73.3 ± 0.8	4.23 ± 0.15	4668 ± 234	1123 ± 50	74
		11-Apr-97	91.9 ± 1.1	3.36 ± 0.19	3441 ± 307	1029 ± 79	31
		12 July 1997	79.2 ± 1.4	4.00 ± 0.25	1599 ± 218	498 ± 72	10
		13 July 1997	74.4 ± 1.6	3.01 ± 0.21	2280 ± 491	756 ± 84	8
		14 July 1997	81.7 ± 1.3	4.72 ± 0.27	1903 ± 261	409 ± 56	17
		15 July 1997	76.6 ± 1.5	3.58 ± 0.21	1573 ± 249	439 ± 67	14
E. devisi	Munda (SI)	1987-1989	50.2 ± 0.8	-	1583 ± 156	1071 ± 93	39[a]
	Vona Vona (SI)	1987-1989	53.2 ± 0.5	-	1239 ± 83	700 ± 52	52[a]
	Tulagi (SI)	1987-1989	55.1 ± 1.0	-	1423 ± 197	710 ± 60	24[a]
	Ysabel P (PNG)	1984	49.2 ± 1.6	-	1337 ± 152	1039 ± 43	17[b]
	Ambon Bay	1993	74.5 - 103.0	-	2457 - 10968	-	50[c]
E. heterolobus	Munda (SI)	1987-1989	57.2 ± 1.2	-	1262 ± 105	652 ± 36	39
	Vona Vona (SI)	1987-1989	55.9 ± 0.9	-	1850 ± 156	901 ± 54	34
	Tulagi (SI)	1987-1989	58.7 ± 0.9	-	1595 ± 130	695 ± 37	48
	Ambon Bay	1993	74.5 - 103.0	-	2457 - 10968	-	30[c]
	Thinadhoo (Mald	1988	69.8 ± 2.9	-	2243 ± 285	653 ± 63	5[d]
	Ysabel P. (PNG)	1984	54.2 ± 2.1	-	1144 ± 144	592 ± 32	17[b]
	Lizard I (AUS)	1990	58.3 ± 1.2	-	1925 ± 220	912 ± 68	13[a]

[a] Milton *et al* (1995); [b] Dalzell (1987); [c] Sumadhiharga (1995); [d] Milton (1992)

Table 4. Mean age at first spawning and the mean and range in the reproductive life-span, number of days between spawnings and the lifetime egg production of *E. heterolobus* and *E. devisi* from Bacan compared with Solomon Islands (SE = standard error; SI = Solomon Islands).

Species	Site	Date	First spawning (days)	Reproductive life-span (days)		Days between spawnings	Lifetime egg production
			Mean ± S.E.	Mean ± S.E.	Range		Mean ± S.E.
E. heterolobus	Bacan	18-Sep-96	142.8 ± 1.9	59.8 ± 6.2	15 - 126	14	31,198 ± 4,328
		19-Sep-96	141.5 ± 4.8	58.7 ± 4.9	12 - 115	10.5	30,363 ± 3,314
		20-Sep-96	128.1 ± 4.9	45.1 ± 4.9	3 - 90	0	2,069 ± 0.8
		3 Nov 96	180.3 ± 5.0	97.3 ± 5.0	12 - 248	1	550,450 ± 3,028
		7 Nov 96	126.6 ± 3.3	43.6 ± 3.3	3 - 167	1.6	202,682 ± 37,546
		11-Apr-97	111.1 ± 1.3	28.1 ± 1.2	3 - 167	3.2	62,886 ± 20,163
		13-Apr-97	110.1 ± 1.4	27.1 ± 1.4	3 - 70	2.2	60,967 ± 3,929
		14-Apr-97	117.5 ± 1.7	34.5 ± 1.7	9 - 115	1.4	84,287 ± 4,230
		15-Apr-97	115.7 ± 1.3	32.7 ± 1.3	3 - 83	1.7	78,547 ± 5,796
		12 July 97	141.9 ± 2.9	58.9 ± 2.9	9 - 115	1.4	84,287 ± 4,230
		13 July 97	119.4 ± 2.8	36.4 ± 2.8	3 - 137	4.1	66,153 ± 7,397.7
		14 July 97	159.8 ± 2.8	76.8 ± 2.8	6 - 212	1.9	181,516 ± 8,986
		15 July 97	138.1 ± 1.8	55.1 ± 3.3	6 - 310	2.4	11,680 ± 10,558
E. devisi	Bacan	14-Sep-96	94.4 ± 1.9	31.4 ± 1.9	3 - 69	8.6	6,472 ± 634
		17-Sep-96	81.6 ± 1.1	18.6 ± 1.1	3 - 38	59.9	2,380 ± 246
		12 July 97	106.0 ± 2.4	43.0 ± 2.4	20 - 103	9.3	53,964 ± 6,014
		12 July 97	103.4 ± 1.2	40.4 ± 1.2	10 - 84	8.2	49,779 ± 2,575
		15 July 97	103.7 ± 1.8	40.7 ± 1.8	17 - 64	2	48,544 ± 3,659
E. devisi [a]	Munda (SI)	1987-1989	168.7 ± 3.0	36.0 ± 10.1	0 - 88	5.0	11,179 ± 4,077
	Vona Vona (SI)	1987-1989	131.1 ± 1.2	51.0 ± 5.2	10 - 90	3.3	8,531 ± 6,698
	Tulagi (SI)	1987-1989	128.6 ± 2.8	65.2 ± 7.2	0 - 126	3.1	8,464 ± 2,363
E. heterolobus [a]	Munda (SI)	1987-1989	87.1 ± 4.7	84.4 ± 6.9	16 - 138	7.7	3,358 ± 2,318
	Vona Vona (SI)	1987-1989	110.0 ± 3.6	33.8 ± 7.2	0 - 84	6.7	7,358 ± 2,708
	Tulagi (SI)	1987-1989	100.6 ± 3.4	35.8 ± 4.8	0 - 88	3.4	13,101 ± 6,753

[a] Milton *et al.* (1995)

Milton, D.A., Blaber, S.J.M., Tiroba, G., Leqata, J.L., Rawlinson, N.J.F. and Hafiz, A. 1990. Reproductive biology of *Spratelloides delicatulus, S. gracilis* and *Stolephorus heterolobus* from Solomon Islands and Maldives. *In* Blaber, S.J.M. and Copland, J.W. (eds.). *Tuna Baitfish in the Indo-Pacific Region. ACIAR Proceedings* 30: 89-99.

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

Muller, R.S. 1976. *Population Biology of **Stolephorus heterolobus** (Pisces: Engraulidae) in Palau, Western Carolines*. PhD Thesis, University of Hawaii. 174 pp.

Royce, W.F. 1984. *Introduction to the Practice of Fishery Science*. Academic Press, California, USA. 423 pp.

Sumadhiharga, O.K. 1995. *Anchovy Fisheries and Ecology with Special Reference to the Reproductive Biology of **Stolephorus spp**. in Ambon Bay, Indonesia*. Ph D Thesis. University of Tokyo, Japan. 143 pp.

Tham, A.K. 1966. A contribution to a study of the growth of members of the genus *Stolephorus* in Singapore Strait. *Proceeding of the Indo-Pacific Fish. Council* 12: 1-25.

Wright, P.J. 1989. *The Growth and Reproductive Biology of **Stolephorus heterolobus** (Engraulididae)*. M. Phil Thesis. University of Newcastle upon Tyne.112 pp.