

DEVELOPMENT STAGE, AGEING AND NATURAL MORTALITY OF ANCHOVY EGGS (*Encrasicholina* SPECIES) FROM BACAN

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ABSTRACT

In order to study the possible application of the Daily Egg Production Method (DEPM) for estimating anchovy (*Encrasicholina* spp.) biomass at Bacan, Maluku, we collected a large series of plankton samples. All the anchovy eggs from these samples were staged and then aged according to the criteria of Moser and Ahlstrom (1985). We recognised 9 stages of embryonic development from 1 h to 15 h. From these data we estimated that anchovy eggs at Bacan hatch between 15 and 24 h after spawning. Natural mortality (M) of these eggs was estimated on three occasions and averaged $0.15 \pm 0.04 \text{ h}^{-1}$. This means that only about 10% of eggs spawned by anchovies at Bacan survive to hatch.

KEYWORDS: anchovies, egg development, age and natural mortality.

INTRODUCTION

The anchovies (*Encrasicholina* species: Family Engraulididae) are the most important of the small pelagic fishes used for live-bait in Maluku. These fish are caught at night by "bagans" to sell to the pole-and-line tuna fishing vessels. Three species of anchovy used as baitfish occur in Bacan waters: *E. heterolobus*, *E. devisi* and *E. punctifer* (in small numbers). Some aspects of the reproductive biology of *Encrasicholina* have been studied in other geographic areas (Tiews *et al.*, 1970; Sumadhiharga, 1995; Milton *et al.*, 1994; Wright, 1992), but there have been no studies in this area of Maluku Province. The present paper is part of a study whose aim was to assess the feasibility of estimating the biomass of anchovies using the Daily Egg Production Method (DEPM). Estimates of biomass are an important first step towards a sustainable management plan for the baitfish resources. In order to estimate such biomass, we first needed information on the time from spawning to hatching, the embryonic stage at which eggs hatch, and then finally egg mortality rates. These values are used in the equation to estimate the biomass of fish and accurate data are important if the biomass is not to be underestimated.

One of the most important parameters needed for the DEPM is an accurate estimate of the number of eggs in the plankton. The high mortality

that occurs in these early life stages is one of the main factors affecting estimates of biomass. The objectives of this part of the study were therefore to document the stages of embryonic development of anchovy eggs, and to estimate the age of each stage in order ultimately to determine natural mortality rates.

Very little information was available on the embryonic development of tropical anchovies, but Moser & Ahlstrom (1985) identified eleven stages of development in the Northern anchovy *Engraulis mordax*, and showed that the rate of development was temperature-dependent. Lo (1985) used these data to fit a temperature-dependent model of the rate of egg development and to estimate the age of eggs at each development stage.

MATERIALS AND METHODS

Sampling

Random plankton tows were collected in September, November 1996 and April, July 1997 from the main spawning grounds within the baitground in Bacan waters. Plankton samples were taken using two plankton nets (0.5 m² and 0.25 m²) of 500- μ mesh. Tows were taken vertically at various depths (5, 10 and 20 m) with the majority at 10 m. These plankton samples were preserved in 10% formalin and taken to the laboratory for analysis.

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Laboratory Analysis

Eggs of anchovies were identified (using the descriptions in Delsman, 1931), sorted and removed from all plankton tows. For staging, each sample was placed in a Bogorov tray and examined under a low power microscope. Anchovy eggs from each sample were counted and staged according to their degree of embryonic development. We recognised 9 developmental stages based on morphological changes that occur during embryogenesis (modified from Moser & Ahlstrom, 1985). Eggs were aged by relating the time of sampling to the distribution of the modes of each development stage. The mean time between samples collected with the largest number of early (Stage 1) and late stage eggs (Stage 9) was used to estimate total hatching time. These results compared favourably with the total development time estimated with the temperature-dependent model of Lo (1985). As a further confirmation that the estimated development time was realistic, we used the equation of Longhurst & Pauly (1987) to relate water tem-

perature and egg diameter to estimate total hatching time. All three approaches agreed that the total time for eggs to hatch was approximately 16 h. Having established that eggs took 16 h to hatch, we then interpolated using the model of Lo (1985) to estimate the age at each of the 9 development stages.

Natural mortality of eggs was assumed to be relatively constant, enabling us to estimate mortality from the exponential decay model (Sparre & Venema, 1992). We sampled continuously for 36 h on seven occasions during the study. This enabled us to identify the peak period of hatching and to try and follow a cohort of eggs through to hatching and thus estimate their mortality. Tows were made from a fixed position during the night (usually from an anchored bagan) and then randomly in the spawning area during the daytime. A linear regression was fitted to the logarithm of the number of eggs in each stage against time (in hrs). The slope of this regression is an estimate of the egg mortality during that period.

Table 1. A description of the embryological development stages of anchovy eggs and the estimated time since spawning.

Development Stage	Estimated age since spawning	Description
Stage 1	1 hour	egg is transparent and cell division has not begun
Stage 2	2 hours	egg has two cells or blastomeres
Stage 3	4 hours	egg has a segmentation
Stage 4	6 hours	egg has two third division with the embryo starting to develop
Stage 5	7.5 hours	head can be identified but the structure is not clearly defined
Stage 6	9 hours	head is clearly defined and vertebrae can be seen in the middle of the egg
Stage 7	11 hours	head, vertebrae and tail make up more than half of the egg
Stage 8	12.5 hours	the tail begins to separate from the yolk
Stage 9	15 hours	the tail is clearly seen and the yolk has begun to be resorbed

RESULTS AND DISCUSSION

Most plankton samples contained eggs in several stages of development. This means that anchovies do not spawn their eggs at the same time. The stages of embryonic development were similar to those identified for *Engraulis mordax* (Moser & Ahlstrom, 1985). The stages and the estimated age are described in Table 1 and shown in Figures 1 to 3. The data suggest that anchovy eggs hatch after at least 16 h. This result is also confirmed when the relationship between mean egg diameter and water temperature is calculated (Longhurst & Pauly, 1987). The estimated mean time to hatching using this equation was also 16 h.

The 36-h plankton sampling did not show any clear pattern of reducing egg abundance with time on four of the seven days. However, the plankton data on the other three days (13 April, 14 and 16 July 1997) could be used to estimate mortality for some of the older age classes. The mean estimated mortality (M) was $0.15 \pm 0.04.h^{-1}$ for those three days (Figure 4). The mortality estimates for each day varied from 0.14 ± 0.03 to $0.17 \pm 0.05.h^{-1}$. This equated to a mean mortality of approximately 90% over the 16 h from spawning to hatching. These values are much higher than those estimated for more temperate species. Koslow & Bulman (1997) estimated egg mortality to be about $5%.d^{-1}$ for Blue

Grenadier *Macruronus novaezelandiae* off southern Tasmania and Fletcher *et al.* (1996) found values between 0.43 to $0.81.d^{-1}$ for the sardine *Sardinops sagax* in Western Australia.

Anchovies have adapted to the high, and probably variable, mortality rates of eggs and larvae by spawning frequent, small batches of eggs (Andamari & Milton, this issue). Both *E. heterolobus* and *E. devisi* have higher lifetime egg production in Bacan than in the Pacific (Solomon Islands) which may be an adaptation to high egg mortality. We tried to separate the anchovy eggs in the plankton into different species according to Delsman (1931) and almost all were of the *E. heterolobus* form. Given that *E. heterolobus* is also the dominant species in adult catches and their higher egg production (Andamari & Milton, this issue), our mortality estimates are probably specific to this species.

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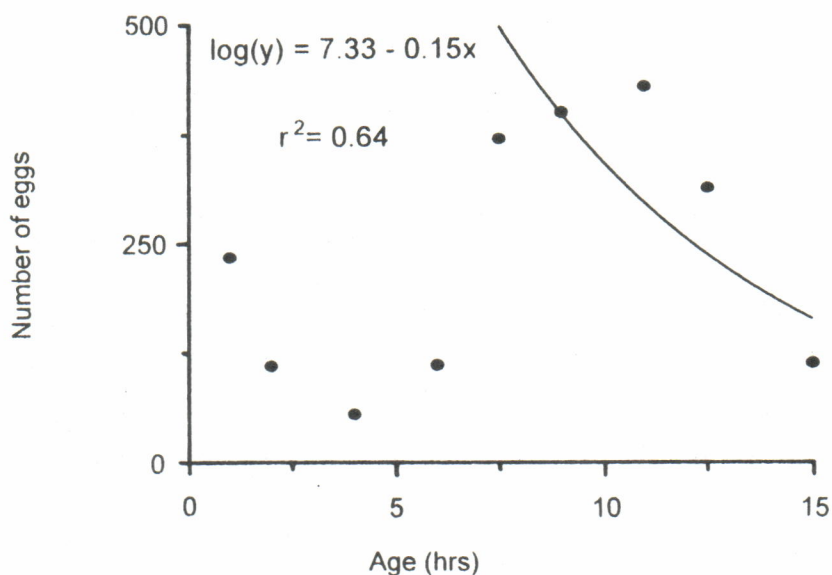


Figure 1. The first four stages of anchovy embryo development and their approximate ages.

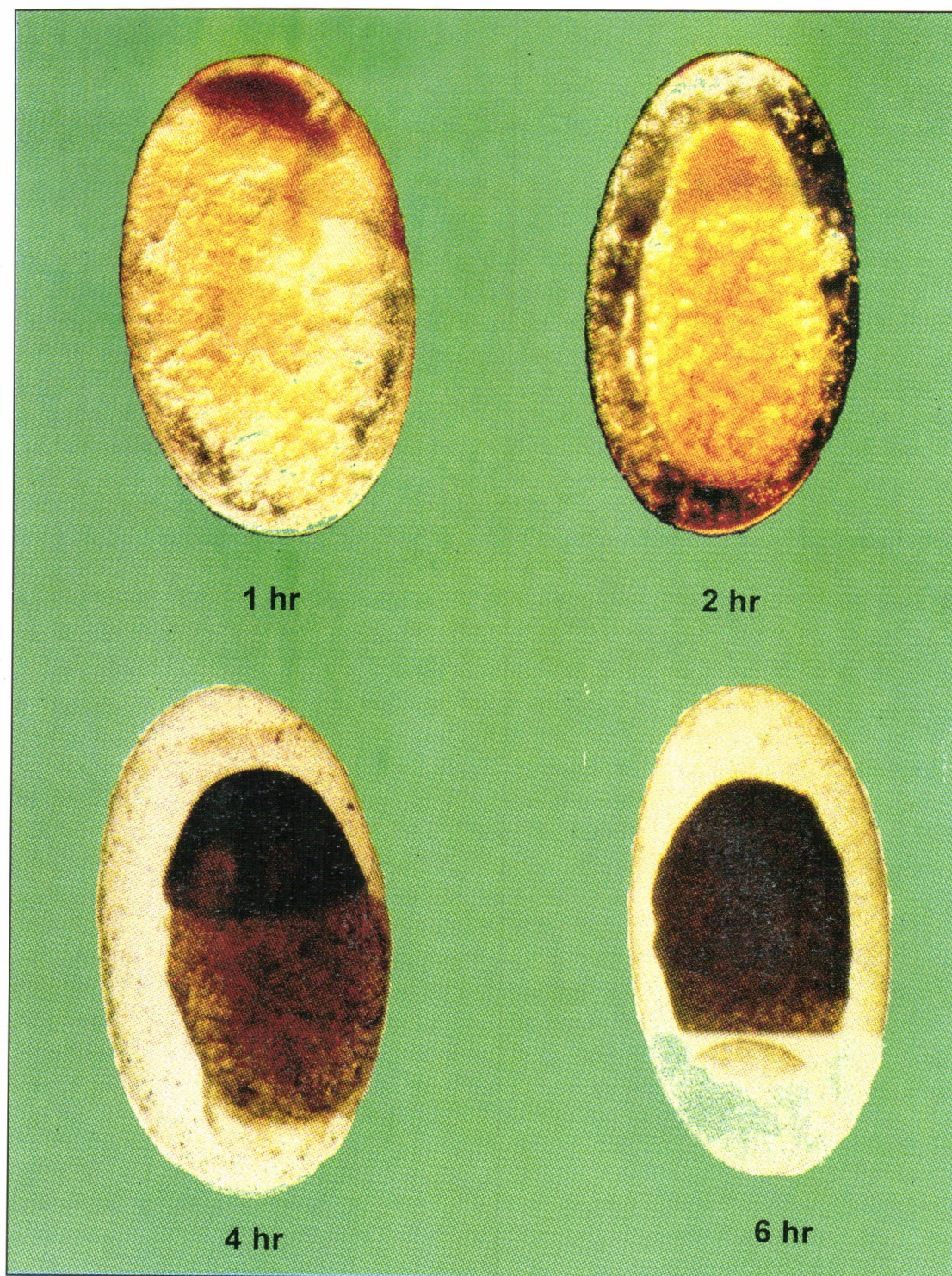


Figure 2. The first four stages of anchovy embryo development and their approximate ages.

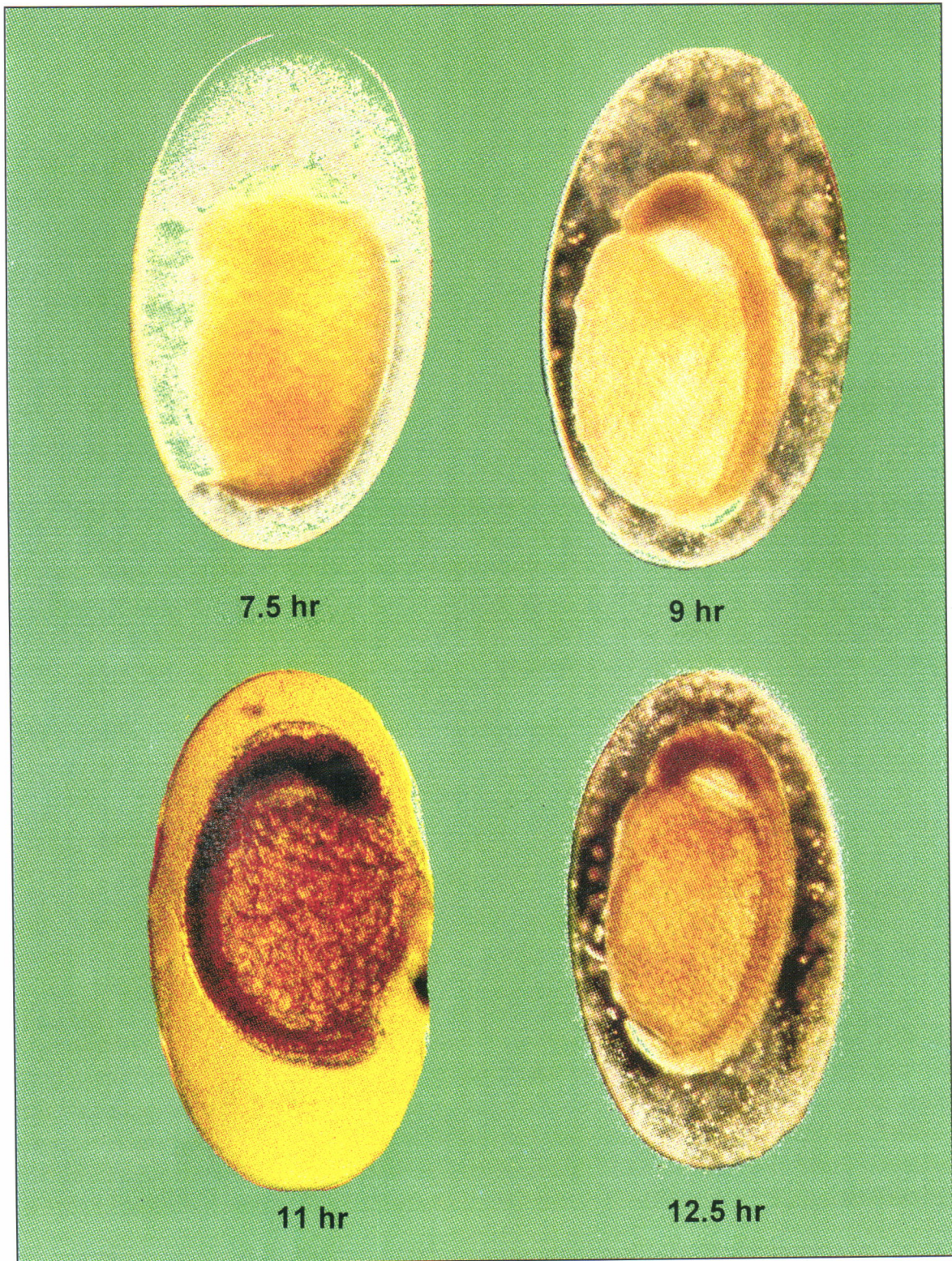


Figure 3. The mid-stages of anchovy embryo development showing the early larvae.



Figure 4. Late stage anchovy larval development just prior to hatching.

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