# CHAPTER V

# DISCUSSION

The population of shorthead anchovy *Encrasicholina heteroloba* in this study is considered spawning stocks as their overall average size of 7.34±0.77 cm in total length are beyond the first size at maturity (4.2-6.0 cm) of this anchovy in the Indo-Pacific region (Tham, 1967; Tiew et al., 1970; Pismorn Dhebtaranon, 1973; Dalzell, 1987).

The predominance of male to female in almost all sampling periods may due to selectivity of fishing gear or the segregation of female school. Somerton, Kobayashi, and Landgrad (1993) on their study on stock assessment of the related species *Encrasicholina purpurea* showed that pre-spawning and non-spawning females segregated spatially for evening spawning and became differentially available to the sampling gear. This result is also corresponding to the study of Rao (1988) on the biology of another closely related species *Stolephorus devisi* that there was a significant dominance of male during the spawning season. The observations of Aoki and Tsuruta (1989) on the reproductive behaviour of Japanese anchovy *Engraulis japonicus* in captivity revealed its mating character. The Japanese anchovy dispersed after sunset lacking one-to-one pairing of male and female, and several males took part in fertilization with eggs released by one female. Alheit (1985) hypothesized that high male to female ratio in night collections was the result of the segregation of spawning female, either by depth or by area, from normal school. Hunter and Goldberg (1980) also mentioned that most spawning of northern anchovy *Engraulis mordax* occurred in male dominated schools.

Detailed study on year-round development as well as size and stage frequency-distribution of oocytes in the ovarian sections of *E. heteroloba* reveals the spawning feature of this anchovy. Although hydrated oocytes were not found, all other stages: immature, developing, and mature oocytes were present in nearly all ovaries examined showing asynchronous reproductive development in the population. Asynchronous pattern of year-round oocyte size-frequency distribution confirms that the samples are in spawning condition. Hunter and Goldberg (1980) showed that in recently spawned females, modal groups of eggs were less distinct and often one mode was existed when the eggs may had been destined to form two separating batches. The recently spawned characteristic is confirmed by the occurrence of postovulatory follicles resulted from the spawning before capture. For the species living in low temperature, postovulatory follicles remain detectable within 48 hours in northern anchovy *Engraulis mordax* (Hunter and Goldberg, 1980; Hunter and Macewicz, 1985), within 24 hours in Japanese anchovy *Engraulis japonicus* (Tsuruta and Hirose, 1989) and within 21 hours in bay anchovy *Anchoa mitchilli* (Luo and Musick, 1991). However, in tropical Hawaiian anchovy *Encrasicholina purpurea*, the deterioration occurrs in less than 24 hours (Clarke, 1987). The postovulatory follicles of *E. heteroloba* in this study were clearly detected and were similar to the early stages of collapse and degeneration described by the studies mentioned. The presence of mature oocytes together with postovulatory follicles suggests that all stages of oocytes develop rapidly following spawning to replace the released oocytes. The stage frequency-distribution of developing and mature oocytes in the ovary which were not separated from one another also indicates that passing of one batch of oocytes into the next stages is a continuous proccess. In addition to postovulatory follicles, atretic oocytes were normally observed in all mature ovaries implying the imminent cessation of spawning (Hunter and Macewicz, 1985; Ebisawa, 1990).

The absence of hydrated oocytes and presence of postovulatory follicles commence the rapid oocyte development in this fish. It should be noted that *E. heteroloba* has a fast hydrating stage and the hydration should complete in the evening or early at night before being captured. This is consistent with the study of Somerton et al. (1993) on Hawaiian anchovy *E. purpurea*, an evening spawning species, that oocytes hydrate during late afternoon and all pre-spawning females have fully hydrating oocytes at about 2 hour before sunset. Clarke (1987) also studied on this Hawaiian anchovy and drew the assumption that this species began to have its hydrating ova only a few hours before spawning and spawned during a short period, 1 or 2 hours after sunset. Luo and Musick (1991) also showed that the hydrated oocyte stage of bay anchovy *Anchoa mitchilli* lasted less than 4 hours and the most advanced mode of oocytes completely separated from the last one at 1700 h when hydration was observed, showing the early-night spawning behavior in this species. For African anchovy *Engraulis capensis,* eggs are spawned in late evening to early night (Melo, 1994b). The spawning time of Japanese anchovy *Engraulis japonicus* which begin to spawn 2 or 3 hours after sunset (Aoki and Tsuruta, 1989) illustrates the early-night spawning behavior in this temperate anchovy. The spawning time of those anchovies mentioned and the statement of Hunter and Macewicz (1985) that fish in tropical zone should have more rapid time for complete hydration than those in temperate zone due to the high temperature also supports the assumption of the evening spawning characteristic of the shorthead anchovy in this study.

Varied batch fecundity of *E. heteroloba* calculated in this study indicated that counts of yolked oocytes instead of hydrated ones can result in error. The oocytes used for counting in this study were the opaque ones rather than transparent hydrated oocytes used in the study of Hunter and Macewicz (1985), may cause incorrect estimation as they were not the true representative of spawning batch. Hunter and Goldberg (1980) stated that fecundity estimates for the less mature females tended to be overestimated because the eggs destined to form a second mode had not grown sufficiently to be separated from the rest of the yolked oocytes. Batch fecundity in this study can also be underestimated as small unyolked oocytes which was going to be mature were not included in the counts. From the assumption that this anchovy had already spawned prior to sampling, time for batch fecundity estimation might not be a suitable one. Underestimated fecundity is shown to be the result of short period of recognizable hydrating oocytes causing few hydrated samples could be collected (Somerton et al., 1993). The degree of error from any particular sample may also vary depending on time before spawning in individual females. Intensive sampling over 24 hours is needed to examine chronological sequence of the hydration of oocytes before appropriate sampling time can be obtained. Females used for estimation should also show no sign of recent spawning (with postovulatory follicles) to avoid unbiased sampling. In conclusion, the potential errors resulted from the use of mature or partially spent, not ripe, females may affect estimates of mean batch fecundity and the relationship between batch fecundity and female size.

Histological indication of recent spawning can be used to clarify the reason of variability in gonadosomatic index. GSI exhibits considerable fluctuation because some individuals have already spawned an undetermined proportion of their eggs when they were captured resulting in changes of ovary mass. Males show higher GSI than females owing to their massive spermatozoa in testes. Aoki and Tsuruta (1989) found that a male Japanese anchovy *Engraulis japonicus* always remained in ripe condition while a female ovulated at intervals of a few days. It is also supported by histological observation on the testes of African anchovy *Engraulis capensis* that there are unrestricted spermatogonial and spermatogenesis occur in the entire testis most of the year (Melo, 1994a). This is said to be a strategy in serial spawning fish with protacted spawning seasons, allowing for a constant supply of spermatozoa while investing minimal energy in spermatogenesis (Prabhu, 1956 cited by Melo, 1994a).

Comparing ovarian macroscopic and microscopic examination of *E. heteroloba* leads to the assumption that the macroscopic examination alone has its limitations. It is obvious that recent spawning females with postovulatory follicles can not be detected by visual observation causing misidentification of the actual ovarian development in the population. Considering the percent of mature gonad determined by eyes, there were no mature females in some months whereas histological features showed mature oocytes along with postovulatory follicle indicating spawning condition throughout the year. The decrease of percent maturity during April to September should be due to the low spawning frequency in this period which is correspondent to the comparatively high number of atretic oocyte in that period. The incidence of ovarian atresia was inversely correlated with the frequency of spawning and this indicated that the decrease in frequency during the season might be caused by a cessation of spawning (Hunter and Macewicz, 1980). Although spawning frequency was not determined, it can be assumed from histological evidences that this fish has a high recruitment of oocytes into advanced stages and the spawning frequency is once every less than 2 weeks in its peak spawning period. Hunter and Goldberg (1980) proposed the interval of 6.25 days in northern anchovy *Engraulis mordax*. Alheit (1985) found Peruvian anchovy spawn every 6.23 days. Hunter and Macewicz (1985) suggested that the fish in tropical zone had higher frequency than those in temperate zone. Aoki and Tsuruta (1989) observed the every-night spawning of Japanese anchovy *Engraulis japonicus* during 1 month experiment in captivity while Tsuruta and Hirose (1989) found the spawning frequency of once every 1.4-4.3 days for the same species in the natural condition. Melo (1994b) presented the 7-8 days spawning interval for African anchovy *Engraulis capensis*. Luo and Musick (1991) found the intervals of 1.3-1.9 days during peak spawning of

Bay anchovy *Anchoa mitchilli*. Clarke (1987) showed that females Hawaiian anchovy *Encrasicholina purpurea* spawned every other day. Concluded from histological results and the spawning frequency of anchovies in the previous studies, it is possible that the shorthead anchovy *E. heteroloba* spawns continuously as frequently as every day in their peak spawning from October to March. However, further investigation is needed.

Spawning activity in this anchovy which was related to the period of Northeast Monsoon and the amount of rainfall is corresponding to the study of Dalzell (1990) who suggested that the production of tropical clupeoid was strongly influenced by environmental effects particularly wind and rainfall. Rain is apparently the most important external factor regulating breeding in clupeoid, and the maximum production is affected by optimum rainfall (Dalzell, 1990). It also agrees to the statement of Csirke (1988) that small schooling pelagic fishes are likely to be susceptible to climate effects on the aquatic environment as their habitat are close to the air-water interface. One evidence of unflavorable environment for maturation in the fish is the incidence of atresia indicating failure of some oocytes to undergo maturation or ovulation and degenerates (Hunter and Goldberg, 1980; Hunter and Macewicz, 1985). The incidence of comparatively high atresia during the low peak spawning period in this study implies that rainfall causes unsuitable spawning condition for this anchovy by possibly causing high turbidity and inhibits the production of plankton. This agrees with the assumption of Melo (1994b) that a high incidence of atresia in ovaries is a result of poor availability of food.

The high proportion of mature fish and high gonadosomatic index during Northeast Monsoon season corresponds with the reports on anchovy larval distribution in this area which has its high peak during November to February in Rayong Bay (Wisid Chantarasakul, 1988) and September to May in Chang Island (Sommai Yoo-sook-swat and Anucha Songchitswat, 1990). The trend is similar to the high abundance of anchovy larvae in the inner Gulf of Thailand during January, February and November (Somyos Sidtichokpan, 1972, 1976). The effect of Northeast Monsoon in this study agrees with those of Dalzell (1987) which concluded that spawning intensity of *E. heteroloba* was thought to be regulated by the monsoon seasonality and this species had peak spawnings during the transitional period between the monsoons. It was also confirmed by the study of Tiew et al. (1970) that although *S. heterolobus* breeded throughout the year, a peak spawning was noted during the Northeast Monsoon season (October to March). The peak spawning period of *E. heteroloba* in this study is similar to that of related species *Stolephorus devisi* in India where mature fish is observed almost throughout the year, but the period from October to February could be considered as the major spawning season (Rao, 1988). Northeast Monsoon peak spawning of shorthead anchovy is evident by the beach-seine fishing season for juvenile of this species along Rayong coast during April and June, the end of Northeast Monsoon season (Pirochana Saikliang, 1994).

However, the information of larval distribution along the southern coast of the Gulf, where there is no effect of Northeast Monsoon elecits their high abundance from March to September (Somyos Sidtichokpan, 1972, 1976; Hayase, 1982;

Chongkolnee Chamchang, 1986; Rangsan Chayakul, 1995), the period considered as low peak spawning period in the eastern coast. According to the data on larval distributions around the Gulf of Thailand, spawning seasons in the adjacent waters (Tiew et al., 1970; Dalzell, 1987), and the results of this study, I concluded that Northeast Monsoon has high possibility to accelerate the spawning frequency of the shorthead anchovy and rainfall seems to slow maturtity development.

The findings of this study may be drawn to the implication that local fishing, even during peak spawning, should not seriously affect the overall fishery, as there will be recruitment to the fishery from spawning fish at other sites.