CHAPTER V

DISCUSSION AND CONCLUSIONS

Sexual dimorphism

Analysis of several morphological characters of males and females of *Malayemys subtrijuga* shows that the two sexes are dimorphic. Females reach larger size than males of the same age. In this study, adult females had a mean carapace length of 155.48 ± 27.91 mm whereas adult males had a mean carapace length of 112.20 ± 09.83 mm. This finding was similar to the result of Berry and Shine (1980), who reported that in many emydids such as *Batagur baska*, *Callagur borneoensis*, *Chrysemys picta*, *Deirochelys reticularia*, *Emys orbicularis*, *Graptemys barbouri*, *Malaclemys terrapin*, *Mauremys caspica*, *Pseudemys concinna*, *Terrapene ornata*, and *Trachemys scripta*, females are larger than males. However, not all emydid females are larger than males : e.g. *Hieremys annandalii*, and *Mauremys mutica*.

Berry and Shine (1980) proposed that there was relationship between male mating strategy and sexual dimorphism. They suggested that reproductive behaviors and structures of some emydids are related to high motility of males. By this strategy, sexual dimorphism may favour small males who invest their available energy into locomotion rather than growth, while females continue growing to increase reproductive output. This contrasts with some terrestrial chelonian species, where larger males are selected since they have to engage in combat in order to mate with females. In addition, Slatkin (1984) proposed that competition between the two sexes for some limiting resource may result in different body sizes.

When comparing body proportions of *M. subtrijuga*, it was found that males compared to females had a significantly narrower carapace; shorter plastron and lower height than that of females. These results agree with a previous study of *B. baska*, where the mean ratio of CW/CL was 0.75 in male and 0.82 in female, PL/CL was 0.90 in male and 0.94 in female, and Ht/CL was 0.41 in male and 0.45 in female (Moll, 1980). These sexual differences should be adaptive and associated with reproductive success, in that the more slender shape of the male makes it easier to copulate with females or is just better for swimming, whereas the wider carapace of the female provides more volume for production of eggs.

It was found in this study that the mean ratio of TW/CL of males (0.19) was significantly greater than females (0.10). This finding agreed with the report of Ernst and Barbour (1989) that some emydids, such as *B. baska*, *C. borneonensis*, *Cuora amboinensis*, *Cyclemys dentata*, *Heosemys grandis*, *Heosemys spinosa*, *Hieremys annandalii*, *Melanochelys trijuga*, *Notochelys platynota*, *Pyxidea mouhotii*, *Siebenrockiella crassicollis* and *Trachemys scripta*, males had thicker and longer tails than females. This character should benefit the male since it can extend its penis from the opening of its cloaca to inseminate the female more efficiently. Furthermore, the longer tail may serve to locate the female cloaca, and may assist in balancing during copulation. Moll (1980) also suggested that long tail in *B. baska* can help the male to reproduce more effectively. In *M. subtrijuga*, it is noted that the different tail sizes between males and females can be seen cleary in subadult and adult turtles.

Another way of representing the sexual dimorphism in *M. subtrijuga* was by using regression analysis. It was found that the slopes of regression equations of many morphological characters between sexes were significantly different. Furthermore, the analysis of the mean ratios of some characters, such as TW/CL, H/CL, Ab/CL and A/CL, shows significant differences. Therefore, by using the method mentioned above, it can be concluded that *M. subtrijuga* is sexually dimorphic. This study was the first attempt to find out the details of the sexual dimorphism in *M. subtrijuga*. Advantages of some persumed adaptive characters in each sex may be clarified experimentally in the future.

Growth rate

It was found that males of *Malayemys subtrijuga* grew slower than females from the first to the fifth year, whereas mean carapace lengths of hatchlings of both sexes were not significantly different. Males increased their carapace length by about 43.63 % in the first year of their life, 24.62 % in the second year, 18.02 in the third year, 13.81 % in the fourth year and 12.23 % in the fifth year, whereas females increased their carapace length by 72.97 % in the first year, 25.68 % in the second year, 21.47 % in the third year, 16.25 % in the fourth year and 12.75 % in the fifth year. This result is similar to the findings of a study on *Trachemys scripta elegans*, concluding that males grew more slowly than females of the same age (Cagle, 1946).

It should also be noted that growth rate may be different in different localities due to food abundance and temperature. Gibbons et al (1981) reported that growth rate of *T. scripta* at Par Pond, South Carolina, which receives thermal effluent from a nuclear reactor plant, was more rapid than that at Ellenton Bay, which is situated about 20 km away. They concluded that this result was a consequence of elevated temperatures which enhanced diet quality. Different growth rate in different habitats were also reported by Moll (1976a) for *Graptemys pseudogeographica* and by Thornhill (1982) for *T. scripta*. Growth rates of *M. subtrijuga* based on the measurement of the annual growth increment tend to decrease from year to year when they become older indicating the rapid growth in young turtles. Graham (1971) indicated a possible relationship between diet quality and growth rate for *Pseudemys rubriventris*, in which the annual growth increment decreased steadily until the fourth year. The growth change in *P. rubriventris* may have been associated with a dietary shift from herbivory to carnivory in the fourth year.

Diet

Many workers reported that *Malayemys subtrijuga* is carnivorous and its main diet consists of snails (Smith, 1931; Taylor, 1970; Prichard, 1979; Nutphand, 1979; Geissler and Jungnickel, 1989). In this study, 2 species of freshwater snails, *Filopaludina sumatrensis* and *Brotia costula* were found in the stomach contents of the samples collected from Rangsit area, Pathum Thani Province. Thus, it is clear that *M. subtrijuga* is a snail-eating turtle. It may have an important role in controlling some snails that are agricultural pests or are the intermediate hosts of human parasites. *M. subtrijuga* was observed to consume *Pomacea canaliculata*. *P. canaliculata* is an introduced species and may have an important role as an agricultural pest in the future. TROPMED Technical Group (1985) reported that *F. sumatrensis* and *B. costula* are of parasitologic importance in Thailand and Malaysia. In Thailand, *F. sumatrensis* is eaten by humans and thus transmits the trematode parasites as known intestinal flukes, belonging to the Family Echinostomatidae (Brandt,1974). However, the role of the snails of the Genus *Filopaludina*, as either the primary or secondary snail intermediate hosts, has not yet been investigated. Thus, the life histories of these intestinal flukes and the Thai Viviparidae in association with the snail-eating turtles will need more investigation in the future. In Malaysia, *B. costula* has been found to be the first intermediate host of the lung fluke (*Paragonimus westermani*) (Kim and Umathevy, 1967). In Thailand, *B. costula* has not been found infected with *Paragonimus spp*.

M. subtrijuga is the most common turtle species found in Thailand, therefore it is one of the species that Thai people as Buddhists will find or buy from the markets to release in a temple's ponds, because they believe that saving a life will gain merit for the saver. Unfortunately, people who perform this traditional event do not realize that most turtles can not live in the wrong habitat and will lack suitable diets, especially the snails eaten by *M. subtrijuga*. Hence, the Thai tradition of releasing turtles for special blessing might turn out to be committing a sin instead. Only releasing turtles into their natural habitats could count for blessing and suitable knowledge of habitats is not generally known. For this reason, there is a great need to do further detailed studies on the natural diets of every species, so as to plan for appropriate conservation action and public relations, in order to find the best way to effectively compromise with cultural beliefs in the future. However, under the 1992 WILDLIFE ACT, collecting, selling, buying and possessing Thai turtles (except soft-shell turtle *Amyda cartilaginea*) is illegal.

Reproductive biology

1. <u>Egg size and Clutch sizes</u>

Clutch sizes of *Malayemys subtrijuga* from Tharang district, Phetchaburi Province, varied from 3-6 eggs, whereas Nutphand (1979) reported that clutch size of this species in Thailand, varied from 5-10 eggs. Clutch sizes of *M. subtrijuga* were similar to other small and medium sized emydids found in Thailand, such as *Cuora* similar to other small and medium sized emydids found in Thailand, such as *Cuora amboinensis* 3-5 eggs/clutch (Nutphand, 1979), 1-4 eggs/clutch (Paull et al, 1982) and 2-4 eggs/clutch (Ernst and Barbour, 1989), *Cyclemys dentata*, 2-4 eggs/clutch (Theobald, 1868; Smith, 1931; Nollert, 1987), 2-3 eggs/clutch (Ernst and Barbour, 1989), *Hieremys annandalii* 4 eggs/clutch (Ernst and Barbour, 1989), *Melanochelys trijuga*, 3-8 eggs/clutch (Ernst and Barbour, 1989), 3-7 eggs/clutch (Das, 1991), and *Siebenrockiella crassicollis*, 1-2 eggs/clutch (Ernst and Barbour, 1989). Clutch sizes of *M. subtrijuga* were small when comparing with large emydids like *Batagur baska*, 20 eggs/clutch (Maxwell,1911), 30-50 (Nutphand, 1979), 26 (Moll, 1984), 13-24 (Ernst and Barbour,1989). However, the number of clutches that *M. subtrijuga* can produce per year is not known and needs further detailed study.

It was found that egg length and egg weight in *M. subtrijuga* were slightly positively correlated with clutch sizes (Pearson correlation coefficient = 0.26, 0.27), whereas Moll (1979) reported that egg size correlated inversely with clutch sizes in several species such as *Chrysemys picta*. More detailed study on this matter should be conducted in the future since in this study only a small number of eggs in larger clutch sizes were measured.

2. Incubation periods and hatching success

From table 10, it is indicated that incubation periods of *Malayemys subtrijuga* eggs from the same clutch were different (range of incubation period of clutch size 3 = 108-225 days, clutch size 4 = 102-292 days, clutch size 5 = 171-223 days, and clutch size 6 = 97-221 days). This phenomenon is contrary to the incubation periods of sea turtles such as *Chelonia mydas*, where eggs of the same clutch will hatch on the same day (Boonlert Phasuk, pers.comm, 1994). In view of evolutionary considerations, both strategies should benefit the species by increasing reproductive success. For *M. subtrijuga*, it may be beneficial in that the hatchlings will not die simultaneously when facing unsuitable conditions like drought just after hatching, whereas hatchlings of sea turtles could avoid being all eaten by their predators so that a few will have a chance to survive and grow. Furthermore, a sea turtle hatchling alone can not dig through 40-70 cm of sand with its soft flippers.

Means of egg length and means of egg weight were not significantly different between hatched eggs and unhatched eggs. Hence, the hatching rate of *M. subtrijuga* did not depend on the egg length and egg weight, whereas Gutzke and Packard (1985) proposed that large eggs of painted turtles (*Chrysemys picta*) have a significantly higher probability of hatching than do small eggs.

The mean weight of hatchlings was positively correlated with the mean of egg weight. This result agreed with reports from many workers (Yntema 1968; Burger 1977; Packard, Packard et al, 1980; Morris et al, 1983) that large hatchlings usually hatch from large eggs.

3. Hatchling survival rate

The survival rate of hatchlings was very high in the first 3 months. The survival rate decreased in the fourth month to 79%, and in the fifth month to 65%. The causes of mortality are unknown but may be related to several factors such as dietary changes, and diseases. Murray, Jonathan (pers. comm, 1994) commented that the mortality of these specimens may have been related to UV spectrum deficiency.

Geissler, L. and Jungnickel, (1989) proposed that *M. subtrijuga* is considered difficult to maintain in captivity. However, further research on husbandry and maturity rates might show potential for captive breeding.

Parasites

This preliminary study of the ectoparasites and endoparasites of *M. subtrijuga* showed that there were at least one kind of the ectoparasite and probably three kinds of the endoparasites. At present, there are very few perspective studies on turtle parasites, so that it is rather difficult to identify the exact Genus and species, and whether or not these parasites can be transmitted to man. However, analysis of stomach contents indicated that *M. subtrijuga* consumed mainly freshwater snails such as *Filopaludina sumatrensis* and *Brotia costula* that are intermediate hosts of human parasites such as intestinal flukes, *Echinostomata spp*. (Brandt,1974) and lung fluke, *Paragonimus westermani* (Kim and Umathevy, 1967) respectively.

Therefore, human may benefit from this snail-eating habit of *M. subtrijuga* since it enhances the control of potential human parasites in the ecosystem.

Further study on these parasites may be carried out in the future because additional knowledge regarding the basic biology of turtle parasites will contribute to a better understanding of the biology and ecology of the sturtles themselves. In addition, such information will be useful in comparing similar phenomena among various freshwater vertebrates, ranging from fish to amphibians and other turtles.