

CHAPTER VII

CONCLUSION

The Cyclophoridae are dioecious terrestrial prosobranch land snails with a long fossil record extending to the European Mesozoic. However, modern cyclophorids as exemplified by the most species rich genus, *Cyclophorus*, range from South Asia to the Western Pacific region. Up to now no modern revisions of *Cyclophorus* have been carried out and existing knowledge is restricted to nineteenth century publications that were based solely on shells.

In my thesis presented here, I examine the taxonomy and systematics of *Cyclophorus* based on field surveys conducted throughout Thailand. In addition to shell morphology, genital and radula morphology were examined and cytological investigations were carried out to critically review species concepts. Morphological characters were used to construct a dichotomous key and a phylogenetic tree. Eventually thirteen species were identified as follows *C. aurantiacus*, *C. cantori*, *C. courbeti*, *C. diplochilus*, *C. fulguratus*, *C. malayanus*, *C. orthostylus*, *C. saturnus*, *C. semisulcatus*, *C. speciosus*, *C. subfloridus*, *C. volvulus* and *Cyclophorus* species nova. In addition, two taxa were attributed subspecies status, although the accumulation of evidence now indicates that they may prove to be distinct species. Furthermore, three shells of a possibly undescribed species were collected but the sample size is considered to be inadequate to justify recognition of a new species until more material is collected.

Shell shape, size, coloration, and especially aperture characters are very significant for species identification. Male seminal vesicle, female seminal receptacle and bursa copulatrix exhibited distinct differences at species level. The radula formula of 2+1+1+1+2 was constant across all

species but there were variations in the structure of the central tooth, most notably between *C. orthostylus* and *C. malayanus*.

Shell morphometric analysis of five characters, SH/SW, SP/SW, AH/SW, AW/SW and MI/SW using ANOVA Duncan's Multiple Range Test showed clear significant differences ($p \leq 0.05$) among 15 species. The morphological phylogeny is congruent with relationships shown by karyotypic analysis.

Karyotypes of ten Thailand species of *Cyclophorus* were examined. Haploid and diploid chromosome numbers were invariant ($n = 14$, $2n = 28$, $FN = 56$), but the karyotypes varied along a continuum ranging from 14 metacentric chromosomes in *C. volvulus* with remaining species containing unique representatives of every summed combination of metacentric and submetacentric types from $13m + 1sm$ to $6m + 8sm$. The two larger species *C. aurantiacus* and *C. malayanus* exhibit the same karyotypes of $7m + 7sm$. Karyotypes among populations of *C. fulguratus* showed variation between the central ($12m + 2sm$) and northeastern regions ($13m + 1sm$) of Thailand. Among the species with unique karyotypes, northern species possess a higher metacentric number relative to southern species. The ZZ-ZW sex determining chromosomes were firstly reported in *C. fulguratus* from Phuwiang, *C. malayanus* from Sramorakot and *C. volvulus* from Wang Kanlueang. Taxonomic and evolutionary implications of the present findings are also discussed.

One notable finding is that individual species within Thailand have somewhat restricted geographical ranges. The existing, largely nineteenth century, literature attributes wide geographical ranges to a number of *Cyclophorus* species. For example, *Cyclophorus volvulus* is recorded as ranging from India through to southern China and throughout Indo-China. On the evidence presented here, it seems likely that if critical studies of

Cyclophorus are conducted from throughout the supposed ranges of wide-ranging species that they may break up into a number of cryptic species. As most type localities of *Cyclophorus* are from outside of Thailand, this could result in the need for new names to be attributed to some of Thailand's *Cyclophorus* species.