

Chapter 2

Literature review

2.1 Biology and taxonomy of land pulmonate snails

Land pulmonate snails were classified basically by the gill types and alimentary tracts as follows;

Kingdom Animalia

Phylum Mollusca Cuvier, 1795

Subphylum Adenopoda Salvini-Plawen, 1971

Class Gastropoda Cuvier, 1797

Subclass Pulmonata Cuvier, 1817

(Salvini-Plawen, 1980, Haszprunar, 1988, Vaught, 1989, and Burch and Pearce, 1990)

Pulmonate snail is the gastropod which its name derived from the conversion of mantle cavity into a air-breathing lung. The edges of mantle cavity have become sealed to the back of animal except for a small opening on the body-side called the pneumostome (respiratory pore). That it's opening and closing controlled by carbondioxide levels within the pallial lung cavity. The gill disappeared and the roof of the mantle cavity developed a network of high vascularized blood vessels. Generally, a shell presents spirally-coiled of various shape from heliciform to a patelliform or flatten disk. Sometimes the shell is wholly enveloped by mantle, or totally lost. An operculum is lacking (except in amphibolids). The radula has numerous teeth usually a small central and many laterals and marginals. The radula serves as a brushing, browsing, scraping, rasping, shoveling, boring, cutting, or piercing instrument (Salvini-Plawen, 1988). The anus is ordinarily situated near the pneumostome. The nervous system usually is euthyneurous showing a marked tendency to shortening for the visceral portions and concentration of the ganglia around esophagus.

Members of the group are hermaphroditic; male and female gonoducts are adjacent and form a spermooviduct, or are separated into a distinct oviduct and sperm duct (Thiele, 1963, Boss, 1982, Barnes, 1987, and Morton, 1988)

Subclass Pulmonata contains 4 orders, Archaeopulmonata, Basommatophora, Systellommatophora (Soleolifera), and Stylommatophora (Vaught, 1989).

Archaeopulmonates is the most primitive group. They bear a pair of retractile tentacles, which eye at the base and kidneys lack a conspicuously developed ureter, which present in others. Members of other 3 orders, Basommatophora, Systellommatophora, and Stylommatophora were classified by position of eyes, number of pairs of tentacles, and contraction of tentacles. Basommatophorans have a pair of retractile tentacles bearing eye at the base. Systellommatophorans have 2 pairs of tentacles, upper ones form contractile stalks bearing eye at the tip and the lower ones are tactile. Stylommatophorans have 2 pairs of usually invaginable tentacles, the upper ones are cylindrical, retractile, and bear eyes at the tips, and lower tentacles are usually cylindrical, tactile, sensory, and retractile tentacles (Boss, 1982).

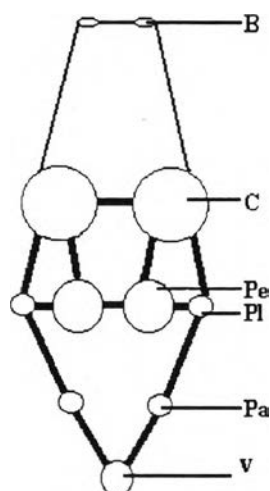


Fig. 2-1 Basic pattern of central nervous system of pulmonate. (B, buccal ganglia; C, cerebral ganglia; Pa, parietal ganglia; Pe, pedal ganglia; Pl, pleural ganglia; V, visceral ganglia) (modified from Barnes, 1987).

The central nervous systems of pulmonates compose of 5 pairs of ganglia (cerebral, pleural, pedal, parietal, and buccal ganglia), and an unpaired visceral ganglion which connected by two commissures (Fig. 2-1) (Martins, 1996a). A tough layer of connective tissues surrounds

the ganglia and nerves. A pair of cerebral ganglia lie on the dorsoposterior of the esophagus and give rise to nerves that connect anteriorly to the eyes, tentacles, statocysts, and a pair of buccal ganglia, which are located in the back wall of the buccal cavity. The buccal ganglia innervates the muscle of the radula and other structure in this vicinity. A nerve cord issues ventrally from each cerebral ganglion on each side of the esophagus. These are two pedal connectives, which extend ventrally to a pair of ganglia. A second pair of cords leaves the pleural ganglion and extends posteriorly until it terminates on a visceral ganglion that is located in the visceral mass that supplies organs in this region. A pair of parietal ganglia innervates the gills and osphradium. Concentrated ganglia is advanced character (Barnes, 1987, Bishop, 1978, and Purchon, 1968).

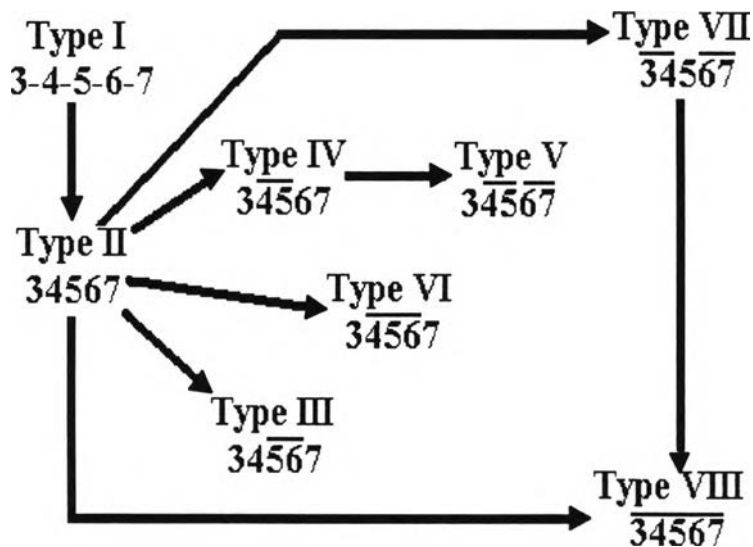


Fig. 2-2 Patterns of ganglia fusion of the visceral chain of pulmonate snails and most probable pathways of fusion in phylogeny. Abbreviations; hyphens represent connectives, bars represent fusion, numbers represent ganglia; 3, left pleural; 4, left parietal; 5, visceral; 6, Right parietal; 7, right pleural (after Bishop, 1978).

The general pattern and the variability of the basommatophoran genital system resemble that of stylommatophora, which are also hermaphrodite. A description of the basic pattern is represent in fig. 2-3. Male and female gametes are produced in the single ovotestis, which is located in the apical part of the visceral hump. When released, both male and female gametes pass anteriorly through the tiny hermaphroditic duct (spermoviduct, gonoduct). In the next part of the system, male and female gametes are transport via separate paths. These may be either functionally separate channels within a common duct, or 2 separate ducts of which the degree of

separation varies. The junction of the hermaphroditic duct and the male and female duct is often called carrefour. Here also opens the albumen gland. An associate with the carrefour is the fertilization pocket (receptaculum seminis), which shows considerable variation in size and structure. The female duct is large and glandular. Its main roles are to secrete material for the formation of eggs and egg masses and to receive the sperm from a copulated partner and transport it to the fertilization site. The principle function of the male duct is to transport sperm and to transfer it to the partner during copulation. A prostate gland is usually presented and sometimes also a sperm duct, located posteriorly to the prostate gland. The ciliated vas deferens, which opens into the penis, is anterior to the prostate gland. The male copulatory organ normally consists of a penis traversed by the vas deferens and enclosed in a penial sheath, through the terminal opening of which the penis can be everted. It must be stressed that there is a wide range of species-specific variation in structure and shape of the copulatory organ (Geraerts and Joose, 1984).

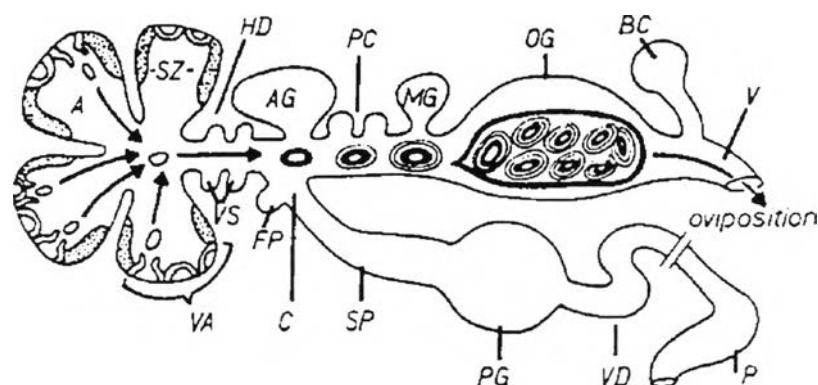


Fig. 2-3 Diagrammatic representation of the functional anatomy of the basommatophoran reproductive system by shows ovulation, eggs, and mass formation. Abbreviaton; A, acinus of the ovotestis; AG, albumen gland; BC, bursa copulatrix; C, carrefour; FP, fertilization pocket; HD, hermaphroditic duct; MG, muciparous gland; OG, oothecal gland; P, penis; PC, pars contarta; PG, prostate gland; SP, sperm duct; SZ, spermatogenic zone; V, vagina; VA, vitellogenic area; VD, vas deferens; VS, vesiculae seminales (from Gerraerts and Joose, 1984).

The first pulmonate snails attain a level considered as "Primitive pulmonate stock" gives risen to urbasommatophora and marine Basommatophora (Siphonariidae, Trimusculidae, and Amphibolidae). An urbasommatophora gives risen to Ellobiidae, Otinidae, and other higher Basommatophora (Harry, 1964). Within the Pulmonata, the subclass Basommatophora forms a

comparatively heterogeneous unit comprising a number of rather clearly defined groups. Hubendick (1978) suggested considerable phylogenetic gaps exist between the groups, and probably it will never be possible to elucidate their relationships. It is very doubtful whether the Basommatophora represent a truly monophyletic group. Nevertheless, many of the 11 families are obviously related to each other, and all can be ranked with regard to probable degree of relationship (Hubendick, 1978).

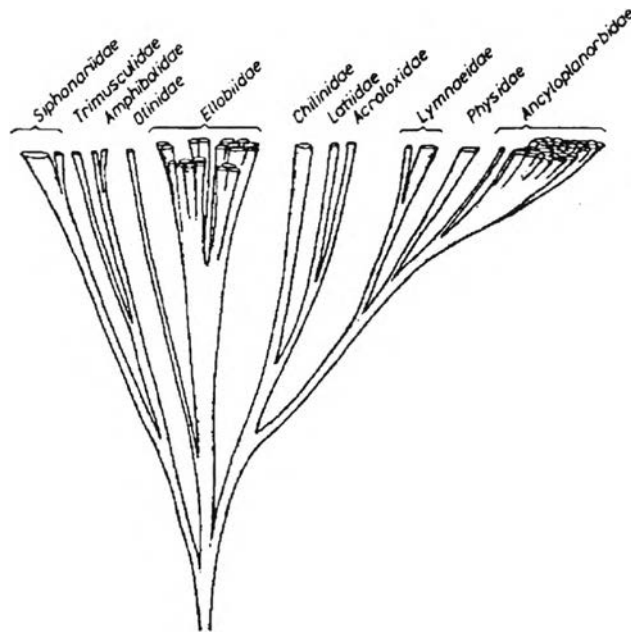


Fig. 2-4 Diagram of probable relationships between basommatophoran families (after Hubendick, 1978).

2.2 Mangrove pulmonate snails in Thailand

Brandt (1974), Isarankura (1976), and Tuntanasiriwong (1978) reported the occurrence of pulmonate snails in the mangroves of Thailand. There are 2 orders and 4 families presented in mangrove. Order Basommatophora has 3 families, Ellobiidae, Siphonariidae, Amphibolidae and Order Systellommatophora has 1 family, Onchidiidae.

The Family Ellobiidae is said to be most primitive group among pulmonate snails (Hubendick, 1978). Recently it was classified in Order Archaeopulmonata (Vaught, 1989). Their shells have both marine and terrestrial forms. The marine form often has an external appearance

similar to the shells of prosobranchs. The terrestrial form of Ellobiidae often possess an alabastrine appearance (Hubendick, 1978). The shell is more or less high and short spire, ovate to cylindrical in shape, mostly dextral, and varies in size from extremely minute to nearly 10 cm in length. The shell of *Pythia plicata* has variation of color pattern which is seldom occurred in Basommatophora (Brandt, 1974, and Cook, 1996). The inner walls of the whorls are mostly resorbed. Shell aperture has parietal, palatal, and columella teeth; the outer margin is often denticulate. The cerebral commissure is longer than the pedal, with the left pleural ganglion closer to the pedal ganglion than the right and the visceral commissure is short. Members are hermaphrodite and protandrous; the retractable penis usually united with the genital opening via a furrow. The penis is provided with a chitinous stylet, a seminal receptacle is present in the oviduct. An ellobiid, *Melampus bidentatus*, have annual reproductive period between early June and mid July, with normally three egg-laying cycles. Each cycle has a definite semilunar periodicity with egg-laying strictly confined to four days in phase with the spring tides. Taking full or new moon as day 0, the patterned behavioral sequence involves aggregation (day -1), copulation (+1), egg-laying (+2 through +6), and dispersion (+6 through +8). Egg laying and hatching shows semilunar synchrony (Apley *et al.*, 1967, and Russell-Hunter *et al.*, 1972).

There are 20 species of ellobiids that were reported in Thailand by Brandt in 1974, only 16 of them present in the Gulf of Thailand i.e. *Auriculastra elongata*, *A. subula*, *Cassidula aurisfelis*, *Ca. mustelina*, *Cylindrotis quadrasi*, *Cy. siamensis*, *Ellobium aurisjudae*, *E. aurismidae*, *Laemodonta monilifera*, *L. punctatostriata*, *L. punctigera*, *L. siamensis*, *Melampus pulchellus*, *M. siamensis*, *Pythia plicata*, and *Py. trigona*.

Family Siphonariidae; the shell is cap-shaped, patelliform, and irregularly oval to elliptical in outline; the apex is blunt, and generally central or placed slightly posterior; the surface has radial striation or ribs. The pedal muscle scar is almost circular, somewhat horse-shoe shaped. The head is wide, tentacles are lacking, the foot is large and rounded. The broad pulmonary cavity has an inserted gill in the posterior portion, the secondary gill consists of numerous triangular leaves, and osphradium is present. The jaws are arched and constructed of small rods. The nervous system is concentrated, and both ganglia of the visceral commissure are united with the pleural ganglion. The kidneys are large on the left side of the body and open near the pneumostome. The gonad is on the right, hermaphroditic, and sometimes protandric, and has

a common opening on the right behind the head. Sperms are contained in chitinous spermatophore (Boss, 1982).

Siphonariids live in intertidal seashore. All siphonariids consume algae as their primary food source. This is shown to have a powerful effect on the structure of shallow-water marine communities and, in at least some instances, appear to have influenced algal evolution (Branch, 1985). Their ecological niche is primary consumer and their predators are other snails (ex. *Thais clavigera*) and starfish (*Coscinasterias* spp.) (Isawaki, 1993). Some chemical substance, such as norsiphorienone A, isosiphorienolone, 2-deoxysiphorieforanone, and isopectinone extracted from *Siphonaria pectinata* may be used for medicine. Biological activities of polypropionate compounds are mainly antibiotic and cytotoxic (Paul *et al.*, 1997). On the other hand their secondary metabolites can defend themselves from their predators. McQuaid *et al.* (1999) proved that by counting the total number of eaten limpets (*Patella granularis* Linn. and *Siphonaria capensis* (Quay & Gaimard)) only 12% (from 331 limpets) were *Siphonaria*. Whelks refused the tissue of *Siphonaria* while accepting of *Patella*. Gobies eat *Siphonaria* tissues, but were reluctant to feed again.

Suvatti (1938) reported one genus *Siphonaria* collected from Rayong Province. Tantanasiriwong (1978) reported 3 siphonariids from Andaman seashores, they are *Siphonaria atra*, *S. kurracheensis*, and *Anthrosiphonaria sirius*.

The Family Amphibolidae is so unique in being the only pulmonate snails, which retain the operculum in adult. Shell is spirally coiled, rounded in shape, dextral, small to medium in size, rarely exceeding 30 mm in height, and wide umbilicate; the spire is short and conical, with an large body whorl. The aperture is large and tooth lacking. The operculum is corneous, oval and has a rapidly expanding spiral and a subcentral nucleus (paucispiral).

The head is large. The eyes are at the base of the short tentacles, the pulmonary cavity is extensive, lacks a gill, but has an osphradium. In living snail the pulmonary cavity is filled with water; the hypobranchial gland is spongy. Jaw is absent. The radula has a central tooth with fine sharp denticles and a small accessory plate behind. The intermediate tooth with three sharply pointed denticles while the lateral is sharp, rather elongate and simple, and oblique arranged. The

stomach has a muscularized gizzard-like portion; the intestine is convoluted; the anus is located in a lobe near the pallial respiratory aperture. The nerve collar is anterior to the pharynx; the visceral commissure is very short, with three ganglia. The kidney is triangular and situated in the mantle, and opens near the pneumostome. Members are hermaphroditic, and monaulic or dialic: a muscularized penis and a large prostate are present; the gonopores are near the right tentacle. Bursa copulatrix are lacking. The eggs are encapsulated and the veliger stage is passed in the capsule; the velum degenerates before hatching (Boss, 1982, and Hubendick, 1978).

A reported species of Amphibolid was *Salinator burmana* from Andaman seashores (Tantanasiriwong, 1978).

The Family Onchidiidae; the animals are oval, rarely rounded, naked, slug-like, and without a shell. The dorsal surface of the body is covered by the mantle, which is smooth, or uneven with papillae or tubercles containing unusual accessory eyes and respiratory bush like processes, siliceous spicules and peripheral repulsive gland or repugnatorial glands are present. Anteriorly, below the mantle edge and above the mouth, a strong, roof-like frontal shield cover the head, with a pair of cylindrical, retractile, and invaginable eye-bearing tentacles, usually with the eye on the outer side. The lower pair are fleshy lobes called sensory tentacles. The sides form a hyponotum or girdle like border continuous with the dorsal notum, but separated from it by a groove, the perinotum. The foot is large and broad, the median sole is truncated in front with narrow and rounded behind. The foot has fine longitudinal and transverse furrows.

The pulmonary cavity is in the posterior portion of the body. The small pneumostome opening is mostly located medially behind the anus and slightly to its right. Jaw is very thin, and transparent. The radula is broad, and the teeth are obliquely disposed. The central teeth is tricuspid, the lateral and marginal teeth are elongate and usually numerous with an outer denticles. The stomach has a muscular gizzard and funnel-shaped digestive portion. The intestine is long and coiled and widened posteriorly. The anus opens behind the end of the foot sole in the median line.

Members are hermaphroditic with widely separated male and female genital pores. The female gonopore is near the posterior extremity. The penis has denticulations and commonly

with an accessory gland. The male gonopore and penis are on the right side of the head, either inside or outside right of the cephalic tentacles. The ovotestis is multilobed. The embryo had a coiled shell. The pelagic veliger larva is two-lobed (Britton, 1984, Boss, 1982, and Solem, 1959).

Onchidiid are resistance to desiccation fairly well and often found making a long journey exposed in warm air. Some species have repugnatorial gland that produced some depsipeptides (polypeptides that contain ester bonds as well as peptides) such as onchidin and onchidin B. Both depsipeptides are cytotoxic metabolites, especially onchidin B can inhibited growth of tumor Kb cells (human epidermoid carcinoma cells) by 97% inhibition to Kb cells at 10 $\mu\text{g/ml}$. (Morton, 1967, and Fernandez *et al.* , 1996).

A reported genus of Onchidiidae was *Onchidium* sp., recorded as mangrove tree fauna (Isarankura, 1976).