

CHAPTER II

LITERATURE REVIEW

2.1 Taxonomy of butterfly lizards

Classification of butterfly lizards is:

Kingdom Animalia

Phylum Chordata

Subphylum Vertebrata

Class Reptilia

Order Squamata

Suborder Sauria

Family Agamidae

Subfamily Leiolepinae

Genus *Leiolepis*

Peters (1971) provided a conclusive dichotomous key to the individual taxa of the genus *Leiolepis* based on the typical scale and skin characteristics as follows:

Key to species of the butterfly lizard, genus *Leiolepis*

- 1 Greater than 20 femoral pores, as well as greater than 16-17 longitudinal rows of enlarged scales on the underside of the lower leg. Over 60 (in female) alternatively, over 70 (in male) tail scales per whorl on the level of the heel when the leg is straightened and laid against the tail. Back markings consist

mainly of closely spaced large and small spots. Flanks are dark with narrow, short and long white cross-stripes (in male) or a uniform grey-brown color with darker brown longitudinal stripes running parallel to the lighter dorso-lateral stripe.....*L. guttata*

1' Fewer femoral pores, tibia-scale rows and tail-whorl scales. Back markings consisting of more or less clear ocelli of equal size. Occasionally ocelli are lacking entirely. Different marking on flanks.....2

2 High contrast flank coloring; light speckling with diagonal or vertical light orange to carmine-red cross spots on a dark background, beginning at the sides of the head or neck, and reaching at least into the post axillary region (in male). A clear contrast marking is missing on the flanks (in male), and on the back at least 2 light longitudinal stripes are discernable. Femoral pores are still clearly visible, but there are rarely more than 19.....3

2' Contrast marking along the flanks, consisting of short light and dark cross stripes not coming in contact with one another. If at all distinctive, beginning behind the front legs. Sides of the neck remain without markings. Traces of light longitudinal stripes on the back are visible at the most near the tail-base. Femoral pores are tiny and often not visible, however, there are usually more than 18 per row.....*L. peguensis*

3 Contrast markings on the flanks of both sexes are clear and complete; a relatively wide light colored “ wedge ”, broken by several dark crossbars. 32-41 (usually 35-39) lamellae under the 4th toe.....4

3' Contrast markings on the flanks of the males can either be limited to the axillary region or moving tailwards become diffuse and unclear. Markings absent or very weak in females.....5

- 4 Markings on the back are comprised of 3 uninterrupted longitudinal stripes of light color, that fade solely in the neck region. Relatively few ocelli (1-3 longitudinal rows) separating stripes.....*L. belliana belliana*
- 4' Back markings are comprised mainly of large ovoid ocelli. Longitudinal stripes only appear clear in the pelvic region..... *L. belliana ocellata*
- 5 In the females at least, the inguinal region is of uniform color (in preserved specimens the color can range from grey to pale pink, and in living specimens the color can be orange to carmine red). Suggestion of middle back stripe. 28-38 (usually 30-34) lamellae under the 4th toe.....6
- 5' Along the flanks only narrow light grey (in living specimens pale yellow to orange) cross stripe, not broken by dark blotches. 3 continuous stripes are present on the back, between which are closely located pale ocelli on a dark polygonal net pattern. 34-39 (mostly 35-37) lamellae under the 4th toe.....*L. triploida*
- 6 Males: Back marking reduced to a black polygonal framework. Contrast markings on the flanks is limited to the pre and post-axillary region. Females: small pale ocelli located within the black framework on back, and flanks uniform on color. 50-65 (mostly 54-60) scales per tail-whorl.....
.....*L. reevesii rubritaeniata*
- 6' Back markings are more or less comprised of clear, typically large and light in color, ocelli on a dark framework. Contrast markings on the flanks in the males reach onto the sides, while in the females only a hint of markings is present. 45-57 (mostly 45-54) scales per tail-whorl.....*L. reevesii reevesii*

According to a major thorough revision by Peters (1971) this genus was represented by four bisexual species (*L. guttata*, *L. peguensis*, *L. belliana*, *L. reevesii*) and one parthenogenetic triploid species, *L. triploida* which described from the south of the Malay Peninsula.

Böhme (1982) found a series of nine female butterfly lizards from Songkhla, southern Thailand which interpreted as a diploid-parthenogenetic clone. He mentioned that these unisexual samples distinguished from normal bisexual populations of *L. b. belliana*, distributed throughout the Malay Peninsula. They shared some characteristics with the triploid-parthenogenetic *L. triploida* but body size was smaller, the middorsal light- coloured strip was absent and all adult females were fertile.

Darevsky and Kupriyanova (1993) reported that the butterfly lizard, Genus *Leiolepis* Cuvier, 1829 included four bisexual (*L. belliana*, *L. guttata*, *L. reevesii*, *L. peguensis*) and three unisexual (triploid - *L. triploida*, *L. guentherpetersi*; probably diploid - *L. boehmei*). A distribution map of main locality records of seven *Leiolepis* species in Southeast Asia was shown in Figure 2.1.

A review of the literature concerning butterfly lizards in Thailand showed that the knowledge of them was still fragmentary.

Taylor (1963) reported that three subspecies were recognized in Thailand, including *L. belliana belliana*, *L. belliana rubritaeniata* and *L. belliana guttatus*.

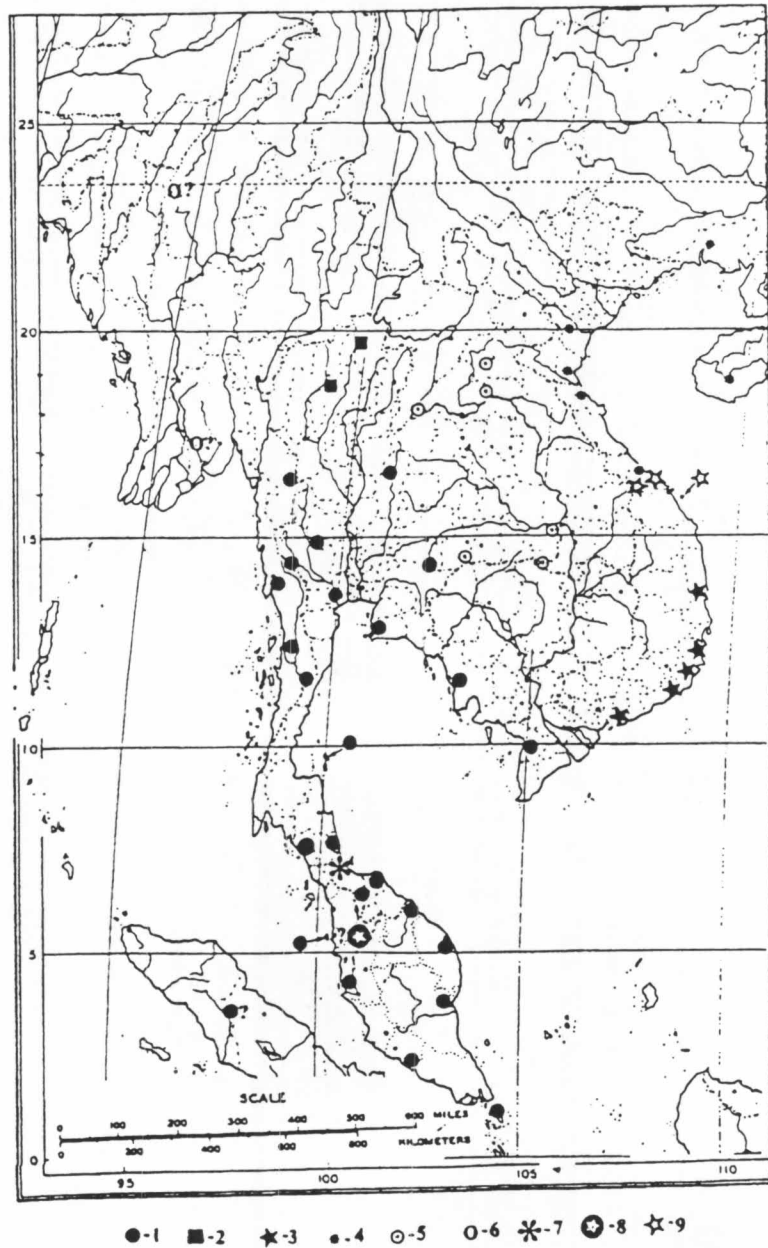


Figure 2.1 Distribution map of *Leiolepis* species (from Darevsky and Kupriyanova, 1993). 1 - *Leiolepis belliana belliana*; 2 - *Leiolepis belliana ocellata*; 3 - *Leiolepis guttata*; 4 - *Leiolepis reevesii reevesii*; 5 - *Leiolepis reevesii rubritaeniata*; 6 - *Leiolepis peguensis*; 7 - *Leiolepis boehmei*; 8 - *Leiolepis triploida*; 9 - *Leiolepis guentherpetersi*.

Satrawaha (1988) stated that there were three subspecies of butterfly lizards in Thailand, consisting of *L. b. belliana* (Gray), *L. b. rubritaeniata* (Mertens) and *L. b. guttatus* (Günther).

Nutaphand (1989) mentioned that three subspecies of butterfly lizards occurred in Thailand i.e. *L. b. belliana* Gray, *L. b. rubritaeniata* (Mertens) and *L. b. guttata* Günther.

Cox et al. (1998) determined that two species of butterfly lizards were recognized in Thailand, consisting of *L. belliana* and *L. reevesii*.

Chan-ard et al. (1999) reported that four species of butterfly lizards were found in Thailand i.e. *L. belliana* (Hardwicke and Gray, 1827), *L. reevesii* (Gray, 1831), *L. triploida* Peters, 1971 and *L. boehmei* Darevsky and Kupriyanova, 1993.

2.2 Natural history of butterfly lizards

Butterfly lizards are ectothermic vertebrates. Most of them are found in the open areas. The burrow of the butterfly lizard is important for reproduction and to avoid predators and extreme climatic conditions. Satrawaha and Tarpsipare (1982) studied the ecology of *L. belliana rubritaeniata* (Mertens) and reported that they were found and tended to occupy their burrows in relatively dry, open habitats. Each burrow had a single daily entry opening and another concealed emergency exit. The dimension of the daily entry opening seemed to depend on their body size and the range of the entry opening was from 1 cm to 3.5 cm. They emerged from their

burrows to bask in the morning sunshine, and foraged during the day and then retreated to their burrows in the late afternoon, closing the entrance with a plug of sand. Above ground activity seemed to be bimodal occurring once between emergent time to about 1 p.m. and again between 3 p.m. to 5.30 p.m. The basking of them was a method of temperature control which differed essentially from that of mammals in that they depended on the availability of the external sources of heat such as the sun, rather than on the ability to conserve or lose heat generated within their body. Voluntary exposure to sunlight was a common reptilian method of raising body temperature in a cool environment. Many lizard species lay motionless in the sun until their body temperature raised to the level requisite for their normal activity (Heatwole, 1976). In addition, thermoregulation by entering burrows was important to a wide variety of lizards (Heatwole, 1970). During the day when the environment becomes unfavorably hot, lizards retreat to the cooler temperatures of burrows. They did not emerge from their burrows between 1 pm. to 3 pm. because they could not put up with heat stress. The closing of their burrows related to the weather that is improper for their foraging.

Satrawaha and Khukusamut (1985) studied the distribution and the population structure of *L. belliana rubritaeniata* (Mertens) and reported that an average home range for this individual lizard was 30 square meters.

Satrawaha and Tarpsipare (1982) reported that the body weight and the body size of the male of *L. belliana rubritaeniata* (Mertens) were higher than those of the female. The sex determination of them was based on the colorful stripes on the flanks and the color spots on its neck. Male lizards had stripes of black and yellowish

orange that were exhibited on the flanks while not appeared in female. Two mating seasons occur in a year, from January to March and from May to August. To attract the female, the male had raised his right forelimbs and hindlimbs in order to run anticlockwise like a dancing around the female burrows until she emerged and followed to copulating by male. They were oviparous lizards. The female laid 3 to 8 eggs in her burrow. The striped juveniles with a reddish tail showed themselves after the rainy season. An average egg size was 1.34 x 2.21 cm which had ellipsoid shape and no hard shell. These eggs incubated under moisture in the maternal burrows. The young lizards showed themselves between June to July and between November to January. They shared the burrows with their mothers for several weeks before digging their own burrows nearby.

All butterfly lizards have fangs on the maxillary bones (Nutaphand, 1989). If they bite, their fangs will drive into the enemies. However, they can escape their predators by running fast into their burrows. They have numerous predators such as snake, vulture, hawk, leopard cat, dog and human. Losos et al. (1989) studied correlation of sprinting, jumping, and parachuting performance in *L. belliana* from Phuket Island, Phuket Province, Thailand and reported that larger butterfly lizards fell, ran faster and jumped further. When the effects of size were removed, limb length was uncorrelated with jumping and running performance.

The best capturing method is using a tool trap (Satrawaha and Khukusamut, 1985). Although, they like to rest in the ground holes, they usually forage on the surface of the ground. They are omnivore, feeding mainly on insects and also buds and young shoots of plants (Satrawaha and Tarpsipare, 1982). Besides being

a high protein source, the butterfly lizards are also beneficial to human beings because they help to control the insect pests.

2.3 Cytogenetic data of butterfly lizards

Hall (1970) examined the karyotypes of *L. belliana* Gray, which were imported from animal dealer in Bangkok, Thailand. These specimens consisted of two males and three females, which probably came from Tak Province in northern Thailand, according to the dealer who supplied them. All karyotypes of five *L. belliana*, made from testis, spleen or bone marrow, had primitive $2n = 36$ chromosomes number that were typical in many lizards. In addition, he karyotyped thirteen female specimens possibly from northern Malaysia and reported their karyotypes were $3n = 54$ chromosomes, readily interpreted as triploid. Eighteen macrochromosomes and thirty-six microchromosomes were present in all cells and one chromosome of the largest trio of the triploid was differentiated by very conspicuous secondary constriction, which might be the nucleolus organizer. There were no indications of sex chromosomal heteromorphism in any of the karyotypes.

According to a major thorough revision by Peters (1971), who described these specimens as *L. triploida*, they were an auto-triploid clone. He presumed the autotriploid nature of the unisexual *L. triploida*, which he thought, could have originated from reorganization of initial diploid karyotype in one of the bisexual ancestors forms, most probably *L. belliana* (Gray, 1827). However, this was in particular deduced from the fact that there were no unisexual diploid species in the

area of the Malayan Peninsular that could have contributed to a possible hybrid origin of *L. triploida* (Darevsky and Kupriyanova, 1993).

Böhme (1982) gave the opinion that *L. triploida* should be an allotriploid hybrid clone between the diploid-parthenogenetic females from Songkhla Province, southern Thailand and males of the normal bisexual species.

Darevsky and Kupriyanova (1993) presented two new all female butterfly lizards, *L. boehmei* from Thailand and *L. guentherpetersi* from Vietnam. In addition, they suggested that both triploid (*L. triploida*, *L. guentherpetersi*) and probably diploid unisexual species (*L. boehmei*) originated from natural hybridization. The females of the triploid species displayed low fertility and some of them being totally sterile. Moreover, they observed the abundance of all female *L. guentherpetersi* in coastal dunes of central Vietnam, which were poorly anchored by sparse bushy and grassy vegetation and examined their karyotypes. The results showed that the triploid karyotype included eighteen metacentric and submetacentric macrochromosomes and thirty-six acrocentric microchromosomes. According to cytogenetic features, *L. guentherpetersi* had a secondary constriction located in the distal zone of the long arm of chromosome no. 1 and presented only in one of the chromosomes of the triplett. It was realized that most of both triploid unisexual *Leiolepis*, were sterile, while only six out of twenty mature individuals of *L. triploida* studied by Peters (1971) were fertile. These were estimated from the developmental stage of their ovaries and oviducts.

The origin of the unisexual species of genus *Leiolepis* was discussed by Darevsky and Kupriyanova (1993). They compared the possibility of the hypothesis origin which could have participated in the formation of the parthenogenetic species. They proposed that *L. triploida* might be originated from *L. belliana* and *L. boehmei* because they observed that there were some characters of *L. triploida* which were intermediate between *L. belliana* and *L. boehmei*. In addition, they believed that *L. guentherpetersi* was hybrid nature and noticed that it possessed a type of coloration and dorsal pattern which was clearly intermediate between both parental forms of *L. reevesii* and *L. guttata*. *L. guentherpetersi* combined the characters of two dorsolateral stripes in *L. guttata*, and forming ocellus with light centers and grayish edges in *L. reevesii*.

The structure of the karyotypes among three diploid species, *L. reevesii*, *L. belliana* and *L. guttata* did not differ which was characterized by 12 metacentric and submetacentric macrochromosomes and 24 acrocentric microchromosomes (Kupriyanova, 1984; Shoubai et al., 1987; Solender and Schmid, 1988).

2.4 Parthenogenesis in lizards

Most of the diploid and triploid parthenogenetic lizard species resulted from a process of natural hybridization as a result of back-crossing between diploid parthenogenetic females and males of their bisexual parental forms (Darevsky et al., 1985; Dessauer and Cole, 1989; Moritz et al., 1989). However, two different hypotheses proposed to explain the origin of parthenogenesis. The first hypothesis was proposed by Lowe and Wright (1966) who generalized that interspecific

hybridization was responsible for the origin for the uniparental species. This hypothesis was based on karyotypes of the parthenogenesis. They found that the parthenogenesis contained chromosomal complements corresponding morphologically to complements from two bisexual groups. In cases of triploid parthenogenesis, they found that all three of the chromosomal complements were morphologically identical, and they concluded that hybridization was occurring between species of the same species group. An alternative hypothesis was proposed by Peccinini (1971) who stated that the parthenogenetic females arose spontaneously within the bisexual population. This parthenogenesis then flourished possibly because of their mode of reproduction. Parthenogenesis would persist because this would serve as an effective barrier to genetic exchange. To explain the hybrid nature of the parthenogenetic species, they suggested that once parthenogenesis was established by hybridization was likely to occur in the allopolyploidy and the various allozyme loci in the species.

Many of the parthenogenesis were described as valid species before it was known that they were all female. Later, they were ascribed to subspecies which were then partitioned from their bisexual counterparts. There were some arguments that the species level granted to these uniparental forms were reverting back to the typological species classification thus ignoring their evolutionary potential and adaptive response (Wright and Vitt, 1993). Others believed that once hybridism was established, species assignments were no longer valid because of the belief that hybrid individuals did not form populations (Mayr and Ashlock, 1991).

Morafka (1977) suggested that parthenogenetic lizards of hybrid origin should not be considered as species, but as cloned hybrids without taxonomic recognition. Dubois and Günther (1982) argued strongly that all female forms of hybrid origin that depend on sperm for reproduction by means of gynogenesis or hybridogenesis should not be regarded formally as species. They proposed the terms *klepton* and *synklepton* for such organisms and their bisexual ancestors.

Cole (1985) regarded the parthenogenetic clonal forms and discussed as species rather than hybrids for the following reasons; (1) individuals have a single parent, although a lineage can be traced back to an F₁ hybrid female; (2) these organisms have distinctive characters that can be diagnosed and are perpetuated generation after generation independent of interaction with any ancestral population, and all ancestors could become extinct while the clone perpetuates itself; (3) such clones are reproductively isolated entities that can undergo dispersal, mutation, natural selection and evolution; (4) some clones with distinctive morphology, ecology and geographic distribution are unknown or uncertain ancestry and, at some localities, they are the only representatives of their family; (5) many are recognized and named as morphological species before it is realized that they represent unisexual clones; and (6) it is not yet certain that all unisexual forms had a hybrid origin (Vanzolini, 1970).

The taxonomy of parthenogenesis faces an additional problem in the classical biological species application in that each individual lizard is potentially reproductively isolated. These nomenclatorial problems with parthenogenesis have been addressed recently in the literature (Smith, 1987; Frost and Wright, 1988). With few exceptions, many are in retaining the species status of parthenogenesis. Their

arguments are that taxonomy must not be inconsistent with phylogeny and to ignore the parthenogenesis is to ignore their origins. Wright and Vitt (1993) also went a step further in making a series of recommendations. The first, diagnosable populations of parthenogenesis should be recognized as a separate species. The second, origins of the uniparentals by hybridization from biparental ancestors constitutes the origin of a new entity and should be recognized as such. The third, historical groups of parthenogenesis resulting from hybridization between a uniparental individual and a male of a bisexual species should also be recognized as a species distinct from both of the parental. The fourth, divergent uniparental that share a common hybrid origin should be recognized by assigning letters to the two or more different groups. The fifth, uniparental populations removed from their parental congeners should be recognized as species regardless of their origin.

3.5 Habitat

In the simplest form, the habitat of an organism is the place where it lives (Odum, 1971). The habitat that an organism preferentially chooses showed the temperature at which that organism functions the most efficiently. Habitat is the resource in an area that provides occupancy, including survival and reproduction, to a given organism. Habitat might be used for foraging, covering, nesting, escaping, or other life history traits. It is the sum of the specific resources that are needed by organisms (Thomas, 1979).

Krebs (2001) defined a habitat as any part of the biosphere where a particular species can live, either temporarily or permanently. If assumed that an

animal could not live in everywhere, natural selection would favor the development of sensory systems that could recognize suitable habitats. Why did organisms prefer some habitats and avoid others? Understanding the links between animal distribution and habitat plays a pivotal role in designing management for threatened species.