Chapter II

Literature Review

2.1 Genus *Bufo*

Genus *Bufo* is in:

Kingdom Animalia
Phylum Chordata
Class Amphibia
Order Anura
Family Bufonidae

Bufo is one of about 35 genera in family Bufonidae. It is suggested to be ancestor of some other genera in the family. The genus contains about 200 species which commonly known as toad. However, it will not be possible to state the exact number in the foreseeable future due to two major reasons. First, there is at present no possibility of estimating the number of cryptic species that have not been revealed by morphological studies. Second, it is highly probable that additional species remain to be discovered in addition to the cryptic species (Taylor, 1962; Inger, 1966; Blair, 1972; Duellman, 1999).

In general, *Bufo* has thick, glandular skin with or without pustular warts. Parotoid gland is present and conspicuous. Tongue is oval and free behind. Neither vomerine nor maxillary teeth is present. Tympanum is distinct or hidden by skin and rarely absent. There is no web on fingers. In contrast to fingers, toes are present with a thickened web, which is a slightly widened digit-tip. Outer metatarsal is united. *Bufo* usually has only a single slit, which enters vocal sac. Pupil is horizontal. Most species are terrestrial or fossorial and have short limbs. Digits are reduced and shortened (Taylor, 1962; Duellman and Trueb, 1994).

The further distinct character of *Bufo* is egged string. Toads of the genus *Bufo* characteristically deposit eggs in paired strings. Each string is from each oviduct. The numerous, small, pigmented eggs are laid in standing or slowly moving water. The

larvae have spheoidal bodies, rather narrow lips, horny beaks, highly coiled intestines, and deep fins (Inger, 1966; Duellman and Trueb, 1994).

Bufo has nearly cosmopolitan distribution but do not occur in the Australo-Papuan Realm, Madagascan and Oceanic regions. However, become a pest species, *Bufo marinus* has been introduced into Australia, New Guinea and many other islands in 1930s. According to fossil history, the genus *Bufo* is known from the upper Tertiary and Quaternary deposits of North America, South America, Europe and Africa. The genus is most speciose in the Neotropical (74 species), and Ethiopian (56 species) Realm, followed by the Oriental Realm (47 species), Palearctic Realm (24 species) and Nearctic Realm (21 species) (Taylor, 1962; Inger, 1966; Blair, 1972; Duellman and Trueb, 1994; Freeland and Kerin, 1988; Seebacher and Alford, 1999; Duellman, 1999).

Blair (1972) suggested that the major evidences that are expected to influence the spread of *Bufo* are the earth features, including:

1. Isolation of the continental landmasses by water gaps at various times in the Tertiary and Quaternary.
2. Existence of climatic zones that might serve as barrier or alternatively as dispersal routs for group with restrictive adaptation to climatic type.
3. Shift of the climatic zones under the influence of Pliocene and Pleistocene continental glaciations and interglacial conditions.
4. Existence of south-to-north-oriented mountain ranges which might act as dispersal routes for cold-adapted types.
5. Existence of east-west-trending mountain chains which would act as lethal traps for warmth-adapted types, that might be forced southward by climatic cooling.
6. Continental mass and environmental diversity which would provide a template for the adaptive radiation of the genus on the respective continents.

In Thailand, four species of *Bufo* are found. The first is *B. melanostictus* which probably occurs in every province. The second is *B. macrotis* which is found in western Thailand. The third is *B. parvus* which has a distribution in southern Thailand and the last is *B.* asper which disperse in peninsular and western Thailand (Taylor,

1962). Except *B. melanostictus*, all of them are protected species in Thailand underly WARPA, 1992.

2.2 *Bufo asper* Gravenhorst, 1829

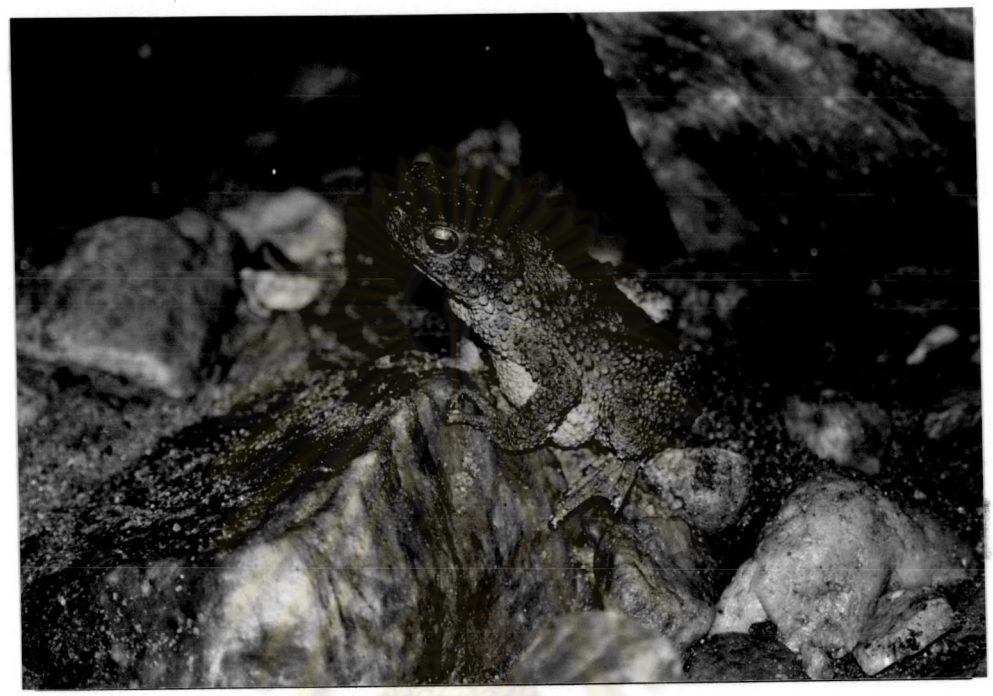

Figure 2.1 *Bufo asper* Gravenhorst, 1829.

Bufo asper is a member of genus *Bufo*. It's English common names are Asian Giant Toad , Cave toad, or River toad and it's Thai common names are จงโคร่ง (Chong Krong), กง (Kong), or หมาน้ำ (Mha Nam). Snout to vent length of male is 69.5-98.2 mm and 95.2-120.8 mm for female. To identify this toad from other species in genus *Bufo*, the toad is moderately stocky. Its limbs are relatively long. Head is wider than long. Supraorbital crest is usually low. Parietal crest is absent. Supratympanic crest is thick. The snout is truncate or obtusely pointed. Furthermore, it is vertical in profile or projecting slightly. Nostril is at the end of snout. Canthus is rounded and distinct. Interorbital is wider than upper than eyelid. Tympanum is distinct and about one-third diameter of eye (Taylor, 1962; Inger, 1966).

Fingers are moderately long. Tips are swollen but not wider than other parts of the fingers. The first finger is usually slightly longer than the second finger. Subarticular

tubercles are large and simple. Supernumerary metacarpal tubercles are present. The tips of toes like those of fingers. The third toe is slightly longer than the fifth. All toes except the fourth are webbed to the swollen tips. The fourth toe is 1-2 phalanges free. The subarticular tubercle is conspicuous, round, and simple. Inner metatarsal tubercle is low, oval and half in length of first toe. The outer metatarsal tubercle is round or oval, and smaller than the inner. Tarsal ridge is sharp (Inger, 1966).

Skin of back is covered with large round warts. There are numerous small tubercles on the skin between warts. Top of head, sides, and dorsal surfaces of limbs are present with many small, conical warts. The most of warts and many small tubercles are persent with melanic tips. There is one (or two) large, conical rictal wart. Ventral is cover with coarsely granular and the granule is usually tipped with melanin. The parotoid gland is round or subtriangular (Inger, 1966).

There is much variation in general coloration. The color may be light clay, olive, blackish or occasionally (probably in the breeding season) may be spotted with orange or crimson (Taylor, 1962). The color of *B. asper* preserved in alcohol is dark brown above, immaculate or with a few black spots in juvenile specimens. The ventral is yellowish brown. Throat, chest, and underside of legs are spotted with black (Inger, 1966).

In Thailand, the species is known in peninsular and western Thailand. In Malaysia, the species is present from sea level to an elevation of 4,500 feet and also found in caves deep in the mountains. Moreover, it has been found in southern Myanmar, Sumatra, Java, and Borneo.

Taylor (1962) studied amphibian fauna of Thailand and reported that *B. asper* usually remains close to small stream. Numerous specimens were acquired from clumps of bamboo growing in the edge of small stream.

Inger (1966) figured out the systematic and zoogeography of amphibia of Borneo and reported that hundreds of collected adults *B. asper* were observed on the banks of small streams and rivers. Furthermore, all of those streams flowed through rain forest.

Berry (1970) investigated food of *B. asper* inhabiting in Malaysia and found that *B. asper* fed upon a wide range of invertebrates, but there was little or no marked seasonal variation in diet.

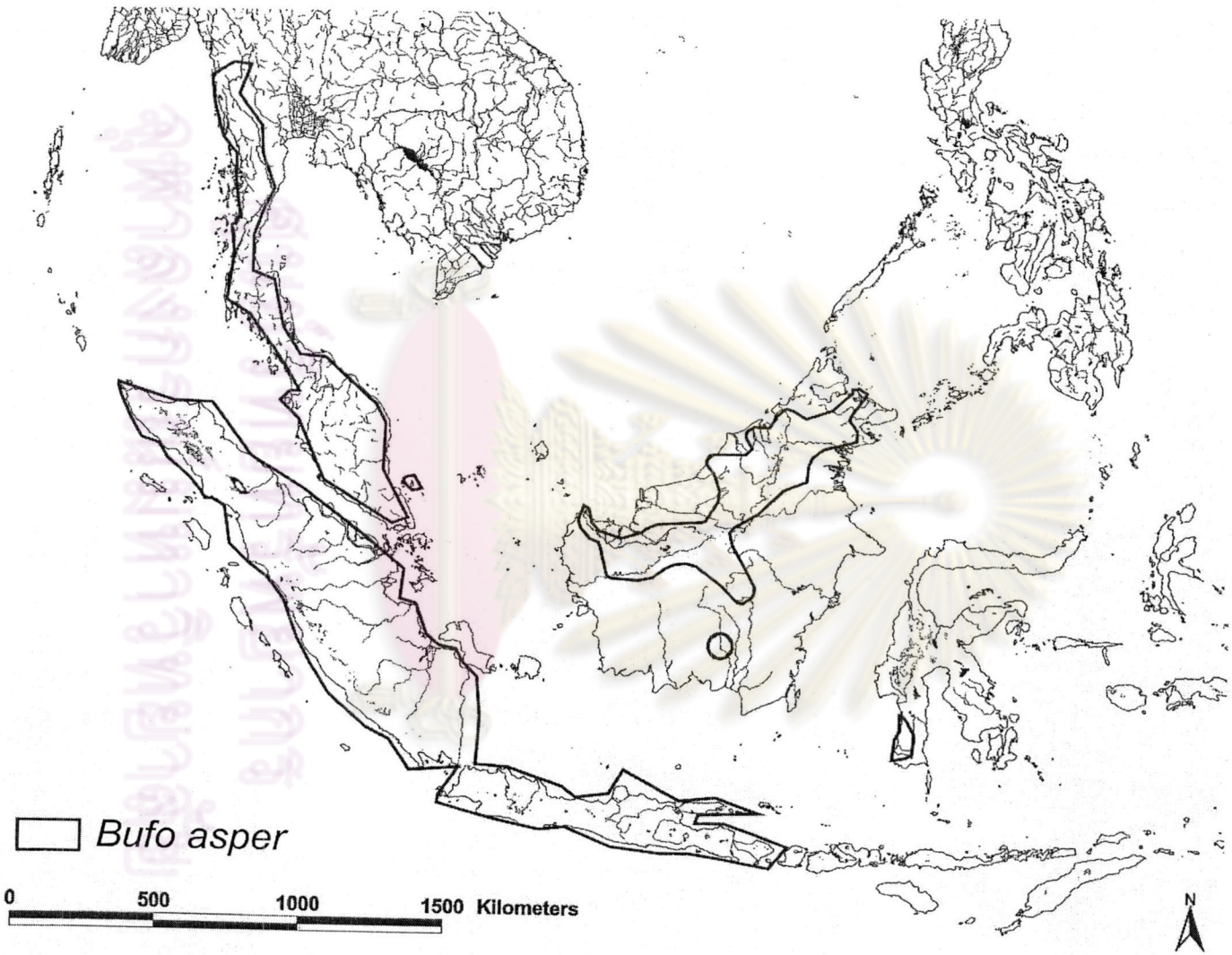

Figure 2.2 Distribution range of *Bufo asper* Gravenhorst, 1829 (modified from IUCN, 2002).

2.3 Population

Population is a collection of organisms of the same species occupying a defined geographic area. A species which is itself a population may consist of local populations. Those populations are separated in distance and that exchange migrants with one another (Ehrlich and Roughgarden, 1987).

Beklemishev (1960) classified populations into 6 types as the followings:

Independent population: population which can persist without any immigration, and its numbers do not depend on immigration.

Semi-dependent population: population which can persist without any immigration, however, its numbers depend on immigration. If there is no immigration, the abundance is much lower than in the presence of immigration.

Dependent population: population that can not persist without immigration. Organisms can reproduce in the area but the reproduction is not sufficient to sustain population numbers.

Pseudopopulation: population that can not reproduce at all. All organisms are immigrants.

Temporary population: In contrast to the first 4 types, this population always gets extinct after a while. Re-colonization is a rare event. For some period of time, the population is absent. Temporary populations may reproduce however it is not sufficient.

Hemipopulation: this is a population that consists of individuals in specific stages. Only those species have hemipopulations that change their environment during the life cycle. Example: a hemipopulation of dragonfly larvae in the lake.

For many ecological studies and conservation planning, the estimate of the abundance of a particular population and the population structure are necessary (Krebs, 1989; Friedl and Klump, 1997).

Ehrlich and Roughgarden (1987) suggested that the size of a population is rarely measured by counting the individuals in it, because all of individuals can not be located and their number may be too large. Instead, the size of a population is usually

measured by counting the number in some subset of the population and then statistically estimating for the total size and the common techniques that are used for measure population size in many species are mark and recapture or resight.

Krebs (1989) reviewed and concluded the method for estimation the size of population as the followings:

- Mark-recapture methods
- Removal methods and resight methods
- Quadrat counts
- Line transects and distances methods

Moreover, the population can be classified into:

- Closed population: the population that does not change in size during the study period. The effects of births, deaths, and movements are negligible and populations are typically closed over only a short period of time.
- Open population: the population that changes in size and composition from births, deaths, and movements. Open population is the more usual case.

Monitoring for amphibian population is the topic of increasing interest due to many species in many parts of the world have been considered as in decline (e. g., Blaustein and Wake, 1990; Crump, 2002; Lehtinen, 2002).

Wake (1994) concluded that species of amphibians in many parts of the world that once were common or occurred in dense populations had indeed declined and some possibly to the point of extinction. No single factor or set of factors could be advance to explain the decline, although habitat destruction and general environmental degradation were clearly implicated in many instances. Especially disturbing was the disappearance of certain celebrated species, such as the gastric-brooding frog and the golden toad, from well protected and large nature preserves.

Houlahan et al. (2001) studied on 936 amphibian populations that are representative of the global amphibian fauna and concluded that amphibians have been and are still declining.

Crump (2002) reported that most herpetologists now agree that amphibians are declining worldwide and reports from five continents reveal that population sizes have decreased, entire populations have disappeared, and some species have gone extinct.

However, Heyer et al. (1994) reviewed and provided a compilation of standardized methods for measuring amphibian biological diversity due to some of the information on amphibian declines was anecdotal and standard methods for documenting population changes did not exist or were not generally known. The methods that were proposed for measuring the population size were mark-recapture method and removal method.

Concerning conservation and other objectives, population ecology of amphibian in many parts of the world were examined.

Thornton (1961) investigated population dynamics in two sympatric species *Bufo woodhousei* and *Bufo valliceps* in Austin, Texas using toe-clipping method to study the habits and population structure with special attention to population size and movements of individuals. It was found that the size of breeding populations of both species was small (less than 200) and individual male toads tended to remain in their original breeding site from season to season.

Frazer (1967) monitored a breeding colony of *Bufo bufo* in Kent from 1955 to 1961 using toe-clipping and bead-sewing method to elucidate the factors concerned in the timing of breeding of the toad. It was reported that the population of breeding males varied between 900 and 2,000 individuals. The female numbers were only half to two-thirds those of the males. Only eleven per cent of the male present one year normally appeared during the next breeding season.

Berven (1990) followed two populations of *Rana sylvatica* in Maryland for 7 years to examine population regulation and reported that the breeding population size fluctuated by a factor of 10. Variation in the adult population among years was largely due to variation in juvenile recruitment. Most variation in the proportion of individual surviving to adulthood was due to variation in larval survival. Adult population size also negatively affected total clutch volume. Mean monthly rainfall positively affected adult survival.

Green (1992) studied population sizes and trend of *Bufo woodhousei* at Long Pont, Ontario using toe-clipping method and found that the calling male abundance rose markedly from 11 toads in the survey area in 1988 to over 245 in 1991. Non calling males, adult females, and juveniles showed a similar trend. The high water levels in Lake Erie in the mid-1980s that could have produced less favorable conditions for tadpole development and survivorship may have been responsible for the previous decline in toad abundance.

Alford et al. (1995) figured out population biology of *Bufo marinus* in Northern Australia since 1986 for examining the possibilities for biological control of this species and reported that no difference in rate of reproduction, growth, and survival between old and recently colonised populations was found.

Barreto and Moreira (1996) studied age structure of savanna larva anurans in central Brazil to obtain basic information for understanding ecological aspects of the adult phase and reported that *Scinax* sp. and *Hyla albopunctata* showed seasonal variation in size structure of their tadpole populations. The juvenile recruitment only occurred during the rainy season although the larva recruitment occurred throughout the year.

Green (1997) investigated abundance of *Bufo foweri* at Long Point, Ontario by tracking and using removal sampling during the breeding season in 1988 to 1994 and reported that the number of captured and marked males rose markedly from 12 toads in 1988 to 294 in 1991 then declined to 83 in 1994. Spring field studies and reference to weather records failed to identify factors correlated with the either the increase in adult males beginning in 1990 to 1991 or the decline of 1994.

Friedl and Klump (1997) examined population aspects of *Hyla arborea* in southern Germany during the breeding seasons in 1990 and 1991 using toe-clipping method and found that males outnumbered females at the breeding site in breeding site in both years. The observed sex ratio was 1.52: 1 and 2.15: 1 in 1990 and 1991, respectively. The age structure of the breeding population differed between the two study years. This difference in the age structure was correlated with yearly difference in the amount of rainfall during the reproductive season.

Magnusson et al. (1999) monitored a population of *Hyla boans* in central Amazonian rainforest during 15 years and reported that the population declined to zero density after nine years of study and the size still had not been recolonized six years later. The exponential rate of decline of the population (-0.58) was more than three times the exponential rate of increase (0.15) at the beginning of the study.

Lowe (2001) studied population structure of two sympatric species salamanders *Plethodon elongatus* and *Ensatina eschscholtzii* in the Klamath Mountains of northern California and found that *E. eschscholtzii* were twice as numerous as *P. elongatus* but both species had similar survival rates.

Patto and Pie (2001) investigated population dynamics of *Hylodes asper* in Southeastern Brazil and reported that there was clear seasonal variation in population structure and the population was characterized by the high juvenile recruitment.

2.4 Habitat Utilization

The need to gain a comprehensive understanding of the habitat utilization of amphibian is increasing in the light of apparent declines of some species. Moreover, the data on movement and habitat utilization are invaluable for management and restoration plan (Matthews and Pope, 1999; Monello and Wright, 1999; Seebacher and Alford, 1999).

Many studies have characterized or examined movement and habitat utilization of amphibians because the habitat is believed to play a role in distribution, abundance, and reproduction of them (Monello and Wright, 1999). Furthermore, movement and aggregation of individuals in the habitat of which the resource distribute have important effects on breeding behavior and survival of them (Marsh, Rand, and Ryan, 2000).

Semlitsch (1981) investigated terrestrial activity of *Ambystoma talpoideum* and reported that emigration of adults from breeding sites occurred in summer. Adults spent 237-354 days in terrestrial habitats before returning to breeding sites during autumn and early winter. Females spent significantly more time in terrestrial habitats than males.

Reading, Loman, and Madsen (1991) examined movement of *Bufo bufo* and found that the degree of relocation between ponds was negatively correlated to the distance between ponds. In any year, between 79% and 96% of adults that survived to breed the following year returned to the original pond.

Schlupp and Podloucky (1994) studied change in breeding site fidelity of a population of strong site fidelity species *Bufo bufo* for 7 years and found that a majority of the adult population became attached to the substitute breeding pond after only two to three years. The migration directed at the old breeding site dropped to approximately 15% after four years and subsequently to less than 1 %.

Spieler and Linsenmair (1998) figured out migration pattern of *Hoplobatrachus occipitalis* using radio transmitters from 1993 to 1995 and found that the frogs were found in diurnal shelters that offered favorable temperature and humidity conditions as well as protection against predators.

Matthews and Pope (1999) investigated movement of *Rana muscosa* using radio transmitters and found that *R. muscosa* had different movement patterns and habitat associations during the summer period compared to the winter when the dormancy period began.

Seebacher and Alford (1999) studied movements and microhabitat use of *Bufo marinus* and found that seasonal patterns in movement and microhabitat use were primarily related to soil moisture, rather than air temperature or relative humidity. Occasionally, toads returned to the same shelter site after activity at night, but the activity of homing was not greater than expected from a random model.

Marsh et al. (2000) investigated movement and aggregation of Physalaemus pustulosus and reported that male site fidelity increased with inter-pond distance and male aggregation decreased with distance. Phonotactic limits might play an important role in movements and spacing patterns.

Miaud, Sanuy, and Avrillier (2000) investigated terrestrial movement of *Bufo calamita* and reported that during the breeding season toads moved distances of up to

500 m between breeding sites. No significant difference in movement patterns was found between sexes but males showed higher terrestrial site fidelity than females.

Griffin and Case (2001) found significant differences between sex in land use and vegetation-type preferences of *Bufo microscaphus californicus*.

Mazerolle (2001) investigated the activity and direction of movement of amphibians in pristine and fragmented bogs of southeaster New Brunswick and found that seasonal activity patterns of amphibians in bogs corresponded to movements of adults and juveniles from adjacent wetlands and suggested that climatic variables, either precipitation or minimum air temperature generally good predictors of amphibian activity.