

NOTES ON THE GENUS *BOMBINA* OKEN

(Anura: Bombinatoridae):

I. RECOGNIZED SPECIES, DISTRIBUTION, CHARACTERISTICS AND USE IN LABORATORY

A series of three papers on the biology of *Bombina*

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INTRODUCTION

This paper is the first portion of a three-part series of papers summarizing pertinent information available on *Bombina*. Overall the series synthesizes information on distribution, external characteristics of recognized species of *Bombina*, together with aspects of external appearances, morphology, life history, systematics, fossil record and biogeography. This work is intended to facilitate further research on this taxon and should also be quite useful for individuals wishing to breed and maintain *Bombina*. This paper focusses on the distribution and characteristics of this genus.

RECOGNIZED SPECIES, SUBSPECIES AND DISTRIBUTION

- Bombina* Oken, 1816, Lehrb. Naturgesch., 3 (Zool.):207; type species *Rana bombina* Linnaeus, 1761. *Distribution*: Southern Sweden, Gulf of Finland south through Europe (exclusive of Iberian peninsula), Turkey, western USSR, eastern USSR, China, Korea, and northern Vietnam (Frost, 1985) (Fig. 1).
- Bombina bombina* (Linnaeus, 1761). Fauna. Svec., Ed. 2:101. *Distribution*: Central and eastern Europe from Denmark and western Germany east to the Ural Mountains and south to the Caucasus Mountains and Turkey; in the north to the Gulf of Finland, southern Sweden (Frost, 1985) (Fig. 1).
- Bombina fortinuptialis* Tian and Wu, 1981. Acta Herpetol. Sinica, 5(17):111. *Distribution*: Yaoshan and Longsheng, Guangxi, China (Fig. 2).
- Bombina maxima* (Boulenger, 1905). Ann. Mag. Nat. Hist., (7)15:188. *Distribution*: Yunnan, Guangxi, ?Guizhou, and Sichuan (Yunkwei Plateau) China; northern Vietnam (Fig. 2).
- Bombina microdeladigitora* Liu, Hu and Yang, 1960. Acta Zool. Sinica, 12(2):157. *Distribution*: Yunnan and Hubei, China (Fig. 2).
- Bombina orientalis* (Boulenger, 1890). Ann. Mag. Nat. Hist., (6)5:143. *Distribution*: Southern part of Soviet far east (Primorsky Krai [=Maritime Territory]); northeastern China (south to Jiangsu) and Korea (Frost, 1985) (Fig. 1).
- Bombina variegata*. *Distribution*: Southern Belgium and France, southward through all of Italy, Sicily, Yugoslavia, the Balkan Peninsula to the Black Sea, northward through Bulgaria, Romania, southeastern USSR, central CSSR, eastern and western Germany. Populations occur within range of *Bombina bombina* in Hungary (Herrmann *et al.*, 1987) (Fig. 1).
- B. v. variegata* (Linnaeus, 1758). Syst. Nat., Ed. 10, 1:211. *Distribution*: Southern Belgium, eastern and western Germany, central CSSR and northern Italy.
- B. v. kolombatovici* (Bedriaga, 1890), Bull. Soc. Natural, Moscou, (n. S) 3:568. *Distribution*: Middle and southern Dalmatia to western Montenegro (Herrmann *et al.*, 1987).
- B. v. pachypus*¹. (Bonaparte, 1838). Iconogr. Faun. ital., 2:23. *Distribution*: Appenninian Peninsula south of Poebene and Sicily (Herrmann *et al.*, 1987).
- B. v. scabra* (Küster, 1843), Isis (Oken), Leipzig, 1843:656. *Distribution*: Romania, Bulgaria, Greece, southern Yugoslavia and southern Turkey.

¹ Nascetti *et al.*, (1982) indicate the possibility of this taxon being a valid species.



Figure 3. TOP: *Bombina bombina* showing dorsal colouration and morphology (photo Max Sparreboom). MIDDLE: Dorsal colouration pattern *Bombina maxima* (female) (photo Max Sparreboom). BOTTOM: Dorsal view of *Bombina orientalis* (photo Wolfgang Böhme).

CHARACTERISTICS

SIZE

The two European species, *bombina* and *variegata*, attain snout-vent lengths of 56mm. *Bombina orientalis* reaches a snout-vent length of 45mm. Average snout-vent length of *Bombina maxima* is 60mm, with maximal size being 75mm.

OVERALL APPEARANCES

The body of *Bombina* is fairly robust, with the head only slightly differentiated and slightly depressed. The tongue is round, and almost entirely attached to the floor of the mouth. Upper part of head is entirely flat, and snout is rounded. There is no canthus rostralis. Pupils are more or less triangular, with apex directed downward. The tympanum is absent. Venter nearly smooth with a gular fold. *Bombina* retains lateral line organs after metamorphosis.

The dorsum of *bombina* has warts, whereas *variegata* and *orientalis* have strongly developed warts covered with horny hooks (Berger and Michalowski, 1971; Kawamura *et al*; Kawamura *et al.*, 1972) (Fig. 3). These warts are intermixed with strongly developed glands studded with pores. In *maxima*, glands lie behind the eyes (true parotid glands), on the tibia, on the tarsus and on the back where they form a pair of curved or angular chains behind the head, with the convexity turned inwards (Fig. 3). In the other species the parotid glands are not distinct. In *variegata* the dorsal papillae are surrounded by a large number of concentrically arranged tiny papillae whereas in *bombina* the dorsal papillae are single. In *fortinuptialis* the flank region and dorsal part of limbs are rather smooth with several flattened tubercles. Fingers are short, obtusely pointed, with the first being shortest, third finger the longest, and fourth a little longer than the second. There are no subarticular tubercles. Two round palmar tubercles are present, with the inner one longer and more prominent. *Bombina microdeladigitora* and *B. fortinuptialis* have slightly webbed toes.



Figure 4: LEFT: Ventral colouration pattern of *Bombina maxima* (female) RIGHT: Ventral pattern of *Bombina orientalis* (photos Max Sparreboom).

COLOURATION

The dorsal colouration of *bombina* varies from a grayish-black to a brown- or green-gray on a green background (Fig. 3). Populations of *bombina* with 10% of the individuals possessing a bright green dorsal colouration and yellowish venter were reported from Hungary (Marian, 1959; Hagedoorn, 1985). The dorsal colouration of *variegata* is a rather inconspicuous grey-black or green, sometimes spotted. The venter in *variegata* is a bright yellow to orange on grey-black, in *bombina* has a bluish-gray to blue-black background with yellow to vermillion

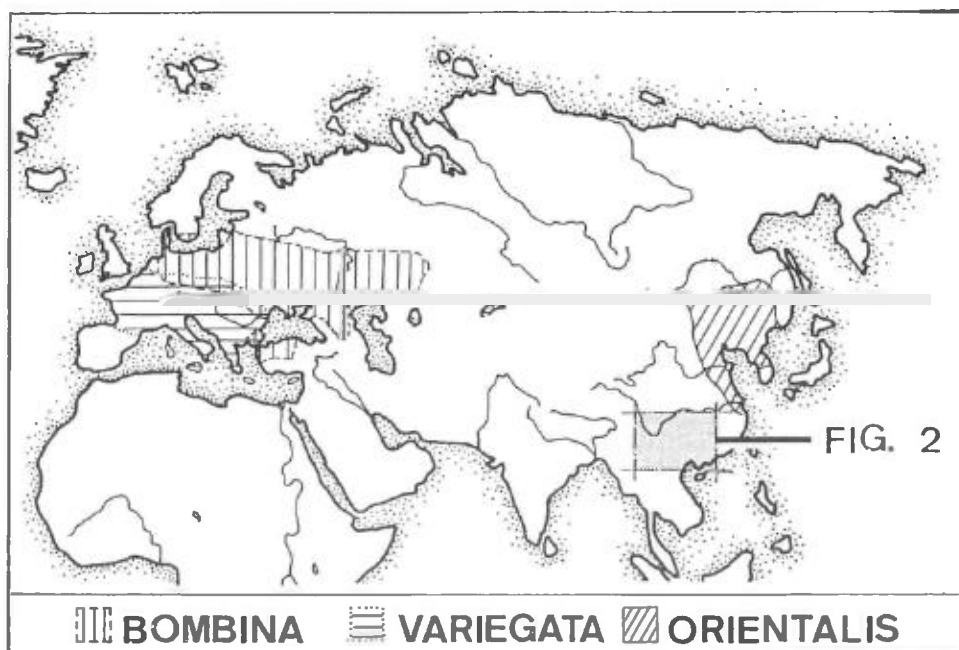


Figure 1: Distribution of *Bombina bombina*, *B. variegata* and *B. orientalis*. Shaded section is enlarged in Fig. 2 and contains the distributional ranges of the remaining 3 species of *Bombina*.

contrasting spots². The anterior portion of the venter is usually lighter than the posterior aspect. Additional colouration characteristics distinguishing the two European species are: the occurrence of two yellow patches on the breast of *variegata* that are connected to yellow patches on the ventral side of the arms, whereas in *bombina* there are two isolated orange patches on the breast. In addition, *bombina* has numerous white spots on the flanks in contrast to *variegata* which either lacks or has very few white spots on the flanks (Madej, 1964; Michalowski and Madej, 1969).

The dorsum of *orientalis* is brown or brilliant green with black spots (Fig. 3). The venter is red to red-orange with black spots (Fig. 4). The presence of carotenes in the epidermis of this species accounts for the ventral bright red-orange colours. These pigments are also present on the dorsum, but to a lesser degree and are in conjunction with coloured (yellow) and colourless pteridines (Frost and Robinson, 1984). The venter in young is white and the finger tips lack colouration.

Bombina maxima has a cinnamon brown ground colour. A green pigmented area is present on the dorso-median part of the shoulder region (Fig. 3). The throat, venter and inferior side of the limbs are black or dark grey variegated with scarlet, orange or orange-yellow (Fig. 4). Additional descriptions of *maxima* can be found in Bourret (1942).

Colouration patterns of *fortinuptialis* and *microdeladigitora* are not reported other than in the original type description.

SEXUAL DIMORPHISM

Bombina maxima exhibits sexual size dimorphism, with females being larger than males. In males a large diffuse nuptial pad covers the inner side of the arm, extending from the distal portion of the upper arm, and covering the inner face of the forearm, and 2/3 of the inner metacarpal tubercle (Liu, 1950, Fig. 16b). Nuptial pads are also found on the thorax near the base of each arm (Liu, 1950 Fig. 16a).

² These patterns are highly variable. Variation of *bombina* is described in Stugren (1980), patterns of *variegata* illustrated in Stugren and Vancea (1968).



Figure 2: Map of SW China with known localities of *Bombina maxima*, *B. microdeladigitora* and *B. fortinuptialis*. *Bombina maxima* (solid circles) is known from the following localities: 1) near Dongchuan (= type locality, Boulenger 1905), 2) Kunming (Schmidt 1927), 3) Xundian (Schmidt 1927), 4) Wuding (Schmidt 1927), 5) Lijiang (Schmidt 1927), 6) Dali (Mell 1922), 7) Chapa (Bouret 1939), 8) Zhaoqiao (Liu 1950), 9) Xichang (Liu 1950), 10) Yanyuan (Liu 1950), 11) Leibo (Bourret 1942), 12) Pingnan (Bourret 1942). *Bombina microdeladigitora* (cross) is known from 13) Jingdong (= type locality, Liu, Hu & Yang 1960), 14) Lichuan (Annon. 1977). *Bombina fortinuptialis* (open circle) has been recorded only from the type locality 15) Yangliuchong, Jin Xiu, Yaoshan Mts. (Tian & Wu 1981) (Locality data provided courtesy of Max Sparreboom).

Male *orientalis* are rougher than females and have fuller webbing, but shorter fingers, while the black dorsal markings are less distinct than in females. In *orientalis* the fore and hind legs of males are comparatively longer than those of the female (Kawamura *et al.*, 1972), but there is no overall size dimorphism.

The inner side of the fore-arm and the inner three fingers of male *fortinuptialis* have scattered cone-shaped black spines. The chest of the males also has a band-like area with many small spiny tubercles, each of which has 2-10 small black spines (Tian and Wu, 1981).

PHOTOGRAPHS AND SONOGRAPHS

Colour photographs of adults and tadpoles are numerous. Some can be found in Engelmann *et al.*, 1985; Grzimek, 1974; Obst *et al.*, 1984; Pracht, 1987; Schulte, 1980; Sparreboom, 1977; van den Elzen, 1979; Guyétant, 1986. Drawings of tadpoles, and tadpole mouth parts can be found in Berger and Michalowski (1971).

Sonographs of *B. variegata* are illustrated in Zweifel (1959) and in Schneider *et al.*, (1986); those of *B. orientalis* in Akef and Schneider (1985). In addition, sonograms of *bombina*, *variegata* and *orientalis* are illustrated in van den Elzen (1979).

LABORATORY USE AND TERRARIUM

Bombina has been regarded as an outstanding laboratory and terrarium amphibian (Nace and Ryuzaki, 1971; Kawamura *et al.*, 1972; Carlson and Ellinger, 1980). Important information on maintenance and breeding is given by Mudrack (1972), Sparreboom (1977), Gassel (1979),

Rogner (1981), Sparreboom and van den Elzen (1982), Obst *et al.* (1984), Herrmann *et al.*, 1987 and literature cited therein.

Following is a summary of pertinent information concerning the maintenance of *Bombina* in captivity. *Bombina bombina*, *B. variegata* and *B. orientalis* have approximate physiological requirements. These *Bombina* species are easily maintained and reproduce several times a year at a normal Day-Night cycle after a short hibernation at 4 degrees C.

The terrarium can be relatively simple and small. Recommended is a larger portion of water (water level from 4 to 7cm) in a terrarium not larger than 20 by 30cm for three pairs. The terrarium itself can consist of a few rocks projecting above the water line or a floating foam islet. Water plants with broad floating leaves are also recommended.

These animals feed readily in captivity. Suggested food items are: tenebrionid larvae, various Diptera and Lepidopterans as well as *Periplaneta*, *Nauphoreta* and *Schistocerca*. *Bombina variegata* also feeds on pieces of meat and liver.

The three pairs of animals are recommended because of mutual stimulation. Breeding can be initiated by changes in moisture and temperature gradients. Optimal breeding temperature is between 22-26 degrees C (Birkmeyer, 1954). Herrmann *et al.*, (1987) indicate that reproduction is stimulated after injections of 120 IE of Human-Choriongonadotrophin per animal in the musculature of the forelimbs. Females are stimulated 4 to 6 hours later than males. Shubravty *et al.*, (1985) experimented with success with synthetic releasing factors to promote reproduction.

Egg deposition usually occurs at night. Tadpoles emerge from eggs at temperatures of 20 degrees C after approximately 7 days. Tadpoles can be fed with dry fish food. Sexual maturity is reached after about 1 year (see sections on reproduction).

To maintain the bright ventral colouration, it is suggested to add beta-karotenes in conjunction with other karotenes to the food items when feeding or to the food medium of the insects themselves.

The larger *Bombina maxima* should be maintained in a correspondingly larger terrarium, also with the greater part containing water. A water level of up to 10cm is recommended. Again, a float, stone islet or water plants are suitable. Temperatures of 10 to 18 degrees C have proven to reduce mortality.

The adults feed well on larger insects, worms and newborn mice. Tadpoles can be fed with dry fish food. *Drosophila* and small insect larvae with a supplement of karotenes are suitable foods for juveniles.

After a short hibernation at approximately 5 degrees C, breeding can be stimulated by temperatures of up to 18 degrees C. Injections of Human-Choriongonadotropins have also proven to be highly successful in this species to stimulate reproduction. In open-air terraria the reproductive season of *B. maxima* is from March to October. Copulation is with inguinal amplexus. In this species both males and females vocalize. Sparreboom and van den Elzen (1982) further describe the mating behaviour of this species.

At temperatures of 16-20 degrees tadpoles emerge from the eggs after 8 to 12 days (Herrmann *et al.*, 1987). Metamorphosis starts at 6 to 10 weeks according to temperature (Bech, 1980) and sexual maturity is attained at circa 3.5cm.

No information on maintenance of either *B. microdeladigitora* or *fortinuptialis* is available.

ACKNOWLEDGEMENTS

I wish to thank to thank Wolfgang Böhme and Max Sparreboom for comments and information on references. Max Sparreboom is thanked for the use of the distribution map of the Chinese *Bombina* and colour slides. William E. Duellman and Linda Trueb reviewed an early draft of the manuscript. This study was supported by a stipend from the Deutscher Akademischer Austausch Dienst.

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