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NOTES ON THE GENUS *BOMBINA* OKEN

(Anura: Bombinatoridae):

II. LIFE HISTORY ASPECTS

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INTRODUCTION

This paper represents the second portion in a three-part series of papers summarizing pertinent information available on *Bombina*. Overall the series synthesizes information on distribution and characteristics of recognized species of *Bombina*, together with aspects of external appearances, morphology, life history, systematics and taxonomy. This paper focusses on the life history aspects of the species of *Bombina*.

LIFE HISTORY ASPECTS

No life history data has been recorded for *microdeladigitora* and *fortinuptialis*, therefore the following descriptions pertain to the remaining four species of *Bombina: bombina, maxima, orientalis* and *variegata*.

HABITAT

These semi-aquatic to aquatic toads live in shallow permanent to periodic bodies of waters and are predominantly diurnal although also active at night. *Bombina orientalis* is frequently found in swamps and rice paddies or low mountain streams. *Bombina maxima*, in contrast, inhabits mountainous regions and is found in small pools and ponds, especially those with dead vegetation. This species is less commonly found in small mountain streams. *Bombina variegata* is found from sea-level up to 1,800 m. and is very salt-tolerant (Parent, 1979), *bombina* at lower elevations, found in a variety of shallow bodies of water such as ponds, drainage ditches, pools and slow streams. *Bombina fortinuptialis* is found at elevations from 1200 to 1640 m in Guagxi, China (Tian and Wu, 1981). Excellent descriptions of habits of the European species can be found in Arnold *et al.* (1978). Day and night activity are predominant at temperatures between 10 and 30 deg. C in spring and summer.

HIBERNATION AND BREEDING SEASON

European *Bombina* hibernate on land in animal burrows or in loose soil. These species emerge from hibernation at different times depending on temperature and the amount of rainfall; usually by mid or late April.

The breeding season of *Bombina orientalis* in Korea is May and June, but eggs can be laid all year round. The breeding season of *maxima* is rather short and is usually restricted to early May.

NUPTIAL PADS

Nuptial pads are prominent on the inner aspects of the forelegs, palmar tubercle and first, second and third fingers during breeding season in *bombina, variegata* (Berger and Michalowski, 1971), *maxima* and *orientalis* (Stejneger, 1907). In addition *variegata* has nuptial pads on the toes of the hind leg (most frequently on the third toe).

VOCALIZATION

Vocal sacs are present in *B. bombina*[1] but are completely lacking in *B. variegata B. orientalis* and *B. maxima*. Conditions in *fortinuptialis* and *microdeladigitora* are not known.

Vocalization occurs at night or during the day (when reproductive activity is at its highest peak) in warm pools, ponds and ditches. Males occupy a specific position along the bank for weeks. Interspecific distances are maintained by calls. These distances are 3 m in *bombina* and slightly less in *variegata* (Lörcher, 1969). A solitary male *variegata* calls with a temperature-determined call. Call repetition rate and pitch in *bombina* and *variegata* show a positive rectilinear correlation with temperature. The duration of the call itself is negatively correlated with temperature (Zweifel, 1959; Akef and Schneider, 1985; Schneider *et al.*, 1986). There is also a difference in frequency of calls. For example a frequency of 80 calls per minute at temperatures of 20 deg. C for *variegata* versus 18 per minute of *bombina* under identical conditions. The calls of these two species can be easily differentiated because *variegata* always has a frequency of more than 40 calls per minute, in addition *bombina* and *variegata* differ significantly in their vocal chord size (Schmid, 1977). Call duration and frequency also changes with animal size, with calls of larger males lower in pitch and longer than those of smaller animals (Akef and Schneider, 1985; Schneider *et al.*, 1986).

European *Bombina* also call while suspended in water. Calling is usually in the evening and may last all night. The minimal vocalization temperature is 11 deg. C and the maximal vocalization temperature is 30 deg. C (Zweifel, 1959). Song in *variegata* is a musical "poop ... poop ... poop", which is brighter and faster than the mournful "oop ... oop ... oop" of *bombina* (Arnold *et al.*, 1978). Mating calls of European *Bombina* as well as hybrids thereof exhibit both intra- and interspecific differences (Schneider *et al.*, 1986).

Male *orientalis* produce five types of calls: normal mating call, modified mating call (= male excitement call), clasping call and male and female release calls. During calling, males distribute themselves in the water in such a way as to maintain distances of a few centimetres from one another. They defend their territories by means of mating calls or aggressive behaviour. The latter takes on three forms: frontal attack, attack from the side, or jumping onto the opponent's back (Akef and Schneider, 1985). The mating calls of *orientalis* is a monotonous "uuh ... uuh ... uuh", sounding like the tinkling of a small bell, that can be rather loud when males use body cavities as resonance chambers on the surface of the water. As is the case with *bombina* and *variegata*, call repetition rate and pitch in *orientalis* show a positive correlation with temperature. The duration of calling is negatively correlated with temperature.

Bombina maxima produces a weak croak like the sound of a very young chicken (Liu, 1950).

Antiphonal calling is also observed in this genus. The calls are long, drawn out and monotonous. Frog "choirs" can be initiated by a single individual.

[1] Male *Bombina bombina* have two vocal sacs in the throat area. Tyler (1980) indicated that these were not true vocal sacs but rather that they represent a resonance chamber involving the ventral protrusion of the buccal cavity (and the *m. geniohyoideii lateralis)* between the superficial mandibular muscles: *m. intermandibularis* and *m. interhyoideus.*

MATING

Female *orientalis* respond to mating calls of males by either swimming into the territory of a calling male or by generating water waves towards which the male swims (Akef and Schneider, 1985). The males clasp females in front of the hind legs in inguinal (lumber) amplexus. There may be two to three spawnings throughout the breeding season, but principally in May and June. However, individual females may spawn only once a year (Freytag, 1967; Kapfberger, 1984). *Bombina maxima* mates in inguinal amplexus in water (Pope, 1931, Sparreboom and van den Elzen, 1982). Mating in *variegata* is similar to that of *orientalis* as described above. Birkenmeier (1954) further gives details on mating behaviour in *variegata.*

EGGS AND TADPOLES

Eggs are greyish-brown and measure 2 mm in diameter in *bombina* and *variegata* and 3 mm in *maxima.* The egg with gelatinous envelope measures up to 8 mm. Clutches of 80-100 eggs are reported for *variegata,* in contrast to 100-300 eggs reported for *bombina.* Eggs are laid several times during the breeding season. The eggs are laid with characteristic movements in small clumps on vertical plant stems or grass outside the water *(bombina)* or sink to the bottom of the pool (Illustration in Engelmann *et al.*, 1985). Development of the eggs of European species can also occur in temporary rain puddles or drainage ditches. The preferred breeding

habitats, however, are small ponds with lots of vegetation, but tributaries with clay and muddy bottoms are also used during breeding. *Bombina maxima* lays its eggmass in open water; the eggs sink to the bottom or attach themselves to the underside of floating vegetation. *Bombina orientalis* attaches its eggs to the under surface of stones in small mountain streams (Liu, 1950).

The fertilized eggs of *orientalis* require 25-30 days before attaining the stage of protrusion of the forelegs at 25 deg. C. The complete development requires between 43 and 48 days. In laboratory studies an average female *orientalis* will produce 100 to 200 eggs per ovulation, when the interval between ovulations is 6 weeks. If the interval is 3 months then the number of eggs expected is 200 to 400. Percentage fertilization of these eggs is 95% (Carlson and Ellinger, 1980).

Eggs hatch after 7 to 9 days. The hatching tadpoles measure 6-7 mm *(bombina* and *variegata)* and up to 10 mm *(maxima),* and weigh from 0.0087 to 0.0113 g.

The metamorphosed young measure 12-15 mm (European species and *orientalis* and 17 mm in *maxima).* The larval development of *variegata* takes about 50 days, with low temperatures and crowding during metamorphosis leading to smaller toadlets (Kapfberger, 1984). Full metamorphosis takes place within 90 days. Larvae at the end of the breeding season, however, will overwinter. The fully metamorphosed young of these larvae usually measure 20 mm or more.

Tadpoles of *variegata* are not inhibited (crowding-effect) by their own species or by 6 other european anurans. In fact, tadpoles of *variegata* that often live in ecological sympatry in temporary rain-water pools with other European species *(Bombina bombina, Bufo calamita,* and *Hyla arborea)* show mutual tolerance (Heusser, 1972).

Life history studies of *Bombina bombina* by Bannikov (1950) indicated rapid growth during the first year followed by determinate growth. Embryonic and larval mortalities were estimated at 45.8% that increased to 97.9% after the first year. The high mortality is due to hibernation death. An estimated population renewal of 3.5 years is predicted. Population studies of *variegata* in northern Bavaria indicate a 1:1 sex ratio (Kapfberger, 1984).

SEXUAL MATURITY AND LONGEVITY

Bombina variegata and *B. bombina* attain sexual maturity in two years, at a length of 30-40 mm (Bannikov, 1950; Madej, 1964; Kapfberger, 1984). Maximal ages of *bombina* of 5 years and 10 months and 2 years 4 months for *orientalis* are reported (Bowler, 1975). Longevity of *Bombina* (sp?) in captivity of 12 years have been recorded. Sexual maturity of *orientalis* is reached at one year in this species and full size is attained at two years.

PREDATORS

Newts and larvae of 4 species of *Triturus* prey on tadpoles of *variegata* (Heusser, 1970).

MIGRATION

Local migrations of *Bombina* have been reported (Mertens, 1928; Madej, 1964). Reasons for migration are various: flooding, drying of bodies of water, looking for breeding sites or food sources and retreats for hibernation (Madej, 1964).

BEHAVIOUR

When disturbed on land, *Bombina* becomes motionless and displays its striking ventral colouration in an "Unkenreflex." The back is arched, the hands are pull forward over the eyes and the feet are pulled into the mid-section of the body. On occasion the animals lie on their back exposing the venter. Cutaneous poison glands secrete a foamy substance irritable to oral-nasal mucosa even without contact in humans (histaminic effect) and can cause death in amphibians (Gessner, 1926. Csordas and Michl, 1972). When disturbed in water, they will dive and bury themselves in the slime or mud at the bottom of the body of water.

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