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ZOOGEOGRAPHY OF *NASIKABATRACHUS SAHYADRENSIS* BIJU-BOSSUYT (AMPHIBIA : ANURA : NASIKABATRACHIDAE) IN THE WESTERN GHATS, INDIA

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INTRODUCTION

For over 250 million years, amphibians have been inhabiting habitats in tropical moist environments, where the bulk of them live. Climatic conditions similar to those of today in the rain forests and cloud forests of the tropics presumably prevailed during the upper Carboniferous when amphibians were already numerous.

A taxonomic scrutiny reveals that India has about 253 species of known native frogs, and researchers estimate that many more are yet to be discovered. Despite observed declines in the amphibian populations, scientists succeed in discovering and describing the amphibian taxa new to science. No other discovery of a biological species in the recent past has become as remarkable as that of *Nasikabatrachus sahyadrensis* (Fig. 1) described new to science, from India, by Biju & Bossuyt (2003). By virtue of its evolutionary antiquity, assessed as a contemporary of the Dinosaurs of Jurassic period, it was veritably 'the coelacanth of frogs' and therefore 'once in a century find' (Hedges, 2003). The molecular-clock dating studies related to phylogenetic DNA analysis of the new frog, recognized under a new family, indicated its relationship to the Sooglossidae, a family endemic to Seychelles, suggesting its evolutionary origin 130 m yrs. ago, even before the break up of the ancient Gondwanan landmass.

Dutta *et al.*, (2004), based on the specimens collected from a few localities in the Anamalais-Cardamom hill ranges of southern Western Ghats in Tamil Nadu and Kerala, described a fossorial frog taxon, without assigning to it a scientific name. They considered the frog taxon similar to *N. sahyadrensis*, under the family Nasikabatrachidae. About the distribution of *N. sahyadrensis* in

the Western Ghats, they presumed the home range of the species to lie between 8° and 11° N latitudes, *i.e.*, the sector of southern Western Ghats just south of the Palakkad Gap.

Our faunal exploratory efforts in the Western Ghats areas north of Palakkad Gap resulted in the collection of two fossorial frog specimens from a plantation-site (Kundode Estate, latitude11°06′·4″ N, longitude 76°64′ E, elevation approximately 500 m), adjoining the premises of a disturbed secondary forest, at Karuvarakundu, Malappuram District, Kerala. Both the adult specimens (ZSI/WGFRS-V/A : 575 and 576, Snout-vent length 57.2 and 87.5 mm, 03.viii.2004 and 06.vii.2005, Coll. K. Sajith and M.J. Palot, respectively) were examined and they proved to be *N. sahyadrensis* Biju & Bossuyt, 2003. The salient characteristics of the specimens agreed not only with the described features of *N. sahyadrensis* Biju & Bossuyt, but also with those of the fossorial frog taxon of Dutta *et al.*, (2004), thereby indicating that specimens illustrated by Dutta *et al.*, are of the species *N. sahyadrensis* itself. Further, our field and lab observations on the bionomics of this species have revealed that this fossorial frog is an underground forager adapted to live on the subterranean termites and ants.

The current collection of this species from an area north of Palakkad Gap, for the first time, indicates the extension of range of distribution of *N. sahyadrensis* to the areas beyond the Palakkad Gap (11° N latitude) in the Western Ghats. It is evident from available data of collections that both the natural and disturbed secondary forests constitute the home habitat of this species. We collected our sample specimens from a degraded forest (plantation) in the peripheral habitat environs of the Silent Valley rainforests of the 'Nilgiris' It is inferred that this fossorial taxon is very likely to inhabit both the prime and degraded/altered forest habitats in the Nilgiris, north of Palakkad Gap also as it has been observed to occur in the allied habitats in the Anamalais and Cardamom hills, south of Palakkad Gap. The range of distribution of this species, evidently, extends to further north of the presumed range of 8–11° N latitudes by Dutta *et al.*, (2004).

Given the availability of potential home habitat, close to the Nilgiris, this fossorial frog is also likely to occur in the forested habitat environs of Kodagu (Coorg) and adjoining areas in Karnataka, in close proximity to the Nilgiri hills. Therefore, it is presumed that the actual range of distribution of *N. sahyadrensis* is the stretch of the southern Western Ghats between 8–13° N latitudes, as this part of southern sector is biogeographically delineated from the Deccan Trap areas of the northern Western Ghats. A close look at the biogeography and the geomorphological evolution of this region, *i.e.*, the Peninsula of India of which the Western Ghats forms a part, would clarify the position.

Radiometric dating estimates have revealed the great antiquity of about 2500–2800 million years for some gneisses and schist in the dominating hill ranges (in Kerala and Southern Karnataka) of the Southern Western Ghats (Crawford, 1969). The basal complex of the Indian Peninsular block, according to Krishnan (1974), has probably been, geomorphologically, a distinct, relatively

little disturbed landmass of Archaean system since very ancient times, at least, from the Pre-Cambrian Era, and at a much later period, an integral part of the Gondwanan Landmass itself. Mani (1974a) is of the view that the true, original Indian flora and fauna, which essentially comprised tropical humid-forest forms, have originated from the ancient stock of the older Gondwanaland floras and faunas, evolved and differentiated throughout the Paleozoic, Mesozoic and Tertiary, even up to the Pleistocene times on the Indian Peninsular block of markedly advanced maturity.

They were widely distributed, ecologically and geographically differentiated and saturated to their maximum level to become evolutionarily stagnated or senile forms. The Gondwana faunal derivatives, therefore, represent the oldest component elements of the character fauna of the Peninsula. They include the Peninsular autochthonous endemics, and also other autochthonous forms having their closest allies in Madagascar (Lemurian faunas), or in South Africa (Ethiopian faunas) (Mani, 1974b). Savage (1973) has stated, in the case of Amphibia, that the historical biogeography of anurans is associated with Gondwanaland, based on the assumption that an ancestral stock of anurans was in Gondwanaland prior to its break up and separation in to continental landmasses.

Madagascar-Seychelles-Indian continent obviously had its share of diversity of life forms at the time of its rift from the rest of Gondwanaland about 140 million years ago (Bossuyt and Milinkovitch, 2001), presumably a biotic ferry transporting several groups of biota of Gondwanan origin, including anurans, and deporting various groups in isolation on fragments left along the path. Madagascar split away in the mid-cretaceous (88 million years ago). India-Seychelles sub-continent broke apart at the Cretaceous-Tertiary transition period (K-T boundary), in the early Paleocene 66–65 million years ago, with the massive flood basalt volcanism (Norton & Sclater, 1979; Mahoney, 1988). The catastrophic lava-deposits (Deccan Traps), which lasted for about 1.0–0.5 million years (Duncan & Pyle, 1988), covering the Western and Central Indian Peninsular plate, exterminated large chunks of the original, older character flora and fauna of the area, altering the effective size of the biogeographical area, shifting and reducing the range of numerous species.

The southern sector of the Western Ghats, which escaped from the massive volcanism and lava-flows, suffered only block fracturing and horst formation in the Archaean rock system, retaining the older, original character fauna of the region (*i.e.*, Peninsular autochthonous Gondwana elements) nearly intact, almost in isolation. The Deccan Trap Area, thus, served as a biogeographical barrier, isolating the original and older character fauna, confining it to the southern Western Ghats.

The drifting Indian plate finally collided with Eurasian continental mass, and the consequent series of intense orogenic movements resulted in the uplift of the Great Himalayan ranges towards the end of the Cretaceous, Tertiary and Pleistocene times (50–30 million years ago). Himalayan

uplift modified the climate and determined the flora and fauna, ultimately altering the biogeographical patterns/composition of India. New biogeographical routes through land connections, especially, the Assam Gateway, became the major thresholds for the influx and intermixing of younger Asiatic fauna with Indian fauna.

The rate and intensity of the older and senile Indian fauna recolonizing the virgin land and soils of the Deccan Trap region, during the intermittent quiescent periods of lava flows, and then making its efflux out of India, was rather much less than that of the profound influx of the Asiatic fauna (mainly from southeast Asia), which partly displaced the Peninsular autochthonous fauna, making them retreat to the extreme south of the Peninsula, even restricting them to isolated pockets/ enclaves.

The Deccan Trap of Western Ghats extends from Lava Traps in the north to the trench of river. Moyar in the South that cuts off Nilgiris from Mysore Plateau. Lava traps of the Ghats from river. Tapti to Goa is dominated by mountain chains with deep ravines and canyons on the western side and flat-topped hills intersected by valleys and table lands, mostly denuded, with terrace topography, cut by river valleys. In the southern edge below 16° N latitude, at the level of Goa, the Deccan Lava is heavily eroded, exposing the older Archaeans, by a series of breaches in the mountain wall, by the rivers Kalinadi, Gangavali-Bedti, Tadri and Sharavati in Karnataka.

The high rising hill-ranges (the Nilgiris, Anamalai-Cardamom Hills) of southern sector, mostly constituted by ancient rocks of Archaean system, and only partly modified by block-fracturing and horst uplifts (Pithawala, 1942), still have the comparatively older stock of the fauna and flora. The evergreen forests in the Western Ghats of Maharashtra (Deccan Trap Region), unlike the typical evergreen forests, are with trees characteristically dwarfish, with no tiers or canopies of tropical species, whereas the evergreen forests along the southern Western Ghats are, characteristically, tropical rain forests, reflecting different tiers, about three or four layers (Subramanyam & Nair, 1974).

In the background of biogeography of the Peninsula in relation to the geomorphologic events, particularly with reference to the formation of the Deccan Trap Area, the distribution of *N. sahyadrensis* is likely to be restricted to the stretch of southern Western Ghats in the range between 8–13° N latitudes, beyond which lies the Deccan Trap Area. As a rare possibility, its range of distribution, owing to reoccupation of the area, may go upto 16° N latitude, spanning the breach areas of lava ghats formed of the river basins. The breach areas with intermittent peaks and valleys receive heavy rainfall and therefore have lush growth of tropical forests, as also of rich soil that enables the reoccupation of the area by this fossorial frog.

The present-day fauna of India is only an impoverished relict of a formerly much larger and more widely distributed complex. Their present-day distribution reflects a heavy concentration of the character forms in the extreme southwest, especially in the southern part of the Western Ghats.

This sector still has some areas of refugial pockets or niches for some of the older character fauna, acting as ecological islands of favourable conditions amidst the disappearing habitats.

Given the phylogenetic antiquity of the species *N. sahyadrensis*, and the biogeography of the Western Ghats in relation to the geomorphologic evolution of the Indian sub-continent, *N. sahyadrensis* is to be deemed a Gondwanan relict of Peninsular autochthonous endemic species. The break of the Deccan Trap Region in the northern sector of the Western Ghats inevitably makes the distribution of this fossorial frog species confined to the range 8–13° N latitudes. Daniels (1992) has observed in an exploratory survey in the Western Ghats that nearly 95% of the amphibian fauna of the Western Ghats are known from the southern segment (8–13° NL), and that except for 3 species, all other species endemic to Western Ghats are confined to this part of the Western Ghats. The influence of the Deccan Traps in the dissemination of taxa is amply reflected here.

The notion that the amphibians and many other ancient fauna of India are mostly of humid forest forms having almost completely derived from Gondwanan derivatives has been emphasized by studies (Mahendra, 1939; Jayaram, 1974 & Mani, 1974b). Molecular phylogenetic analyses and dating estimates (Bossuyt and Milinkovitch, 2001) suggest that multiple lineages of frogs had diverged in Indian Peninsular landmass before KT boundary, and that India being the center of dispersal, different lineages radiated to Asia and other parts of the world, after an 'out of India' dispersal mode, contradicting the earlier belief of an 'out of Africa' trend (Savage, 1973). In that case, it is to be surmised that they have been an integral component of the original and older character fauna of the Peninsula of India, very much susceptible to the phases of both extinction/ evolution in the evolutionary biogeography of this region even after the break up of the Gondwanan land mass and drift of the 'biotic ferry' block of the Peninsula in the ancient geological past.

If Sooglossidae is related to Nasikabatrachidae, as suggested by Biju and Bossuyt (2003), sooglossids can be considered as isolated relicts, a derivative of the ancient lineage that is represented in India by *N. sahyadrensis* (Nasikabatrachidae). There is no compelling reason to assume that nasikabatrachids, the relatives of sooglossids, and other groups like microhylids, ranids and rhacophorids were not there in Seychelles; but those groups must have obviously embraced the fate of many island biota—extinction.

Molecular-clock-based dating estimates indicate that the origins of all the major neobatrachian lineages might have taken place in the Middle/Late Jurassic and Early Cretaceous period (Biju and Bossuyt, 2003), at around a time when the Gondwana supercontinent broke up into the western and eastern Gondwanan landmasses. One remarkable result of the phylogenetic DNA studies and the dating estimates, associated with the discovery of *N. sahyadrensis* is that it has, in the absence of conclusive fossil records, revealed information on the divergent times of the origin of major neobatrachian lineages, throwing light on their antiquity and evolution.

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