

Studies on Amphibians of Odisha: An Overview

Abstract

The work presented here is a compilation of information on various studies carried out on the amphibian species in Odisha. First hand information on updated taxonomy, distribution and threats to the species are provided. Distribution of three species of amphibians, namely *Microhyla rubra*, *Philautus sanctisilvaticus* and *Raorchestes terebrans* are reported for the first time from Odisha. The amphibian faunal diversity is represented by 29 species under 2 orders (Anura and Gymnophiona) and 6 families. The anurans are represented by 14 genera comprising 3 species of Bufonids, 11 species of Dicroglossids, 2 species of Ranids, 6 species of Microhylids and 6 species of Rhacophorids. Additionally, one species of Gymnophiona of family Indotyphlidae has recently been described from Eastern Ghats including Odisha. Besides taxonomic and ecological studies sizable literatures are available from studies on biology and applied research related to many amphibian species distributed in the state.

Introduction

Situated in the peninsular India, Odisha is one of the biodiversity rich states because of its varied physiographic and climatic conditions. The physiography of the state is an amalgamation of Chotta Nagpur plateau on the north, Deccan peninsula in west, Eastern Ghats in south and coastal plains towards the eastern side (Rodgers et al. 2003). The dominant forest types in Odisha are of dry deciduous type comprising northern tropical dry deciduous, moist deciduous, mixed forest, coastal mangrove forest and patches of semi-evergreen forests (Meher - Homji, 2001). The varied forest types and ecosystems offer suitable habitat for 29 species of amphibian species distributed in different habitat and ecological landscapes.

The first ever documentations of amphibian fauna of Odisha are from the survey records by Annandale (1915 & 1921). Stray records of amphibians pertaining to Odisha are also available from Boulenger (1890 & 1920). Behura (1965) compiled the information regarding amphibian fauna of Odisha in Odia language, describing four species of

frogs. Subsequent studies by Mohanty-Hejmadi (1976), Mohanty-Hejmadi & Dutta (1976), Dutta (1987a, 1987b, 1997, 1998 & 2003), Dutta & Routroy (1990) and Dutta & Acharjyo (1990) added more number of species to the checklist. Sarkar (1993) recorded 16 species of amphibians based on collection of 2401 specimens from various parts of the state. Various site specific surveys carried out in protected and outside protected areas of Odisha also contributed significantly in knowing the amphibian diversity of the state. Some of the important survey records are by Dutta et al. (2009) from Similipal Biosphere Reserve,

Key words:

Biology, conservation, distribution, ecology, status.

Polypedates cf. teraiensis
and *Chiromantis* sp

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Mohapatra et al. (2010) from Mahendragiri, Deuti & Raha (2010) from Karlapat and Konark-Balukh and wildlife sanctuaries, Sahu et al. (2012) from Hadagarh wildlife sanctuary, Mohapatra et al. (2013) from Nandankanan Wildlife sanctuary, Jena et al. (2013) from Bhitarkanika Mangroves, Sahu et al. (2014) from Gandhamardam Hills, Mishra et al. (2013) from Bolangir district and Rout et al. (2016) from Kuldiha wildlife sanctuary.

Amphibian fauna in the state is also well studied in terms of ecology, breeding biology and ecological energetics which has enlightened our knowledge on various aspects of amphibian biology other than taxonomy. Studies undertaken on these aspects are highlighted under each species. Age determination through skeletochronology technique has been carried out and Dutta et al. (2011) compiled the available information on eight different anuran species distributed in the state. Besides, studies on haematology, physiology and toxicology have also been pursued on many species of amphibians of Odisha. The most remarkable studies on amphibians in Odisha have been in developmental biology, where homeotic transformation of tail to limbs was observed in the tadpoles after the cut end of their tails were exposed to vitamin-A (Mohanty-Hejmadi and Crawford, 2003). Recently, Mahapatra and Mahapatra (2013) gave a detailed account of tail regression in some anuran tadpoles of Odisha. Apart from these works karyotypic work on one species of toad has been carried out in Odisha. Another study by Manna & Bhunya (1966) reported about 22 diploid chromosomes in most of the toads belonging to the genus *Bufo* (= *Duttaphrynus*) in both the sexes, though inconstancy of the chromosome number in various organs of adult and larval toad, *D. stomaticus* has been reported by Sharma, et al. (1965).

Although, great volume of work has been done on the amphibians of Odisha, the biology of many species is still poorly represented. Moreover, the studies are scattered and there was a need for compilation of the reports to give immediate information on various studies undertaken to outline future projects on amphibians of

the state and elsewhere. Hence, the present review gives a lucid account on the studies carried out on amphibians of Odisha and emphasizes the need for extensive studies on their biology.

Amphibian Diversity in Odisha

Amphibian fauna of Odisha is represented by two orders, Anura and Gymnophiona comprising 28 species of anurans and one species of caecilian. Status of each species with existing information on biology of the species are discussed as follows and summarized in Table 1. The nomenclature of amphibians followed here is after Frost (2017).

Order Anura

Till date 28 species of anurans are recorded from Odisha under 5 families and 14 genera comprising 3 species of Bufonids, 11 species of Dicroglossids, 2 species of Ranids, 6 species of Microhylids and 6 species of Rhacophorids.

Family Bufonidae

Genus *Duttaphrynus* Frost, Grant, Faivovich, Bain, Haas, Haddad, de Sá, Channing, Wilkinson, Donnellan, Raxworthy, Campbell, Blotto, Moler, Drewes, Nussbaum, Lynch, Green, and Wheeler, 2006.

Three species of toads under the genus *Duttaphrynus* are distributed in the state. Earlier mentions of *Bufo* for all the toad species of Odisha are now placed under the genus *Duttaphrynus* (see Frost, 2017). Among the toads, *Duttaphrynus melanostictus* is the most common species

Duttaphrynus scaber



and has a very wide habitat range throughout the state. Consequently, extensive studies on various biological aspects have been carried out on *D. melanostictus*. Studies on feeding habits, breeding biology and development of this species have been carried out by Behura et al. (1972) and Hota & Dash (1983). A very strange case of true hermaphroditism was observed in one specimen of this species from Bhubaneswar by Behera et al. (1971). Behura (1948a) reported *Acacia* thorn in the stomach of a toad and in another report, abnormalities of the oesophageal artery was reported by him (Behura 1948b).

Skeletochronology studies revealed the maximum longevity of this species to be 12 years (Nayak et al. 2007; Dutta et al. 2011). Effects of heavy metals and pesticides on physiology of *D. melanostictus* has also been assessed by various workers (Parida, Kisku et al. 2014; Parida, Mangaraj et al. 2014; Parida, Naik et al. 2014; Parida, Pal et al. 2014; Parida, Tudu et al. 2014; Parida, Naaz et al. 2015; Parida and Pattanayak, 2015; Pattanayak and Parida, 2014). Similarly, studies on tadpoles of *D. melanostictus* revealed that lysosomal enzymes and melanocytes act as key players in bringing about cell death during tail regression, an important event during metamorphosis (Mahapatra and Mahapatra, 2012; 2013; 2015a & b). Another study by Mahapatra et al. (2011) on two populations of *D. melanostictus* proposed that, apart from environmental factors, variations in the activity of lysosomal enzyme-acid phosphatase also mediates variations in the duration of larval period. Extraneously applied thyroxine showed toxic and teratogenic effects on the tadpoles of *D. melanostictus* and the effects were dose and stage specific (Mahapatra et al. 2015). Das and Dutta (1996) reported the development of ectopic supernumerary limbs in the tadpoles of *D. melanostictus* from cut end of tails exposed to vitamin-A.

Duttaphrynus scaber was first recorded from Odisha by Dutta (1987a) based on specimens collected from Sambalpur by Dr D. Platt during 1955-57. Later, this species was reported from Balugaon and other coastal districts of the state. Earlier mention of *Bufo andersonii* (a junior synonym of *D. stomaticus*) from Sambalpur by Mohanty-



Hylarana tytleri

Hejmadi (1976) actually corresponds to *Duttaphrynus scaber* (vide Dutta, 1987a). Dutta et al. (2009) mentioned distribution of the species throughout the state and this species is mostly restricted to agricultural fields and scrub forests.

Duttaphrynus stomaticus was first reported from the state by Dutta (1987a) from Sambalpur and Brajarajnagar. Later, this species was recorded from northern Odisha in Similipal, Thakurmunda (Dutta et al. 2009). The authors recorded small populations near Dhenkanal railway station and in Kamakhya Nagar. This species has patchy distribution in Odisha, living in sympatry with *D. melanostictus*. Parida et al. (1988) reported 22 diploid chromosomes in this species. Studies on growth and development of tadpoles of this species have been carried out by Dash and Mahapatro (1990), Hota et al. (1991), Mahapatro and Dash (1987, 1990, 1991a, 1991b, 1992).

Family Dicroglossidae

This family is represented by 11 species under 4 genera such as *Euphlyctis* (2 species), *Fejervarya* (4 species), *Hoplobatrachus* (2 species) and *Sphaerotheca* (3 species).

Genus *Euphlyctis* Fitzinger, 1843

This genus is represented by two species, namely *E. cyanophlyctis* and *E. hexadactylus*. The Indian skittering frog (*E. cyanophlyctis*) is one of the most common frogs found in all kinds of water bodies. Many colour morphs, such as olive green with dark blotches, reddish without any

marking, brownish and dark grey are observed in various populations of this species. Mohanty-Hejmadi and Dutta (1979) studied the breeding biology of this species. The maximum age of *E. cyanophlyctis* was recorded to be 6 years and sexual maturity was attained at the age of two years (Dutta et al. 2011). The other most conspicuous frog of this genus is the green pond frog (*E. hexadactylus*). This species was first recorded from the state by Dutta and Routray (1990) and the authors gave detailed description about ecology and natural history of the species. This species is distributed along the coastal districts of Odisha starting from Ganjam in the south to Balasore in the north and has also been recorded from Cuttack (Choudwar, Anshupa lake), Khurda, Bhadrak and Jajpur districts. Jena et al. (2013) reported this species from Bhitarkanika mangrove ecosystems. Singh and Dutta (1995) has discussed about various problems and suggested remedies for conservation of this species. Maximum age of this species has been reported to be at least 14 years in nature, whereas maturity in both males and females were attained at the age of two years (Nayak et al. 2008 & Dutta et al. 2011).

Genus *Fejervarya* Bolkay, 1915

The genus *Fejervarya* is represented by three species and one undescribed species, with certainty (pers. obs.). Of these, *Fejervarya syhadrensis* is most common and widespread, occurring in varied habitat types. The earlier records of *Fejervarya limnocharis* (= *Limnonectes limnocharis*) corresponds to *F. syhadrensis*, as the distribution of the former species is restricted to South East Asia (Frost, 2017). Several studies have also been carried out on the species under the nominal taxon *L. limnocharis*. Dutta and Singh (1997) discussed about status of *Limnonectes limnocharis* species complex in Asia and Mohanty et al. (1995) reported polymorphism and inheritance of mid-dorsal strip in the species hitherto referred as *Rana limnocharis*. Similarly study on breeding and life history of *L. limnocharis* was carried out by Mohanty et al. (1996) and later Mohanty et al. (1997) reported the population dynamics and growth of the species in natural conditions in Odisha. There are also reports of homeotic

transformation of tails to limbs on exposure to vitamin A in this species (Das & Dutta, 1996).

Another species under this genus is Dutta's cricket frog (*Fejervarya orissaensis*), which is widely distributed throughout the state but mostly confined to the agricultural fields. Dutta (1997) described the species as *Limnonectes orissaensis* based on specimens collected from Bhubaneswar, Balasore and Sambalpur.

The most interesting species of this group is the crab-eating frog (*Fejervarya moodiei*), which was earlier known by the name *F. cancrivora*. This species is distributed in coastal Odisha in the brackish water habitats of Balasore coast, Bhitarkanika, Dhamra and Chilika Lagoon.

It is presumed that the genus *Fejervarya* is represented by more numbers of taxonomically cryptic taxa in Odisha and in this paper we report occurrence of a most distinct form of undescribed species. Besides taxonomic studies, skeletochronology in *Fejervarya* sp. in Odisha revealed the maximum age to be four years and age of sexual maturity to be two years (Dutta et al. 2011).

Genus *Hoplobatrachus* Peters, 1863

The genus *Hoplobatrachus* comprises two species, i.e., the Indian Bull frog and the Jerdon's bull frog and both the species are distributed in Odisha. Apart from these two species there is an isolate population of *Hoplobatrachus* in Mayurbhanj district having external resemblance with *H. crassus* but differs from the later in colouration, call pattern and genetics.

The Indian bull frog breeds in temporary pools and the males become yellowish in colour during breeding season. The mating takes place during night time and continues till morning in rainy days. Dutta & Mohanty-Hejmadi (1976; 1981) studied the breeding, life history, sex ratio and size correlation of *H. tigerinus* and studies on larval biology were carried out by Dash & Hota (1980), Hota (1981) and Mohanty & Dash (1986). Some studies on effect of pesticides on the tadpoles of this species were also under taken by Dutta (1995), Dutta & Mohanty-Hejmadi (1978) and Mohanty-Hejmadi & Dutta (1981). Similarly, studies on larval

energetics of the species have been carried out by Hota (1986), Mohanty and Dash (1988). Inter and intra specific predation of *H. tigerinus* tadpoles was recorded by Mohanty-Hejmadi & Dutta (1981) and Hota & Dash (1983); the later study reporting predation of Indian bull frog tadpoles on *D. melanostictus* larvae. Mitra (1975) reported predation on adult *H. tigerinus* by giant water bug (*Belostoma indicum*). Homeotic transformation of cut end of tails to limbs upon exposure to vitamin A has also been observed in the tadpoles of *H. tigerinus* (Das & Dutta, 1996). Recently, there have been reports on tail regression (Mahapatra et al. 2012) and toxicological effects of pesticides on the tadpoles of *H. tigerinus* (Parida, Biraja et al. 2015; Parida, Jena et al. 2015). With reference to the Jerdon's bull frog Dutta et al. (1992) studied sexual dimorphism in the species and later in 1994 the authors studied the breeding and development of this species.

Genus *Sphaerotheca* Günther, 1859

The genus *Sphaerotheca* was earlier placed under the genus *Rana* and *Tormopterna* and is represented by three species in Odisha such as *Sphaerotheca breviceps*, *S. dobsonii* and *S. rolandae*. All these species are burrowing in habit and are mostly seen during breeding season, commencing from June to October, i.e. monsoon to post monsoon. The short-headed burrowing frog (*S. breviceps*) and the Indian burrowing frog (*S. rolandae*) are distributed throughout the state. Dutta (1988b) reported Dobson's burrowing frog (*S. dobsonii*) from Odisha and this species has been recorded from Mayurbhanj, Keonjhar, Cuttack, Khordha, Angul, Nayagarh and Kalahandi districts (Dutta et al. 2009 & pers. obs.). Das et al. (1996) studied population dynamics and growth while Dutta et al. (2005) analyzed the clutch and body size of the Indian burrowing frog. Das and Dutta (1996) also reported the formation of odd number of ectopic limbs in the tadpoles of *Tormopterna rolandae* (= *S. rolandae*) in their homeotic transformation experiments. Similarly, Mohanty-Hejmadi et al. (1979) studied the life history of the short-headed burrowing frog.

Family Ranidae

In Odisha, this family is represented by two genera (*Hydrophylax* and *Hylarana*) comprising two species.

Genus *Hydrophylax* Fitzinger, 1843

The earlier report of *Hylarana malabarica* from Sambalpur, Similipal, Keonjhar, Dhenkanal, Angul, Nayagarh and Khurdha districts are now placed under *Hydrophylax bahuvistara* (See Padhey et al. 2015). Sarkar (1993) recorded the species from Odisha, based on two specimens collected from Badrama and Bhawanipatna and provided a comparison between the two morphs. Kar et al. (2011) recorded predation of an adult fungoid frog by a giant water bug.

Genus *Hylarana* Tschudi, 1838

One species of frog under this genus has been known to occur in Odisha, namely *Hylarana tytleri*, which was earlier reported as *Rana erythraea* from Bhubaneswar and Cuttack (Mohanty-Hejmadi, 1997; Sarkar, 1993). This species has been further recorded from Kendrapada, Jagatsinghapur, Puri, Khurdha and Cuttack districts of Odisha. Frost (1997) mentioned about *H. taipehensis* from Odisha, which probably corresponds to *H. tytleri*.

Family Microhylidae

This family is represented by six species in the state under two genera *Uperodon* (4 species) and *Microhyla* (2 species).

Genus *Uperodon* Duméril and Bibron, 1841

Earlier names of *Kaloula taprobanica* and *Ramanella variegata* are now synonymised under genus *Uperodon*. Dutta (1987b) recorded *Kaloula pulchra* from Konark-Balukhand area of Odisha which actually corresponds to *Uperodon taprobanicus* (= *Kaloula taprobanica*).

Life history study on marbled balloon frog (*Uperodon systoma*) was carried out by Mohanty-Hejmadi et al. (1979a). A famous experiment conducted in the Cell and Developmental biology laboratory of Utkal University, Odisha was the first report of homeotic transformation in vertebrates where extra limb generation was observed in marbled balloon frog, *U. systoma* at site of tail amputation after vitamin-A treatment (Mohanty-Hejmadi et al. 1992). Later,

homeotic transformation was also reported in the tadpoles of *M. ornata* and other anurans as discussed above (Das and Dutta, 1996).

Genus *Microhyla* Tschudi, 1838

Two species, namely ornate narrow-mouthed frog (*Microhyla ornata*) and red narrow-mouthed frog (*M. rubra*) are distributed in the state, of which the former is common throughout. The red narrow-mouthed frog is reported for the first time from the state based on photographic evidences and collection of voucher specimens. The species has been recorded from South Odisha, specifically in Nayagarh (Baisipalli WLS), Ganjam and Phulbani districts. Khan et al (1979), Mohanty-Hejmadi et al. (1980); Dei et al. (1994) and Dash and Dei (1998) have given detailed account on life history of the ornate narrow-mouthed. Dey et al. (1989) discussed about chondrification and osteological development of vertebral column in the tadpoles of the species through differential staining and mentioned that the chondrification as well as ossification occurs proximo-distally. The maximum age of *Microhyla ornata* was found to be four years by skeletochronology studies and although the females attained sexual maturity at two years, males became sexually mature at one year (Dutta et al. 2011). Recently, Hota et al. (2013) published the blood cell profile of developing tadpoles and adults of ornate frog, *Microhyla ornata*.

Family Rhacophoridae

This family is represented by six species under three genera, such as *Chiromantis* (1 species), *Philautus* (2 species), *Raorchestes* (1 species) and *Polypedates* (2 species).

Genus *Chiromantis* Peters, 1854

The genus *Chiromantis* (= *Chirixalus*) was first reported by Dutta et al. (2009) from Similipal, Balasore, Dhenkanal, Cuttack, Khordha, Nayagarh and Ganjam districts of Odisha, which corresponds to *Chiromantis simus*. Age estimation studies in *Chiromantis simus* show the maximum age of the species to be four years in nature (Dutta et al. 2011). Das and Mahapatra (2016) have recently described the blood cell profile of developing tadpoles of *Chiromantis simus*.

Genus *Philautus* Gistel, 1848 and

Raorchestes Biju, Shouche, Dubois, Dutta, and Bossuyt, 2010

Dutta (2003) discovered *Philautus similipalensis* from Similipal Biosphere Reserve based on specimens studied from the Reserve and later this species was recorded from Mayurbhanj, Khurdha, Dhenkanal, Ganjam, Gajapati and Rayagada districts. The other two species of bush frogs recorded for the first time from Odisha are *Raorchestes terebrans* from Koraput and Mahendragiri and *Philautus sanctisilvaticus* from Potangi, Koraput district based on specimens collected from these localities. *R. terebrans* and *P. sanctisilvaticus* are reported for the first time from the state by the authors. Deuti et al. (2014) also reported *P. sanctisilvaticus* from Araku valley, Andhra Pradesh, which is close to Potangi hills.

Genus *Polypedates* Tschudi, 1838

This genus is represented by two species, namely Indian tree frog (*Polypedates maculatus*) and six-lined tree frog (*P. teraiensis*). Among these species the former is widely distributed in the state where as the later has a patchy distribution in Mayurbhanj, Cuttack and Khurdha districts of Odisha (Dutta et al. 2009). Dutta et al. (2001) studied breeding and development of *P. maculatus* and reported the clutch size of 107-678 with hatching success of 90%. Das and Mahapatra (2012 and 2015) have elaborated the blood cell profile of developing tadpoles of *Polypedates teraiensis* and *P. maculatus*. The haematology of adult *P. maculatus* (Mahapatra et al. 2012) and *P. teraiensis* has also been worked out by Das and Mahapatra (2014). Age estimation studies in *Polypedates teraiensis* shows the maximum age of the species to be five years (Dutta et al. 2011). Numerous studies on vitamin A mediated tail regeneration have been done on rhacophorids especially *P. maculatus* (Mahapatra et al. 2001; Mohanty-Hejmadi and Crawford, 2003; Mahapatra et al. 2004). Recently, Mahapatra et al. 2017 studied the immunohistochemical localization of acid phosphatase in non-amputated, normally regenerated and vitamin A treated abnormally regenerated tails (a prerequisite for ectopic organ development) of tadpoles of *P. maculatus*. Studies on tail regression in tadpoles of *P. maculatus* revealed the involvement of cathepsin D as an important

enzyme for causing cell death in the resorbing tail (Mahapatra and Mahapatra, 2011). Inter-specific variations in the duration of tail regression in *D. melanostictus*, *P. maculatus* and *H. tigerinus* were also attributed to the differential levels of cathepsins in the regressing tails (Mahapatra et al. 2012; Mahapatra and Mahapatra, 2013).

Order Gymnophiona

Family Indotyphlidae

The Order gymnophiona is represented by one family and a recently described species from Eastern Ghats, named *Gegeneophis orientalis*. This species is the first caecilian reported from the state of Odisha, the first teresomatan caecilian from the Eastern Ghats, and is the only Indian indotyphlid known from outside the Western Ghats region. The Eastern *Gegeneophis* is known only from above 1,100 m in habitats with canopy cover and most preferably in riparian zones. The species appears to be tolerant of some anthropogenic disturbance, because it was locally abundant in coffee estates, but it has not been found where the canopy is open, and much forest habitat has been lost (Agarwal et al. 2013). Till now the only known habitat of this caecilian species is at Deomali in Odisha, which is being degraded rapidly through large-scale livestock grazing and fuel wood collection, and the hills in Koraput District are facing threats from mining and monoculture social forestry activities. Nothing is known about the biology and ecology of this species.

Conservation of Amphibians in Odisha

Major predicted threats to the amphibian fauna are habitat loss, pollution, poaching, diseases and climate change (Stuart et al. 2004). Impact of pollution due to pesticides is a well known negative factor affecting all aquatic life including amphibians, which has been highlighted by various workers (Mann et al. 2009; Khangarot and Ray, 1987; Birge et al. 2000). Broadly, pollution is the impact of anthropogenic activities and water pollution directly affects the amphibian population causing various genetic and morphogenetic deformities. Sometimes the overdose cause complete wiping out of the population as observed in several agro-ecosystems (pers. obs.).

Industrial effluents drained to aquatic ecosystem, eutrophication, and washed off agricultural pesticides are some of the major threats to the aquatic amphibian species (Broomhall, 2004). Thus, amphibians are also good bio-indicators of pollution. Dutta (1997) also discussed about various threats and conservation measures for amphibians of north-eastern Orissa, with special reference to Similipal.

Similarly, habitat degradation or loss due to conversion of wetlands to human habitation and agricultural fields are equally major threats for survival of many amphibian species. Although reports on amphibian poaching cases in Odisha are negligible, many of the amphibians (mostly the *Hoplobatrachus* species and the green pond frog) are consumed for their meat. However, from unofficial sources poaching of frogs still continues by some specific communities in rural and urban Odisha though no commercial exploitation has been noticed. In traditional medicine, meat of *Hoplobatrachus tigerinus* is believed to have zootherapeutic use to cure asthma. It is also pertinent here to mention that some of the frogs of genus *Rana* (now placed under genera *Euphlyctis* and *Hoplobatrachus* of Family Dicroglossidae) are listed in Schedule - IV of Wildlife (Protection) Act, 1972. In addition, the export of these species requires permits under CITES and the Indian Wildlife (Protection) Act, 1972.

There are some records of diseases due to fungal infection and nematode parasites among amphibians in India (Dhanukar et al. 2013; Molur et al. 2015). However, impacts of such diseases are not studied in Odisha. Furthermore, diseases are often climate related, so surveillance and monitoring of such diseases in nature will be effective to control any epidemic in future.

Studies conducted elsewhere in the world has shown that many frog populations are forced towards extinction, seemingly from climate warming (Pounds & Crump, 1994; Pounds et al. 1999) and for tropical species of amphibians rainfall seems to be the most significant climatic factor (Bickford et al. 2010). Climate change along with other habitat related threats have visible impact on some of the amphibian species in Odisha which are yet to be reported. Studies have also shown that many amphibian species

have adapted to prolonged breeding period and skip hibernation.

Many of the ecological assessment projects made for clearance of developmental activities have underestimated the actual species diversity either in favour of the companies or due to ignorance. Similarly road traffic poses some serious threats on amphibian species as the road kill incidents increases and many frog and toad populations might completely cut-off from the nearby populations (Fahrig et al. 1995; Vijaykumar et al. 2001). Hence developmental projects without scientific validation of impact assessments severely affect the local fauna. Furthermore, with the advancement of modern techniques and scientific thought a better management strategy can be developed without affecting much to the ecosystem.

Apart from the continuous taxonomic resurrections in amphibian species, there are several erroneous records and incomplete reports with reference to amphibian fauna of the state. Murthy (1987) reported six species of amphibians from Chilka lagoon, which was with many typological errors (repeat of the species name *Rana breviceps*; typological error in the name Bufo and record of *Rhacophorous leucomystax*). Sarkar et al. (1993) reported *Rana keralensis* for the first time from Odisha from Simlipal and mentioned that the species is rare in the state, which probably corresponds to *Fejervarya orissaensis*. Similarly, survey report of Rout et al. (2016) from Kuldiha wildlife sanctuary is with taxonomic errors and probably due to incomplete survey the mentioned amphibian species diversity suffers from underestimated species diversity.

Conclusion

Current knowledge on amphibian species diversity and distribution in Odisha still need more systematic approach. With increasing popularity of molecular taxonomy, the rate of describing cryptic species has increased many folds. Hence, it is believed that modern taxonomic tools will be of utmost use in resolving the taxonomy of the cryptic amphibian species of the state. The current compilation also indicates enormous scope to undertake studies on ecology, toxicology, physiology; developmental biology and ethology since the basic biology of the amphibians found in Odisha is still unknown. Sincere conservation efforts and long term surveys to assess and mitigate various levels of threats including climate mediated changes on amphibians are some of the challenges to be addressed.

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PLATE-1



Duttaphrynus melanostictus, Bhuvaneshwar



Amplexing pair of *Duttaphrynus stomaticus*, Sambalpur



Duttaphrynus scaber male, Bhuvaneshwar



Duttaphrynus scaber female, Dhenkanal



Euphlyctis cyanophictis, Ganjam



Euphlyctis cyanophictis, Baisipalli WLS



Amplexing pair of *Euphlyctis hexadactylus* from Ganjam



Euphlyctis hexadactylus, Bhitarkanika WLS

PLATE-2



Fejervarya orissaensis, Baisipalli WLS



Fejervarya orissaensis male, Choudwar, Cuttack



Fejervarya syhadrensis, Sambalpur



Fejervarya sp., Barbara



Fejervarya mogdiei, Bhitarkanika WLS



Hoplobatrachus tigerinus, Koraput



Hoplobatrachus crassus, Ganjam



Amplexing pair of *Hoplobatrachus crassus*, Mayurbhanj



Sphaerotheca breviceps, Mahendragiri



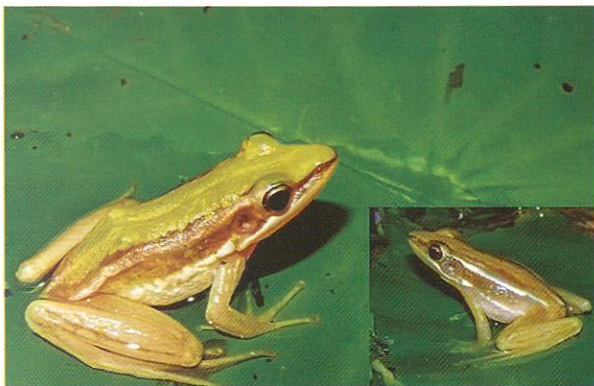
Sphaerotheca rolandae, Barbara RF, Khurdha



Hydrophylax bahuvistara, Baisipalli WLS



Hydrophylax bahuvistara, Simlipal



Hylarana tytleri, Bhitarkanika WLS



Microhyla ornata, Kotagarh WLS



Microhyla rubra, Baisipalli WLS



Uperodon variegatus, Mayurbhanj

PLATE-4



Uperodon globulosus, Mayurbhanj



Uperodon systoma, Bhubaneswar



Polypedates maculatus, Angul



Polypedates teraiensis, Barbara, Khurdha



Chiromantis simus, Kalinga, Phulbani



Philautus sanctisilvaticus, Gupteswar, Koraput



Raorchestes terebrans, Potangi hill, Koraput



Gegeneophis orientalis, Deomali, Koraput

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Amplexing pair of *Duttaphrynus stomaticus*

Table 1. Diversity, distribution and conservation status of amphibians of Odisha

S. No.	Taxon	Taxonomic remarks	Distribution	Status		Threats & Conservation
				IUCN	WLPA	
Order Anura						
Family Bufonidae						
1	<i>Duttaphrynus scaber</i> (Schneider, 1799)	Earlier records of <i>Bufo fergusonii</i> , <i>B. scaber</i> and <i>B. andersonii</i> from Odisha refer to this species.	Throughout the state	LC	NL	As this species is most common in agricultural fields, use of excessive pesticide may have serious impact on the population
2	<i>Duttaphrynus stomaticus</i> (Lütken, 1864)	Earlier report of <i>Bufo stomaticus</i> refers to this species.	Mayurbhanj, Keonjhar, Sambalpur, Dhenkanal districts	LC	NL	Patchy distribution and may be occurring in low population.
3	<i>Duttaphrynus melanostictus</i> (Schneider 1799)	Earlier records of <i>Bufo melanostictus</i> refers to this species.	Throughout the state	LC	NL	No major threats
Family: Dicroglossidae Anderson, 1871						
4	<i>Euphlyctis cyanophlyctis</i> (Schneider, 1799)	Earlier reports of <i>Rana cyanophlyctis</i> and <i>R. keralensis</i> from Odisha refer to this species.	Throughout the state	LC	IV	There is no major threat to the species
5	<i>Euphlyctis hexadactylus</i> (Lesson, 1834)	Earlier records of <i>Rana hexadactyla</i> refers to this species.	Coastal districts	LC	IV	Meat consumption, habitat loss/ degradation, excessive use of pesticide.

S. No.	Taxon	Taxonomic remarks	Distribution	Status		Threats & Conservation
				IUCN	WLPA	
6	<i>Fejervarya orissaensis</i> (Dutta, 1997)	Earlier record of <i>Limnonectes orissaensis</i> belongs to this species	Throughout the state	LC	NL	Use of pesticide is the major threat to the species.
7	<i>Fejervarya syhadrensis</i> (Annandale, 1919)	Earlier reports of <i>Limnonectes limnocharis</i> belongs to this species.	Throughout the state	LC	NL	Use of pesticide is the major threat to the species.
8	<i>Fejervarya moodiei</i> (Taylor, 1920)	Earlier records of <i>Rana cancrivora</i> and <i>Fejervarya cancrivora</i> are considered to be this species.	Along the east coast in Bhitarkanika, Kendrapada, Balasore, Bhadrak and Chilika	DD	NL	Habitat destruction and degradation are some of the common threats in its distribution range in Odisha.
9	<i>Fejervarya</i> sp.	Taxonomic status of this frog population is pending but from preliminary molecular and morphological investigation, it is inferred that this species is new to science.	Similipal, Satkosia, Nayagarh, Phulbani, Gajapati, Koraput and Kalahandi			No immediate threat envisaged. In Koraput, this species was found in agricultural fields and use of pesticides might have adverse impact on the population.
10	<i>Hoplobatrachus crassus</i> (Jerdon, 1854)	An interesting colour morph has been recorded from an isolated patch in Northern Odisha, which warrants detailed taxonomic investigation.	Throughout the state.	LC	IV	Habitat degradation and pesticide.
11	<i>Hoplobatrachus tigrinus</i> (Daudin, 1802)	Earlier records of <i>Rana tigrina</i> and <i>R. tigrina</i> refer to this species.	Throughout the state	LC	IV	Major threats are from poaching for consumption of meat (also ethnozoological value), habitat degradation and pesticide.
12	<i>Sphaerotheca breviceps</i> (Schneider, 1799)	Earlier records of <i>Rana breviceps</i> and <i>Tomopterna breviceps</i> refer to this species.	Throughout the state.	LC	NL	No major threats envisaged.
13	<i>Sphaerotheca dobsonii</i> (Boulenger, 1882)	Earlier records of <i>Tomopterna dobsonii</i>	Mostly in Sal forests of the state.	LC	NL	No major threats envisaged.
14	<i>Sphaerotheca rolandae</i> (Dubois, 1983)	Earlier records of <i>Tomopterna rolandae</i> refer to this species.	Throughout the state.	LC	NL	No major threats envisaged.
Family: Ranidae Rafinesque-Schmaltz, 1814						
15	<i>Hydrophylax bahuvistara</i> Padhye, Jadhav, Modak, Nameer, and Dahanukar, 2015	Earlier report of <i>Rana malabarica</i> and <i>Hydrophylax malabarica</i> from Odisha refer to this newly described species.	Throughout the deciduous forests of the state.	NE	NL	No immediate threats envisaged. This species naturally occur in low population.

16	<i>Hylarana tytleri</i> Theobald, 1868	Earlier records of <i>Rana tipegensis</i> by Dutta & Acharjyo (1990) and <i>Rana erythraea</i> by Sarkar (1993) from Odisha corresponds to this species. Two distinct colour morphs, green and brown are observed in the state, warranting taxonomic investigation.	Kendrapada, Jagatsinghapur, Puri, Khurdha and Cuttack districts.	LC	NL	Habitat loss due to clearing of floating aquatic vegetations and clearing of weeds around the water bodies are some common threats to the species. Run-off residual pesticides might have deleterious impact on this species.
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Family: Microhylidae Günther, 1858

17	<i>Microhyla ornata</i> (Dumeril and Bibron, 1841)	Two distinct morphotypes are observed in the state, warranting taxonomic investigation.	Throughout the state.	LC	NL	Conversion of wetlands in to human habitation and use of pesticides are some of the threats to the species.
18	<i>Microhyla rubra</i> (Jerdon, 1854)	Sexually dichromatic species, needs validation.	South Odisha, specifically in Nayagarh (Baisipalli WLS), Ganjam and Phulbani districts.	LC	NL	This species naturally occur in low population. In the known distribution localities small scale sand mining might have adverse impact on the population.
19	<i>Uperodon taprobanicus</i> (Parker, 1934)	Earlier records of <i>Kaloula taprobanica</i> and <i>K. pulchra</i> from Odisha refer to this species.	Throughout the state including mangrove forests.	LC	NL	Habitat loss due to cutting of trees with holes and buttresses are threats to this species. Use of pesticides might have adverse impact on the larvae as well as adults.
20	<i>Uperodon variegatus</i> (Stoliczka, 1872)	Earlier records of <i>Ramanella variegata</i> refers to this species.	Throughout the state.	LC	NL	Use of pesticides in agricultural fields might be adversely impacting the population.
21	<i>Uperodon globulosus</i> (Gunther, 1864)	Possibility of hybrid population between <i>U. systoma</i> and <i>U. globulosus</i> observed in Odisha from Mayurbhanj.	Throughout the state.	LC	NL	In some areas the early breeders suffer from quick drying of temporary water bodies and hence cause mass mortality of tadpoles.
22	<i>Uperodon systoma</i> (Schneider, 1799)	Same as above.	Throughout the state.	LC	NL	Same as above.

Family: Rhacophoridae Hoffman, 1932

23	<i>Chiromantis simus</i> (Annandale, 1915)	Earlier record of <i>Chirixalus</i> sp. and <i>Chiromantis</i> sp. from Odisha	Mayurbhanj, Dhenkanal, Angul, Cuttack,	LC	NNL	Habitat loss and infection due to a flesh fly are some of the known threats to this
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S. No.	Taxon	Taxonomic remarks	Distribution	Status		Threats & Conservation
				IUCN	WLPA	
		are now placed under the said species.	Khurdha, Ganjam, Gajapati			species.
24	<i>Philautus similipalensis</i> Dutta, 2003	Several morphs are recorded from the state, warranting in-depth taxonomic study.	Similipal (Mayurbhanj dist.), Kuldiha (Balasore dist.), Kapilas (Dhenkanal dist.), Barbara (Khurdha dist.)	LC	NL	No major threats envisaged.
25	<i>Philautus sanctisilvaticus</i> Das and Chanda, 1997	New record from the state.	Koraput.	CR	NL	No major threats envisaged.
26	<i>Raorchestes terebrans</i> (Das and Chanda, 1998)	New record from the state. Earlier known from the type locality Vishakhapatnam, Eastern Ghats, Andhra Pradesh.	Koraput and Gajapati districts.	DD	NL	No major threats envisaged.
27	<i>Polypedates maculatus</i> (Gray, 1830)	Earlier records of <i>Rhacophorus maculatus</i> refers to this species.	Throughout the state.		NL	Nest predation due to a flesh fly for the individuals breeding during post-monsoon seasons (August-September) is the major threat to this species.
28	<i>Polypedates teraiensis</i> (Dubois, 1987)	Confusion related to the exact distribution status of this species in Peninsular India.	Mayurbhanj, Cuttack and Khurdha districts.		NL	Habitat loss/ degradation might have adverse impact on the species.

Order: Gymnophiona

Family: Indotyphlidae Lescure, Renous, and Gasc, 1986

29	<i>Gegeneophis orientalis</i>	Newly described species from Eastern Ghats and Odisha.	Deomali	NE	NL	Habitat loss, deforestation, fishing activities near the stream, forest fire, collection of tubers and other livelihood dependency from the forest. This species has only been recorded from non-protected area in the state, so Deomali should be declared as a biodiversity heritage site considering the unique biodiversity.
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NE: Not evaluated by IUCN; NL: Not listed in Indian Wild Life (Protection) Act, 1972

Uperodon systoma,
Marbled balloon frog
Photo : Varun Kher

