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Exploitation of frogs – a review with a focus on West Africa

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Abstract. With a continuously growing global human population the exploitation of natural resources is likewise increasing. Herein we provide an overview on exploitation and trade of amphibian species in different regions of the world, with a main emphasis on West Africa. Whereas particular West African tribes have always used frogs as food, medicine or for cultural reasons, the current increase in frog hunting seems to be new. Amphibian declines are likely and may result in measurable changes to aquatic and riparian ecosystems.

Key words. Amphibia, Anura, Benin, Burkina Faso, freshwater ecosystem, *Hoplobatrachus occipitalis*, Nigeria, over-exploitation, West Africa.

Introduction

The human reliance upon natural resources is often seen as one of the strongest political arguments to preserve the global biodiversity (Convention on Biological Diversity – CBD 2008 – www.biodiv.org, last accessed on 22 April 2008). However, an over-exploitation of these resources is one of today's major threats to biodiversity, leading e.g. to habitat degradation and conversion, erosion of genetic diversity, species decline and loss, destabilization and destruction of ecosystems and hence is jeopardizing present and future livelihoods (Cowlishaw 2005, CBD 2008).

Amphibians are one of the most threatened groups of animals, with at least one third of the ca. 6,000 known species being threatened with extinction (Stuart et al. 2004, 2008). Reasons for this are numerous but besides habitat degradation and loss, disease and rapid enigmatic declines, over-exploitation is mentioned as one of the main causes (Gibbons et al. 2000, Stuart et al. 2004, Halliday 2008). Whereas habitat destruction, global change and most of all disease have gained much research interest, overexploitation of frogs is rarely mentioned to be of any importance. However, a recent report by Niasse et al. (2004) states that utilization is the main threat for 281 amphibian species (mainly anurans), 54% of these being already listed as Vulnerable, Endangered or Critically Endangered when IUCN Red List categories and criteria are applied. The results of the IUCN Global Amphibian Assessment (now under the IUCN Red List of Threatened Species) support this statement by listing 220 species that are currently used for food, already indicating that many more species might be affected (Cox et al. 2008). Amphibian species are harvested and used worldwide mainly as a food source, i.e. frog legs are thought to be delicacies in many regions of the world. However, frogs are also collected for leather production and souvenirs, for the pet trade and for cultural reasons including traditional medicine (Oza 1990, Veith et al. 2000, Stuart et al. 2004, Young et al. 2004, Kusrini & Alford 2006, Gonwouo & Rödel 2008). Most attempts to commercially breed frogs in larger quantities under artificial, farm-like conditions have failed (Oza 1990, Helfrich et al. 2001) and hence the majority of amphibians are still taken directly from the wild (Helfrich et al. 2001, Kusrini & Alford 2006).

Where this exploitation exceeds sustainability amphibian species are doomed with local declines or extinctions (Jensen & Camp 2003). In addition to these direct impacts on particular species, other indirect effects like

the loss of ecosystem functions are likely consequences (Duffy 2002, Wright 2006). For example, amphibians play an important role in various terrestrial and aquatic ecosystems, both as predators and as prey (Toledo et al. 2007, Halliday 2008, Mohneke & Rödel 2009). A decline of particular amphibian species may thus result in an overabundance of prey species, i.e. various pest arthropods, and/or leave predators with a limited food supply. From our long-term personal experience it seems that the use of particular frog species recently has dramatically increased in West Africa. The consequences are unknown. In this paper we will summarize the most prominent examples of over-exploitation in amphibians worldwide. We provide a first insight into the West African situation and we highlight respective research needs.

Unsustainable use of amphibians

Although many amphibian species are adapted to high mortality rates and hence to moderate exploitation alike, an intensive harvest at least of particular species, may result in an over-exploitation of local population or even whole species and thus in their decline. However, hard data on actual harvested frog numbers and respective consequences for populations are still scarce or completely lacking. In Table 1 we provide information on the main frog and salamander species harvested, including their respective uses. In the following paragraphs we briefly summarize amphibian exploitation in different regions of the world. We mainly focus on the use of frogs for consumption. Besides food trade, particular amphibians are also caught in large quantities for the pet trade (Schlaepfer et al. 2005). The species in greatest demand are the African dwarf clawed frogs (*Hymenochirus* spp.; 2.4 million individuals officially imported into the US between 1998 and 2002), followed by the Chinese fire-bellied newt [*Cynops orientalis* (David, 1871), approximately 1.6 million] and the Oriental fire-bellied toad [*Bombina orientalis* (Boulenger, 1890), approximately 1 million] (Schlaepfer et al. 2005). About 13,000 poison-dart frogs (Dendrobatidae) were exported from Latin America between 1987 and 1993, the majority, nearly 8,000 individuals, being imported into the US (Gorzula 1996). A total of 221,000 frogs of different species (approximately 70% of them identified as *Mantella* spp.) were exported from Madagascar for the international pet market between 2000 and 2006 (Carpenter et al. 2007).

Europe

Frogs were already consumed during the Roman Empire, and presumably much earlier. Since the 16th century frogs and their legs in particular, have became a delicacy in European gastronomy (Neveu 2004). The majority of them were harvested from nature. In smaller quantities this was sustainable for centuries. However, after World War II the demand seemed to increase tremendously. The European green frog complex, *Pelophylax* spp. in particular, has served as the main resource for frog legs especially in France, followed by Belgium and the Netherlands (responsible for 80-90% of the European trade). Due to the large numbers of harvested frogs in France (40-70 t per year; Neveu 2004), the collecting, transport and sale of native frog populations was prohibited by French law in 1980. As a consequence France leads the world today in the import rates of frog legs (3000-4000 t per year) and living frogs (700-800 t per year) (Neveu 2004) from Southeast Asia (see Veith et al. 2000). A more recent example of autochthonous frog use in Europe is from Romania (Török 2003). As fish stocks declined drastically in the Danube Delta the sustainable exploitation of frogs was proposed. Between 1960 and 1970, an annual amount of 120 t of frogs was collected from Romanian waters, resulting in many depopulated biotopes which previously had been crowded with frogs.

Asia

Asian countries currently export the highest numbers of frogs (see Warkentin et al. 2009). Until 1985, 200 million frogs were exported each year from Asia to Europe, e.g. West Germany imported 500 t (12 million frogs) from Bangladesh in 1984 (Oza 1990). For many years, India and Bangladesh were the main Asian exporters for frog legs. However, as a consequence of declining frog populations [mainly *Hoplobatrachus tigerinus* (Daudin, 1802) and *Euphlyctis hexadactylus* (Lesson, 1834)], and a resulting increase of insect pests, India banned exportation in 1985 (Oza 1990). Unfortunately there seems to be no research to examine the potential recovery of these species since then.

With 4000 t of frogs harvested annually (Kusrini & Alford 2006), Indonesia is today's world leading export country for frog legs, most of them (83.2%) still sold to Europe. Because of limited supplies, particularly during the dry season, the export numbers sometimes do not even meet the demand. Established frog farms do not cultivate native species, but introduced species like the North American bullfrog, *Lithobates catesbeianus* (Shaw, 1802) (Kusrini & Alford 2006). If these frogs make their way into the wild, this might pose a further threat to the native fauna. Bullfrog larvae are known to have strong negative effects on the growth and survival rate of tadpoles of other species (Kupferberg 1997, Kiesecker et al. 2001) and adults regularly devour other amphibian species (Ficetola et al. 2007). Furthermore, *L. catesbeianus* is a successful carrier of chytridomycosis (Daszak et al. 2004), an emerging infectious disease of amphibians caused by the amphibian chytrid fungus.

Indonesian frogs are however, not only harvested for the overseas market, the local market seems to play an equal or even greater role (Kusrini & Alford 2006). As the human population grows and resources such as fish decline, people often switch to other protein sources like particular frog species, mainly larger ranids. Recent investigations have shown that in Indonesia large frogs have already completely disappeared from habitats such as paddy fields and riversides close to human settlements, where they usually should be common (Veith et al. 2000). Depleted frog populations due to over-exploitation seem to be a common Southeast Asian phenomenon. In China, 84 species are negatively affected by utilization, because of illegal collecting and a high domestic demand for these species. Especially, ranoid species, like *Hoplobatrachus rugulosa* (Wiegmann, 1835), are harvested for utilization. Twelve out of 39 utilized species decline rapidly and are threatened with extinction (Carpenter et al. 2007). The collapse of populations of favorite frog leg species in Asia shows that even in common, fast-growing and fecund species such levels of exploitation are not without limit (Lau et al. 2008).

North and South America

Whereas frogs were probably used as food by many Native American peoples for a long time, it was the European immigrants who introduced the commercial utilization of frogs in North America. Native frogs became important food sources and between the late 1800s and early 1900s, amphibians were exploited for the American frog leg market. During this period, hundreds of thousands of Red-legged frogs (*Rana aurora* Baird & Girard, 1852) and over 20 million Leopard frogs [*Lithobates pipiens* Schreber, 1872) and allied species] were collected annually from California wetlands and northwestern Iowa (Gibbons et al. 2000). It has been estimated that between 1920 and 1992 amphibian populations in an Iowa county declined from at least 20 million to 50,000. At least one-third of this decline could be attributed to harvesting; two-thirds however were due to wetland drainage (Lannoo et al. 1994). As local populations started to decline, frog legs have been imported from Asia, e.g. in 1976

Tab. 1. List of exploited amphibian species (excluding dendrobatid frogs), the scale of trade (R = regional, N = national, I = international) and the current conservation status based on the IUCN Red List of

Species	Utilization	Region
Urodela		
Ambystoma dumerilii	Food, medicine	Mexico
Ambystoma mexicanum	Food, medicine, pet trade, research	Mexico
Cynops orientalis	Pet trade	China
Anura		
Astylosternus spp.	Food	Cameroon
Bombina orientalis	Pet trade	East Asia
Chaunus marinus	Food, souvenir, pet trade, research	America, Australia
Conraua crassipes	Food	Cameroon
Conraua goliath	Food	Cameroon
Conraua robusta	Food	Cameroon
Euphlyctis hexadactylus	Food	India, Bangladesh
Fejervarya cancrivora	Food	Indonesia
Hoplobatrachus occipitalis	food	Africa
Hoplobatrachus rugulosus	Food	South and Central China
Hoplobatrachus tigerinus	Food	Southern Asia, India
Hyla cinerea	Pet trade	United States
Hyla eximia	Pet trade	Mexico
Hymenochirus curtipes	Pet trade	DRCongo
Kassina decorata	Food	Cameroon
Limnonectes macrodon	Food	Indonesia
Lithobates catesbeianus	Food	North America
Lithobates pipiens	Food, research	North America
Mantella spp.	Pet trade	Madagascar
Pachymedusa dacnicolor	Pet trade	Mexico
Pelophylax lessonae	Food	Europe
Pelophylax nigromaculata	Food	Central and Northeast China
Pelophylax ridibundus	Food, medicine, research	Europe
Pyxicephalus adspersus	Food, pet trade	Africa
Rana aurora	Food	North America
Rana chensinensis	Food, medicine	Central and Northeast China
Rana plancyi	Food	Central and Northeast China
Rana temporaria	Food	Europe
Rhinella arenarum	Research	Argentina
Rhinella arunco	Research	Chile
Telmatobius culeus	Food (human & animals), medicine, leather	Peru, Bolivia
Telmatobius marmoratus	Food, medicine	Peru
Trichobatrachus robustus	Food, cultural purpose	Cameroon
Xenopus amieti	Food	Cameroon
Xenopus laevis	Research, food	Africa

Threatened Species (LC = Least Concern, VU = Vulnerable, NT = Near Threatened, EN = Endangered, CR = Critically Endangered).

Scale	Time of exploitation	IUCN Status	Reference
I	Present	CR	Carpenter et al. 2007
I	Present	CR	Carpenter et al. 2007
I	Present	LC	Schlaepfer et al. 2005
R	Present	LC-CR	Gonwouo & Rödel 2008
I	Present	LC	Schlaepfer et al. 2005
R, N, I	Present	LC	Pough 2001
R	Present	LC	Gonwouo & Rödel 2008
R	Present	EN	Gonwouo & Rödel 2008
R	Present	VU	Gonwouo & Rödel 2008
I	Past	LC	Oza 1990, Veith et al. 2000
R, I	Present	LC	Veith et al. 2000, Kusrini & Alford 2006, Carpenter et al. 2007
R, N	Present	LC	pers. obs.
R, N, I	Present	LC	Jensen & Camp 2003, Carpenter et al. 2007
I	Present	LC	Pough 2001, Oza 1990, Carpenter et al. 2007
I	Present	LC	Schlaepfer et al. 2005
I	Present	LC	Carpenter et al. 2007
I	Present	LC	Schlaepfer et al. 2005
R	Present	LC	Gonwouo & Rödel 2008
R, I	Present	VU	Kusrini & Alford 2006, Carpenter et al. 2007
	Present	LC	Pough 2001, Carpenter et al. 2007
R, N, I	Present	LC	Jensen & Camp 2003
I	Present	LC-CR	Carpenter et al. 2007
I	Present	LC	Carpenter et al. 2007
N, I	Present	LC	Jensen & Camp 2003
R, N	Present	NT	Carpenter et al. 2007
R, N, I	Present	LC	Pough 2001, Jensen & Camp 2003, Neveu 2004, Carpenter et al. 2007
R, N	Present	LC	pers. obs., Pough 2001, Carpenter et al. 2007
R, N	Past	NT	Jensen & Camp 2003
R, N, I	Present	LC	Carpenter et al. 2007
R, N	Present	LC	Carpenter et al. 2007
N, I	Past	LC	Neveu 2004
N	Present	LC	Young et al. 2004
I	Present	LC	Young et al. 2004
R, N	Present	CR	Angulo 2008
R	Present	VU	Angulo 2008
R, I	Present	LC	Gonwouo & Rödel 2008
R	Present	NT	Gonwouo & Rödel 2008
R, I	Present	LC	Weldon et al. 2007

2500 t of frog legs were imported to the US, predominantly from Japan and India.

It seems that some South American indigenous people were always familiar with the use of frogs. Frogs of the genus *Telmatobius* have traditionally been consumed or used for medicinal and ritual purposes by locals in the Andes of Peru and Bolivia. Their medicinal use locally varies, comprising treatment of asthma, epilepsy, headaches, and stress (Angulo 2008). Today, the overall numbers of consumed *Telmatobius* is on the increase and populations of different species [e.g. *T. arequipensis* Vellard, 1955, *T. culeus* (Garman, 1876), *T. gigas* Vellard, 1969, *T. jelskii* (Peters, 1873)] are declining dramatically (IUCN 2008). In Peru, dealers were selling about 180 frogs daily at one market in Cusco (Angulo 2008). Each week between 1200 and 2400 frogs are requested per dealer. Thus, besides agricultural practices and water pollution, commercial utilization is one of the main threats to many members of this severely threatened genus (De la Riva & Lavilla 2008).

Several American frogs have also been collected for research and teaching purposes, especially leopard frogs during the 1960s and 1970s in the US. In South America thousands of *Rhinella arunco* (Molina, 1782) in Chile and *R. arenarum* (Hensel, 1867) in Argentina were collected for science and education (Young et al. 2004). Today, more than 1000 t of amphibians and reptiles still cross the US border each year, 96% of them for commercial purposes (Schlaepfer et al. 2005). The consequences for the respective source populations and ecosystems are unknown.

Africa

For research and medical purposes the African clawed frog [*Xenopus laevis* (Daudin, 1802)] has been used since the 1930s. In South Africa each year over 10,000 of these frogs are collected from the wild and exported to over 30 different countries since 1998 (Weldon et al. 2007). The four major suppliers for *Xenopus laevis* in South Africa are restricted to certain areas and during specific time periods to prevent over-exploitation. However, it has been hypothesized that *X. laevis* is a successful carrier of chytridiomycosis and that the international trade in this species might have introduced this fungal disease to other regions of the world (IUCN 2008). In general the African frog trade and especially the actual dimension of frog harvest and consumption have not yet been a topic of scientific investigation.

In some regions amphibians (mainly toads) are used for medical treatments by villagers (e.g. south-eastern Guinea and Benin). Children's cough, appendicitis or skin injuries are among the diseases treated with toads. However, in Africa most amphibians are collected for food. The consumption of larger frog species like *Pyxicephalus adspersus* Tschudi, 1838, *P. edulis* Peters, 1854, *Hoplobatrachus occipitalis* (Günther, 1858), *Trichobatrachus robustus* Boulenger, 1900, *Conraua* spp. or *Ptychadena* spp. is known from a wide range of African countries e.g. Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Guinea, Namibia, Nigeria, South Africa and Togo (Okeyo 2004, Gonwouo & Rödel 2008, authors' unpubl. data). A variety of different ethnic groups from West Africa, e.g. the Gourmanché and Mossi in Burkina Faso (Fig. 1), the Yacouba in Côte d'Ivoire, the Bakossi in Cameroon, and the Yoruba in Nigeria, traditionally use frogs as food or for medical and cultural reasons. African amphibians are mainly harvested and consumed in and around the villages and often there is little selection for particular species other than size, i.e. larger species are preferred. Even toads [Fig. 2, *Amietophrynus maculatus* (Hallowell, 1854), *A. regularis* (Reuss, 1833)] and tadpoles (Fig. 3) are harvested, prepared and sold in local markets.

On the Obudu plateau, Nigeria, we observed a very intense collection of frogs and their tadpoles from small rivers (Fig. 3). This traditional use of frogs seems to have become unsustainable in recent years. Women harvesting these species now have to walk much

Fig. 1. Gourmantché woman offering *Hoplobatrachus occipitalis* as travel snack along a main road in southern Burkina Faso (Photo: A. Thiombiano).

Fig. 3. *Astylosternus* tadpoles and small catfish, smoked for sale on the Obudu Plateau, Nigeria.

Fig. 2. Mossi woman preparing toads (*Amietophrynus maculatus* and *A. regularis*) for sale in southern Burkina Faso. The toads are beheaded, skinned, disembowelled, washed and cut into pieces before being dried. These toads are the harvest of one day.

Fig. 4. Adult *Hoplobatrachus occipitalis* dried, smoked and packed for sale on a Nigerian market close to the Benin border. One sack contains about a thousand dried adult frogs, all caught along River Niger in northern Benin.

longer distances than previously to arrive at rivers that still provide enough amphibians to make the harvest feasible (authors' unpubl. data). A similar situation has been recently reported from nearby Cameroon (Gonwouo & Rödel 2008). Harvesting the larval stage in addition to adults may lead to a much faster breakdown of populations than collecting adults only, as this could result in an even more substantial loss of juvenile recruitment.

Besides a mainly local or national trade market, we also detected larger cross-border trade of amphibians from northern Benin into Nigeria. We are currently investigating the amount of harvested frogs and the trade routes this commercial use follows. Especially *Hoplobatrachus occipitalis* is harvested and traded in huge quantities (Fig. 4). One frog collector was observed harvesting between 150 and 200 adult *H. occipitalis* per day. On average collectors needed 7 to 10 days to fill up one large sack of dried frogs (app. 1000 individuals, Fig. 4). One sack sold to Nigerian traders generates an income between 15 € and 45 € depending on the season (2.50-4.50 € per day). Selling fish only yields a daily

income of 1.50-3.00 € and hence many fishermen change to hunting frogs. During one season a collector catches a minimum of 0.9 t of *H. occipitalis* from a maximum area of only 20 square meters (m^2) along the river banks of the Niger River, where the frogs accumulate during the dry season. With the beginning of the rains *H. occipitalis* usually migrate far into the savanna (Spieler & Linsenmair 1998). Thus the removal of frogs affects not only the area along the rivers, but huge parts of the hinterland.

In Burkina Faso we detected commercial frog trade in some regions (Ganzourgou province), whereas in other regions (Gourma province) frogs are harvested for local consumption. In the province of Ganzourgou 10 frog collectors caught approximately 2.2 t of *H. occipitalis* during one dry season, the actual number of active frog collectors, however, being much higher in this area. Ganzourgou province comprises 185 villages and 36,969 households (INSD 2006). Assuming there would be only one frog collector in every village, the actual amount of collected frogs would exceed 40 t. Judging from interviews with villagers and colleagues (i.e. Prof. Dr. A. Thiombiano, Université de Ouagadougou and member of the royal family of the Gourmanché, pers. comm. 20 May 2008) it seems that in the province of Gourma, the hot phase of frog harvest is already over, due to declining populations of *H. occipitalis* and other frog species. Comparable West African ecosystems are still rich in amphibians and all frogs from these regions so far tested for chytridiomycosis have been found to be chytrid negative (150 samples of 20 aquatic and semi-aquatic species; C. Weldon & M.-O. Rödel, unpubl. data). The frog declines in south-eastern Burkina Faso hence seem to be at least mainly driven by human collectors.

Economic consequences of over-exploited frog populations

Frogs play a vital role in eradicating insect pests. These pests destroy crops and carry diseases. One of the few studies estimating the effects of frog species removal from the wild was done in India (Abdulali 1985). An adult *Hoplobatrachus tigerinus* devours approximately 10% of its own weight in insects every day. During legal exports of Indian frog legs, 9000 t of *Hoplobatrachus tigerinus* were harvested annually. Hence, 900 t of insects, including mosquitoes and agricultural pests, survived daily and instead had to be controlled by other means, such as insecticides (Abdulali 1985). The commercial frog exploitation and resulting decline thus resulted in an increased use of agrochemical products in rice paddies, leading to increased environmental pollution and higher financial investment to achieve harvests comparable to the previous ones. Thus in summary the frog leg trade resulted in minor economic gains in the form of foreign exchange, but simultaneously has led to major ecological and economic losses (Oza 1990). Unfortunately, similar studies are lacking for most parts of the world, including Africa.

In West Africa, the arid and semi-arid regions in the Sahel and Sudanian zones are already affected by climate change (De Wit & Stankiewicz 2006). Alterations in rainfall patterns, increasing droughts, and decreasing availability of open waters will strike local human populations as well as wildlife. Unreliable and shrinking crops, however, do lead towards increasing dependence upon and use of natural resources. Under this scenario, it is unlikely that the demand for amphibians will diminish in the near future. In case of a potential overexploitation of particular frog species, the effects on the respective ecosystem may be inevitable (Lau et al. 2008). In a second paper we will summarize which effects potentially may result from declining frog populations (Mohneke & Rödel 2009).

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