

A survey of amphibians and reptiles in Chu Mom Ray National Park, Vietnam, with implications for herpetofaunal conservation

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ABSTRACT

A herpetological survey was conducted in spring 2012 in the eastern part of Chu Mom Ray National Park, Kon Tum Province, southern Vietnam, to create a first inventory list of amphibians and reptiles and record threats to the local herpetocommunity. We also evaluated the efficiency of two faunistic inventory methods, drift fences and transect visual encounter surveys, in detecting reptiles and amphibians under the given circumstances. Five drift fence arrays with pitfalls and double-ended funnel traps were set up in lowland evergreen forest at elevations from 777 to 846 m a.s.l. and monitored over 40 nights. Additionally, 22 night excursions were conducted along an adjacent forest stream transect. A total of 62 species of amphibians and reptiles were recorded, comprising 24 anurans, one caecilian, 20 lizards, 16 snakes and one freshwater turtle. Because all specimens were released after capture in the field, proper identification and taxonomic revision are required for at least ten recorded amphibian and six reptile species. Four species are listed in the Vietnam Red Data Book (2007) and two species are listed in the Governmental Decree No32/2006/ND-CP (2006). In terms of distribution patterns, old-growth forest habitat harbored the highest number of recorded reptiles and amphibians (41 species), followed by open land (18 species) and secondary forest (14 species). Most species were captured opportunistically (34), followed by the drift fences (29) and transect night surveys (18). Opportunistic encounters provided for most reptiles (22), while most amphibians were recorded at the drift fence arrays (15). Poaching of wildlife proved to be the major threat to the local herpetofauna, in particular large reptiles. In the study area, reptiles and amphibians are also at risk from habitat loss and degradation. Recommendations for reptile and amphibian conservation are provided.

Keywords: Herpetofauna, diversity, ecological indicators, threats, conservation.

INTRODUCTION

In the past decades the knowledge about the herpetofaunal diversity of Vietnam has significantly increased, and many new discoveries have been published regularly (Ziegler & Nguyen 2010). In contrast, Vietnam's biodiversity faces a distinct depletion (Ziegler 2002, Stuart 2004, Brunner 2012), which makes continuous research fundamental for adequate conservation. This study focuses on the herpetofauna of Chu Mom Ray National Park, an unexplored forest area in the western part of Kon Tum Province. In their report on the vertebrate fauna of Chu Mom Ray National Park, Ngo *et al.* (2006) provided the first list of 47 species of reptiles and 18 species of amphibians. However, neither information about voucher specimens nor references are given. Based on the novel data collected during the field work in 2012, we herein present a herpetofaunal list of Chu Mom Ray National Park and provide additional data about the natural history of amphibians and reptiles. In addition, major threats to the herpetofauna are evaluated and recommendations for improved conservation measures are also provided.

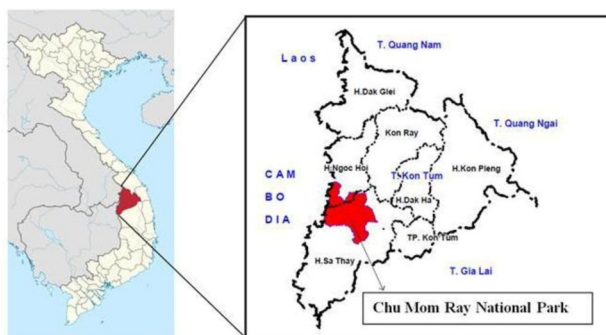


Figure 1. Map showing the Chu Mom Ray National Park in Kon Tum Province, Vietnam.



Figure 2. Chu Mom Ray National Park: overview (left) and land cover map (right). Yellow central line: Road 14C. Source: <http://maps.google.de/>

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Figure 3. 1) Agricultural lands in Chu Mom Ray buffer zone, habitat of *Fejervarya limnocharis*, 2) Tropical lowland evergreen forest with *Lagerstroemia* sp., habitat of *Acanthosaura coronata*, 3) Old-growth forest: habitat of *Lygosoma corpulentum* and *Ingerophrynus galeatus*, 4) Secondary forest in the national park core zone, 5) Habitat of *Boiga cyanea* inside the canyon of a dried-out creek, 6) Surveyed forest stream, habitat of various reptiles and amphibians, including *Physignathus cocincinus* (photographs by D. Jestrzemski).

MATERIALS AND METHODS

Sampling

Field survey was conducted by Daniel Jestrzemski in Chu Mom Ray National Park (NP) from 30 March to 09 June 2012. This national park is located in Sa Thay and Ngoc Hoi districts in the western part of Kon Tum Province, stretching from 14°18'00" to 14°38'45"N and from 107°29'45" to 107°47'08" E, with a core zone of 56,771 ha and a buffer zone of 188,749 ha (Nguyen *et al.* 2006b, Dang *et al.* 2006, Do *et al.* 2006). The annual mean temperature is 23.4°C and the annual precipitation averages to 1,783 mm (Nguyen *et al.* 2006b). The habitat sampled with the drift fence arrays was secondary and old-growth forest near the edge in the eastern part of the national park, with varying levels of disturbance (e.g., poaching, illegal logging and plastic litter pollution).

Drift fence method

Five drift fence arrays were erected inside old-growth forest, close to a partially cemented trail at the forest edge at elevations between 580 and 850 m a.s.l. The array design was roughly geared to the models provided by Greenberg *et al.* (1994), Crosswhite *et al.* (1999), Leaché *et al.* (2006), Fisher *et al.* (2008) and Laurencio (2009). Each array was composed of three approximately 10 m long arms (drift fences) which intersected

in the center, forming three idealized angles of 120° (Y-shape). The drift fences consisted of air-permeable plastic tarps which were attached to wooden piles. The bottom lines of the tarps were buried under topsoil and small rocks to prevent animals from passing through. Each drift fence had an average height of 65 cm. Every array contained seven pitfall traps (35 liter plastic buckets) and six self-made, double-ended funnel traps which were evenly distributed over the arms. In total, 35 pitfall traps and 30 funnel traps were installed. At each array, the pitfalls and double-ended funnel traps were spray-tagged with the numbers 1 to 6, rotating anti-clockwise. The five drift fence arrays (65 traps in total) were controlled on a daily basis, between six and nine days in a row. Apart from one test night (05 April 2012) all arrays were opened (08 April 2012) and closed (06 June 2012) simultaneously. The controls took place during five periods of eight, six, eight, nine and nine days, 40 nights in total. In between these periods, all pitfall traps were closed and all funnel traps opened.

During the daily controls, all amphibians or reptiles encountered within the pitfall or funnel traps were removed, weighed, measured, photographed and released at least five meters away from the end of the arm at which they had been encountered.



Figure 4. 1) Drift fence array inside a forest opening. 2) Daily controls of traps at a drift fence array. Here: funnel traps 5-6 and pitfall traps 5-6 (photographs by D. Jestrzemski).

Transect visual encounter survey

Another sampling method was the application of visual encounter surveys (VES). This technique is an effective tool for the sampling of reptiles and amphibians in the rainforest (Doan 2003). In Chu Mom Ray, VES was conducted along a forest stream section of about 500 m linear distance (subsequently referred to as "transect") from 7 May 2012 to 9 June 2012. The stream transect was bordered by the forest edge and the interior forest, with the averaged starting point at 747 m a.s.l and the averaged ending point at 806 m a.s.l. While walking upstream and returning downstream, all encountered amphibians and reptiles were registered. At least all newly observed specimens of amphibians and reptiles were captured and measured, photographed and released. All stream transect surveys took place on 22 days after sunset, usually between 8:30 and 11:30 PM. The survey days were distributed over five weeks with four to five night walks per week.

We considered all amphibians and reptiles, which were recorded in the vicinity of the field station (684 m a.s.l., 14° 25.559'N, 107° 43.253'E), on the way to the drift fences or stream transect, or during night excursions, as opportunistic encounters. For every species, at least one individual was measured, photographed and the GPS data

taken. From 17 to 20 April 2012, surveys were conducted from a camp in the core zone of the national park (384 m a.s.l., 14°26.442'N, 107°38.472'E).

Ecological data

Photographs of habitat types were taken, including the 360° panorama around the center points of all drift fence arrays. Four days after the first drift fence control, a thermo-hygrometer (TFA Dostmann) was installed in the old-growth forest, next to the first drift fence array. From 14 April to 06 June 2012, the climate data of temperature and humidity were recorded on a daily basis, at the beginning of every drift fence check. However, at times when this weather station was not in use, the thermo-hygrometer was kept at the field station or taken to the forest, and values were directly noted (e.g., during the four-day-excursion). During all days in the field, the times of rainfall and the rainfall intensity were noted as well. The pH value of the forest stream was measured at six survey points, on three days (15, 22 and 30 May 2012). These points were situated inside and outside of the old-growth forest. The vegetation at the drift fence arrays was surveyed as well. This was done by placing a 30 m transect line in North-South direction across each array, with the array center forming the transect center point. A wooden pole of 2 m length was placed perpendicularly onto the loose soil, from the transect beginning onwards every meter. All tangent vegetation was registered otherwise the nearest canopy height was measured. The diameter at breast height (DBH) of every tangential shrub or tree was taken, as well as leaf litter depth and substrate type of each survey point. All plants up to 0.5 m height were defined as herbs and up to 3.0 m as shrubs. Larger plants were recorded as trees.

Deadwood was sampled along the stream transect by recording the altitude and geographical position of all trees that had collapsed over the water and were bridging the two banks. The condition was that the main stem had a minimum diameter of 10 cm at every section. Coordinates and elevation were taken for sites of illegal logging and trapping as well.

Taxonomic identification

In the field, recorded herpetofauna was provisionally identified with the photographic guide of Nguyen *et al.* (2009). Detailed identification subsequently took place based on photographs taken in the field; however, in some cases this allowed only generic allocation or allocation to species complexes, in particular in potential cases of cryptic taxa, which could not be determined by this methodological approach (i.e., without collecting voucher specimens).

Detailed identification of frogs, lizards, snakes and turtles followed Günther (1864), Smith (1921, 1935, 1943), Bourret (1936, 1941b, 1942), Campden-Main (1970), Darevsky & Nguyen (1983), Cox (1991), Manthey & Grossmann (1997), Nutphund (2001), Daltry & Wüster (2002), Daniel (2002), Malkmus *et al.* (2002), Ziegler (2002), Ao *et al.* (2003), Bain *et al.* (2003), Ohler (2003), Greer & Biswas (2004), Das (2005), Stuart & Bain (2005), Stuart *et al.* (2006), Stuart & Emmett (2006), Ziegler *et al.* (2006), Ye *et al.* (2007), Fritz *et al.* (2008), Leviton *et al.* (2008), Rösler

et al. (2008), Hendrix *et al.* (2009), Rowley & Cao (2009), Wood *et al.* (2009, 2010), Inger & Stuart (2010), Nguyen *et al.* (2010), Geissler *et al.* (2011), McGuire & Dudley (2011), Nguyen *et al.* (2011), Rösler *et al.* (2011), Stuart *et al.* (2011), Ng (2012), Nishikawa *et al.* (2012), Rowley *et al.* (2012) and Chan *et al.* (2013). In the case of *Leptolalax*, identification was done by Jodi Rowley.

Frequency of occurrence

At the drift fence, individuals of the same species were distinguished from each other based on comparisons of photographs (see Glandt 2011). In some cases, specimens were morphologically similar to each other so that individual allocation was not possible. Hence, in such cases the number of individuals encountered at the drift fence arrays could only be estimated to be between a minimum and a maximum.

RESULTS AND DISCUSSION

Systematics

Amphibia Linnaeus, 1758 – Amphibians

Anura Fischer von Waldheim, 1813 – Frogs

Bufoidea Gray, 1825 – Toads

***Duttaphrynus melanostictus* (Schneider, 1799)**

Asian common toad / Coc nha, (Figure 5).

Natural history: The species was among the most commonly observed amphibians during the field survey. It was encountered at the field station, along the road and inside the old-growth forest (at elevations from 676 m to 847 m a.s.l.). 11 different individuals were captured at the drift fence arrays, with the SVL ranging from 35 to 97 mm (mean 77.3 mm), and body weights between 3 and 79 g (mean 48.4 g). Other specimens were also captured by pitfall traps. One individual was found dead with a hole in its body. Almost all toads were captured after rainfalls, with the humidity ranging between 86 and 99% and temperatures varying from 21 to 28°C.

***Ingerophrynus galeatus* (Günther, 1864)**

Cambodian toad / Coc rung (Figure 5).

Natural history: Two adult specimens were encountered in pitfalls at the drift fence, with SVLs of 86 and 88 mm and weights of 56 and 79 g, respectively. The whole morning of that day had been rainy, and humidity had been constantly at 99% and temperature variation from 21.9 to 24.7°C.

***Ingerophrynus cf. macrotis* (Boulenger, 1887)**

Big-eared toad / Coc tai to (Figure 5).

Natural history: The single encountered specimen was a subadult, found next to a funnel trap (SVL 15 mm). Measured air humidity was 99% and temperatures ranged from 21.7 to 22.8°C.

Remarks: This represents the first record of the species for Kon Tum Province.

Megophryidae Bonaparte, 1850 – Spadefoot frogs

***Leptobrachium cf. pullum* (Smith, 1921)**

Vietnam spadefoot toad / Coc may viet nam (Figure 5).

Natural history: All three adult specimens were captured at the drift fence. One was found inside a funnel trap, two had fallen into pitfall traps. *L. cf. pullum* was recorded on days with and without preceding rainfalls. Humidity had varied between 97 and 99% and temperatures between 20.8 and 23.1°C. The SVL ranged from 43 to 55 mm and body weight from 8 to 12 g.

Remarks: Four species of *Leptobrachium* are known to possess orange or scarlet colored eyes, viz. *L. smithi*, *L. pullum*, *L. hendricksoni* and *L. hasseltii* (Ohler *et al.* 2004). Specimens recorded in Chu Mom Ray were assigned to *L. pullum* based on morphological features described by Stuart *et al.* (2011). The red-eyed *Leptobrachium* species from Kon Tum Plateau was identified as *L. mohouti* by Bain & Nguyen (2006) and later as *L. pullum* by Matsui *et al.* (2010) (see Stuart *et al.* 2011). Since no vouchers were collected, exact species assignment is not possible at time.

***Leptotalax cf. applebyi* (Rowley, 2009)**

Appleby's Asian leaf litter toad/Coc may ap-li-bai (Figure 5).

Natural history: Two individuals, SVL of 25 and 18 mm, were captured in the same pitfall trap after rainfall. Temperature had varied from 21.3 to 24.5°C and the humidity being constantly around 99%.

Remarks: Morphologically, *L. applebyi* is relatively similar to *L. bidoupensis* and *L. melicus*, which were discovered on the Kon Tum Plateau as well (Rowley *et al.* 2011). The species occurs in syntopy with *L. firthi*, *L. croceus* and *L. tuberosus* (Rowley *et al.* 2012). Since no vouchers were collected, a clear species assignment is not possible at time.

***Leptotalax cf. firthi* (Rowley, 2012)**

Firth's Asian Leaf Litter Toad/Coc may fir-thi (Figure 5).

Natural history: In Chu Mom Ray, two individuals (SVL 24 and 26 mm) were captured at the drift fence, inside a pitfall trap and next to the traps. Temperatures had ranged from 21.6 to 23.0°C and the humidity had been 99%.

Remarks: *L. firthi* occurs in syntopy with *L. applebyi*, *L. croceus* and *L. tuberosus* (Rowley *et al.* 2012). The Chu Mom Ray specimens could not be clearly determined to species level, since no vouchers were collected.

***Ophryophryne cf. hansii* (Ohler, 2003)**

Hans' mountain toad / Coc nui han-x (Figure 5).

Natural history: Two subadult individuals were captured in a pitfall and a funnel trap (SVL 16 and 18 mm, respectively). During the day before, heavy rainfall had occurred. Before trap control, the humidity had been 99% and temperature was between 21.6 and 23.6°C.

***Xenophrys major* (Boulenger, 1908)**

Anderson's spadefoot toad / Coc mat ben (Figure 6).

Natural history: *X. major* was encountered at the drift fence arrays and during the transect nightwalks at the forest stream. A total of 12 subadult specimens were captured at the drift fences. Five frogs were found in pitfall traps and seven in funnel traps (mean SVL 23.6 mm).



Figure 5. 1) *Ingerophrynus cf. macrotis*, 2) *Duttaphrynus melanostictus*, 3) *Ingerophrynus galeatus*, 4) *Leptobrachium cf. pullum*, 5 & 6) *Leptotalax cf. applebyi* (lateral and dorsal view), 7) *Leptotalax cf. firthi*, 8) *Ophryophryne cf. hansii* (photographs by D. Jestrzemiński).

Encounters were made both during dry and rainy days, with a constant humidity of 99%. Three adult individuals were recorded on rocks and twigs at the forest stream at night, two of which had SVLs of 75 mm.

Microhylidae Günther, 1858 – Narrow-mouthed frogs

***Kaloula indochinensis* Chan, Blackburn, Murphy, Stuart, Emmett, Ho & Brown, 2013**

Brown bullfrog / Enh uong dong duong (Figure 6).

Natural history: One specimen was found inside a funnel trap (SVL 53 mm, weight 13 g). In the early morning of this day, heavy rainfall in combination with thunder had taken place. The humidity before trap checking had fluctuated between 95% and 99%, with temperatures between 22.3°C and 24.5°C.

Remarks: This represents the first record of the only recently described species for Kon Tum Province.

***Microhyla fissipes* Boulenger, 1884**

Ornate pigmy frog / Nhai bau hoa (Figure 6).

Natural history: *M. fissipes* was commonly observed around and inside the field station, frequently entering the veranda and bathroom. Encounters were made more often at night than during the day. An adult specimen found at the field station had a SVL of 25 mm. During that

afternoon, rainfall had occurred. Other individuals were found on agricultural land in the buffer zone (e.g., on cassava fields and on muddy trails besides paddies).

***Microhyla heymonsii* (Vogt, 1911)**

Taiwan rice frog, black-flanked pigmy frog / Nhai bau hay-mon (Figure 6).

Natural history: This species was encountered both at the drift fence, at the field station and at the stream close to the station, inside a small forest patch of 1-2 ha size and about 1 m away from the stream edge. SVL ranged from 19 to 28 mm.

***Micryletta inornata* (Boulenger, 1890)**

Deli paddy frog / Nhai bau tron (Figure 6).

Natural history: Three adult individuals were observed at Chu Mom Ray, with SVL ranging from 21 to 29 mm. One frog was found on a paved road (SVL 29 mm) and two specimens at the drift fence arrays (SVL 21 and 19 mm). The encounters took place on days preceded by rainfall, with significant humidity amplitudes (80% to 99%).

Remarks: This represents the first record of the species for Kon Tum Province.

Dicroglossidae Anderson, 1871 – True frogs

***Fejervarya limnocharis* (Gravenhorst, 1829)**

Grass frog / Ngoe, nhai (Figure 6).

Natural history: In Chu Mom Ray, this species was commonly observed around the field station, on the paved road to the old-growth forest, on muddy trails, in paddy fields, inside a bamboo forest stand and at the drift fences. Five juvenile specimens belonging to at least four individuals were encountered at the drift fence arrays (three in pitfalls and one in a funnel trap), with a mean SVL of 22.8 mm. Rain had fallen before all encounters. Air humidity had been constantly around 99%, and temperatures had ranged from 21.1°C to 23.6°C. One adult specimen (SVL 55 mm, weight 17 g) was encountered at the edge of a muddy footpath about 10 m away from a paddy field (660 m a.s.l.).

***Limnonectes dabanus* (Smith, 1922)**

Annam wart frog / Ech gay do (Figure 7).

Natural history: In Chu Mom Ray, at least two specimens of *L. dabanus* were observed in different habitats, including a forest stream, at the edge of degraded forest, in the vicinity of a banana grove and on small patches of open grassland. A single adult individual had a SVL of 63 mm. All frogs were recorded on a day without rainfall, with humidity levels ranging from 79 and 97%, and temperature extremes from 23.6 to 29.5°C.

***Limnonectes cf. bannaensis* (Tschudi, 1838)**

Kuhl's creek frog / Ech nheo (Figure 7).

Natural history: *L. cf. bannaensis* was commonly observed at a forest stream during transect surveys. In contrast to Malkmus *et al.* (2002), none displayed bright dorsal stripes. The encounters took place between 7:35 and 10:34 PM (765 m to 822 m a.s.l.). Almost all frogs were spotted in the water and quickly disappeared



Figure 6. 1) *Xenophrys major*, 2) *Kaloula indochinensis*, 3) *Microhyla fissipes*, 4) *Microhyla heymonsii*, 5) *Micryletta inornata*, 6) *Fejervarya limnocharis* (photographs by D. Jędrzejewski).

underneath rocks and mud when being approached. During six of the eight night surveys (75%), no rain was falling. However, previous to two of these surveys, rainfall had occurred during the afternoon or evening. During the observation of the last individual (a large specimen of about 80 mm) humidity was 99% and aerial temperature 23.0°C.

Remarks: In his revision of the *L. kuhlii* species complex, McLeod (2010) renamed the Vietnamese populations of *L. kuhlii* as *L. bannaensis*, which is widely distributed over Northern and Central Vietnam (McLeod 2010). Therefore, the specimens recorded in Chu Mom Ray are denominated as *L. cf. bannaensis*. Although their geographic location in Vietnam's Central Highlands supports this assignment, no specimens were collected, making a classification based on morphological or genetic analysis impossible. Also, the description of *L. kuhlii* fits better to the photos of the Chu Mom Ray specimens than the description of *L. bannaensis* (see Ye *et al.* 2007). A final species determination requires the collection of voucher specimens in Chu Mom Ray and subsequent molecular analyses.

***Limnonectes cf. limborgi* (Slater, 1892)**

Limborg's frog / Ech lim-borg (Figure 7).

Natural history: Nine specimens of *L. limborgi* were found at the drift fences. Six of the eight days of encounter had been dry before trap controls, one with rain in the earlier morning and one day with unclear rainfall status. Temperatures ranged from 20.8 to 23.6°C, humidity from 94 to 99%. The four specimens captured in pitfall traps yielded higher mean SVL and mean body weight than the five specimens recorded in funnel traps (33 mm vs. 24 mm and 5.67 g vs. 1 g, respectively). Average SVL and body weight of all specimens are 27.38 mm and 2.75 g, respectively.

Remarks: Smith (1929) synonymized *L. limborgi* with *L.*

hascheanus (Stoliczka 1870) based on the morphological similarity between these species. However, *L. limborgi* was revalidated as a distinct species by Dubois (1987) and Inger & Stuart (2010). *L. limborgi* has been reported from Kon Tum Province, along the Cambodian-Vietnamese border (Inger & Stuart 2010).

***Limnonectes poilani* (Bourret, 1942)**

Poilan's frog / Ech poa-lan (Figure 7).

Natural history: Three specimens of *L. poilani* were recorded in a muddy rivulet inside mixed bamboo forest and in a forest stream, at elevations between 368 and 757 m a.s.l., during dry and humid days. All frogs were observed at night, with SVLs ranging from 50 to 99 mm.

cf. *Quasipaa* sp.

Spiny frog / Ech gai (Figure 7).

Natural history: Three individuals of cf. *Quasipaa* sp. were observed at a forest stream during night surveys. All frogs were located at the stream bank next to the water, sitting on small rocks. During all days of encounter, no rain was falling.

Remarks: Three species of the genus are recorded for Vietnam: *Q. boulengeri*, *Q. spinosa* and *Q. verrucosinosa* (Nguyen *et al.* 2009). With photographic records only, proper generic and specific assignment is not possible at time.

***Occidozyga martensii* (Peters, 1867)**

Martens' oriental frog / Coc nuoc mac-ten (Figure 7).

Natural history: Two individuals were found inside a pitfall trap and in a muddy rivulet of about 1 cm depth, next to a stream barrage. The specimen from the trap had a SVL of 33 mm and a weight of 6 g. The humidity was 99% and the temperature had ranged from 21.6°C to 23.6°C. During the night before, heavy rainfall had occurred, opposite to the other encounter.

Ranidae Rafinesque, 1814 – Ranids

***Hylarana* cf. *nigrovittata* (Blyth 1856)**

Black-striped frog / Ech suoi (Figure 8).

Natural history: In Chu Mom Ray, *H.* cf. *nigrovittata* was found in different habitats, including a dried out creek bed surrounded by degraded, young forest, a pool formed by a forest stream and a shallow, muddy rivulet. All observations were made at night, at elevations between 384 and 745 m a.s.l. SVLs ranged from 52 to 55 mm. The 52 mm individual had a body weight of 11 g.

Remarks: Ohler *et al.* (2002) described *Hylarana nigrovittata* ("*Rana nigrovittata*") as a species complex, which includes two groups of frogs in the subgenus *Sylvirana* (collected in the Cambodian Cardamon Mountains). According to Gawor *et al.* (2009) phylogenetic studies in *Hylarana* are badly needed. In order to properly determine the population from Chu Mom Ray, vouchers are required.

***Odorrana* cf. *choloronota* (Günther 1876)**

Green cascade frog / Ech xanh (Figure 8).

Natural history: During transect night surveys, four specimens were recorded in a forest stream. Three encounters were made at elevations from 774 m to 799 m



Figure 7. 1) *Limnonectes dabanus*, 2) *Limnonectes* cf. *banaensis*, 3) *Limnonectes* cf. *limborgi*, 4) *Limnonectes poilani*, 5) cf. *Quasipaa* sp., 6) *Occidozyga martensii* (photographs by D. Jestrzemski).

a.s.l. One specimen was recorded on a day without rain while three were observed after rain had fallen in the afternoon.

Remarks: *O. chloronota* is a cryptic species complex of which two to three species occur sympatrically at every surveyed location in Vietnam, and it is possible to encounter up to three species in the same stream (Bain *et al.* 2003). In Northern Vietnam *O. chloronota* is present in sympatry with *O. bacboensis*, *O. hmongorum*, *O. daorum* and *O. megatypanum*, whereas in the Central Highlands it also occurs sympatrically with *O. banaorum* and *O. morafkai* (Bain *et al.* 2003). Due to the rather high number of morphologically similar species (see Bain *et al.* 2003) no precise assignment could be made for the specimens photographed in Chu Mom Ray National Park.

***Odorrana* cf. *tiannanensis* (Yang & Li 1980)**

Tiannan frog / Ech ti-an-nan (Figure 8).

Natural history: *O.* cf. *tiannanensis* was encountered during night surveys along a forest stream transect, at elevations 771 to 806 m a.s.l. Six observations were made on rainy days and four observations on days without rain before the encounter. In one incident, a couple in axillary amplexus was found on a large rock. That day had been dry, but heavy rain started to fall around midnight. Most frogs were observed sitting on rocks (diameters roughly 0.5 to 1.5 m) in the stream, but some were also found resting on branches, lianas and deadwood.

Rhacophoridae, Hoffman 1932 – Tree frogs

***Polypedates* cf. *megacephalus* (Gravenhorst, 1829)**

Java whipping frog / Ech cay (Figure 9).

Natural history: Six specimens were observed inside and



Figure 8. 1) *Hylarana* cf. *nigrovittata*, 2) *Odorrana* cf. *chloronota*, 3) *Odorrana* cf. *tiannanensis* in axillary amplesus, 4) *Odorrana* cf. *tiannanensis* (photographs by D. Jestrzemski).

around a field station, on sandy footpaths bisecting agricultural lands (paddies, cassava and banana plantations), in the branches of trees and on the paved road surrounded by secondary forest. All encounters took place at night, at elevations from 657 m to 725 m a.s.l. The SVLs of four examined specimens ranged from 59 mm to 67 mm. The 65 mm-SVL individual weighed 12 g. Observations were made on dry and on rainy days. Tadpoles and adults of *Polypedates* sp. were constantly recorded inside a subterranean concrete cistern at a field station, with advertisement calls commonly arising in the evening. In the beginning of June 2012, a foam nest was discovered about 10 cm above the water line in the underground cistern, next to a freshly metamorphosed frog (*Polypedates* sp.). Breeding activities inside the water cistern seemed to have increased in late May, when rainfall levels were rising.

Remarks: Recent phylogenetic analyses revealed that the cryptic *Polypedates leucomystax* complex, whose members are notoriously difficult to classify, consists of several clades, such as *P. macrotis*, *Polypedates* sp. (Malay Peninsula), *P. braueri* (North China), *Polypedates* cf. *mutus* 1 (South China), *P. megacephalus* (Indochina), *P. leucomystax* (Sunda) and *Polypedates* cf. *mutus* 2 (Laos) (Kuraishi *et al.* 2012). Based on this new classification, all Chu Mom Ray specimens formerly identified as *P. leucomystax* have been renamed as *P. cf. megacephalus*. However, for proper species determination, voucher specimens would be required.

***Polypedates* cf. *mutus* (Smith, 1940)**

Burmese whipping frog / Ech cay mi-an-ma (Figure 9).

Natural history: Three individuals of *P. cf. mutus* were recorded in altitudes between 657 m and 695 m a.s.l. Observations were made at the field station and in a very shallow streamlet (depth around 2 cm) passing over a muddy trail next to a paddy field.

Remarks: The specific assignment is based on characteristic morphological features and color patterns discernible from the photos (see Ziegler 2002). This

represents the first record of the species for Kon Tum Province.

Order Gymnophiona Müller, 1831 – Caecilians

Ichthyophiidae Taylor, 1968

***Ichthyophis* cf. *nguyenorum* (Nishikawa 2012)**

Nguyen's caecilian / Ech giun nguyen (Figure 9).

Natural history: At Chu Mom Ray, 20 adult specimens of *I. cf. nguyenorum* were observed, with total length up to 326 mm. Three examined individuals weighed 11 g, 9.5 g and 20 g, with respective total lengths of 241 mm, 253 mm and 300 mm. 19 specimens had fallen into a sewage drain along the paved road leading from a field station to old-growth forest. This road was surrounded by secondary or rehabilitation forest. The drain had a depth of about 0.5 m and a slope angle of circa 45° to each side, and had been completed in the first week of April 2012. A strip of excavated soil (average width 1-3 m) was located between the concrete drain and the forest. Yellow-striped caecilians kept falling into the drain along its whole length. Of the 12 caecilians found at night, three were dead, while of the eight caecilians found during the day, seven were dead or dying. Nine of the 10 dead or dying individuals were found in this sewage drain. Two of the dead individuals in the drain were being eaten by army ants. Nocturnal encounters were usually made after or during rainfall while at day, specimens were found in the open sun. All observations were made at elevations between 670 m and 727 m a.s.l.

Remarks: The species was determined as *I. cf. nguyenorum* based on the geographic location and color pattern. However, a final determination will only be possible with voucher specimens, especially since the Vietnamese populations of *I. bannanicus* may occur sympatrically with *I. nguyenorum* (Nishikawa *et al.* 2012).



Figure 9. 1) *Polypedates* cf. *megacephalus*, 2) *Polypedates* cf. *mutus*, 3) *Ichthyophis* cf. *nguyenorum* (photographs by D. Jestrzemski).

Class Reptilia Laurenti, 1768 – Reptiles**Order Squamata Opperl, 1811 – Lizards and snakes****Sauria - Lizards****Agamidae Gray, 1827*****Physignathus cocincinus* (Cuvier, 1829)**

Indochinese water dragon / Rong dat (Figure 10).

Natural history: *P. cocincinus* was observed inside a field station, on the rocks of a dam barrage and most commonly resting on branches above forest streams, shallow rivulets and dried-out creek beds. Observations were made at elevations between 352 and 796 m a.s.l. The only specimen encountered at day was a juvenile found inside a building (total length 165 mm, weight 3 g). All individuals found resting on branches appeared to be subadult, with body lengths not exceeding 50 cm.

***Acanthosaura coronata* (Günther, 1861)**

Coronated tree lizard / O ro vanh (Figure 10).

Natural history: In Chu Mom Ray, 14 specimens of *Acanthosaura coronata* (at least 13 different individuals) were recorded at all arrays of the drift fence. 11 lizards were captured with traps, three were recorded at the fence (two juveniles and 12 adults). Nine lizards were found in pitfall traps and five in funnel traps. Mean length was 73.82 mm (SVL) and 179.91 mm (total length), and mean body weight was 13.36 g. Nine specimens were recorded during or after rainfall. Humidity ranged between 95% and 99%, and temperatures varied from 20.8°C to 24.5°C. Apart from the traps, lizards were recorded on trees at the forest edge (at day) and resting on shrubs (during night).

***Acanthosaura nataliae* (Orlov, Nguyen & Nguyen, 2006)**

Natalia's tree lizard / O ro na-ta-li-a (Figure 10).

Natural history: Three specimens were found at the drift fence arrays (two in pitfalls and one in a funnel trap), and another resting on the buttress root of a large tree (DBH 1.2 - 1.5 m) next to a cemented trail in moderately disturbed old-growth forest. At the same spot, an individual of *Rhabdophis chrysargos* had been spotted nine days before. SVLs recorded from the trap captures ranged from 107 mm to 122 mm, and the weights from 39 g to 45 g. While the lizard on the tree was observed during dry weather, all drift fence specimens were recorded after rainfall, with humidity levels ranging from 94% to 99%. Measured temperature extremes before drift fence checkings ranged from 20.8°C to 24.5°C.

***Calotes emma* (Gray, 1845)**

Emma forest lizard / Nhung em-ma (Figure 10).

Natural history: An adult specimen was found resting at the forest edge, on a cemented path surrounded by bamboo and thorn shrubs (808 m a.s.l.). The observation took place during a dry morning.

***Calotes versicolor* (Daudin, 1802)**

Garden fence lizard / Nhung xanh (Figure 10).

Natural history: In Chu Mom Ray, nine individuals of *C. versicolor* could be observed mainly at and around a field station and along a paved road leading to old-growth forest (673 m to 710 m a.s.l.). The habitats included a garden adjacent to the field station, a paved road and the rocky edge of a disturbed forest stream adjacent to the road. With exception of a juvenile specimen (276 mm total length) sleeping on a small conifer planted at the entrance of the field station, all lizards were encountered at day. Apart from 29 May 2012, all days of observation had been dry.

***Draco* sp.**

Flying lizard / Than lan bay (Figure 10).

Natural history: An individual of *Draco* sp. was discovered at 10:22 AM on a tree next to a cemented footpath at the forest edge, at elevation of 815 m a.s.l. Initially, the lizard was around 2 m above the ground, but gradually moved up the stem when being approached. Simultaneously, it kept hidden behind the trunk. The lizard climbed up to at least 4 m before disappearing. The total length was about 300-350 mm. That day was without rainfall.

Remarks: The photos of the Chu Mom Ray specimen only permit determination to genus level. Three flying lizard species are known from Vietnam: *D. maculatus*, *D. taeniopterus* and *D. indochinensis*. While Inger (1983) accounted *D. indochinensis* a synonym of *Draco blanfordii*, Musters (1983) considered it to be a subspecies of *D. blanfordii*. McGuire & Heang (2000) recognized *D. indochinensis* as an own species due to its allopatric distribution and unique morphological characteristics.



Figure 10. 1) *Physignathus cocincinus*, 2) *Acanthosaura coronata*, 3) *Acanthosaura nataliae*, 4) *Draco* sp., 5) *Calotes emma*, 6) *Calotes versicolor* (photographs by D. Jestrzemiński).

Gekkonidae Gray, 1825 – Geckos***Cyrtodactylus* cf. *pseudoquadrivirgatus* (Rösler, Nguyen, Vu, Ngo & Ziegler 2008)**

Bow-fingered gecko / Thach sung ngon (Figure 11).

Natural history: *C. cf. pseudoquadrivirgatus* was captured at the drift fence (three records) and very commonly observed at the forest stream (18 nocturnal encounters), where they could be found on trees, lianas, deadwood and rocks at elevations ranging from 757 m to 834 m a.s.l. SVLs of four specimens ranged from 39 mm to 82 mm, and weights from 2 g to 6 g respectively. Of all 18 specimens at the forest stream, seven were observed on four days without any rain, while 11 geckos were seen on eight days with rainfall.

Remarks: Since information about the examined specimens was only available from photos, voucher specimens are required to confirm the species assignment.

***Gehyra mutilata* (Wiegmann 1834)**

Stump-tailed gecko/Thach sung cut thuong (Figure 11).

Natural history: After sunset, *Gehyra mutilata* was commonly observed on the walls of field station buildings. A juvenile had a total length of 54 mm.

Remarks: Species assignment is based on a photo taken at the field station, which is the first record of *G. mutilata* for Kon Tum Province.

***Gekko* cf. *gecko* (Linnaeus, 1758)**

Tokay / Tac ke.

Natural history: On 11 June 2012, the characteristic calls of at least one male were heard in a dormitory, outside of the national park (Sa Thay Town). Each call started off with a creaking sound, being followed by several very loud repetitions of “Tac-Kea”. The calling began in the afternoon and stopped during the night. While the gecko could not be spotted, the sound could be traced back to the tin roof.

Remarks: Males of *G. gecko* produce a characteristic call (Ziegler 2002, Rösler *et al.* 2011). While formerly regarded to be synonymous with *G. gecko*, the more northerly occurring *G. reveesi* was revalidated at species rank by Rösler *et al.* (2011).

***Hemidactylus* cf. *frenatus* (Duméril and Bibron, 1836)** (Figure 11).

Natural history: In Chu Mom Ray, *Hemidactylus* cf. *frenatus* was observed entirely at the field station, inside rooms or outside on the porch. The total length of four individuals ranged from 34 mm to 55 mm.

Scincidae Opell, 1811 – Skinks***Eutropis multifasciatus* (Kuhl, 1820)**

East Indian brown mabuya / Than lan bong hoa (Figure 11).

Natural history: *E. multifasciatus* was observed in various habitats of Chu Mom Ray, including rocky streambeds and the forest surrounding the drift fence arrays (583 m to 818 m a.s.l.). Encounters were made during the day, under dry and sunny conditions. A juvenile had a SVL of 27 mm and a total length of 76 mm.

The species was commonly observed around a field station.

***Lipinia vittigera* (Boulenger, 1894)**

Striped tree skink / Than lan vach (Figure 11).

Natural history: *L. vittigera* was occasionally observed near the entrance of a field station building, where it could be spotted running up and down the basal trunks of three interlocked trees a few meters away from the porch (9:08 AM).



Figure 11. 1) *Cyrtodactylus* cf. *pseudoquadrivirgatus*, 2) *Gehyra mutilata*, 3) *Hemidactylus* cf. *frenatus*, 4) *Lipinia vittigera*, 5) *Eutropis multifasciatus* (photographs by D. Jestrzanski).

***Lygosoma corpulentum* (Smith, 1921)**

Corpulent supple skink / Than lan chan ngan beo (Figure 12).

Natural history: Three adults were captured in pitfall traps, with SVLs between 147 mm and 195 mm, and total lengths from 304 mm to 334 mm. Body weights ranged from 58 g to 127 g. One skink had a wound on the left side of the silver-colored rostral shield. All observations were made on days with no rainfall before and during trap checkings. Temperatures ranged from 21.6°C to 27.5°C, and humidity from 80% to 99%.

***Lygosoma* sp.**

(Figure 12).

Natural history: An individual (41 mm SVL, total length 85 mm) was captured at the drift fence, inside a pitfall trap. The day of capture was without rain.

Remarks: Voucher specimens are required for proper species determination.

***Scincella rufocaudata* (Nguyen *et al.* 2011)**

Red-tailed ground skink / Than lan phe-no duoi do (Figure 12).

Natural history: In Chu Mom Ray, *S. rufocaudata* was captured in a pitfall trap at the drift fence (old-growth forest) and observed in young forest at the edge of agricultural land, which was heavily frequented by local people (collection of firewood). Two adult individuals had total lengths of 95 mm and 139 mm respectively. The smaller lizard had a SVL of 45 mm.

***Sphenomorphus cf. buenloicus* (Darevsky & Nguyen, 1983)**

Buonluoi forest skink / Than lan phe-no buon loi (Figure 12).

Natural history: In Chu Mom Ray, *Sphenomorphus cf. buenloicus* was observed entirely in old-growth forest, on days without rain. Two individuals were captured at the drift fence, in a pitfall and in a funnel trap (SVLs 45 mm and 51 mm). One individual (140 mm in total length) was encountered at the forest stream at night (806 m a.s.l.), resting on a large rock (about 1.5 m in diameter).

***Sphenomorphus stellatus* (Boulenger, 1900)**

Starry forest skink / Than lan phe-no sao (Figure 12).

Natural history: One specimen was captured in a pitfall trap (total length 127 mm, SVL 56 mm). The temperature had varied between 22.1°C and 23.4°C, and the humidity between 96% and 99%.



Figure 12. 1) *Lygosoma cf. corpulentum*, 2) *Scincella rufocaudata*, 3) *Lygosoma* sp., 4) *Sphenomorphus cf. buenloicus*, 5) *Sphenomorphus stellatus* (photographs by D. Jestrzemiński).

***Tropidophorus cocincinensis* (Duméril & Bibron, 1839)**

Cochinchinese water skink / Than lan tai nam bo (Figure 13).

Natural history: In Chu Mom Ray, two specimens of *T. cocincinensis* were encountered inside and next to a stream in old-growth forest. One skink captured in a pitfall at the drift fence had a SVL of 101 mm and a total length of 247 mm, with a weight of 31 g. Another

lizard was encountered during a night survey, resting in the water at a shallow stream section (2-3 cm water depth) (758 m a.s.l.). Its SVL was 81 mm, the total length 200 mm. Rain had fallen on both days before the encounters.

***Tropidophorus* sp.**

(Figure 13).

Natural history: This *Tropidophorus* specimen could be captured and photographed during a night survey at the same forest stream as *T. cocincinensis*. However, *Tropidophorus* sp. was recorded inside a stream section surrounded by degraded and partially open forest (747 m a.s.l.). Before capture, the skink had rapidly left the water and moved onto small rocks at the stream edge. When handled, the skink dropped its tail. The total length of the remaining body was 133 mm.

Remarks: The photos did not provide sufficient information for species assignment.

Varanidae Gray, 1827 – Monitor lizards

***Varanus nebulosus* (Gray, 1831)**

Clouded monitor / Ky da van (Figure 13).

Natural history: *V. nebulosus* was recorded entirely during the day, on forest trails, on an unsecured road and inside the old-growth forest (684 to 843 m a.s.l.). Two examined juveniles had SVLs of 121 mm and 134 mm, and total lengths of 285 mm and 332 mm. Their body weights were 31 g and 45 g. In one case, a young individual of *Varanus* sp. (maximum total length 50 cm) was observed quickly climbing up a tree next to the cemented footpath at the forest edge.



Figure 13. 1) *Tropidophorus cocincinensis*, 2) *Tropidophorus* sp., 3) *Varanus nebulosus*, juvenile (photographs by D. Jestrzemiński).

Xenopeltidae Bonaparte, 1845 – Sunbeam snakes***Xenopeltis unicolor* (Reinwardt, 1827)**

Sunbeam snake / Ran mong (Figure 14).

Natural history: A specimen (total length 50 cm, SVL 46 cm) was encountered on 8:34 PM inside a concrete sewage drain at the edge of a paved road leading to old-growth forest (693 m a.s.l.). While being handled, it did not attempt to bite. Before the observation, rain had fallen from 5:00 to 6:30 PM.

Colubridae Opperl, 1811 – Colubrids***Boiga cyanea* (Duméril, Bibron & Duméril, 1854)**

Green cat snake / Ran rao xanh (Figure 14).

Natural history: Six adult individuals were found close to a field station, in habitats such as a dried out creek bed, a forest stream, a paved road and a bird's nest that had fallen down from a tree. Measured total lengths ranged from 93 cm to 163 cm. All observations were made at elevations between 684 and 723 m a.s.l. One snake was picked up when climbing in tree twigs, while another had been put into a bottle by a staff member. After this individual was taken out of the bottle, it appeared to be injured and delivered a quick bite to the hand. No symptoms of envenomation or inflammation occurred afterwards. With exception of this specimen, all snakes were encountered at night.

***Coelognathus flavolineatus* (Schlegel, 1837)**

Yellow-striped snake / Ran soc vang (Figure 14).

Natural history: An adult specimen was encountered at the beginning of the forest stream transect (8:18 PM), when it was about to cross the shallow water by using large rocks as stepstones (about ½ m diameter). The snake had a SVL of 125 cm and a total length of 160 cm. During handling, the individual made some attempts of biting. The elevation was 745 m a.s.l. On that day, rain had fallen from the early morning to 1:30 PM.

Remarks: This is the first record of this species for Kon Tum Province.

***Dendrelaphis ngansonensis* (Bourret, 1935)**

Nganson bronzeback / Ran leo cay ngan son (Figure 14).

Natural history: An individual was encountered on the interprovincial road inside Chu Mom Ray National Park (9:58 AM). The snake was lying in a small pond inside a muddy wheel track and wrestling with a prey item. When being approached, it rejected the prey, which appeared to be an adult of *Polypedates* sp. While handled, the snake repeatedly tried to bite. Its total length was 158 cm and the weight 115 g. The frog had a SVL of 89 mm and a weight of 33 g. During handling, the amphibian suddenly became active and jumped off, escaping into the bushes. Temperature was 29.8°C and humidity 76%. The road section was inside a bamboo stand and heavily frequented by passengers.

Remarks: This is the first record of this species for Kon Tum Province.

***Lycodon fasciatus* (Anderson, 1879)**

Banded wolf snake / Ran khuyet dom (Figure 14).

Natural history: Two adults and one juvenile were observed during night surveys at the forest stream

transect (798 m, 791 m and 774 m a.s.l.). Two examined specimens had SVLs of 47 cm and 22 cm, and total lengths of 59 cm and 27 cm respectively. In contrast to the adults, the juvenile did not show escape behavior when being approached, and also not after handling. Observations were made after rainfall and during rain, respectively.

***Lycodon septentrionalis* (Günther, 1875)**

White-banded wolf snake / Ran lech dau tham (Figure 14).

Natural history: *L. septentrionalis* was among the most commonly encountered snakes in Chu Mom Ray. Nine adult specimens were observed during nightwalks at the forest stream transect, where they were found at the stream bank or crossing the water (745 to 795 m a.s.l.). Two examined specimens had SVLs of 87 cm and 61 cm and total lengths of 101 cm and 78 cm. All snakes were observed on days with rainfall before or after the encounter. The snakes were sighted together with *L. fasciatus* and *Bungarus candidus*, in the same habitat (forest stream) and during the same season.

Remarks: This represents the first record of *L. septentrionalis* for Kon Tum Province. Siler *et al.* (2013) could prove that the colubrid genus *Dinodon* is enclosed in *Lycodon* and synonymized the former genus with the latter.



Figure 14. 1) *Xenopeltis unicolor*, 2) *Boiga cyanea*, 3) *Coelognathus flavolineatus*, 4) *Dendrelaphis ngansonensis*, 5) *Lycodon septentrionalis*, 6) *Lycodon fasciatus* (photographs by D. Jędrzejewski).

***Oligodon chinensis* (Günther, 1888)**

Chinese kukri snake / Ran khiem trung quoc (Figure 15).

Natural history: An adult specimen was encountered basking on the interprovincial road around noon (711 m a.s.l.). Total length was about 61 cm, and the weight 65 g. The weather was sunny, with a temperature of 29.7°C and a humidity of 85%. When handled, the snake fiercely defended itself.

Remarks: This is the first record of the species for Kon Tum Province.

***Psammodynastes pulverulentus* (Boie, 1827)**

Mock viper / Ran ho dat nau (Figure 15).

Natural history: Four individuals were observed in different habitats. One snake was captured in a funnel trap, two were sunbathing on a cemented forest footpath and another resting on a small tree near a forest stream. This was the only specimen found at night (9:16 PM, 774 m a.s.l.). Measured total lengths ranged from 17 cm to 40 cm. Observations were made on dry days and after rain.

Remarks: This is the first record of this species for the province.

***Rhabdophis chrysargos* (Schlegel, 1837)**

Speckle-bellied keelback / Ran hoa co vang (Figure 15).

Natural history: An individual (total length 68 cm, body weight 34 g) was spotted at a cemented footpath inside old-growth forest (10:39 AM), suddenly appearing between the buttress roots of a large tree next to a stream, where *Acanthosaura nathaliae* was recorded nine days later (834 m a.s.l.). That day was without rain.

Remarks: This is the first record of the species for Kon Tum Province.

***Rhabdophis subminiatus* (Schlegel, 1837)**

Red-necked keelback / Ran hoa co nho (Figure 15).

Natural history: *R. subminiatus* was the most commonly encountered snake during the survey, with all encounters taking place between morning and noon. Nine individuals were found in a sewage drain along a paved road. Of these, eight were dead. The living individual vomited the remainings of a small unidentifiable frog after capture. A living juvenile was encountered on a sandy footpath near the edge of the old-growth forest (9:00 AM). Total lengths ranged from 20 cm to 71 cm, and weights from 4 g to 65 g. All observations were made at elevations between 667 and 737 m a.s.l. Seven specimens were observed on days without rain before the encounter, two on days with rainfall before the observation and one individual during rainfall.

***Pareas hamptoni* (Boulenger, 1905)**

Hampton's slug snake / Ran ho may-ton (Figure 15).

Natural history: An individual (53 cm total length, 24 g weight) was encountered inside a moderately disturbed old-growth forest stand (7:20 PM). The docile snake was slowly moving across the forest floor, climbing over leaf litter and branches (380 m a.s.l.). This landscape was characterized by a patchwork of old-growth forests and secondary forest stands with pioneer vegetation, also including bamboo stands and dense thickets rattan.

***Pareas margaritophorus* (Jan, 1866)**

White-spotted slug snake / Ran ho may ngoc (Figure 15).

Natural history: In Chu Mom Ray, two individuals of *P. margaritophorus* were found during night surveys (699 and 761 m a.s.l.). The first specimen (SVL 28 cm and total length 32 cm) was located inside a sewage drain, the second (SVL 29 cm and total length 34 cm) at the edge of a forest stream. While the first observation

was made under dry conditions, the second snake was discovered on a day with periodic rainfall in the morning, afternoon and night.

Remarks: With this survey, the species is newly recorded for Kon Tum Province.

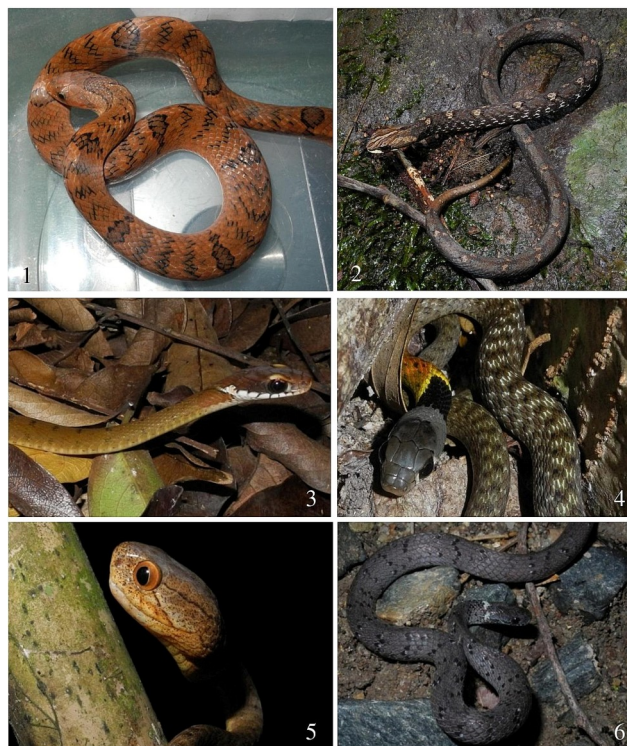


Figure 15. 1) *Oligodon chinensis*, 2) *Psammodynastes pulverulentus*, 3) *Rhabdophis chrysargos*, 4) *Rhabdophis subminiatus*, juvenile, 5) *Pareas hamptoni*, 6) *Pareas margaritophorus* (photographs by D. Jestrzemiński).

***Pseudoxenodon macrops* (Blyth, 1854)**

Big-eyed bamboo snake / Ran ho xien mat to (Figure 16).

Natural history: A specimen (SVL 25 cm) was encountered at a drift fence, about 3 m from a pitfall trap (11:17 AM). After being discovered, the snake flattened its body and formed a hood. Simultaneously, it erected the anterior part of its body and tried to bite. This day was without rainfall.

Elapidae Boie, 1827 – Kraits, coral snakes and cobras***Bungarus candidus* (Linnaeus, 1758)**

Blue krait / Ran cap nia nam (Figure 16).

Natural history: Four individuals of *B. candidus* were encountered during night surveys at a forest stream, at elevations ranging from 773 to 811 m a.s.l. All snakes were moving determinedly through leaf litter at the stream edge, and in three cases tried to escape into ground holes when being approached. One specimen could be observed hunting and devouring unidentifiable prey from inside a ground hole for about 21 minutes. The snake became increasingly alerted and quickly moved into the forest, where it increased its speed. All observations were made between 9:38 PM and 10:07 PM, and on days with rainfall in the morning or afternoon. Two examined specimens had SVLs of 65 cm and 77 cm, with total lengths of 75 cm and 88 cm.

***Calliophis maculiceps* (Günther, 1858)**

Small-spotted coral snake / Ran la kho dom nho (Figure 16).

Natural history: After sunset (7:00 PM), an individual (SVL 33 cm, total length 36 cm) was found crossing a sandy footpath which connected two buildings (694 m a.s.l.). The trail was surrounded by open woodland whose underwood vegetation was regularly burned down. On this day, soft rain had fallen in the morning.

Remarks: This survey represents the first record of the species for Kon Tum Province.

Viperidae Oppel, 1811 – Pitvipers and vipers

***Trimeresurus albolabris* (Gray, 1842)**

White-lipped pitviper / Ran luc mep trang (Figure 16).

Natural history: Around 10:00 PM, an adult of 53 cm total length was encountered at the edge of a forest stream (786 m a.s.l.). The docile pitviper was slowly crawling on a rock of about 0.5 m diameter, at the edge of a banana grove surrounded by moderately disturbed old-growth forest. After being released on the same spot, the snake climbed up a small shrub where it remained for at least 36 minutes. That day was without rainfall. Another individual was encountered inside a sewage drain around noon, being exposed to the sun (717 m a.s.l.). The dying juvenile had a total length of 24 cm, a SVL of 20 cm and weighed 6 g.

Remarks: This is the first record of this species for Kon Tum Province.



Figure 16. 1) *Pseudoxenodon macrops*, 2) *Bungarus candidus*, 3) *Calliophis maculiceps*, 4) *Trimeresurus albolabris*, 5 & 6) *Cyclemys cf. oldhamii*, same juvenile (photographs by D. Jęstrzemiński).

Order Testudines Linnaeus, 1758 – Turtles

Geoemydidae Theobald, 1868 – Old World pond turtles

***Cyclemys cf. oldhamii* (Gray, 1836) (Figure 16).**

Natural history: A juvenile specimen of *C. cf. oldhamii* was found on the sandy edge of a shallow stream surrounded by bamboo forest (352 m a.s.l., 7:22 PM). Carapace length and width were 81 mm and 74 mm, while the plastron measured 72 mm in length and 45 mm in width. Total length was 131 mm, with a weight of 66 g. Temperature was 24.9°C and humidity 95%. At the same creek, a juvenile of *Physignathus cocincinus* as well as several individuals of *Limnonectes poilani* and *Hylarana sp.* were observed.

Remarks: Since the distribution map of *C. oldhamii* (Fritz *et al.* 2008) does not include Central Vietnam at the Laos-Cambodian border, this survey represents the first record of *C. cf. oldhamii* for Kon Tum Province.

Species composition

A total of 62 species were recorded from Chu Mom Ray NP, comprising 25 species of amphibians (seven families) and 37 species of reptiles (nine families) (Figure 17). Among the amphibian families, Dicroglossidae contained the highest number of species (seven), while Colubridae was the most diverse family of reptiles (12 species) (Figures 18, 19). Other evidences of snakes were shown by staff of the national park but have not yet been recorded by our survey.

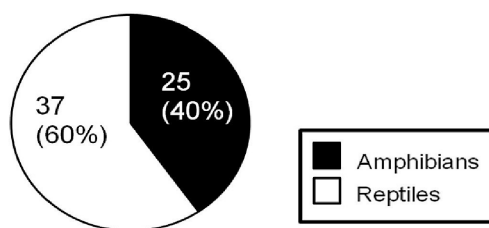


Figure 17. Number and percentage of recorded amphibian and reptile species.

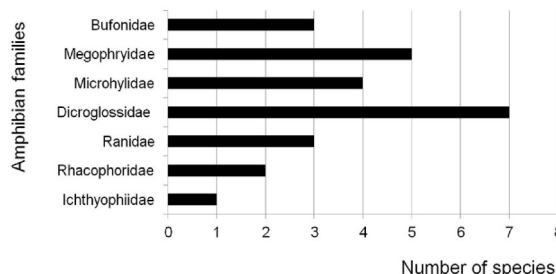


Figure 18. Species diversity of amphibian families.

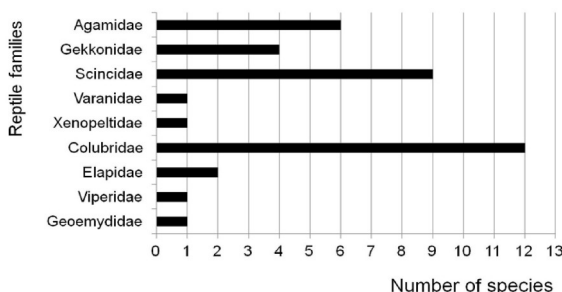


Figure 19. Species diversity of reptile families.

Table 1. List of amphibian species found in Chu Mom Ray National Park with information of associated habitat.

Amphibian species	Field station	Road, open land	Secondary forest	Secondary bamboo forest	Old-growth forest
<i>Duttaphrynus melanostictus</i>	X	X	X		X
<i>Ingerophrynus galeatus</i>					X
<i>Ingerophrynus cf. macrotis</i>					X
<i>Leptobrachium cf. pullum</i>					X
<i>Leptotalax cf. applebyi</i>					X
<i>Leptotalax cf. firthi</i>					X
<i>Xenophrys major</i>					X
<i>Ophryophryne cf. hansii</i>					X
<i>Kaloula indochinensis</i>					X
<i>Microhyla fissipes</i>	X	X			
<i>Microhyla heymonsi</i>	X		X		X
<i>Micryletta inornata</i>		X			X
<i>Fejervarya limnocharis</i>	X	X			X
<i>Limnonectes dabanus</i>			X		
<i>Limnonectes cf. bannaensis</i>					X
<i>Limnonectes limborgi</i>					X
<i>Limnonectes poilani</i>			X	X	X
<i>cf. Quasipaa sp.</i>					X
<i>Occidozyga martensii</i>		X			X
<i>Hylarana cf. nigrovittata</i>			X	X	X
<i>Odorrana cf. chloronota</i>					X
<i>Odorrana cf. tiannanensis</i>					X
<i>Polypedates cf. megacephalus</i>	X	X			
<i>Polypedates cf. mutus</i>	X	X			
<i>Ichthyophis cf. nguyenorum</i>	X	X			

Table 2. List of reptile species found in Chu Mom Ray National Park with information of associated habitat.

Reptile species	Field station	Road, open land	Secondary forest	Secondary bamboo forest	Old-growth forest
<i>Physignathus cocincinus</i>	X	X	X	X	X
<i>Acanthosaura coronata</i>					X
<i>Acanthosaura nataliae</i>					X
<i>Calotes emma</i>			X		
<i>Calotes versicolor</i>	X	X			
<i>Draco sp.</i>			X		
<i>Cyrtodactylus cf. pseudoquadrivirgatus</i>			X		X
<i>Gekko cf. gekko</i>	X				
<i>Gehyra mutilata</i>	X				
<i>Hemidactylus cf. frenatus</i>	X				
<i>Eutropis multifasciatus</i>		X			X
<i>Lipinia vittigera</i>	X				
<i>Lygosoma cf. corpulentum</i>					X
<i>Lygosoma sp.</i>					X
<i>Scincella rufocaudata</i>			X		X
<i>Sphenomorphus cf. buenloicus</i>					X
<i>Sphenomorphus stellatus</i>					X
<i>Tropidophorus cocincinensis</i>					X
<i>Tropidophorus sp.</i>			X		
<i>Varanus nebulosus</i>			X		X
<i>Xenopeltis unicolor</i>		X			
<i>Boiga cyanea</i>	X	X	X		
<i>Coelognathus flavolineatus</i>					X
<i>Dendrelaphis ngansonensis</i>		X			
<i>Lycodon fasciatus</i>					X
<i>Lycodon septentrionalis</i>					X
<i>Oligodon chinensis</i>		X			
<i>Psammodynastes pulverulentus</i>			X		X
<i>Rhabdophis chrysargos</i>					X
<i>Rhabdophis subminiatus</i>		X			
<i>Pareas hamptoni</i>				X	
<i>Pareas margaritophorus</i>		X			X
<i>Pseudoxenodon macrops</i>					X
<i>Bungarus candidus</i>					X
<i>Calliophis maculiceps</i>	X				
<i>Trimeresurus albolabris</i>		X			X
<i>Cyclemys cf. oldhamii</i>				X	

From the 25 amphibian species recorded during the survey, seven species were encountered at or around the field station, particularly often *Polypedates* sp., *Microhyla fissipes* and *Duttaphrynus melanostictus*. Among eight species observed at the road, *Fejervarya limncharis* and *Ichthyophis* cf. *nguyenorum* were the most common. Five species were found in secondary forests around the field station. Only two anurans were observed in bamboo forest (field excursion), while 20 species were recorded in evergreen old-growth forest near the field station (Figure 20). Hence, the latter habitat type is the most important for amphibian species in Chu Mom Ray NP.

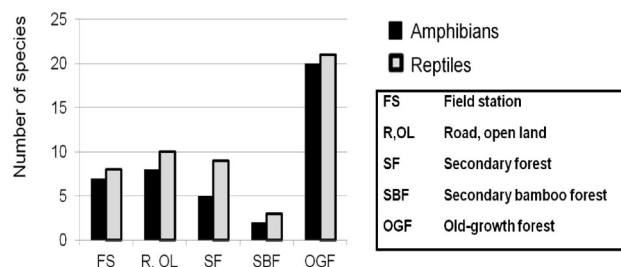


Figure 20. Species diversity of amphibians and reptiles associated with habitat types.

Of the 37 reptile species, eight could be found at the field station or the headquarters of the national park (e.g., *Gekko* cf. *gecko*, *Gehyra mutilata*, *Hemidactylus* cf. *frenatus* and *Calliophis maculiceps*); 10 species were spotted in the open land (e.g., *Calotes emma*, *Xenopeltis unicolor*, *Dendrelaphis ngansonensis*, *Oligodon chinensis* and *Rhabdophis subminiatus* found on roads and trails); nine species were encountered in secondary forest near the field station and *Boiga cyanea* was the most common snake; four species were observed in or near bamboo stands, of which three were found only in this vegetation type. 21 species were encountered in old-growth forest, and typical representatives are *Acanthosaura*, *Lygosoma*, *Sphenomorphus* and *Cyrtodactylus* cf. *pseudoquadrivirgatus*.

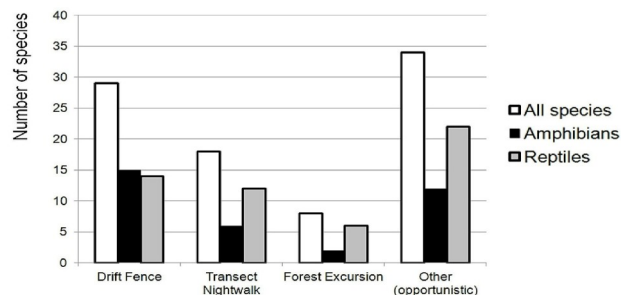


Figure 21. Number of recorded amphibians and reptiles by survey methods.

Based on our data, opportunistic encounters and the drift fence survey yielded the highest number of recorded species. We recorded 22 species of reptiles and 12 species of amphibians by opportunistic encounters and 15 species of amphibians and 14 species of reptiles by drift fence arrays. A total of 18 species were observed at the stream by transect night surveys and eight species were found during the forest excursion (Figure 21).

Ecological data

Temperature, humidity and pH tests

Averaged minimum and maximum temperatures measured in the old-growth forest (next to array 1 of the drift fence, 846 m a.s.l.) ranged from 21.6 to 23.9°C. Recorded mean humidity was between 95.1 and 98.9%. The data was collected during 35 nights, at an elevation of 843 m a.s.l. The pH tests at the transect forest stream showed pH values between 6.5 and 7.0 for all sample points. The pH values from the three upstream locations with a closed forest cover were higher (mean 6.94) than the test results from three downstream locations with degraded forest and open land (mean 6.67) (Table 3). The results also differed over time, as the means of the upstream and downstream pH values taken on 15 May 2012 were higher than the means from 30 May 2012. In the case of the downstream values, the mean declined during the three measurements.

Table 3. Results of pH tests at a forest stream in Chu Mom Ray National Park (six sampling points along 1.65 km of stream length).

pH Test	Upstream (forested)	Downstream (deforested, damaged)	Total stream section
pH mean value (15 May 2012)	7	6.83	6.92
pH mean value (22 May 2012)	7	6.67	6.83
pH mean value (30 May 2012)	6.83	6.5	6.67
pH mean value (all)	6.94	6.67	6.81

Vegetation of the surveyed areas

Apart from the core zone, several surveyed sites were situated at the edge of the national park (at elevations ca. 660-850 m a.s.l.). This area was characterized by agricultural lands (cassava, paddies and banana fields) and patches of degraded or secondary forest which turned into old-growth forest towards the interior of the national park. All five drift fence arrays were situated in broadleaf evergreen forest. Drift fence arrays 1, 3, 4 and 5 were inside disturbed old-growth forest, with exception of array 2 which was situated at the inner edge of a forest clearance dominated by pioneer vegetation, including small trees (less than 20 cm diameter at breast height), thickets of thorny shrubs and bamboo. Trees of all age classes including those with a minimum breast height diameter of 80 cm were present on or near to all arrays, including Dipterocarpaceae, *Ficus* sp. and *Lagerstroemia* sp. Lianas were abundant as well, with some reaching diameters of 10 cm and more. Along the forest stream, banana shoots were found, sometimes in clusters covering several m². The vegetation type around the excursion camp (Chu Mom Ray core zone) was mixed secondary bamboo forest in altitudes of 300 to 400 m a.s.l.

Deadwood and saproxylic beetles

Large rotting tree trunks were abundant around all drift fence arrays. Over the length of the surveyed stream transect (490 m linear distance), 14 rotting tree stems (diameter ≥10 cm) were counted. Different saproxylic beetle species were recorded around the field station.

4. Threats to the herpetofauna in Chu Mom Ray

Poaching and illegal logging

During the field stay, local people were constantly crossing the inter-provincial road bisecting the core zone of the national park and passing the field station. On 11 May 2012, two men on motorcycles were observed, with sounds of singing birds coming out of their bags. At one point of the way, they exchanged their cargo, which included a bird trap. During the field excursion (17 to 20 April 2012), a single bundle of 15 snare traps was found next to a site of illegal logging (N 14°26.635", E 107°38.062"), inside the core zone of the national park. Each snare consisted of rusty steel wire, with a diameter of about 4 mm and a total length of 227 cm. Another logging site was situated 740 m away from the first site. This site marked the beginning of a forest trail along which 15 steel wire snares (1.5 mm diameter) were attached to thin wooden sticks plugged into the ground. The distance from the starting point to the end of the trail measured 190 m. The snares were hanging down from a height of about 2 m, with the nooses 0.5 m to 1 m above the ground. Noose diameters varied from 2 cm to 15 cm. All snares were tagged with small red plastic bands. The trail starting point was 100 m from the excursion camp. At least five sites of illegal logging were found in the vicinity of the excursion camp. A local guide, who did not belong to Chu Mom Ray staff, said that he would visit the forest in the core zone on a regular basis for "working", staying up to one month in the national park. On 18 April 2012, a group of four middle-aged men stating to be fishing was encountered less than 500 m away from a ranger station (at road 14C) visited during the excursion. This station was frequented by trucks loaded with large-diameter logs. According to a forest ranger, armed forces were patrolling the area as it forms part of the border region with Laos and Cambodia (Pers. comm., 18 April 2012). On 27 April 2012, a snare trap was found hanging down from a wooden stick next to a drift fence. Another type of snare trap was found 160 m away from the field station (01 May 2012). Its noose consisted of a thin string. When a wooden stick of about 1 cm diameter was put inside the noose, the trap was immediately triggered, with the string tightening around the stick. Situated at a small, steep footpath at the edge of a cassava field and a forest patch next to the field station, this trap was attached to a large branch, in a height of about 1 m. Two old and defunct traps of the same type were found inside another, adjacent patch of young forest, between agricultural land and the road leading to the core zone. During the drift fence survey, local people were encountered on three occasions. On 22 May 2012, two men of about 18 years appeared at the same spot, stating that they were collecting wild honey. One of them reported the price to be 100.000 VND per unit.

Road-killed species

A number of reptiles and amphibians were found inside a concrete drain next to a paved road leading to the old-growth forest, for instance *Trimeresurus albolabris* (one dead juvenile), *Rhabdophis subminiatus* (eight

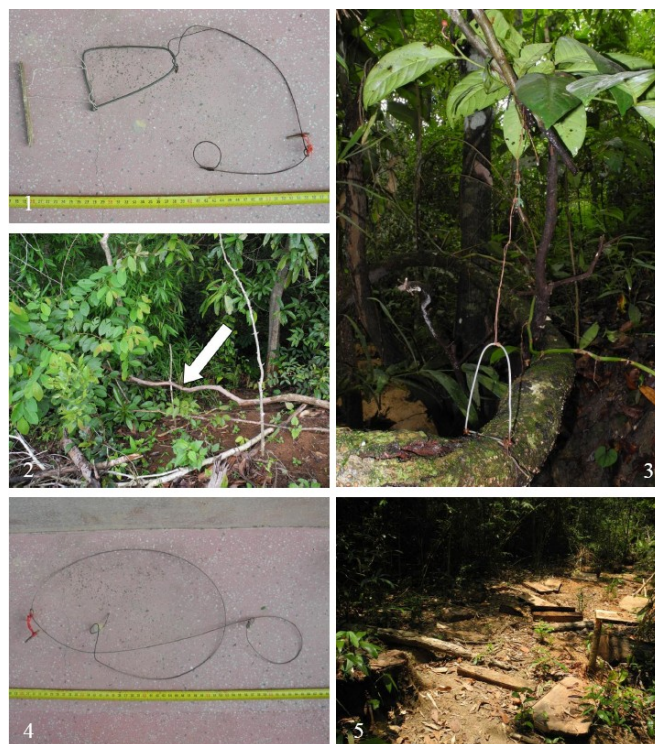


Figure 22. 1) Spring snare trap found and triggered on 01 May 2012, 160 m of the field station, 2) Place of discovery of the spring snare trap: at the edge of agricultural land and a forest patch surrounding the field station, 3) Defunct spring snare trap set up in the same way, 240 m from the field station, at the edge of the interprovincial road bisecting the national park, 4) One of 15 snares found along a trail, starting 100 m from the excursion camp, 5) Illegal logging site discovered on 18 April 2012 (photographs by D. Jestrzemski).



Figure 23. 1) Dead individual of *Rhabdophis subminiatus* found in a concrete drain near the field station (03 May 2012), 2) Close-up view of the same individual, 3) Living individual of *Ichthyophis cf. nguyenorum* in the same drain (14 April 2012), 4) Three dead individuals of *Ichthyophis cf. nguyenorum* in the same drain (06 May 2012), 5) Large plastic bag in a forest stream (photographs by D. Jestrzemski).

dead, one alive), and *Ichthyophis* cf. *nguyenorum* (nine dead, 10 alive). Other species encountered inside the drain at night time were *Xenopeltis unicolor* and *Pareas margaritophorus* (one individual each) (Figure 23).

DISCUSSION

Species diversity

This 2012 survey represents the first systematic study of herpetodiversity in Chu Mom Ray National Park. Although the park's herpetofauna is reported to comprise 65 species of reptiles and amphibians (Do *et al.* 2006), i.e. 47 reptiles and 18 amphibians (Ngo *et al.* 2006), only single herpetofaunal records for Chu Mom Ray have been published. These include *Calotes versicolor* (Ananjeva *et al.* 2007), *Dopasia sokolovi* (Nguyen *et al.* 2011) and *Boiga cyanea* (Ziegler *et al.* 2010). With 60 new discoveries, the number of all amphibians and reptiles known for the park rises to 63. Among these, 16 species including nine snakes were newly recorded for Kon Tum Province: *Ingerophrynus* cf. *macrotis*, *Kaloula indochinensis*, *Micryletta inornata*, *Polypedates* cf. *mutus*, *Acanthosaura coronata*, *Gehyra mutilata*, *Coelognathus flavolineatus*, *Dendrelaphis ngansonensis*, *Lycodon septentrionalis*, *Oligodon chinensis*, *Psammodynastes pulverulentus*, *Rhabdophis chrysargos*, *Pareas margaritophorus*, *Calliophis maculiceps*, *Trimeresurus albolabris* and *Cyclemys* cf. *oldhamii*.

Unidentified species and related genera

Since all data consisted primarily of photo vouchers, clear species identification was impossible for different taxa. These include at least 10 cryptic amphibians (*Leptobrachium* cf. *pullum*, *Leptotalax* cf. *applebyi*, *Leptotalax* cf. *firthi*, *Ophryophryne* cf. *hansi*, *Limnonectes* cf. *bannaensis*, cf. *Quasipaa* sp., *Odorrana* cf. *chloronota*, *Odorrana* cf. *tiannanensis*, *Polypedates* cf. *leucomystax*, *Polypedates* cf. *mutus*, *Ichthyophis* cf. *nguyenorum*) and six reptiles (*Draco* sp., *Cyrtodactylus* cf. *pseudoquadrivirgatus*, *Gekko* cf. *gecko*, *Lygosoma* sp., *Tropidophorus* sp. and *Cyclemys* cf. *oldhamii*). Some of these genera are of particular research interest in Chu Mom Ray because they are still subject of taxonomic uncertainty or contain very rare and possibly endangered species (particularly testudines such as *Cyclemys* sp.). The herpetological diversity recorded in a small part of Chu Mom Ray arises hopes that future surveys in the national park could unveil the existence of yet undescribed species.

Effectiveness of survey methods

All 62 species of reptiles and amphibians were recorded with four different methods. These varied in sampling intensity and time effort, and were implemented over a different time span. Thus the results cannot be used to compare the efficiency of the applied methods. The fact that most species were recorded during opportunistic encounters (34), followed by the drift fence survey (29), the transect night surveys (18) and the forest excursion (8) reflects the effort and time intensity of the different sampling methods in the field (Figure 21). Since opportunistic encounters were made during any time that was

not spent at the drift fence, transect night surveys and the forest excursion, species could be actively sampled at all places. Although the drift fence traps were open for 24 hours a day, they represented a passive technique (Willson & Gibbons 2009). This means that reptiles or amphibians could spend many hours at the fence but were not recorded unless being trapped. Furthermore, the applied pitfalls and funnel traps were geared towards smaller species, therefore systematically excluding large frogs, lizards and snakes (see Greenberg *et al.* 1994). Hence, it is not much surprising that more species were recorded opportunistically. The smaller number of species observed during the transect night walks when compared to the drift fence survey seems logical regarding the time effort. While the drift fence survey comprised 65 traps open for 24 hours during 40 days (= 62,400 trapping hours), the transect night surveys made up for a sampling time of nearly 50 hours distributed over 22 nights. This imbalance in time was obviously significant enough to outweigh the advantage of the active over the passive sampling technique. Also, the five drift fence arrays had the capacity of simultaneously capturing animals in 65 traps while the researcher was not capable of registering more than one animal at a time. Hence, the observation and processing of a frog at a certain transect point could prevent the capture of a snake 20 m upstream. Other factors influencing the success of species registration were differences in sight during day and night and the degree of comfortability of the researcher during the fieldwork. These factors were more limiting at night than at day, increasing the likelihood that small and cryptic species were overseen at the stream transect. As drift fence capture rates did not depend on the ability of the researcher, this technique provided for species samples that were probably more representative for actual population densities. The rather low number of eight species recorded during the forest excursion is not surprising as well due to the short duration of the trip (four days), when compared to the number of days spent on the other three methods. However, four reptiles were found with no other method.

Evaluation of ecological indicators

The presence of different species of saproxylic beetles around the field station indicated the presence of deadwood and mature trees, which is commonly associated with old-growth forest structures (Lachat & Bütler 2009, Nieto & Alexander 2010). Although the forest stands contained several trees with a breast height diameter of at least 0.5 m, this is not necessarily an old-growth indicator since primary forests can be dominated by trees with low diameters in breast height (Hadi *et al.* 2009). However, it shows a certain maturity of the surveyed forest stand. The abundance of relatively thick lianas in the forest patches around the drift fences was another evidence for old-growth forest structures and large-diameter trees (Calvi 2005). During the field stay at Chu Mom Ray, climatic data could only be recorded for the transition period between the dry and rainy season (see Wode 2000). However, the low recorded variation in mean day and night temperatures (21.6 to 23.9°C) and the high minima and maxima of humidity (95.1 to 98.9%) measured next to a drift fence array denoted rainforest climate (Galvin, 2009).

Based on these indicators, it is likely that the habitats surveyed with the drift fences belonged to old-growth forest and as such harbored a higher herpetological diversity than degraded forest stands or open areas in the buffer zone (Gardner *et al.* 2007). Ranging from 6.5 to 7.0, the pH value of the sampled forest stream could be considered nearly neutral (Gerstmeier & Romig 1998) and therefore not negatively influencing the development of anuran larvae (Levey 2003).

Threats to the herpetofauna of Chu Mom Ray National Park

Impact of poaching, illegal logging and non-timber forest products extraction

In Chu Mom Ray National Park, poaching takes place almost any time during the year and is conducted by local ethnic people and neighborhoods nearby as well as professional hunters and trappers coming from the other provinces (Do *et al.* 2006). Therefore, uncontrolled hunting was identified as the single most important threat to the larger snakes, turtles and monitor lizards in Chu Mom Ray. While the 30 snare traps discovered in Chu Mom Ray core zone were suited for larger mammals, the functioning spring snare trap found 160 m of the field station seemed to be geared to smaller, elongated wildlife and dangerous for snakes and lizards, particularly those with an arboreal lifestyle.

Illegal logging poses another threat to herpetofauna in Chu Mom Ray. Although timber extraction often increases the abundance of deadwood (Hérault *et al.* 2010), a valuable habitat of wildlife, it also causes the extraction of biomass, damages the stand structure (Sajwaj *et al.* 2008) and initiates the conversion of closed forests into open woodlands and finally grasslands (Kartawinata *et al.* 2001). As a consequence, daily temperatures increase and humidity is reduced (Davies-Colley *et al.* 2000). While studies do not indicate significantly lower herpetodiversity for logged forests, it was observed that the abundance of forest-interior species such as non-heliotherm lizards and specialized frogs decreased while the abundance of heliotherm lizards and generalized frogs increased (Azevedo-Ramos *et al.* 2005).

Wild honey extraction, such as pursued by the two strangers encountered on 22 May 2012, includes firemaking (Nguyen *et al.* 2006a, Wode 2000) and thus contributes to forest fires in the park (Nguyen *et al.* 2006a). The collection of rattan is a common practice in Chu Mom Ray (Nguyen *et al.* 2006a). The side effects are of particular concern, since rattan collectors in Vietnamese protected areas frequently poach wildlife (Mahood & Hung 2008). Moreover, the heavy use of the endemic species *Aquilaria rugosa* (Nguyen *et al.* 2006a, Nguyen *et al.* 2006b) is the major cause of the extinction of the species in the core and buffer zones (Do *et al.* 2006), with unknown consequences for the herpetofauna. According to Do *et al.* (2006) and Nguyen *et al.* (2006b), slash and burn farming takes place in Chu Mom Ray as well, especially in Dak Car near the core zone and Bar Gok ranger station.

Roads, infrastructure and trash

Illegal activities in the park are greatly facilitated by the

presence of large public roads such as 14C and the inter-provincial road connecting Sa Thay town and Mo Ray commune (Do *et al.* 2006, Nguyen *et al.* 2006b). According to Nguyen *et al.* (2006b) the length and flat terrain of these roads allow the large-scale encroachment of the national park by poachers. With only three guard stations (each used by 3-4 staff members) along these roads in intervals of 10-15 km, forest rangers face significant difficulties to control and prevent illegal activities. Any extension or upgrading of the roads will promote illegal activities in the park and make law enforcement more difficult (Do *et al.* 2006, Nguyen *et al.* 2006b).

Furthermore, the construction of infrastructure without ecological considerations causes mortalities among certain species of reptiles and amphibians in the national park. During the field study, this concerned a concrete drain along a dead-end street leading from the field station to old-growth forest. As the drain was surrounded by open land, it heated up significantly when the sun came out. Animals entering the drain could only escape if they managed to climb up the smooth 45° cement slope. If they failed to do so, their only option was to spend the daytime hours in the drain until they died from overheating and dehydration. It can be concluded that potential victims are not only caecilians and small snakes, as observed in the field, but also toads, non-saltatory frogs, smaller lizards and terrestrial turtles. Larger herpetofauna trapped in drains faces the additional danger of being systematically collected by people along the road. Although small reptiles and amphibians falling into the drain at night probably have much more time to escape than during the day, they easily become prey for passing predators. This was confirmed by the observation of two caecilians being eaten and a third attacked by army ants at night. Finally, the large amounts of plastic trash found along the surveyed forest stream are of concern as well, since reptiles and amphibians can get entangled or suffocate in plastic waste (Walde *et al.* 2007, Science For Environment Policy 2011).

Endangered reptiles and amphibians

Four species which are listed in the Vietnam Red Data Book (2007) were recorded in Chu Mom Ray National Park: one toad (*Ingerophrynus galeatus*), one gecko (*Gekko cf. gekko*), one agamid (*Physignathus cocincinus*), and one monitor lizard species (*Varanus nebulosus*). Two recorded species (*Varanus nebulosus*, *Bungarus candidus*) are listed in the Governmental Decree No32/2006/ND-CP (2006) (see also Table 4). The only species from the IUCN Red List found in Chu Mom Ray was *cf. Quasipaa sp.* All three *Quasipaa* species native to Vietnam (see Nguyen *et al.* 2009) are ranked from NT to EN in the IUCN Red List. Since only one turtle specimen was recorded (*Cyclemys cf. oldhamii*), it must be assumed that chelonians are very rare and heavily collected in the park. This species was listed in the IUCN Red List as near threatened (under *C. dentata* complex). Due to the relatively small area surveyed and the sighting of some larger serpents (one of which was the rat snake *Coleognathus flavolineatus*), it can be assumed that more protected snake species are native to the national park, e.g. other rat snakes, cobras, kraits and pythons. The long, gray serpent displayed on a photo by a staff member could have been a rat snake as

Table 4. Threatened species of amphibians and reptiles from Chu Mom Ray National Park (Vietnam Red Data Book: EN = Endangered, VU = Vulnerable; Decree 32/2006/ND-CP = Governmental Decree No.32 dated on 30 March 2006 by the Government of Vietnam, IUCN Red List: NT = Lower Risk/near threatened).

Species	Vietnam Red Data Book (2007)	Decree 32 (2006)	IUCN Red List (2013)
<i>Ingerophrynus galeatus</i>	VU		
<i>Gekko gekko</i>	VU		
<i>Physignathus cocincinus</i>	VU		
<i>Varanus nebulosus</i>	EN	Group IIB	
<i>Bungarus candidus</i>		Group IIB	
<i>Cyclemys oldhamii</i> (<i>C. dentata</i> complex)			NT

well, and the very large dark unidentified snake observed on the interprovincial road (17 April 2012), was possibly a king cobra (*Ophiophagus hannah*). However, large reptiles seemed to be rare, and neither snakes above 163 cm length nor adult specimens of *Cyclemys* cf. *oldhamii* and *Varanus nebulosus* were recorded in the field. This could be an indicator of the heavy hunting pressure on the national park's larger herpetofauna. Diurnal reptiles crossing the main roads in the park are in particular danger of being killed by accident or collected for trade.

OUTLOOK

Future herpetological surveys in Chu Mom Ray are urgently needed and likely to reveal the existence of further species. Recommended field methods for data collection are visual encounter surveys (VES) and expeditions to more remote areas of the national park. If time, team size and preparation are sufficient, drift fences with pitfalls respectively double-ended funnel traps should be applied to detect more secretive species. Larger pitfalls (at least 80 liter barrels) are necessary to include snakes as well, but they can be installed probably only in open areas without large tree roots and rocks in the topsoil. Road cruising can be effective as well, particularly for snakes.

The main threat to the Chu Mom Ray herpetofauna is poaching, while illegal logging and slash and burn farming cause habitat degradation. Illegal activities in the park are greatly facilitated by the network of roads bisecting the park. The high levels of wildlife exploitation in Chu Mom Ray National Park are alarming. If the current trend continues or increases, many populations of larger reptiles are likely to break down in the near future. As a major step of action against poaching, ranger capacities need to be enlarged based on persistent training, promotion of commitment and extended equipment and facilities. It is highly recommended to strictly control illegal logging and hunting. Ranger training should also include the promising SMART tool developed by global conservation organizations to fight poaching in protected areas and other hotspots of endangered biodiversity. Forest patrols need to be carried out on a regular basis and all over the park. It is recommended to introduce trained guard dogs in order to

facilitate the detection of criminals and protection of forest rangers. Awareness programs should focus on all wildlife trade stakeholder groups and foster markets for sustainably harvested products. International partnerships need to be developed. The work of conservation and development organizations should be promoted and new innovative services established in the park's buffer zone and surrounding communities. Based on the successful Indian model "Snake Help Line" (Nath *et al.* 2010), forest rangers could cooperate with the buffer zone villages to transfer living snakes, lizards and turtles from settlements into wilderness areas. Green clubs should be re-opened. The development of eco-tourism in the national park and surrounding communities would provide local people with financial incentives while promoting conservation. Alternative livelihood programs need to be extended for all local people. The national park should be protected from unsustainable economical activities (e.g. logging, mining and rubber tree plantations) and further construction of public roads.

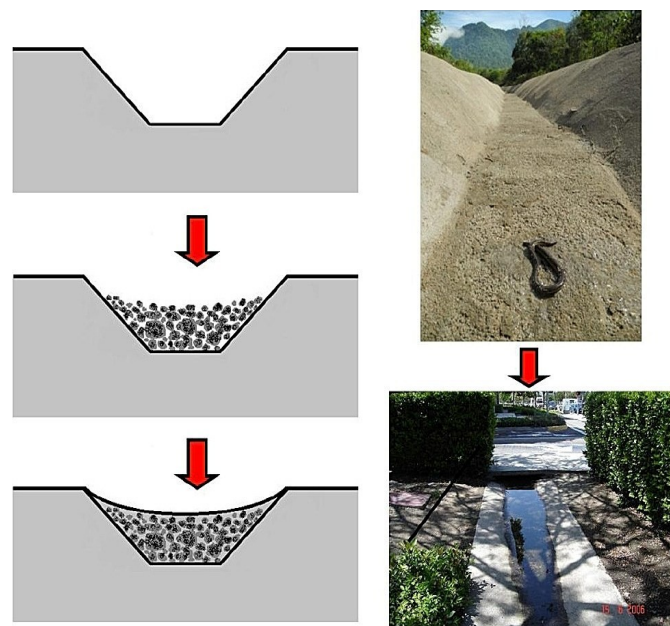


Figure 24. Proposed changes for an eco-friendly sewage drain (picture at bottom right is from <http://www.geocaching.com>).

This requires a firm stand of the People's Committee by recognizing the value of nature conservation for present and future generations of Vietnamese. It is very important to support extended field research on the herpetofauna of Chu Mom Ray National Park. Flagship species should be identified and promoted to raise awareness and funds from the international community. Research should also include wildlife trade stakeholders, trends and alternatives, with the results being disseminated to decision-makers. The streams and other water bodies of Chu Mom Ray National Park are particularly biodiverse habitats, and their protection is extremely important for herpetological conservation.

Steep concrete drains cause high mortalities among small snakes and caecilians, and consequently should be filled up with rocks and cement to flatten the slopes and enable the escape of entrapped herpetofauna (Figure 24). Most important, future drains should be shallow and not steep, permitting small herpetofauna and other wildlife to pass them without being trapped. Current high levels of (plastic) trash pollution in the forest should be systematically reduced by awareness programs, trash collection and trash bin allocation to ranger stations.

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