Nature Conservation 33: 1–19 (2019)
doi: 10.3897/natureconservation.33.33590
http://natureconservation.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
Nature Conservation
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# A case study on trade in threatened Tiger Geckos (*Goniurosaurus*) in Vietnam including updated information on the abundance of the Endangered *G. catbaensis*

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Academic editor: *Klaus Henle* | Received 1 February 2019 | Accepted 11 March 2019 | Published 1 April 2019

*http://zoobank.org/AFB147A3-617F-4B1D-9F62-CDC195C37B48*

**Citation:** Ngo HN, Nguyen TQ, Phan TQ, van Schingen M, Ziegler T (2019) A case study on trade in threatened Tiger Geckos (*Goniurosaurus*) in Vietnam including updated information on the abundance of the Endangered *G. catbaensis*. Nature Conservation 33: 1–19. https://doi.org/10.3897/natureconservation.33.33590

## Abstract

Tiger geckos of the genus *Goniurosaurus* are considered as a susceptible reptile group, due to their restricted distribution ranges, specialisation to specific microhabitats and generally low population densities. While still new species have been discovered recently, *Goniurosaurus* species are threatened by extinction through habitat loss and collection for the pet trade. Of the 19 described species, for only eight species, the conservation status has been assessed within the IUCN Red List between 2016 and 2018 and all have been classified in the threat categories VU (Vulnerable), EN (Endangered) and CR (Critically Endangered). *Goniurosaurus* spp. are popular in the international pet market at least since the 1990s and several species experienced local extirpations as a consequence of massive over-collection in the past. However, tiger geckos have not been paid much attention for conservation, amongst others, due to the lack of comprehensive knowledge on their conservation status and biology. This study provides an overview of international trade in *Goniurosaurus* based on available data from 1999 to 2018 in the U.S. as well as data from online surveys

and interviews in Europe and Vietnam, with the main focus on species native to Vietnam. All five tiger gecko species known from Vietnam were found in the local trade as wild captures for the national and international market and / or in the U.S. and Europe for relatively higher prices. We found that entire trade chains are very long (including several transfers and dealers involved) and that keeping and transport happen under poor conditions. We herein provide updated information on the abundance of the Endangered Cat Ba Tiger Gecko, which was recently shown to not only occur at its type locality, Cat Ba Island, Hai Phong City, North Vietnam, but also to inhabit small offshore islands in the Ha Long Bay, Quang Ninh Province. While the wild effective population was found to be relatively stable on four islands in Ha Long Bay, consisting of about 124 and 129 individuals in July 2017 and April 2018, respectively, the abundance of other sub-populations, impacted by anthropogenic pressures were found to be very low (2–10 individuals). Based on our findings, we propose stringent conservation measures to more efficiently protect wild tiger gecko populations, such as the inclusion in the Governmental Decree in Vietnam, the assessment of remaining species in the IUCN Red List of Threatened Species and the inclusion in the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

**Keywords**
Pet markets, Vietnam, abundance, anthropogenic pressures, conservation

## Introduction

Tiger geckos of the genus *Goniurosaurus* currently comprise 19 species with a disjunct distribution in Southeast Asia and East Asia (Chen et al. 2014; Grismer et al. 1994, 1999; Honda and Ota 2017; Liang et al. 2018; Yang and Chan 2015; Zhou et al. 2018; Ziegler et al. 2008). The genus contains a high level of local endemism and many species have been recorded only from a single locality, mountain range or archipelago of China, Japan and Vietnam. *Goniurosaurus* is also considered as one of the most susceptible reptile groups due to its generally low population densities and restricted distribution areas, which make tiger geckos particularly threatened by extinction through habitat loss and over-harvesting for the pet trade (Ngo et al. 2016b; Yang and Chan 2015).

Tiger geckos have been recorded in the international pet market at least since the 1990s (Rösler 1995; Stuart et al. 2006; Yang and Chan 2015). Some rare species are fetching high prices in relation to other gekkonids (e.g. US$2000 / per individual of *Goniurosaurus luii*), which provides great incentives for poaching and excessive collection (Grismer et al. 1999; Stuart et al. 2006). However, the scale of the international demand for tiger geckos, as well as trade levels and patterns, are unknown due to tiger geckos are not listed in CITES. Thus, we herein present an attempt to outline domestic and international trade activities in *Goniurosaurus* species in order to inform decision-makers and develop conservation strategies.

The insular Cat Ba Tiger Gecko (*Goniurosaurus catbaensis*) was originally discovered on Cat Ba Island in Hai Phong City, north-eastern Vietnam (Ziegler et al. 2008). A preliminary population assessment of *G. catbaensis* revealed that its effective population size at the type locality is extremely small with less than 24 individuals (Ngo et al. 2016b). The species are considered to be vulnerable to anthropogenic disturbances and

ongoing demand has been recorded in pet markets, as well as on internet platforms for many years (Ngo et al. 2016b; Ngo et al. in press). Over-collection for the pet trade has probably led to local extirpation of *G. luii* and *G. araneus* from their respective type localities in the past (Stuart et al. 2006; Yang and Chan 2015). In addition, habitat destruction for touristic purposes may increase the pressure on the wild *G. catbaensis* population (Ngo et al. 2016b; Nguyen et al. 2018b).

Recently, Ngo et al. (in press) confirmed for the first time that *G. catbaensis* occurs outside its type locality, , by also providing a microhabitat characterisation of *G. catbaensis* throughout its distribution range in Cat Ba Ha Long archipelagos. The present study was conducted to further provide a first assessment on the population size of and threats impacting subpopulations of the Cat Ba Tiger Gecko from Ha Long Bay.

## Methods

### Analysis of trade

To obtain an overview on the availability and evidence for trade in *Goniurosaurus* spp. in Vietnam, we surveyed several pet markets in both southern and northern Vietnam (including Hai Phong City, Quang Ninh Province, Ha Noi City, Ho Chi Minh City and Dong Nai Province) in March 2018, based on public information on the internet. Five local dealers were questioned in order to determine the origin, availability, demand, price and use of traded species. To investigate the reptile market in the European Union (EU) for the availability of *Goniurosaurus* spp., we further screened online markets (online shops, internet platforms and forums, Facebook) and visited the largest reptile fair "Terraristika" in Hamm, Germany in March and June 2018. Names of interviewees were kept anonymous to ensure data privacy rights.

Furthermore, we analysed import volumes of *Goniurosaurus* spp. into the United States (U.S.). Data were obtained from the LEMIS database of the U.S. Fish & Wildlife Service, which included all recorded imports of *Goniurosaurus* spp. into the U.S. from 1999 to 2018. The purpose of trade in *Goniurosaurus* was categorised as (B) "breeding in captivity or artificial propagation", (H) "hunting trophies", (P) "personal", (S) "scientific", (T) "commercial" and (Z) "zoo". The source of specimens was differentiated between wild (W), captive bred (C), captive born (F) and ranched (R), animals following the CITES definition in Res. Conf. 12.3 (Rev. Cop17).

### Field survey

Field surveys were conducted in Ha Long Bay in July 2017 and April 2018 during the non-hibernation season of *Goniurosaurus catbaensis* (Grismer et al. 1999; Ngo et al. 2016b). We conducted a total of 24 night excursions between 19:30 h and 05:00 h of the next day, when the lizards were found to be active (Ngo et al. 2016b; Ziegler et al.

**Table 1.** Study sites in Ha Long Bay, Quang Ninh Province, Vietnam.

| Study sites (Transect) | Transect Length (m) | Area of survey sites ($m^2$) | Elevation a.s.l. (m) | Habitat types |
|---|---|---|---|---|
| Island 1 (T-1) | 380 | 5 000 | 4–99 | Shrub vegetation on limestone karst |
| Island 2 (T-2) | 300 | 2 180 | 5–20 | Shrub vegetation on limestone karst |
| Island 3 (T-3) | 200 | 1 180 | 10–72 | Shrub vegetation on limestone karst |
| Island 4 (T-4) | 410 | 5 560 | 14–67 | Shrub vegetation on limestone karst |
| Total | 1290 | 13 920 | 4–99 | Shrub vegetation on limestone karst |

2008). Four survey transects (T-1 to T-4) were set up on four offshore islands, with length of 200 to 410 m each. The islands, covering a total area of 13,920 $m^2$ (Table 1). Thereof, two transects (T-3, T-4) were selected based on previous surveys by Ngo et al. (2016b) and two further sites were surveyed according to recommendations by interviewed staff of the Management Board of Ha Long Bay (T-1, T-2). Study sites were located within shrub vegetation on limestone outcrops at elevations between 4 and 99 m a.s.l (Table 1). Boat surveys were also conducted at night to search for animals on out-surfaces of limestone karsts close to the oceanic surface. Coordinates and elevations of each captured individual were recorded with a GPS Garmin 64. However, GPS data is not presented herein, to prevent the misuse of the data.

## Population analysis

To estimate population, a "mark-recapture method" was applied. In case of one-time mark and recapture event at two sites (T1, T3), the "Lincoln-Peterson Index" and, in the case of several recapture events at two remaining sites (T2, T4) (e.g. Caughley 1980; Schlüpmann and Kupfer 2009; Smith and Smith 2009; Nguyen et al. 2018a), the "Schnabel Index" was applied. Therefore, all encountered individuals were captured and individually marked with passive integrated transponder (PIT) tags (ISO FDX-B Glastransponder, 1.4 × 9 mm). The microchip was injected under the skin on the left body side behind the shoulder. All captured and recaptured individuals were identified with a transponder reader and afterwards released immediately at the spot of capture (van Schingen et al. 2014; Smyth and Nebel 2013). Each transect was repeatedly surveyed in intervals of two days. Estimated population sizes only refer to the surveyed sites and do not encompass the entire wild population of the species. Since it is impossible to survey all potentially suitable habitats in the region, density estimates with reference to transect lines were used as relative abundances.

To assess the population structure of *G. catbaensis*, lizards were categorised into three age classes, based on the snout-vent length (juvenile with SVL < 85 mm, sub-adult with 85 mm ≤ SVL < 105 mm and adult with SVL ≥ 105 mm) (Ngo et al. 2016b). We also differentiated between sexes and between gravid and non-gravid females. Sexes could only be determined clearly for adult and sub-adult specimens as males have enlarged swollen cloacal and 16–21 precloacal pores, while those are lack-

ing in females (Ziegler et al. 2008). Furthermore, the time was noted for each encounter to evaluate the activity pattern of the species. To test for differences in population structure between July 2017 and April 2018, as well as between islands and time of the day, a $c^2$ test with $P \leq 0.05$ was applied. Statistical analyses were performed with the SPSS software, version 16.0 (SPSS Inc., Chicago).

### Anthropogenic Impacts

Potential threats to *G. catbaensis* were investigated in Ha Long Bay and Cat Ba Archipelago. Evidence for harvesting of *G. catbaensis* was obtained through interviews with local dealers, market surveys and a literature survey. Other potential anthropogenic impacts, namely "tourist activities" and "habitat degradation" were recorded by our own observations and interviews with local fishermen (Ngo et al. 2016b; Ngo et al. in press). Depending on the frequency and extent of recorded negative impacts, threats to each of the sub-populations were classified as "not recorded", defined as never being recorded, "low" as being rarely observed, "medium" as being recorded several times, or "high" as being recorded frequently or the extent of destruction was evaluated as too high.

## Results

### Trade

Most, if not all *Goniurosaurus* species were found being sold in the international pet market in Europe and the U.S. during the present study. According to the LEMIS database of the U.S. Fish & Wildlife Service, a total of 16,714 specimens of *Goniurosaurus* spp. have been imported into the U.S. (mean of 835 ± 1082 individuals annually) between 1999 and 2018 (Fig. 1A). The majority of specimens were imported on genus level as *Goniurosaurus* spp. (44.5%). Amongst the others, the most imported species was *G. lichtenfelderii* (43.6%, n = 7281 individuals), followed by *G. hainanensis* (6%), *G. luii* (3.6%), *G. orientalis* (1.3%) and *G. kuroiwae* (1%) (Fig. 1C). The vast majority of imported specimens were traded for commercial purposes (97%), while only 3% were imported for scientific and zoo purposes (Fig. 2B). A number of 11,515 specimens (68.9%) were wild caught and 5,086 animals (30.4%) were imported as bred in captivity (Fig. 2A). Thereby, most *Goniurosaurus* species imported into the U.S. were from Taiwan (40.5%) as a major exporter, followed by Hong Kong (32.2%), China (15.7%), Indonesia (5.2%) and other CITES Parties (6.4%) (Fig. 1B).

In March 2018, market surveys showed that the trade in *Goniurosaurus* in the EU mainly takes place online, but also in reptile fairs. It was recorded that specimens for sale fetch prices between US$35–200 on the international internet markets, e.g. price for two unsexed juveniles or one male of *G. araneus* was recorded for sale for US$150, *G. bawanglingensis* for €175 per pair (US$200), *G. catbaensis* for US$195–230 per

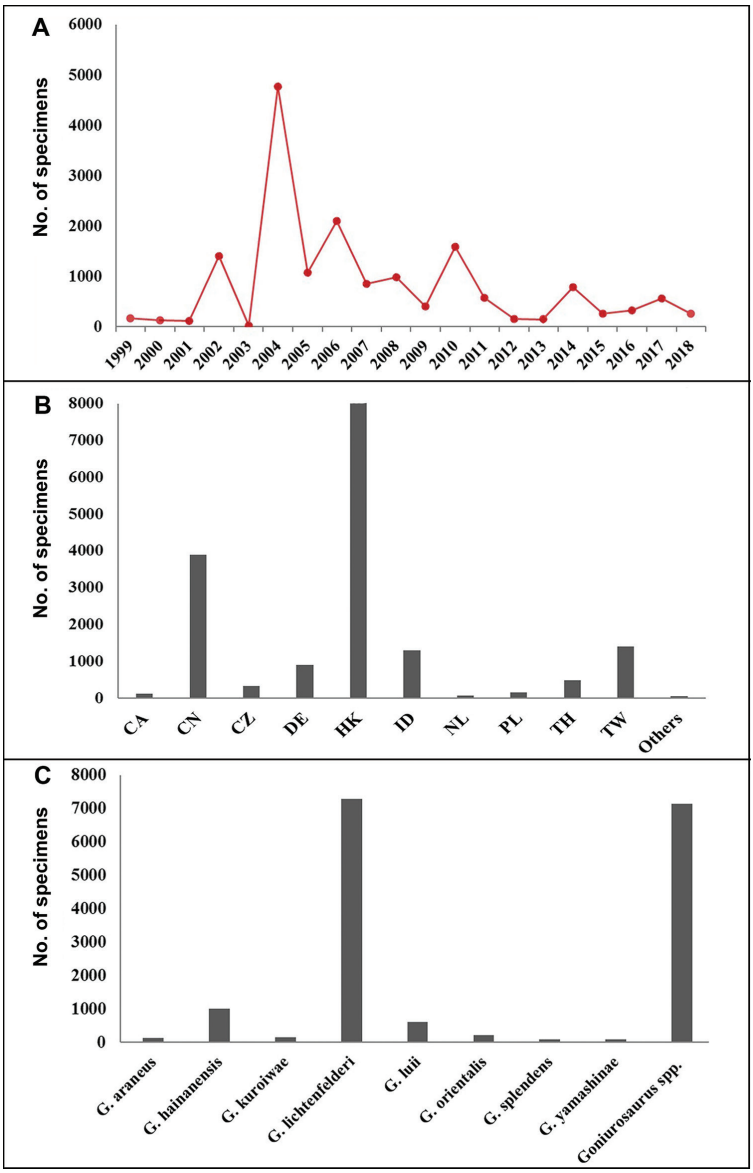


**Figure 1.** International trade in *Goniurosaurus* species between 1999 to 2018 to or from the U.S. **A** Annual volumes of import into the U.S. **B** number of exported specimens per exporting party (CA = Canada; CN = China; CZ = Czech Republic; DE = Germany; HK = Hong Kong; ID = Indonesia; NL = Netherlands; PL = Poland; TH = Thailand; TW = Taiwan) **C** number of imported specimens per species into US. Source: LEMIS database of the U.S. Fish & Wildlife Service (1999–2018).

specimen or for €300 (US$340) per pair, *G. hainanensis* for US$45–150 per specimen, *G. huuliensis* for US$400 per pair or US$150 for one male, *G. lichtenfelderii* for US$70–100 per specimen and *G. luii* for US$175 per two juveniles or for US$40–60 per pair or one (Table 2).

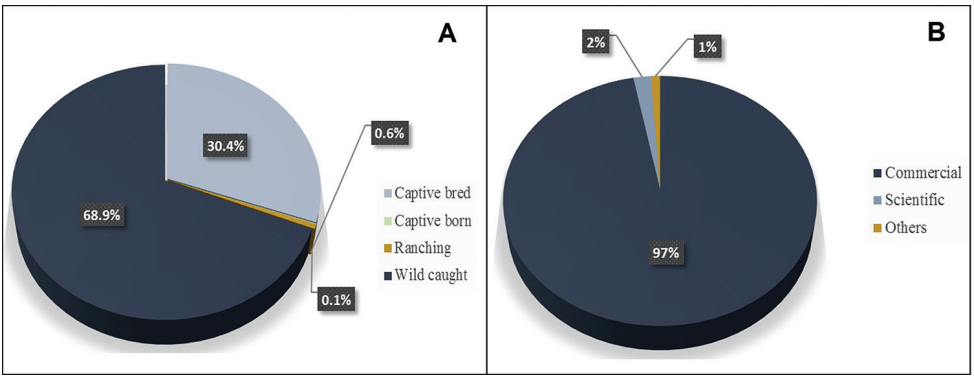


**Figure 2.** International trade in *Goniurosaurus* species from 1999 to 2018 to or from the U.S. **A** Source of animals **B** purpose of trade. Source: LEMIS database of the U.S. Fish & Wildlife Service (1999–2018).

**Table 2.** International trade in several *Goniurosaurus* species in Europe based on online investigations and interviews with dealers on reptile fairs (own surveys in 2018 and data from Altherr et al. *in lit.* 2019).

| Species | Trade type | Place | Country | Price (USD) per specimen |
|---|---|---|---|---|
| *G. araneus* | Offer | Internet Shops | Europe | 150–170 (€142) |
| *G. bawanglingensis* | Offer | Fair, Internet Shops | Germany, Europe | €67–250 (or €175 per pair) |
| *G. catbaensis* | Offer | Fair, Internet Shops | Germany, Europe | 195–230 (or €300 per pair) |
| *G. hainanensis* | Demand and Offer | Internet Shops, Shops, and Private | Czech Republic, France, Germany | 45–150 |
| *G. huuliensis* | Demand and Offer | Internet Shops and Private | Europe | €160–220 (€400 per pair) |
| *G. lichtenfelderii* | Demand and Offer | Internet Shops and Private | Europe | 70–100 |
| *G. luii* | Demand and Offer | Fair, Internet Shops | France, Germany, Europe | 40–170 |

Furthermore, Altherr et al. (*in lit.* 2019) reported a total of 835 specimens of *Goniurosaurus* spp. were observed for sale on 142 different online adverts with prices ranging from €35–300 (US$40–365) between September 2017 and September 2018, whereof, *G. araneus* (n = 56) were offered for sale of €142, *G. bawanglingensis* (n = 102) for €67–250 *G. catbaensis* (n = 29) for €170, *G. hainanensis* (n = 162) for €35–140, *G. huuliensis* (n = 41) for €160–220, *G. lichtenfelderii* (n = 97) and *G. luii* (n=150) for €35–142.

According to interviews with local dealers in Vietnam in March 2018, all five native *Goniurosaurus* species have been frequently recorded in local pet shops from Dong Nai Province and Ho Chi Minh City in northern Vietnam, on Social Media, e.g. Facebook, Zalo online and other internet platforms. These tiger geckos were usually wild-caught by local villagers who live within the species' distribution range and then sold for little money to dealers to be either offered in local pet shops or be sold to other traders. *Goniurosaurus* specimens were found to be locally offered for sale at US$7–25 per animal in pet shops in Vietnam (Table 3). According to dealers in pet shops, *Goniurosaurus* specimens have been regularly exported from Vietnam to Thailand and Indonesia without any permits for higher prices of US$100–150 per individual. Charges consist of at least 20–50 specimens per deal. Afterwards, specimens would allegedly be mainly exported further to Europe and the United States (Table 3).

**Table 3.** Information on local trade in and international trade pathways for *Goniurosaurus* species in Vietnam based on interviews with local dealers in 2018.

| Species | Sources | Offered in pet shops | Country of destination | Minimum quantity per deal for export | Price (USD) per specimen* |
|---|---|---|---|---|---|
| *G. araneus* | China | Dong Nai Province | Thailand, Indonesia, EU and the U.S. | 50 | (2): 100–150 |
| *G. catbaensis* | Cat Ba NP, Hai Phong city, Viet Nam | Dong Nai Province, Ho Chi Minh City | Thailand, Indonesia, EU and the U.S | >= 20 | (1): 7–25<br>(2): 150 |
| *G. huuliensis* | Huu Lien NR, Lang Son Province, Viet Nam | Dong Nai Province, Ho Chi Minh City | Thailand, Indonesia, EU and the U.S. | >= 20 | (1): 20–25<br>(2): 100 |
| *G. lichtenfelderii* | Yen Tu, Quang Ninh Province, Viet Nam | Dong Nai Province | Thailand, Indonesia, EU and the U.S. | >=20 | (1): 20–25<br>(2): 100 |
| *G. luii* | Cao Bang Province, Viet Nam | Dong Nai Province, Ho Chi Minh City | Thailand, Indonesia, EU and the U.S. | 50 | (1): 20–25<br>(2): 100–150 |

*(1): for locals; (2): for export

## Population status of *Goniurosaurus catbaensis*

We observed a total of 73 animals (54 adults) in July 2017 on four islands and a total of 93 individuals (70 adults) in April 2018 within sites covered by the shrub vegetation on three islands in Ha Long Bay. We did not find any specimens of *Goniurosaurus* on out-surfaces of karst formations by boat surveys. The total population size at the survey areas was estimated at 175 individuals in July 2017 and 180 animals in April 2018. Regarding the effective population size – considering only mature animals – this estimated wild population was relatively similar to about 124 and 129 individuals in July 2017 and April 2018, respectively (Table 4). With respect to each sub-population, the number of estimated animals was highest on island 1 (86 individuals) (Table 4).

The mean density of *G. catbaensis*, along suitable habitat sites in Ha Long Bay, was estimated to be around 6 individuals and 4.5 adults per 100 m transect length during April and 9.1 individuals and 7 adults per 100 m transect length during July. By comparing different sites, the highest abundance was estimated at nearly 12 individuals per 100 m/ transect length at site 1 in April, while we found the lowest density of 2 animals per 100 m/ transect length at site 2 in July (Table 4).

In both investigated months, the sex ratio of adults was relatively balanced with a little higher percentage of females of *G. catbaensis* (57% and 55%, respectively). The percentage of gravid and non-gravid females significantly differed between both months ($c^2 = 21$; df = 2; $P < 0.001$), while 44% of females (n = 14) were gravid in July 2017 (Fig. 3A) and 95% of females (n = 41) were non-gravid in April 2018 (only two females were gravid). With respect to the presence of different age classes, the population structure was relatively similar between two months ($c^2 = 3.04$; df = 2; $P = 0.219$) with most of the observed animals being identified as adults (75% in July 2017 and 80% in April 2018 see Fig. 3B). Frequency histograms of SVL (Min–Max = 53.42–125.28 mm, n = 149) showed a slight shift in the presence of small juveniles between July and April ($c^2 = 19.88$; df = 7; $P = 0.006$). Individuals with the smallest SVL

**Table 4.** Summary of the population assessment of *Goniurosaurus catbaensis* including observed individuals, densities (D) and population size estimates (N) in Ha Long Bay in July 2017 and April 2018. Ind: individuals; Asterisks indicate missing data (no survey).

| | Island 1 (T-1) | Island 2 (T-2) | Island 3 (T-3) | Island 4 (T-4) | Total |
|---|---|---|---|---|---|
| **July-2017** | | | | | |
| Total (observed) | 27 | 7 | 20 | 19 | 73 |
| Mature (obs.) | 17 | 3 | 16 | 18 | 54 |
| D observed [ind/100 m of route] | 7.1 | 2.3 | 10 | 4.6 | 6 |
| D [mature/ 100 m of route] | 4.5 | 1 | 8 | 4.4 | 4.5 |
| $N_{mature}$ | 36 | 4 | 33 | 50 | **124** |
| $N_{total}$ | 56 | 16 | 49 | 54 | **175** |
| **April-2018** | | | | | |
| Total (observed) | 45 | * | 15 | 33 | 93 |
| Mature (obs.) | 28 | * | 12 | 30 | 70 |
| D [ind/100 m of route] | 11.8 | * | 7.5 | 8.1 | 9.1 |
| D [mature/100 m of route] | 7.3 | * | 6 | 7.5 | 7 |
| $N_{mature}$ | 60 | * | 27 | 45 | **129** |
| $N_{total}$ | 86 | * | 45 | 49 | **180** |

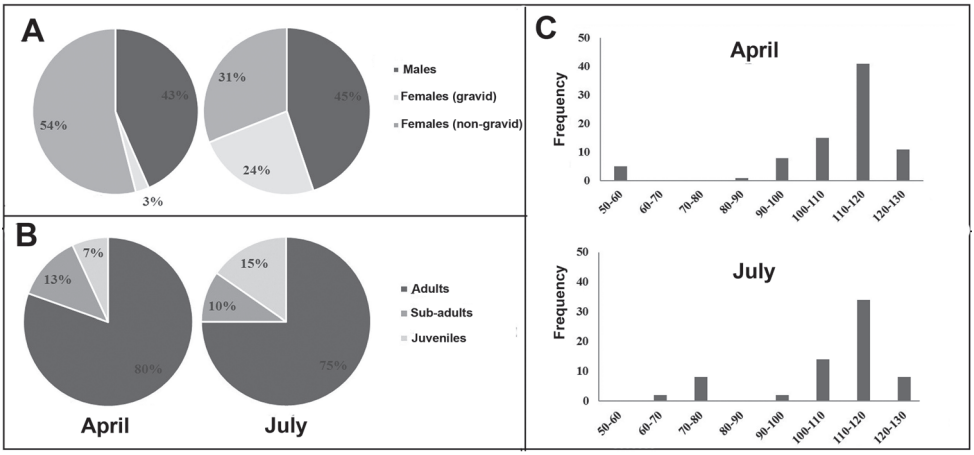


**Figure 3. A, B** Population structure of *Goniurosaurus catbaensis* from Ha Long Bay (July 2017 and April 2018, respectively) **C** Frequency histogram of snout-vent length of *G. catbaensis* for the months April and July.

(50–60 mm) were only found in April, while juveniles with longer SVL (60–80 mm) were exclusively found in July. The number of adults with SVL ranging between 110–120 mm accounted for the highest percentage in both months (Fig. 3C).

## Daily activity

With regard to the daily activity pattern, *G. catbaensis* was found to be active at night from approximately 20:00 h to 04:00 h. The vast majority of lizards (98 animals or

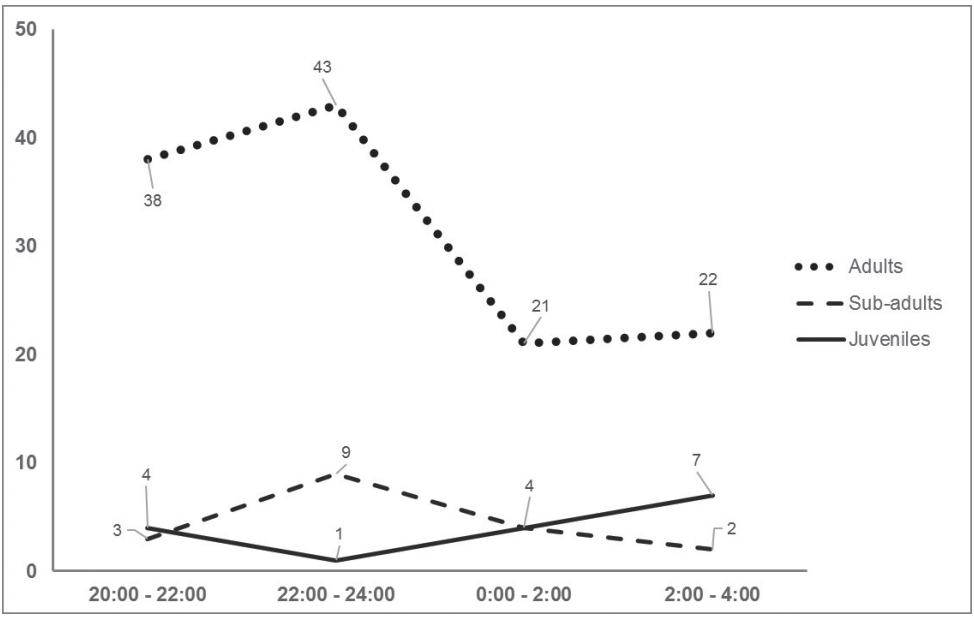


**Figure 4.** Number of observed *Goniurosaurus catbaensis* specimens at different time intervals in Ha Long Bay.

62% of the recorded lizards) were observed between 22:00 h and 24:00 h. We further found a difference in population structure amongst different times of the day ($c^2$ = 14.39; df = 6; P = 0.026 < 0.05). Particularly, we observed that more adult specimens were active during the first four hours between 20:00 h and 24:00 h (n = 81 account 65.3% of captured adults), while juveniles were frequently found either before 22:00 h or mainly between 00:00 h and 04:00 h. Most juveniles were found between 02:00 h and 04:00 h (Fig. 4).

## Threat evaluation

The number of captured animals and the size of sub-populations of *G. catbaensis* from Ha Long Bay in Quang Ninh Province were compared with other differently affected sub-populations in Cat Ba Archipelago of Hai Phong City. In the Cat Ba National Park and Ha Long Bay's tourist caves, total anthropogenic impacts were considered to be "Medium" and local populations were relatively small (2–10 individuals). A strong flood event in 2015 appeared to have caused the local extirpation of *G. catbaensis* at one site in Viet Hai Commune on Cat Ba Island (Table 5). The mean population size of the species was highest within untouched sites on four islands in Ha Long Bay (Table 5), where total anthropogenic impacts were considered as "Low".

**Table 5.** Recorded impacts on *Goniurosaurus catbaensis* at known sites. Single impacts were ranked according to severity as "not recorded" defined as never being recorded, "low" as being rarely observed, "medium" as being recorded several times, or "high" as being recorded frequently, or the extent of destruction was evaluated too high.

| Study sites | Population size (Mean) | Harvest | Tourist activities | Habitat degradation | Total impacts |
|---|---|---|---|---|---|
| Sites near the headquarters of Cat Ba National Park (NP) – Ngo et al. 2016b | 5 | Medium | High | Medium | Medium |
| Viet Hai Commune – Cat Ba NP – Ngo et al. 2016b | 10 | Medium | Medium | Low | Medium |
| One site in Viet Hai Commune – Cat Ba NP – Ngo et al. in press | 0 (in August 2015) | Not recorded | Not recorded | High | High |
| Ha Long Bay (4 islands) – Current study | 51 | Not recorded | Not recorded | Low | Low |
| Ha Long Bay's Caves (4 caves) – Current study | 2 (total animals) | Not recorded | High | Medium | Medium |

## Discussion

### Trade

Ngo et al. (in press) provided evidence for the collection of at least three of five native species, namely *G. catbaensis, G. huuliensis* and *G. luii* in Vietnam for the domestic trade. During our recent market surveys in 2018, we further recorded that all five native tiger geckos are being collected for sale and also kept as pets in Vietnam, while some tiger geckos including *G. araneus, G. luii* (Grismer et al. 1999), *G. catbaensis* (Bauer 2009) and *G. lichtenfelderii* (Liu 1993) were reported to be used in traditional medicine in China. Our interviews identified commercial revenues in relation to the domestic and international pet trade as the most common incentive for domestic collection in Vietnam. Janssen and Shepherd (2019) documented that the *Goniurosaurus* is the most popular endemic genus offered for sale on the Nansei Islands in Japan.

All tiger geckos have a restricted distribution ranges and are – like many endemic reptiles – extremely vulnerable to exploitation, so that international trade can quickly become a significant threat for extinction (Janssen and Indenbaum 2019; Janssen and Shepherd 2018; Lyons and Natusch 2013). Accordingly, many endemic species have not been seen any more over a long period of time in recent years and some taxa are considered extinct at their type localities (Lindenmayer and Scheele 2017; Meiri et al. 2018). Evidence from extensive field works in recent years suggests that populations of *G. araneus* in Vietnam and *G. luii* in China have been extirpated at their respective type localities in the past due to over-harvesting for the pet trade (Stuart et al. 2006, Yang and Chan 2015, pers. obs.).

*Goniurosaurus* spp. have been popular in the international pet market at least since the 1990s (Stuart et al. 2006; Yang and Chan 2015). According to the LEMIS database, a total of 16,714 specimens of *Goniurosaurus* spp. have been imported into the U.S. between 1999 and 2018. The U.S., together with Japan and the European Union, are considered as three important destinations for the transaction of reptile species

including tiger geckos (Auliya et al. 2016; Janssen and Indenbaum 2019; Sollund and Maher 2015). Several individuals of the Huu-Lien Tiger Gecko, endemic to Vietnam, were observed in some reptile shops in Japan (Janssen and Indenbaum 2019). Janssen and Shepherd (2019) found that all *Goniurosaurus* species, endemic to Japan and being nationally protected by law, are offered for sale in the EU and the U.S. in large quantities for prices reaching up to US$714 for single specimens.

We herein observed most *Goniurosaurus* species for sale in the EU online as well as in reptile fairs. Accordingly, Altherr et al. (*in lit.* 2019) spotted a total of 835 specimens of *Goniurosaurus* spp. for sale on different social media platforms between 2017 and 2018. These observations, during random physical as well as internet market surveys, only reflect snapshots of current EU trade in tiger geckos. Actual trade volumes remain unknown – as *Goniurosaurus* spp. are not as yet listed in the CITES Appendices – but are likely to be higher.

Stuart et al. (2006) supported the idea that captive breeding can reduce further demand on wild-caught animals. Our study indeed showed that a large quantity of animals offered for sale was labelled as captive bred in Europe and several reports on successful captive breeding in *Goniurosaurus* species exist (e.g. Einsfelder 2016; Kaverkin 2000). However, wild-caught animals are still being imported into the EU and the U.S. in large quantities. During the recent ten years, there were still about 4,000 imports of wild specimens to U.S. recorded. Endemic tiger geckos of China and Vietnam, which were imported into the U.S. as wild-caught specimens, originated from non-range states, likely without any related permits from countries of origin.

According to interviewees in Vietnam and Europe, captive-bred animals were not yet available in quantities to meet the global demand and wild animals were generally offered for much cheaper prices than captive-bred animals. Furthermore, wild-caught specimens are considered to have a high mortality rate during transport and stockpiling (Sollund and Maher 2015), even though no studies exist that assessed mortality rates between collection and export or between export and country of destination in *Goniurosaurus*. According to local dealers, wild animals are usually kept for a long time clumped together in small boxes and then transported with motorbikes, trains, ships or air freights under poor conditions without supply of food and water. It is likely, that many of the sensitive animals die before reaching their final destination. According to our interviews, local dealers from Vietnam nowadays usually contact local collectors who are living close to the habitats of *Goniurosaurus* species via online wildlife trade groups, for example, on Facebook and pay about US$4 – 5 per individual for collection during the active season of the species. We found *G. araneus* amongst the animals offered in Vietnam (likely imported from China), a species which has probably already been extirpated from its type locality in Vietnam (Ngo et al. 2016b). After collection, specimens are frequently transported via motorbike to Hanoi, northern Vietnam and then transported by train or motorbike to pet shops in Dong Nai and Ho Chi Minh City, southern Vietnam. Some specimens are sold in Vietnam, but the majority of animals are allegedly transported by train or boat to Thailand and Indonesia as intermediary countries without any permits, as they reach higher prices than on the national market. From there, these animals are mainly exported to Europe and the U.S. (Fig. 5). As such, the entire trade chains are rather long as they include numerous stations.

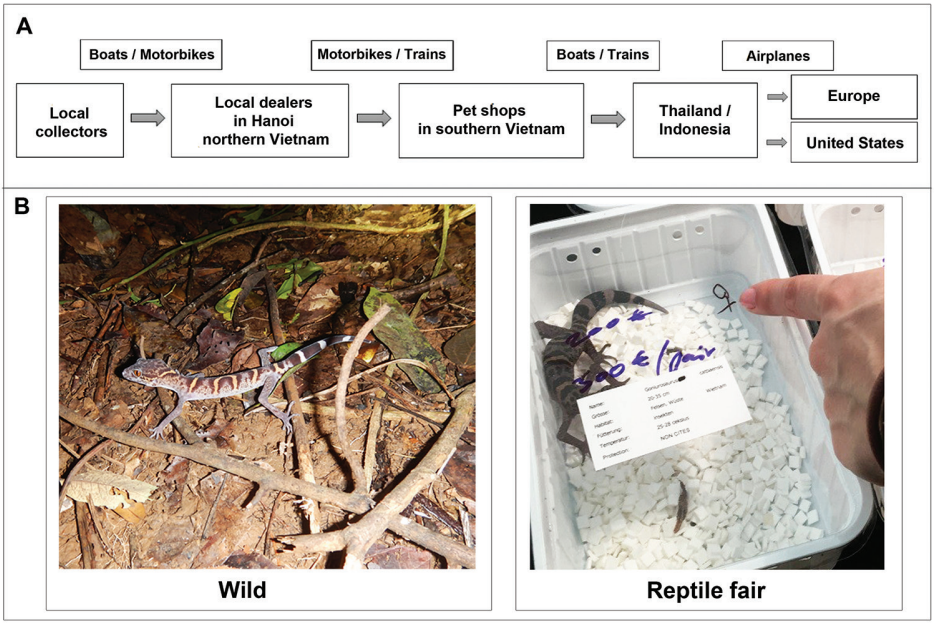


**Figure 5.** One case example showing the route of local and international trade in *Goniurosaurus catbaensis*.

## Population status of *Goniurosaurus catbaensis*

Recent population estimates of the Cat Ba Tiger Gecko at its type locality on Cat Ba Island suggested extremely low population sizes (Ngo et al. 2016b; Nguyen et al. 2018b). Ngo et al. (in press) recently recorded new sub-populations of *G. catbaensis* on further small islands in the adjacent Ha Long Bay. The present data suggest that these sub-populations are stable and actively reproducing. Densities of *G. catbaensis* on islands in Ha Long Bay were, on average, 6 animals / 100 m, some magnitudes higher than on Cat Ba Island (0.08 – 0.17 animals / 100 m, Ngo et al. 2016b). The species is not evenly distributed over the small islands, but only occurs along limited habitat sites. A survey on a population of the closely related *G. luii* in the north of Vietnam revealed a similar low density of 0.08 specimens / 100 m (Ngo et al. 2016b). Extremely high exports and a local extirpation have been reported for this species in the past (Stuart et al. 2006).

Similar research on another enigmatic Vietnamese gecko species, *Cnemaspis psychedelica,* endemic to small islands in the south of Vietnam, revealed a density of 12–19.2 animals / 100 m and an estimated population size of 365–732 individuals (Ngo et al. 2016a). The population of the threatened gecko, *Gonatodes daudini* endemic to St. Vincent and the Grenadines, was estimated at abundances of 87–218 animals / ha in 2010 and has significantly declined to 19 animals / ha) in 2018 (with a total population of 9952 individuals) and over-harvesting being reported as the major threat to the species (Bentz et al. 2011; Shepherd et al. 2019). Overharvesting for the international trade has also been reported as a major threat to *Lygodactylus williamsi*, an electric blue gecko endemic to a small range in Tanzania. Flecks et al. (2012) estimated a density of 353 specimens / ha and

a total population size of 148,684 ± 112,365 adults of this species. As such, these geckos are examples for range restricted, endemic species with small populations that appear to be especially threatened by trade. As a consequence, all three gecko species have been recently included (*C. psychedelica* and *L. williamsi* at CoP17) or proposed for inclusion (*Gonatodes daudini* for CoP18) on CITES Appendix I to regulate international trade in these species.

The recorded abundances in *G. catbaensis* also appear to be extremely low compared to other threatened and endemic geckos. The lowest abundances of *G. catbaensis* were found at touristic sites on Cat Ba Island. Conversely, abundances were relatively stable on the islands in Ha Long Bay, which comprised intact habitats and were not affected by human activities, as they were too small and inaccessible. Harvesting has not been recorded on these small islands so far. Thus, it is likely that the much lower densities of the species on Cat Ba Island are the result of anthropogenic pressures, especially collection for the pet trade.

## Conclusions

As *G. catbaensis* was found to occur in very low densities and has extremely restricted habitat ranges (small islands) that are subject to stochastic weather events, the species appears to be extremely vulnerable to harvesting, which appears to be the case for the entire genus.

Endemic species are considered to be especially vulnerable to over-exploitation (Janssen and Indenbaum 2019). The present study confirmed that tiger geckos are not only locally used, but a subject of the international pet market. Compared to the low densities and small populations in the wild, the number of specimens currently found in the international trade appears to be considerably large. As such, it can be assumed that ongoing uncontrolled harvesting might further imperil *Goniurosaurus* spp. in the future. Tiger geckos are neither sufficiently protected by law nor part of conservation programmes, due to the lack of substantial knowledge on the species conservation status and probably due to the general lack of public as well as political interest in biodiversity conservation. To date, exact impacts of trade on the species cannot be identified, as data of legal trade are only recorded for species listed in the CITES Appendices in most countries. However, at the time of writing, the inclusion of all *Goniurosaurus* species from China and Vietnam in CITES Appendix II has been proposed by China, Vietnam and the EU to be decided at the Conference of the parties (CoP18) in May-June 2019, in Sri Lanka.

## Recommendations for conservation

Some *Goniurosaurus* taxa are only found within protected areas in Vietnam, for example *G. catbaensis* in Cat Ba National Park and Ha Long Bay World Heritage site, *G. huuliensis* in Huu Lien Nature Reserve, *G. lichtenfelderi* in Bai Tu Long National Park and animals can only be collected with appropriate permits from local authorities. At the time of writing this manuscript, all *Goniurosaurus* species native to Vietnam

have been included in Group IIB of the Governmental Decree 06/2019/ND-CP, which came into force on 10 March 2019 and prohibits the collection of and trade in respective species without permits in Vietnam (The Government of Vietnam 2019). In China, *G. hainanensis* was listed as a species of terrestrial wildlife, which are beneficial or of important economic or scientific value. Furthermore, *G. hainanensis* and *G. bawanglingensis* were listed as wildlife under special protection in Hainan Province. According to Janssen and Shepherd (2019), all *Goniurosaurus* species, endemic to Japan, are currently listed under the law for the Conservation of Endangered Species of Wild Fauna and Flora (LCES), which prohibits – amongst others – the collection and selling of respective species. Eight species of *Goniurosaurus* have been recently included in the IUCN Red List and were assessed in the threat categories VU, EN and CR. In fact, it has been specifically paid more attention regarding conservation activities for *G. catbaensis* after its inclusion in the IUCN Red List as "Endangered" in 2016 (Nguyen et al. 2016). Training programmes have been held by IUCN Vietnam since November 2018 to enhance monitoring skills of researchers in Ha Long Bay and Cat Ba National Park in order to protect wild sub-populations of *G. catbaensis*. Signboards highlighting the conservation needs of *G. catbaensis* have been provided to the scientific department of Ha Long Bay (Fig. 6), which represents a first step towards meaningful conservation of the species.


**Figure 6.** Signboard handed over to the Ha Long Bay Management Department to point to the threats and conservation need of the Cat Ba tiger gecko in English and Vietnamese languages.

To further improve the conservation status of *Goniurosaurus* species, we recommend the following measures:

- The inclusion of *Goniurosaurus* spp. in the Appendices of CITES in order to better control and monitor trade in wild specimens. The current proposal to include all *Goniurosaurus* species from China and Vietnam in CITES Appendix II should be supported. Likewise, we acknowledge that the Japanese *Goniurosaurus* clade may warrant listing in the CITES Appendices. Therefore, a listing could be considered in the future, as also proposed by Janssen and Shepherd (2019). A listing of the Japanese species in Appendix III, as suggested by Janssen and Shepherd (2019), might be a favourable interim solution.
- As the lack of adequate information on the biology and conservation status of single species can impede conservation measures, a timely assessment of the remaining *Goniurosaurus* species in the IUCN Red List is strongly advised. Therefore, more species specific research is needed to fully understand conservation requirements.
- It is likely that, with more research, further cryptic species or new occurrences of this genus will be discovered in the future. Thus, it is strongly recommended to conceal exact locality data as well as detailed descriptions of localities for such new species or population records in order to prevent targeted collection, as has happened in the past.
- We recommend to improve or establish coordinated ex-situ breeding programmes for all species and to build up a stable captive population in order to a) serve as the backup population for restocking measures (also in the light of extreme population declines e.g. due to stochastic weather events) and b) to meet the demand for tiger geckos in the trade and thereby reduce the pressure on wild populations.

## Acknowledgements

For supporting fieldwork and issuing relevant permits, we thank the authorities of the Cat Ba National Park (CBNP), Hai Phong City and the Management Department of Ha Long Bay (MDHLB), Quang Ninh Province. We are very thankful to K. X. Nguyen (CBNP), M. L. Pham (MDHLB) and H. Q. Nguyen (Ha Noi National University of Education) for assistance in the field. We are grateful to T. Pagel and C. Landsberg (Cologne Zoo), M. Bonkowski (University of Cologne), T.H. Tran, T. H. Vu, C. T. Pham, T. V. Nguyen, N. H. Nguyen (IEBR, Hanoi), M.T. Nguyen, L.V. Vu and T.T. Nguyen (VNMN, Hanoi) for their support of conservation-based biodiversity research in Vietnam. Thanks to S. Altherr (Munich) and M. Auliya (Leipzig) for improving a previous version of the manuscript. This research is supported by the National Foundation for Science and Technology Development (NAFOSTED, Grant No. 106.05-2017.329). Field surveys were partially funded by Cologne Zoo, the Mohamed bin Zayed Species Conservation fund (Project: 170515492), equipment was supported by the Idea Wild. Cologne Zoo is partner of the World Association of Zoos and Aquariums (WAZA): Conservation Project 07011, 07012 (Herpetodiversity Re-

search, Amphibian and Reptilian Breeding and Rescue Stations). Research of Hai Ngo in Germany is funded by the German Academic Exchange Service (DAAD).

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Nature Conservation 33: 21–31 (2019)
doi: 10.3897/natureconservation.33.30397
http://natureconservation.pensoft.net

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# A scaling down mapping of *Pinna nobilis* (Linnaeus, 1758) through the combination of scientific literature, NATURA 2000, grey literature and citizen science data

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Academic editor: *Diana Galassi* | Received 7 October 2018 | Accepted 7 March 2019 | Published 18 April 2019

*http://zoobank.org/6EEC423D-6AFB-411A-9C7F-4736E7CF3180*

**Citation:** Marrocco V, Zangaro F, Sicuro A, Pinna M (2019) A scaling down mapping of *Pinna nobilis* (Linnaeus, 1758) through the combination of scientific literature, NATURA 2000, grey literature and citizen science data. Nature Conservation 33: 21–31. https://doi.org/10.3897/natureconservation.33.30397

## Abstract

This research investigates the occurrence of *Pinna nobilis* (Linnaeus, 1758) in the Mediterranean Sea, where it is an endemic and the largest bivalve species. Such a species is protected under the European Council Directive 92/43/EEC since 1992, being exposed to anthropogenic impacts. The distribution of this species has been known, in the past, only from reports in scientific literature. Presently, the concerns, threats and risks for *P. nobilis* are increasing and a more detailed mapping of the actual distribution from a largest to a local spatial scale is essential for the implementation of monitoring, management and conservation actions. Here we provide a systematic review on the occurrence of *P. nobilis*, employing and combining different sources of information, such as scientific and grey literature, NATURA 2000 geodata and citizen science records. The methodological approach is a pilot test based on a scaling down of the geographical area of study, from the whole of the Mediterranean Sea to the Italian and Apulian coastline (South-East Italy); accordingly, the above mentioned sources of data have been gradually included. The results show that the combination of multiple sources of information provide a more exact determination of the species distribution at a local scale, identifying sites where in-depth actions are required to ensure the species conservation and restoration. Also, the IUCN has recently underlined that the conservation of *P. nobilis* has become a difficult challenge, so that each of the spatial scales for the investigation is crucial to enable a better preservation and conservation of the species in the Mediterranean Sea.

**Keywords**
Pen shell, endangered species, Mediterranean Sea endemism, geographical scaling down, conservation and restocking

## Introduction

The fan mussel *Pinna nobilis* (Linnaeus, 1758) is the largest endemic bivalve of the Mediterranean Sea. Specimens grow up to 120 cm in total shell length (Zavodnik et al. 1991). It is a long-lived species reaching up to 45–50 years old (Richardson et al. 1999, Katsanevakis 2005, Galinou-Mitsoudi et al. 2006, Rouanet et al. 2015). *P. nobilis* occurs in soft-bottom habitats of transitional water ecosystems and in marine coastal zones at depths between 0.5 and 60 m, mostly in seagrass meadows of *Posidonia oceanica* or *Cymodocea nodosa* (Zavodnik et al. 1991, Richardson et al. 1999, García-March et al. 2007, Orfanidis et al. 2007, Coppa et al. 2010; 2013, Prado et al. 2014), but also in bare sandy bottoms (Katsanevakis 2005). The fan mussel lives with around 35% of its shell length buried in the bottom and the shell is attached to the substratum by a ropey texture called *byssus* (Papaconstantinou et al. 2007).

The species *P. nobilis* is an important benthic filter feeder contributing to water clarity (Davenport et al. 2011, Trigos et al. 2014, Alomar et al. 2015). Furthermore, a stable isotopes analysis (SIA) has demonstrated the response of *P. nobilis* to environmental and anthropogenic variables. There is scientific evidence that this species is a good indicator of changes in marine ecosystems providing information on biotic response to anthropogenic pressures (Alomar et al. 2015). *P. nobilis* supplies some ecosystem services by retaining a large amount of organic matter from the water column, hosting other species, working as a hard substrate in the soft-bottom seafloor, providing a surface that can be colonized by other benthic species, improving the local biodiversity (Basso et al. 2015), and attracting scuba-divers (e.g. tourism and recreation) (Marrocco et al. 2018).

During the 20$^{th}$ century, *P. nobilis* populations have greatly declined due to anthropogenic activities, including recreational and commercial fishing, ornamental harvesting, and accidental killing by anchoring, bottom nets and trawlers (Richardson et al. 2004).

Threatened by human activities and parasites, nowadays *P. nobilis* is a protected species under the Annex IV of EU Habitats Directive 92/43/EEC (EEC 1992) and Annex II of Barcelona Convention. Due to its ecological relevance, *P. nobilis* has recently been suggested as being a reliable bioindicator for benthic coastal ecosystems according to the Descriptor 1 "*Biological diversity"* and 4 "*Status of the single structural components of ecosystems*" of the EU Marine Strategy Framework Directive (MSFD 2008/56/EC), useful to achieve the Good Environmental Status (GES) by year 2020 (Vázquez-Luis et al. 2017a, Marrocco et al. 2018).

According to Basso et al. (2015), currently gaps in the knowledge of the species occurrence and behavior preclude the formulation of effective conservation strategies for *P. nobilis*. Studies on distribution and conservation status of this endangered species should be evaluated in different habitats, in different regions of the Mediterranean Sea and on

different time scales (e.g., long-term studies) to identify probable, common, or peculiar sources of mortality within the Mediterranean Sea (Basso et al. 2015). For this reason, here we provide a systematic review on the occurrence of *P. nobilis*, using and combining different sources of information such as scientific and grey literature, NATURA 2000 geodata and citizen science records. NATURA 2000 Network was established by the European Union to safeguard all the sites characterized by threatened environments and habitats as well as rare plants and animal species. It represents an official source of data about protected species and habitats in the EU. It is also a model of innovative conservation, which sees the integration of needs for protection with the economic, social and cultural needs of local populations (Genovesi et al. 2014). The methodological approach is based on a pilot test consisting of a gradual scaling down of the geographical area of study, from the whole Mediterranean Sea to Italy and, finally, to the Apulian coastline (South-East Italy). Along with such geographical decrease, the sources of data have been increased to reach a more detailed mapping of the species on a local scale. The objectives of the research are essentially the integration and combination of different sources of data about the distribution of *P. nobilis*. Currently, each source of data is characterized by gaps. We assume that the description of the occurrence of *P. nobilis* could be under-estimated when the data from scientific literature and NATURA 2000 Network are the unique source of information taken into account. To avoid or to bridge these gaps, we sustain that the actual distribution of *P. nobilis* can be determined by integrating different sources of data, including those from grey literature and citizen science, in a comprehensive map.

## Materials and methods

Scientific literature about *P. nobilis* has been retrieved from multiple databases related to cross-disciplinary research, which allow an in-depth exploration of specialized subfields within a certain academic or scientific discipline, such as Web of Science (http://www.webofknowledge.com/), Science Direct (http://www.sciencedirect.com) and Google Scholar (http://scholar.google.com). Scientific literature until September 2018 was selected; according to Basso et al. (2015), different combinations of the keywords "*Pinna nobilis*", "pen shell" and "fan mussel" were used.

Scientific literature data were mapped at the Mediterranean Sea scale. In this research we retrieved data published in peer-reviewed scientific journals as this is believed to ensure data reliability throughout the review process before publication.

The implementation of the Mediterranean Sea scale was done by consulting NATURA 2000 Standard Data Forms and Network Viewer (http://natura2000.eea.europa.eu/), typing "*Pinna nobilis*" as keyword. Within this analysis, we also considered data from grey literature and citizen science records when scaling down the geographical area to Italy, and lastly to the Apulian coastline.

The search for grey literature was introduced exclusively at a national scale with regard to Italy and was conducted by typing the same keywords used during the scientific literature search in the most common web search engines.

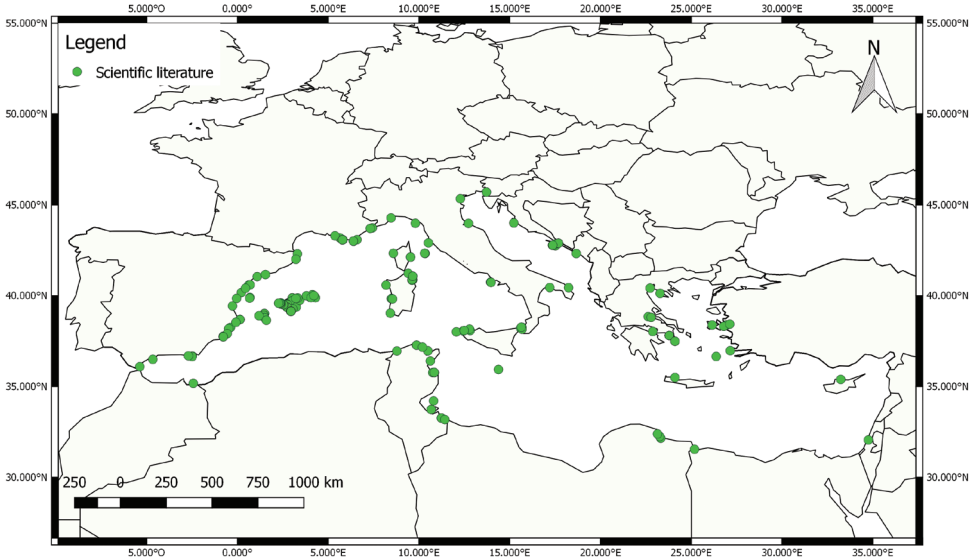


**Figure 1.** Map of *Pinna nobilis* distribution in the Mediterranean Sea based on scientific literature.

For what concerns the citizen science data, we focused on the Apulian coastline (South-East Italy). We collected information on the sightings of *P. nobilis* by personal communications and through direct interviews with fishermen, divers, tourists and staff from the local marine protected areas. About 100 people were interviewed during this process, but only the sightings that could certify the presence of the species through photos and videos, were taken into consideration. When possible, the sightings on those filed were verified by ourselves.

Using the data extracted, we drew five maps using the QGIS software, so as to identify possible patterns of the spatial distribution of *P. nobilis*.

The first map (Fig.1) was built considering all the scientific references obtained through the above-mentioned web channels. The second map (Fig. 2) shows data from NATURA 2000 Network Viewer integrated to those from scientific literature. The third map (Fig.3) further enriches the knowledge of the fan mussel distribution using data from grey literature, such as newspaper and journal articles, technical reports and theses. The fourth map (Fig. 4) focuses on the Apulian (South-East Italy) coastline, where we could access citizen science. By analyzing the data of such maps, we build a further map (Fig. 5) showing the occurrence of the fan mussel populations in the Mediterranean Sea.

## Results

The database obtained contains data until September 2018 and consists of a total of 187 scientific references, 398 points from NATURE 2000 Network Viewer, 63 points from grey literature and 8 citizen science records.

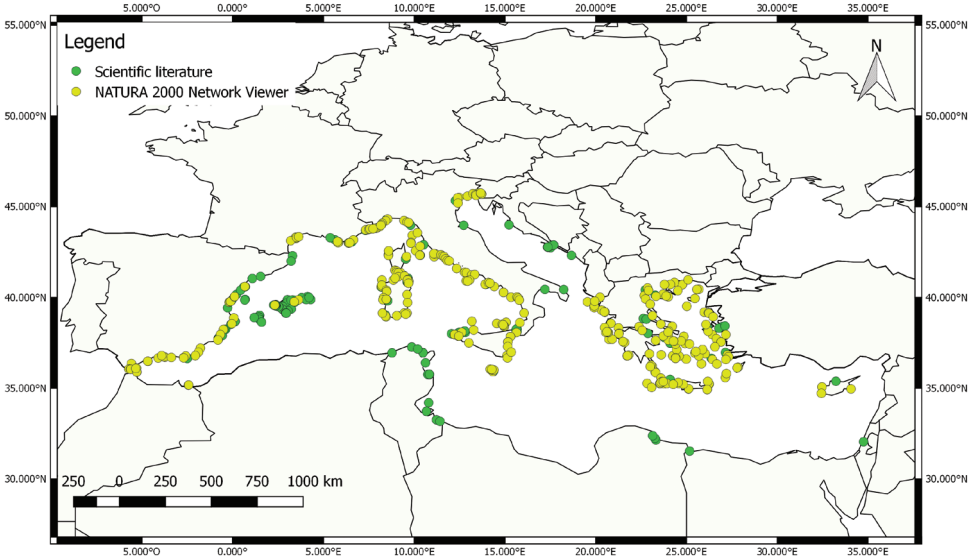


**Figure 2.** Map of *Pinna nobilis* distribution in the Mediterranean Sea based on scientific literature and NATURA 2000 Network Viewer geodata.

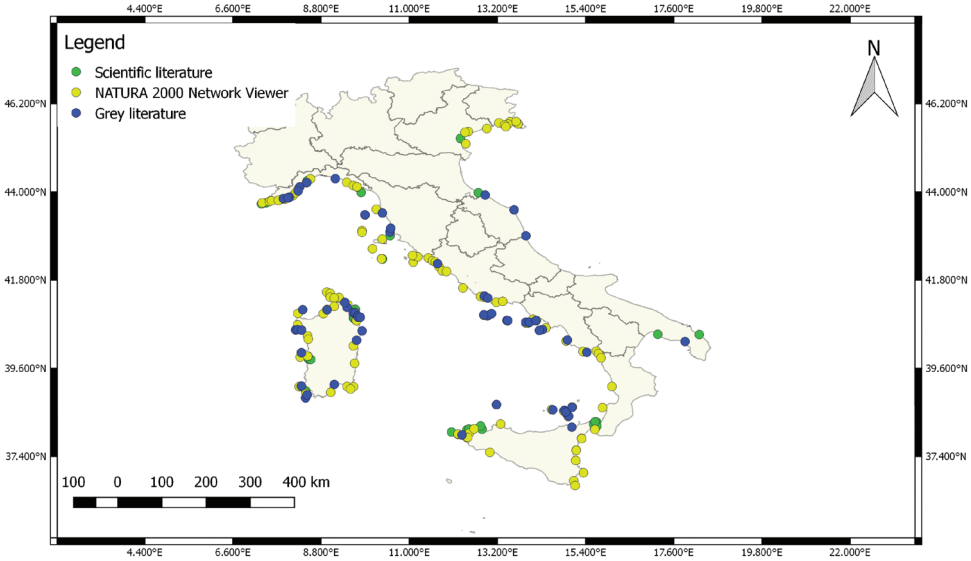


**Figure 3.** Map of *Pinna nobilis* distribution along the Italian coasts based on scientific literature, NATURA 2000 Network Viewer geodata and grey literature.

Considering the actual knowledge of the fan mussel distribution, based on all the scientific literature available until 2018 at the Mediterranean Sea scale, 187 records were mapped. In the scientific literature the species is mostly reported in the North-

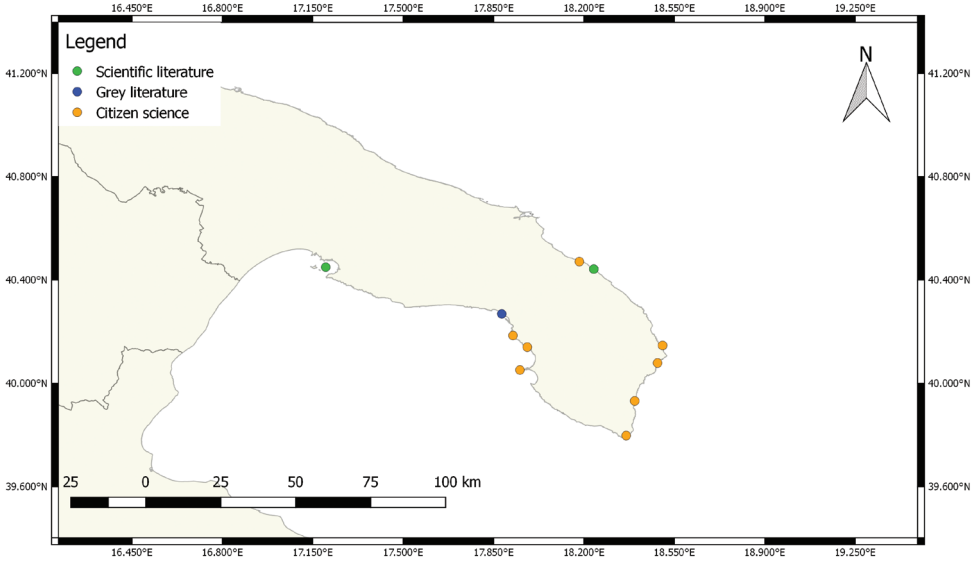


**Figure 4.** Map of *Pinna nobilis* distribution along the South Apulia coastline (Salento Peninsula) based on scientific literature, grey literature and citizen science data. In this area no NATURA 2000 Network Viewer geodata were recorded.

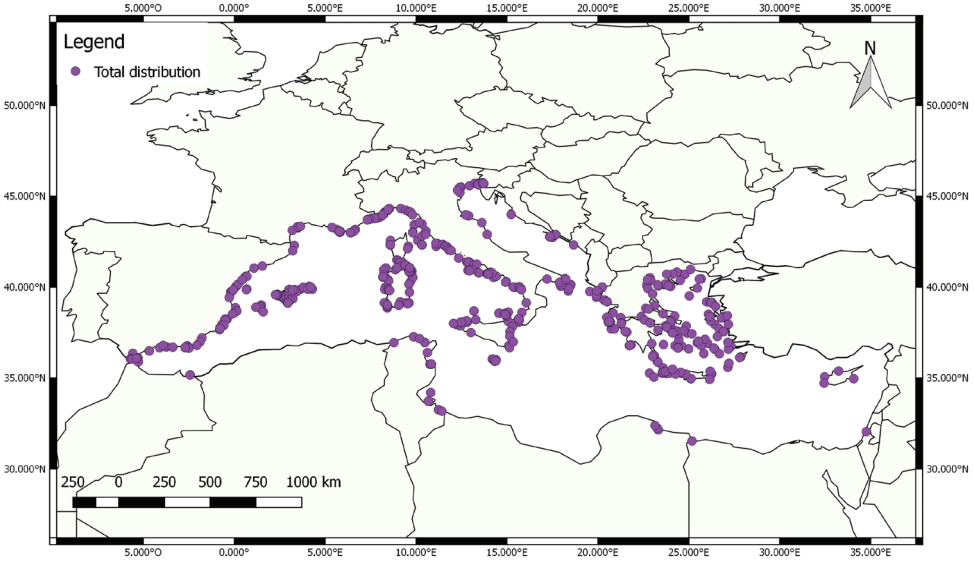


**Figure 5.** Map of *Pinna nobilis* distribution in the Mediterranean Sea obtained by combining all the points showed in the previous maps.

West area of the Mediterranean Sea, showing a higher concentration along the latitudinal gradient (Fig. 1). The implementation of a second mapping level including also 398 records of the NATURA 2000 Network Viewer is shown in figure 2. Since the

NATURA 2000 Network is employed officially in EU Countries, a wider distribution of *P. nobilis* at the Mediterranean Sea spatial scale can been observed along the coastline of EU Countries (Fig. 2). The overlapping of records has been considered only once. In the scaling down at the Italian coastline scale, 63 records of grey literature were integrated (Fig. 3), showing a further widening of *P. nobilis* distribution. Additionally, along the coasts of Campania and Lazio regions, a high presence of this species is reported in grey literature, but no results are found in scientific literature. In the region of Sardinia, the data from scientific literature are very scarce in comparison to those present in grey literature. Besides, in grey literature the presence of some individuals in the central area of Adriatic Sea has been observed.

Focusing on the Apulian Region, it can be noticed that scientific literature is limited only to the area of the Gulf of Taranto, but we found one record in grey literature related to the presence of the fan mussel in the Marine Protected Area of Porto Cesareo (Italy); furthermore, 8 new records were retrieved from citizen science (Fig. 4).

Gathering information obtained from the previous maps, figure 5 shows the total distribution of *P. nobilis* in the Mediterranean Sea, as a result of the integration and combination of four sources of data along with the decrease of the spatial scale.

## Discussions and conclusions

Presently, the conservation and management of the *P. nobilis* is an urgent challenge and more detailed maps of the species distribution are essential to investigate the habitat of the species, to identify available areas for restocking and to implement awareness campaigns to involve the general public and stakeholders. Furthermore, the aim of this work is to demonstrate that, in order to obtain a clear and complete *P. nobilis* distribution framework, it is necessary to integrate all the data and information available in relation to the spatial scale identified. We can certainly affirm, however, that through the integration of NATURA 2000 Network Viewer, grey literature and citizen science data, the resulting distribution of *P. nobilis* is wider compared to the measurements based only on scientific literature.

This work allowed the collection of datasets on the distribution of *P. nobilis* in the Mediterranean Sea, which can be a useful basis either for further studies in the waters of the Basin and for a time-space comparison of the same populations in order to monitor their status. The map (Fig. 1) built using the data collected from scientific literature made us conclude that the distribution of *P. nobilis* is concentrated in the Northern area of the Sea (except for the Tunisian coast). Nevertheless, we cannot identify whether the species is actually present in the southern Mediterranean Sea or if research efforts have been concentrated only in certain areas. This debate is open, since in this work we have been dealing with the implementation of the NATURA 2000 Network focusing on the Italian and Apulian coasts, including data from grey literature and citizen science. This approach shows a completely different scenario of the distribution of *P. nobilis*. Particularly, the distribution of data available in the NATURA 2000 Network allowed an extraordinarily accurate and updated knowledge of the species (Fig. 2).

Unfortunately, considering the NATURA 2000 Network has been commissioned by the European Union, it does not include data from non-European Countries bordering the Mediterranean Sea. The data on the bivalve distribution available in scientific literature are scarce for the Mediterranean basin, especially along the Italian coastline (Fig. 3) if compared to the apparent distribution range reported in grey literature. In Italy, the presence of the mollusk (considering only scientific literature) is limited exclusively to the coasts of Sardinia and Sicily, the Gulf of Trieste and the Venice Lagoon, the Tuscan Archipelago, the Liguria Sea and the Gulf of Taranto. By integrating data from scientific literature with those from grey literature and NATURA 2000 Network, a new map reveals a huge gap in scientific literature regarding this species distribution. Furthermore, in this work we focused on the presence of this species along the Apulian coastline. This choice was determined by the purpose of integrating the abovementioned literature with observations reported by scuba divers, fishermen and other people, which were obviously easier to be found in our region. Along the Apulian coastline (Fig. 4), the presence of *P. nobilis* in scientific literature is only reported in the Gulf of Taranto and, more recently, in the NATURA 2000 site of Aquatina di Frigole (Pinna et al. 2018). If we add citizen science to these records, we notice clearly that the species is present in many other areas of Salento sub-peninsula, like in Otranto, Porto Badisco, Santa Maria di Leuca, Gallipoli, Santa Caterina di Nardò, Tricase Porto, Torre Inserraglio and Regional Nature Park Bosco e Paludi di Rauccio. Combining all data coming from all types of records, we notice (Fig. 5) how the *P. nobilis* distribution is actually wider than has been reported exclusively in scientific literature. This discrepancy demonstrates that the information about the species distribution is not yet wholly available. In order to fill these information gaps and to enhance monitoring, it is necessary to integrate citizen science from all the states bordering the Mediterranean Sea to our current literature data. The study of some ecological or natural phenomena, such as species' geographic distribution or abundance of populations, requires a huge quantity of data and extensive sampling efforts. Usually, the support of volunteers proves to be decisive for the success or even for the feasibility of this type of studies. At the Mediterranean Sea scale, citizen science requires a structured framework, the identification of groups of interest and a focused training. The amount of data that can be obtained through public participation highly exceeds the investigations of a few researchers, making it possible to obtain results on a wider spatial and temporal scale. The result is the creation of a "bridge" between scientists, the academic world and the general audience, fundamental for scientific research to step forward and to become also able to exploit the potential of the web and social media. Additionally, citizen science creates participation and knowledge sharing, bringing society closer to science. The sensitization of the surrounding population shows itself an added value when it comes to conserving a protected species. Furthermore, over the last few years, this species has also been threatened by a parasite from the genus *Haplosporidium* that has affected all populations along the Spanish coast (with >80% mortality) and several other areas in France (Corsica) and Italy (Sicily, Apulia and Campania) (Vázquez-Luis et al.

2017b, IUCN 2018). For this reason, mapping at different spatial scales can be useful to carry out research, monitoring and conservation actions, e.g. the implementation of species conservation by captive breeding programs for the future restocking of resistant juveniles may be one of these. Therefore, it is important to complete the culture of the conservation of *P. nobilis* (Dégremont et al. 2015). The restocking could be concentrated into dense patches, higher rates of successful fertilization are probable, thus the positive impact of transplantation actions on fan mussel populations could be great due to higher fertilization and increased recruitment (Katsanevakis 2016). To do this, we need to have a detailed knowledge about *P. nobilis* distribution in the Mediterranean basin; furthermore, it is important that not only research efforts are made, but also the media and public should participate in learning about, and protecting, this species.

## Acknowledgements

This research was supported by *ex*-60% fund (FUR, Italian MIUR), by FFABR (Italian MIUR) and by *ImPrEco* Project (Interreg ADRION Programme 2014–2020; CUP C69H18000250007) attributed to M. Pinna. The authors are grateful to Inter-Asia Project (CUP F82I17000000008) for supporting the mobility and study activities of the Kazakh students N. Bizhanova and G. Utebayeva during the period of data collection. We sincerely thank the two anonymous reviewers whose comments helped in improving the preliminary draft of the manuscript. Francesca Giannotta revised the English grammar.

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Nature Conservation 33: 33–54 (2019)
doi: 10.3897/natureconservation.33.30781
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RESEARCH ARTICLE

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# Moving beyond the illusion of participation in the governance of Yangambi Biosphere Reserve (Tshopo Province, Democratic Republic of Congo)

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Academic editor: *J.M. Martínez-Paz* | Received 23 October 2018 | Accepted 1 March 2019 | Published 22 April 2019

*http://zoobank.org/8C8CBA52-0E54-4DE3-A84F-56EB1C0BE01C*

**Citation:** Koy JK, Ngonga AMM, Wardell DA (2019) Moving beyond the illusion of participation in the governance of Yangambi Biosphere Reserve (Tshopo Province, Democratic Republic of Congo). Nature Conservation 33: 33–54. https://doi.org/10.3897/natureconservation.33.30781

## Abstract

The participation of local communities in the governance of protected areas in the Democratic Republic of Congo is challenged by several external and local factors. This article aims to understand the representation of local communities and factors that influence their participation in the governance of the Yangambi Biosphere Reserve. Three principal sources of information (archival records, focus group and semi-structured interviews) were used to collect data. The results indicate a top-down participatory approach. The cumulative failure of several projects in the context of local development has led to different perceptions by local communities of their role in the participative governance of Yangambi Biosphere Reserve. Initiatives in participatory management and local development only function during the lifetime of externally-funded projects when initiators are present in the intervention area. The results call into question formal claims made by both conservation projects and the Congolese government regarding the actual participation of local communities in the governance of Biosphere Reserves. Furthermore, although Biosphere Reserves in DRC are recognized as part of the national network of protected areas since 2002, their management is still not aligned to either the Seville Strategy or the statutory framework of the world network of Biosphere Reserves. To achieve this, local development initiatives need to focus on poverty alleviation (through the diversification of income sources, entrepreneurship, farmer training and the creation of employment opportunities) and a better understanding of local practices and cultures in the design of such projects.

## Keywords

Democratic Republic of Congo, Yangambi Biosphere Reserve, governance, protected areas, community participation

## Introduction

As noted by Mehta and Kellert (1998), "community-based conservation (CBC) has been projected as the most practical approach to stem biodiversity loss in developing countries. Since CBC is 'people centred' and experience with it is relatively new, it is important to know the views of local communities regarding implemented policies and programmes". In some developing countries, nature conservation in protected areas (PAs) is poorly supported by local communities (LCs) (Bennett and Dearden 2014a). While some studies indicate that protected areas help to improve the socio-economic conditions of local people, the reality in many developing countries, particularly in Africa and Southeast Asia, suggests the opposite (Christie 2004). Despite the often disappointing outcomes in Africa (Blaikie 2006), the participation of local actors in the management of PAs is based on two fundamental logics: the questioning of top-down approaches, which are considered less able to articulate solutions adapted to local needs, and the recognition of the capacity of local actors to take the reins of their own development into their own hands (Ribot1999; Poteete and Ribot 2011).

Participation is, nevertheless, a concept that divides social actors and scientists and has not found a unanimous definition. Following Rodaly (1998),"depending on the degree of actors" involvement, participation extends from simple information on projects developed and managed by external actors, to taking the initiative of the local populations without professional intervention. It thus takes different forms: consultation, material or financial incentive, participation in the running of programs and participation in the decision". Meister (1977) distinguishes three modes of participation: voluntary participation, on the initiative of the participants, in relation to the objectives and goals they choose themselves; participation elicited by an objective approved by the community but whose aims are determined by external actors; and participation of group members through membership (of a group or association) and learning. Stakeholder involvement in forest policy and management decisions has increased over the last twenty years in Central Africa (Buttoud and Nguinguiri 2016). In the Democratic Republic of Congo (DRC), even though community participation practices existed before independence (for example, rural cooperatives, self-help associations and public enquiries with local communities), it was formally incorporated into law when the Forest Code was promulgated in 2002. Overall, participation, through locally-owned processes, tends to improve the use of resources and environmental management (Kellert et al. 2000; Borrini-Feyerabend et al. 2007).

The implementation of this approach in the management of Biosphere Reserves has not been extensively studied. Despite being part of a global network, thanks to recognition by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1977, few studies have been conducted on the socio-economic impacts of Biosphere Reserves (see Rao et al. 2003). This paper analyses the contribution of local development initiatives and the degree of peoples' participation in the governance of the Yangambi Biosphere Reserve (YBR), focusing on the representation of local communities, and the factors that influence it. Community development and participatory initiatives implemented in Yangambi since the colonial era to the pre-

sent-day have not led to any significant improvement in the living conditions of the rural communities living in and around YBR. The national institute for agricultural study and research in Congo (INERA), which manages YBR, has been affected by the crisis affecting state services (Hiergens 2010). This has resulted in the widespread occupation and use of YBR by local communities struggling to survive through hunting, fishing, agriculture, logging, making canoes and mining, underlining the structural bankruptcy of the Congolese State. The reserve thus has become an area where the different actors have difficulties reconciling their interests. On the one hand, land conflicts oppose LCs and the INERA, and the other hand, different LCs themselves.

## Materials and methods

### Study site

The YBR is located about 100 km west and 62 km north of the city of Kisangani in the DRC (Map 2). At its creation in 1939, YBR was known as the "Réserve Floristique de Yangambi". Its legal area was estimated at 225,000 hectares when gazetted during the colonial period (INEAC 1939). Its geographical coordinates are between 24°18' and 25°08' of longitude East and 00°43' and 01°08' of latitude North, with altitudes varying between 400 and 500 m. The region is located in the equatorial zone with a climate of the type *Af of Köppen*. The average annual rainfall in the study area is 1,837 mm (Kombele 2004). YBR's streams and rivers flow either into the Congo River in the southwest, the Aruwimi River in the North, or the Lindi River in the East. The area was the subject of extensive floristic and agronomic studies carried out during the colonial era by National Institute for Agronomic Study in the Belgian Congo (INEAC) scientists. Today, Yangambi boasts a herbarium, xylarium (tropical wood collection), poorly equipped research laboratories and a library as well as coffee, cocoa, banana, oil palm, rubber and tree plantations (Hiergens 2010). Before the establishment of the Yangambi Research Centre, Turumbu and Bamanga indigenous communities inhabited the area and practiced their customary hunting, fishing, agriculture and artisanal logging activities as well as the collection of non-timber forest products. The survival of these autochthones people depended mainly on the forest.

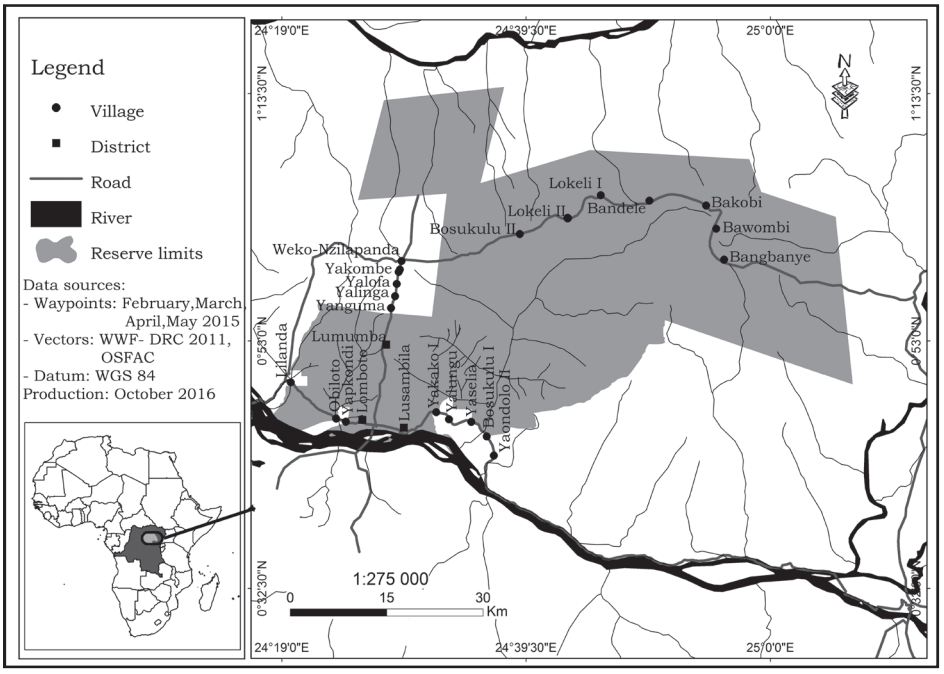
### Data sources and sampling

The data presented in this article are from archival sources as well as focus group discussions and semi-structured interviews. The documentation was consulted at the libraries of INERA and the Man and the Biosphere (MAB) offices in Yangambi and Kinshasa, DRC, the Royal Museum of Central Africa (RMCA), Turvueren and the Botanical Gardens, Meise in Belgium. Analysis of these documents was conducted to trace and develop a better understanding of the policies and projects implemented in and around YBR since its creation. Focus group discussions, understood in the sense of Moreau et al. (2004) were mobilized to better understand the perception of different actors about

community-based initiatives implemented by different institutions including INEAC and INERA. Interviews were conducted in February, March and May 2015 with local leaders and village elders. In order to generate productive group dynamics in each of these focus groups, the number of participants was limited to between six and twelve on average (Touré 2010). Each focus group was made up of women (a maximum of four) and men (a maximum of eight) of different ages: young people (18 to 29 years), adults (30 to 59 years) and old people (from 60 years old). Criteria used to select focus group participants included age, gender, and ethnicity. In each village, the average duration of the interviews with the focus groups was approximately two hours.

Semi-structured interviews were conducted with household members based on a general questionnaire of the first author's doctoral thesis comprising ca. 100 questions. Taking into account the objective pursued in this article, eight questions were analyzed to obtain the results presented below. The data from the other questions (92) were used in other articles.

The selection of 20 villages and 3 neighbourhoods constituting the geographic sample (Esiso Asia Amani 2013) was based on the criterion of their proximity to the reserve (Map 1). This was based on a demographic sample of 300 subjects (including 77 women and 223 men) out of 5 278 households identified by the medical service and local administration. This sample (n=300) represented two indigenous groups (163 Turumbu and 67 Bamanga) and a group of 70 allochthones people encountered in Yangambi. The choice of interviewees was made according to the convenience technique (Gavard-Perret et al. 2011).




**Map 1.** Location of the sample villages in the study area.

### Data processing

The collected data was first encoded into an Excel spreadsheet. They were then pre-processed to correct the typing errors. In addition to calculating percentages and arithmetic averages, data processing and analysis focused both on the search for dependencies between measured variables, and on the comparison of ethnic groups. The link between the (qualitative) variables was measured using the Chi-square test of independence under the validity conditions described by Gavard-Perret et al. (2011) and Howell (2004). These are conditions related to the qualitative nature of the variables and the sample size (greater than 30 observations). This data processing task was facilitated by the use of Excel and R software (version 2.10.0).

Moreover, the participation of LCs in the design of local development policies was analyzed using three indicators tested by Simard (2000): the perceived control by the actors about their participation in the project and their influence on the decision-making process; satisfaction that expresses a positive or negative opinion about a project and its attributes; as well as the symbolism that emanates from the effective use of project achievements. Success in these three perceptions thereby becomes a measure of the ownership of these initiatives by local actors.

## Results

### Historical context of participatory initiatives in the governance of YBR

#### *From 1933 to 1960*

INEAC (replaced by INERA in1970), was entrusted with the management of the Yangambi Floristic Reserve (now YBR) by the Belgian colonial administration. INEAC depended, in part, on male labour hired from villages bordering YBR. Archive data collected show that after its establishment in 1934, INEAC engaged with the following villages: in Bosukulu I, 88 adult men out of 147; in Yandimbia, 18 out of 60; in Yalolia, 29 out of 106. In the Yalibua and Yakombe villages, it recruited 58% and 32% of all adult men respectively (Steens 1934; Laurent 1937).

INEAC attempted to protect YBR against slash and burn agriculture by, initially, limiting access to the reserve, and after 1942 by grouping farmers (Malengreau 1952; Staner 1955). For example, in 1948 Turumbu farmers established a cooperative as part of an INEAC initiative involving more than a thousand farmers. Earlier efforts by INEAC (and previously the Régie des Plantations de la Colonie) had focused on developing commercial agricultural plantations of palm oil and rubber. Their farm plots were located along the roads, around road intersections and/or near the source of a watercourse. The family land reserve was divided each year into corridors. Individual land ownership was not permitted. The farmers were supervised by INEAC agricultural engineers responsible for providing advice on different crops and the provision of agricultural inputs (tools and seeds). This allowed them to produce agricultural surpluses and to become progressively

sedentarized (Malengreau 1952). All agricultural products were purchased by INEAC. Village elders interviewed between February and May 2015 claimed that the socio-economic conditions of the people had visibly improved before independence in 1960.

Another project carried out in the Lilanda village, from 1956 by INEAC, concerned the production and processing of cassava (AIMO 1957). However, its activities were stopped in 1957 because of the low cassava production in this village (AIMO 1957).

### *After independence*

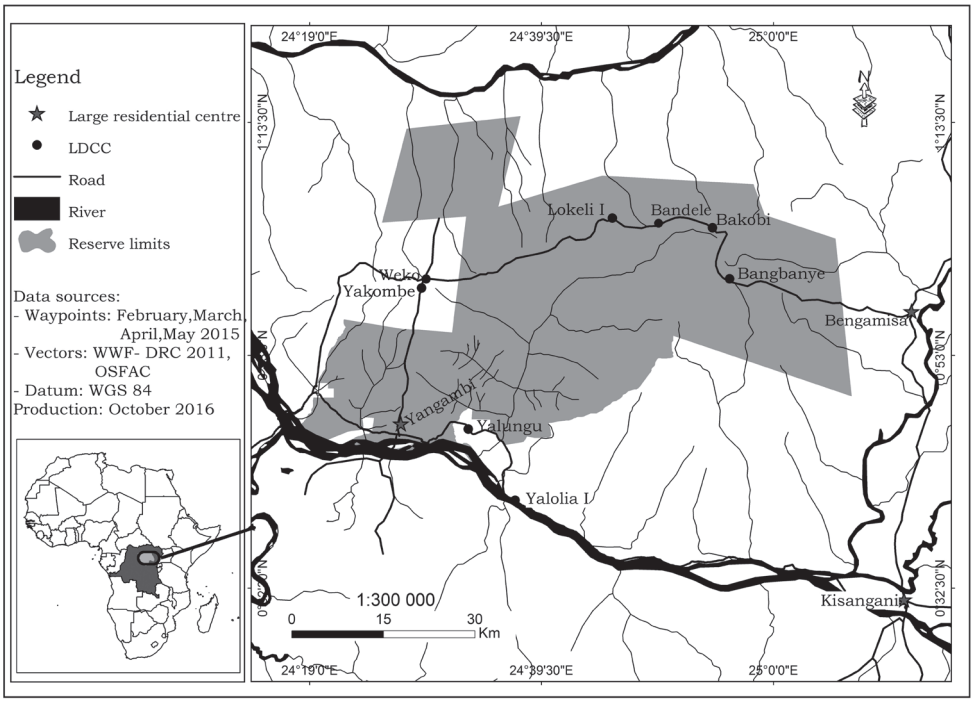
An effort to initiate management of YBR by multiple stakeholders was started in 1978 through a framework agreement on a Man and the Biosphere (MAB) Reserve concluded between UNESCO and the Congolese Government (RDC 2005). Under this agreement, the Department of the Environment, Nature Conservation and Tourism was to facilitate the coordination of actors, ensure the remuneration of MAB Project officers (eco-guards), maintain equipment and facilitate the movement of personnel between Kinshasa and Kisangani. INERA was to make premises, laboratories and workers including researchers available to the MAB project. Furthermore, the Institute Faculty of Agronomic Sciences (IFA) and the (then) Kisangani Campus of the National University of Zaire (UNAZA) were to ensure the provision of a team of researchers capable of conducting interdisciplinary field studies. UNESCO, for its part, was to support the project with assistance of US $ 26,000 (for the purchase of vehicles, materials and other equipment) and US $ 17,000 (to finance the training of local staff).The role and responsibilities of local communities in the MAB project was not discussed nor defined. The zoning carried out in the YBR was completed by INERA, IFA and UNAZA experts.

A subsequent project initiated in 2009 and implemented from 2010 with financial and technical support of the World Wildlife Fund (WWF), ensured that all YBR management stakeholders (MAB, INERA, IFA, LCs, civil society and local government) were structured and organized within a Local Steering Committee (LSC) based in Yangambi (Toirambe 2011). This provided a platform for consultation and reflection involving all stakeholders engaged in the management of the reserve. Semi-annual meetings were held in Yangambi throughout the duration of the project (2010–2012). Motorcycles, raincoats and bicycles were distributed to *eco-guards* who also received a monthly bonus of approximately US$ 5 to US$ 10.

At the village level, the WWF project contributed to the creation of Local Development and Conservation Committees (LDCCs). These structures were intended to bring together village members who were supposed to carry out activities contributing to both local development and nature conservation (Toirambe et al. 2011). A total of eight LDCCs were established (Map 2). WWF provided each of the LDCCs with four bags of cement, 18 metal roofing sheets, 10 wooden planks and three kilograms of nails for the construction of simple village offices. In addition, US $180 and 40 Kg of rice

seed were also provided to each LDCC (Interview with intern, socio-economic aspects of the WWF project, 15 May 2015). During fieldwork in Yangambi it was noted that apart from the office of the LDCC of Yalolia, built with complementary support from the Belgian technical cooperation (Bonkena and Vancutsem 2013), all other structures remained unfinished. Roofing sheets and other building materials were used for other purposes by the local communities. The rice seed distributed to LDCCs did not yield a satisfactory return.

Most recently, another project carried out by the World Conservation Union (IUCN) between 2014 and 2016 tried to revitalize the activities of the LDCCs by focusing on the rehabilitation and equipping of the MAB Yangambi office, the recruitment, paramilitary training, equipment, uniforms and monthly bonuses for 20 eco-guards, construction of two monitoring stations in Yapkondi and Yakombe, and drafting of the statutes and rules of procedure of the Local Steering Committee (Begaa Yendjogi 2016). Neither the WWF nor the IUCN project were able to establish a single LSC and none of the LDCCs were rendered autonomous. The impacts of their activities were, consequently, mixed (Bonkena and Vancutsem 2013; Begaa Yendjogi 2016).The following sections present the results of the interviews conducted with the different ethno-linguistic communities living in and around Yangambi Biosphere Reserve.




**Map 2.** Location of Local Development and Conservation Committees.

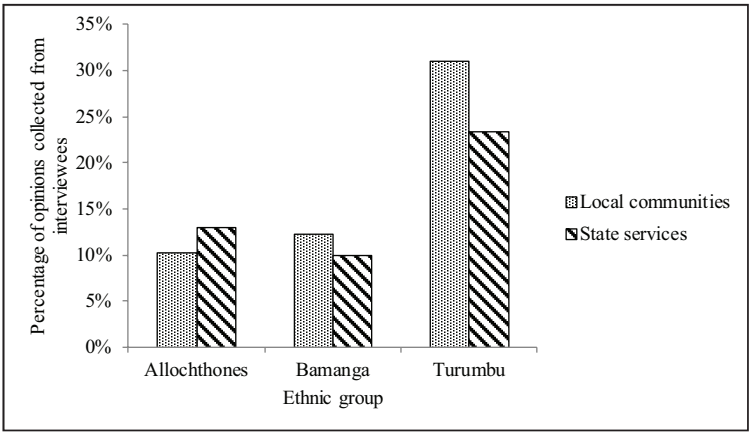



**Figure 1.** Perceptions of actors involved in the management of Yangambi Biosphere Reserve.

## Who are the actors managing YBR that are recognized by the local communities?

It is perceived that the management of YBR is equally facilitated by the local communities and services provided by state institutions, notably INERA, MAB, IFA and the Superior Institute of Agronomic Studies of Bengamisa (Figure 1). From a statistical point of view, this perception does not depend on the ethno-linguistic group (X-squared = 0.31, df = 2, p-value = 0.86).

## Limited local involvement in participatory initiatives

The participatory management initiatives of the WWF and IUCN projects described above were not influenced by local communities and had little impact. Most of these views were expressed in terms of local communities not being consulted during the establishment of the reserve nor in the design of the projects (Figure 2). This opinion was shared by the members of all ethno-linguistic groups surveyed (X-squared = 0.79, df = 2, p-value = 0.67).

In addition to the lack of consultation with local communities, state-backed managers of YBR and their global partners tried to educate and sensitize the local communities about reserve management and the importance of conservation in protecting YBR. We therefore asked the following question: were you made aware of the importance of nature conservation in the YBR? The interviews indicated that awareness had not been raised amongst most respondents (Figure 3). This opinion was expressed in similar terms by all ethno-linguistic communities interviewed (X-squared = 3.73, df = 2, p-value = 0.17).

This lack of consultation with, and limited awareness of local communities, did not facilitate the flow of information concerning project initiatives and the management of YBR. In fact, the perceptions expressed by interviewees about the ownership of this protected area – by the State or in the customary domain were not unanimous (Figure 4).

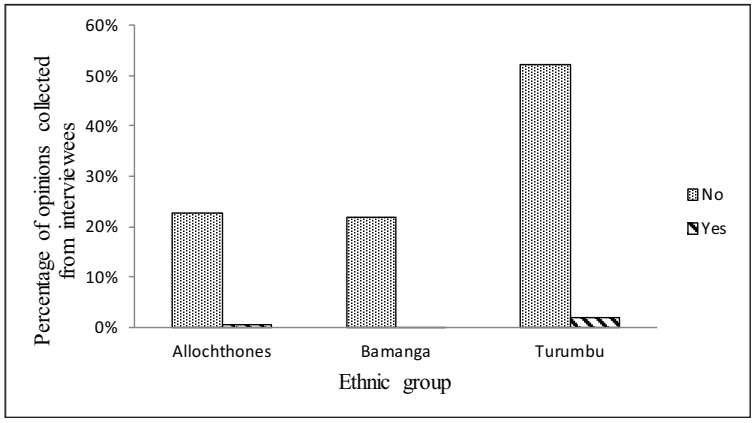



**Figure 2.** Extent to which local communities were consulted in the creation of YBR and in project design.

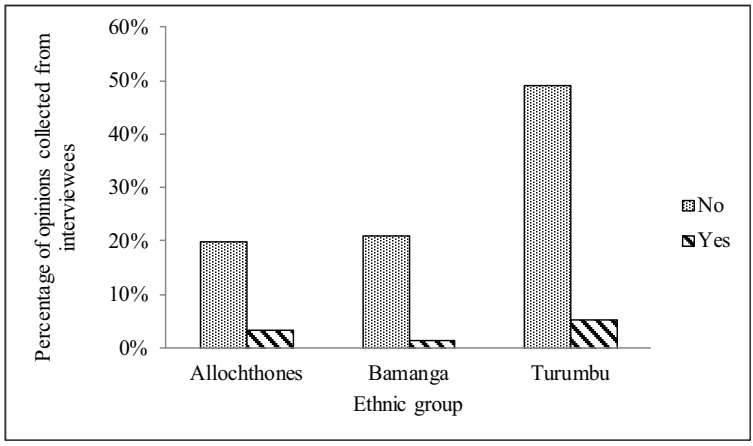



**Figure 3.** Opinion on awareness raising on conservation in Yangambi Biosphere Reserve management.

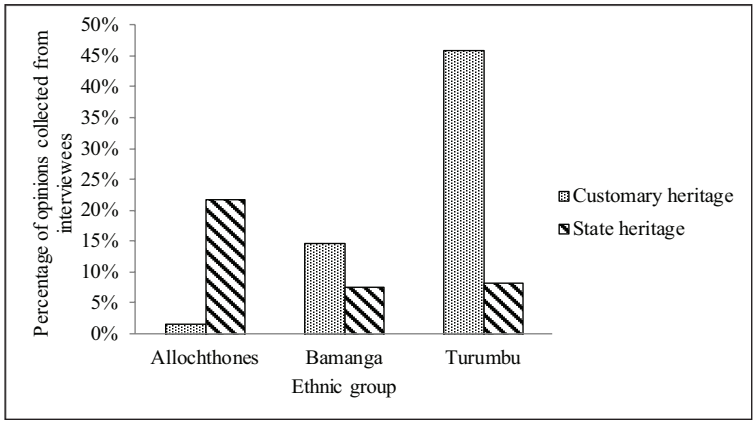



**Figure 4.** Local community perceptions of who owns Yangambi Biosphere Reserve.

Most of the Turumbu and Bamanga communities noted that this classified forest remains the customary property of local communities. Allochthones, on the other hand, to a small extent recognized the state property of this land and appeared to be aware about the activities of development partners and state management services. Statistically, the results showed a strong dependence between ethno-linguistic groups and respondents' opinions on state or local heritage of YBR (X-squared = 128.11, df = 2, p. value <2.2e-16).

## Local communities dissatisfied with participatory project initiatives

The interviews indicated that local development projects implemented to facilitate the participation of local communities did not have any significant impacts. Furthermore, most respondents considered the impacts to be negative, although a few thought the impacts were low i.e. not significant (Figure 5).

From a statistical point of view, a significant dependence was noted between the ethno-linguistic groups and their opinions on the impacts of such projects (X-squared = 42.28, df = 2, p-value = 6.59e-10). The allochthones (generally met in Yangambi centre) and a few of the Turumbu people had varying opinions between low impact and negative impact. In contrast, for the Bamanga community, impacts were negative for all criteria surveyed.

This dissatisfaction of local communities reflected *inter alia* the limited knowledge of the importance or role of YBR in the area. A few people consider that YBR plays an important conservation role although the majority supports the opposite point of view, emphasizing YBR's importance in providing local communities with multiple natural resources to support their subsistence economy and survival (Figure 6). Some went even further by denying the importance of YBR in their community. Statistically,

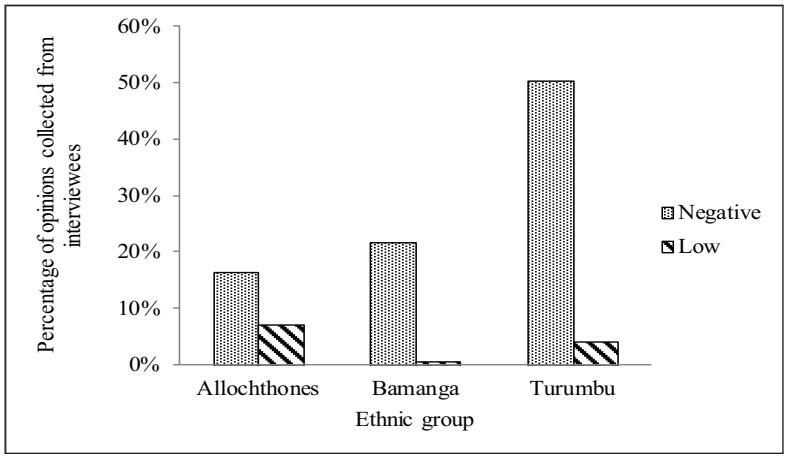



**Figure 5.** Opinion on the impact of development projects in the community.

results show a strong dependency between these opinions and the ethno-linguistic group (X-squared = 97.52, df = 4, p-value <2.2e-16).

In addition to the limited awareness of the ecological functions and importance of YBR, the management of the latter by state services was not favorably appreciated by the interviewees. Across all ethno-linguistic groups, most interviewees gave an unfavorable opinion on the management of YBR (Figure 7) although the respondents' opinions are not significantly dependent on the group to which they belong (X-squared = 1.01, df = 2, p-value = 0.61). In all the ethnic groups studied, the non-favorable opinion remained more important.

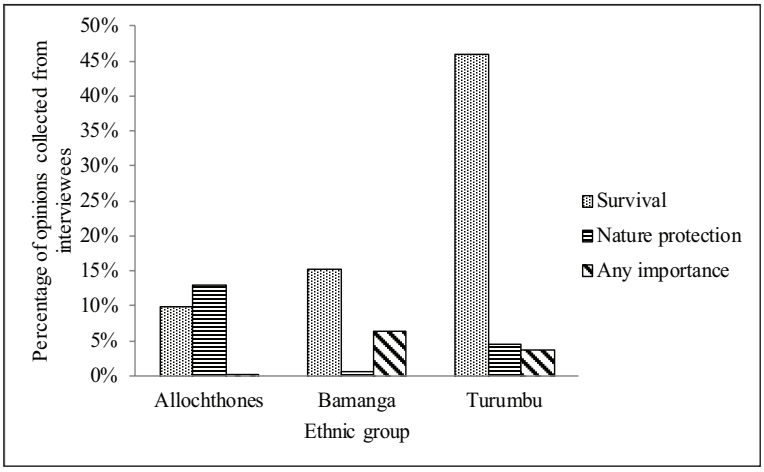



**Figure 6.** Importance of Yangambi Biosphere Reserveto local communities in the area.

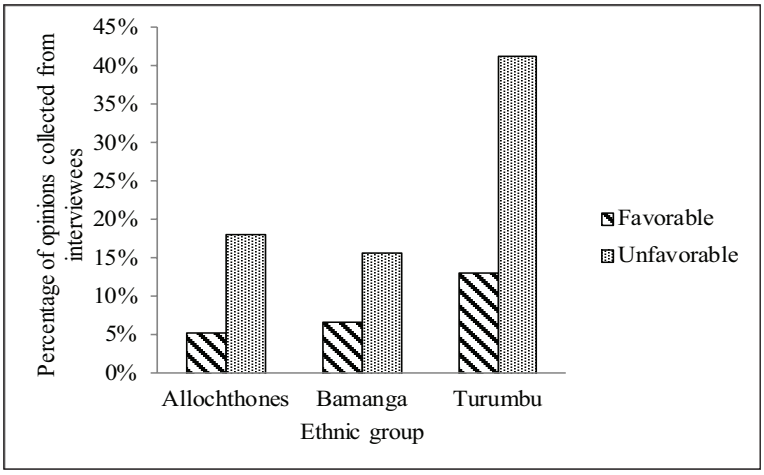



**Figure 7.** Opinion of interviewees on the management of Yangambi Biosphere Reserve.

**Low sustainability of project achievements**

The policies and projects implemented by different actors in order to involve local actors in the management of the natural resources of YBR have not contributed to developing sustainable land use systems. Archival sources show that until 1956 the Turumbu cooperative produced about 2,000 tons of agricultural products annually (AIMO 1957). By 1957 the activities of the Turumbu co-operative and Lilanda's "Cassava Plan" were already beginning to decline (AIMO 1957). After the departure of the Belgian colonial administration, the achievements of the cooperative and farmers in Turumbu were reduced to zero. In 1968, the cooperative was closed.

The MAB project has in turn met similar problems in its implementation. Even though its aim was to strengthen human and institutional capacities, the sustainability of the actions envisaged at the beginning has not been achieved. The maintenance of vehicles, outboard motors and laboratory equipment made available to the project by UNESCO has not been carried out by either the local or national government. UNESCO subsidies did not reach their intended beneficiaries. Four research programs were planned covering both the human and natural aspects of the YBR in the MAB-DRC agreement. None of these have been achieved. The internships and fellowships financed by UNESCO did not serve in the management of the YBR. This must, therefore, be considered a poor result of the MAB program.

The project implemented by WWF between 2010 and 2012 in the YBR failed to sustain its achievements. Today, the LSC and LDCCs are, to all intents and purposes, non-operational in the field. The same applies to the IUCN project. To collect the information on this subject, the following question was asked of the respondents: do you have some memories of the achievements of the projects implemented in your region? Across all ethno-linguistic groups, most of those surveyed said that, in the current context, the achievements of the local development projects are non-existent (Figure 8) (X-squared = 2.68, df = 2, p-value = 0.26). Those who remember some achievements that are still

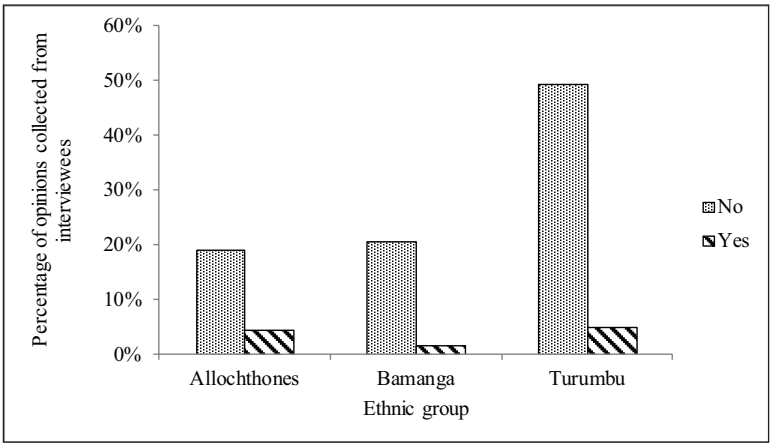



**Figure 8.** Perceptions of the achievements of local development projects.

visible in the area alluded to the presence of *eco-guards* and/or some roofing sheets that continue to be guarded by the presidents of the LDCCs. This concerns usually the inhabitants of the villages where the LDCCs and the MAB stations were originally established.

## Discussion

### Local communities marginalized during the design and implementation of local development projects

The results show that for local communities there are two categories of management actors for YBR: state services and communities. However, it would be difficult to suggest that LCs are very much involved in making decisions about the management of the reserve. This perception arises because YBR offers almost completely open access for the communities, despite the presence of state management structures. YBR is, therefore, understood by local communities as simply a space for exploitation and extraction of natural resources where one rarely meets the state actors who are supposed to monitor and control such activities.

The results also revealed that LCs were not consulted either during the establishment of the reserve or the design of local conservation and development projects for which they were supposed to be the main beneficiaries. This state of affairs can be explained by several pieces of logic. On the one hand, projects carried out in the field were based either on experiences acquired elsewhere, or on the basis of studies in and around Yangambi carried out only by researchers. To facilitate community ownership of these projects, local knowledge remained poorly mobilized. As Kellert et al. (2000) noted in Kenya and Nepal "…local communities were frequently only marginally more empowered than prior to the implementation of community-based natural resource management, with considerable control still residing in national and state authorities".

How was it possible that all local communities who were members of the LDCCs were supposed to benefit from the same goods and services considering that their priority needs differed between them? Since the benefits for the local communities did not emanate from their own needs the actual intervention logic applied was already predisposed to failure and weak ownership. According to some authors, greater local participation in decision making or, at the very least, a better understanding of local needs and desires and the incorporation of these are key aspects in the design and implementation of conservation and development programs, and underpin decentralization theory (Ribot 1996; Agrawal and Ribot 1999). Pamard and Fauroux (2004) noted, for example, that "the failure of development interventions in western Madagascar is mainly linked to a top-down approach that does not allow people to truly take ownership of innovation". It can also lead to the disempowerment of local actors by conservation professionals (Rodaly 1998).

The Belgian colonial period was not renowned for consultation with local communities. The establishment of YBR in 1939 was no different as INEAC expanded

the area under its control. Rural farmers were considered as subjects (having only subsistence and usufruct rights) and not citizens (Ribot 2001; Mamdani 2018). This is clearly noted in the annual report of INEAC in 1939: "the northern limits of the reserve will not be marked because our ambition is to extend it to the left side of the Aruwimi River".

Customary rights of local communities can be substantially reduced through policy interventions in biosphere reserves (Maikhuri et al. 2001). Bennett and Dearden (2014a) also noted a lack of transparency in processes of establishing national parks in Thailand. This can result in sustained conflicts with state actors because, as Castro and Nielsen (2001) noted, "the low participation of local actors is often the source of conflicts between state services and local communities". West et al. (2006) also commented that "…conflict is often at the heart of protected area establishment and maintenance. In part, this is because of clumsy top-down approaches by states that fail to appreciate, or work with, local practices and interests".

To compound matters, the legal texts that have governed the conservation of nature in DRC since the Belgian colonial era until 2014 have not been favorable to the participation of local communities. Utshudi Ona (2008) noted that the colonial era was characterized by Congolese submission to the colonial system, and did not allow rural communities to participate in the elaboration of texts or standards related to the conservation of nature. The ordinance establishing the YBR excluded all LCs in the demarcated area. Similarly, the ordinance-law n° 69-041 of August 22nd 1969 which governed the conservation of nature until it was replaced in 2014 by the law n° 14/003 of February 11th 2014 confirmed the exclusion of local communities in any process of establishing protected areas in its first article, viz., "… any part of the Republic may be constituted as a nature reserve when the conservation of fauna, flora, soil, water and in general, of a natural environment with a special interest and it is important to exclude this environment from any intervention likely to alter its appearance, composition and evolution ".

The exclusion of local communities mitigates against the conservation of nature in protected areas, and constitutes a real challenge in the implementation of participative approaches and can be a frequent source of conflicts with states services. According to Shackleton et al. (2002), the exclusion of traditional leaders from conservancy committees in Namibia was counterproductive, resulting in conflict and delays, until these leaders were co-opted on to the committees. Promoting dialogue between managers of protected areas and local communities, involving affected stakeholders in protected area planning and implementation, identifying areas of common interest between protected areas and local communities, and including community representatives on advisory management boards for protected areas can greatly assist in reducing conflicts between parks and local people (Hough 1988). Fontanon (1994) noted, furthermore, that the "…socio-economic exclusion of individuals and territories reflects a lack of citizenship and establishes a partial citizenship within a society". Again, it should be stressed that biosphere reserves in DRC have an unclear legal status as so-called 'protected areas', which also renders community participation problematic.

The concept of "biosphere" or MAB is a construct of UNESCO and has not yet been accompanied by legal texts that clearly describe their conservation objectives within DRC. This leads to a situation in which LCs rights are challenged, yet the establishment of a biosphere reserve establishes flexible and adaptive partnerships between LCs and the responsible authorities.

The results of the study also highlighted that most respondents were not aware of either the importance of YBR and/or the different participatory projects implemented in and around YBR. Several factors could explain this state of affairs. First, there is weak representation of grass root representatives at the LSC level. Local chiefs have been negotiating compensation for land appropriated by INEAC/INERA and the Turumbu community spanning more than 80 years. This compensation has been the subject of complaint up to today by the local communities (Interviews with Basanga, Bosala Selenga and Kaisala Bosendji respectively on March 11, 2015, April 1, 2015, April 25, 2015). Second, project leaders often prefer to spend all their time in Yangambi where they have relations with INERA and MAB to the detriment of the local communities. Finally, isolation due to poor rural infrastructure and limited public transport services does not facilitate the movement of state and private actors involved in the management of the YBR. This is particularly acute for the Bamanga community.

**Yangambi Biosphere Reserve – between state and customary ownership?**

The results of the study showed a strong dependence between ethno-linguistic groups and respondents' opinions on the ownership of YBR which is contested between the state and local communities. The Bamanga people because of the isolation are rarely associated with the management activities of YBR. This has accentuated their relative ignorance about the very existence of the reserve. As a result, the "protected area" of YBR continues to be perceived as a part of customary lands managed by the LCs. Ciocănea et al. (2016) also noted in their study that 21.7% of the respondents declared that they did not know about the existence of the Iron Gates Natural Park in Romania. Similarly, the findings of Rao et al. (2003) in the Nanda Devi Biosphere Reserve in India showed that local residents did not have extensive knowledge of the objectives of this biosphere reserve.

The question of meeting subsistence needs to survive is clearly mentioned in the respondents' opinions on the importance of the reserve to the community (Figure 6). The forest in a poor rural environment provides the population with a multitude of Non Timber Forest Products as critical seasonal sources of food as well as building and craft materials, medicines and minerals. Thus, YBR constitutes a critical source of livelihoods to sustain its riparian communities. Given the demographic pressure in the region (37,679 inhabitants in Yangambi, 79,098 inhabitants in Turumbu and 110,154 inhabitants in Bamanga), if YBR had not been established as a Floristic Reserve, a higher rate of deforestation and forest degradation would have probably been recorded.

**Mixed social representation on the management of the *YBR* by the State and its partners**

Local community perceptions of protected areas management can be either favorable (Ciocănea et al. 2016) or unfavorable (Bennett and Dearden 2014a). This study also revealed that the way in which YBR is managed benefits from weakly favorable opinions amongst the local communities. Several factors explain this.. First, the mode of management that prevails in the context of YBR has remained predominantly authoritarian. This shows that despite the participatory discourses mentioned by different actors, state services continue to exercise authoritarian power in practice. Neumann (1997) also concluded that, "despite the emphasis on participation and benefit-sharing, in Africa, many of the new projects replicate coercive forms of conservation practice and often constitute an expansion of state authority into remote rural areas". Denieuil (2008) also noted that "the failure of approaches to both community development and rural animation in Africa is due to the contradictions on the ground between the democratic and humanitarian basic participatory approach, and the sometimes directive and not always differentiated application of the authoritarian and dictatorial structures of African public administrations". *Eco-guards* recruited within MAB since 1979 contributed to the destruction and expropriation of canoes built by local communities. One member of the Turumbu community was killed when he refused to surrender his canoe. Some chiefs had canoes made for them, others charged taxes to the LCs who carry out informal activities in YBR. Artisanal mining prospecting and logging licenses were granted by MAB personnel in accordance with decisions of state services. Such types of informal activities often associated with slash-and-burn agriculture remain a major challenge in the management of YBR.

As a result, prohibited activities are often practiced by agents who should normally be committed to their prohibition. Thus, INEAC/INERA which appropriated the customary lands of the Turumbu and Bamanga peoples and which has managed YBR since its creation, has not managed to put an end to the land disputes with the local communities.

Another factor concerns the relative lack of information about YBR, or access to information by local communities despite several conservation and development projects and their failed environmental education efforts. As Ciocănea et al. (2016) noted, "Limited knowledge, information sources and activities carried out in protected area lead to a deformed perception on protected areas. These represent real challenges for authorities and administrations involved in protected areas management that should straighten their objectives to a better communication and collaboration with the residents of Iron Gates Natural Park, because it is essential to encourage public participation and deliberation to achieve a sustainable management of protected areas".

Finally, there is limited representation of, and consultation with, local communities. LCs representatives are often only associated in the last instance. One of the critical steps for sustainable management of protected areas is to know that the people living nearby have to be informed about permitted and prohibited activities, and they need to trust the responsible institutions for environmental management and their effective-

ness (Bogaert et al. 2009; Kim 2009). This is a big challenge in the management of YBR because many authors argue that local participation in decision making makes people more likely to have a sense of 'ownership' of those decisions (Larson and Ribot 2004).

**A local culture hostile to the appropriation of development initiatives**

The results highlighted weak sustainability in terms of the achievements of conservation and development projects. Apart from farmers linked to the Turumbu cooperative, which had produced results recognized by the people of the Yangambi region, the projects implemented by WWF and IUCN have generated very limited impacts. According to Gibson and Marks (1995), many integrated conservation and development projects in Africa have failed in their goal of conservation because the incentives presented to communities are public goods and are insufficient to alter individual behaviour. Poteete and Ribot (2011) also noted that in Botswana, "residents of wilderness areas complain bitterly about the lack of local benefits from tourism and the limits placed on their livelihood strategies in the name of conservation. According to one popular refrain, the government only cares about the welfare of wild animals". The lack of linkages between development and conservation is a factor in the failure of livelihoods programs in protected area management (Torell et al. 2010; Bennett and Dearden 2014b).

In some cases the local communities argued that farmers and the Turumbu cooperative contributed to improving their basic socio-economic conditions in the past. This seems to be corroborated by the point of view of Ahrouch (2011) who emphasized that "through their values of democracy, solidarity, sharing and mutual aid, cooperatives play an increasingly important role in economic and social development". However, it seems paradoxical that these initiatives did not survive after the country's independence. Speaking of the future of farmers in the Congo, Staner (1955) had already stressed that "the native cannot succeed alone in modernizing his agriculture. The operation will raise delicate political and psychological problems. The intervention of the public authorities will therefore remain indispensable in the years to come ".Unfortunately, the postcolonial Congolese state has failed to consolidate such a policy that could solve the problem of poverty in the rural world despite the State creating the Cooperative Development Office (ODCO) in 1963 as the administrative structure responsible for supporting cooperatives in the fields of training and information, as well as legal support.

However, even if the public authorities are failing in this area, it also seems necessary to analyze this issue from the angle of African tradition or culture. Tradition is marked by inequalities between ethno-linguistic group, status, roles, age and gender. To consider implementing cooperatives and/or participatory systems in this context remains a delicate undertaking. Denieuil (2008) emphasized in this regard that the African tradition opposes participatory approaches because it does not postulate autonomy of the individual, who often remains blocked in a highly hierarchical group. Participatory community development implies equality between individuals in the African village, and therefore challenges the organization of traditional systems (Meister 1977).

## Conclusion

The participation of local communities in the governance of Biosphere Reserves is still controversial to the present-day in the Democratic Republic of Congo some forty years after their establishment. The challenges are many and their origins are diverse. Focusing on the case of Yangambi Floristic reserve created in 1939/Yangambi Biosphere Reserve (YBR) (after 1977), this paper has identified the many challenges in the implementation of participatory approaches to managing YBR. In terms of external factors, it is important to underline the predominance of 'logic from above' comprising both the explicit and legal exclusion of local communities in protected area management and in the design of local conservation and development projects and policies. In terms of internal constraints, the almost permanent dependence of local actors on external support limits the sustainability of the impacts of local development projects. Thus, in the context of YBR, the participatory approach adopted has been essentially top-down, as defined by Beuret and Trehet (2001).

The failure of local development and/or participatory projects and policies has resulted in the emergence of mitigated perceptions of local communities about their place in the participatory governance of YBR. Participatory management and/or local development initiatives are only functional while their initiators are present in the project area. Once the project is finished, any achievements are unlikely to be sustained by the local communities. Thus, the participatory approach is still an illusion in the context of the management of Biosphere Reserves in the DRC. Furthermore, although Biosphere Reserves in DRC are recognized as part of the national network of protected areas since 2002, their management is still not aligned to either the Seville Strategy or the statutory framework of the world network of Biosphere Reserves (UNESCO 1996). As Bennett and Dearden (2014a) noted with reference to marine protected areas in Thailand, successful implementation of such an approach requires the definition of local development policies focused on the reduction of poverty through the diversification of sources of income, creating an enabling environment to promote rural development and investments to revive the activities of cooperatives, Small and Medium Enterprises and private companies, and the integration of local and traditional knowledge into management.

## Acknowledgements

The authors express their gratitude to the European Union for the funds allocated to research in DRC through the Forestry and Climate Change in the Congo project (FCCC). They thank the Centre for International Forestry Research (CIFOR), the Centre for International Cooperation in Agronomic Research for Development (CIRAD) and the University of Kisangani (UNIKIS) for scientific supervision of the first author's doctoral research. Resources and Synergies Development (RSD) is also thanked for the efficiency of its logistics management during the data collection period.

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