



The existence of black macaque (*Macaca nigra*) population in Bogani Nani Wartabone National Park, Bolaang Mongondow, North Sulawesi of Indonesia: The valuable economical investment of the endemic fauna in the forest environmental sustainability

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Abstract

The existence survey of the black macaque (*Macaca nigra*) population was conducted at the Bogani Nani Wartabone National Park (BNWNP), Bolaang Mongondow, and North Sulawesi of Indonesia from December 2021 to November 2022. The survey using line transect by 'Complete Count' method was used to determine population size. The direct observations and questionnaire surveys of the local people were applied to identify the potential threats to the macaque existence. The population comprised 183 individuals from four multimale-multifemale groups and fourteen solitary individuals. The group density was 1.22 groups/km², and the group size ranged from 34 to 55 individuals (mean of 42.25 ± 9.53). The mean ratio of adults to non-adults were 1:1.35, and the adult male to female ratio was 1:0.96. *Macaca nigra* was observed to forage and sleep inside range forest adjacent to the limited production forest. The survival of the macaque was threatened by the habitat loss, fragmentation, illegal logging and illegal mining. Other local human activities in opening forest for clove plantation were identified as potential stressors. Therefore, it should be recommended strictly to implement the existing management plan by the Directorate General of Natural Resources Conservation of the Republic of Indonesia. The monitoring and strengthening the capacity of forest departmental staffs should be focused to conserve the endemic fauna including *M. nigra* and flora vegetation of the animals' habitats as the valuable economical investment in the forest environmental sustainability of the BNWNP.

Keywords: Endemic primate density; Biological plant conservation; North Sulawesi natural threat.

1. Introduction

In recent years, the world's primate populations are declining across large parts of their range due to escalating anthropogenic pressures on primates and their habitats, or infectious diseases [1, 2, 3]. About 75 percent of primates have declining populations and about 60 percent of their worldwide are now threatened with extinction [2]. The collection of baseline information on primate distribution, abundance, and population trends is a vital first step in efforts to protect them from the extinction process [4]. The monitoring of primate population can enable direct measurement of the effect of local threats and allow an assessment of the effectiveness of conservation [4, 5].

The primate community in Bogani Nani Wartabone National Park, Bolaang Mongondow (BNWNP), North Sulawesi of Indonesia consists of small Tarsier sp. and two species of Macaques (*Macaca nigra* and *Macaca hecki*). A limited number of studies have estimated primate populations in this site. Generally, about seventy percent of primate species in South Asia are listed under threatened categories by the IUCN Red List of Threatened Species [6]. The last record of Macaque

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(*M. nigra*) species was suspected to be extinct in North Sulawesi [7, 11]. A long decade ago from surveys of primate known distribution in Bangladesh was reported that only three individuals of Long-tailed Macaque *M. fascicularis* (Raffles) were existing [8], but the current status is unknown.

The Macaque (*M. nigra*) is listed as a globally endangered primate species [9]. Its distribution ranges at northern part of Sulawesi in Bogani Nani Wartabone National Park, Bolaang Mongondow [10]. *Macaca nigra* is declining globally and is predicted to decline by more than 30% in the next three generations [9]. The *M. leonina* was listed as an endangered primate in Bangladesh [9]. Several previous attempts have been made to estimate the population size of *M. nigra* in Tangkoko Nature reserve based on observations [11]. During the 1980s and 1990s, observations of primates ranged from 128- 326 individuals with population estimates ranging from 250–1200 individuals [12, 13, 14]. In the early 2000s, approximately 350 individuals, including less than 110 adults, were reported to occur in the countries of South East Asia [15]. The most recent assessment, which is likely based on assumptions or old data, estimated a population of less than 1000 individuals [6]. No survey-based *M. nigra* population data have been published in recent decades, but the *M. nigra* population is thought to be in steep decline in North Sulawesi, with an estimated decline of more than 20% from 2015 to 2020 [6, 11].

Primate habitats and their quality have been diminishing [6]. To initiate site-based, species-specific conservation efforts, it is a prerequisite to have insight into the population status and threats affecting their survival [4, 6, 11]. The local community often makes the Bogani Nani Wartabone National Park area into many types of utilization. They opened up agricultural land, settlements, and shifting cultivation. In addition, there is often excessive logging, theft of flora and fauna species, and mining within the area. As a result, the area that is still sustainable in the Bogani Nani Wartabone National Park has decreased about 4.3 percent of each area of 300,000 hectares [4].

The environmental problem caused by forest destruction is the decrease in the quality of clean water in river basins. The endemic fauna including *M. nigra* are those animals restricted to a geographical area and do not occur naturally in any other part of the world. Thus, the *M. nigra* is categorized into the economical valuable investment in the forest environmental sustainability [16] of the BNWNP in Bolaang Mongondow regency, North Sulawesi of Indonesia. The goal of this study was to estimate the existence of the population of *M. nigra* including group composition, age-sex structure, external threats of their habitats and the continuing activities for the vigilance afforded to conserve the valuable economical investment of the endemic fauna in the forest environmental sustainability in the Bogani Nani Wartabone National Park, Bolaang Mongondow, North Sulawesi of Indonesia.

2. Material and methods

2.1. Study Area

Bogani Nani Wartabone National Park (BNWNP) is a rainforest vegetation area. On the island of Sulawesi, the Bogani Nani Wartabone National Park is the largest onshore national park covering the land of 282,008.757 hectares [17]. Besides having a wealth of flora and fauna, Bogani Nani Wartabone National Park also has natural attractions such as waterfalls, hot springs, stone caves and Hungayono stalactites, maleo bird habitat in Hungayono, and natural scenery on Peapata Hill. There live four main endemic species, namely the black macaque (*Macaca sp.*), maleo bird (*Macrocephalon maleo*), anoa (*Bubalus depressicornis*) and babirusa (*Babirousa babyrussa*).

Survey location is situated at the middle parts of the three regencies of East Bolaang Mongondow (EBM) including both districts of Nuangan and Modayag, South Bolaang Mongondow (SBM) including district of East Pinolosian and Bolaang Mongondow (BM) including both districts of Lolayan and Dumoga in North Sulawesi, Indonesia (Figure. 1). The BNWNP as the location of this study covers samples of five transects with total length of 10.79 km or within areas of 3.38 ha in each regency of EBM, SMB and BM (Table 1). These areas are parts of an extended protected area system as border of the limited production forest used by the mining company of PT JRBM in North Sulawesi province.

2.2. Data collection

The study was conducted at part of the Bogani Nani Wartabone National Park (BNWNP) from January 2022 to December 2022. In each of three months, observations were conducted by spending three consecutive days in collecting data. Surveyor walked five transects for a total distance of 10.79 km (Table 1). Each transect was repeatedly walked between three to eight times. An observer with two assistants moved quietly along the transect at about 1.5 km/h. Population surveys were conducted in between 06:00 h to 11:00 h. Surveyors stopped every 100 m for approximately 2-3 minutes and searched for *M. nigra*. Surveyors categorized all detected individuals as either in groups or solitary, based on 'Complete Count' methodology [4, 18]. On encounter, surveyors recorded the group size, age-sex of each individual,

sighting location, and habitat type. The macaques were classified into four age categories: adult, sub-adult, juvenile and infant. We also photographed the individuals whenever possible.

2.3. Parameters measured

The total population by of *M. nigra* was estimated by cross-checking the individual counts and the number of *M. nigra* groups encountered at each location. Group sizes fluctuated with dispersal and births. Hence, the last count for each group was used to estimate the *M. nigra* population structure. Lacking enough pictorial evidence of visible markings, individual identification of all the solitary animals was not possible. Instead, surveyor categorized groups based on their age-sex composition and locations. The group encounter rate was calculated by dividing the number of sightings by the total length of transects walked [19]. The group or individual density in the area was calculated by dividing the total number of groups or individuals by the total area [4, 19].

Mean group size was calculated from total group size excluding solitary individuals (SI) divided by total animal group. Animal group average was calculated from total animal group encountered divided by size areas surveyed. In addition, the individual average per square km was calculated from total animal group size including SI divided by size areas surveyed [11].

Solitary individuals (SI) were included in the individual density estimations; individuals of unknown sex were excluded from sex ratio calculations. Potential threats to *M. nigra*, and their habitats were identified through direct observation [20]. Surveyor also interviewed stakeholder villagers and staff of local Regency Forest Department of Bolaang Mongondow. The questionnaire focused on the harmful and beneficial aspects of *M. nigra* to villagers and determining the influences of human-macaque interactions [20].

3. Results

A total of 20 survey samples with five transects representing 10.79 km were completed during four quarters survey periods for a year of 2022 (Table1). Group size ranged from 34 to 55 individuals (42.25 ± 9.53). On average, surveyor walked about 1.85 km/ transect/ day, and the macaque encounter rate was 0.37 groups/km (N=18). The highest number of encounters (N=7, 44% of total sightings) was around the clove plantation. The groups were observed to split into smaller foraging units and then fuse again at sleeping sites.

Table 1 Characteristics of *Macaca nigra* survey transects

Transect	Length (km)	Habitat Type	Disturbance
1	2.17	Road, roadside teak, clove plantation and mixed vegetation	Vehicle noise at border of SBM and BM regencies
2	2.92	Mixed vegetation, human habitation, and the edge of clove plantation	Human settlements, seasonal tourism in SBM regency
3	2.35	Mixed vegetation, dried stream bed and bamboo	Seasonal tourists, firewood collection in both SBM and BM regencies
4	1.9	Mixed vegetation, dried stream bed, community garden and bamboo	Seasonal tourists, firewood collection, and cultivation in both SBM and BM regencies
5	1.45	Mixed vegetation, community garden and forest edge	Firewood collection in both SBM and BM regencies
Total	10.79 (2.16 km/transect)		

Group 2 was observed feeding and sleeping in the border of the clove plantation on transect 1 (Figure 1). Group 1 was encountered in mixed vegetation and clove plantation around garden area by community of Bakan village district of Lolayan in Bolmong regency. Group 2, 3 and 4 were recorded in three vegetation types including forest edges in proximity to Dumagin garden area of human settlements, and forest edges of South Bolmong regency. All of the solitary

adult males were encountered in mixed vegetation except one on the forest edge. Encounter locations suggested that the home ranges of the groups overlap with each other, especially during the monsoon.



Figure 1 Map of Bogani Nani Wartabone National Park [17] and location of the *Macaca nigra* survey line transects

The mean ratio of adults to non-adults was 1: 1.36 (Table 2). The adult male to female ratio was 1:0.96 (Table 2). A total of 183 individuals, comprising four groups and six solitary adult animals (42.25 ± 17.42), were recorded at part of the Bogani Nani Wartabone National Park (BNWNP) (Table 2). Loss of natural forest cover, increasing fragmentation, habitat disturbance, and human-macaque interactions were recorded as threats towards the long-term persistence of *M. nigra* in BNWNP. The clearing of forests for agriculture by the local community, and monoculture plantations (e.g., clove plantation) have fragmented the forest. Illegal logging and unregulated extraction of firewood were observed. It was commonly accessed by social media and found the adult male *M. nigra* killed to be consumed by some community in the remote areas of rainforest (Figure 2).

Table 2 The age-sex composition of *Macaca nigra* population in the BNWNP

Groups	Group Size	Adults (A)			Non-adults (NA)				A:NA	Un-known
		AM	AF	AM:AF	SAM	SAF	J	I		
1	44	12	9	1:0.75	5	6	6	4	1:1	2
2	55	8	11	1:1.37	9	8	10	4	1:1.63	5
3	34	7	6	1:0.86	4	5	6	3	1:1.38	3
4	36	8	7	1:0.87	5	6	7	3	1:1.4	0
SI	14	8	1	0	1	1	1	1	0	1
Total	183	43	34		24	26	30	15		11
%		24	19		13	14	16	8		6
Mean	42.25	8.75	8.25	1:0.96	5.75	6.25	7.25	3.5	1:1.36	2.75

The BNWNP becomes congested along years, when many visitors of illegal logging and mining enter the forest, make noise, disturb animals, and throw out food waste, and plastic bags and containers (Figure. 2). The *Macaca nigra* usually showed aggressive behavior in proximity to visitors and was not observed to take food directly from them. An adult male was witnessed licking a packet of potato chips thrown by visitors. Such uncontrolled visitor activity severely interrupts daily activities of diurnal mammals and could potentially spread diseases to non-human primate populations [6].

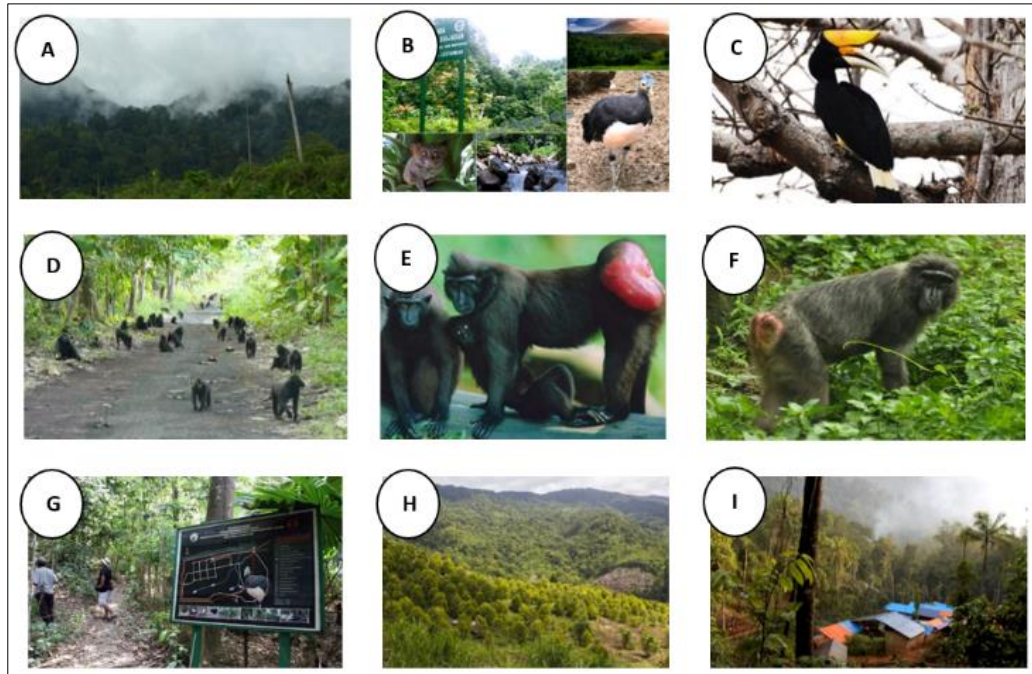


Figure 2 Threats to *Macaca nigra* at the Bogani Nani Wartabone National Park (BNWNP) Great Forest (A) with Flora and Fauna Biodiversity (B) and Julang Sulawesi bird (*Rhyticeros cassidix*) as the endemic bird in North Sulawesi (C), the endemic *M. nigra* group (D), an estrus female *M.nigra* (E) and post-estrus female *M.nigra* (F). The activities of illegal logging at the BNWNP (G), forest conversion of clove plantation adjacent to BNWNP (H) and illegal mining threatening the conservation of the BNWNP (I)

The group density was 1.22 groups/km², and the individual density was 55.8 individuals/km² (Table 3). Uncontrolled tourist activities were found to disturb the entire forest ecosystem. From January 2022 to August 2022, when the highest numbers of tourists visited the forest, tourists visiting the park made loud sounds, exploded fireworks, and discarded food waste in the forest. The *Macaca nigra* was not observed to be directly provisioned but may have eaten the food left behind by visitors (Figure 3).

Table 3 Abundance estimates of the Sulawesi Black Macaques (*Macaca nigra*) at the Bogani Nani Wartabone National Park (BNWNP) in North Sulawesi province

Quarter (Q) Periods of 2022	km surveyed	km ² surveyed	Group encounters	Groups/km ²	Mean group size	Individuals/km ²
1 (Jan-Mar), Q1	10.79	3.28	4	1.22	42.25 ± 9.53	55.8
2 (Apr-Jun), Q2	10.79	3.28	4	1.22	42.25 ± 9.53	55.8
3 (Jul-Sep), Q3	10.79	3.28	4	1.22	42.25 ± 9.53	55.8
4 (Oct-Dec), Q4	10.79	3.28	4	1.22	42.25 ± 9.53	55.8

This study did find the evidence of ongoing hunting in the BNWNP and trading of *M. nigra* at several local markets. In North Sulawesi and small city nearby the BNWNP regions, trade in *M. nigra* bones for traditional medicine, meat for food, and the live monkeys as pets was reported at some studies [15], but the current situation is unknown. Monkey performers often catch monkeys, including *M. nigra*, from local forests, or buy them from villagers who catch and sell monkeys illegally [21], yet the extent of live trade in non-human primates remains undetermined in Northern parts of Sulawesi [22]. *Macaca nigra* is legally protected in the BNWNP, and killing or illicit trading of the animal is a punishable offence, but law enforcement remains deficient [6]. The penalty for killing primates is still unclear [23, see Section 37]. Therefore, it is suggested a further clarification of the relevant regulations. Strict implementation of the BNWNP management plan may eradicate the conservation problems affecting *M. nigra* that have been identified (Figure 3).

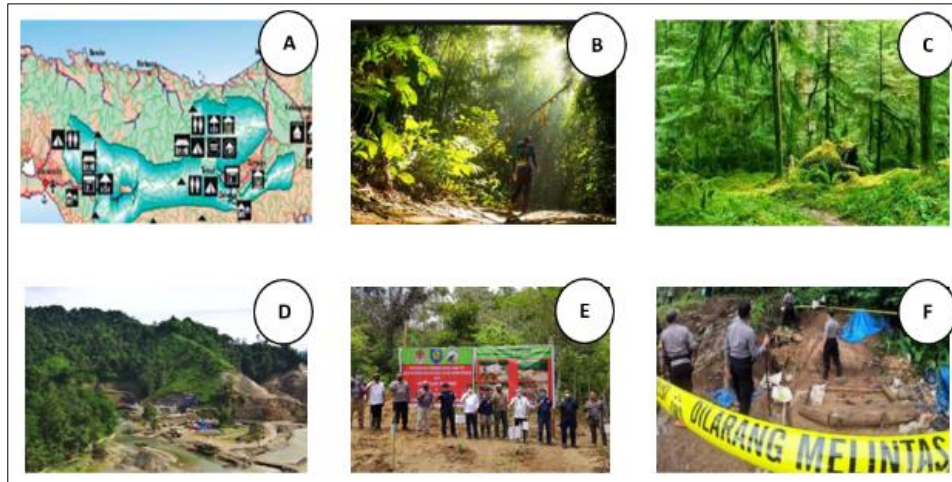


Figure 3 The process of restoring the Bogani Nani Wartabone National Park (BNWNP) ecosystem by the Directorate General of Natural Resources Conservation of the Republic of Indonesia with the activities: The education places for biodiversity conservation of flora and fauna habitats including the BNWNP -Global positioning system-GPS (A) [16], Indonesian Tourism destinations (B), bird hatching conservation of *Maleo macrocephalon* at the villeges of Tambun and Pusian (C), the relocation area for residents affected by the Bulango Dam at the edge border of BNWNP at the South Bolmong regency which was moved to the other outside areas of the BNWNP (D), the BNWNP's joint operation team for the valuable economical recovery of the BNWNP (E) and closing of the 141 illegal mining pits at the areas of North Dumoga district (F)

4. Discussion

Feeding ecology of *M. nigra* in coconut plantations has not yet been studied; therefore, whether they also act as biological pest control is still unknown. Studies on the feeding ecology of *M. nigra* at the BNWNP are pivotal to determine how this ecologically flexible species meets its nutritional requirements in coconut plantations alongside mixed evergreen forests. Further study is also needed to understand the relationship between foraging strategies and the higher individual densities of *M. nigra* at the BNWNP when compared with other sites in and around the BNWNP of northern of Sulawesi Island [11, 24, 25].

Natural forest cover at the BNWNP has been decreasing due to the expansion of monoculture plantations of clove plantation, and illegal wood harvesting [11, 26]. In Bangladesh, altogether 38% of dense forests were degraded in 1993–2006 and 42% in 2006–2019 [27]. Meanwhile, the increase in canopy gaps at the forest might negatively impact the *Macaque's population*, which is already small and isolated [15]. Interviews of local people around the BNWNP revealed that *M. nigra* travels to human settlements to forage on seasonal fruits. The people generally tolerate the macaques for their socio-cultural and religious value. However, sometimes the macaques badly damaged storage sheds in human settlements and in such cases, people repulsed the macaque using bamboo or wooden sticks. No injury to either *M. nigra* or human is known to have occurred in such conflicts throughout this study period. Moreover, some villagers that passes through the forest have been responsible primate mortality by hunting as their food. In Bangladesh, from 2016 to 2018, at least seven individual primates, were killed on the road by accidents and further eleven individuals were killed by electrocution [26].

A plausible explanation for the higher individual density at the BNWNP is that our survey was confined within the park boundaries, while the home ranges of *M. nigra* groups included the adjoining forests beyond the park area. However, the mean group size of *M. nigra* in the BNWNP of 42.25 individuals (Table 2) was close to reported estimates around the Tangkoko nature reserve in North Sulawesi ranging from 40.3 to 62.5 individuals [11]. Group size in primates is dependent on ecological and social drivers [28]. In particular, a major factor constraining group size in social foragers is the feeding competition [29].

The distribution and abundance of native fruits affected foraging patterns of primates [30] including *M. nigra*. Boundary parts the BNWNP as location of this study at small forest generates limited food, which may cause competition among animals. Competition may involve directly observable interactions [25]. In the present study, surveyor observed aggression at food sources between two endemic primates of *M. nigra* and *M. hecki*. Furthermore, *Macaca nigra* has a

dietary overlap of about 35% with *M. hecki* at the boundary parts the BNWNP, indicating that these species are potential competitors.

The group of *Macaca nigra* seems to have adapted well to clove plantations at the edge boundary of BNWNP. Almost half (33.3 %) of *M. nigra* encounters were in the roadside clove plantation. *M. nigra* used banana plant of the community garden as a food resource. Multiple variables, including predator avoidance, range defense, and access to food, affect the selection of sleeping sites in primates [31]. The roadside clove and coconut plantation at the boundary sides of BNWNP may be an important food source for *M. nigra* and food proximity might favor the selection of the plantation as a sleeping site. In Malaysia, *M. nemestrina* acts as a potential biological pest control agent in Oil Palm plantation by hunting rats (*Rattus* spp.) [32].

The steep decline of the BNWNP's overall population of the *M. nigra* is thought to be occurred. Based on the types and intensities of threats, it was predicted in 2015 to decline by more than 20% by 2020 (6). Then again, there is no recent estimate of *M. nigra* abundance in the BNWNP, so the accuracy of this prediction cannot be assessed. The numbers of adult males and adult females in the population of the BNWNP were almost equal of ratio 1:0.96 (adult male to adult female ratio 1:1) as shown in Table 2. In Bangladesh, it was reported a substantially higher number of adult females than adult males (adult male to female ratio 1:3) [12]. The *M. nigra* individual density at the BNWNP was 55.8 individuals/km², which was higher than earlier estimates in Bangladesh of 2.5–6.9 individuals/km² [31, 33, 34]. Surveys in the forests of Assam, India revealed densities of 8–33.3 individuals/km² [33, 24, 35].

Nineteen villagers and forest guards were interviewed (age 36.7±11.2 years; 92% males). Livelihoods of 58% of the respondents (n=11) were directly or indirectly dependent on the forest. They reported being involved in a variety of activities including firewood collection from the forest, cultivation, living inside the forest and running tourist-based shops. Over half of the respondents (53%) in interviews opined that the *M. nigra* population at BNWNP is stable.

According to 68% of the respondents (n=13), both *M. nigra* and *M. hecki* raided homesteads for seasonal fruits (e.g., mangosteen, papaya) and the villagers usually tolerate the macaques. Only in cases of extreme detriments, such as damaging sheds, people used bamboo or wooden sticks to repulse the macaques. Interviews suggested that primates are not hunted at BNWNP. In recent decades, countries of South East Asia including Indonesia's forest cover has deteriorated at an alarming rate due to expanding agricultural practice, monoculture plantations and selective logging [35].

5. Conclusion

This collective effort by local and international groups may be helping to reduce illegal activity in the BNWNP reserve (hunting and habitat destruction) and generate greater awareness of this critically endangered species. Without the continued vigilance afforded by the existing research, training programs, the support and involvement of the local people, the *M. nigra* at the BNWNP will likely face further decline. The existing BNWNP management plan aims to protect, maintain, and enhance the biological significance and aesthetic value of BNWNP by integrating a community-based management system. In the long term, though, threatened species, including *M. nigra*, may require specific management schemes. Population monitoring by the forest departmental staff every year would help to reveal population trends for *M. nigra*. Over-exploitation of forest products requires systematic enforcement of regulations. Further conversion of the limited production forest for clove cultivation by local community within edge boundary of the national park and illegal encroachment should be prevented. Controlling the number of visitors from overseas countries and their activities in the forest will facilitate eco-tourism. Finally, the key of effective implementation of management plans and enhancing the protection of the endemic animals and forests is building the capacity of forest departmental staff through training and modernized equipment in conservation of the endemic fauna including *M. nigra* as the valuable economical investment in the forest environmental sustainability of the BNWNP.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declared no conflict of interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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