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Seasonal Distribution and Habitat Use of Green Peafowl *Pavo muticus Linnaeus*, 1766, in Nam Whean Forest Protection Unit, Northern Thailand

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Abstract

The distribution and habitat use of the globally endangered Green Peafowl was studied in the Nam Whean Forest Protection Unit, Phayao province, Northern Thailand. Green Peafowl sightings or traces were recorded across a 3×3 km grid-system (total area of 9 sq.km. divided into 100×100 m grid-squares). Global positioning systems were used in order to analyze seasonal distribution and habitat use. Green Peafowl sightings and traces were detected in 88 grid-squares. In the dry season (March to May), the birds and their traces were detected in 48 grid-squares; mixed-deciduous forests covering 40 grid-squares (83.3 %), and community forests covering 8 grid-squares (16.7 %). In the wet season (June to November) bird sightings and traces were recorded in 40 grid-squares; mixed-deciduous forests covering 21 grid-squares (52.5 %) and community forests covering 19 grid squares (47.5 %). No birds or traces of the birds were detected in agricultural areas during either season. For the whole year, most birds were distributed within 0 - 1,000 m of the reservoir and 101 - 300 m of streams, and kept a distance of 1,001 - 2,000 m from human settlements. The Green Peafowl's main habitat in this study was mixed-deciduous forest, due to their using of this area for routine foraging, as a breeding ground in the dry season, and as a brood rearing ground in the wet season. Management strategies were proposed and discussed based on our key findings.

Keywords: *Pavo muticus*, green peafowl, seasonal distribution, habitat use, Thailand

Introduction

The Green Peafowl *Pavo muticus* Linnaeus, 1766, is an endangered species in the Order Galliformes, Family Phasianidae [1-3]. Their habitats are primary forests, secondary forests, grassland, and agricultural areas [2,3]. However, the most common habitat is deciduous forests, including dry-dipterocarp forests and mixed-deciduous forests [2,3]. This species inhabits areas close to water resources (rivers, streams, and ponds) undisturbed by human activities [2-5]. In the past, Green Peafowl distribution ranged from Yunan province, China, to the Java islands of Indonesia, North-East India, and Bangladesh, at sea levels up to 2,100 m [1-3]. Recently, Green Peafowl populations have decreased throughout these countries within the last 2 decades [3]. In some areas, the birds were even reported as "extinct", such as in the southern part of Thailand, Malaysia, and North-East India (Manipur and Southern Mizoram), due to the loss of habitat and overexploitation, including illegal hunting. Currently, the world status of this bird has been classified as an endangered species [2,3].

In Thailand, the Green Peafowl is also classified as an endangered species by the Office of Natural Resources and Environment Policy and Planning [4]. The population of the bird has been decreasing over the last 2 decades due to habitat loss, habitat fragmentation, and illegal hunting [3].

In Thailand, Green Peafowl is found in 2 major populations. The western population is found in the Huai Kha Khaeng and Thung-Yai Naresuan Wildlife Sanctuaries, in the northern part of Khuean Srinagarindra National Park in Kanjanaburi province [6-11], whilst the northern population is found along the Ing and Yom rivers in Phayao province, the Nan river in Nan province, and the Ping river in Chiang Mai province [6-12]. In Haui Kha Khaeng, the Green Peafowl has been studied continuously for the last 2 - 3 decades [8-12]. The population trend seems to have slightly increased. The northern population was later studied from 1992 until now; however, there were limited studies conducted in restricted areas, and the population trends of each area were unknown [6,12-15]. This limitation might have been due to the difficulty of accessing the study areas in the northern region, most of which were made up of mountains and steep areas.

Many factors influence the Green Peafowl's survival rate and distribution, especially human activities. In order to design a suitable management plan for Green Peafowl, it is important to have prior knowledge of its biology, distribution, and seasonal habitat use, and the impact of natural and anthropogenic factors [5,16,17]. Knowledge of adaptations for survival in different landscapes [16] is useful in predicting habitat suitability for peafowls and in designing suitable conservation methods and management plans in order to maintain and increase populations [17].

Most prior research was conducted on the western population and was focused in the dry season [6,8-11] in large and continuous forest area. This is because, in the dry season, the birds usually inhabited open areas along the rivers, which in turn made them easy to spot during the study. Due to this, however, there is no complete research on seasonal distribution (for both the dry and wet seasons) in the northern population. As a result, there is still a lack of understanding on seasonal distribution and patterns of habitat use [6,8-11,13,15]. However, the study of peafowl viability in small fragmented forest area is very important for this large bird. Therefore, this research was concentrated in seasonal distribution in a small forest protection area, namely "Nam Whean", located in Phayao province, northern Thailand. The objective was to investigate seasonal distribution and habitat use of the Green Peafowl using a grid-based system, in order to obtain details of the Green Peafowl's ecology and disturbance factors for the improvement of Green Peafowl conservation strategies.

Materials and methods

Study area

The field work was carried out in the Nam Whean Forest Protection Unit (NWFPU), Chiang Kham District, Phayao Province (19°21′882′′–19°20′244′′N, 106°15′694′′–106°17′415′′E) (**Figure 1**). The average temperatures during the dry and wet seasons were 28 and 27 ºC respectively. The annual precipitation, measured from Rain station number 310005 in Chun district, Phayao province, ranged from 11.30 to 323.66 mm. This rainfall data was used to define the dry and the wet season in this study. Elevations ranged from 420 to 700 m above mean sea level (amsl) [18]. Within the total study area of 9 km^2, the vegetation comprised of primary mixed-deciduous forest, community forest, and agricultural areas. There was also a reservoir, namely the "Nam Whean reservoir", which was constructed mainly for agricultural purposes.

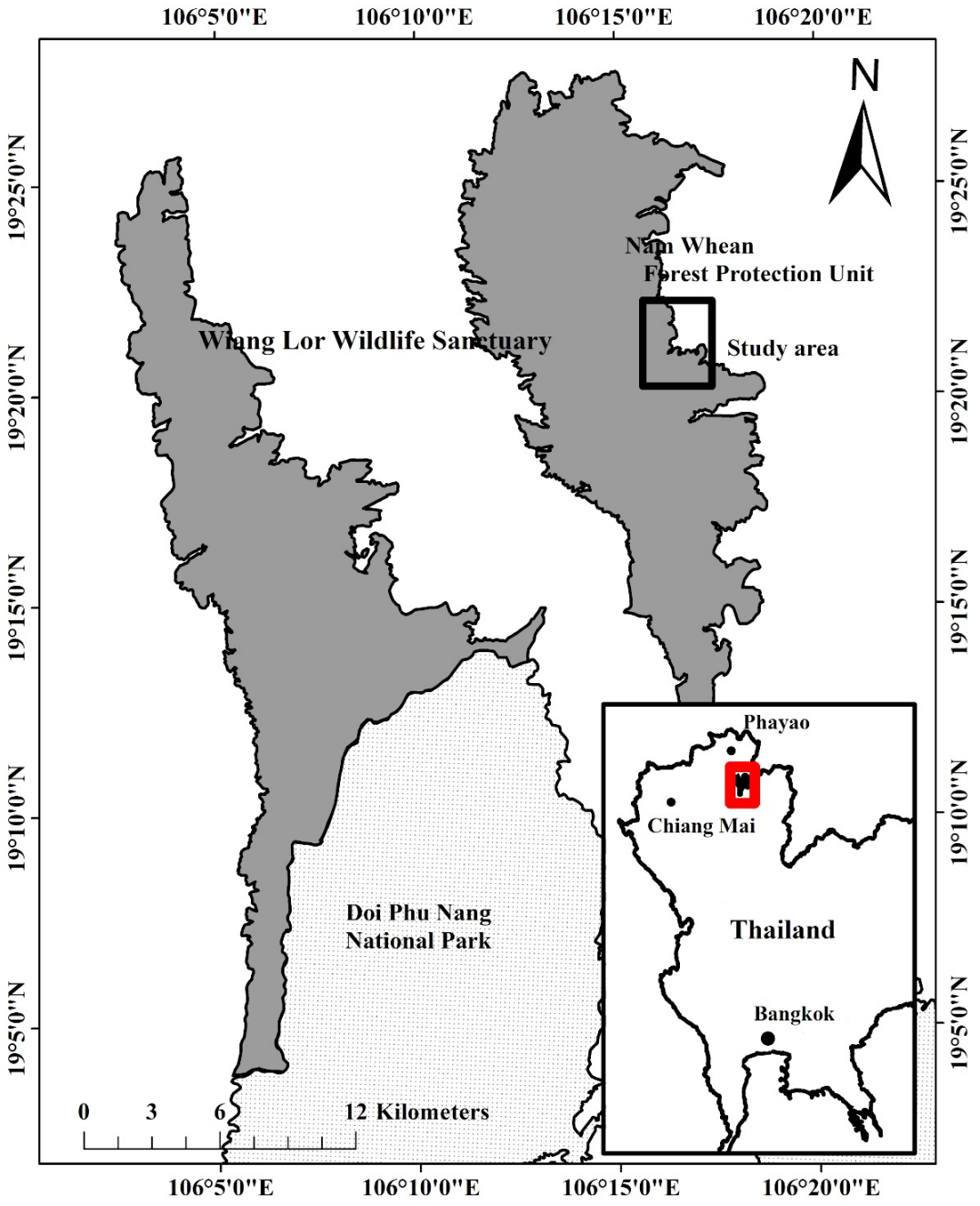

Figure 1 The study area at Nam Whean Forest Protection Unit, Chiang Kam District, Phayao Province.

Habitat classification and data collection

The field survey was carried out using Royal Thai Survey Department topographic maps (scale 1: 50,000), land use and land cover maps from the Land Development Department (DATE), and NWFPU boundary and contour lines from the Wiang Lor Wildlife Sanctuary. In the survey map of 3×3 km^2, a grid based system technique was used to set up the study plots. There were 900 grid-squares (plots) of 100×100 m^2 used for the field surveys (**Figure 1**).

Each grid-square was classified as one of 3 habitat types, based on plant community and land use as follows [18,19]:

1. Mixed-deciduous forests: This habitat was dominated by broad leafed tree species, and accounted for 624 grid-squares; 69.3 % of total study area (900 grid-squares).

2. Community forests: This habitat was a mixed-deciduous forest that was used and managed by local people cooperating with NWFPU officers. Local people harvested non-timber forest products, such as mushroom and herb, and hunted small animals. The community forest area is located outside the NWFPU boundary, and accounted for 196 grid-squares; 21.8 % of total study area.

3. Agricultural areas: This referred to arable land at the boundary of the NWFPU near the villages. This area was covered by annual crops (e.g. cotton, rice, maize, and vegetables) and perennial crops (e.g., longan and para rubber). It accounted for 80 grid-squares; 8.9 % of total study area.

In the case of a single grid-squares containing more than one habitat type, the dominant habitat type was used to classify the habitat type of that grid.

Field surveys were performed by visiting each grid-square and checking the habitat type in order to confirm the accuracy of the survey map [20-22]. In 2013, the surveys were conducted 3 times per month during March to May, representing the dry season, and June to November, representing the wet season. Generally, the dry season is the breeding season of the Green Peafowl [6,13,15] and the wet season is the non-breeding season [6,13,15]. Each time, 2 surveys were conducted from 6.30 - 10.30 a.m. and 02.00 - 06.30 p.m. These times were chosen because they were the foraging periods of the Green Peafowl, which in turn allowed a greater probability of detecting them [6,11-15,23].When Green Peafowls and their traces , including foot prints, droppings and feathers, were detected, the coordinates and elevation were marked by a Global Positioning System (GPS), Garmin e-Trex H handheld model.

Data analysis

Seasonal distribution and habitat use: Coordinates and elevations recorded from the field surveys were used to create an overall seasonal distribution map of Green Peafowls in the study site. Then, the seasonal distribution boundary and total area of Green Peafowl distributions in both dry and wet seasons were estimated by the Minimum Convex Polygon method (MCP) under the ArcGis program [20,22]. In addition, the percentage of each habitat type was calculated to identify the habitat preferences of the birds.

Distance to key features: The distance to 3 key features, i.e. the reservoir, streams, and human settlements, of each sighting was also measured. These factors are known to influence the distribution of the birds [5-6,8,11-12,23-25].

Chi-square goodness-of-fit [24-26] was used to determine whether the observed occurrence of birds or traces (proportion between total detected grid-square in each habitat and total available grid-square of each habitat) was similar to the expected.

Results and discussion

Distribution and habitat use

Overall distribution and habitat use: Green Peafowl sightings and traces were recorded in 88 grid-squares out of the total 900 grid-squares within an elevation of 460 - 580 m amsl. Most Green Peafowls, in 43 out of 48 grid-squares in the dry season and 30 out of 40 grid-squares in the wet season, were found at elevations between 500 - 560 m amsl. The bird distribution boundary in the dry season and the wet season was 1.2 km^2 (129 grid-squares) and 3.6 km^2 (360 grid-squares), respectively (**Figure 2**). The

habitats used by the Green Peafowls were mixed-deciduous forest (69.3 %) and community forest (30.7 %), while no bird sightings or traces were detected in agricultural areas.

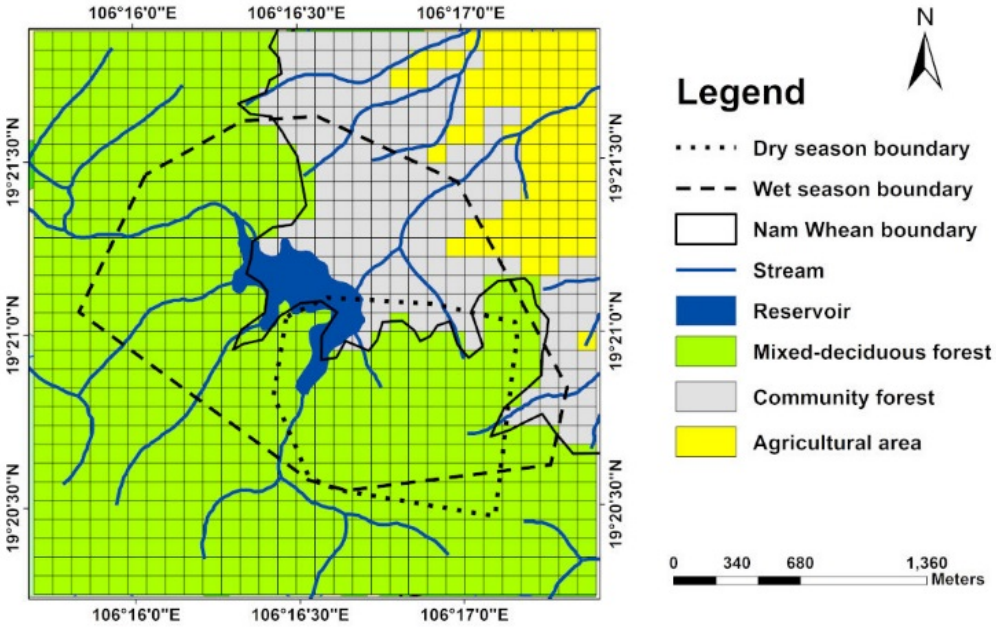

Figure 2 The grid system used to cover the 3×3 km^2 area, also showing the distribution boundary of the Green Peafowl *Pavo muticus* in the dry season (dotted line), and the wet season (dashed line).

Distribution and habitat use in the dry season: The results showed that a total of 48 grid-squares of differing habitats were recorded (**Table 1**). The most common habitat was mixed-deciduous forest (83.3 %), which was used as the Green Peafowl's breeding ground. The other habitat used by the birds was the community forest (16.7 %). No birds or traces were detected in agricultural areas (**Figure 3**). In the dry season, Green Peafowl sightings and traces were recorded within elevations of 480 - 580 m amsl (average 531 ± 26 m). Most of the observed Green Peafowl sightings and traces appeared at 560 m (32.7 %) and 520 m (26.2 %), respectively. Occurrences of birds and traces were not significantly different between mixed-deciduous forest and community forest, as well as not significantly different among elevation zones (Chi-square test, $P<0.05$) (**Table 2**).

The distribution of birds in the mixed deciduous forest was similar to previous studies of the western population in the Huai Kha Khaeng Wildlife Sanctuary [7,9-12] and the northern population in Doi Phu Nang National Park [13,23] and Doi Saket [14,15]. The birds used open areas on hill ridges and mountain tops (the maximum elevation in the study area was 700 m amsl) for their acts of display, and used mountain slopes for nesting and brood rearing sites during the early hatchling period. This pattern was similar to the reports of the northern population in Doi Phu Nang National Park [13,23] and Doi Saket [14,15]. However, these patterns were different compared with reports of birds in the western forest complex, which found that the birds used sand bars along the river for displaying and used areas covered with dense grass as nesting and brood rearing sites [6,8,9,11]. These differences might be due to a limitation of open and clear space in the mountainous topography of northern Thailand. Therefore, the bird has to adapt, especially in order to find an open enough clearing for their displaying behavior.

In community forests, the observed birds and traces were fewer than in the mixed-deciduous forest. Normally, the area is regularly disturbed by human activities, especially the collection of non-timber

forest products. In spite of these disturbances, the Green Peafowls still use this area in the dry season. This might be because the birds use this area as a water and food source during the dry season.

No bird sightings or traces were observed in agricultural areas. This may relate to the frequent disturbances and farming activities of the local villagers. Most of the agricultural lands are dominated by Para rubber. Farmers regularly access their farmlands in the early morning for latex collection. This activity overlapped somewhat with bird foraging periods in the mornings. Therefore, the birds most likely avoided the rubber plantation areas altogether. There are also maize and paddy fields that the farmers usually access in the late mornings. The farming activities, especially land preparation through the use of heavy machinery, may have affected bird use of the area. However, there were some studies that showed the birds accessing agricultural areas in the dry season in order to use water from irrigation canals [13-15,23].

Distribution and habitat use in the wet season: A total of 40 grid-squares were recorded (**Table 1**). The most common habitat used was, again, mixed-deciduous forest (52.5 %) and community forest (47.5 %) (**Figure 4**). In the wet season, the distribution of Green Peafowls was slightly different to the dry season. They were found in a broader range of elevations (460 - 560 m amsl; average 520 ± 32 m). Most of the observed sightings and traces were located at 560 m (30.4 %) and 500 m (26.8 %), respectively. Occurrences of birds and traces were significantly different between mixed-deciduous forest and community forest, as well as significantly different among elevation zones (**Table 2**, **Figure 5**).

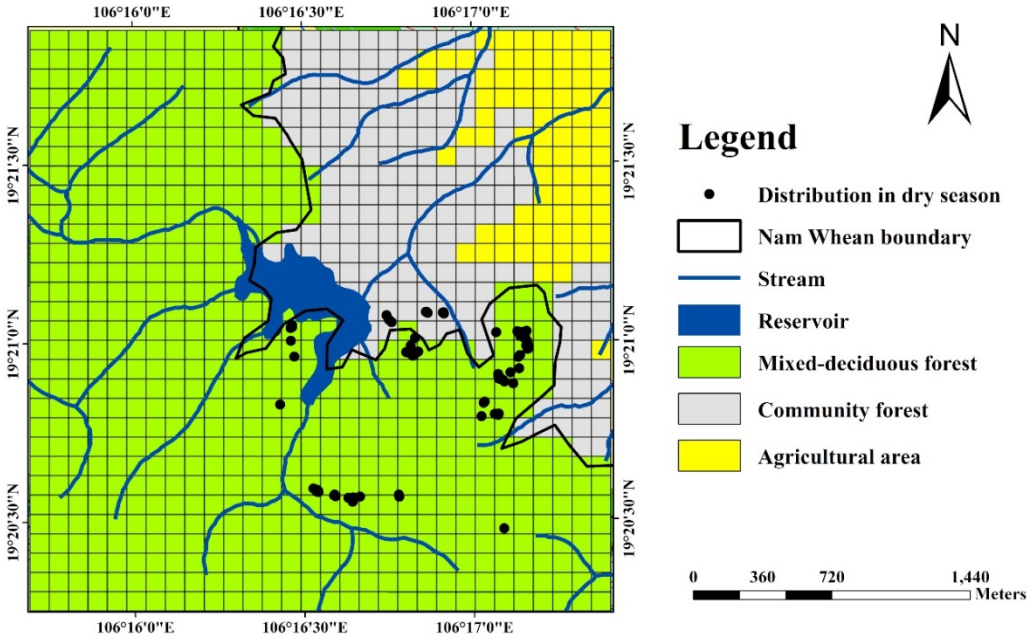

Figure 3 Distribution of the Green Peafowl *Pavo muticus* in the dry (breeding) season (March, April, and May).

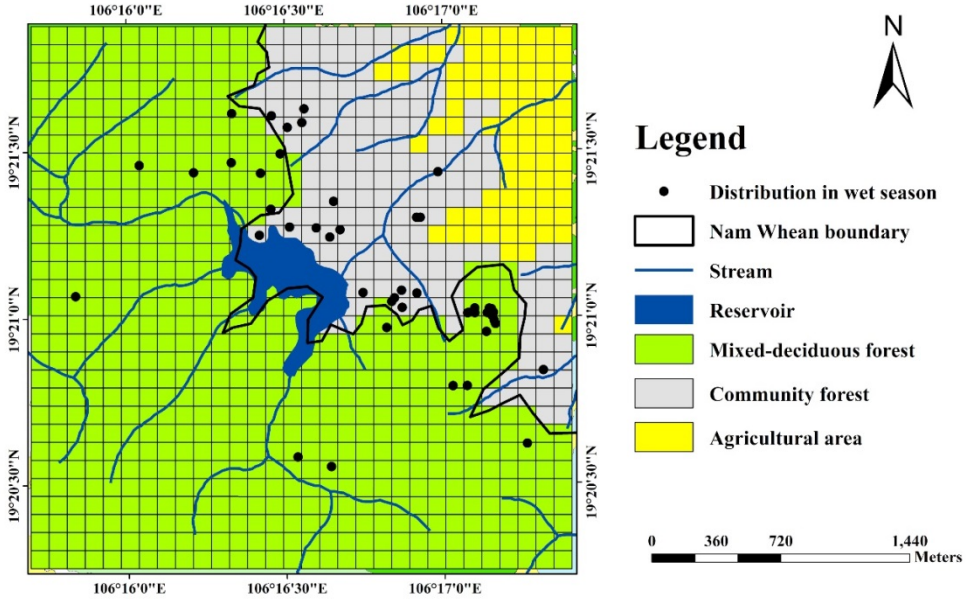

Figure 4 Distribution of the Green Peafowl *Pavo muticus* in the wet (non-breeding) season (June, July, September, October, and November).

Table 1 Numbers and percentages of grids in the different habitat types and seasons in which Green Peafowl *Pavo muticus* or their traces were detected.

Season	Month	Number of grid-squares in the different habitat types in which Green Peafowl or traces were detected			Total
		Mixed-deciduous forest	Community forest	Agricultural area	
Dry	March	36	7	0	43
	April	45	3	0	48
	May	13	3	0	16
	Total	40 (83.3%)	8 (16.7%)	0	48 (100%)
Wet*	June	0	1	0	1
	July	3	6	0	9
	September	10	9	0	19
	October	7	4	0	11
	November	14	2	0	16
	Total	21 (52.5%)	19 (47.5%)	0	40 (100%)
Overall		61[a] (69.3%)	27[a] (30.7%)	0	88 (100%)

Note: * = Proportion between total detected grid-square of each habitat and total available grid-square of each habitat is significantly different across habitat types in particular seasons (Chi-square test, $P<0.05$)
Note: a = Proportion between total detected grid-square of each habitat and total available grid-square of each habitat is significantly different across dry and wet seasons (Chi-square test, $P<0.05$)

Table 2 Numbers and percentages of grids in which Green Peafowl *Pavo muticus* or their traces were detected in the different elevations.

Season	Month	Number of grid-squares in different elevation in which Green Peafowl or traces were detected								Total
		460 amsl	480 amsl	500 amsl	520 amsl	540 amsl	560 amsl	580 amsl	600 amsl	
Dry	March	0	4	9	9	9	12	0	0	43
	April	0	2	3	16	9	17	1	0	48
	May	0	1	5	3	1	6	0	0	16
	Total	0	5 (10.4%)	13 (27.1%)	12 (25%)	8 (16.7%)	9 (18.8%)	1 (2.1%)	0	48 (100%)
Wet	June	0	1	0	0	0	0	0	0	1
	July	0	4	3	2	0	0	0	0	9
	September	1	4	6	3	4	1	0	0	19
	October	0	0	5	1	0	5	0	0	11
	November	0	1	1	2	1	11	0	0	16
	Total	1 (2.5%)	9 (22.5%)	15 (35.7%)	6 (15%)	4 (10%)	5 (12.5%)	0 0	0 0	40 (100%)
Overall		1 (1.1%)	14 (15.9%)	28 (31.8%)	18 (20.5%)	12 (13.6%)	14 (15.9%)	1 (1.1%)	0 0	88 (100%)

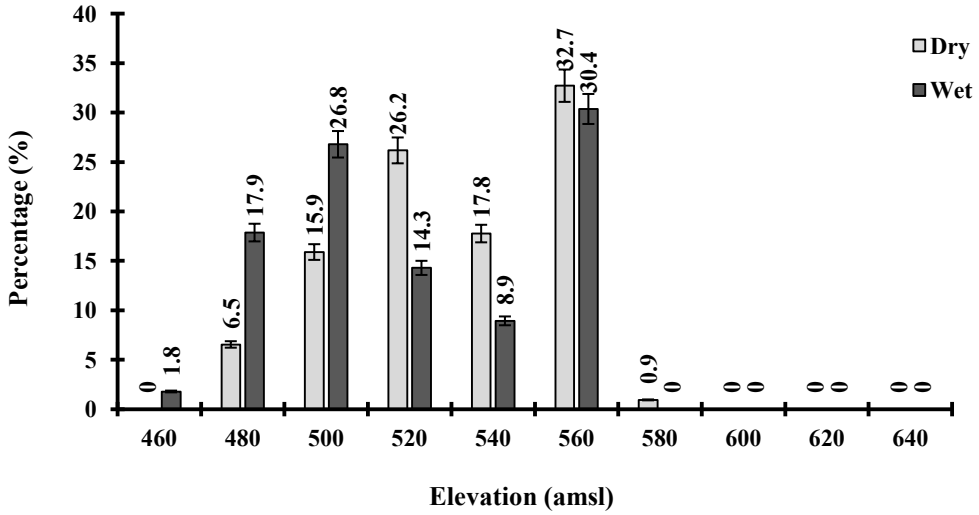

Figure 5 Grid percentages of Green Peafowl *Pavo muticus* distribution in terms of the elevation detected in the dry and wet seasons (the vertical bars represent percentage ± SD).

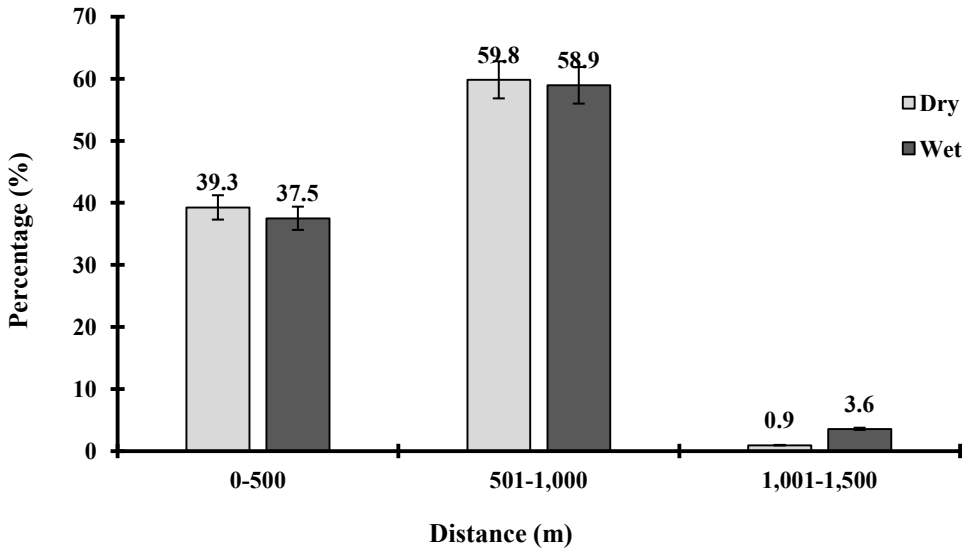

Figure 6 Grid percentages of Green Peafowl *Pavo muticus* distribution in terms of the distance detected from the reservoir edge in the dry and wet seasons (the vertical bars represent percentage ± SD).

In this season, Green Peafowls were distributed across natural forests near reservoirs and streams. This was similar to the previous reports of the northern [14,15] and western [8] populations. The patterns were similar to that found in the Doi Saket population, where the birds were using habitats along water sources (reservoirs and streams) for foraging and brood rearing, due to the availability of food and water for their chicks [14,15]. However, the patterns were slightly different when compared to reports of the western population in the Huai Kha Khaeng Wildlife Sanctuary [8], which reported that the birds used natural forests far from streams and rivers as foraging and brood rearing grounds. This may be because the large stream flow and rapid currents at that site may cause peafowls to avoid rivers at that time of years [8].

Proportionately more bird sightings and traces were recorded in the community forest in the wet season than the dry season. This might be due to the birds searching for more food to feed their chicks. Although human disturbance continued in the wet season, the community forest was located adjacent to a natural forest so the birds were able escape when they detected humans or were disturbed by noise. As in the dry season, no bird sightings or traces were recorded in the agricultural areas. Arable land was even more heavily disturbed in the wet season, due to agricultural activities (planting, herbicide and pesticide spraying, and harvesting at the end of the season).

Distance to key features

Distance to the reservoir edge (main water source): Our results showed that Green Peafowls stayed relatively close to the reservoir (average 552 ± 283 m in the dry season and 551 ± 298 in the wet season) (**Table 3**, **Figure 6**), Fully 97.9 % of detections and 90 % of detections were within 1 km for dry and wet seasons, respectively. They were rarely found more than 1 km from the reservoir's edge. In the dry season, most birds were observed within 501 - 1,000 m (59.8 %), followed by a lesser amount at a distance of 0 - 500 m (39.3 %). This was similar to the wet season, where most of the birds were found within a distance of 501 - 1,000 m (58.9 %), rather than 0 - 500 m (37.5 %). Occurrences of birds and traces were significantly different among different ranges of distance to the reservoir in both seasons (**Table 3**).

Table 3 Numbers and percentages of grids in which Green Peafowl *Pavo muticus* or their traces were detected at different distances to the reservoir.

Season	Month	Number of grid-squares in the different distance to the reservoir in which Green Peafowl or traces were detected			Total
		0-500 m	501-1,000 m	1,001-1,500 m	
Dry*	March	16	27	0	43
	April	19	28	1	48
	May	7	9	0	16
	Total	23 (47.9%)	24 (50%)	1 (2.1%)	48 (100%)
Wet*	June	1	0	0	1
	July	5	4	0	9
	September	8	11	0	19
	October	4	5	2	11
	November	3	13	0	16
	Total	19 (47.5%)	17 (42.5%)	4 (10%)	40 (100%)
Overall		42 (47.7%)	41 (46.6%)	5 (5.7%)	88 (100%)

Note: * = Proportion between total detected grid-square of each distance to the reservoir and total available grid-square of each distance to the reservoir is significantly different across distances in particular seasons (Chi-square test, $P<0.05$)

Distance to the nearest stream: Green Peafowls tended to stay close to the streams as well as the reservoir (198 ± 67 m in the dry season and 187 ± 75 m in the wet season) (**Table 4**, **Figure 7**). In the dry season, most birds were observed within a distance of 201 - 300 m (45.8 %), followed by slightly fewer at 101 - 200 m (44.9 %), and the least at 301 - 400 m (1.9 %). In the wet season, most of the bird sightings and traces were found slightly closer to the nearest stream. Most of the birds stayed within 101 - 200 m (44.6 %), followed by 201 - 300 m (41.1 %) and the least amount at a distance of 301 - 400 m (1.8 %). Occurrences of birds and traces were significantly different among different ranges of distance to the nearest stream in both seasons (**Table 4**).

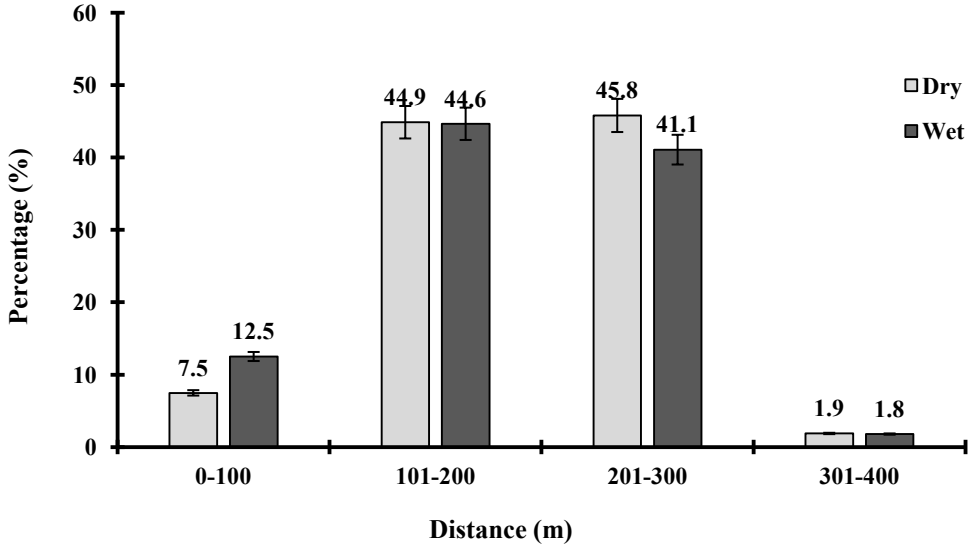

Figure 7 Grid percentages of Green Peafowl *Pavo muticus* distribution in terms of the distance detected from the nearest stream in the dry and wet seasons (the vertical bars represent percentage ± SD).

Table 4 Numbers and percentages of grids in which Green Peafowl *Pavo muticus* or their traces were detected at different distances to the nearest stream.

Season	Month	Number of grid-squares in the different distance to the nearest stream in which Green Peafowl or traces were detected				Total
		0-100 m	101-200 m	201-300 m	301-400 m	
Dry*	March	4	22	15	2	43
	April	4	18	26	0	48
	May	0	7	9	0	16
	Total	12 (25%)	30 (62.5%)	5 (10.4%)	1 (2.1%)	48 (100%)
Wet	June	0	1	0	0	1
	July	1	6	2	0	9
	September	4	8	6	1	19
	October	1	3	7	0	11
	November	1	7	8	0	16
	Total	14 (35%)	14 (35%)	12 (30%)	0	40 (100%)
Overall		26 (29.5%)	44[a] (50%)	17 (19.3%)	1 (1.1%)	88 (100%)

Note: * = Proportion between total detected grid-square of each distance to the nearest stream and total available grid-square of each distance to the nearest stream is significantly different across distances in particular seasons (Chi-square test, $P<0.05$)

Note: a = Proportion between total detected grid-square of each distance to the nearest stream and total available grid-square of each distance to the nearest stream is significantly different across dry and wet seasons (Chi-square test, $P<0.05$)

Distance to water sources (reservoir and stream) was similar to the reports in the Huai Kha Khaeng Wildlife Sanctuary [6,8,9,11], Doi Phu Nang National Park [13], Vietnam [5] Java [27-29], and China [30]. In the dry season, which is the breeding season, the birds spent more time in the hill ridges. The male birds needed to defend their display sites and territories on the mountain ridge, whilst female birds chose dense shrub areas on the hills as nesting sites. After mating, Green Peafowls will search for a suitable place to lay and incubate their eggs [5,12]. Therefore, the birds usually move to lowland forests, where reservoirs are located, for drinking [28,29]. After that, they will return to their breeding grounds. Regarding these reasons, sightings and traces were less frequently observed near streams in the dry season. In the wet season, the bird distribution was closer to the water sources. This may relate to the brood rearing activities and food availability along water resources. Some birds were observed along the river bank, where the rapidly growing seedling plants and grasses provided a suitable habitat for small invertebrates and vertebrates, which are important foods necessary for the birds and their chicks [5,7,14,27].

Distance from human settlements: The closest distance of human settlement to forest edge was 700 m. The Green Peafowls in the study areas tended to remain at a distance from human settlements (1,814 ± 429 m in the dry season and 1,741 ± 421 m in the wet season) (**Table 5**, **Figure 8**). In the dry season, a majority of the birds kept at distances of 1,501 - 2,000 m (43.9 %) from human settlements, followed by a lesser amount at 1,001 - 1,500 m (32.7 %). These findings were slightly similar to the wet season, where many Green Peafowls stayed far away from the settlement areas at distances of 1,501 - 2,000 m (42.9 %), and lesser numbers at 1,001 - 1,500 m (39.3 %). No birds or traces were detected within 1 km of the human settlements. Occurrences of birds and traces were significantly different among different ranges of distance from human settlement in both seasons (**Table 5**).

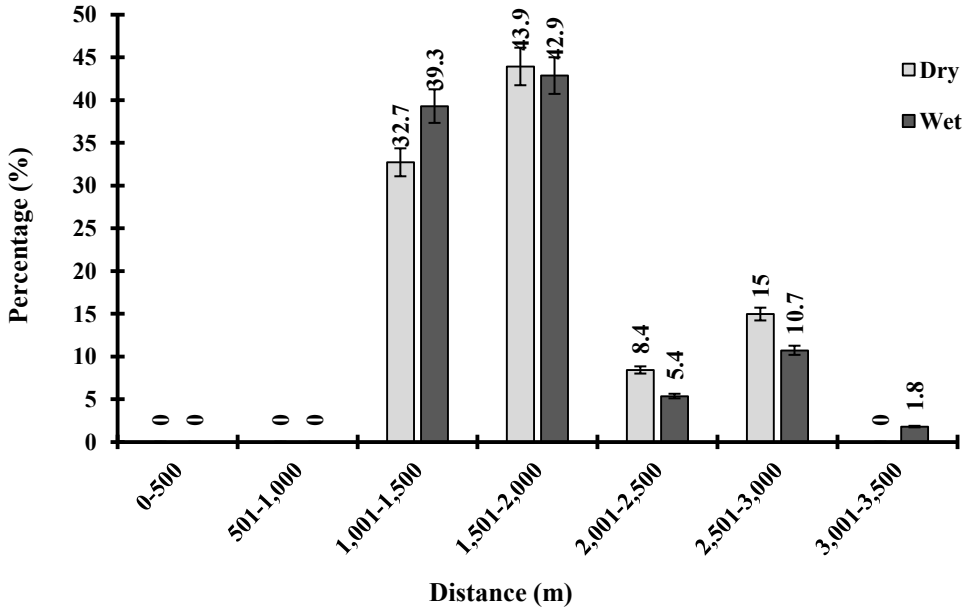

Figure 8 Grid percentages of Green Peafowl *Pavo muticus* distribution in terms of the distance detected from the nearest human settlement in the dry and wet seasons (the vertical bars represent percentage ± SD).

Table 5 Numbers and percentages of grids which Green Peafowl *Pavo muticus* or their traces were detected at different distances to human settlement.

Season	Month	Number of grid-squares in the different distance to human settlement in which Green Peafowl or traces were detected							Total
		0-500 m	501-1,000 m	1,001-1,500 m	1,501-2,000 m	2,001-2,500 m	2,501-3,000 m	3,001-3,500 m	
Dry*	March	0	0	11	18	7	7	0	43
	April	0	0	18	21	1	8	0	48
	May	0	0	6	8	1	1	0	16
	Total	0	0	7 (14.6%)	25 (52.1%)	7 (14.6%)	9 (18.8%)	0	48 (100%)
Wet*	June	0	0	0	1	0	0	0	1
	July	0	0	0	7	1	1	0	9
	September	0	0	8	7	2	1	1	19
	October	0	0	6	5	0	0	0	11
	November	0	0	8	4	0	4	0	16
	Total	0	0	9 (22.5%)	24 (60%)	3 (7.5%)	4 (10%)	0	40 (100%)
Overall		0	0	16 (18.2%)	49 (55.7%)	10 (11.4%)	13 (14.8%)	0	88 (100%)

Note: * = Proportion between total detected grid-squares of each distance to human settlement and total available grid-squares of each distance to human settlement is significantly different across distances in particular seasons (Chi-square test, $P<0.05$)

Elsewhere, it was reported that the Green Peafowls kept at least 2 km away from the nearest human settlements, [5] In this study, most birds were found within 1.5 - 2 km, and occasionally even closer to human settlements, seeking water from the irrigation canals in the agricultural areas during the dry season, or foraging for plant seeds during the cropping period [5,6,13-15,29].

Suggestions for Green Peafowl management

Our findings suggest a new management plan for Green Peafowl conservation in the NWFPU area, as follows. Since the areas around the reservoir and adjacent streams are important for the Green Peafowls year round and serve as important water sources, routine foraging grounds, breeding grounds in the dry season, and brood rearing grounds in the wet season, they should be managed as a restricted area. Because these areas are still accessed by local people, both law enforcement and the participation of the local people in protection activities are important [31]. The NWFPU rangers should patrol the area regularly. In conjunction with this, the forest rangers and officers should communicate with neighboring villagers and community leaders to pass on knowledge of Green Peafowl (e.g. its biology, distribution, and habitat use, etc.) and its importance on the ecosystem and local culture [31]. Conservation measures need to be agreed with villagers so as to avoid unnecessary disturbance. These should include avoiding bringing domestic dogs and vehicles (e.g. motorbikes and cars) into the NWFPU, and reducing loud noises so as to avoid disturbance disturbing the birds, especially during the incubation and brood rearing periods. If possible, these measures should be extended to community forests adjacent to the NWFPU and to restricted areas, with cooperation from the villagers.

Secondly, we suggest the NWFPU create artificial water resources in suitable areas. More water resources would not only have a positive effect on Green Peafowls, but also a positive effect on other birds and wildlife, especially during the dry season [32-34]. Water sources should be built with denser vegetation for shelter, in order to attract a greater number of wild animals [32-35]. In addition, we suggest

building check dams along the stream's gradient. The check dams could decrease the water flow rate, delay evaporation, help the soil to absorb more water from the stream, and most importantly, store water for wildlife [36], especially in the dry season. Check dams could be built up from simple materials, including bamboo, stone, and mud. Check dams need to be repaired and rebuilt over successive years; however, maintenance needs might be reduced through joint cooperation between the NWFPU and local villagers in both the co-design and co-building of the dams.

Conclusions

A study on the seasonal distribution and habitat use of the Green Peafowl was carried out in the NWFPU. The results showed that the main habitat used by the Green Peafowl was the mixed-deciduous forest in both the dry and wet seasons. The distribution of the birds in the wet season was generally broader than in the dry season. In the dry season, (coinciding with the breeding season), the birds used open areas along the mountain ridges in mixed-deciduous forests. The male birds used these sites as display areas, while the female birds used the nearby slopes as nesting and brood rearing sites during the early hatchling period. During the wet season, the birds used mixed-deciduous forest as an important foraging and brood rearing ground, especially in the riparian area. Use of agricultural land was avoided throughout the year. Water scarcity in the dry season and human disturbances are important issues to be mitigated through collaboration between the NWFPU and local villagers, whose lives still depend on the forest's resources. Further studies should concentrate on population dynamics, reproductive biology, and population genetics of Green Peafowls. Moreover, analysis of habitat suitability, using geographic information systems (GIS) and participatory mapping, in order to identify hotspots for Green Peafowl conservation, are other areas necessary of attention for the long-term conservation of the Green Peafowl.

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