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Research Article

Occupancy and activity pattern of Asiatic golden cat and terrestrial pheasants in Bhutan's Phrumsengla National Park

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Abstract

The ecological relationship between the polymorphic Asiatic golden cat (*Catopuma temminckii*) and terrestrial pheasants, apparently threatened due to habitat degradation and hunting in Bhutan's Phrumsengla National Park, has never been studied yet. This research, which assessed the occupancy and activity pattern of 5 polymorphic Asiatic golden cats and 4 terrestrial pheasants such as blood pheasant (Ithaginis cruentus), Himalayan monal (*Lophophorus impejanus*), satyr tragopan (*Tragopan satyra*), and kalij pheasant (*Lophura leucomelanos*) to determine their predator-prey relationship, has the potential to significantly impact conservation strategies. The images of 5 polymorphic Asiatic golden cats (n= 158) and 4 species of terrestrial pheasants (n=242) captured by infrared digital camera traps (n=24) from October 29th, 2015, to March 13th, 2016, were analyzed using the CameraSweet programs. Our study revealed negligible predator-prey correlation in the occupancy of polymorphic felids and pheasants despite co-occurring across broadleaf through subalpine forests. On the contrary, the Chi-square test inferred a significant predator-prey relationship in the paired activity patterns of tightly-rosette (first ever recorded for Bhutan in 2015), golden and gray morphs with blood pheasant, thus suggesting it as a potential prey base. Feral dogs that appeared to form predator guild must be decimated to reduce food competition with Asiatic golden cats and prevent the potential risk of transmitting canine distemper and rabies. We recommend reviewing the protection status of pheasants and Asiatic golden cats and delving into the diet composition of polymorphic cats to gain critical insights into formulating an effective conservation strategy amid growing anthropogenic pressure in Phrumsengla National Park.

Keywords: diseases, feral dog, predator-prey, threats

Introduction

Unlike large felids, the polymorphic Asiatic golden cat (*Catopuma temminckii*) remains poorly studied throughout its range of countries. The International Union for Conservation of Nature (IUCN) listed it as "Near Threatened" in 2014 (McCarthy et al., 2015; IUCN, 2024) and is protected by the Convention on International Trade in Endangered Species of Wild Fauna and Flora under Appendix I (CITES, 2023). The altitudinal range of polymorphic cat varies from sea level to over 4000 m in its range countries, including Sumatra, Cambodia, Myanmar, Thailand, Indonesia, northeast India, Nepal, Bhutan, and China (Vernes et al., 2015; McCarthy et al., 2016; Nijhawan et al., 2019). Bhutan's rugged mountains have a presence of between 80 m in tropical forests (Tempa et al., 2013) and 4248 m in subalpine forests (Dhendup, 2016). A study by Vernes et al. (2015) recorded 4 morphs of the Asiatic golden cats (melanistic, gray, golden, and ocelot) co-occurring in a small locality in the Bumthang district located in the north-central part of Bhutan. Other morphs, such as the cinnamon and tightly-rosetted morphs, were not reported from Bhutan, although they co-occur in the adjoining state of Arunachal Pradesh in India (Nijhawan et al., 2019). The Asiatic golden cats are threatened by illegal poaching for their pelts and habitat loss across various countries (McCarthy et al., 2015; Nijhawan et al., 2019).

These polymorphic cats are known to prey on a wide range of species, varying from small rodents, reptiles, amphibians, and avifauna to small ungulates like muntjak (*Muntiacus muntjak*) (Shrestha, 1997; McCarthy et al., 2015; Kamler et al., 2020), and even calf of a cattle as referenced in the study of (Nijhawan et al., 2019). Appropriate body-sized prey species like muntjak, goral (*Naemorhedus goral*), musk deer (*Moschus chrysogaster*) and porcupine (*Hystrix sp*.) share habitats with 4 terrestrial pheasants such as blood pheasant (*Ithaginis cruentus*), Himalayan monal (*Lophophorus impejanus*), satyr tragopan (*Tragopan satyra*) and Kalij pheasant (*Lophura leucomelanos*), which are perceived potential prey of the Asiatic golden cat in PNP. These habitats are also intensively used by people dwelling in the park's precinct as their primary source of timber, non-wood forest products, and free-range grazing lands for migratory cattle herds. The park is bisected by a stretch of 91 km of east-west national highway in addition to several secondary and tertiary roads that appeared to inflict adverse impacts on the habitats of the Asiatic golden cat and their prey.

The co-occurrence of terrestrial pheasants with the Asiatic golden cats in PNP enticed us to pitch an overarching hypothetical question: Does the assemblage of 4 species of terrestrial pheasant form a potential prey base for the Asiatic golden cats? Do spatial and temporal habitat sharing (Brown et al., 1994; Franchini et al., 2023) by pheasants and Asiatic golden cats signify

predator-prey relationship? In order for us to address these two hypothetical questions, we intend to examine occupancy (Gaston et al., 2000; Mackenzie et al., 2002) and the activity patterns of the Asiatic golden cats and terrestrial pheasants. According to Roy et al. (2023), the activity patterns are crucial aspects of the predator-prey relationship of a species of conservation concern. Based on the findings of our study, we consider suggesting policy transformation and conservation strategy for the welfare of the polymorphic cats and terrestrial pheasants amid growing anthropogenic challenges in PNP.

Study area

We investigated the occupancy and activity pattern of the Asiatic golden cats and terrestrial pheasants in Phrumsengla National Park (PNP), which encompasses a geographical area of 905 km^2 (TNP 2013) in central Bhutan (Fig. 1). The park is predominated by fir forests (267.16 km^2) followed by mixed temperate conifers (256.47 km^2) and broadleaf forests (238.25 km^2), while alpine meadows and scrub cover about 27.43 km^2 and 48.33 km^2 respectively. Heterogeneous geomorphology and a wide elevation that ranges from 900 to 4530 m are attributes to the formation of special habitats for wildlife in the park (TNP, 2013). The conservation landscape hosts at least 71 species of mammals, 362 species of avifauna, 3 species of amphibians, 4 species of lizards, and eight species of reptiles (TNP, 2013). The large co-predators such as Bengal tiger (*Panthera tigris*), leopard (*Panthera pardus*), clouded leopard (*Neofelis nebulosa*), wild dog (*Cuon alpinus*), marbled cat (*Pardofelis marmorata*), red fox (*Vulpes vulpes*), leopard cat (*Prionailurus* bengalensis) and Himalayan yellow throated marten (*Martes flavigula*) share a wide range of habitats with potential avian prey species like satyr tragopan, blood pheasant, Himalayan monal and kalij pheasant in the study area (Drakpa & Namgyel, 2013; Wangchuk & Namgyel, 2016). Over 75% of the park area is under the registered grazing grounds of the people, with over 7,500 cattle and feral dogs in the area (TNP, 2013). Migratory cattle herds use the park as grazing lands throughout the year varying to the change in the seasons.

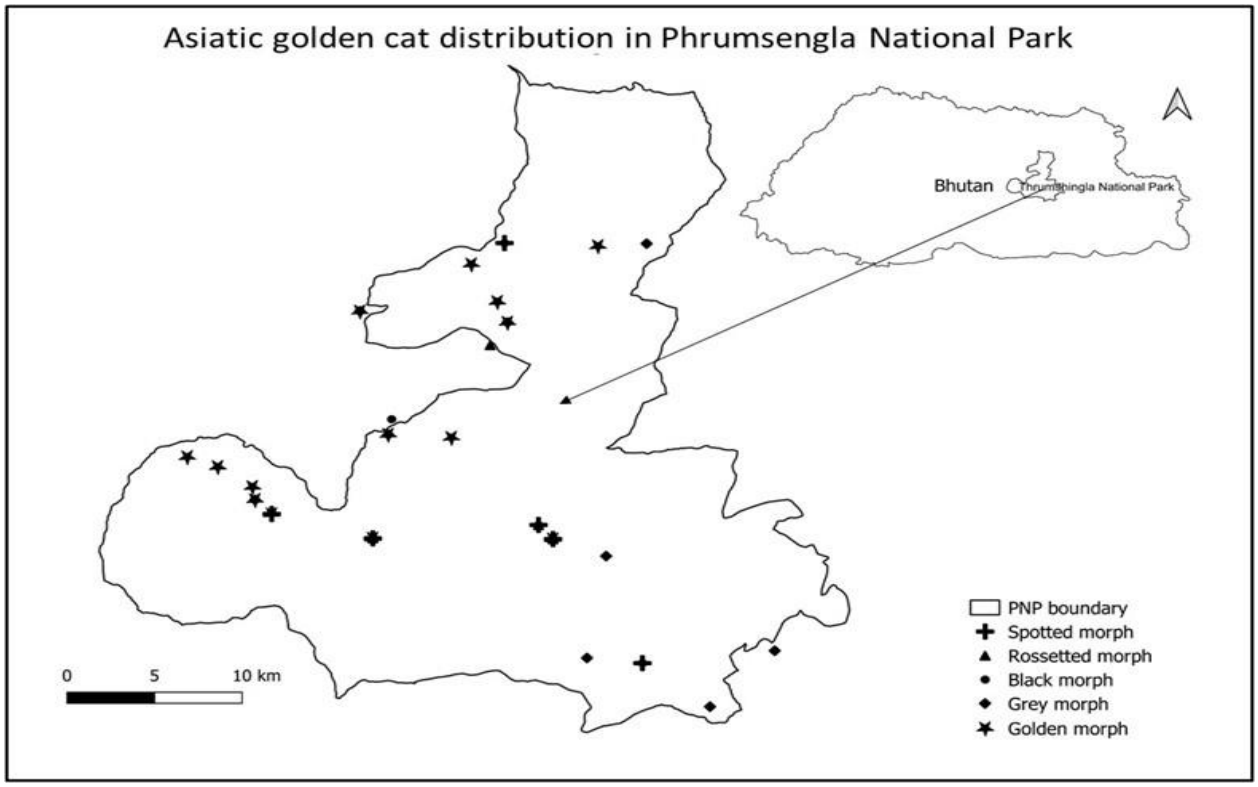

Figure 1. Study area with a distribution of 5 different morphs of Asiatic golden cats

Material and methods

We used camera traps (Lynam et al., 2013; Vernes et al., 2015; Nijhawan et al., 2019; Adewale et al., 2022; Bhardwaj et al., 2022) to capture images of intended species as a source of primary data for our study. The camera stations of 5 km x 5 km were adopted from Bhutan's national tiger survey (DoFPS, 2015). Thus, 905 km^2 of our study area required us to install at least 36 camera traps at various strategic locations. However, due to limited funding, we could only afford 24 infrared digital cameras (Cuddeback 5-megapixel attack trail camera) to be deployed in data collection. In view of the shortfall in 12 camera traps we foresighted underrepresentation in the images of the Asiatic golden cats and pheasants. Therefore, in order for us to increase image capture opportunity of target species, we prioritized optimal camera stations based on a suite of criteria, including trail crossings, waterholes, valleys, and ridge tops, from October 29th, 2015 until March 13th, 2016 across all types of forest ecosystem. We set the camera sensitivity to 'high' to capture 3 photos per trigger with no quiet time between the triggers (Vernes et al., 2015). We ensured that the battery life of each camera lasted for at least 3 months and replace thereafter. To determine the occupancy of the Asiatic golden cats and terrestrial pheasants, the study adopted the ecosystem classification used by Sherub et al. (2007), which included: warm broadleaf forest (900–2150 m), cool broadleaf forest (2150–2900 m), temperate dry conifer forest (2100–3100 m), temperate moist conifer forest (3100–3800 m), and sub-alpine temperate

conifer forest (3800–4200 m) and placed the camera traps across these ecosystem classes. Two groups installed camera traps in 9 days, while camera collection took us a week.

Despite the shortfall in 12 camera traps, many images of the Asiatic golden cats and pheasants were captured in more than 4 active months. We processed a total of 400 images of 5 polymorphic Asiatic golden cats: black morph (n=5), golden morph (n=33), gray morph (n=43), ocelot morph (n=19), tightly-rosette morph (n=58), recorded for the first time in Bhutan, and 4 species of terrestrial pheasants: blood pheasant (n=189), Himalayan monal (11), kalij pheasant (n=35), and tragopan (n=7). We used CameraSweet programs developed by Sanderson and Harris (2013) to classify, organize, and analyze camera trap data (https://smallcats.org/resources/#camerasweet). We ran the SpecialReNamer (version 1.1) to re-label the wrong date and time, DataOrganize (version 4.5) to validate the data, and DataAnalyze programs (version 6.1) to produce naïve occupancy of all sites (Haris et al., 2010; Jenks et al., 2010; Sanderson & Harris, 2013). We also performed a Chi-Square test for paired activity patterns of the Asiatic golden cats and pheasants whereby the number of independent photos captured in a segment of 1 hour was divided by the total number of photos for all individual species (Sanderson & Harris, 2013). Taking into account the minimum of 5 images of all species in 4 months period of active camera traps, we also deployed the OccupancyMatrix program (Harris et al., 2010; Sanderson & Harris, 2013) to assess the habitat overlap between different morphs and pheasants by the percentage of locations where both species were photographed. The correlation between the Asiatic golden cat and terrestrial pheasants was determined by their coinciding activity patterns in a specific time frame and place by computing in MS Excel. We used QGIS (3.0) to produce the study map and occurrence of different morphs of the Asiatic golden cats.

Results

Naïve occupancy (proportion of camera traps to detect species, *n=24*) and habitat overlap of the Asiatic golden cat and terrestrial pheasants

Out of 24 camera stations, golden morph was captured at least 13 stations, thus indicating the highest naïve occupancy (Mackenzie et al., 2002) rate of 54.2%, followed by gray (45.8%), ocelot (25%), melanistic (20.8%), and tightly-rosetted morphs (16.7%) in PNP (Fig. 2). Golden and ocelot morphs occupy temperate dry conifer (2100–3100 m), temperate moist conifer (3100–3800 m), and sub-alpine temperate conifer forests (3800–4200 m). Melanistic and gray morphs inhabit warm broadleaf (900–2150 m), cool broadleaf (2150–2900 m), temperate dry conifer (2100–3100 m), and temperate moist conifer forests (3100–3800 m) while tightly-rosetted morph is confined to temperate moist conifer forest (3100–3800 m) only.

In the case of our focused prey species, blood pheasant indicated a naïve occupancy rate of 45.8% in temperate moist conifer (3100–3800 m) and sub-alpine temperate conifer forests (3800–4200 m). In comparison, Himalayan monal is 20.8% across temperate moist conifer and subalpine temperate forests too. The naive occupancy rate of satyr tragopan is 8.3%, thus confining it to temperate moist conifer forests (3100–3800 m), unlike kalij pheasant that occupies warm broadleaf and cool broadleaf forests (Fig. 2).

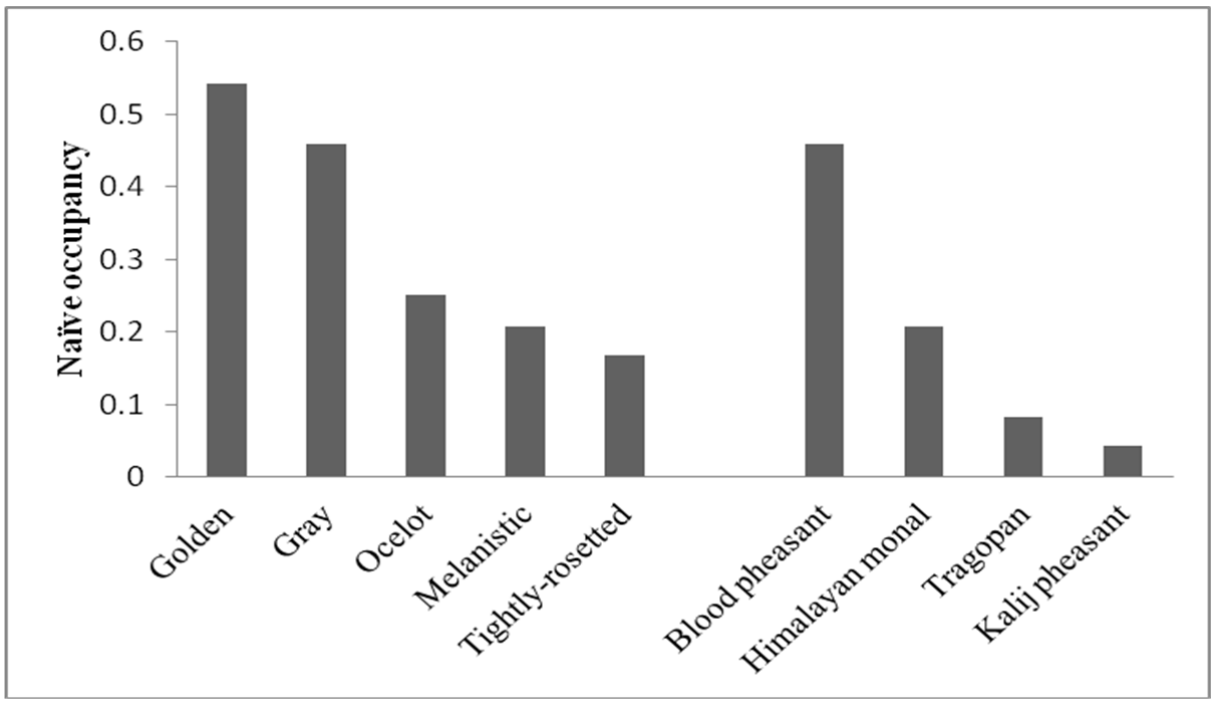

Figure 2: Naive occupancy of 5 morphs of the Asiatic golden cats and 4 pheasant species

The co-occurrence of 4 species of terrestrial pheasants and 5 polymorphic cats varied from warm broadleaf through subalpine forests in the park. Blood pheasant detection in 11 out of 24 locations indicated significant co-occurrence, thus overlapping the habitat with all 5 morphs (Table 1) compared with 3 other pheasant species. In the case of polymorphic cats, the golden morph's occurrence in 13 camera stations indicated a wide range of habitat overlap with all other morphs. The gray morph, despite its occurrence across the widest altitudinal range, appeared to avoid habitat use with tightly-rosetted morph, which tends to overlap the habitat use with all other morphs. The ocelot morph overlaps its habitat vastly with the golden morph. Kalij pheasant barely overlaps habitat except with gray morph, while Himalayan monal appeared to avoid habitat overlap with melanistic morph. Satyr tragopan appeared to avoid the habitat use with gray and melanistic morphs distinctly.

Table 1. Co-occurrence matrix of Asiatic golden cat and terrestrial pheasants

	Golden	Gray	Melanistic	Ocelot	Tightly-rosetted	Blood pheasant	H. Monal	Kalij pheasant	Satyr tragopan
Golden	13	4	2	3	2	8	5	0	2
Gray	4	11	1	2	0	3	2	1	0
Melanistic	2	1	5	2	2	3	0	0	0
Ocelot	3	2	2	6	3	4	1	0	1
Tightly-rosetted	2	0	2	3	4	4	1	0	1
Blood pheasant	8	3	3	4	4	11	4	0	1
Himalayan monal	5	2	0	1	1	4	5	0	1
Kalij pheasant	0	1	0	0	0	0	0	1	0
Satyr tragopan	2	0	0	1	1	1	1	0	2

Activity patterns of Asiatic golden cats and pheasants

The timed photographic evidence revealed that pheasants were active from dawn through dusk. The blood pheasants' photographic detection rate was highest (44.26%) which coincided with the gray and golden morphs. About 64% of images captured during daylight (0600–1700 hours) indicated diurnal behavior in the case of the gray morph, while the golden morph, as revealed by Lynam et al. (2013), exhibited cathemeral behavior in PNP. The melanistic morph exhibited crepuscular behavior (photographed chiefly at dusk and dawn), coinciding with its activity pattern largely of tragopan, kalij pheasant, and Himalayan monal. At least 64% of ocelots and 73% of the images were captured mainly during the night (1800–0500 hours), indicating nocturnal behavior, thus avoiding the pheasants vastly. However, the day activity pattern of the ocelot morph coincided with the Himalayan monal and blood pheasant. In contrast, the tightly-rosette morph's activity pattern during the day matched that of the blood pheasant (Fig. 3).

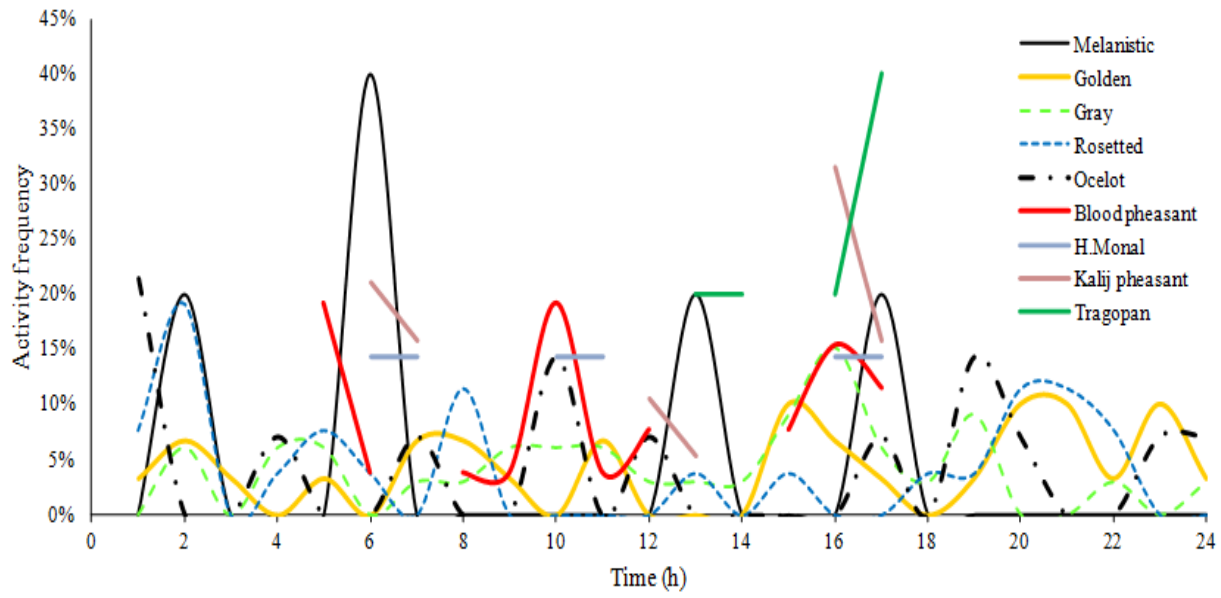

Figure 3. Activity pattern of 5 polymorphic Asiatic golden cats and 4 pheasant species

Correlation between the Asiatic golden cat and terrestrial pheasants

Our study revealed a negligible predator-prey relation (r = 0.06) in the occupancy of the Asiatic golden cats and terrestrial pheasants. On the contrary, a Chi-square test for the paired activity patterns revealed that golden, gray, and tightly-rosetted morphs have a significant predator-prey relationship with the activity patterns of blood pheasants (Table 2).

Table 2. Chi-square test of paired activity patterns (significant: 1; not significant: 0)

Pheasant species	Golden	Gray	Melanistic	Ocelot	Tightly-rosette
Blood Pheasant	1	1	0	0	1
Himalayan monal	0	0	0	0	0
Kalij pheasant	0	0	0	0	0
Satyr tragopan	0	0	0	0	0

Discussion

Despite the co-occurrence of 4 species of terrestrial pheasants and 5 polymorphic Asiatic golden cats across warm broadleaf through subalpine forests in PNP, the predator-prey relationship appears to be negligible. On the other hand, the study reveals a significant relationship in the paired activity patterns of blood pheasants with golden, gray, and tightly-rosetted morphs. We could not substantiate this finding due to limited resources in carrying out scat collection and DNA analysis of the diet composition of the Asiatic golden cats within our study period. Regarding the habitat use amongst 5 polymorphic cats, the gray and tightly-rosetted morphs,

although both of them overlap their habitat with three other morphs, barely share the habitat between them. In the case of focused prey species, blood pheasants largely overlap the habitats with all 5 morphs followed by Himalayan monal and kalij pheasants.

Earlier studies (Jigme, 2011; Vernes et al., 2015; Nijhawan et al., 2019; Wangyel et al., 2020) reveal mixed findings about the occupancy of the Asiatic golden cats. Studies from Bhutan reported that melanistic and gray morphs occur above 2500 m (Jigme, 2011; Vernes et al., 2015; Wangyel et al., 2020). In contrast, our findings reveal that melanistic and gray morphs occur from 1886 m through 3948 m, as Nijhawan et al. (2019) reported in the Indian state of Arunachal Pradesh. A wide altitude range of the melanistic Asiatic golden cat suggests its ability to adapt and occupy an alternative ecological niche, similar to the behavior of melanistic oncillas compared to spotted oncillas (Graipel et al., 2014). Our findings also corroborate the earlier studies that ocelot and golden morphs occupy a narrower range (Vernes et al., 2015). A broad distribution of golden morph in temperate and sub-alpine ecosystems corroborates with studies from India (Nijhawan et al., 2019). The occupancy of tightly-rosetted morph in the temperate forest of PNP indicates the narrowest distribution and begs the question: Why do different morphs of the Asiatic golden cats vary in altitudinal range and distribution patterns in PNP? On the other hand, Nijhawan et al. (2019) reported that polymorphism in the Asiatic golden cat helps in concealment from larger sympatric predators and ecological niche selection. The co-existence of 5 different morphs with large co-predators like tigers, leopards, clouded leopards, and wild dogs in PNP indicates that polymorphism in Asiatic golden cats maximizes their concealment ability from detection. This is substantiated by the study by Kawanishi et al. (2010) that melanistic leopards better conceal and evade encounters with the tiger. Therefore, the brightest color in golden morph might be a limiting factor that results in occupying a narrower altitudinal range, thus confining only to the sub-alpine temperate conifer ecosystem as indicated by our study. A study in Arunachal Pradesh revealed rare habitat overlap between tightly-rosetted and melanistic morphs (Nijhawan et al., 2019). In contrast, the habitat overlap between tightly-rosetted (43.75%) and the melanistic morphs in PNP is evident, while a lack of habitat overlap between gray and tightly-rosetted indicates distinct habitat partitioning. Thus, our study infers that polymorphism in Asiatic golden cats facilitates their inhabitation across a wide altitudinal range in exploiting alternative ecological niches.

Several studies revealed mixed findings on the activity patterns of the Asiatic golden cats (Vernes et al., 2015; Nijhawan et al., 2019; Yongdrup et al., 2019; Wangyel et al., 2020). The Asiatic golden cats are generalist and opportunistic predators (Kamler et al., 2020). Their prey varies from mice to birds (Kawanishi & Sunquist, 2008). Therefore, the occurrence of 4 species of terrestrial pheasants, which likely are potential prey, indicates an influence of the activity

pattern of 5 polymorphic cats in PNP. The cathemeral behavior of gray and golden morphs coincides with the activity patterns of blood pheasants, while the activity patterns of Himalayan monal, kalij, and tragopan match the melanistic morph. A variation in the activity patterns of 5 morphs indicates avoidance of food competition in the overlapping habitats with other co-predators. To put this into perspective, a significant matching in the paired activity pattern (timing) and the occupancy with terrestrial pheasants, especially blood pheasants, with almost all morphs in PNP, indicates a positive predator-prey relationship.

Perception of threats posed on the Asiatic golden cats by feral dogs was evident from a significant number of images captured during our study's almost 5-month period of active camera traps. The various studies revealed a potential risk in carrying and spreading zoonotic diseases like canine distemper and rabies (Cleaveland et al., 2000; Haydon et al., 2002; Vial et al., 2006; Carella et al., 2022), which are not very uncommon in Bhutan (Rinchen et al., 2020), to the Asiatic golden cats and other wild animals in PNP. A study by Haydon et al. (2002) found that rabies spread by domestic dogs threatened Ethiopian wolves (*Canis simensis*) and African wild dogs (*Lycaon pictus*). A growing population of feral dogs may also exacerbate food competition with the Asiatic golden cats and other wild predators (Vanak et al., 2013). In one incidence, two feral dogs were sighted feeding on a male Himalayan monal (personal observation in PNP by authors) in the open meadows. However, this evidence was unverified if the pheasant's carcass was snatched from other predators or preyed on directly. Apart from this, feral dogs' incidences of preying on wild pigs, sambar deer, and muntjak are reportedly common in PNP and other parts of Bhutan.

Conclusion

According to our study, the golden morph indicated the highest naïve occupancy rate of 54.2%, followed by gray, ocelot, melanistic, and tightly-rosetted morphs. In the case of prey species, blood pheasant indicated a naïve occupancy rate of 45.8%, followed by Himalayan monal and tragopan. While our study revealed negligible correlation in the occupancy of polymorphic Asiatic golden cats and pheasants despite co-occurring across broadleaf through subalpine forests, we observed significant predator-prey relationship in the paired activity patterns of tightly-rosetted, golden, and gray morphs with blood pheasant thus suggesting it as a potential prey-base. We could not substantiate this finding because our study was beyond the scope owing to limited resources and time. Therefore, we recommend an in-depth study by performing a scat analysis of Asiatic golden cats to examine their diet formation by terrestrial pheasants and other prey species in the future. Further study on the ecological behavior of all morphs of the Asiatic golden cats could gain critical insights for developing a better conservation management strategy. We also found that unaccountable human-associated activities induce challenges

against the welfare of the Asiatic golden cat and terrestrial pheasants in PNP. Besides hunting and killing by people, the guarding dogs owned by herdsmen pose direct threats to both Asiatic golden cats and pheasants. People purportedly hunt pheasants for dual purposes: meat for consumption and feathers to use on arrows for national sport (archery). Therefore, the Department of Forests and Park Services critically needs to review and elevate the protection status of three other pheasants on par with the Himalayan Monal under Schedule I (DoFS, 1995), which prohibits hunting and killing by people. The PNP should emphasize conservation and awareness education programs with necessary follow-up actions by conducting monitoring patrols to transform people's negative attitudes and behavior concerning pheasants and polymorphic cat conservation. We recommend that dog owners be strictly obliged by the existing pet norms of Bhutan to control the domestic dog population and prevent it from overflowing into the forests and taking refuge to form a predatory guild. The PNP should collaborate with the Department of Livestock in applying a suitable strategy to control the existing feral dog population, thus reducing the potential risk of inducing or transmitting zoonotic diseases and interrupting the wild predator-prey relationship, especially between the Asiatic golden cats and pheasants. Not least, the PNP must strengthen local people's participation for a long-term conservation benefit by engaging and empowering them in sustainable forest resource management, thus protecting the habitats of the Asiatic golden cats and pheasants in the face of inescapable climate change despite Bhutan's carbon-negative status.

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