Large carnivores as potential predators of sun bears

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Abstract: Sun bears (*Helarctos malayanus*) have a wide distribution in Southeast Asia, but little is known about their natural predators. During a camera-trap survey in 2018 in Htamanthi Wildlife Sanctuary, Myanmar, we photographed a male leopard (*Panthera pardus*) carrying a sun bear cub by the throat. This is the first reported case of probable predation on sun bears by leopards, and only their second confirmed predator. A literature review showed that consumption of sun bears and Asiatic black bears (*Ursus thibetanus*) by tigers (*P. tigris*) was widespread in Southeast Asia, whereas consumption of both bear species by leopards and dholes (*Cuon alpinus*) was less common. Outside of Southeast Asia, tigers and leopards, but not dholes, were shown to kill or consume other bear species. Future research should examine interspecific relationships between sun bears and large felids to better understand what, if any, impacts large felids have on sun bear ecology.

Key words: *Helarctos malayanus*, leopard, Myanmar, *Panthera pardus*, *Panthera tigris*, predation, Southeast Asia, sun bear, tiger

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The sun bear (*Helarctos malayanus*) historically occurred throughout mainland Southeast Asia, Sumatra, and Borneo. However, distributions have contracted considerably during the past 30 years, especially on mainland Southeast Asia, and consequently the species is classified as Vulnerable by the International Union for Conservation of Nature (Scotson et al. 2017). Despite their threatened status and widespread distribution, there is still relatively little known about the ecology of sun bears. For example, there have been only 3 studies that determined their movements and home ranges (Wong et al. 2004, Fredriksson 2012, Cheah 2013). Even less is known about their natural predators. The only confirmed natural predator is the reticulated python (*Python reticulatus*), which swallowed an adult female sun bear on Borneo (Fredriksson 2005). Tigers (*Panthera tigris*) are assumed to be predators of sun bears because of the presence of sun bear hairs in 3 tiger scats in Malaysia (Kawanishi and Sunquist 2004).

We describe here the probable predation on a sun bear cub by a leopard (*Panthera pardus*) in Myanmar. To better elucidate probable predation on sun bears by large carnivores, we conducted a literature review of dietary studies in Southeast Asia of the 3 apex large carnivores occurring in the region: tigers, leopards, and dholes (*Cuon alpinus*). We also reviewed other dietary studies outside of Southeast Asia to determine if these large carnivores killed or consumed other bear species in Asia. Our results increase the knowledge about potential predators of sun bears in Southeast Asia, and help determine if predation by large carnivores could affect their ecology.

Methods

We conducted long-term camera-trap surveys (Dec 2014 to Mar 2018) focusing on the felid community in Htamanthi Wildlife Sanctuary (2,151 km^2), northwestern Myanmar (Naing et al. 2018). The habitat of the sanctuary is dominated by tropical evergreen forests, with some mixed deciduous forests in the western part and some dry mixed deciduous forests in the eastern part. Seven streams flow in parallel from the eastern and northeastern hills to the western and southwestern part of the sanctuary (Naing et al. 2018). The sanctuary contains Asian elephant (*Elephas maximus*), gaur (*Bos frontalis gaurus*), wild boar (*Sus scrofa*), northern red muntjac (*Muntiacus vaginalis*), sambar (*Rusa unicolor*), and Chinese serow (*Capricornis milneedwardsii*). Felids and other large carnivores include Asiatic black bear (*Ursus thibetanus*), sun bear, tiger, leopard, dhole, clouded leopard (*Neofelis nebulosa*), golden cat (*Catopuma temminckii*), marbled cat (*Pardofelis marmorata*), and leopard cat (*Prionailurus bengalensis*).

Each year during the study, we placed 80 camera stations in a grid, with 1.0–1.5 km between stations, and ran them from December to March, which corresponds to the dry season. At each station, we placed cameras in

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pairs approximately 3.5 m from each side of the trail, and at approximately 45 cm height from ground level. We used 2 models of camera traps—Cuddeback (Non Typical, Inc., De Pere, Wisconsin, USA) and ScoutGuard (HCO Outdoor Products, Norcross, Georgia, USA).

We conducted a literature review of dietary studies in Southeast Asia of the 3 apex large carnivores occurring in the region: tigers, leopards, and dholes. We searched Google Scholar (Google LLC, Mountain View, California, USA) for publications from 1980 to 2018 for dietary studies of tigers, leopards, and dholes, using the search terms "*Panthera tigris,*" "*Panthera pardus,*" and "*Cuon alpinus,*" in combination with "diet," "food habits," "predation," "*Helarctos malayanus,*" and "*Ursus thibetanus.*" We limited the dietary studies to those that occurred within the current distribution of sun bears in Southeast Asia as shown by Scotson et al. (2017; Fig. 1). We also included the Asiatic black bear in our search because if the 3 apex carnivores were found to consume this bear species in Southeast Asia, then they would likely consume the sympatric sun bear as well. We then searched the Literature Cited of the papers we collected to find additional dietary studies on these species in the region. Additionally, we included unpublished data from one of our authors (JFK) about a recent study of the dhole diet in Cambodia. Finally, we also reviewed >100 additional dietary studies of tigers, leopards, and dholes outside of Southeast Asia to determine whether they killed or consumed other bear species in Asia.

Results

During the camera-trap survey in Htamanthi Wildlife Sanctuary from December 2017 to March 2018, we obtained a photograph (24 Feb 2018; 1138 hr; ScoutGuard camera) of an adult male leopard carrying a sun bear cub by the throat (Fig. 2). It is not clear whether the cub was dead or alive. A pair of canine puncture holes is visible on the cub's throat (Fig. 2), which likely represents the kill bite. Such deep canine puncture holes on a vital area of the cub's body would not have been necessary if the leopard had found the cub already dead. This male leopard was photographed on 22 different occasions during the survey.

We reviewed 17 dietary studies of large apex carnivores in Southeast Asia, including 6 studies on tiger diets from 4 different sites, 5 studies on leopard diets from 4 sites, and 6 studies on dhole diets from 5 sites (Fig. 1; Table 1). Tigers consumed sun bears and/or Asiatic black bears in all 4 sites where their diet was studied, and bears comprised 3–60% of tiger diets when consumption occurred (Table 1). Leopards consumed Asiatic black bears in 1 of 4 sites where their diet was studied, and bears comprised <1% of their diet when consumption occurred (Table 1). Dholes consumed Asiatic black bears in 1 of 5 sites where their diet was studied, and bears comprised <1% of their diet when consumption occurred (Table 1).

In areas outside of Southeast Asia, tigers were shown to consume brown bears (*Ursus arctos*) in Russia (Miquelle et al. 1996, Seryodkin et al. 2018), Asiatic black bears in Russia (Miquelle et al. 1996; Seryodkin et al. 2003, 2018) and northeastern China (Yang et al. 2018), and sloth bears (*Melursus ursinus*) in India (Schaller 1967, Biswas and Sankar 2002, Reddy et al. 2004, Ramesh et al. 2012, Kolipaka et al. 2017) and Nepal (Kapfer et al. 2011). Leopards were shown to kill or consume Asiatic black bears in Russia (Salmanova et al. 2013), giant pandas (*Ailuropoda melanoleuca*) in China (Schaller et al. 1985), and sloth bears in Sri Lanka (Kurt and Jayasuriya 1968). Dholes were not found to consume bears in any studies outside of Southeast Asia.

Discussion

We provided the first record of probable predation on sun bears by leopards, which is only the second confirmed natural predator of sun bears, in addition to reticulated pythons. Leopards are adaptable and opportunistic predators, and prey size ranges from insects to young elephants (*Loxodonta* spp.; Hayward et al. 2006). In Southeast Asia, leopards typically prey on ungulates and primates, although smaller carnivore species are often consumed (Rabinowitz 1989, Grassman 1999, Rostro-García et al. 2018). In fact, smaller carnivores comprised 46% of the leopard diet in western Thailand (Grassman 1999). Thus, it is not surprising that a leopard probably preyed on a sun bear cub in Myanmar, especially given that leopards in other regions were shown to kill or consume larger bear species. Nonetheless, leopards were found to consume bears in only 1 of 4 sites in Southeast Asia where their diet was studied, and consumption was <1% of their diet when it occurred, suggesting that consumption of bears by leopards is not common or widespread in Southeast Asia. However, further studies of leopard diets are needed in other areas of Southeast Asia, especially Myanmar, to better determine the extent to which leopards consume sun bears. The probable predation event we recorded occurred in the late morning (1138 hr), which is not an unusual time for leopards to be active—previous studies in Southeast Asia showed that leopards had arrhythmic active patterns and often were active during the daytime (Rabinowitz 1989, Grassman 1999, Ngoprasert et al. 2007). We

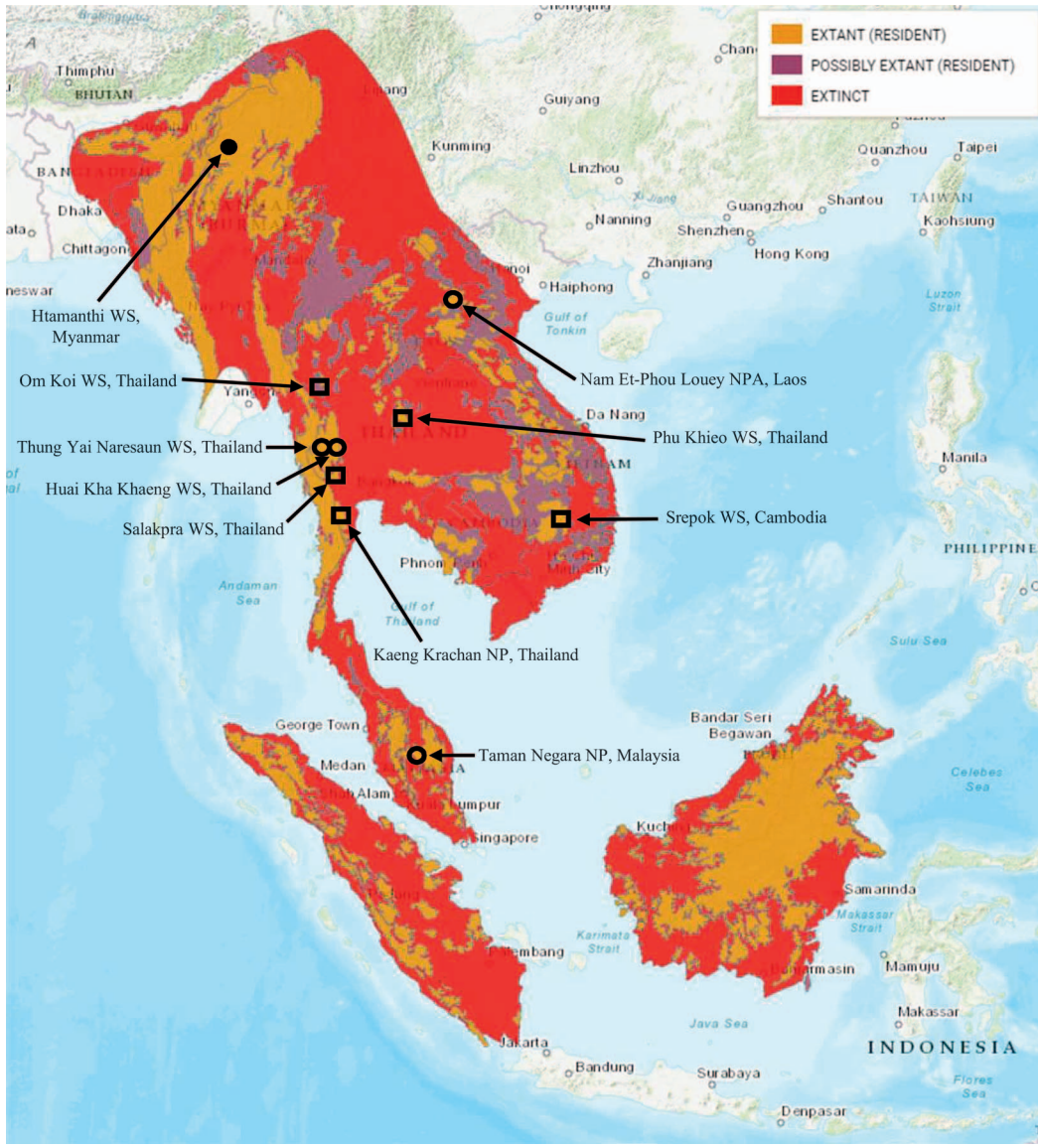

Fig. 1. Distribution map of the sun bear (*Helarctos malayanus*), used with permission from Scotson et al. (2017). Shown on the map are the location of the probable predation on the sun bear cub by the leopard (*Panthera pardus*) in Myanmar (closed circle), along with the locations of the dietary studies of tigers (*P. tigris*), leopards, and dholes (*Cuon alpinus*) in Southeast Asia, including those where bear remains were found (open circles) and where bear remains were not found (open black squares).

suspect that most predation on sun bears by leopards would be of cubs and subadults, given that leopards typically prefer prey weighing 10–40 kg (Hayward et al. 2006). That said, leopards in Southeast Asia can prey regularly on banteng (*Bos javanicus;* 600–800 kg, Rostro-García et al. 2018), so predation on adult sun bears also is possible.

Tigers were found to consume sun bears or Asiatic black bears in all 4 sites where their diet was studied in Southeast Asia, suggesting consumption of bears by tigers might be widespread in Southeast Asia. Additionally, the percent of bears in tiger diets was relatively large at sites in Malaysia (60% of diet) and Laos (19%), although these results might be biased because of

Fig. 2. Adult male leopard (*Panthera pardus*) carrying a sun bear (*Helarctos malayanus*) cub by the throat in Htamanthi Wildlife Sanctuary, northwestern Myanmar, 2018. Note the pair of canine puncture holes on the cub's throat, which likely represents the kill bite.

relatively small sample sizes. Nonetheless, the large amount of bears in tiger diets in Malaysia and Laos indicate tigers can be major predators of bears in some areas. Furthermore, in other regions of Asia, tigers consumed several species of bears that were larger than sun bears, indicating that in general tigers commonly prey on bears throughout their distribution.

Dholes were found to consume bears in only 1 of 5 sites where their diet was studied in Southeast Asia, and consumption was $<1\%$ of their diet when consumption occurred, suggesting that consumption of bears by dholes is not common or widespread in Southeast Asia. Furthermore, dholes were not found to consume any bear species outside of Southeast Asia, indicating that dholes probably rarely prey on any bear species. Interestingly, the utilization of bears by dholes and tigers could be directly compared in Taman Negara National Park, Malaysia, and Nam Et–Phou Louey National Protected Area, Laos, because the dietary studies of tigers and dholes occurred at the same time. In both sites bears were common food of tigers, whereas they were rarely if ever consumed by dholes (Kawanishi and Sunquist 2004, 2008; Vongkhamheng 2011; Kamler et al. 2012). This indicates that, even when exposed to the same availability of bears, tigers consume significantly more bears than do dholes. This also suggests that consumption of bears by tigers was due to predation instead of scavenging, because both tigers and dholes would have been expected to consume bears in similar amounts if bear carcasses had been available on the sites.

We conclude that tigers and leopards, but not dholes, are potentially important predators of sun bears on mainland Southeast Asia and Sumatra. Both large felids exhibit opportunistic diets with a wide range of prey sizes (Hayward et al. 2006, 2012). Additionally, both large felids have been confirmed to kill or consume sun bears, and kill or consume larger bear species in other regions of Asia. Tigers, in particular, might be the most important predator of sun bears on mainland Southeast Asia and Sumatra, given that bear remains were found in all sites within Southeast Asia where their diet was determined, and in 2 of those sites bears were common prey items. We recommend future research that investigates the interspecific relationships of sun bears and

Table 1. Summary of dietary studies of tigers (*Panthera tigris*), leopards (*P. pardus*), and dholes (*Cuon alpinus*) in Southeast Asia with regards to consumption of bears.

Species	Site[a]	Total no. of of scats/kills	Bear species consumed	Percent of diet (%)[b]	Reference
Tiger					
	Laos: Nam Et–Phou Louey NPA	16	Asiatic black bear and/or sun bear[c]	18.8	Vongkhamheng 2011
	Malaysia: Taman Negara NP	5	Sun bear	60.0	Kawanishi and Sunquist 2004
	Thailand: Huai Kha Khaeng WS	246	Asiatic black bear	2.5	Simcharoen et al. 2018
	Thailand: Huai Kha Khaeng WS	150	None	0.0	Pakpien et al. 2017
	Thailand: Huai Kha Khaeng WS	38	None	0.0	Rabinowitz 1989
	Thailand: Thung Yai Naresaun WS	43	Asiatic black bear	NA[d]	Prommakul 2003
Leopard					
	Cambodia: Srepok WS	73	None	0.0	Rostro-García et al. 2018
	Thailand: Huai Kha Khaeng WS	356	Asiatic black bear	0.4	Simcharoen et al. 2018
	Thailand: Huai Kha Khaeng WS	237	None	0.0	Rabinowitz 1989
	Thailand: Kaeng Krachan NP	42	None	0.0	Grassman 1999
	Thailand: Om Koi WS	33	None	0.0	Lovari and Mori 2017
Dhole					
	Cambodia: Srepok WS	164	None	0.0	J.F. Kamler, unpublished data
	Laos: Nam Et–Phou Louey NPA	76	Asiatic black bear	0.7	Kamler et al. 2012
	Malaysia: Taman Negara NP	40	None	0.0	Kawanishi and Sunquist 2008
	Thailand: Phu Khieo WS	33	None	0.0	Slangsingha et al. 2007
	Thailand: Phu Khieo WS	186	None	0.0	Grassman et al. 2005
	Thailand: Salakpra WS	175	None	0.0	Charaspet et al. 2015

[a]NPA = National Protected Area, NP = National Park, WS = Wildlife Sanctuary.
[b]Percent biomass consumed is given if available, otherwise percent frequency of occurrence is given.
[c]Hairs of bears found in scats were not identified to species, and both Asiatic black bears (*Ursus thibetanus*) and sun bears (*Helarctos malayanus*) occurred on the study site.
[d]NA = Not Available. Remains of Asiatic black bears were found in scats, but the no. of scats containing bears was not given.

large felids because predation by large felids might affect important aspects of sun bear ecology, such as their movements and activity. For example, tigers are behaviorally dominant over leopards and dholes; thus, the latter 2 species avoid tigers by using suboptimal habitat (Steinmetz et al. 2013, Carter et al. 2015, Rayan and Linkie 2016). Furthermore, tigers kill and displace leopards; thus, leopard numbers often decrease with increasing tiger numbers (Seidensticker 1976, McDougal 1988, Odden et al. 2010). In turn, leopards have been shown to negatively affect numbers of their prey (Brashares et al. 2010, Braczkowski et al. 2018). That both large felids probably kill sun bears suggests that the population dynamics of sun bears might be affected by large felids, although future research is needed to test this hypothesis. Tigers and leopards are absent from Borneo; therefore, comparative studies on sun bear ecology between this island and both Sumatra and mainland Southeast Asia might help elucidate the effects of large felids on sun bear ecology.

The distribution of sun bears is contracting at an alarming rate, and populations are becoming more fragmented and increasingly restricted to protected areas, especially on mainland Southeast Asia (Scotson et al. 2017). Similarly, tigers and leopards have recently experienced dramatic declines in numbers and distributions in Southeast Asia, and their populations are almost exclusively restricted to protected areas (Goodrich et al. 2015, Rostro-García et al. 2016). It is likely that these 3 carnivore species will become increasingly confined to the same isolated protected areas within Southeast Asia; thus, it will become even more important to study and understand the ecological relationships between sun bears and large felids because predation impacts likely will become amplified under such conditions.

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