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Cover: Common Silverline *Spindasis vulcanus vulcanus* in poster colours adapted from photograph by Kalpesh Tayade. © Pooja R. Patil.

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REVIEW

A systematic review on the feeding ecology of Sloth Bear *Melursus ursinus* Shaw, 1791 in its distribution range in the Indian subcontinent

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Abstract: The Sloth Bear being myrmecophagous is specialized to feed on ants, termites, and fleshy food; however, no discernible comparison exists on a diet, seasonal feeding pattern, and factor influence in a different habitat of an Indian sub-continent. A review of available literature suggested the dominance of plant matter in the Sloth Bear diet during the summer season, while an equal quantum of plant & animal matter was recorded in the monsoon & winter seasons. Fleshy fruits, flowers, flower buds, delicate leaves, and sometimes roots are considered plant food items in different studies, while ants, termites, honey, honey wax, and carrion feed are recorded as animal food items. Availability and accessibility of food materials in the different seasons, energy requirements, geographical variations, and human interference are notable factors influencing the feeding strategy of Sloth Bears. Cumulative data on food & feeding behavior of Sloth Bears helps to understand the pivotal role of species across various habitats. A systematic review of all the available studies to understand the diet of Sloth Bears in different seasons across its distribution range is presented in this paper, which can be a holistic approach to know the habitat selection with reference to the availability of food. A better understanding of such behavior also provides a key strategy for the management of large mammals in different geographical areas.

Keywords: Conservation, diet, Indian Bear, myrmecophagous, nutrition, scat analysis.

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INTRODUCTION

Nutrition plays an important role in the growth and development of every organism consequently need of healthy diet influences habitat selection. The family Ursidae comprises eight species of bears, widely distributed throughout northern hemisphere and partially in southern hemisphere. The food & feeding habit of bears are largely influenced by the geographical regions (Joshi et al. 1997). Out of the eight bear species, the Polar Bear is carnivorous and the Giant Panda is dependent on bamboo, while the rest of them are known to feed on a variety of foods and are termed omnivorous. Mostly they are opportunistic feeders, for growth and reproductive success they need a good amount of protein in their diet along with fat and carbohydrate for metabolism and energy fulfillment they feed on both plants and animals (Noyce et al. 1997). Varied habitat conditions majorly determine the feeding habits of bears with some similarities intact. The Sloth Bear is unique among all the bear species in being myrmecophagous in nature, feeding on ants, termites, honey, and fruits depending on availability (Joshi et al. 1997; Sukhadiya et al. 2013). Sloth Bear has a special feeding adaptation, it has highly specialized morphological features characterized to feed on insects which include a lack of upper incisor, broad palate, protrusible mobile lips, long snout, and nostrils that can be closed to create suction (Launre & Seidensticker 1997). They also possess a distinctively long shaggy coat with no underfur and reduced hair on the snout, which helps in the defense against honey bees and termite secretion during feeding. Competitive pressure and the temporal patterning of resource availability are two major factors in the evolution of Sloth Bear feeding specialization towards myrmecophagy (Launre & Seidensticker 1997).

The studies on the feeding behavior of Sloth Bears are well documented in different parts of the Indian subcontinent, but there is a need of a concrete review on diet of Sloth Bear to understand food preferences in different season as well as in different geographic regions through the Indian sub-continent. Thus, this review is aimed to compare variations in diet and dietary patterns of Sloth Bears in its distribution range along with the comparison of the methods by which it was studied.

Methods

The distribution of Sloth Bears is constrained by the ocean to the south, desert to the north-west, and mountains to the north & east. Although, they are found abundantly in Indian peninsula with a patchy, disturbed, and fragmented habitat due to anthropogenic pressure. Their actual distribution is confined to India, Nepal, and Sri Lanka and they have been recently extirpated from Bangladesh. In India, the Sloth Bears are patchily distributed in five different regions—northern, northeastern, central, southeastern, and southwestern (Johnsingh 2003; Yoganand et al. 2005; Dharaiya et al. 2016).

The literature survey was performed for published articles using keywords 'Sloth Bear', 'food', 'diet', '*Melursus ursinus*', 'nutrition', 'scat analysis' and fecal material', 'feeding behavior' in the search engines such as Google Scholar and Research Gate and also found from references cited in available papers. The review was conducted from the oldest literature on Sloth Bear diet in 1967 to the most recent by Schaller & Philip et al. (2021). A total of 21 literatures were used in this study relevant to Sloth Bear feeding behavior through its distribution range; out of which, 17 studies were conducted in India, three in Nepal, and one in Sri Lanka (Figure 1). To understand the dietary habit of Sloth Bears and the relative composition of plants and animal matter, we used the percentage volume of different food items in scats of Sloth Bears from all checked literature.

RESULTS AND DISCUSSION

Sampling methods used in different studies

The nocturnal foraging habits of Sloth Bears primarily do not permit adequate data to be gathered based on direct observation of their feeding behavior. Feeding ecology is mainly studied by scat analysis, one of the widely used techniques to study the diets of large carnivores and also described as one of the best available methods for studying the food habits of Sloth Bears (Dharaiya & Ratnayeke 2009; Mewada 2010). Scats of Sloth Bears can be more easily identified than scats of other mammals in the area on the basis of shape, size, and undigested food (seeds, bee wax, ant heads, and insect body parts). The scats were collected in different studies by surveying forest trails, bear dens, and resting sites. It is noted that collection of scats during the monsoon is quite difficult due to increased vegetation cover and erosion by rains where den sites are considered a prime way for scat collection during the monsoon (Bargali et al. 2004). Although direct observation is used to study foraging behavior of bears in Kumbhalgarh Wildlife Sanctuary, Rajasthan (Chhangani 2002) and in Royal Chitwan National Park (Joshi et al. 1997). Radio-collared

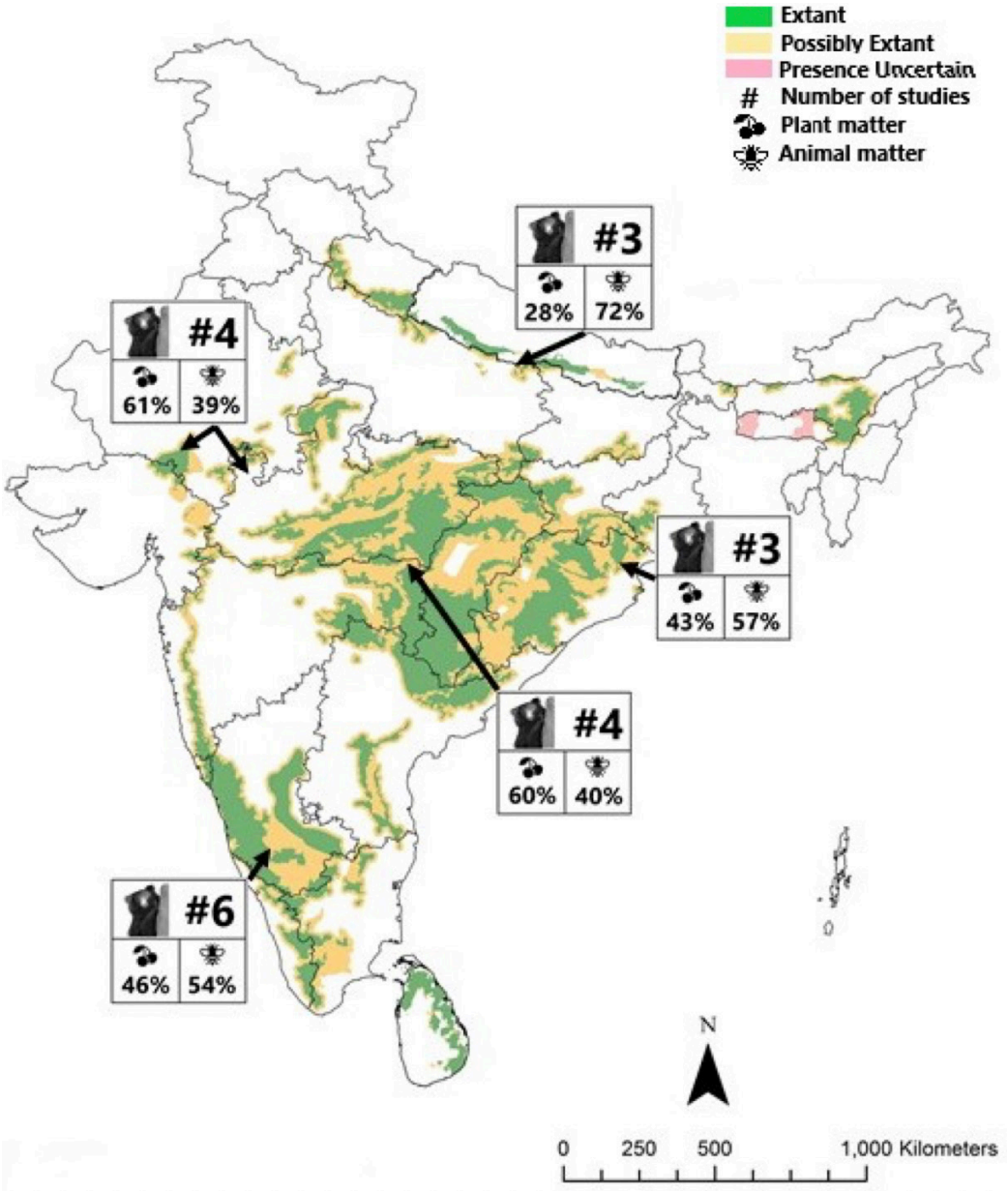

Figure 1. Distribution of Sloth Bears and locations of diet studies carried out by different researchers (West—#4 | Central—#4 | East—#3 | Northeast—#3 | South—#6) (Dharaiya et al. 2016).

Sloth Bears were monitored in Royal Chitwan National Park from the back of an elephant using binoculars at a distance of 30–50 m without disturbing their activities.

Plant and Animal-based diet

Studies on feeding behavior show that sloth bears consume both animal and plant matter in their regular diet. According to Akhtar et al. (2004) among the Ursidae, only the Sloth Bear is uniquely adapted for feeding on insects and fruit and a less amount of vegetables, mammals, fishes, and other insects. Being an opportunistic feeder, the Sloth Bear has been observed to switch between fruits and insects depending on the availability and amount as mainly fruit content is recorded in fruiting seasons and vice versa.

Plant matter was found to be dominating the diet of Sloth Bear in comparison to animal matter due to less availability of the latter in the Kumbhalgarh Wildlife Sanctuary (Chhangani 2002). Similarly, Schaller (1967), Bargali et al. (2004), Yoganand (2005), Mewada & Dharaiya (2010), Sukhadiya et al. (2013), Mewada (2015), and Kumar & Paul (2021) found plant material in abundance than animal matter in Sloth Bear scat on the basis of dry-weight in central and western India

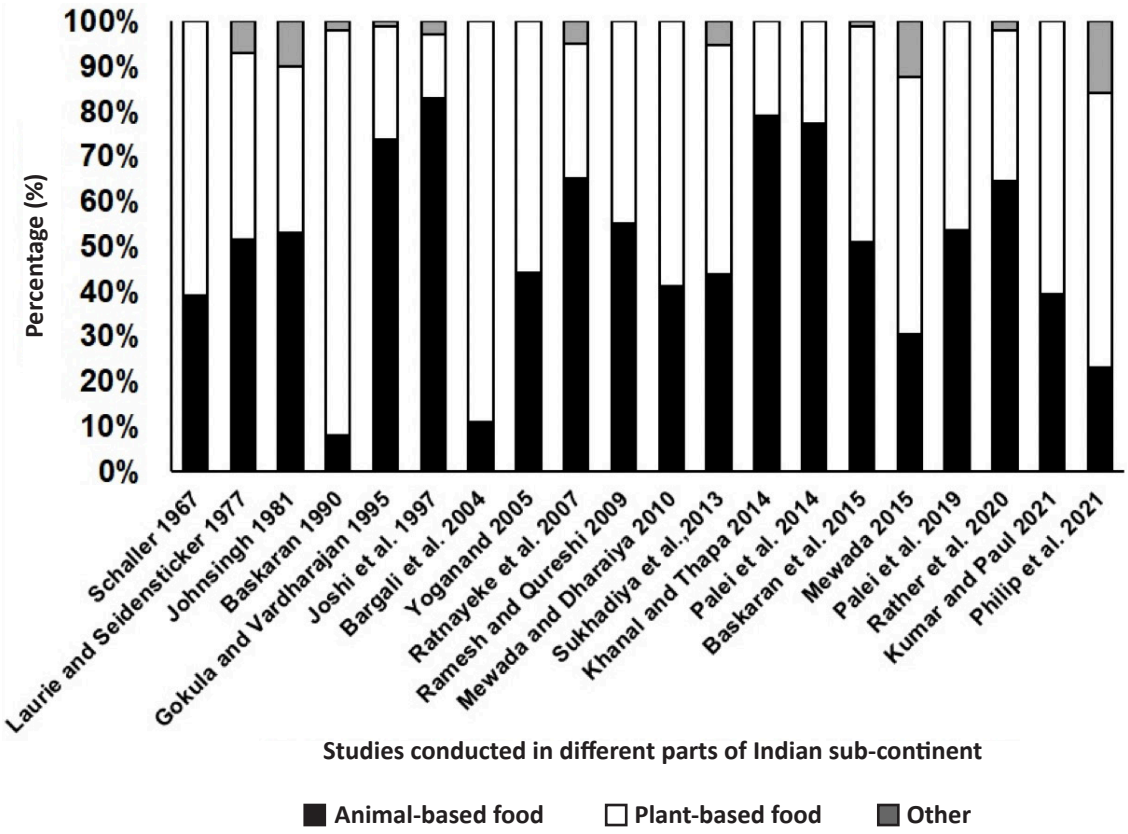

Figure 2. Diet composition of Sloth Bear based on the available literature surveyed in this review.

(Figure 2, 3). According to Chhangani (2002), 40 species have been recorded in Kumbhalgarh wildlife sanctuary as the preferred food by Sloth Bear among them 22 are natural, while the rest are cultivated plants. These plant species are consumed by Sloth Bear in the form of young & mature leaves, flowers & flowers bud, unripe & ripe fruits, and sometimes roots, shoots, bark, and seed (Chhangani 2002). While, animal matter was reported higher in Sloth Bear scats by Laurie & Seidensticker (1977), Josnsingh (1981), Gokula & Vardharajan (1995), Joshi et al. (1997), Ratnayeke et al. (2007), Ramesh et al. (2009), Khanal & Thapa (2014), Palei et al. (2014, 2020), and Baskaran et al. (2015) possibly due to less availability of flashy fruits in the southern, eastern, and northeastern parts of the Indian sub-continent (Figure 2,3). Garshelis (1999) also noted higher animal matter than fruits in Sloth Bear scats in the Terai areas of the Indian sub-continent. Animal matter is composed of mainly termites, ants, honey bees, and bee wax.

In the majority of studies, plant-based food was recorded more abundantly than animal-based food, probably due to hard soil during the summer season make difficult to dig for ants and termites. It is also believed the greater importance of plant matter in the bear diet during summer is due to seasonal flowering and fruiting. While almost equal dietary pattern was observed during the winter and monsoon seasons between plant and animal-based food (Figure 4). It is assumed that bears feed on ants and termites throughout the year while fruits are the most preferred food; when fruits are available, they shift their diet towards plant matter. With the availability of both fruits and insects, bears feed on fruits to fulfill nutrition requirements due to the bulk of availability and easy access of fruits than insects. Fleshy fruits are rich in sugar provide instant energy to Sloth Bears, and excess sugar can be converted and stored as tissue fat for further utilization (Palei et al. 2020). Although the insects are rich in protein than fruits but being a larger body size of Sloth Bears, an adequate amount of food required to quench the hunger in less time may influence the animal to shift on fruits (Baskaran et al. 2015).

Generally, Sloth Bears do not prey on carrion or other mammals, but McDougal recorded one instance in which a sloth bear was feeding on buffalo killed by a tiger during a tiger baiting program in western Chitawan (Laurie & Seidensticker 1977). A similar instance was recorded by Sanderson (1890) where Sloth Bears

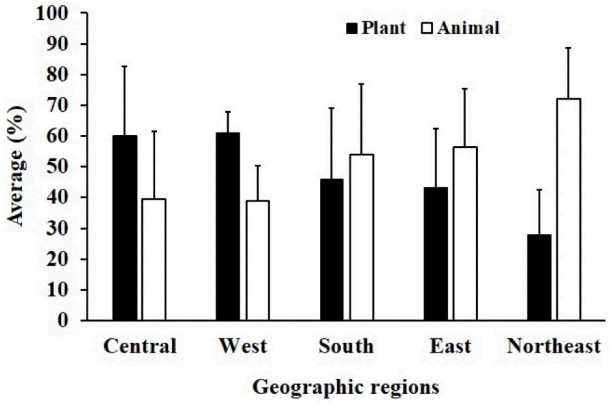

Figure 3. An average (%) diet composition of Sloth Bear across different geographic regions based on the available literature surveyed in this review (error bar represents standard deviation).

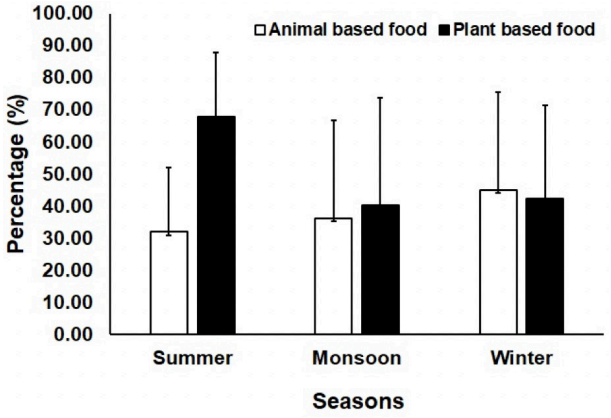

Figure 4. A mean percentage of seasonal diet of Sloth Bears, according to checked literature (error bar represents standard deviation).

scavenged on tiger kills and gnawed on cattle bones. A 37 cm long, digested snake was found in the scat of Sloth Bear by Hasted (1903). In Kumbhalgarh Wildlife Sanctuary, carcasses of dead wild & domestic animals are also recorded as a possible food content of Sloth Bear (Chhangani 2002). Remains of Sambar were reported in Mudumalai Tiger Reserve, Tamil Nadu (Ramesh et al. 2009). The incidence of observing animal carcasses in Sloth Bear scat has been dated to the late 19th century and no concrete proofs have been given in recent studies on Sloth Bear consuming carcasses. But recently, mammalian hairs were reported in Sloth Bear scats in Chitwan National Park, Nepal by Khanal & Thapa (2014). Similarly, mammalian hairs and bones were reported in Sloth Bear scats in Nawada Forest Division, Bihar by Kumar & Paul (2021) probably suggests carrion feeding behavior of Sloth Bear.

Feeding patterns of Sloth Bears have been also reported with some rare and extreme observations in western India. In the Jessore Sloth Bear Sanctuary (Gujarat), cicadas (*Platypleura spp.*) were found for the first time in the scats of Sloth Bears (Patel et al. 2017). Singh et al. (2017) reported two instances of Sloth Bear attractant towards house and temple in search of food. Similarly, two bears were feeding on sweets, coconuts, and licking the 'Sindoor' around a sacred fire at a pilgrimage site, Mount Abu, Rajasthan, India (Koli & Prajapati 2022).

Habitat selection

Habitat use by an animal largely depends upon the biological requirements of species based on the quality of habitat known by species-habitat relationships (Ramesh et al. 2012). According to Bargali et al. (2004), availability of dietary components greatly influences Sloth Bear habitat use. Fruits and insects comprise the majority of Sloth Bear diet, but it varies seasonally and geographically across their range from Nepal through India, and Sri Lanka (Baskaran 1990; Dharaiya et al. 2016). Depending on the nutrition requirements, bears tend to feed on ants and termites (Noyce et al. 1997). Plant biomass directly or indirectly influences termite growth, thus favorable climate and soil texture increase productivity and biomass of plants, resulting in the high availability of termites in different habitats. While Launre & Seidensticker (1997) suggested that movement of bears is associated with fruiting species of the area, it can be concluded that habitat selection is driven by the availability and accessibility of food (Laurie & Seidensticker 1977; Dharaiya et al. 2016).

Factors affecting food selection

The food habit of sloth bears is determined by several factors that have been classified into four categories— food availability, seasonal variation, energy requirement, and geographic location. Many studies have reported seasonal food availability determines what food resource Sloth Bears use (Bargali et al. 2004; Sukhadiya & Dharaiya 2013; Khanal & Thapa 2014; Baskaran et al. 2015; Rather et al. 2020). Among all bear species, the Sloth Bear seems almost entirely depends on insects for protein requirements (Yoganand et al. 2005; Khanal & Thapa 2014). Moreover, to fulfill immediate energy requirements, Sloth Bears are reported to feed on fleshy fruits during the fruiting season (Palei et al. 2020). According to Palei et al. (2014), Sloth Bears feed on diverse food items in different seasons to avoid deficiency of protein, calcium, starch, and other necessary nutrients. Several authors have depicted diet pattern of Sloth Bears varies with geographical location

as per availability and accessibility of fruiting species and colonies of ants and termites (Schaller 1967; Joshi et al. 1997; Mewada & Dharaiya 2010).

Is the food responsible for Human-Bear interaction?

Sloth Bears are facing multiple threats, mainly due to the increasing trend of human population causes habitat fragmentation, degradation, decreased natural resources, and conflict with humans (Garcia et al. 2016). Mewada & Dharaiya (2010) suggested that bears use less human-dominated areas when forest is available. It is reported that Sloth Bear competes with humans for the same resource utilization like fruits and honey (Bargali et al. 2004). During the summer season, most fruits are ripe and eaten by Sloth Bears (Baskaran et al. 1997; Joshi et al. 1997; Akhatar et al. 2004) and also collected by local people for their own or to sell in the market. In monsoon, the human-bear encounter was reported higher at agriculture fields where humans and bears spend their time for own purpose (Debata et al. 2017). Also, during monsoon and winter, local villagers go to forest areas for grazing their livestock might be the reason of encounters due to less detection of Sloth Bears in increased vegetation. People continuing harvest of timber and firewood cause an extensive loss of habitat (Garcia et al. 2016). Similarly, Chhangani (2002) suggests that due to dispersion of ground cover by overgrazing and agriculture practices near the bear habitat, chances of human-bear interaction increase, which leads to conflicts in some situations. Potential mitigation ways to reduce Sloth Bear intake of human grown food, is to grow crops not preferred by Sloth Bears (Bargali et al. 2004) and proper burial or disposal of carrion. Beyond this, movement in larger groups in the forest during the collection of natural products may reduce human-bear conflict.

Application for Management

However, only 10% of the good quality of habitat for Sloth Bears is left in India (Yoganand et al. 2005). The Sloth Bears are inhabiting fragmented habitats, continuously facing habitat disturbance, retaliatory killing, and poaching. These days, resource sharing is emerging as a major threat between humans and Sloth Bears (Rajpurohit & Krausman 2000; Dharaiya & Ratnayeke 2009). Lack of natural food resources, habitat fragmentation, and increased anthropogenic activities would clearly support that most attacks happen outside protected areas. The availability of adequate food may reduce the movement of bears out of the protected area, which will result in fewer encounters with humans. This review reveals that important fruiting species play a vital role on the Sloth Bear movement and the plantation of such trees within the forest will increase food availability for Sloth Bears that can be the backbone of further management practices.

CONCLUSION

Studies on the feeding habits of Sloth Bears in the different regions reveal that Sloth Bears feed on both plants and animal matter based on food availability. It is clearly stated that their feeding habit change with the season, geographic region, as well as the availability of food resources. By knowing these different results, we can conclude that bears are playing a vital role as an indicator of climate because they are vulnerable to changes in the landscape influenced by deforestation, logging, habitat destruction, and changing plant phenology. They are an umbrella species in the protected areas, but their actual role in the forest ecosystem has been quite unclarified. The need of high nutritious food converts their feeding pattern towards the intake of fruit, making them more effective as a seed disperser.

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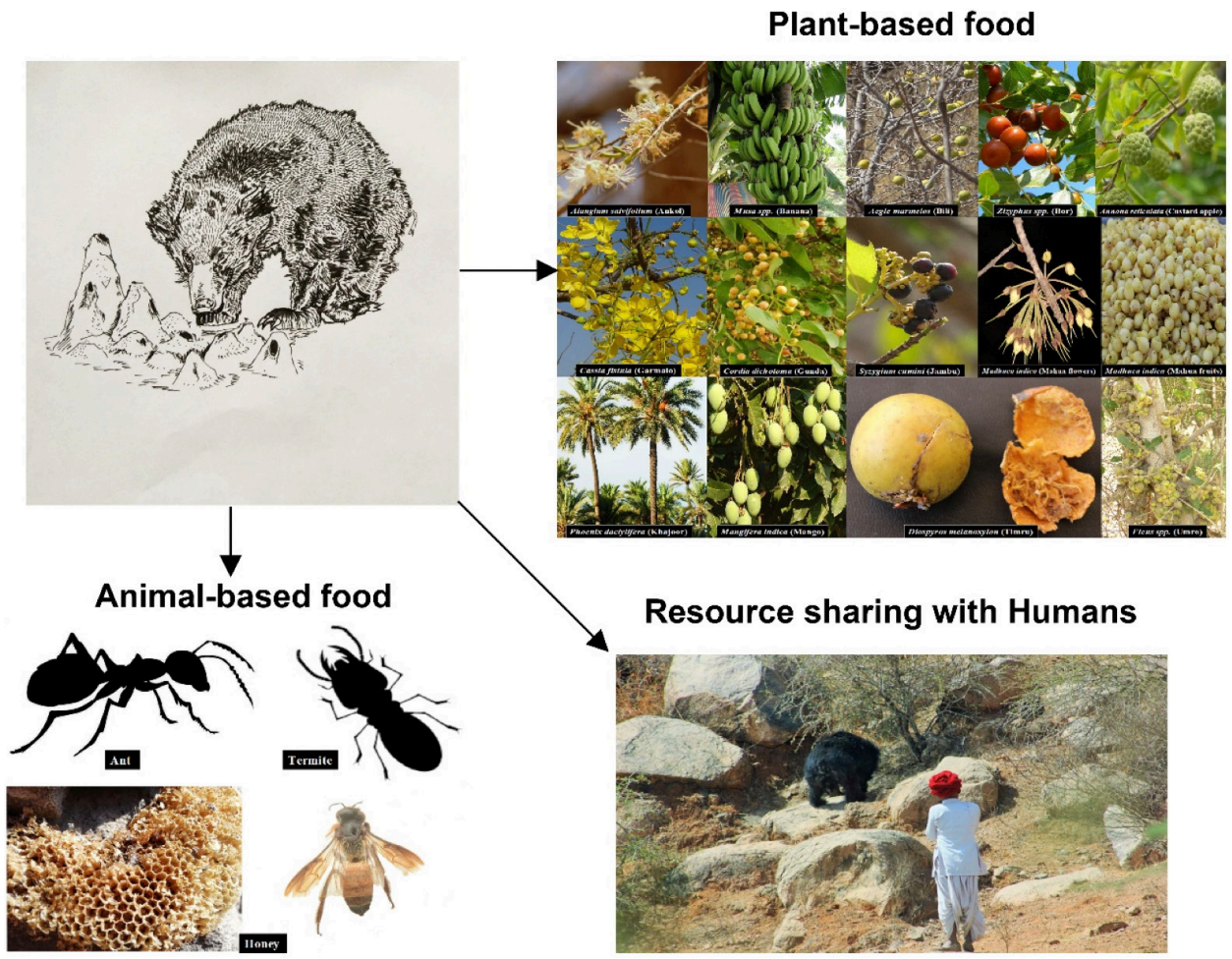

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