HOME RANGE SIZE, DENSITY ESTIMATION AND FOOD OF MALAYAN TAPIRS *(Tapirus indicus)* AT KRAU WILDLIFE RESERVE

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by

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SAIZ KAWASAN KEDIAMAN, ANGGARAN KEPADATAN DAN MAKANAN TAPIR MALAYA *(Tapirus indicus)* DI REZAB HIDUPAN LIAR KRAU

ABSTRAK

Kajian ini telah dijalankan di Rezab Hidupan Liar Krau dari November 2002 hingga Mei 2007 dengan menggunakan teknik perangkap kamera, kaedah penjejakan beradio dan juga transek garis lurus. Terdapat 698 '*trap-nights*' dan 295 adalah gambar Tapir Malaya atau 21 individu dikenalpasti (73.37% daripada keseluruhan gambar hidupan liar). Anggaran kepadatan adalah 7 individu/100km^2 dengan saiz populasi antara 28 hingga 32 individu. Didapati, 100% gambar spesies ini yang direkodkan adalah di antara jam 2000 hingga 0600. Tiada gambar spesies ini direkodkan di waktu siang (0700 hingga 1900). Tapir Malaya menunjukkan kekerapan berada di Jenut Bayek secara signifikan berbanding di kawasan lain ($p<0.05$, ujian t). Lima individu berjaya dipasang dengan transmiter iaitu Siti (dewasa ♀), Sanusi dan Manja (dewasa ♂), Adik Merdeka (remaja ♂) dan Akak Ramadhan (remaja ♀). Hanya data bagi Adik Merdeka, Akak Ramadhan dan Manja mencapai asimptot bagi lengkuk titik bacaan minimum. Ketiga-tiga individu yang dipasang transmiter menunjukkan kekerapan berada di Jenut Bayek secara signifikan berbanding di kawasan lain ($p<0.05$, ujian t). Banjaran Kediaman Bulanan mencatatkan pertambahan saiz kediaman mengikut pertambahan peratus. Kajian ini mendapati bulan pertama selepas individu ditangkap, didapati corak banjaran kediaman tidak sekata. Dijangkakan corak ini ditunjukkan kesan tekanan akibat individu ini terdedah secara langsung kepada manusia. Secara tidak langsung, ini menunjukkan tempoh sekurang-kurangnya satu bulan diperlukan bagi setiap individu bagi membangunkan semula banjaran kediaman yang stabil. Banjaran Kediaman Bulanan terbesar dicatatkan oleh remaja ♂ iaitu iaitu 0.73±0.13km^2 diikuti ♂ dewasa iaitu 0.60±0.09km^2 dan remaja ♀ iaitu 0.52±0.14km^2. Tiada perbezaan yang signifikan di antara individu. Kedua-dua individu remaja berkongsi banjaran kediaman. Sejumlah 138 tumbuhan dari 15 famili dan 24 genus dimakan haiwan ini di kedua-dua belah rentis sepanjang 800m. Kajian ini mendapati Tapir Malaya merupakan peragut memilih berbanding peragut umum.

HOME RANGE SIZE, DENSITY ESTIMATION AND FOOD OF MALAYAN TAPIRS *(Tapirus indicus)* AT KRAU WILDLIFE RESERVE

ABSTRACT

This study was conducted in Krau Wildlife Reserve from November 2002 to May 2007 using camera-trapping, radio telemetry, direct observation and line transect techniques. It took over 698 trap-nights to accumulate 295 photographic captures of Malayan tapirs or 21 identified individuals, which constituted 73.37% of the total wildlife photos. An estimated density of Malayan tapirs is 7 individuals/100km^2 with the estimated population size between 28 to 32 individuals. It is clearly showed that 100.00% of the photographs are recorded in between 2000 until 0600. None of the photograph is recorded in the day (0700 until 1900). Malayan tapirs were recorded significantly more often at Bayek Saltlick than other areas ($p<0.05$, t-test). For the purposes of studying home range, five individuals were fitted with transmitters named Siti (adult ♀), Sanusi and Manja (adult ♂), Adik Merdeka (sub adult ♂) and Akak Ramadhan (sub adult ♀). Only point locations of Adik Merdeka, Akak Ramadhan and Manja reached asymptote for the cumulative area curve. All three collared individuals were recorded significantly more often at Bayek Saltlick than other areas ($p<0.05$, t-test). As for and monthly home range, it increased accordingly to the percentage increament. This study discovered that the first month after the individual being captured, its home range pattern showed uneven pattern. It is assumed that this pattern is showed due to post-stress effect after individuals were exposed to human contact. Indirectly it shows that after being captured, each individual needs at least one month duration to develop its normal home range pattern. The largest home range is recorded by subadult male with 0.73±0.13km^2 followed by adult male with 0.60±0.09km^2 and subadult female with 0.52±0.14km^2. However, there is no difference between respective individuals. The subadults were sharing its home range during the study. A total of 138 plants of species from 15 families and 24 genuses were recorded eaten on both sides of a 800m length of trail. This study revealed that Malayan tapir was selective browser rather than generalist.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Since independence in 1957, large areas of lowland forests in Malaysia have been converted into oil palm and rubber plantations through government agricultural development schemes. Due to this habitat loss and fragmentation, the population of many large mammals has declined. Javan rhino (*Rhinoceros sondaicus*) and banteng (*Bos javanicus*) are now believed to be extinct in Peninsular Malaysia (Kawanishi *et al.*, 2002).

Malayan tapir has appeared frequently in Department of Wildlife and National Parks (DWNP) field surveys. It is the most common detected species (DWNP, 1993a; 1993b; 1994a; 1994b; 2002a; 2002b; 2005). Such data has led to a conclusion that the animal is plentiful in peninsula forests. It is the third most abundant large ungulate after wild boar (*Sus scrofa*) and barking deer (*Muntiacus muntjak*) (Chiew, 2003).

The seemingly large number of Malayan tapirs, however, works against the species' long-term survival. In order to survive in the wild, every species needs to maintain its external needs. Those needs would include home range size, food source availability and opposite sex individuals for mating purposes. The external needs are also imperative to maintain the population size and the internal needs of tapirs such as their ideal body weight and energy consumption.

However, due to human factors including deforestation, poaching and disturbance in the species' habitat, the pressure to survive has increased. Thus, authorities and related organizations need to play a major role to overcome or minimize the pressure. Malayan tapir often fail to gain rightful attention and ranks lowly among species that need to be conserved. It has been studied only in brief and their important information such as population and distribution remains unclear (Williams, 1979).

There is a great lack of available data and information on the preferred habitats of Malayan tapirs in the wild. The available ones are mostly reliant on secondary data or indirect observation while focusing on other wildlife species. Therefore more studies are needed in order for DWNP to address several issues that are directly related to its conservation efforts, which include the fatalities of tapirs in Malaysia.

One of the issues faced by DWNP is the reported cases of fatalities among tapirs. DWNP Law Enforcement Division, for instance, had filed a case of a tapir poacher who possessed a severed tapir head after the flesh was cooked and served in his restaurant in 1997. Another case which is closely related to the issue is a male tapir which was killed in a road accident at Jalan Kuantan-Pekan. It was found without its teeth and foot, which is believed to be stolen by the locals for various traditional practices (Anonymous, 2009). Similarly, a tapir's skull was found at a site of a ritualistic ceremony in Lata Tembakah, Terengganu. It is believed that the tapir has been killed by illegal poachers from Thailand as Thai words were written on it (Rani, 2005). In addition to the stated case, there are also other occurrences in which tapirs were killed in road accidents (Zainal-Zahari & Jawahir, 1998). Consequently, signboards were placed in April after the death of seven tapirs on the road that cuts through what was once Bukit Cerakah Forest Reserve Selangor (John & Chelvi, 2004).

The reported cases mentioned earlier have clearly shown an alarming threat on the survival of Malayan tapirs. The threat is even more significant as information regarding the species' distribution of population is unknown. Current incidents can be a clear indicator of how little is known about our wildlife's natural distribution, especially big mammals like

Malayan tapir. The problem could also be a probable rationale for tapirs being killed for specific purposes, such as for ritualistic ceremonies or even for aphrodisiac. More studies should be done to discern the distribution and population of tapirs in Malaysia.

1.2 Study Objectives

This study was conducted in order to gain more data on the ecological background of Malayan tapir in its natural habitat. The main objective of this study was:

a) to estimate the population density of Malayan tapir in Krau Wildlife Reserve based on radio telemetry and camera trapping procedures,
b) to estimate the home range size of Malayan tapir in the wild using radio telemetry procedure, and
c) to determine its food and feeding behavior in the wild

It is hoped that this study will increase the understanding of Malayan tapirs' basic need in the wild and the results of the study can be used in the management of Malayan tapir at the study area as well as in other areas.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Tapirs

Tapirs have been called the living fossils, survivors' from the past eras. Not only in their physical structure that rather primitive, but their present distribution in widely separated areas indicate that they originated from a group of animals from a geological era. In the past, the Tapiridae were much more widespread, with a remarkable variety of species, than today (Fradrich & Thenius, 1968; Orcutt, 1948; Radinsky, 1963; Simpson, 1945). The mammalian family Tapiridae comprises a single extant genus containing four species. The closest relatives of the tapirs are the members of the horse family, Equidae, and the rhinoceros family, Rhinocerotidae (Nowak, 1991).

Tapirs show relatively little differentiation from the common ancestor of horses and rhinoceroses. There are four *Tapirus* species and they inhabit tropical forests in both the Old World and the New World (Nowak, 1991). The New World tapirs are the mountain tapir, *Tapirus pinchaque* lives in the high Andes of Venezuela, Colombia, Ecuador and northern Peru. The South American tapir, *T. terrestris* occurs over most of the Amazon Basin while the Central American tapir, *T. bairdii* ranges from southern Mexico to the western coasts of Colombia and possibly Equador (Grasse, 1955; Hershkovitz, 1954; Lekagul & McNeely, 1988; Schauenberg, 1969; Simpson, 1945; Williams, 1991). The Old World tapir is the black-and-white Malayan tapir is found in Burma (Anderson & Jones, 1984), Thailand, Peninsular Malaysia and the Indonesian island of Sumatra (DeBlase, 1979; Medway, 1969; Sanderson, 1967; Williams, 1991).

Despite a plethora of studies of tapirs in Latin America, there is only one radio telemetry study (Williams, 1978) and camera trapping study (Novarino *et al*., 2004; Novarino *et al*., 2005a; Novarino *et al*., 2005b) of this species in the wild.

2.1.1 Physical Characteristic

All three of the New World tapirs are reddish to dark brown. The mountain tapir has characteristic white lips. The South American tapir has a narrow short mane from forehead to shoulder and the Central American tapir has white or gray cheeks and chest (Williams, 1991). This strange mammal is smaller than the hairy rhino but larger than a wild pig (Payne, 1990). Malayan tapir is the largest of the tapirs, and the female is often larger than the male (Barongi, 1986). One Malayan tapir killed in Burma weighted over 540kg (Lekagul & McNeely, 1988).

The general form of all tapirs is rounded in back and tapering in front, making them well suited for rapid movement through thick underbrush (Lekagul & McNeely, 1988; Nowak, 1991). The skin of the neck is thick and very hard. This is a defense against predator and gives protection to the neck when the animal is moving through dense undergrowth (Lekagul & McNeely, 1988). The snout and upper lips are elongated and the extremely flexible and somewhat prehensile nose (DeBlase, 1979; Nowak, 1991). The transverse nostrils are located at its tip (Nowak, 1991). Tapirs use the muscular appendages for pushing food into the mouth and plucking leaves from branches and to smell (Barongi, 1993b; Williams, 1991).

The eyes are small and flush with the side of the head. The ears are oval, erect and not very mobile (Nowak, 1991). There are white-tips at the end of the ears (Kuiper, 1926). Auditory and olfactory senses apparently are well developed but sight seemingly poor (Anderson & Jones, 1984; Lekagul & McNeely, 1988). Short, bristly hairs are scattered on the body and it is used to control its body temperature (Anderson & Jones, 1984; DeBlase, 1979; Nowak, 1991).

The forefoot has three main digits and a smaller one (DeBlase, 1979), for a total of four (Radinsky, 1963). The small digit is functional only on soft ground (DeBlase, 1979; Hall, 1951; Nowak, 1991). The hind foot has three digits (Anderson & Jones, 1984; Williams, 1978). Large callous pads and oval hoofs support the weight of the body (Anderson & Jones, 1984) especially the mesoxonic digit (DeBlase, 1979). Mesoxonic digit is the large central digit and completely separate from the others (Medway, 1969). Tapir track sizes are between 15-17cm diameters (Medway, 1969; Tweedie, 1978). It seems like the rhino tracks but a bit smaller (Payne, 1990; Zainal *et al.,* 2000).

The Malayan tapir is also known as the saddleback tapir because of the characteristic black and white coloration in adults. All newborn tapirs are striped and resemble furry watermelons (Nowak, 1991). A melanistic Malayan tapir was described in 1924 found in Palembang, Sumatra (Kuiper, 1926). He proposed a separate subspecies for this animal based on a presumed genetic basis for this coloration. Recently, Azlan (2002) recorded two melanistic or black Malayan tapirs (*Tapirus indicus brevetianus*) on two occasions in Jerangau Forest Reserve, Ulu Terengganu, Malaysia in 2000.

2.1.2 Habitat Preference

Habitat preference is habitat chosen by animals for most of times spend for daily activities in their life such as searching the food, resting, sleeping, mating and other social activities (Robinson & Bolen, 1971). Tapirs are forest dwellers. According to Lekagul & McNeely (1988), Malayan tapir is described as an inhabitat of dense primary rainforests. The study carried out by Williams & Petrides (1980) in Taman Negara, Malaysia strongly supports Lekagul & McNeely's observations in Thailand. Novarino *et al.* (2004) reported that Malayan tapir prefers secondary forests over primary forests. Hislop (1961) and Khan (1971) reported that Malayan tapirs occur at lowland forests. Tapirs may live in nearly any wooded or grassy habitats where there is a permanent supply of water (Anderson & Jones, 1984; Nowak, 1991). They commonly shelter in forests and thickets by day, emerging at night to feed in bordering grassy or shrubby areas (Nowak, 1991).

2.1.3 Social Behaviour

Nowak (1991) reported that except for females with young, tapirs are primarily solitary and nocturnal. When two individuals meet in the wild, they generally behave aggressively toward one another. Recent field studies by Fragoso (1987), Terwilliger (1978) and Williams (1978) have suggested that they are more tolerant of conspecifics than previously realized and demonstrate crepuscular rather than completely nocturnal activity in undisturbed forests (Eisenberg, 1989; Emmons, 1990). Urine is used in territorial marking (Schauenberg, 1969; Terwilliger, 1978). Tapirs are usually silent (Lekagul & McNeely, 1988), the best known noise emitted by tapirs is a continuous whistling sound, usually followed by an answering whistle from another tapir some distance away. They also make a sound much like clicks (Barongi, 1986; 1993a; 1993b) and repeated 'wha-cha' hiccup-like (Barongi, 1993b; Terwilliger, 1978). During under-stress, high pitched squeals are performed (Hislop, 1952; Lekagul & McNeely, 1988; Medway, 1969).

Tapirs are generally shy and docile and seek refuge in water or crash off into the brush when threatened, but they can and will defend themselves by biting (Barongi, 1993b; Nowak, 1991; Sanderson, 1967). Reports of violent behavior, including biting humans seem to come most often in situations of confinement such as zoos (Barongi, 1986; 1993a; 1993b). Gripping small saplings in their teeth, the tapirs snap them off about three feet above the ground so they can reach the foliage. Williams (1991) reported that saplings as big as 4.45cm in diameter and 3.96m tall snapped off and picked clean. Tapirs use their muscular elongated nose to bring the food to their mouth and have been known to stand on their hind legs to reach a particularly desirable morsel. By feeding in this fashion, they avoid competition with other browsers.

Unlike their rhinoceros relatives, Malayan tapirs do not wallow in muddy pools but instead keep cool by swimming in rivers and streams (Payne, 1990). Tapirs are excellent swimmers and spend a good deal of time in rivers and pools, cooling off and ridding themselves of parasites. If threatened, they may seek refuge in water and can submerge for several minutes (Anderson & Jones, 1984; Barongi, 1993b; Lekagul & McNeely, 1988; Williams, 1991). The paths worn by tapirs frequently lead through large, leafy treefalls, which are a rich source of food and which provide excellent camouflage (Terwilliger, 1978).

2.1.4 Threat on Tapirs

Tapirs are one of the first species to disappear from a disturbed habitat, its large size, heavy food intake and slow rate of reproduction making it extremely vulnerable to changes in the environment (Santiapillai & Ramono, 1990). Their low reproduction rate means they could not recover quickly if their population declines (Cohn, 2000). Tapir populations are declining worldwide, largely because of increasing deforestation (Janzen, 1983; Williams & Petrides, 1980) by humans for agricultural purposes and cattle grazing (Nowak, 1991). Although the three lowland species often feed on forest edges and sometimes raid plantations and small cultivated fields, none of the tapirs appears to tolerate much habitat disturbance by man (Harper, 1945; Sanborn & Watkins, 1950).

In some areas, tapirs are hunted (Barongi, 1993b) extensively for food and sport (Nowak, 1991; Williams, 1991). For religious reasons, however, certain Indian tribes do not kill tapirs. In Islamic areas of Malaysia and Sumatra, where Muslim beliefs forbid the eating of tapir meat (Blouch, 1984; Williams, 1991) as they belief that tapir is a type of pig (Barongi, 1993b).

In Malaysia, tapir is listed on Schedule One of the Wildlife Protection Act 1972 as a totally protected animal. Such listing generally implies that the animal is threatened and warrants protection. It is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which means it faces the threat of extinction. IUCN Tapir Specialists Group (TSG) initially assigned the Malay tapir as Vulnerable (IUCN, 1996). A recent revision (Medici *et al*., 2003) listed it as Endangered. This status was revised and confirmed in a recent Population and Habitat Viability Analysis (PHVA) workshop, and priority conservation actions were established.

2.2 Previous Study on Camera Trapping

Camera trapping have been used for recording wildlife since the early 1900's (Champion, 1992; Cutler & Swann, 1999; Griffiths & van Schaik, 1993b; Karanth & Nichols, 1998; Shiras, 1906) and were actually used to document tapirs on Barro Colorado Island (Chapman, 1927). In their most advanced form, wildlife moving on forest trails takes their own flash photographs when they trigger infra red beams linked to automatic cameras (Wilson & Cole, 1996). In the 1990's camera traps were used to monitor levels of wildlife and human traffic in Sumatran rainforests (Griffiths & van Schaik, 1993a), to monitor human impact on rain forest wildlife in Guatemala (Kawanishi, 1995) and to census tiger population in India (Karanth & Nichols, 1998).

Recently in Asia, camera trapping method was used for Malayan tiger (*Panthera tigris jaksoni*) surveys which also include other mammals including Malayan tapirs (Azlan, 2002; Azlan & Dionysius, 2003; Carbone *et al.*, 2001; Franklin *et al.*, 1999; Holden, 1999; Kawanishi, 2001; Kawanishi *et al.*, 1999; Kawanishi *et al.,* 2002; Laidlaw, 1998; Laidlaw & Wan, 1998; Laidlaw *et al.,* 2000; Lynam, 1999). In 2001, camera traps were used to estimate tapir populations in Sumatra (Holden *et al.*, 2003), to determine distribution of tapir in comparison with other ungulates (Khadijah-Ghani, 2001) and Kawanishi *et al.* (2002) reported that tapirs are among the most abundant and widespread large mammals in Taman Negara National Park. All these researchers are using the same data from tiger survey. Tiger survey projects' main objective is to capture tiger photos where camera traps were set up at well used game trails with focal range between 3-5m (Kawanishi *et al.*, 1999). At this range, if there is any tapir photo, it is difficult to identify the individuals.

2.3 Previous Study on Radio Telemetry

Radio telemetry was widely use in home range study involving from insect to big mammal such as elephant. It brought two new advantages to wildlife research: the ability to identify individual animals and the ability to locate each animal when desired. These advantages have led to the wide application of radio-tracking since the first complete workable system was designed (Cochran & Lord, 1963).

According to Mech (1983), radio telemetry tracking can determine the location of animals through the use of a radio receiver and directional antenna that trace attached transmitter to the animals. Radio telemetry is the most accurate method to study home range and compare to other methods. For example home range from grid-trapping method is only 70% closest to radio telemetry (Hackett & Deutsch, 1982).

The first radio telemetry project on tapirs was conducted in 1978; three Malayan tapirs were captured in Taman Negara and fitted with radio-transmitters (Williams, 1978). The study revealed that tapirs are territorial and utilise up to 12.75km^2 for their territory and the average straights line distance traveled per day by a male was 0.32km. An area of 0.52km^2 was occupied over a period of at least 27 days, during which time an association with a female and her young occurred (Khan, 1997). More extensive radio telemetry project was conducted on the three New World tapirs including the Mountain tapir (Downer, 2002; Lizcano & Cavelier, 2004a), the Baird's tapir (Foerster, 2001; Naranjo & Bodmer, 2002) and the Lowland tapir (Ayala, 2002; Medici, 2002). Recently in August 2002, a radio telemetry project on Malayan tapir is conducted in Krau Wildlife Reserve Malaysia (Khadijah-Ghani & Traeholt, 2004).

2.3.1 Home Range Estimation

There are three home range estimation used in order to analyse radio telemetry data including Harmony Mean (HM), Minimum Convex Polygon (MCP) and Kernel.

2.3.2 Minimum Convex Polygon (MCP)

This method is the oldest and most common method of estimating home range (Mohr, 1947). Meanwhile, this method also can be used to make a comparison between home range studies (Harris *et al*., 1990). The area of minimum convex polygon was build from connecting the outsider point to make a convex and calculate the inner area. The advantages of the convex polygon are simplicity, flexibility of shape and ease of calculation. However, the disadvantages are major.

The size of the home range estimate increases indefinitely as the number of locations increases because the minimum area polygon is estimating total area utilized, not the area in normal movements. As more locations are taken, the chances that a location is taken that is outside the existing polygon continues to be a finite probability. It also suffers from sample size effects, is greatly affected by outliers, and contains much area never used by an animal.

One approach to correct the problem of increasing home range size with increasing sample size is to eliminate the outliers before the home range polygon is calculated such as removing certain percentage of points such as 5%, can mitigate the outlier effect (White & Garrot, 1990).

2.3.3 Harmonic Mean (HM)

The harmonic mean (HM) is the non parametric approach that was suggested by Dixon & Chapman (1980). In this method, it can identify more than one central activity, the size of home range and the shape of home range. Central activity is calculated based on movement antenna and calculates the average distance from central activity. The movement also can calculate center of tendency, average location and distribution (Harris *et al*., 1990; White & Garrot, 1990).

This method generally developing the configuration of range with more reflection on distribution true points although some areas are not use at all by individuals. The advantage of this method is that it can calculate the central activity at most accurate (Harris *et al*., 1990). The central activity was introduced because most wildlife not uses the home range area at uniform shape. The central activity is most frequently animals using the area. However, this method is considered less robust than the kernel (Worton, 1987).

2.3.4 Kernel (K)

Probabilistic home range techniques are better than MCP's for describing how animals actually use the area within their home ranges (Anderson, 1982; Ford & Krumme, 1979; Jennrich & Turner, 1969; Worton, 1989).

One of the most robust of the probabilistic techniques is the kernel home range (Worton, 1989). Kernel is flexible estimator that can fit nonconvex, multimodal and irregularly shaped distribution (Seaman *et al.*, 1998). The probability density estimate that is produced by kernel methods may be directly interpreted as a utilization distribution (van Winkle, 1975). Kernel methods have several desirable qualities for home range estimation: (1) they are nonparametric, and therefore have the potential to accurately estimate densities of many shape, provided that the level of smoothing is selected appropriately; (2) they produce a density estimate directly; and (3) they are not influenced by grid size or placement (Silverman, 1986).

There are two major variants of kernel methods including the fixed kernel and the adaptive kernel. In the fixed kernel method, a single smoothing width is used on all the observations in the sample. In the adaptive kernel method, local adjustments are applied to the width of individual kernels. Observations in areas of high density get less smoothing (tighter fit), and observations in areas of low density get more smoothing (looser fit). Although the adaptive kernel was expected to produce better results, the fixed kernel generally produces estimates of home range size and contours with lower bias than the adaptive kernel in simulation studies (Worton, 1995; Seaman & Powell, 1996).

2.4 Previous Study on Food and Feeding

Every species in order Perissodactyla are herbivorous (DeBlase, 1979; Payne, 1990). Rhinos and horses live on grassy or in open scrub country, while tapirs are found in humid tropical forests (DeBlase, 1979; Nowak, 1991). Tapirs are browser-frugivores feeders (Bodmer, 1989; 1990; 1991; Janzen, 1982a; 1982b; Salas, 1996; Salas & Fuller, 1996; Terwilliger, 1978), most species feeding on a wide diversity of fruit (Olmos *et al.*, 1999). Most of the tapirs' waking hours were spent foraging in a zig-zag pattern (Lekagul & McNeely, 1988; MacKinnon, 1984; Terwilliger, 1978). Tapirs feed on tree foliage in the forest understorey or at its edge along streams, and also on aquatic vegetation (Sanderson, 1967), grass especially bamboo sprouts and succulent species, and fallen fruit (Anderson & Jones, 1984; Medway, 1969). Occasionally, cultivated plants are eaten (Medway, 1974). Tapirs are generalist non-ruminant herbivores able to digest many types of leaves, fruits and tubers. Post-gastric digesters (hind gut fermenters) are more generalized in their food intake than true ruminants (Bodmer, 1989; 1990). They have simple stomach structure with a large cecum (DeBlase, 1979; Hyman, 1942; Romer, 1966; Zittel, 1925).

Study on diet of Central and South American tapirs had been well established. Janzen (1982b) and Terwilliger (1978) had provided information on plant species consumed by Baird's tapir. Naranjo (1995) observed leaves, stems, flowers, fruits and bark consumed by the same species at Costa Rica while Williams (1984) reported that leaves, stems, flowers, and fruits were taken from at least 54 species of herbs, vines, shrubs, saplings and a fern, from the forest understory and forest edge. Henry *et al*. (2000) in French Guiana reported that list of fruits consumed by Lowland tapirs while Bodmer (1990) gives a shorter list of fruits eaten by Lowland tapirs in Peru. Salas & Fuller (1996), reporting information derived from ethnoecological investigation as well as conventional ecological research techniques, give a list of thirty-three fruits eaten by Lowland tapirs at their research site in Southern Venezuela.

Mountain tapirs (*Tapirus pinchaque*) eat considerable amounts of grasses, bamboo, sedges, and bromeliads in their high altitude habitats (Downer, 1996). Lizcano & Cavelier (2004b) had reported that Mountain tapir consumed 35 plant species during his study at Colombia.

It is essential to understand the role of tapirs as seed dispersers especially for large-seeded species in maintaining plant species diversity. Studies on frugivory and seed dispersal by tapirs have been conducted at several Neotropical sites (Bodmer, 1990; Fragoso, 1997; Fragoso & Huffman, 2000; Olmos *et al*., 1999; Rodrigues *et al*., 1993; Salas & Fuller, 1996). Tapirs disperse large-seeded species, especially palms (Bodmer, 1990; 1991; Fragoso, 1997). In fact, they digest many seeds and generally defecate in areas not favorable for the establishment of seedlings such as water channels (Janzen, 1971; Salas & Fuller, 1996). In addition, they typically defecate large quantities of seeds in a single place, thus causing high competition among seedlings (Howe & Schupp, 1985) or facilitating location by seed predators (Fragoso, 1997).

Too little is known about Malayan tapirs to state how many different fruits they eat or which of the seeds they effectively disperse compare to the other three species. Medway (1974) reported that a wild Malayan tapir had a very restricted diet. The young leaves of ‘Mahang’ (*Macaranga hypoleuca* and *M. hosei*) were the preferred food, with ‘Gaboit’ (*Ficus sp.*) and ‘Senduduk’ (*Melastoma malabaricus*) also taken. There was no evidence that it had taken clubmoss, fern, ginger, banana or any other herbaceous plant.

Williams & Petrides (1980) reported that Malayan tapir fed on more than 115 species, representing 70 genera and 40 plant families (but species of the Euphorbiaceae and Rubiaceae constituted 42% of the item eaten). They also found Malayan tapirs to be selective browse feeders that ate young leaves and twigs from only a few of the many species available in primary old-growth forest to secondary forest.

CHAPTER 3

MATERIALS & METHODS

3.1 Description of Study Site

Southeast Asian tropical rain forests support some of the richest assemblages of plants and animals in the world. Within Southeast Asia, Sundaland hotspot covers the western half of the Indo-Malayan archipelago and an arc of some 17,000 equatorial islands. It is dominated by two of the largest islands in the world which are Borneo and Sumatra, Java, southern part of Thailand, Singapore, Brunei and also Malay Peninsula. Sundaland is considered species ‘hot spot’ with 15,000 endemic plant species, 60 endemic threatened mammals, 59 endemic threatened amphibians and 43 endemic threatened birds (www.biodiversityhotspots.org).

The largest forest block in the Peninsula, which consists of Taman Negara, extends into Pahang, Terengganu and Kelantan and westwards to the main range, covering an area of about 3.5milion hectares (ha). Krau Wildlife Reserve (KWR) is situated in the geographical center of Peninsular Malaysia (coordinate: 3°35’N, 102°10’E) (Appendix 1), east of the forested main mountain range and south of the Peninsula’s largest protected area, Taman Negara. It is located in one of the driest regions of Peninsular Malaysia. This can be attributed to its location relative to the Terengganu Highlands in the east and the main range in the west, which shield Krau from the effects of the north-east and south-west monsoons, respectively (Ebil & Sorenson, 2000). The Reserve was declared ‘Game’ Reserve on 22 May 1923 (gazettement notice in the FMS Government Gazette dated at 15 June 1923), primarily for the protection of gaur (Hislop, 1953; Stevens, 1968). At 624km^2, it is the third largest protected area in Peninsular Malaysia (DWNP-DANCED, 1996; Elagupillay *et al.*, 2001).

Krau Wildlife Reserve is dominated by Gunung Benom (2107m), an isolated mountain, which is the fourth highest in Peninsular Malaysia. Its drainage system is made of four surrounding rivers, namely Sungai Krau, Sungai Lompat, Sungai Teris and Sungai Tekal Besar. KWR comprises one of the two largest tracts of natural lowland rain forest remaining in Peninsular Malaysia. A total of 39% of the vegetation in the Reserve is made up of lowland dipterocarp forest, 49% of hill dipterocarp forest and 4% of montane forest (Chua & Saw, 2001). Krau is a 603km^2 (60,338ha) surrounded by protected area. Most of the earlier land clearance was for rubber, but most of the surrounding land is now planted with oil palm (DWNP, 2002b). Ebil & Sorenson (2000) reported that in a 5km buffer area around the reserve, land use data from 1995 indicates:

a) 14.5% of the area was plantation agriculture, commercial as well as FELDA estates

b) 26.7% was small holdings and local community settlements and

c) The remaining 58.65% were reserved and unreserved state forest

Based on the work that has been done so far in Krau and on information from other parts of Peninsular Malaysia, the following five floristic altitudinal forest zones in Krau can be recognized:

a) Lowland dipterocarp forest

b) Hill dipterocarp forest

c) Upper dipterocarp forest

d) Montane oak-laurel forest

e) Montane ericaceous forest

Lowland dipterocarp forest occurs below 300m and dominant species include *Dipterocarpus cornutus, D. baudii, Hopea sangal, Shorea accuminata* and *S. ovalis.* Hill dipterocarp forest is found up to 750m, and some of the most abundant species are *Anisoptera laevis, Dipterocarpus grandiflorus, Shorea leprosula, S. curtisii* and *Vatica cuspidate.* From 750m to 1,200m, the vegetation type becomes upper dipterocarp forest, where *Shorea curtisii* becomes scarce and exclusive high hill dipterocarp such as *S. platyclados* and *S. ciliate* appears as well as *Eugenia sp*. and *Crytocaria sp.* This merges into montane oak-laurel forest at about 1,200m. This forest type is tall and two-storied and characterized by the abundant of oak species such as *Quercus sp*. and *Lithocarpus sp*. and the presence of *Crayoxylon arborescens, C. formosum, Erodia glabra* and *Merrillia caloxylon*. Dipterocarps are not usually present. Finally, montane ericaceous forest occurs on the highest mountain ridges above the oak forest. This is represented by dwarf and mossy vegetation. The number of oak species is low while species of ericaceous trees such as *Cythear sp., Vaccinium sp.* and *Rhododenrion sp*. are prevalent. Pitcher plant, *Nepenthes sp*. and orchids are also abundant at higher altitudes (Chua & Saw, 2001).

There are three different groups of local indigenous people living inside and around Krau known as Che Wong, Jah Hut and Temuan (Milton, 1962). Jah Hut (more than 700 households) and Temuan (less than 40 households) live around Krau. Only Che Wong (less than 70 households) live inside the reserve and are still practicing a nomadic lifestyle.

Accounts of earlier ascents of Benom have been published by Barnes (1903), Evans (1924), Henderson (1927) and Strugnell & Willbourn (1931). Medway (1972a) had reported scientific expeditions to examine flora and fauna in Krau in 1920’s. A joint expedition between British Museum of Natural History, University Malaya and Institute of Medical Research was conducted using continuous transect from lowlands to the summit of Gunung Benom (Grandison, 1972; Hill, 1972; Medway, 1972b; Whitmore, 1972; Yong, 1972). The DWNP mounted an expedition of their own that compiled a species list, mostly of mammals and birds, in parts of the reserve (DWNP, 1995; Medway & Well, 1971). Since the 1970's students from local and international universities have used Kuala Lompat as a research site to study birds (Choo & Ong, 2001; Othman *et al.*, 1983; Teresa *et al.*, 2000), bats (Davidson & Zubaid, 1992; Hodgkison, 2001; Kingston, 1997; Kingston *et al.*, 1997), langurs, (Hardy, 1988), squirrels (Payne, 1979), tragulids (Ratnam, 1982).

Recently, more research had been conducted throughout the reserve on mammals (Aminuddin *et al.*, 1999; Lopez, 2000), large mammals (Hassan *et al.*, 1999; Laidlaw *et al.*, 2000), small mammals (Saharudin & Azmi, 1995; Saharudin *et al.*, 1998; Sahir & Lim, 2000; Sirka & Olson, 2000), primates (Chivers & Davies, 1979), birds (Choo & Teresa, 2001; Mohd Taufik *et al*., 1999), bats (Saharudin *et al.*, 2000), fishes (Azizan Hadi, 2001; Jasmi & Nor Alif Wira, 2000; Jasmi *et al.*, 1995; Mohd Zakaria, 1993; Rozidan *et al.*, 1999; Zakaria-Ismail, 1993), herpetofauna (Jasmi *et al.*, 1999; Norsham *et al.*, 2001; Salman *et al.*, 1999), rafflesia (Laidlaw *et al.*, 2001), flora and fauna (Lim, 1999) and assessment of habitat (Saharudin, 2001).

3.1.1 Temperature, Humidity and Rainfall

The annual mean precipitation for 1980-1999, recorded at the nearest weather station at Temerloh to the south-east of the reserve was 1,968mm, with slight peaks in April-June and in November. The annual 24-hour mean temperature for 1999 at Temerloh was 26.40°C (Malaysia Meteorological Service, 2000). The annual mean precipitation for 2001-2006, recorded at the same weather station at Temerloh showed that the value increased by 1.9 times with the value of 3794.77±66.92(SE)mm. Slight peaks are showed in April-May and in September-December. The annual 24-hour average temperature varies between 26.63°C to 27.12°C. The annual 24-hour average humidity varies from 80.81% to 84.34%.

3.2 Camera Trapping

The use of camera trapping has two advantages. First, activity periods are particularly difficult to study because they may be subject to modification by the presence and activity of humans, and hence the observational work itself. Camera trapping minimizes disturbance and secondly, camera trapping may help to characterize activity patterns more accurately. Camera trapping also helps researchers to distinguish crepuscular activity patterns form cathemerality (van Schaik & Griffiths, 1996).

Most of camera trapping reports conducted in Malayan tapir range was using data from Malayan tiger survey. Malayan tiger survey projects' main objective is to capture Malayan tiger photos where camera-traps were set up at well used game trails with focal range between 3-5m (Kawanishi *et al.*, 1999). At this range, if there is any Malayan tapir photos occur, it is difficult to differentiate the individuals and it may leads to double counting and bias estimates.

3.2.1 Sampling Technique

Camera trapping method was used in this study from November 2002 to June 2006 to compare abundance between different saltlicks, to estimate the population size, to determine the density estimates and to obtain activity pattern of Malayan tapirs in the study area. In order to avoid double counting and therefore bias in estimates, two cameras were set-up at each location in order to get a picture of both flanks of each individual.

All of the cameras are passive infrared heat-in-motion detectors. The cameras are triggered by the sensor detecting heat and motion within range of a conical infrared beam. In this study, all camera-traps triggering mechanism were set with the same delay of 5 minutes and operated continuously both by day and night in the forest or 24 hour continuous mode. The cameras were also programmed to print the date and time (24 hour clock) of the photographs as they were taken during the period of this study.

Cameras were set along well-used tapir trails and mounted on sturdy trees 50cm above the ground with a focal range of 1-2m. There were 47 camera locations for 698 trap nights (Table 3.1). The main reason why cameras were set along well-used tapir trails is to maximize the capture probability especially trails leading to active saltlicks.

Table 3.1 Occasion Details for Camera Trapping Set-Up at KWR During the Study.

No.	***Occasion***	***Camera Location***	***No. of Month***	***Trap-nights***
1	16	Bayek	19	243*
2	1	Bayek Neram	1	20*
3	2	Baik Pauh	2	30*
4	9	Wan Bulan	9	110*
5	4	Rumah Tok	5	73*
6	8	Neram	9	113*
7	1	Mengkuang Senil	1	15
8	1	Kongsi Enam	1	18
9	1	Senderuk	1	5
10	1	Padang Seladang	1	19
11	1	Kuala Liau	1	13*
12	1	Bukit Gahun	1	25
13	1	Bukit Reroh	1	14*
TOTAL	***47***		***52***	***698***

*Date and trap-nights are according to when it is Open/Close,
as there is no date and time recorded on the photos.

Sometimes, the time records on certain photographs were illegible. This was due to the over exposure of flash in the corner of the photograph in which the time was marked. Occasionally, also, the time and date were not printed on the photographs. This was largely due to human error during the process of setting up and programming of the cameras. These photographs, without inscribed times, were not used in analysis of activity patterns (Laidlaw & Wan, 1998).

After the photos were printed, it was arranged in a photo album with specific labels. The information was then recorded in Excel file as softcopy. There are some needs for consideration during the photo classification:

a) Trap-night was counted from the ‘Open’ to ‘Close’ occasion for photo with date and time. ‘Open’ and ‘Close’ is the team member’s photo crawling in front of the camera.

b) Project team setting the camera at first photo was set as ‘Open’/’Close’ not ‘Human Activity’

c) Project team other than ‘Open’/’Close’ counted as ‘Human Activity’

d) Photo without date and time

    a. The absence of same species such as Wild boar or Barking deer with the same physical appearance continuously was counted as one image except for Malayan tapir. All photograph of Malayan tapir will go to a specific process of identification as mention in Chapter Four (refer Figure 4.2)

    b. Tapir photos, continuous identified individuals were counted as one image

e) Photo with date and time

    a. The absence of same species with similar physical appearance within 5 minutes continuously was counted as one image except for tapir

    b. The absence of same species with similar physical appearance within 24 hours were counted as one image except for tapir

    c. Tapir photos, identified individuals continuously counted as one image

The absence of same species with similar physical appearance continuously or within a period of 5 minutes or 24 hours was counted as one image. This is so because it is assumed that the species is actually the same individual except for tapir. As for tapir, each photo was compared in order to identify each individual. The known individuals were labeled with specific numbers. Photos from the two different cameras set up at the same location were arranged according to time. Individuals with photos of both flanks were identified. If there was no time printed, estimation of the same picture taken was done by looking at the animal position and the surrounding.

3.2.2 Assumptions and Data Analysis

The ratio of tapirs photo-captured per unit sampling effort is calculated in order to compare it with other camera-trap report. It calculates the number of times that Malayan tapir passed through the camera per number of trapping hours.

Relative Abundance Index (RAI) is another form of quantitative data on abundance of large mammals in a form other than ‘number of tracks’. A reliable abundance assessment requires that information be accountable and in relation of space and time (Kawanishi *et al.,* 1999).

In order to calculate the Relative Abundance Index (RAI), the trap-night (tn) is calculated using the formula of $tn = \sum_{i=1} tn_i$, where i is the number of camera location and tn is the value of trap-night at i location. In other word, this value is the total number of camera operates in the field. The value of tn=1 showed that the camera is left 24 hours (Kawanishi, 2001; Kawanishi *et al.,* 1999). RAI is calculated using the formula, $RAI = \sum_{i=1} [d_i (100)]/tn$, where i is the camera location and d is the present of species at i location (Edsel *et al.,* 2003; Kawanishi, 2001; Kawanishi *et al.,* 1999). This Index is used to estimate the abundance of Malayan tapir at different saltlicks in the area of study.