TAPIR BEHAVIOR- AN EXAMINATION OF ACTIVITY PATTERNS, MOTHER YOUNG INTERACTIONS, SPATIAL USE, AND ENVIRONMENTAL EFFECTS IN CAPTIVITY ON TWO SPECIES

(*Tapirus indicus* & *Tapirus bairdii*)

By

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CHAPTER I

INTRODUCTION

The four species of tapirs rank among the most poorly studied mammals on Earth (Morris, 2005). Relatively little is known about the social structure, mating systems, population structure, and dispersal patterns of tapirs (Ashley et al., 1996; Cohn, 2000; Norton and Ashley, 2004a). The tapir literature, however, indicates that these animals are important ecosystem components, and may serve as a keystone species (Downer, 2001). Tapirs are seed dispersers, seed predators, and promote new growth by clearing patches within the forest (Bodmer, 1991; Fragoso and Huffman, 2000; Galetti et al., 2001; Holden et al., 2003; Janzen, 1981; Naranjo Pinera and Aldan, 1998; Olmos, 1997; Wright et al., 2000).

The number of tapirs is declining worldwide, and all extant species of tapir are either threatened or endangered (Alais et al., 2002; Downer and Castellanos, 2002a; Downer and Castellanos, 2002b; Kawanishi et al., 2003). This decline is due to habitat loss and degradation, as well as, hunting (Alais et al., 2002; Bodmer, 1995; Bodmer and Brooks, 1997; Bonaudo et al., 2005; Costa et al., 2005; Downer and Castellanos, 2002a; Downer and Castellanos, 2002b; Downer, 1996; Downer, 1997; Flesher, 1999; Hill et al., 2003; Kawanishi et al., 2003; Naranjo Pinera, 2004). Advancing our understanding of tapir behavior will provide important knowledge for captive propagation programs, as well as, allowing for better management and conservation of wild populations.

Currently, the Malay tapir (*Tapirus indicus*) is the most abundant in North American zoos followed closely by the lowland tapir (*Tapirus terrestris*) (Figure 1). The mountain tapir (*Tapirus pinchaque*) is the least abundant species in captivity. The American Zoo and Aquarium Association (AZA) has decided to focus its efforts on the conservation of both the Malay and Baird's tapir (*Tapirus bairdii*). Research of these two species was one of the recommendations made in the Tapir Taxon Advisory Group (TTAG) report. (Barongi, 2003).

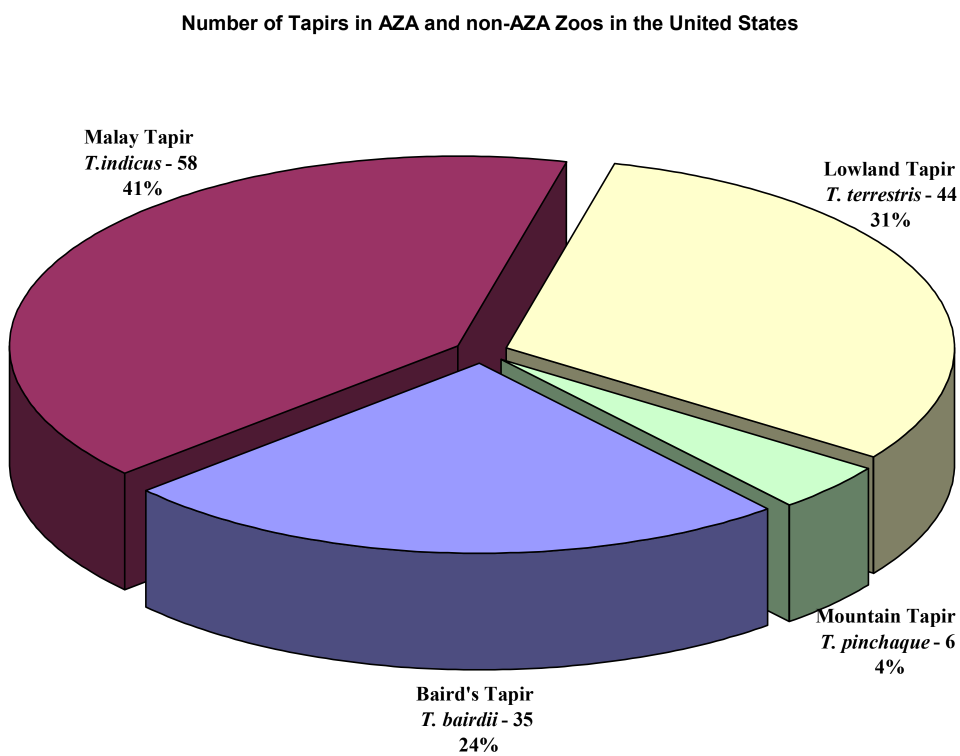

Figure 1. The number and percent of tapirs in United States zoos by species (based on Barongi, 2003).

The majority of the scientific literature on captive tapirs has focused on all four species; most of these papers focused on genetics, anatomy, or physiology. The Malay tapir was the most studied species of tapir, although only a third of publications were scientific research papers (Figure 2 & Appendix- Table 10). The mountain tapir was the least studied.

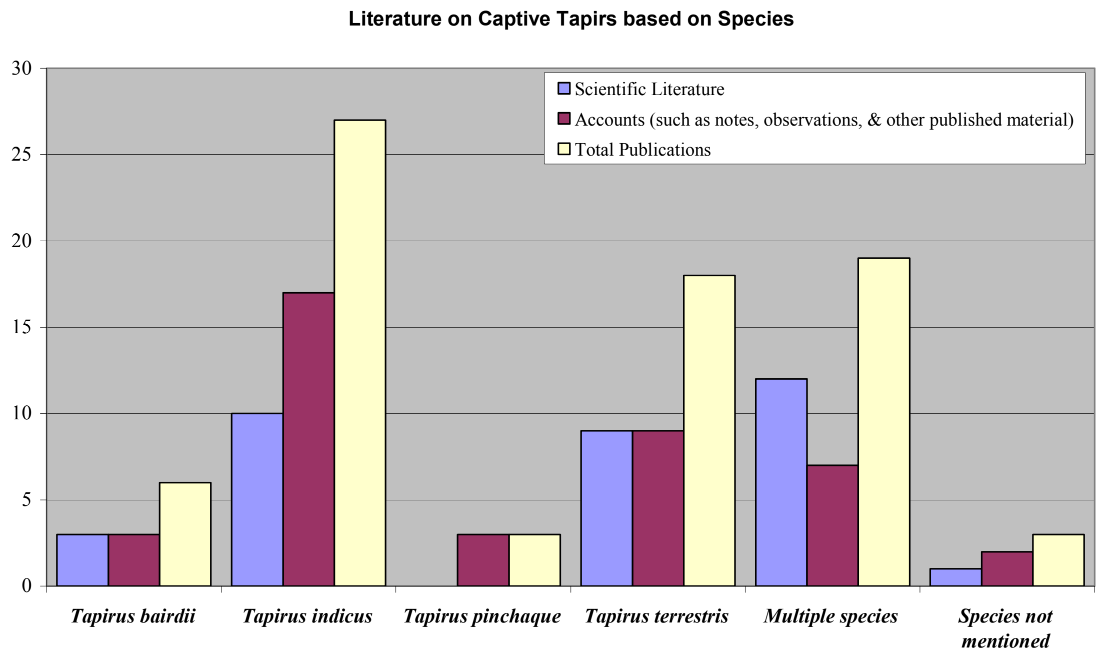

Figure 2. Publications on tapirs in captivity by species.

Much of the literature published on captive tapirs focuses on reproduction, anatomy, physiology, nutrition, medical care, and husbandry practices (Figure 3 & Appendix- Table 11). Most scientific research has focused on anatomy, physiology, genetics, or medical care. Little research has been published on the behavior of captive tapirs, and most behavioral studies have focused on time budgets (Mahler, 1984b; Seitz, 2000a; Torres et al., 2004a). Even less has been studied regarding comparisons among different species, and only general behaviors were compared via basic time budgets (Seitz, 2000a). Research that has focused on specific behaviors has centered on reproduction and enrichment; however, some mention of aggression toward conspecifics has been made and one study looked at preference testing in tapirs (Appendix- Table 11).

The purpose of this study was to advance understanding of captive tapir behaviors. Specific objectives were to:

1. determine activity patterns,
2. study the effect of environmental variables on tapir behavior,
3. investigate spatial use of enclosures and its relationship to behavior, and
4. examine the interactions between mother and young.

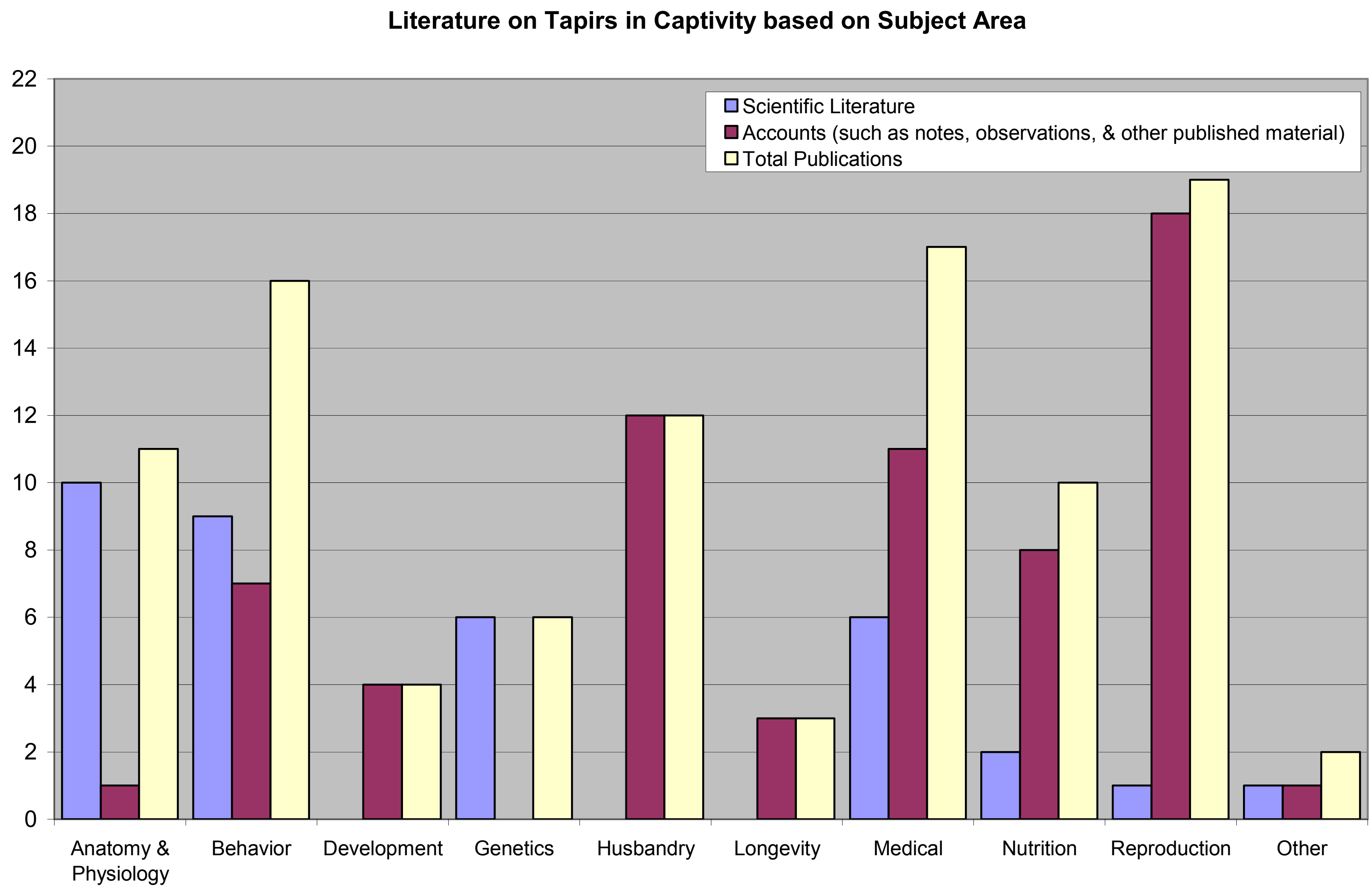

Figure 3. Publications on captive tapirs by subject area.

CHAPTER II

REVIEW OF LITERATURE

GENERAL

Within the mammalian order of Perissodactyla are three families; Tapiridae (tapirs), Equidae (horses, zebras, and asses), and Rhinocerotidae (rhinoceroses). First appearing in the Paleocene, the extant Perissodactyla have a modified ankle joint with restricted lateral movement which serves as an adaptation for running (Hooker, 1994; Norman and Ashley, 2000).

Tapiridae includes four extant species, three in the New World and one Old World. This discontinuous distribution is the remnant of a former widespread distribution across Europe, North America, Asia, and South America during the Pleistocene. The number of tapirs is declining worldwide, and all species of tapir are either threatened or endangered due to habitat loss and fragmentation and/or hunting (Ashley et al., 1996; Cohn, 2000). As with many large mammals, tapirs are more prone to extinction; part of what makes them particularly vulnerable is a low reproductive rate (Cohn, 2000; Daily et al., 2003).

All species of tapir share a similar morphology- long rounded body, stout legs, a trunk-like proboscis, three toes on each hind foot, and four toes on each front foot

(Barongi, 1993; Cohn, 2000; Witmer et al., 1999). The Malay tapir *(Tapirus indicus)* is the largest of the extant Tapiridae. The most distinctive physical difference from the South and Central American species is a striking black and white color pattern in the Malay tapir. The head, limbs, and front half of the body are black whereas the torso, rump and thighs are white along with the tips of the ears; however, a rare all-black melanistic variation does occur (Azlan, 2002; Harper, 1945; Thom, 1936). The Baird's tapir (*Tapirus bairdii*) is the largest American species and is solid brown in color. The lowland tapir (*Tapirus terrestris*) is also brown in coloration but has a distinctive sagittal crest (Eisenberg et al., 1990). The mountain tapir (*Tapirus pinchaque*) is the smallest of the extant tapirs, and has a thick wooly coat to stay warm on the mountains it inhabits. Its pelage ranges in color from black to brown to a reddish hue (Eisenberg et al., 1990). All young tapirs are brown with white stripes and spots; this pattern aids in camouflaging the young until they are larger and less vulnerable to predation (Eisenberg et al., 1990).

Tapirs experienced rapid divergence 20-30 million years ago (Figure 4). Phylogenetic analysis supported the Malay tapir as a sister group to the Neotropical species which diverged 21 to 25 million years ago. The Baird's tapir diverged 19 to 20 million years ago from the other South American species, while the mountain tapir and the lowland tapir are the most closely related species of extant tapirs, diverging 3 million years ago. (Ashley et al., 1996).

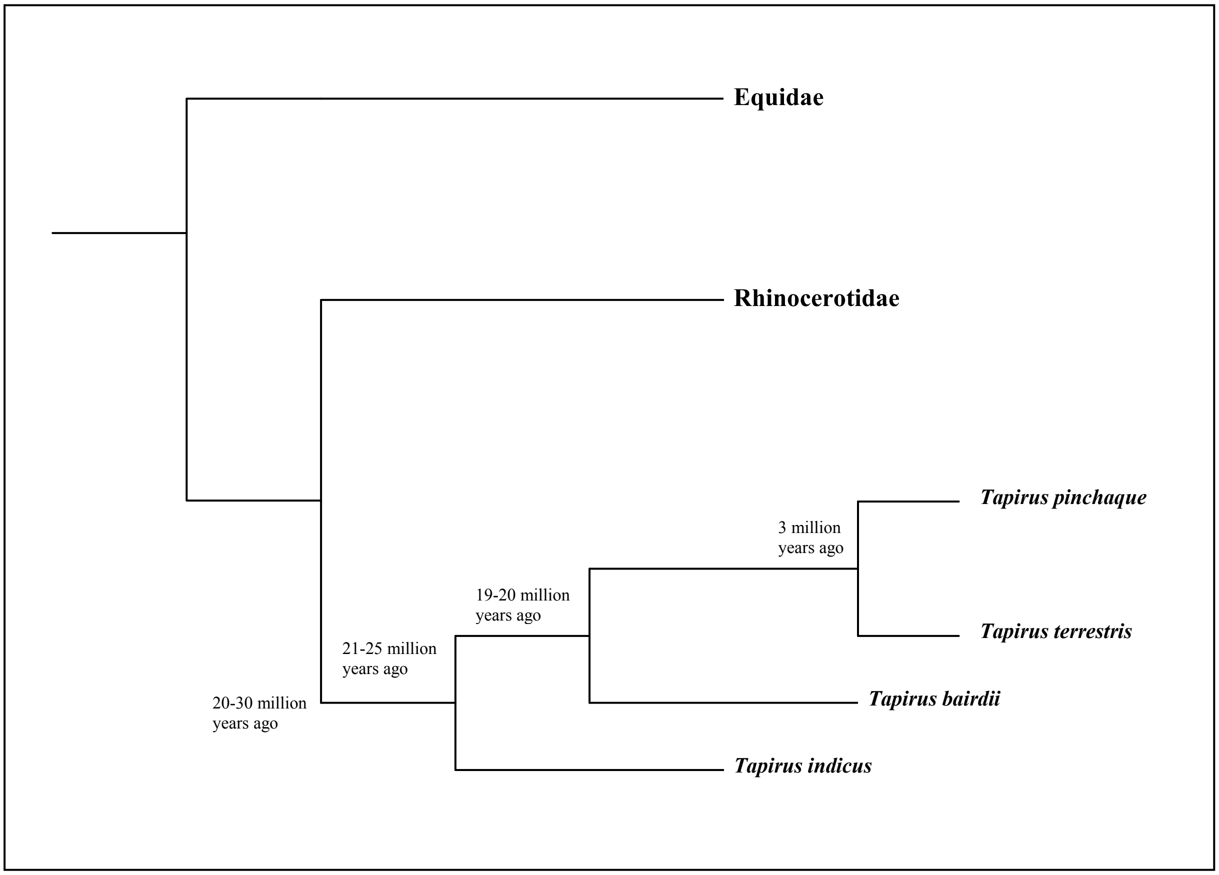

Figure 4. Cladogram of Tapiridae based on (Ashley et al., 1996; Norman and Ashley, 2000)

BAIRD'S TAPIR (*Tapirus bairdii*)

Distribution and Threats

Baird's tapir (*Tapirus bairdii*) has a limited and highly fragmented range extending from southern Mexico to the northwestern section of Ecuador (Figure 5). Locally extirpated from El Salvador, and regions of Ecuador, Mexico, and Central America; Baird's tapir is considered highly vulnerable and is endangered due to habitat loss and hunting. (Alais et al., 2002; Daily et al., 2003; Eisenberg, 1988; ESA, 2005; Flesher, 1999; Fumagalli, 2004; Norton and Ashley, 2004a).

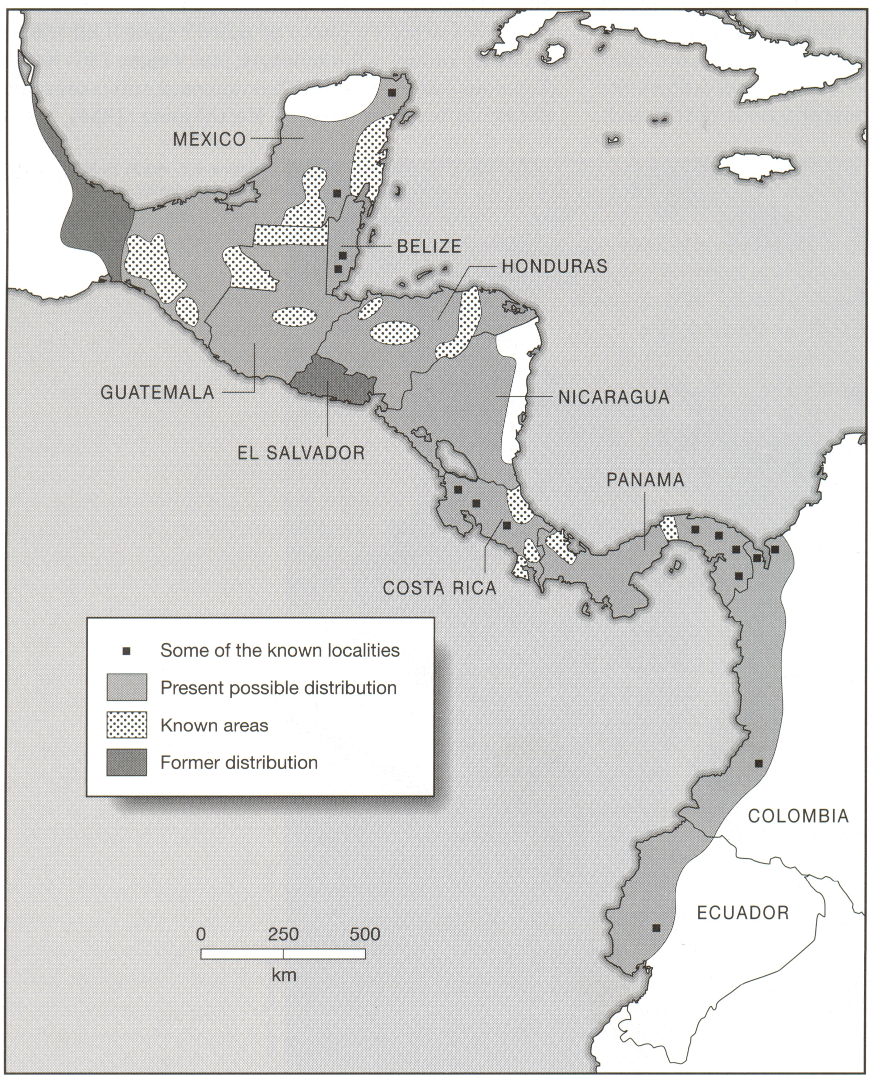

Figure 5. Distribution of the Baird's tapir (Matola et al., 1997).

Habitat loss and fragmentation is the major threat to Baird's tapir (Flesher, 1999). Seventy five percent of Baird's tapir habitat in Central America has been destroyed over the past forty years and habitat availability models estimate tapir habitat will continue to decline (Cohn, 2000; Cuaron, 2000). The fragmented nature of the range has increased the probability of demographic, genetic, or environmental stochasticity causing extinction (Scott and Castleberry, 2004). Throughout this range, some areas are protected in parks and reserves; however, only a handful are large enough to sustain long term populations of tapirs (Norton and Ashley, 2004a).

Baird's tapir is preferred game in most of the Neotropics and hunted throughout its range (Daily et al., 2003; Estrada, 2004; Wright et al., 2000). Tapirs are hunted, not only because they provide a large amount of meat, but in some areas can increase the status of the hunter (Cohn, 2000; Townsend, 2002). Overhunting is extremely common, and as early as the 1930s, Baird's tapir began showing reduction in area occupied due to hunting and poaching (Enders, 1939; Naranjo Pinera, 2002). Hunting has reduced tapirs in some areas from 20.6% to 3.6% of the mammalian biomass (Eisenberg and Thorington, 1973). Tapirs are vulnerable to hunting and have slow recovery rates (Naranjo Pinera, 2002). Poaching increases during Christmastime because people want extra money (Morris, 2005).

Baird's tapirs have among the lowest heterozygosity and allelic diversity reported in large mammals (Norton and Ashley, 2004a). This is consistent with a history of isolation or a bottleneck which occurred about 25-50 generations earlier (Norton and Ashley, 2004a). At that time throughout Central America, major industrial and agricultural development was beginning, resulting in habitat destruction and fragmentation, as well as increased hunting (Norton and Ashley, 2004a). To reduce further loss of heterozygosity, biological corridors should be established throughout the range of the Baird's tapir (Norton and Ashley, 2004a).

Folklore

In some regions of Central America, the tapir thought to be the master of the forests and other forest animals (Paulson and Auer, 1964). In Mexico, many deities share similar traits to the tapir, particularly the nose (Gunckel, 1897; Yetts, 1924). The tapir is considered to be close relatives, as well as, of deep symbolic and sacred value to the indigenous communities of Bribris and Cabecares (Carbonell and Torrealba, 2004). In other cultures, such as the Coshiro-wa-teri of Brazil and Venezuela, and the Achuar of Ecuador) there are taboos prohibiting the consumption Baird's tapir (Colding and Folke, 2001).

Population Dynamics

Very little data about wild population size and structure is available on *T. bairdii* (Norton and Ashley, 2004a; Norton and Ashley, 2004b). Population density is hard to calculate and easy to over-estimate (Eisenberg and Thorington, 1973). Population density estimates range from 0.05-1.33 individuals/km^2 (Matola et al., 1997; Naranjo Pinera, 2002; Naranjo Pinera and Bodmer, 2002; Torres et al., 2004b).

Home range size ranged from 0.15-1.80km^2 for males and from 0.50-3.22km^2 for females depending on the habitat type (Foerster, 2002a; Foerster, 2002b; Foerster and Vaughan, 2002; Matola et al., 1997; Morris, 2005; Williams, 1991). Home ranges overlapped extensively with other individuals (Foerster and Vaughan, 2002; Matola et al., 1997). In degraded habitat, the size of home ranges increased (Morris, 2005). The area occupied during the day was much larger than what was used at night (Matola et al., 1997). Males would occasionally travel outside of their home range for a day or two (Williams, 1991). To establish a new home range, dispersing individuals have moved over 20 km in a day (Naranjo Pinera, 2002; Naranjo Pinera and Bodmer, 2002).

Habitat Use

Baird's tapir have been found at elevations from sea level to 3600m in a variety of habitats included marshes, mangroves, swamps, wet tropical forests, riparian woodlands, monsoonal deciduous forest, dry deciduous forests, and montane cloud forests (Foerster and Vaughan, 2002; Matola et al., 1997). Generally, tapirs occurred in humid habitats, preferring areas with permanent bodies of water (Matola et al., 1997; Morris, 2005; Williams, 1991). Favored browsing sites tended to have less herbaceous cover and relatively flat elevation (although tapirs traveled up slopes as steep as 45 degrees) such as flood-plains (Matola et al., 1997; Tobler, 2002). Tapirs used trails and riverbeds to travel through the forest (Matola et al., 1997).

Preferred habitat includes cloud forests, semi-deciduous tropical forests, deciduous tropical forests, and palm swamps (Matola et al., 1997; Naranjo Pinera and Aldan, 1998; Torres et al., 2004b). Although tapirs require primary forests, studies have shown that secondary forest in advanced regenerative state is preferred habitat (Foerster, 2002b; Foerster and Vaughan, 2002; Fumagalli, 2004; Matola et al., 1997; Morris, 2005). In one study tapirs used secondary forest 61.3% of the time and primary forest 25.0% of the time (Foerster and Vaughan, 2002). Habitat usage also varies by season; primary forest use is greater in wet season, most likely due to increased fruit availability (Foerster and Vaughan, 2002).

Tapirs avoided areas where human activity was high, such as ecotourism sites, hunting sites, and disturbed habitats such as grasslands, pine forests, and cultivated areas (such as those for coffee and banana plantations, and cattle farms) (Constantino and Ho, 2002; Naranjo Pinera and Aldan, 1998; Torres et al., 2004b). Tapirs traveled and rested within 300m of houses within a village; however, tracks and other signs were less abundant near the village than in other parts of the forest (Flesher and Ley, 1996; Tobler, 2002).

Daily activity patterns

Baird's tapirs are mainly active at night but not strictly nocturnal (Park, 1938; Terwilliger, 1978; Williams, 1991). Diurnal activity averaged 20.2% of the time and nocturnal activity averaged 80.4%, although daily activity pattern varied seasonally, as well as, monthly (Foerster and Vaughan, 2002; Leal and Foerster, 2004). Diurnal activity increased during the wet season (Foerster and Vaughan, 2002). Peak activity occurred from 0400-0700 EDT and 1800-2000 EDT (Williams, 1991).

During the day, tapirs primarily rested in dense vegetation and near or in water (Eisenberg et al., 1990; Foerster and Vaughan, 2002; Williams, 1991). Water played a very minor role in site selection at night (Foerster and Vaughan, 2002). During the dry season almost all resting sites were in mud wallows (Foerster and Vaughan, 2002). All resting sites had a canopy cover greater than 55%; however, wet resting sites (mud holes and stream sites) had a lower canopy cover than dry forest sites (Alger, 1998). Site type, as well as, the amount of shade was affected by the time of day, whereas substrate type, substrate hydration, site type, and percent of canopy coverage were affected by weather conditions (Alger, 1998). Alger (1998) suggested that tapirs may use microhabitat selection to facilitate thermoregulation. Resting sites were visited an average of 2.6 times (Alger, 1998).

Diet

The Baird's tapirs are general browsers (Mendoza et al., 2002). Tapirs wander through the forest in a zigzag fashion feeding on a few leaves from one plant to another (Matola et al., 1997; Terwilliger, 1978). Tapirs use their proboscis to pull leaves off branches and bring the food to their mouth much as elephants do (Eisenberg et al., 1990; Williams, 1991). To reach desired foliage, saplings up to 4.5cm in diameter are snapped off at a height ranging from 1 to 4 meters (Terwilliger, 1978; Williams, 1991). Tapirs have the ability to reach higher branches by standing on their hind legs (Williams, 1991).Young trees are also knocked down to reach desired vegetation (Terwilliger, 1978). This method of feeding reduces competition with collared peccary (*Peccari tajacu*) and white-tailed deer (*Odocoileus virginanus*), and makes vegetation available to smaller mammals (Williams, 1991).

Baird's tapir required at least 40kg of vegetation a day and consume leaves, buds, stems, bark, herbs, sedges, grasses, vines, shrubs, saplings, ferns, flowers, fruits, and aquatic vegetation (Eisenberg et al., 1990; Foerster and Vaughan, 2002; Galetti et al., 2001; Janzen, 1981; Janzen, 1982; Matola et al., 1997; Morris, 2005; Naranjo Pinera and Aldan, 1998; Olmos, 1997; Terwilliger, 1978; Tobler, 2002). The composition of *T. bairdii*'s diet varied greatly by habitat, season, and month (Torres et al., 2004c). Leaves and stems made up 15.3%-98.6% of the diet, fruit made up 1.4%-3.9%, fibers (not used in all studies) made up 50.0%-50.6%, twigs (also not used in all studies) ranged from 14.4% to a portion was too fine to distinguish (Aldan et al., 2004; Tobler, 2002; Torres et al., 2004c). During the dry season (December to late April) the quantity of fruit eaten increases due to the peak of fruit production and loss of deciduous plant leaves (Williams, 1991). Tapirs will repeatedly visit a fruit patch, consuming as much of the fruit as possible (Naranjo Pinera, 2002).

Baird's tapir ate over 192 species, but selectively browsed for *Licania platypus, Quercus costaricense, Anthurium sp., Buddleja sp.,* and *Columnea sp.* (Table 12) (Foerster and Vaughan, 2002; Tobler, 2002). Solanaceae, Rubiaceae, and Asteraceae were eaten most frequently, although one study found that the most abundant plants in an area were the ones tapirs ate (Terwilliger, 1978; Torres et al., 2004c). *Syagrus romanzoffiana* and *Chusquea sp.* are of particular importance to the diet of tapirs in some areas (Galetti et al., 2001; Torres et al., 2004c). Exotic species such as *Mangifera indica* and *Psidium guajava* were eaten more in the dry season (Galetti et al., 2001).

Tapirs are considered important dispersers of seeds because they can disperse a large quantity of seeds long distances (Bodmer, 1991; Fragoso and Huffman, 2000; Galetti et al., 2001; Naranjo Pinera and Aldan, 1998; Olmos, 1997; Wright et al., 2000). Seeds up to 4 cm in diameter were dispersed by the Baird's tapir (Galetti et al., 2001). Over 2103 seeds were found in the feces of tapir (Galetti et al., 2001). Forty plants have been found to be dispersed by *T. bairdii*. Both *Syagrus oleracea* and *Enterolobium contortisiliquum* are known to be dispersed by Baird's tapirs (the only extant mammal that can disperse the seeds for these plants through feces) (Galetti et al., 2001). Tapirs have been shown to serve both as seed predators and seed dispersers of *Enterolobium cyclocarpum* (Janzen, 1981). Tapirs also clear areas in the forest thus promoting growth (Cohn, 2000).

To obtain detoxifying chemicals, tapirs will visit salt licks and salt water sites, consuming salt, salt water, and even eat dirt (Cohn, 2000).

Water usage

Surface water is extremely important in the natural history of Baird's tapir (Eisenberg et al., 1990; Matola, 2002a). Defecation occurs both in water and in latrines (Eisenberg et al., 1990; Matola et al., 1997; Williams, 1991). Baird's tapir can hold its breath underwater for 10 minutes and walk along the bottom as do hippopotami (Barongi, 1993; Matola et al., 1997; Morris, 2005). Wallowing in mud provides a coating of mud on their hide which inhibits insects from biting (Eisenberg et al., 1990). Tapirs also use water to escape predators, keep cool, and, occasionally, for mating (Eisenberg et al., 1990; Matola, 2002a).

Social Behavior

Originally thought to be essentially solitary, tapirs do form groups at times (Williams, 1991). Family groups composed of a monogamous pair and their young, share overlapping home ranges and both travel and rest together (Foerster, 2002a; Foerster and Vaughan, 2002; Terwilliger, 1978). When the next offspring is born, the oldest offspring is aggressively chased off by the mother (Foerster and Vaughan, 2002; Williams, 1991). Sibling tapirs may spend a great deal of their time together resting and foraging (Foerster and Vaughan, 2002). Tapirs spray urine but the reason is unknown. Although some suggest that the male is marking his territory against other males; however, territories are not always aggressively protected and other tapirs may wander into conspecific's home range in search of fruit or salt licks (Eisenberg et al., 1990; Foerster and Vaughan, 2002; Morris, 2005; Terwilliger, 1978; Williams, 1991). Males have been known to show aggression to new individuals introduced on an island setting (Eisenberg and Thorington, 1973). It is likely that tapirs live in a community in which they know one another and tolerate known individuals but not strangers (Eisenberg and Thorington, 1973). Tapirs will forage in groups at times (Terwilliger, 1978). Terwilliger (1978) observed tapirs touching noses and vocalizing to each other.

Communication

Several different vocalizations have been reported for the Baird's tapir, including whistles, squeals, squeaks, whimpers, grunts, and a hiccup sound (Morris, 2005; Terwilliger, 1978). The whistling sound was heard most often and was used for communication over longer distances. The squeals and squeaks were high pitched and made when frightened; as the tapir ran away the intensity of these calls lessened. Grunts were made when aggravated, while the hiccup sound may indicate agitation or may be a call between mother and young. The whimper was heard in response to the hiccup vocalization. (Terwilliger, 1978).

Reproduction

Baird's tapir form monogamous pairs, staying paired until the death of one partner (Morris, 2005). The male may "cheat" if the opportunity arises but he stays near his mate when she is in estrus, guarding her from other males (Morris, 2005). Males will fight for an untaken female until the strongest male chases the other away (Morris, 2005). Sexual maturity occurs between 22 and 24 months (Matola et al., 1997).

Tapir gestation is 390 to 410 days (Eisenberg et al., 1990; Matola et al., 1997; Ramsay et al., 1994). The average interbirth interval is 20.9 months and on average the female has one young every two years (Foerster, 2002a). In captivity, tapirs have fast growth during the first year of their life, growing an average of 450g /night, 28.4 mm/ month in the body, and 7.5 mm/ month in the limbs (Morris, 2005; Sanchez and Aldan, 2004). While its mother is foraging, the newborn is hidden away in an isolated place; after 10 days the young is able to follow the mother (Eisenberg, 1988; Eisenberg et al., 1990; Matola et al., 1997). Weaning occurs within a year (Terwilliger, 1978). The mother will protect her young by charging the threat and raising her proboscis to one side in a stereotypic behavior (Terwilliger, 1978). The role of the father in raising the young is not clearly understood; however, he is a part of the family group and spends some of his time with the offspring (Terwilliger, 1978). Tapirs stay with their mother until the next offspring is born (Williams, 1991).

Predation

Predation on tapirs by cougars (*Felis concolor*) or jaguars (*Panthera onca)* is rarely observed; however fecal samples reveal that tapir occurs in the diets of both cats with medium frequency making it is an important component of their diet (Mendoza and Aldan, 2004). Crocodiles (*Crocodylus sp.*) will sometimes prey upon young tapirs (Matola, 2002b). When confronted in the wild, tapirs flee, often seeking water for refuge (Cohn, 2000; Eisenberg et al., 1990; Morris, 2005; Williams, 1991). Tapirs also have strong jaws and sharp incisors (Morris, 2005).

Mutualism

Coatis (*Nasua nasua*) have been seen grooming ticks (Metastigmata sps.) from the Baird's tapir, this mutualism is thought to be a human-created behavior which only occurred at the feed box and most likely nowhere else (McClearn, 1992). Similar behavior has been noted in captivity in which a peccary (*Pecari sp*.) groomed ticks from the tapir (Eisenberg, 1988). Small fish in freshwater streams will eat external parasites from tapirs (Morris, 2005).

MALAY TAPIR (*Tapirus indicus*)

Distribution and Threats

The Malay tapir (*Tapirus indicus*) has a limited and highly fragmented range in Myanmar, Thailand, Viet Nam, Cambodia, and Sumatra due to habitat loss (Figure 6) (Khan, 1997).

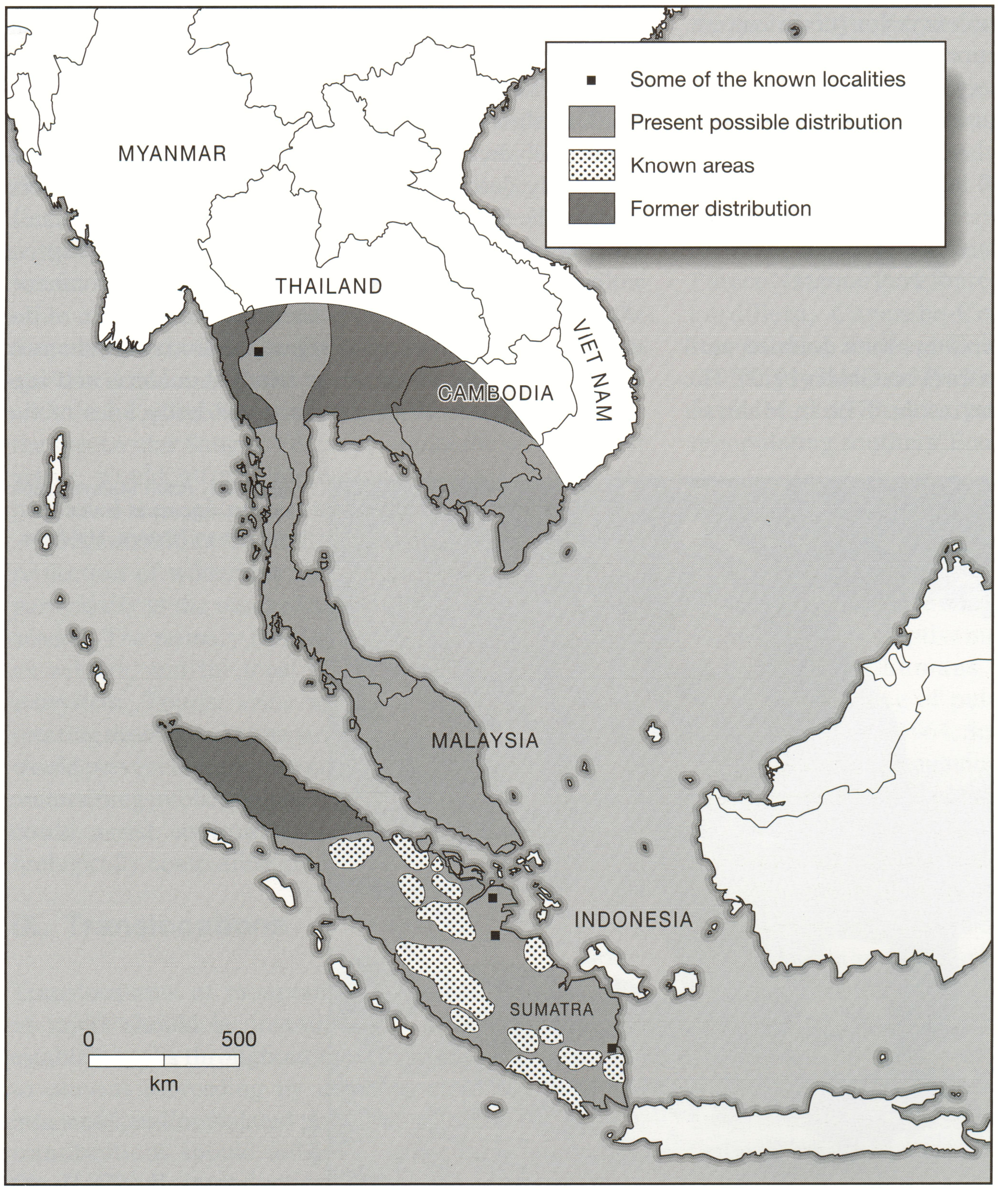

Figure 6. Distribution of the Malay tapir (Khan, 1997).

Tapirs are infrequently hunted due to various cultural taboos and myths, although in some areas they are hunted for food. Hunting also occurs when tapirs eat crops or the bark off plantation trees (Holden et al., 2003). The major threat to the Malay tapir is not hunting but habitat loss and fragmentation. The forests they inhabit are being cleared for rubber and palm oil plantations, cropland, and cities (Anon., 1999). The Malay tapir is currently listed on the IUCN red list as vulnerable and the Sumatran population is listed as endangered (Kawanishi et al., 2003).

Folklore

The Siamese name for the tapir was “P’som-sett” which means a mixture of things. Folklore stated that tapirs were created last out of the parts leftover from all the other animals (Morris, 2005; Sandborn and Watkins, 1950). In Malaysia, Chinese immigrants called the tapir a strange “Si-bu-xiang” (their name for Père David’s deer) because it had the face of a horse, hooves of a rhino, nose of an elephant, and nostrils of a pig. “Si-bu-xiang” translates as four images and nothing is like it (Kawanishi et al., 2002).

Population Dynamics

Densities of the Malay tapir range from 0.30-0.44 ind/km^2 in high quality undisturbed swamp forest and lowland forests respectively, to as low as 0.035ind/km^2 (Medici et al., 2003). One male had a home range of 12.75km^2 and a female had a home range of 25km^2, traveling over 4km in a single day (Traeholt, 2004; Williams, 1978). It is thought that females may have larger ranges than males (Williams, 1991). Tapirs show intraspecific tolerance and have overlapping home ranges (Williams, 1978).

Habitat use

Tapirs are nocturnal forest dwellers. They occur in primary forests, secondary forests, mature rubber plantations, forest edges, and even open fields (Holden et al., 2003). Tapirs are found at approximately equal numbers both near and far from the forest edge, tending either to be deep (3+ km) or just inside (1-2km) the forest and occasionally outside the forest (Kinnaird et al., 2003). Tapirs may use previously logged forests for browsing but may require areas of nearby primary forest as refugia (Santiapillai and Ramono, 1990; Williams, 1991).

Elevation is an important factor in tapir habitat. Holden et al. (2003) found a negative correlation between tapir abundance and elevation. Over half the individuals observed were seen at the lowest elevation. Williams (1978) found the most signs of tapirs in lower slopes and valley bottoms. Khan (1997) limited the Malay tapir to an elevation of about 1220m; however, a lone tapir was observed at an elevation between 1800-2400m (Holden et al., 2003).

Tapirs are sometimes found close to villages and will even come within a 5km radius of major cities (Khan, 1997; Thom, 1936). A tapir was also spotted swimming in the Straits of Malacca (Anon., 1999). Tapirs wander haphazardly on and off manmade trails only using the trails to cross gullies and rivers, at saddles between hills, or near salt licks (Williams, 1978).

Daily Activity Patterns

Daily activity patterns may consist of searching for food at night and resting periodically throughout the day (Anon., 1834). Tapirs have been observed traveling to marshy grassland or floodplains to feed at night while spending the day in dense vegetation and swamp forests (Dudgeon, 2000a; Dudgeon, 2000b). However, Williams (1978) found the behavior of a radio-tracked individual to be random.

Tapirs rest in dense underbrush (Eisenberg et al., 1990), small hollows, level ground, high ridge tops, spurs, and open areas often choosing a site near water (Williams, 1978). Resting spots are sometimes used several times (Williams, 1978).

Diet

The Malay tapir is a forest herbivore. MacKinnon (in Santiapillai and Ramono 1990) refers to the tapir as a wasteful feeder. The selective browsing and grazing nature and suggests that tapirs select high quality food when available (Medway, 1974; Mendoza et al., 2002; Olmos, 1997; Santiapillai and Ramono, 1990; Williams and Petrides, 1980). The proboscis is ideal for browsing on green shoots allowing it to pluck leaves from branches and place them into its mouth (Barongi, 1993; Santiapillai and Ramono, 1990). The tapir wanders through the forest in a zigzag fashion feeding on a few leaves from one plant then moves on to another, and often travels great distances while feeding (Sandborn and Watkins, 1950). The tapir is an unspecialized feeder; however, its selective nature translates into broad habitat requirements (Santiapillai and Ramono 1990).

In captivity tapirs consume 4-5% of their body weight daily; although pregnant or lactating females consume slightly more (Barongi, 1993). The Malay tapir weighs between 250-450kg (Barongi, 1993; Eisenberg et al., 1990), so it needs at least 10-22.5kg of food/day in the wild.

Tapirs ate leaves, buds, growing twigs, bark, herbs, low growing succulents, fruits, club moss, grasses, and aquatic vegetation (Khan, 1997; Santiapillai and Ramono, 1990; Williams and Petrides, 1980). The diet of tapirs in Thailand was composed of 86.5% leaves, 8.1% fruit, and 5.4% twig matter (Khan, 1997). The Malay tapir has been known to feed on more than 122 species of plants (Table 12) (Khan, 1997). The diet of tapirs relied heavily on two of the largest woody plant families in the forest, Euphorbiaceae and Rubianceae, which made up 41.7% of the total plants consumed (Williams and Petrides, 1980). In primary forest, 27 species of plants were favored by the tapir (Williams and Petrides, 1980), while for a tapir in secondary forest 9 plant species were favored (Medway, 1974). In Thailand, 39 plant species were selectively browsed (Khan, 1997). Tapirs also ingested large amounts of a plant containing laxative properties (Wilson and Wilson, 1973). To reach desired branches, saplings less than 3.8cm in diameter were snapped off while saplings 2-6.5cm in diameter were pushed over or walked down (Williams, 1978; Williams and Petrides, 1980). Tapirs have been considered a pest species in some areas for eating the bark of rubber trees or consuming watermelon and cucumber crops (Holden et al., 2003).

Tapirs ate both small fruits (1-6cm diameter), as well as, larger fruits (such as durian- *Durio zibethinus* and jackfruit- *Artocarpus heterophyllus*) (Holden et al., 2003; Williams, 1978). Jackfruit and durian seedlings were observed sprouting from mounds of tapir dung (Holden et al., 2003). Tapirs may serve as seed dispersers, carrying seeds long distances and depositing them with their feces (Bodmer, 1991; Fragoso and Huffman, 2000; Olmos, 1997). Downer (2001) stated that the tapir may act as a keystone species, as a result of its seed dispersing capabilities.

In photo-trapping projects, many photos are taken on trails to or near salt licks (Holden et al., 2003; Kawanishi et al., 2002). Tapirs crave salt and seek out salt licks; one individual walked 5.6km to use one (Eisenberg et al., 1990; Williams, 1978)). Thom (1936) noted “the animal is considered to be holy, and more or less sacred because periodically about the full and new moon it visits the nearest salt-lick or hot sulphur springs of mineral and saline mud in the vicinity of its haunts as if to go into retreat or to make as it were its orisons.” Artificial salt licks constructed in Taman-Negara National Park in West Malaysia attract tapirs (Eisenberg et al., 1990). Tapirs in Krau Reserve visit the salt lick 2-3 times a week- more often than any of the other animals in the park; (Traeholt, 2004). In 1957, Wharton (Williams and Petrides, 1980) suggested that without salt licks ungulates would have to migrate or perish, but Williams (1978) stated the true importance of salt licks to tapirs remains unknown.

Water usage

The Malay tapir is the least aquatic of the extant Tapiridae; however, it is considered to have an “amphibious nature” and readily seeks out marshes and rivers for swimming (Anon., 1834; Rabinowitz, 1997). Tapirs walk along the bottom as do hippopotami remaining submerged for long periods (Barongi, 1993; Dudgeon, 2000a; Dudgeon, 2000b; Morris, 2005). The Malay tapirs spend the hottest time of the day in the water and wallow in mud holes, coating their hides with mud to inhibit biting insects (Eisenberg et al., 1990). The tracks of tapirs can often be found at tributaries and tapirs are commonly seen near headwaters, swamps and rivers (Harper, 1945; Khan, 1971). Frequently they will walk into rivers following them for 100-150m or more (Williams, 1978). Tapirs also use water to escape predation, cool off, and sometimes for mating (Abdulali, 1952; Eisenberg et al., 1990; McClure, 1963).

Social Behavior

Once thought to be solitary creatures, recent photo-trapping has shown greater social interaction than expected. Tapirs were photographed in pairs 20% of the time where 14% of those were two adults while 6% was an adult with a calf (Holden et al., 2003). Williams (1978) noted that a radio-collared male spent an afternoon resting with a female and her young and tapirs had intraspecific tolerance and overlapping home ranges.

Communication

A shrill fluctuating squeal has been the only reported vocalization in the Malay tapir, it was made in response to fear or pain, as an appeasement to conspecifics, as a warning call, and as a protest when forced to do something (Ferris, 1905; Hislop, 1950; Hunsaker and Hahn, 1965; Klingel, 1977). Communication is assumed to be similar to other tapir species.

Reproduction

The Malay tapir produces young every 1.6 years and the young stays with its mother until the birth of a new offspring, occasionally even longer (Williams, 1978). During births in captivity the female finds a protected place to lie down until the birthing process begins and then stands for the delivery (Eisenberg et al., 1990). No information was found on the wild birthing habits of the Malay tapir.

Predation

Tigers (*Panthera tigris*) are the major natural predators of the tapirs; however, the tapir is not often preyed upon (Abdulali, 1952; Anon., 1834; Holden et al., 2003; McClure, 1963). The disrupted bodylines make the Malay tapir more difficult for predators to recognize as potential prey (Khan, 1997). One-inch thick skin on the back of the neck is also thought to serve as protection against predation (Sandborn and Watkins, 1950). If a tiger does attack a tapir, the tapir will run away seeking water to escape (Morris, 2005). If the tiger attaches to a tapir's neck, the tapir will attempt to bash the tiger against a tree (Anon., 1834).

CHAPTER III

METHODOLOGY

STUDY AREA

All the tapirs observed in this study were housed at the Sedgwick County Zoological Gardens in Wichita, Kansas, USA.

The Malay tapirs were housed in an enclosure open to birds within the Asian exhibit (Figure 7). The birds included demoiselle crane (*Anthropoides virgo*), white stork (*Ciconia ciconia*), white pelican (*Pelecanus onocrotalus*), bar-headed goose (*Anser indicus*), and ruddy shelduck (*Tadorna ferruginea*). The Indian muntjacs (*Muntiacus muntjak*) were housed adjacent to the tapirs and occasionally jumped the fence and moat into the tapir area. There was a hut which serves both as double doors to keep the animals within the confines of the display, as well as, a bridge over the stream-shaped pool which ran through the exhibit. At the base of the hut was wire mesh fencing, which served to separate the tapir enclosure from the rest of the exhibit. The public observation area had decorative plantings of hostas, daylilies, and grasses; which separated the dry moat from a post and rail fence used to keep the public out. The moat was concrete and about a meter wide and a meter deep. The stream was deepest at the hut then became progressively shallower and narrower. Most of the enclosure was surrounded by a tall chain link fence. Vegetation consisted of a few large trees, some saplings (both along the stream bank and on the hill), ferns, and other vegetation (ranging in height from ground to over a meter tall). Hay and drinking water were kept in the back of the enclosure on the stream bank.

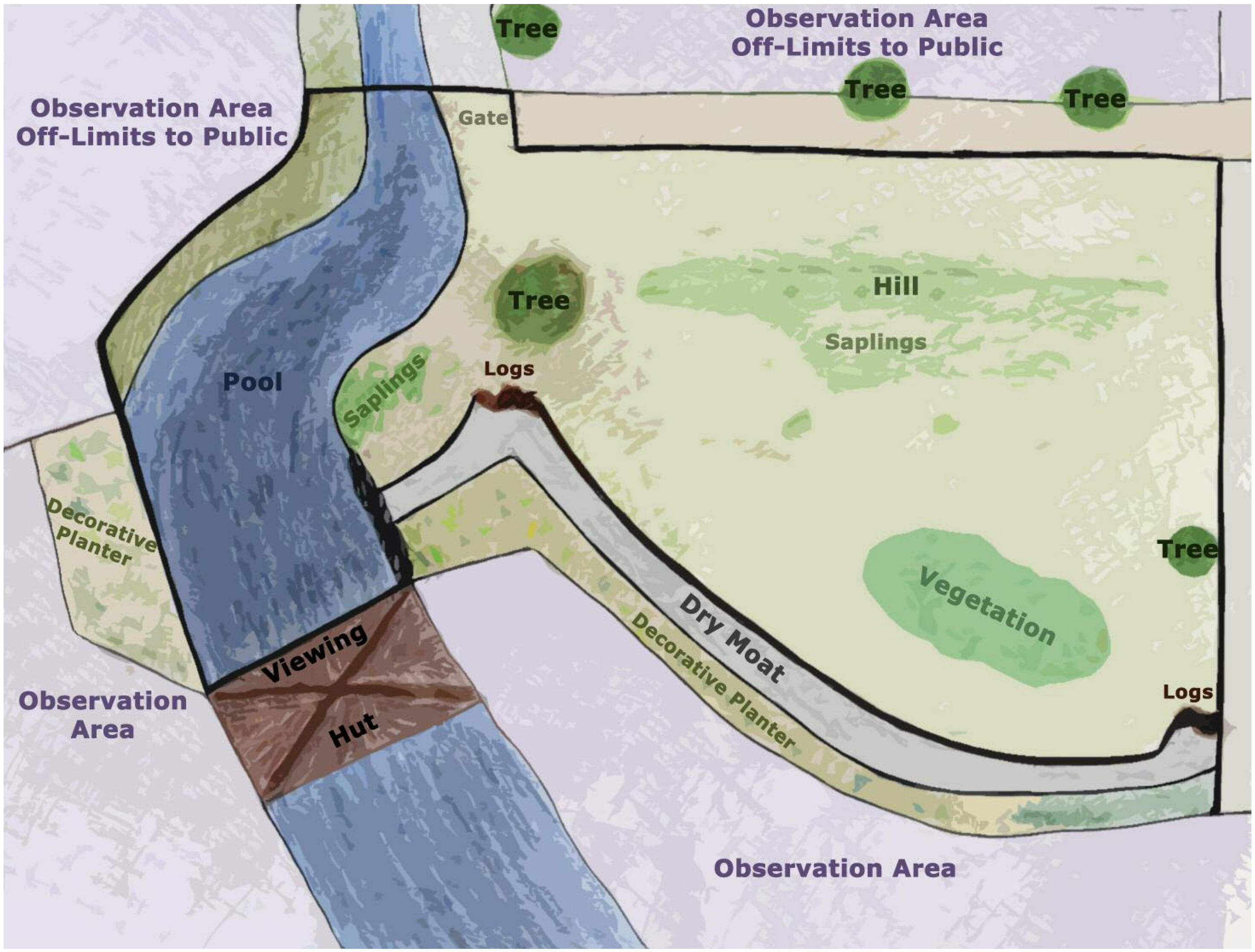

Figure 7. Schematic of the Malay tapir exhibit at Sedgwick County Zoological Gardens, Wichita, KS.

The Baird's tapirs were housed in a shared exhibit within the South American aviary, residing with various birds (Figure 8). Birds seen in the exhibit included black bellied whistling duck (*Dendrocygna autumnalis*), roseate spoonbill (*Ajaja ajaja*), king vulture (*Sarcoramphus papa*), American avocet (*Recurvirostra americana*), black necked stilt (*Himantopus mexicanus*), greater Brazilian teal (*Amazonetta brasiliensis*), chiloe widgeon (*Anas sibilatrix*), and Cuban Amazon parrot (*Amazona leucocephala*). The birds could move freely in and out of the enclosure. A black jaguar was housed adjacent to the tapirs. The public looked down into the enclosure from an observation area. Most of the enclosure was surrounded by a very tall chain link fence. Posts within the enclosure held up part of the netting which enclosed the Australian and South American exhibit keeping the birds from flying away. The pool was walled off by a cement wall and logs stacked on one another. Only one area of the enclosure had vegetation, which mostly consisted of saplings. A mud wallow was present along one edge of the cage. When present, hay was located around some upright logs. The display consisted of two tiers created by boulders; the upper area was half a meter or higher than the lower area and never more than 3 meters wide. The majority of the exhibit was in the lower tier. Shade was provided by a hut with slatted roof and a thatched roof on one of the posts.

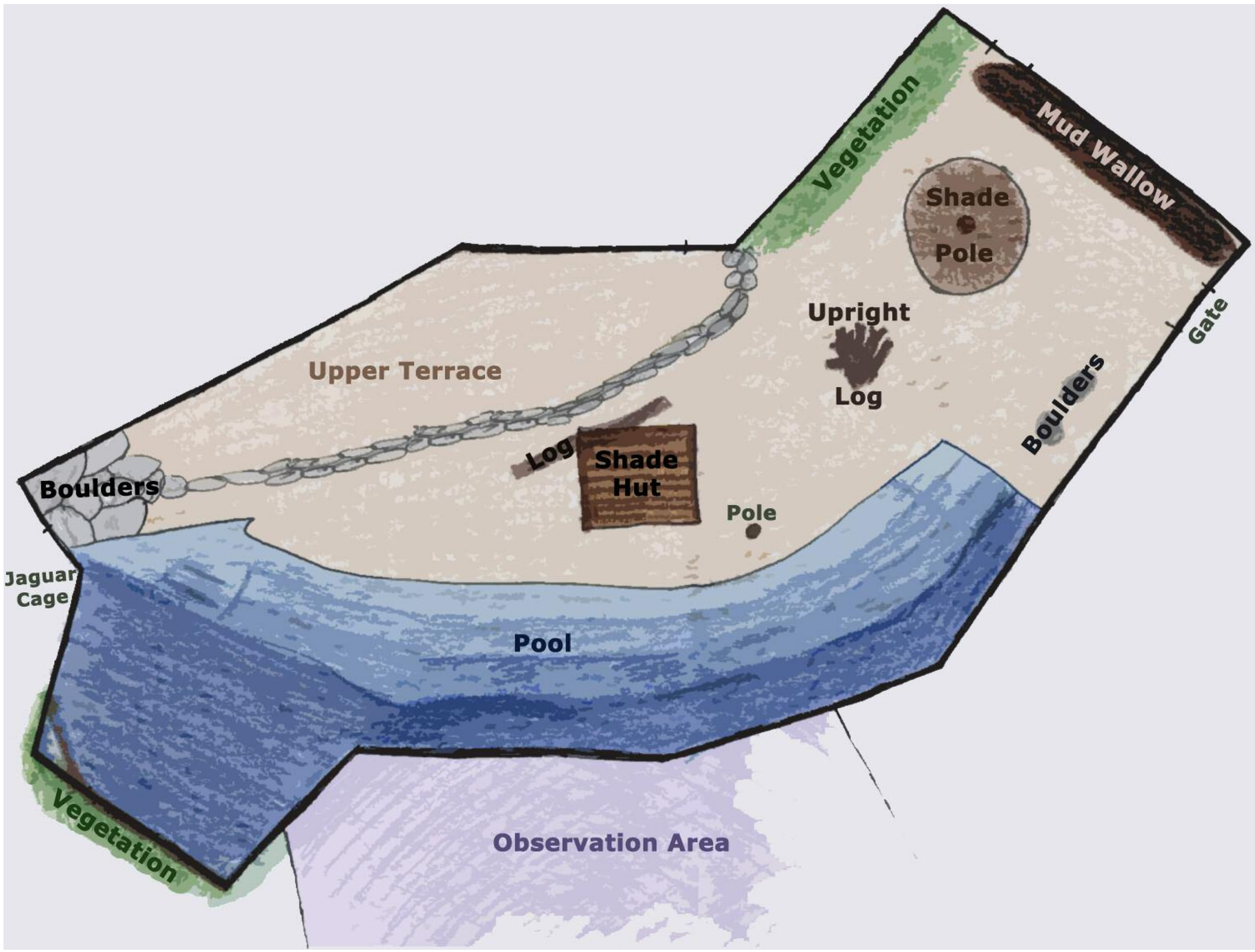

Figure 8. Schematic of the Baird's tapir exhibit at Sedgwick County Zoological Gardens, Wichita, KS.

The tapirs were allowed to be outside on display until temperatures dropped below 50 F° and then they were housed in barns (Figure 9). The Baird's tapirs were housed in the quarantine area of the zoo if they were off display and the Malay tapirs were housed in the barn stall adjacent to the main exhibit. The barn enclosures were two stalls wide adjoined by a door way, one half was a swimming pool. The barns had a textured rubber floor. There were doors to an outdoor area and water was available at all times. In the quarantine barns, a wire hay feeder was attached to one wall and an automatic water bowl was available on the adjacent wall.

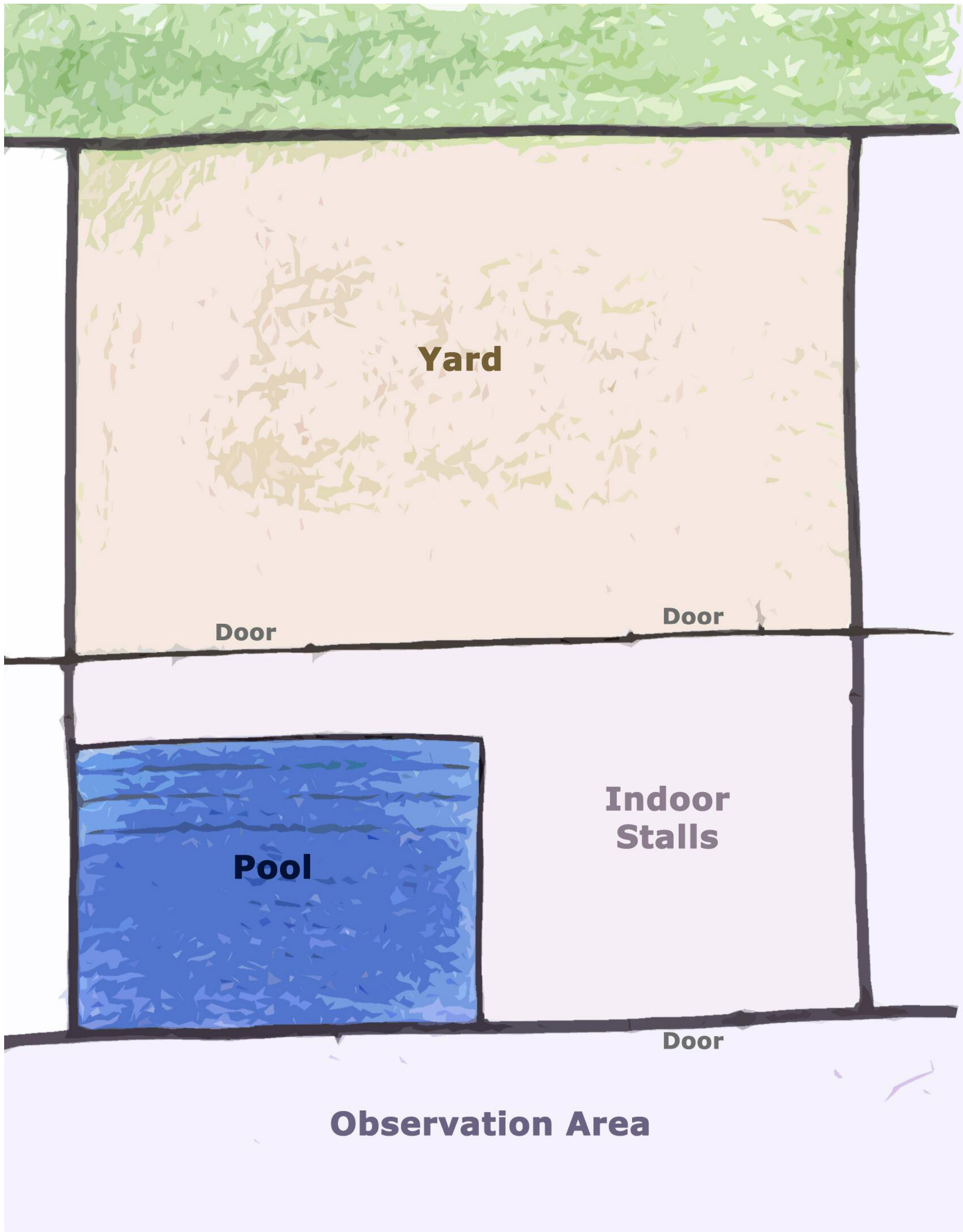

Figure 9. Representative schematic of the off-exhibit housing (barns) at Sedgwick County Zoological Gardens, Wichita, KS. Presence of shade structures in the yard varied between enclosures.

STUDY SUBJECTS

I observed 5 captive tapirs for this study. The tapirs ranged in age from 4 months to 20 years. Two of the individuals were Malay tapirs (*T. indicus*) and three of the individuals were Baird's tapirs (*T. bairdii*) (Table 1). Allie (a Malay tapir) had recently arrived to zoo as a mate for Ernie; however, his poor health eventually ended in death before mating could take place. Data collected on Ernie was only used in the pilot study. Melvin (a Baird's tapir) mated with Schnapps (also a Baird's tapir) and produced Cayos (a male).

Individual	**Species**	**Sex**	**Age**	**Date of Birth**	**Zoo of Origins**	**Been at Sedgwick**
Allie	*T. indicus*	Female	3 (yrs)	August, 2002	Jackson, Mississippi	Since April 30th, 2005
Ernie	*T. indicus*	Male	20 (yrs)	1985	Houston, Texas	
Melvin	*T. bairdii*	Male	15 (yrs)	July 25, 1990		
Schnapps	*T. bairdii*	Female	12 (yrs)	October 27, 1992		
Cayos	*T. bairdii*	Male	4 months	May 3, 2005	Born at Sedgwick Zoo	Since May 3, 2005

Table 1. Information on the research subjects used in this study.

Both species were fed a diet of ADF grain 16 and hay, along with daily vitamin E supplement, and Equisil fiber weekly. The Baird's tapirs were also fed fruit (apples and bananas) daily, while in the Malay tapirs fruit and alfalfa were given as enrichment periodically. Fly spray was applied to the tapirs on a daily basis when the tapirs were out on display.

Pilot Study

In August 2005, I conducted a pilot study using focal-animal continuous recording sampling method of Ernie, Allie, and Melvin. Behavior was recorded for one individual for one hour and then I took a 10 minute break before switching to another individual. During this time, I was able to observe my study subjects, map out my study area, ask questions of the zoo staff, and revise my methods. This information allowed me to become familiar with the behavior of the subjects, as well as, modify the ethogram and data sheets used in this study.

ACTIVITY PATTERNS

Observations were recorded for the four individuals from September 2005-October 2006 (Table 2). An ethogram composed from a literature review of tapir behavior and modified with the preliminary data (see pilot study above) was used to focus (but not limit) behavioral observations (Table 3). I used instantaneous sampling in 20 minute periods at an interval of 30 seconds with a 15 minute break in between periods (Altmann, 1974; Lehner, 1996; Martin and Bateson, 1993). Time budgets were created for each individual, and for all individuals combined. Monthly (June, July, and August only) and hourly activity patterns were examined to see the pattern through the summer and over the duration of an average day for each individual, as well as, all individuals combined. For this analysis behavior grouping 3 was used (Table 4). Comparisons were made between individuals, species (*T. bairdii* vs. *T. indicus*), age groups (young vs. adult), sex (female vs. male), and the number of tapirs in exhibit (1 vs. 2).

Table 2. Individual and the dates and reasons they were in different enclosures.

Individual	Species	Date	Enclosure	Reason
Allie	*Tapirus indicus*	August- October, 2005	Display	
		December 2005	Barn	Winter
		June- July 12, 2006	Display	
		July 12-13, 2006	Barn	Display landscaped and repaired
		July 14- October, 2006	Display	
Ernie	*Tapirus indicus*	September- December, 2005	Barn	Sick
Melvin	*Tapirus bairdii*	August- October, 2005	Display	
		December- October, 2006	Quarantine Barn	Winter/ Separated from Schnapps & Cayos/ Awaiting transfer to another zoo
Schnapps	*Tapirus bairdii*	September- December, 2005	Quarantine Barn	Separated from Melvin & the public for Cayos' birth/ Winter
		June- October, 2006	Display	
Cayos	*Tapirus bairdii*	September- December, 2005	Quarantine Barn	Separated from Melvin & the public
		June- October, 2006	Display	

Table 3. Ethogram summarizing behavior noted in tapirs by previous research and used for data collection in this study. Compiled from (BAG, 2005; Hunsaker and Hahn, 1965; Lehner, 1996; Mahler, 1984b; McDonnell, 2002; McDonnell and Haviland, 1995; Seitz, 2000a; Torres et al., 2004a; Waring, 1983).

Behavioral Unit	Abbreviation	Description
Aggression	Ag	The subject is demonstrating behaviors toward a conspecific (c), another species (sp) or an object (o) that are violent in nature
Approach	Ap	One animal moves toward the other animal
Attempted Nursing	AN	The attempt to suckle for milk.
Bite	Bite	The closing of the jaw on self (s) conspecific (c) another species (sp) or an object (o)
Defecating	Def	The expelling of fecal matter
Drinking	Dr	The intake of water- defined by the moment at which the animal introduced the snout in the water & sucks
Eating	E	The intake of food
Flehmen	Fh	Head elevated & neck extended, with eyes rolled back, the ears rotated to the side, & the upper lip curled exposing the upper incisors & adjacent gums. The head may roll to one side or from side-to-side. Typically occurs in association with olfactory investigation
Following	Follow	The animals travels in the same direction as a conspecific (c), another species (sp) or an object (o)
Grooming	Gr	Cleaning of self (s), conspecific (c), another species (sp)
Kick	Kick	Movement of one leg while standing.
Licking	Lick	Movement of tongue on a conspecific (c), another species (sp) or an object (o)
Lying down	L	The animal rests on the ground in a horizontal position
Mating/ Courtship	Mt	The female moves near the male. The male sniffs & bites. The female complies & the male supports the mandible on her back. The female is mounted & copulation occurs.
Mouth Movement	MM	The movement of the mouth- not biting, chewing, or eating.
Moving away	MA	The animal travels in a direction away from a conspecific (c), another species (sp) or an object (o)
Pawing	Paw	To touch or strike at with a hoof
Play	Play	Includes solitary locomotive (sl), chasing (c), object (o), & fighting (f)
Push	Push	One animal uses the force of its body to move an object (o) or conspecific (c)
Rolling in dust	RD	Rolling on the ground in substrate
Rubbing	Rub	Moving body back & forth on an object (o) or conspecific (c)
Running	R	The animal moves at a quick pace. During a complete cycle, the animal could touch the ground with one, two & occasionally three extremities; in this last case one only occurs when gallop is slow.
Scratching	Sc	Rubbing of the body against a different body part or a surface.
Shake	Shake	Moment of the body/ body part from a side to side
Sitting	St	Position where an individual was supported on hind quarters with rear on the ground.
Smelling	Sm	The inhalation of air- either directed at an object, determined site, or in the air.
Soliciting	So	Seeking attention
Spray	Sp	Urination or defecation in defined places
Standing	Std	The animal remains unmoving in an upright position.
Submission	Sb	The subject is demonstrating behaviors toward or in reaction to a conspecific (c), another species (sp) or object (o) that are passive in nature
Suckling	Suck	Young suckles teat for milk
Swimming	Sw	Animal is fully or partially in the water
Touching	T	Movement of the proboscis on a conspecific (c), another species (sp) or an object (o)
Urinating	U	The expelling of urine
Vocalization	V	Sound produced by the tapir through the oral or sinus cavity
Walking	Wk	Movement at a slower speed & during a complete cycle, the animal alternates on three extremities
Watching	Wa	To look at something

Table 4. Different groupings of behaviors used for various statistical analyses.

Behaviors Observed	Behavior Groupings		
	1	2	3
Aggression	Aggression	Other	Other
Attempted Nursing	Feeding	Ingest	Ingest
Bite	Aggression	Other	Other
Combination Urination & Spray	Other	Other	Other
Cough	Other	Other	Other
Defecation	Other	Other	Other
Drinking	Drinking	Ingest	Ingest
Eating	Feeding	Ingest	Ingest
Fart	Other	Other	Other
Follow	Locomotion	Locomotion	Locomotion
Hit	Aggression	Other	Other
Kick	Aggression	Other	Other
Lying Down	Lying Down	Lying Down	Stationary
Lick	Licking	Lick	Other
Move Away From	Locomotion	Locomotion	Locomotion
Mouth Movement	Other	Other	Other
Nudge	Other	Other	Other
Nursing	Feeding	Ingest	Ingest
Paw	Other	Other	Other
Play	Other	Other	Other
Push	Aggression	Other	Other
Rub	Other	Other	Other
Run	Locomotion	Locomotion	Locomotion
Shake	Other	Other	Other
Sigh	Vocalization	Other	Other
Sit	Sit	Sit	Stationary
Smelling	Investigation	Investigation	Investigation
Sneeze	Other	Other	Other
Spray	Other	Other	Other
Standing	Stand	Stand	Stationary
Stretch	Other	Other	Other
Swimming	Swim	Swim	Swim
Touch	Investigation	Investigation	Investigation
Trot	Locomotion	Locomotion	Locomotion
Urination	Other	Other	Other
Vocalizations	Vocalization	Other	Other
Walk	Locomotion	Locomotion	Locomotion
Watch	Investigation	Investigation	Investigation
Yawn	Other	Other	Other
Bad	BAD	BAD	BAD

Environmental Effects

The weather and astronomic conditions for each day sampling occurred were collected from Weather Underground for station KICT (Weather Underground, 2007). In this analysis, 441 twenty minute sessions from the summer (June, July, and August) were used. Any session with less than 75 % of the total observations were also dropped (i.e. less than 31 observations). Group 1 behaviors were used in this analysis (Table 4). The individuals were coded as four dummy variables. The daily values of 4 climatic variables (mean temperature, dew point, average humidity, and total rainfall) were used along with the percent of moon illumination. Three dummy month variables plus an additional scaler month variable were used.

Redundancy Analysis (RDA) is also known as reduced rank regression and is an outbranch of multiple regression analysis (Ter Braak and Šmilauer, 2002). By using a linear combination of environmental or constraining variables, it attempts to explain the variation in the behaviors. Each analysis was done in Canoco and yielded an estimate of the variance explained by each canoncial axes (eigenvalues) (Ter Braak and Šmilauer, 2002). The eigenvalues are analogous to the sum of squares in regression analysis (Peres-Neto et al., 2006). A sum of all the canonical eigenvalues is the total amount of variance explained by the constraining variables. A partial RDA can factor out the influence of variables, when variables are factored out they are termed covariables. By computing a single total RDA and 5 partial RDAs, all the explained variation in the behavior dataset was partition into three components: individual, time, and environmental effects.

Spatial Use

Each enclosure was divided into sections based on location, function, relative size, existing structures, and vegetation (Figures 10 & 11). The barns were divided into 3 sections: inside, pool, and outside (Figure 12). If the tapir was in more than one section, whichever section the tapir's eye was in was the section counted. I recorded the section and behavior of each individual in the enclosure at 30 second intervals for 20 minutes with a 15 minute break in between. The time of day was varied each time the individual was observed to eliminate a time bias.

A Fisher's exact test was performed to test independence between behaviors and exhibit sections for each tapir individually using function *chisq.test* in the *stats* package of R (R Development Core Team, 2006). The relationship between exhibit section and behavior is not one directional so it would be misleading to use exhibit section as a constant variable in an RDA. An alternative approach is to perform a Principle Components Analysis (PCA) on the behavior and then project the exhibit sections onto the ordination diagram as supplemental variables (Palmer, 2007). A PCA was performed using exhibit section as supplemental variables for each individual tapir in Canoco (Ter Braak and Šmilauer, 2002). Group 2 behaviors were used for these analyses (Table 4). Another approach that was utilized was Canonical Correlation Analysis (CCA) which also considers both variables (behavior and exhibit section) as response variables and derives canonical axes which maximizes the correlation between two sets of variables (section and behavior). This was done in R using the function *cancor* in the *stats* package. For Allie, Schnapps and Cayos, RDA's were also performed. Time of day was used as a scaler variable in Allie, because of the significant effect time of day had on her;

whereas, in Schnapps and Cayos, individual was used as a dummy variable, so we could more readily compare their usage.

In addition to the spatial use analyses, experimental treatments were also done with Allie. On July 12 and 13 in 2006, Allie was kept inside the barn because the zoo staff was landscaping her exhibit (Table 2). This allowed two different comparisons on exhibit and spatial use to be made- inside the barn vs. outside on exhibit, and before vs. after the landscaping.

A partial Redundancy Analysis (pRDA) was done to explain variation in the abundance of behaviors based on enclosure type (inside vs. outside) after factoring out time of day (tclass). Monte Carlo randomization test was used to test whether the pRDA was significant. The Monte Carlo randomization test was constrained to randomizing the rows of the data matrix only within a given tclass – resulting in a more conservative test of enclosure than an unconstrained permutation. Each 20 minute session was used as a sample in Canoco (Ter Braak and Šmilauer, 2002). A total of 16 sessions were compared, 8 from each treatment. Two days (7/5/2006 & 7/6/2006) made up the outside treatment and 2 days (7/12/2006 & 7/13/2006) made up the inside treatment.

A pRDA of behavior abundance for the landscaping treatments (before vs. after) was done to explain variance in behaviors by using Canoco (Ter Braak and Šmilauer, 2002). A pRDA of spatial usage was also done in Canoco to explain variance in section use. Monte Carlo randomization test was used to test whether the pRDA was significant. Each 20 minute session was used as an individual sample and time of day was factored out (tclass). 82 samples were used in these analyses, 42 from before the landscaping and 40 from after, totaling to 3077 observations. A total of 9 days between 6/21/2006 &

7/7/2006 made up the before landscaping group and 8 days between 7/26/2006 & 8/11/2006 made up the after landscaping group.

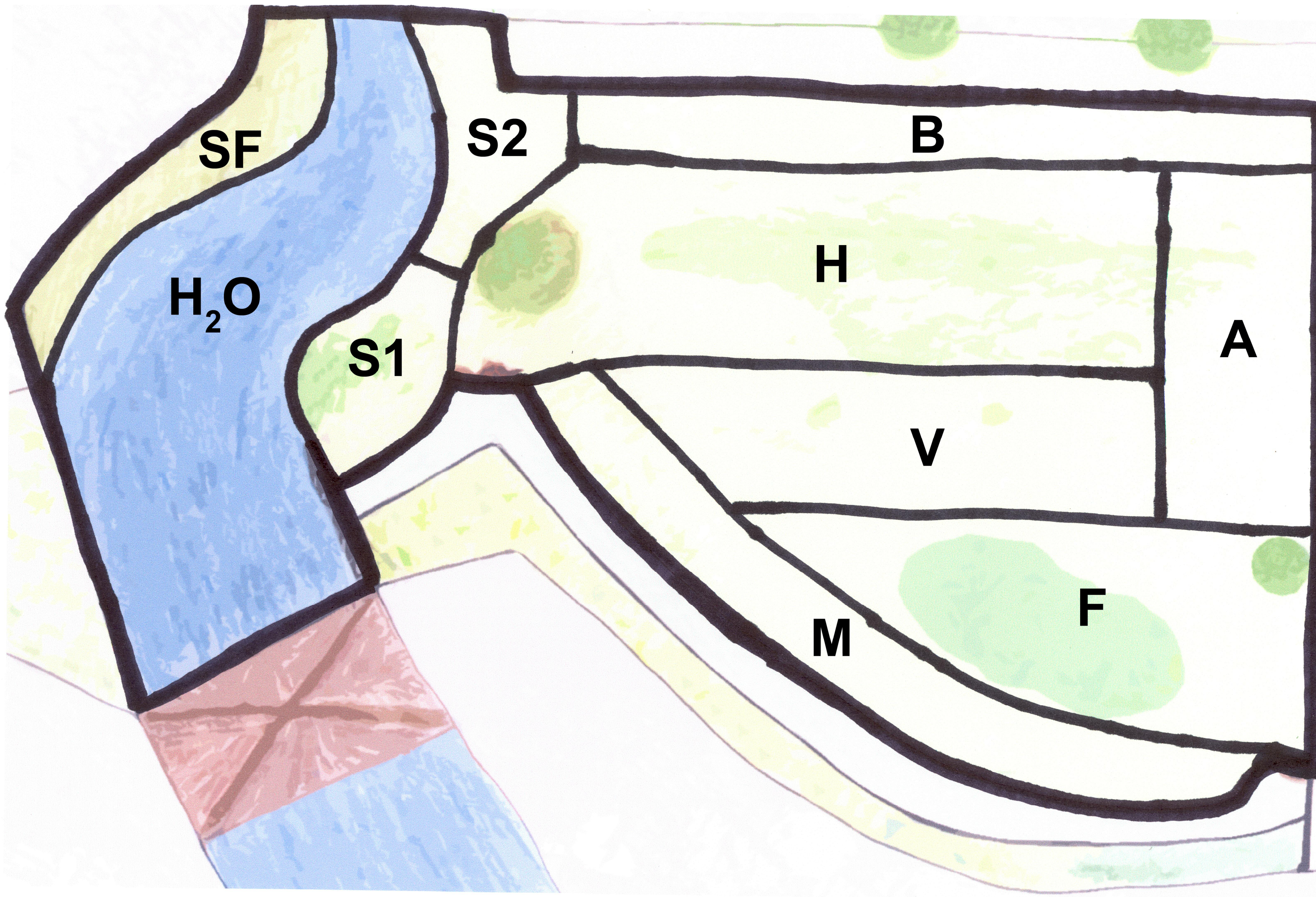

Figure 10. Malay tapir exhibit sections.

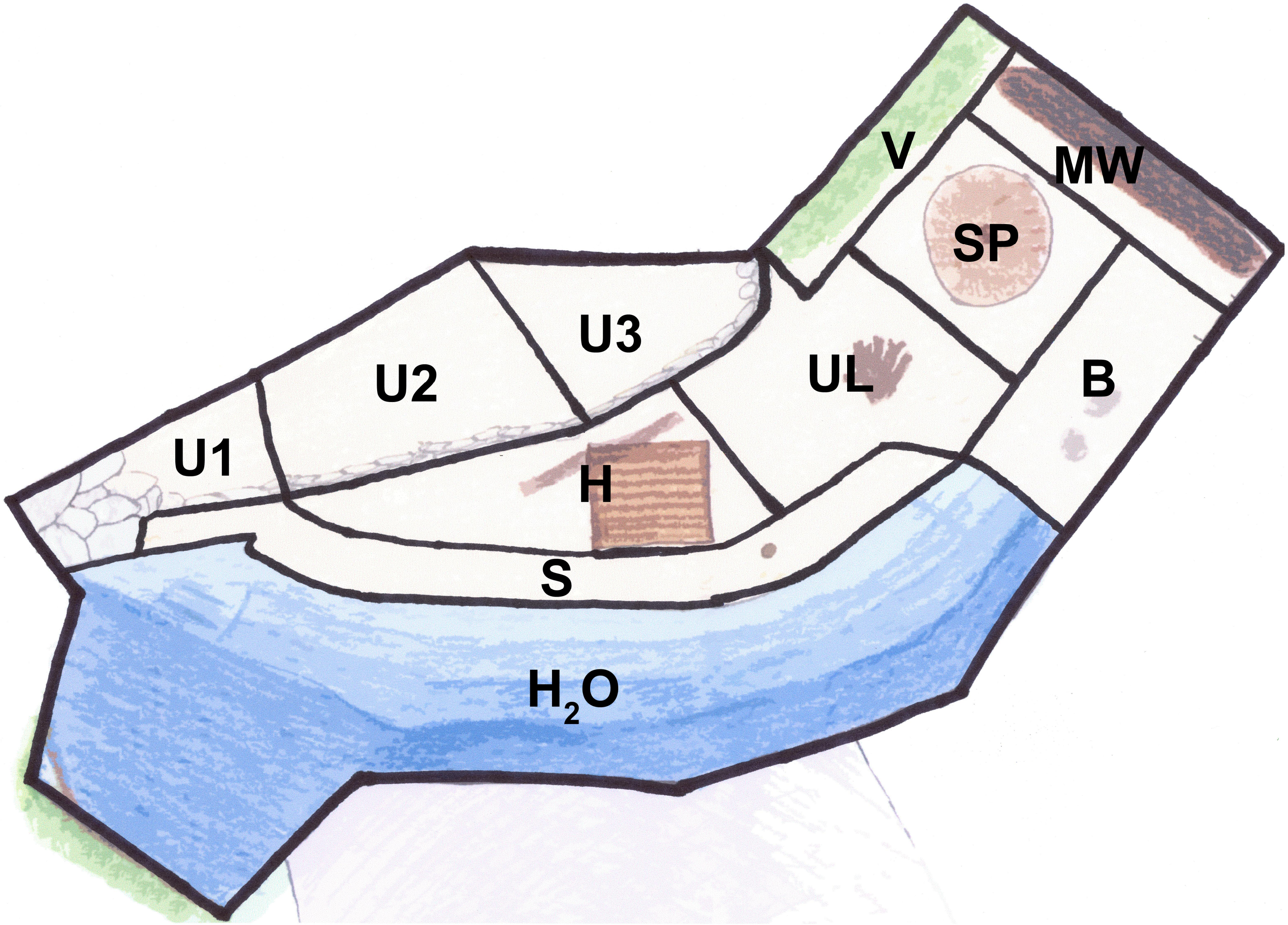

Figure 11. Baird's tapir exhibit sections.

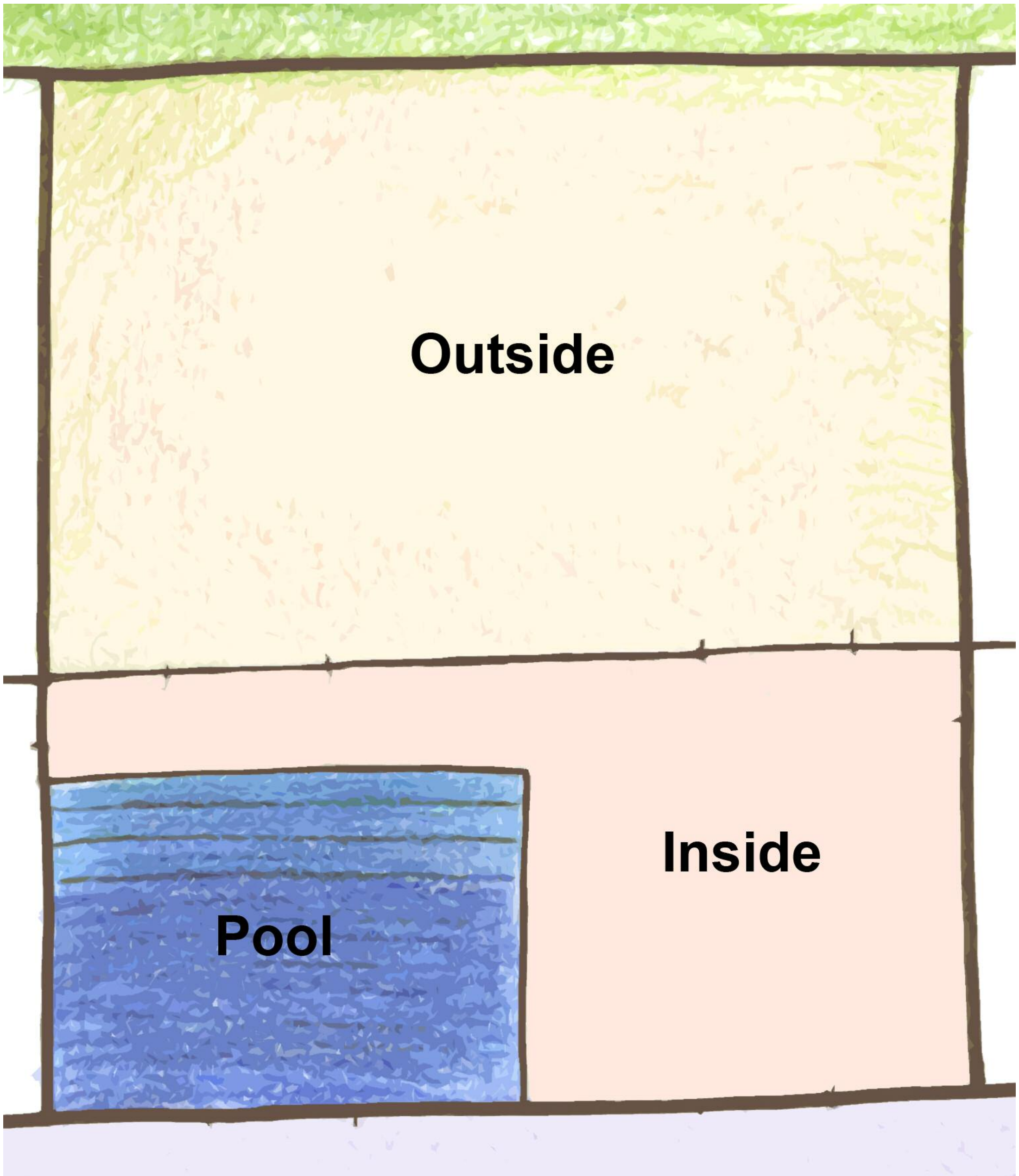

Figure 12. Barn enclosure sections.

Mother- Young Interactions

The physical distance between the mother and young was studied. The distances were divided into 8 categories based on the enclosure size (Table 5). I recorded the behavior of each individual in the enclosure and the distance between them at 30 second intervals for 20 minutes with a 15 minute break in between. The time of day was varied each time the individual was observed to eliminate a time bias.

I constructed two and three way contingency tables to investigate the independence of Cayos and Schnapps behaviors relative to each other. The two-way table displayed Schnapps' behavior as the rows and Cayos' behavior as the columns. This table allows us to understand what behaviors the mother and young were displaying at the same instant in time. The three-way table incorporated distance classes into the two-way behavior table. A total of 4825 observations were used. Behavior group 2 was used for this analysis and the distance classes were grouped as well (Tables 3 & 5). Only the observations recorded while Schnapps and Cayos were on exhibit were used for these analyses (June- October 2006) and those observations in which the section was not recorded or the distance was unknown were not used.

Table 5. The distance classifications for mother-young interactions.

	Original	Grouped
T	Touching	Touching
A	1-6 inches	0-1 feet
B	6-12 inches	0-1 feet
C	1-3 feet	1-3 feet
D	3-6 feet	1-3 feet
E	6-9 feet	3-18 feet
F	9-18 feet	3-18 feet
G	> 18 feet	> 18 feet

The independence of behaviors in the two-way table was tested with Fisher's exact test. This test was calculated with R version 2.4.0 using the function *chisq.test* in the *stats* package (R Development Core Team, 2006). Fisher's exact test was used (instead of a chi-square test) because of the many low expected values in our contingency table (Quinn and Keough, 2002). Degrees of freedom were not applicable in this test because the -value was computed with a Monte Carlo test with 2000 replicates and not from a chi-square table (Hope, 1968). The simulation was done by random sampling from the set of all contingency tables with given marginal totals (row and column totals). The standardized residuals were calculated from the test to assess which cells in the table deviated strongly from the assumption of independence.

To further investigate the deviations from independence in the behaviors of Cayos and Schnapps at different times, hierarchical log-linear models were constructed with three factors (Cayos, Schnapps, and distance class) and their interactions. These three factors were used to form a three-way contingency table upon which the models were tested. Log-linear models are the best method for analyzing contingency tables (Quinn and Keough, 2002). They are a special type of generalized linear model (GLM) with a Poisson error distribution. In other words, these models treat the cell frequencies as counts distributed like a Poisson random variable. These models were fit using a maximum likelihood technique and the accuracy of the fit was measured by the log-likelihood. They consider both variables to be response variables, therefore neither variable is considered to be forcing. This analysis was performed with the R function *loglm* in the *MASS* package. Model comparison was performed using the calculated deviance (G^2) and degrees of freedom of the model with the function *anova* in the *stats* package of R.

CHAPTER IV

RESULTS

ACTIVITY PATTERNS

Approximately 20,154 observations were recorded for the four individuals from September 2005- October 2006. Overall, all the individuals spent the majority of observations lying down (56.17% ±7.10%), with Allie (the Malay tapir) lying down the most and Melvin (the male Baird's tapir) the least (Table 6 and Figures 13 &14). Schnapps (the female Baird's tapir) investigated more than any other individual (24.85%) and Allie investigated the least (13.65%). Feeding was one of the most variable behaviors across individuals. Melvin spent the most observations feeding while Allie spent the least. Cayos (the juvenile Baird's tapir) spent 10.32% feeding and 2.27% nursing, totaling to 12.59%. Allie swam the most and Melvin moved around the most. Schnapps licked the most (1.37%) while Melvin and Cayos licked the least (0.51% and 0.50% respectively). Cayos stood the most and Allie the least; whereas Melvin sat the most and Allie the least. Melvin drank three times as much as than any other individual. Vocalization, aggression and the "other" category had the least amount of variability, 0.05%, 0.06%, and 0.07% respectively; however, they all occurred infrequently. Allie never showed aggression and Schnapps was never seen performing eliminatory behaviors. Allie vocalized the most (0.24%), whereas Melvin only vocalized once. Melvin performed the fewest of the behaviors in the “other” category than did any other individual. Melvin and Allie had relatively equal numbers of “bad” observations (1.07% and 0.91% respectively) and Cayos and Schnapps had an equal number of bad observations (0.02%).

Table 6. The relative frequencies of behavior for each individual as well as for all individuals combined including their standard error.

Grouped Behavior	Allie	Cayos	Melvin	Schnapps	Pooled	Pooled Standard Error
Lying Down	68.85%	57.79%	35.38%	59.47%	56.17%	7.10%
Investigation	13.65%	18.73%	16.03%	24.86%	18.53%	2.41%
Feeding/ Nursing	1.71%	10.33% 2.27%	30.48%	4.68%	11.64%	6.46%
Swim/ Bath	8.49%	4.86%	3.07%	3.61%	5.04%	1.22%
Locomotion	3.55%	2.45%	7.85%	2.90%	3.99%	1.24%
Stand	0.58%	1.39%	0.98%	0.73%	0.93%	0.18%
Sit	0.28%	0.38%	1.90%	1.18%	0.89%	0.38%
Licking	0.81%	0.50%	0.51%	1.37%	0.81%	0.20%
Drinking	0.30%	0.36%	1.63%	0.37%	0.62%	0.32%
Other	0.42%	0.54%	0.21%	0.45%	0.42%	0.07%
Aggression	0.00%	0.18%	0.23%	0.30%	0.18%	0.06%
Vocalization	0.24%	0.13%	0.02%	0.07%	0.12%	0.05%
Elimination	0.20%	0.09%	0.65%	0.00%	0.21%	0.14%
BAD	0.91%	0.02%	1.07%	0.02%	0.46%	0.28%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	

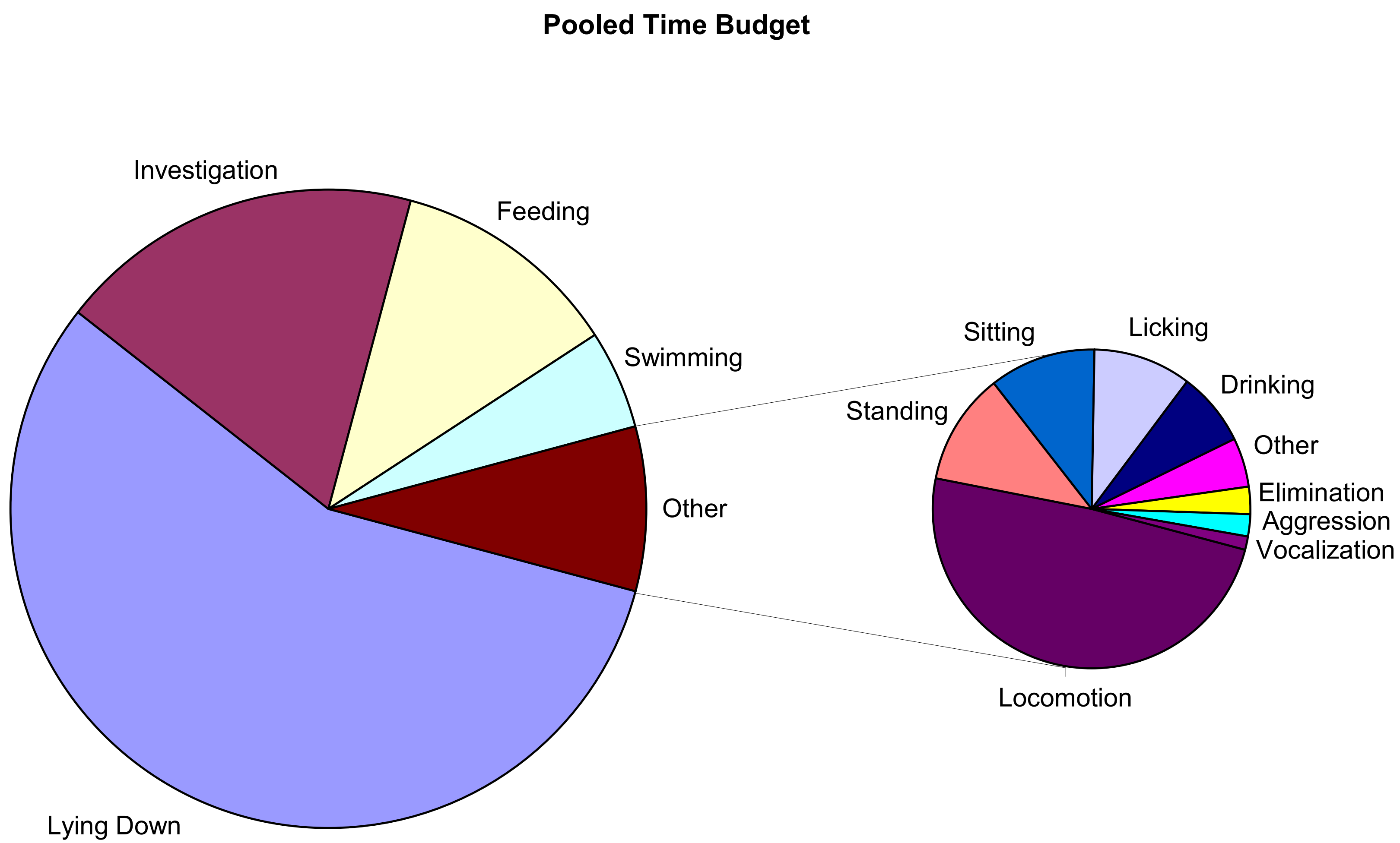

Figure 13. Time budget for all individuals combined.

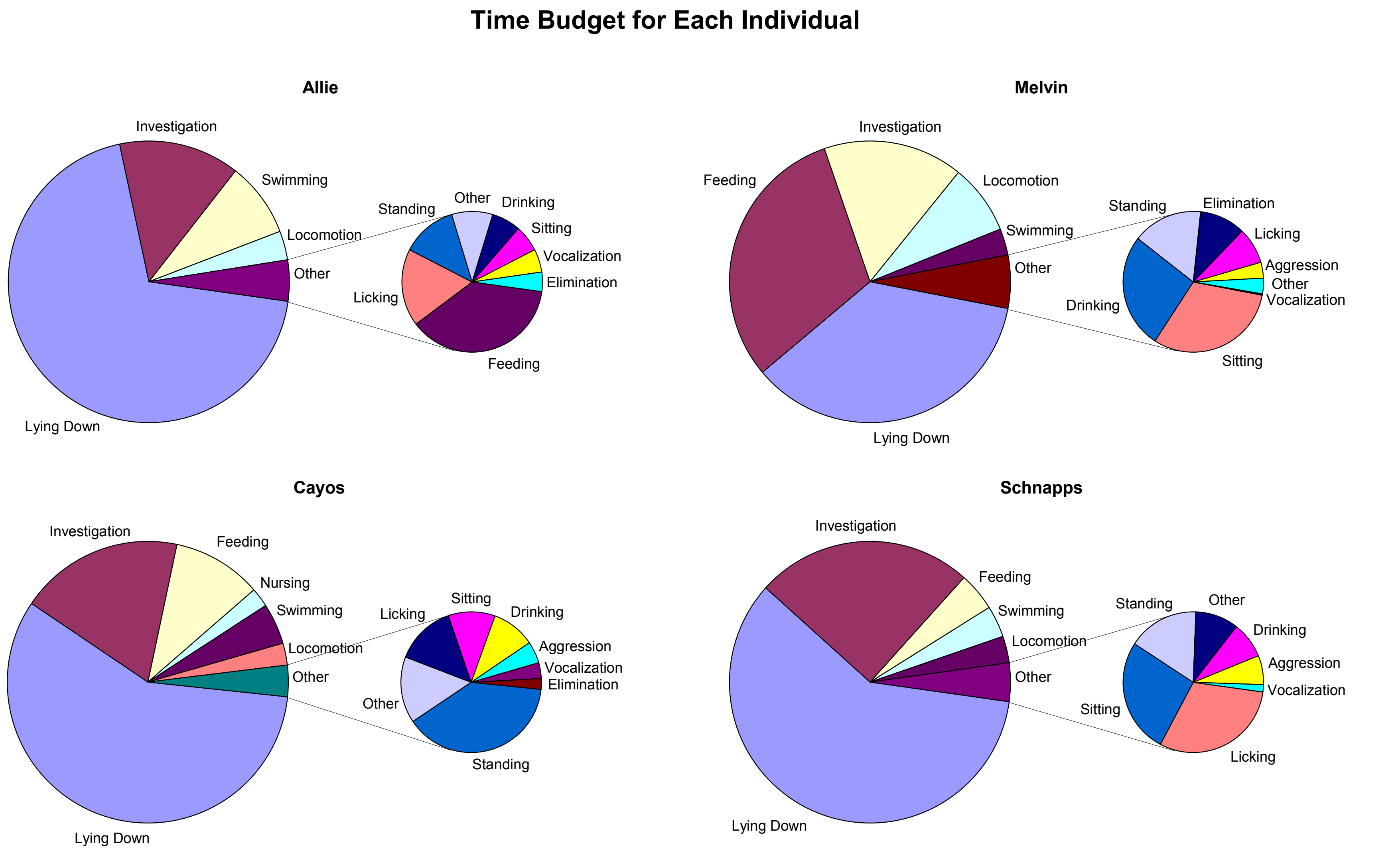

Figure 14. Time Budgets for each individual.

Overall, sleeping and swimming occurred most frequently in June, whereas investigation and locomotion were the most frequent in July (Figure 15). Allie slept almost 20% more in June than in other July or August (Figure 16). Over the course of the summer, she investigated, ingested, and moved more. Allie swam the most in July. Melvin slept slightly more in August. Over the course of the summer, he investigated less whereas, ingestion remained fairly constant. Both locomotion and swimming were the highest in July. Cayos investigated more and he slept and swam less over the course of the summer. He was observed ingesting the least in July. Locomotion remained fairly stable for him throughout the summer. Schnapps slept the least and increased her investigating and movement in July. Ingestion and swimming remained fairly constant for her throughout the summer.

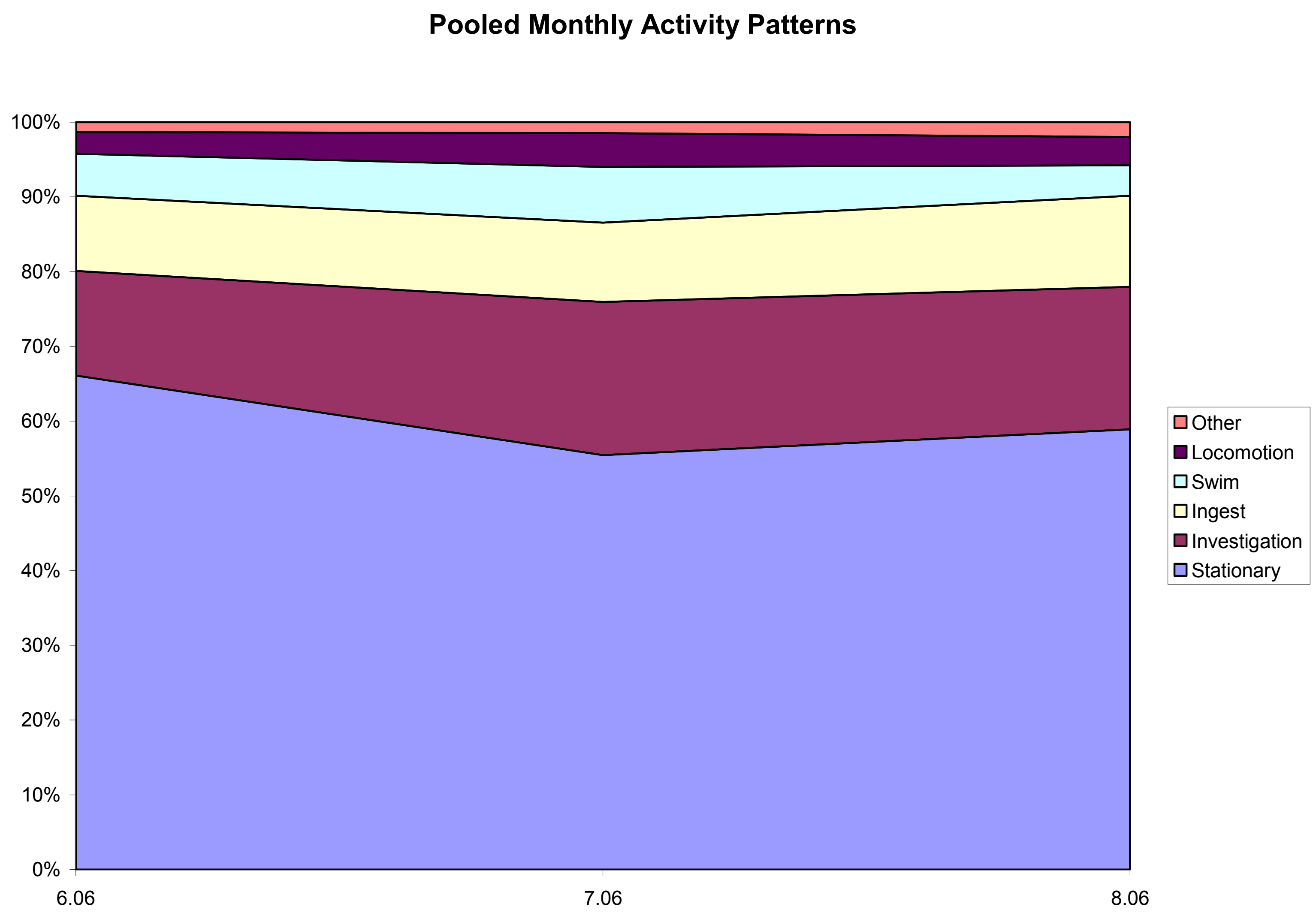

Figure 15. Monthly activity patterns for all individuals combined during the summer (June- August).

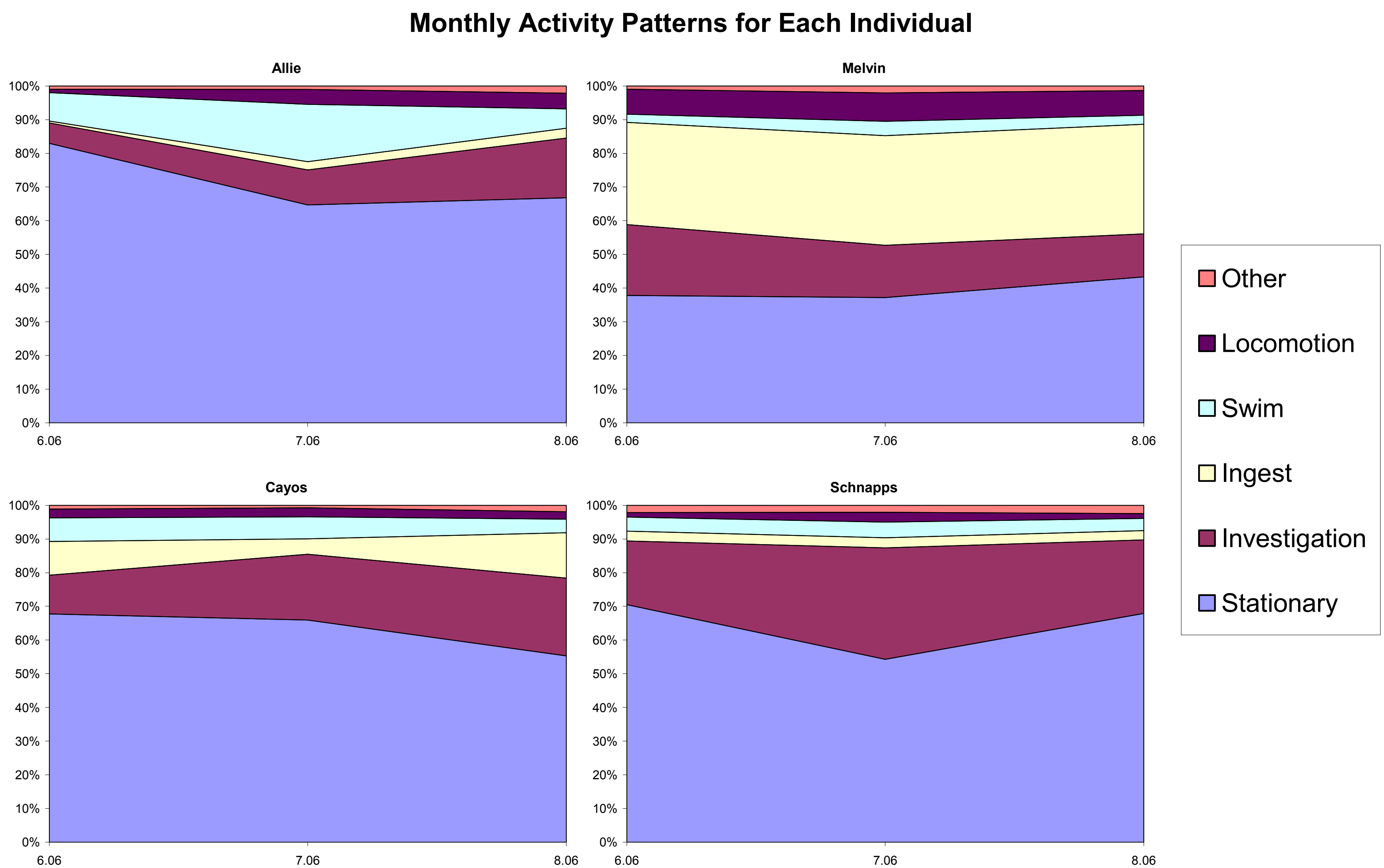

Figure 16. Monthly activity patterns for each individual during the summer (June- August).

Stationary behaviors had were low in the morning (8-9pm), from 5-6pm and 7pm on (Figure 17). From 1 to 2pm there was a strong peak followed by a decline which was strongest in Allie and only slight in Schnapps (Figure 18). This decline continued in all individuals but Melvin until 6pm. In Melvin, stationary behaviors declined until 2pm and then steadily increased (observations for Melvin ended at 6pm). Cayos and Schnapps had an additional peak from 6 to 7pm and then stationary behavior dropped to zero for the remainder of the day. After 5pm, Allie was never stationary for more than 5% of the observations.

Investigation peaked between 8 and 9am, 11am and noon, 2 to 6pm and 7pm on. Cayos followed this pattern. Allie had a slight drop from 3 to 4pm. Melvin did not have the 8-9am peak and he had a drop between 4 and 5pm before an increase at 5pm. Schnapps had a slight drop from 5 to 6pm.

Ingestion was the most variable among individuals. Allie ingested the most after 5pm, whereas, for Cayos, Melvin, Schnapps it was in the morning. Melvin also had increased ingestion from 2-5pm. Cayos had peaks between 1 and 2pm, 4 and 5pm and at 7pm.

Swimming peaked at 11am to 1pm and 3pm to 5pm. Allie also peaked during between 6 and 7 pm. Melvin did not follow this pattern, his peaks occurred between noon and 1pm and between 2pm 2 and 3pm. Cayos and Schnapps had very similar swimming and locomotive activity throughout the day. Both had increased swimming in the afternoon with a slight peak from 5 to 6pm and from 7pm on.

Locomotion was greatest at the zoo’s regular closing time, after (5pm on), and in the morning. Both Schnapps and Cayos had a decrease from 6 to 7pm. Melvin was active at 5 to 6pm but also from 10am to noon, and 2 to 4pm. The “other” category for behaviors remained fairly constant throughout the day. Both Allie and Schnapps had some peaks which were never greater than 5%.

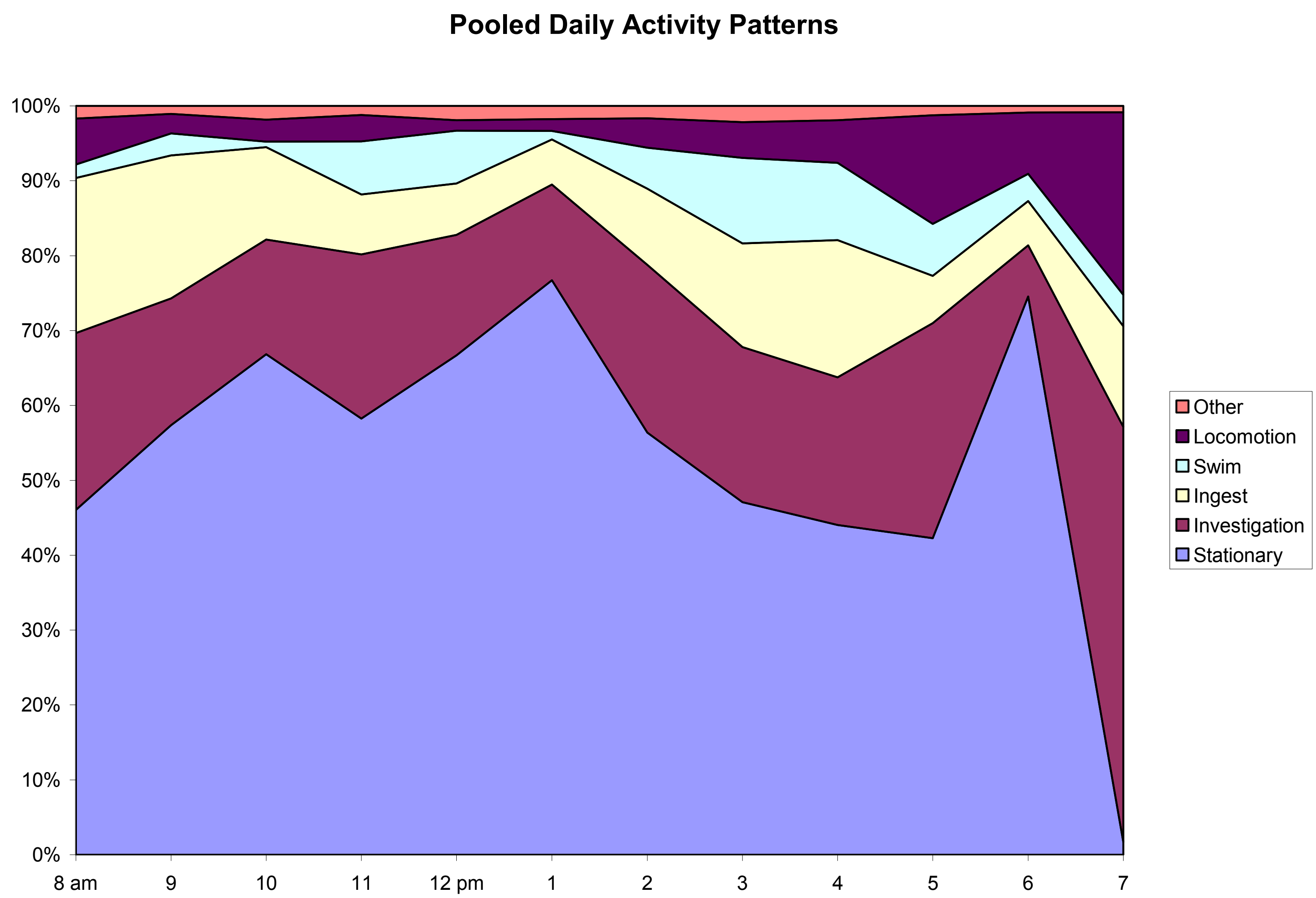

Figure 17. Daily activity patterns for all individuals combined from 8am to 7pm.

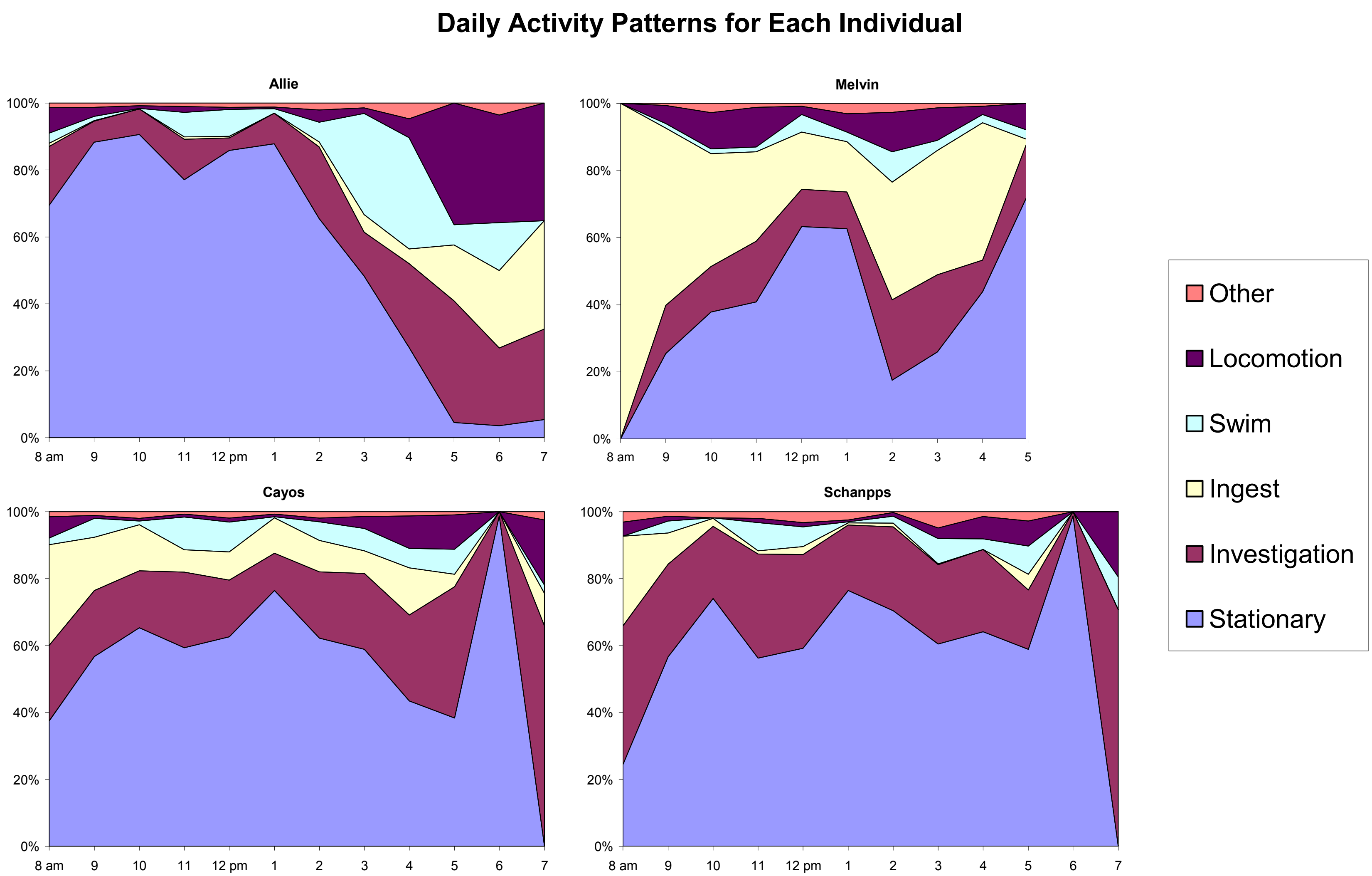

Figure 18. Daily activity patterns for each individual between 8am and 7pm. Melvin did not have any observations between 6 & 7pm.

When comparing species, the Malay tapir demonstrated more lying down, swimming, and vocalizing while the Baird's tapirs displayed more investigation, feeding, and aggression (Figure 19). In the comparison between the sexes, females spent more observations lying down and licking, whereas, males spent more observations feeding (Figure 20). When comparing age, adult tapirs licked more than young tapirs (Figure 21). The comparison between the number of tapirs in an exhibit found increased investigation when two tapirs are housed together and increased locomotion and elimination when tapirs are housed singly (Figure 22).

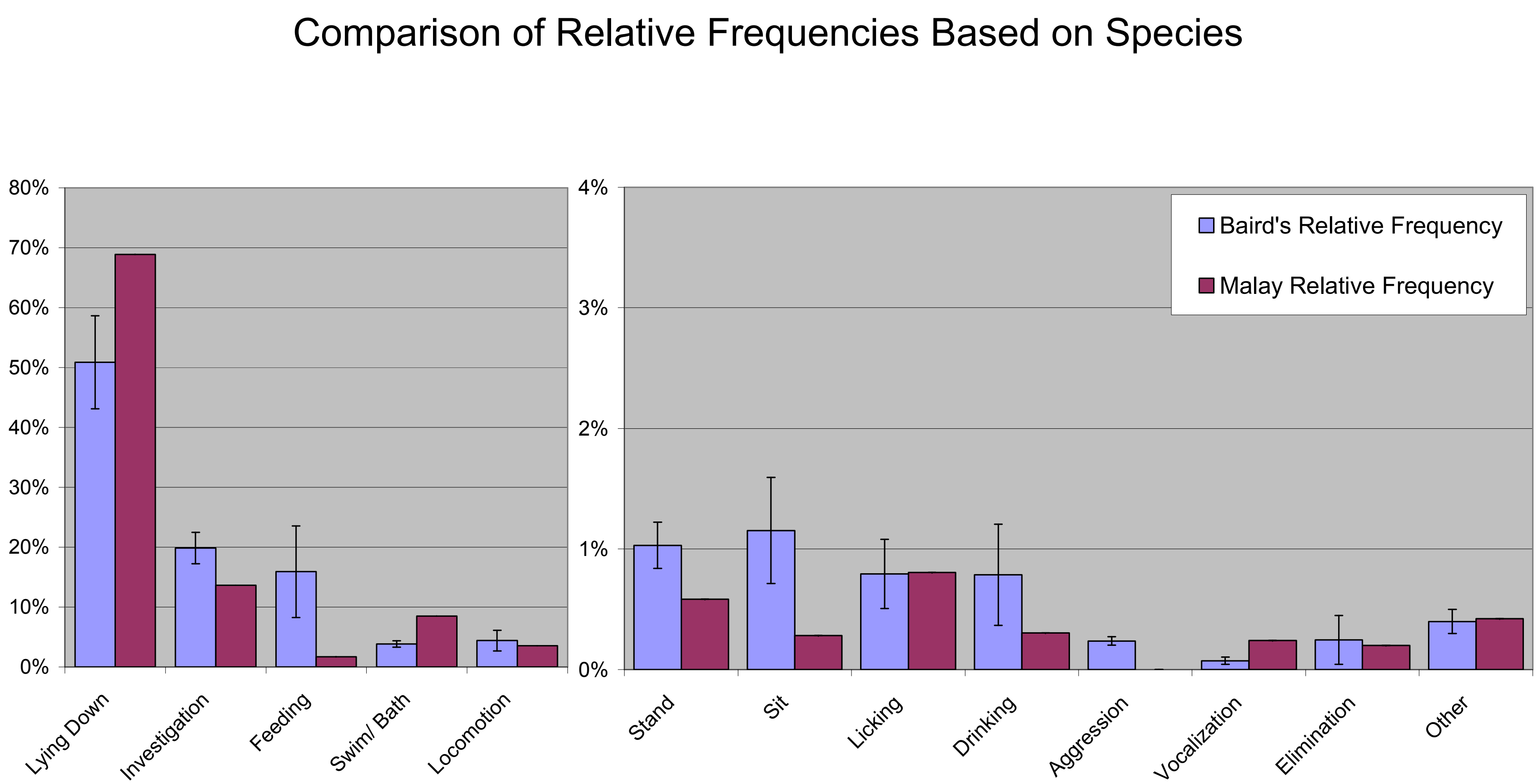

Figure 19. *Tapirus bairdii* relative frequencies compared to *Tapirus indicus* relative frequencies with standard error bars.

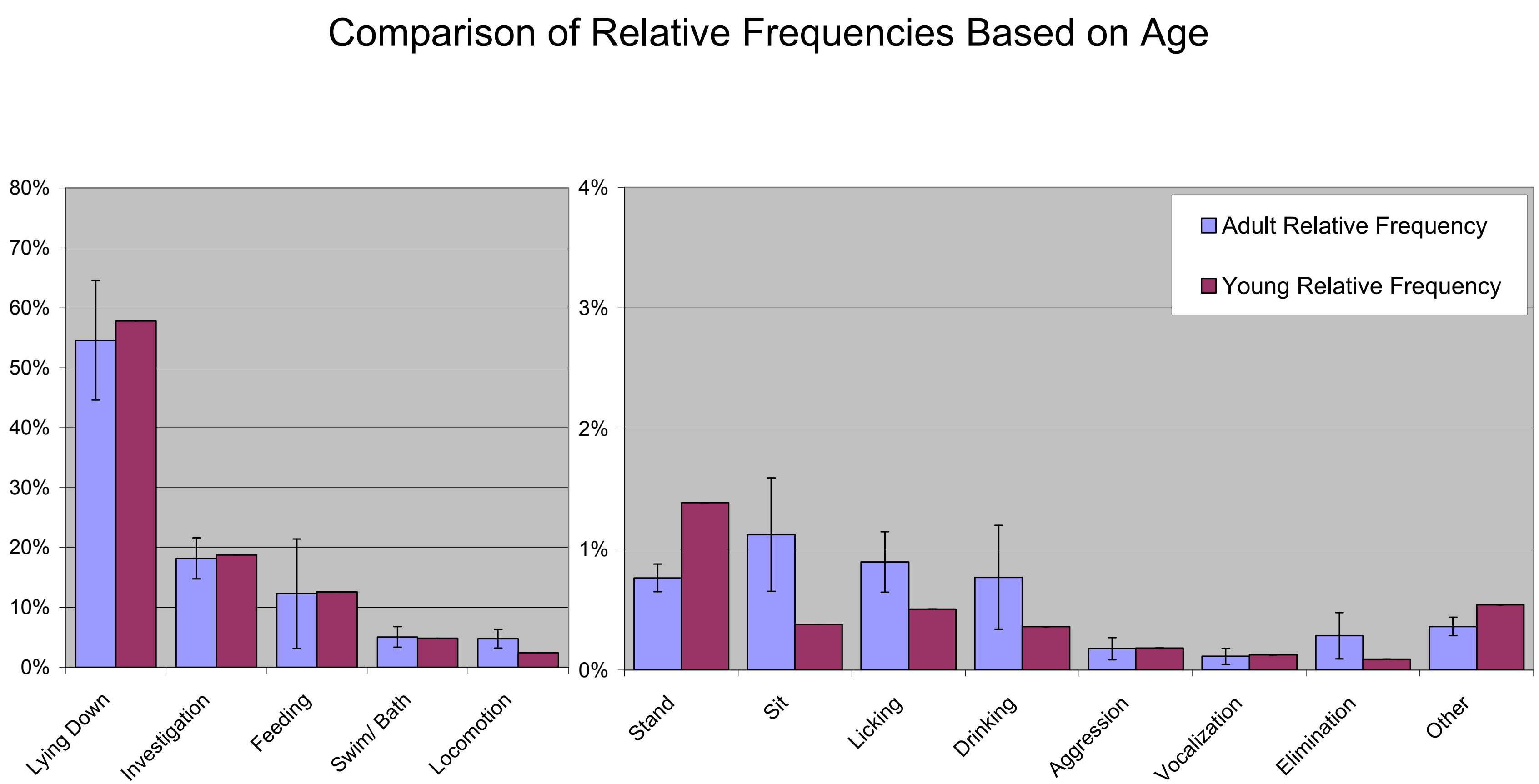

Figure 20. Adult relative frequencies compared to young relative frequencies with standard error bars.

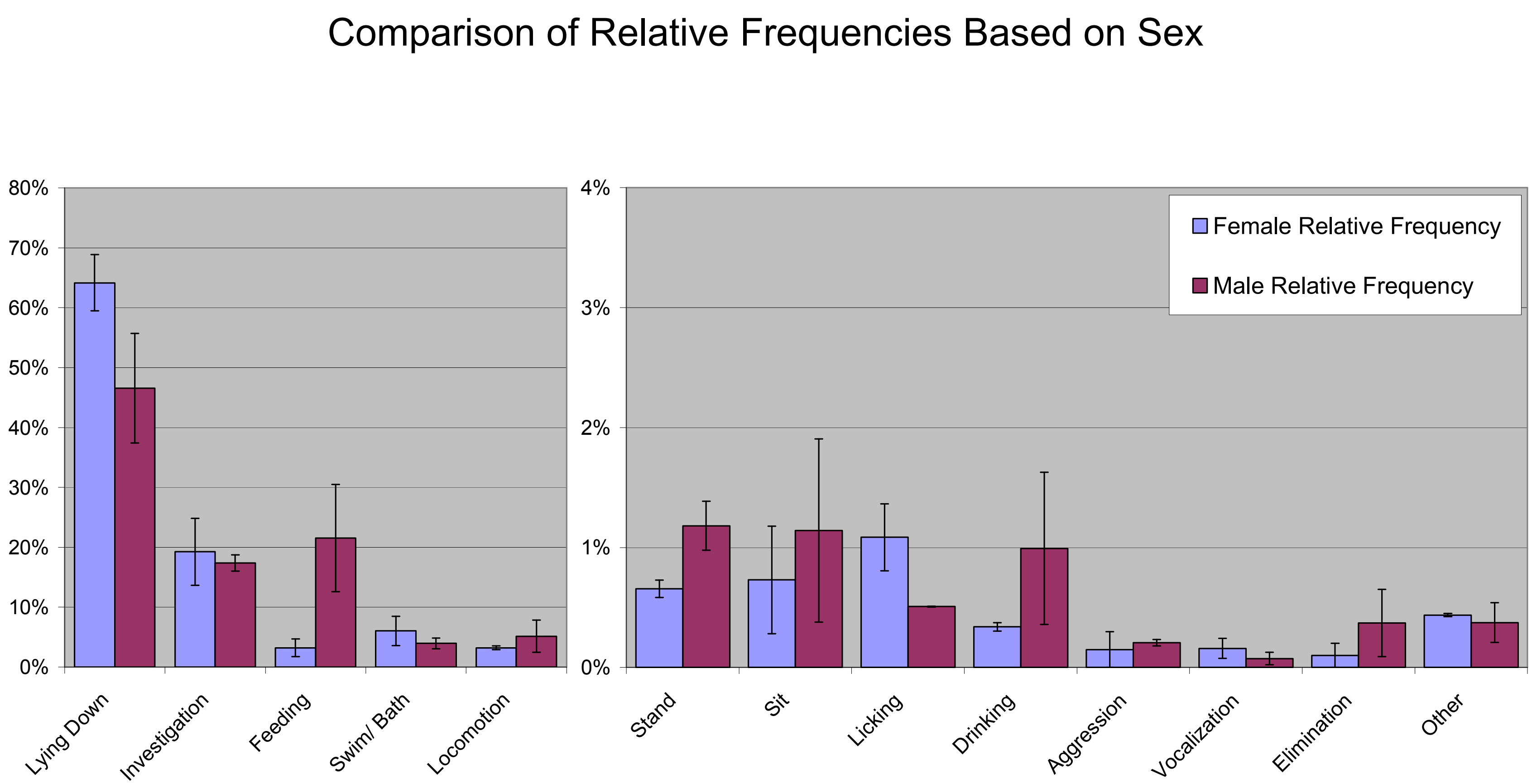

Figure 21. Female relative frequencies compared to male relative frequencies with standard error bars.

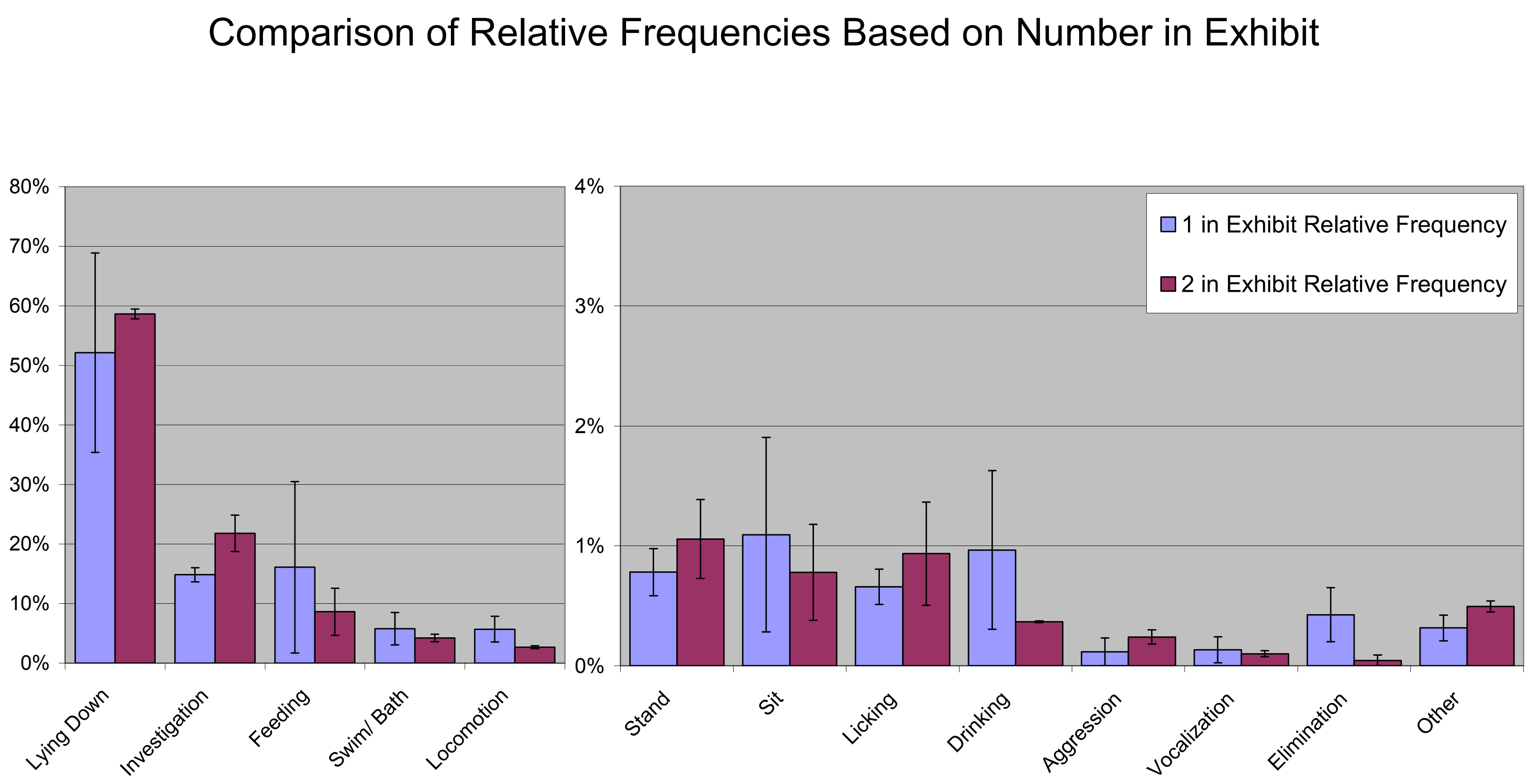

Figure 22. The relative frequencies of one tapir in an exhibit compared to the relative frequencies of two tapirs in an exhibit with standard error bars.

Environmental Effects

13.4% of the variance in behavior was accounted for by individual, climate, or month (Figure 23). Of that explained variance, individual explained 70.9% of the variation, climate explained 17.2% of the variation, and month explained 11.2% of the variation. There was very little to no shared variance among these variables.

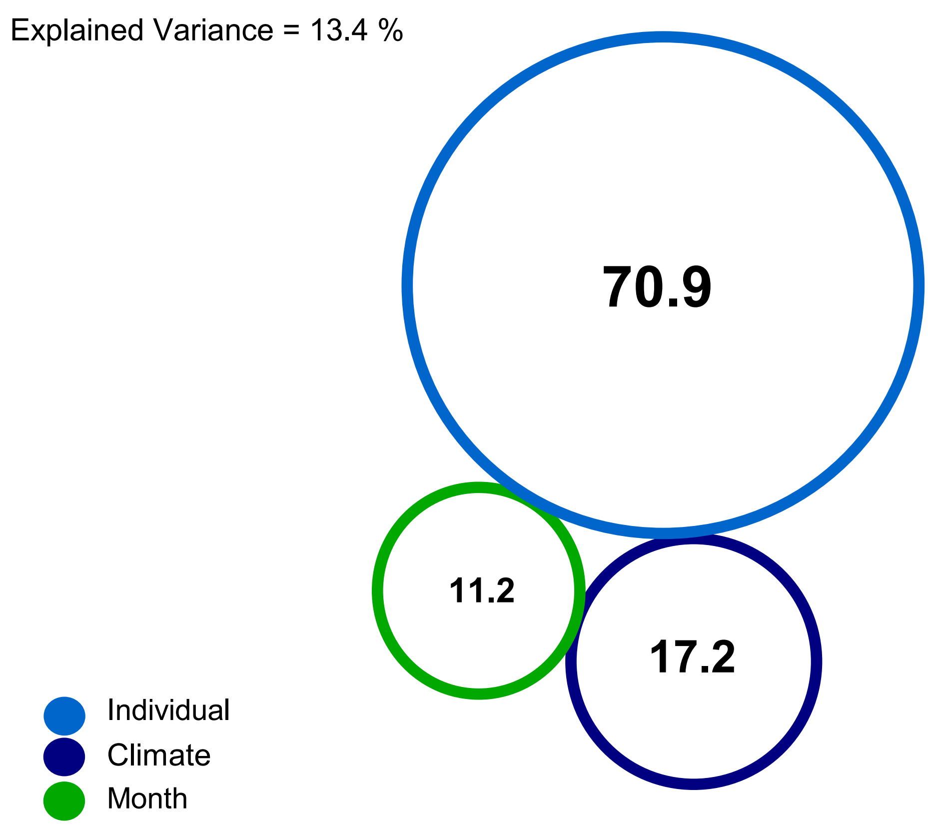

Figure 23. A skewed Venn diagram indicating the percentage of the explained variation of an RDA that is explained by three explanatory variable groupings: individual, climate, and month.

The first axis explained 8.9% of the variation and the second axis explained 0.9 % of the variation. Melvin encompassed the most variation in behavior, followed by Schnapps and Allie (Figure 24). Cayos location near the origin indicates that is behaviors were close to the average for all the tapirs. Feeding behavior was most strongly related to

Melvin, whereas investigation was associated with Schnapps and vocalization was correlated with Allie. Melvin was negatively associated with lying down behavior; however, fell between Schnapps and Allie evenly between it. All of the individual variables were significant.

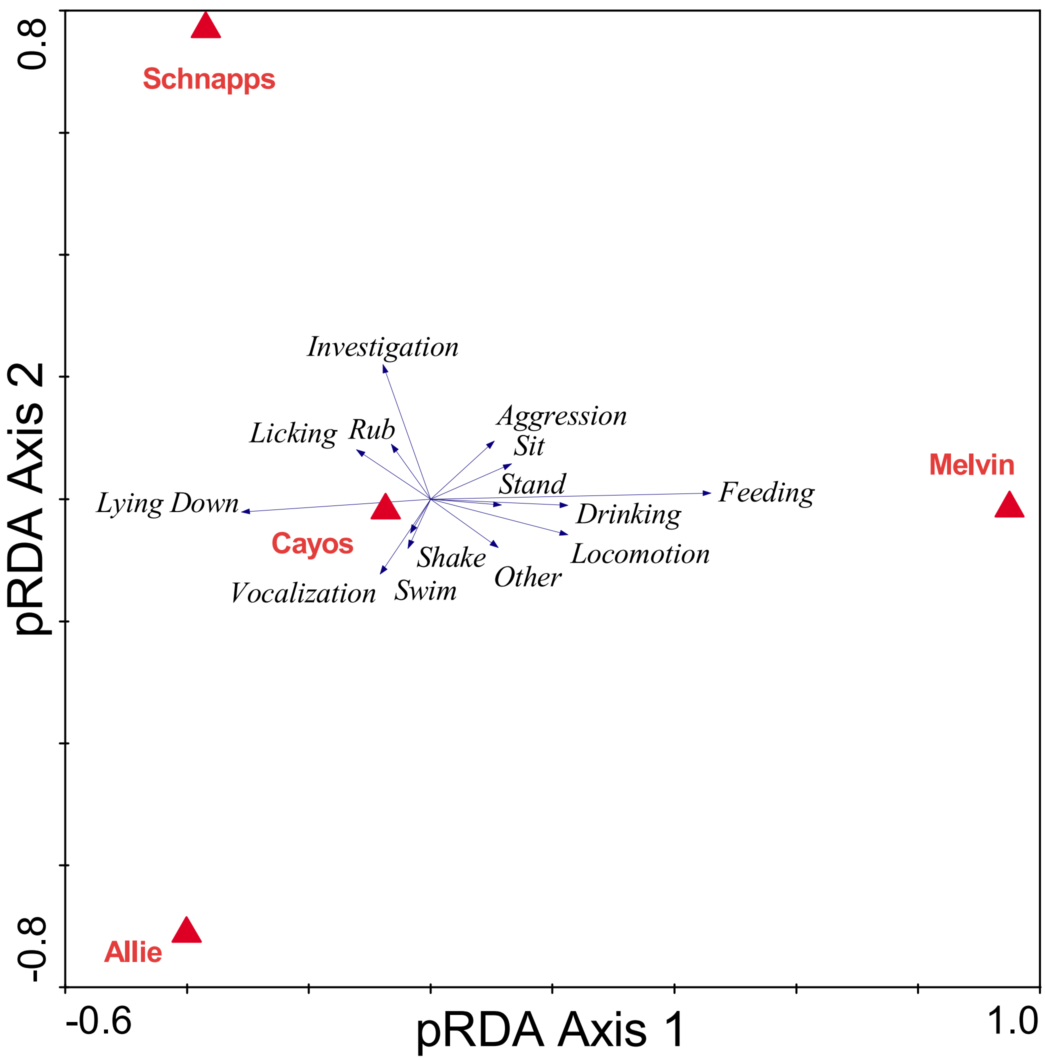

Figure 24. The relationship of behaviors to different individuals after factoring out climate and month variables. The eigenvalues were 0.084 and 0.009 for the first and second axes respectively.

Dew point and rainfall explained the most variation in behavior, followed by mean temperature and average percent humidity (Figure 25). The percent lunar illumination (% Moon) explained only a small amount of the variation. Increased investigation was associated with dew point; increased locomotion was associated with rainfall. A decrease in lying behavior was associated with both of these variables.

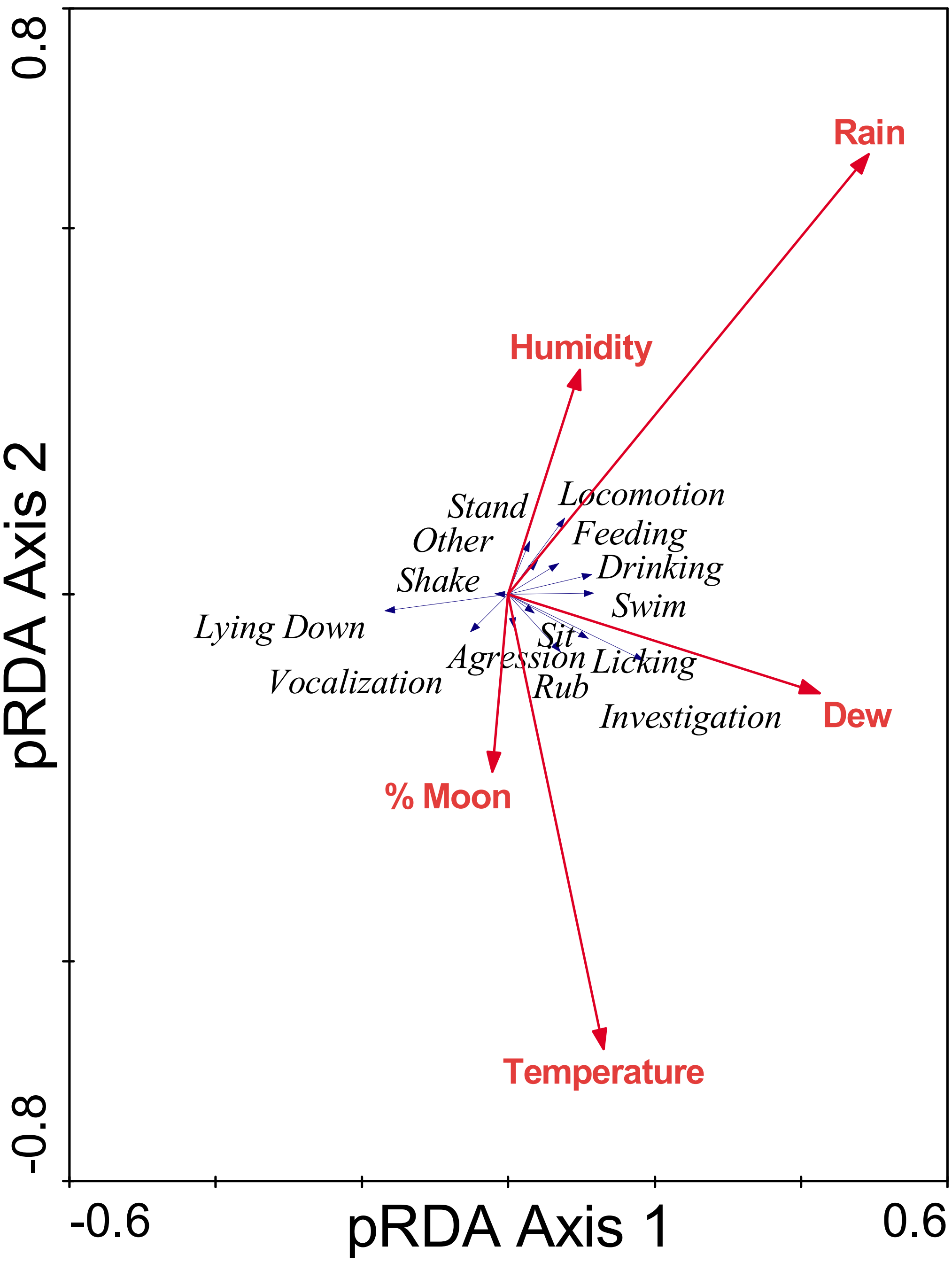

Figure 25. The relationship of behaviors to climatic variables after factoring out the influence of individuals and month. The eigenvalues were 0.019 and 0.003 for the first and second axes respectively.

SPATIAL USE

For each individual, the Fisher's exact test was highly significant (p<0.001). The CCA confirmed many of the results of the PCA but those results were more ambiguous and, therefore, will not be discussed.

The first and second PCA axes together explained 79.9 % (axis 1, 65.3%; axis 2, 14.6%) of the variance in Allie's behaviors. Out of the nine behavior groupings, lying down most strongly loaded on the first PCA axis. This behavior was associated with exhibit sections SF, S1, and B (Figure 26). Not surprisingly, section H_2O and swimming were also highly associated. Most interesting, is where the time classes fall with morning and noon associated with lying down and afternoon associated with swimming. The rest of the behaviors and sections were clumped together with evening.

For Melvin the first two PCA axes captured 85.6 % (axis 1, 60.8%; axis 2, 24.8%) of the variance in his behaviors. As in the analysis for Allie, lying loaded heavily on the first principle component; however, in contrast to her, Melvin appears to sleep the most during the noon hours. Ingestion also appeared as an important behavior and was most correlated to inside and morning (Figure 27). Most of the other behaviors were clumped with pool and most closely associated with afternoon.

Axis 1 explained 63.8 % of the variance in behavior and 72.6 % of the variance in the behavior-section-distance relationship for Cayos (Figure 28). He showed an association between section U1 and lying down. Section V was between lying down and ingestion, while section U2 was also associated with ingestion. Sit showed and association with MW, whereas, the rest of the behaviors and section were clumped together.

For Schnapps, Axis 1 explained 63.4 % of the variance in behavior and 78.1 % of the variance in the behavior-section-distance relationship (Figure 28). Lying down was between sections V, MW, and U1. Ingestion was correlated with section U3 and investigation fell between sections U2 and U3. Swimming and section H_2O were highly associated while the rest of the behaviors and sections were clumped together.

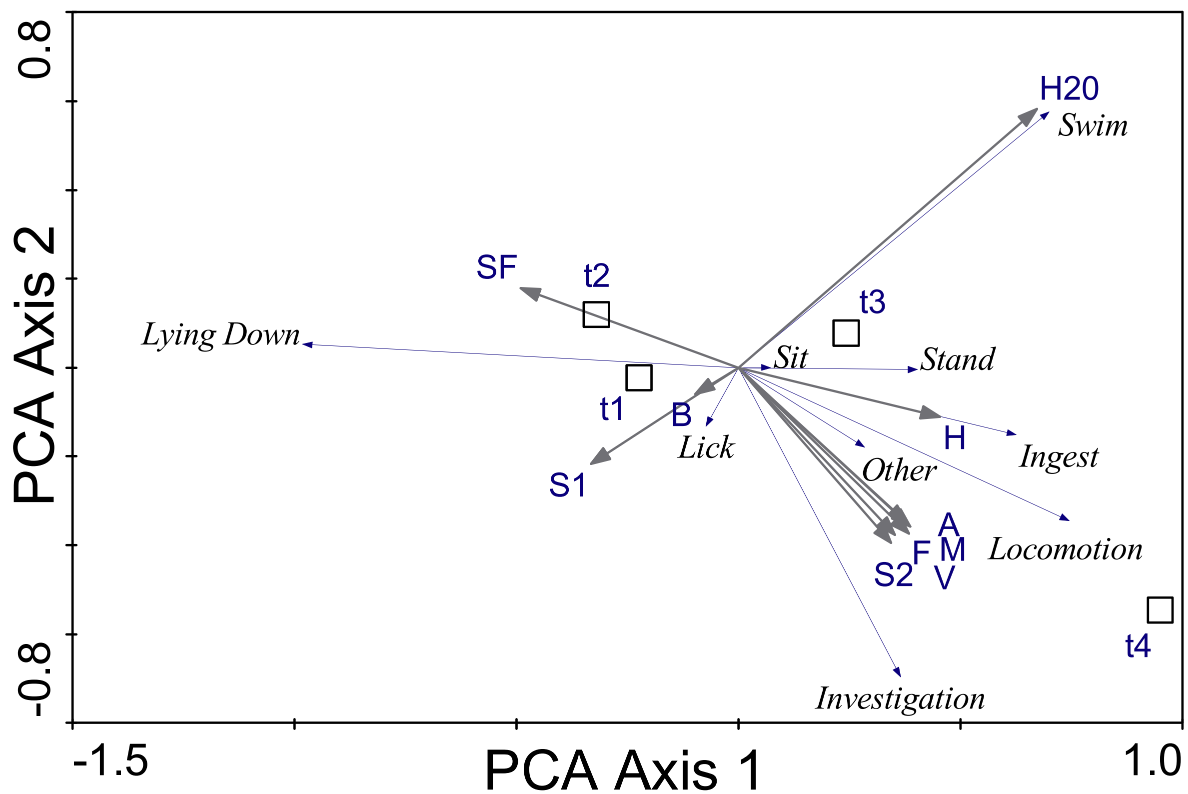

Figure 26. PCA for Allie's behaviors with the exhibit sections and time of day classes projected into the ordination space. The first two PCA axes captured 85.6% (axis 1, 65.3%; axis 2, 14.6%) of the variance in her behaviors.

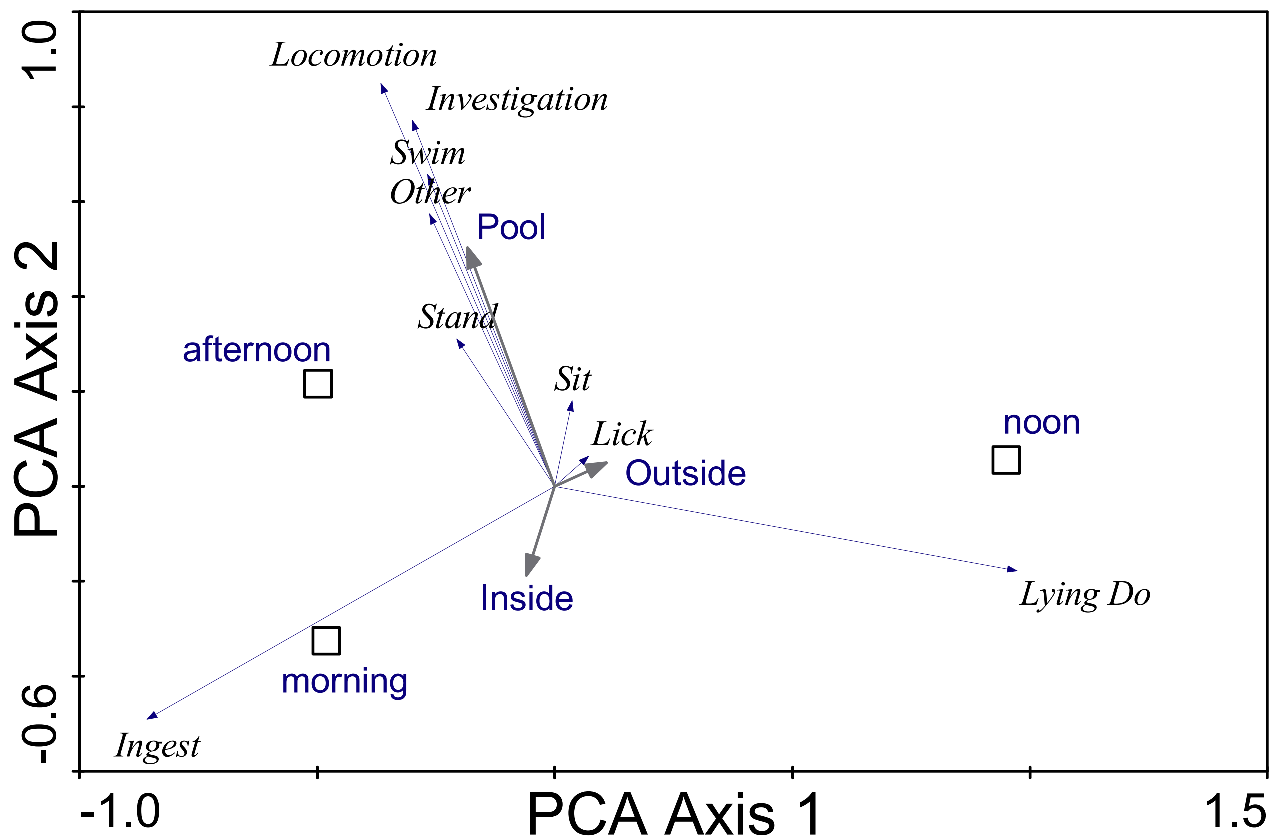

Figure 27. PCA for Melvin's behaviors with the exhibit sections and time of day classes projected into the ordination space. The first two PCA axes captured 85.6 % (axis 1, 60.8%; axis 2, 24.8%) of the variance in his behaviors.

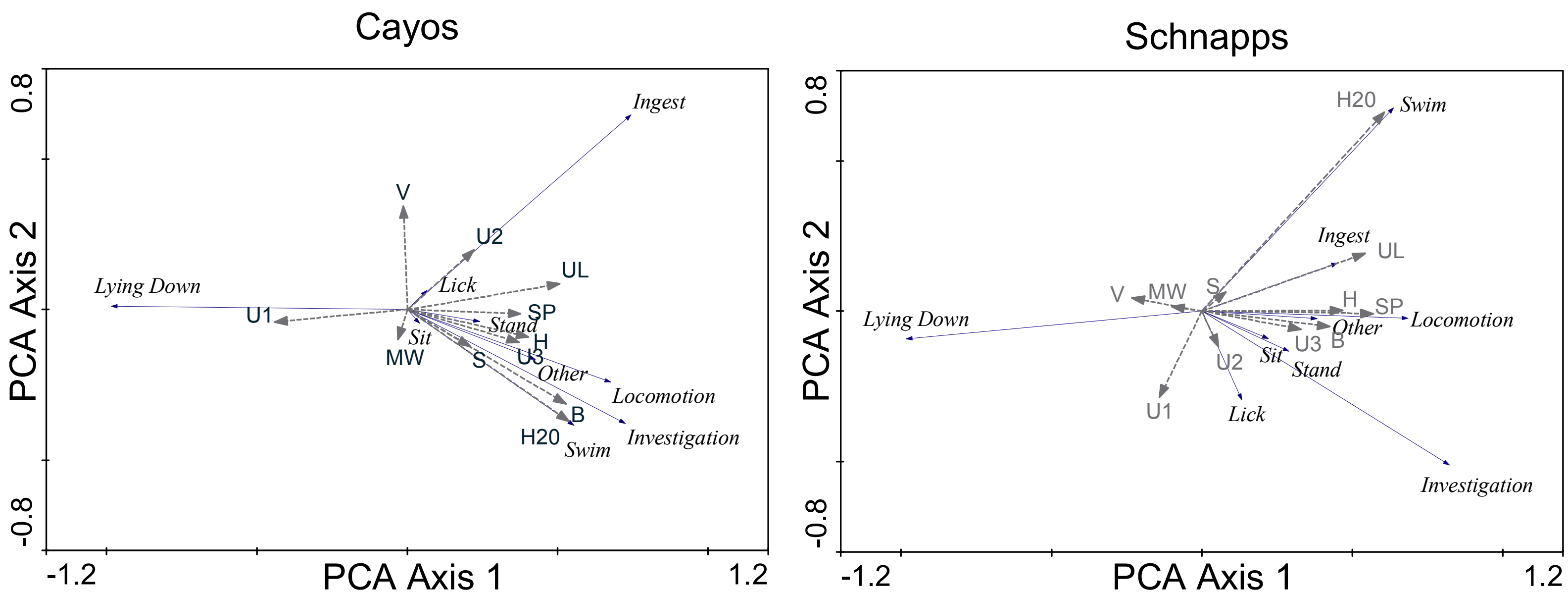

Figure 28. Two PCA biplots on behavior (solid blue arrows) which have exhibit sections (gray arrows) overlaid in the ordination space as passive variables. In the PCA for Cayos' behavior, Axis 1 explained 63.8 % of the variance in behavior. In the PCA for Schnapps' behavior, Axis 1 explained 63.4 % of the variance in behavior.

In Allie's behaviors, unlike the other tapirs, an RDA with four time class dummy variables explained a significant amount of variation (23.3%, *F*-ratio = 11.569, *P* = 0.001). Morning and noon were associated with lying down and sections B, S2, SF (Figure 29). Evening was associated with locomotion and afternoon was associated with section H_2O and swimming. Cayos and Schnapps were very similar in behavior, but Cayos was more correlated with V, where Schnapps was associated with sections U1 and U2 (Figure 30).

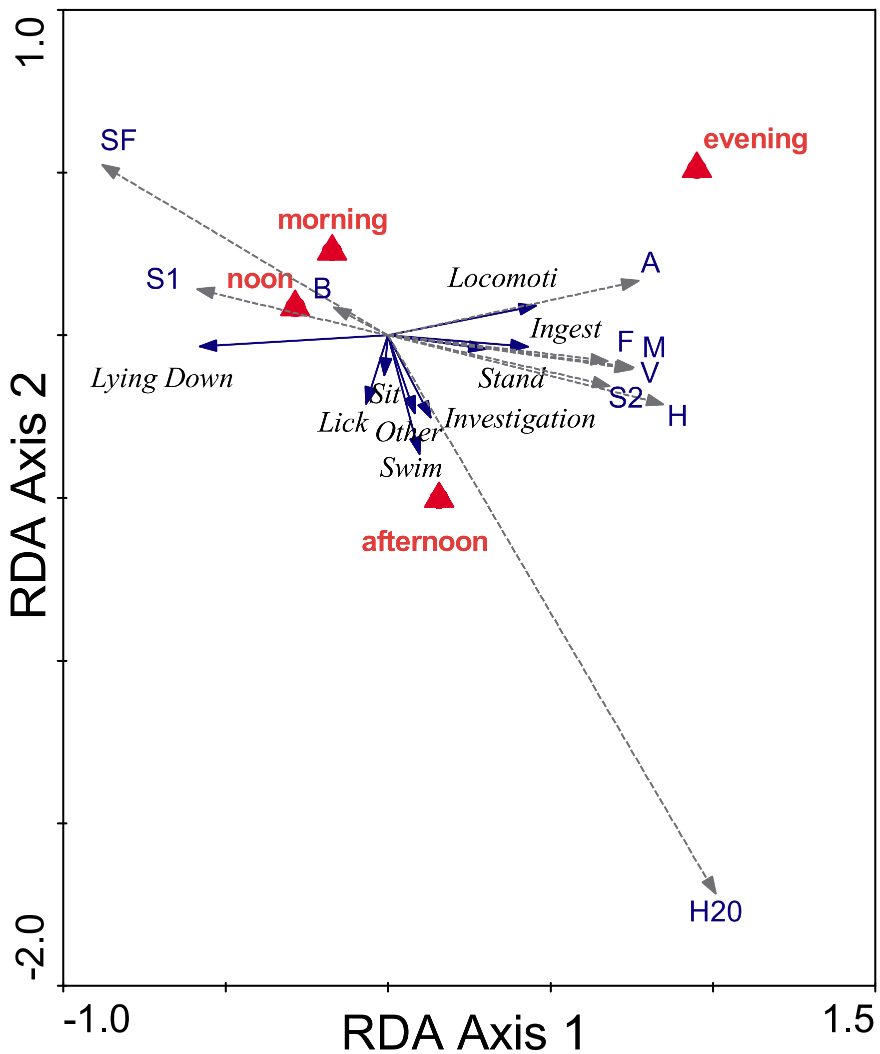

Figure 29. RDA for Allie with four time class dummy variables, a significant amount of variation in Allie's behaviors was explained (23.3%, *F*-ratio = 11.569, *P* = 0.001).

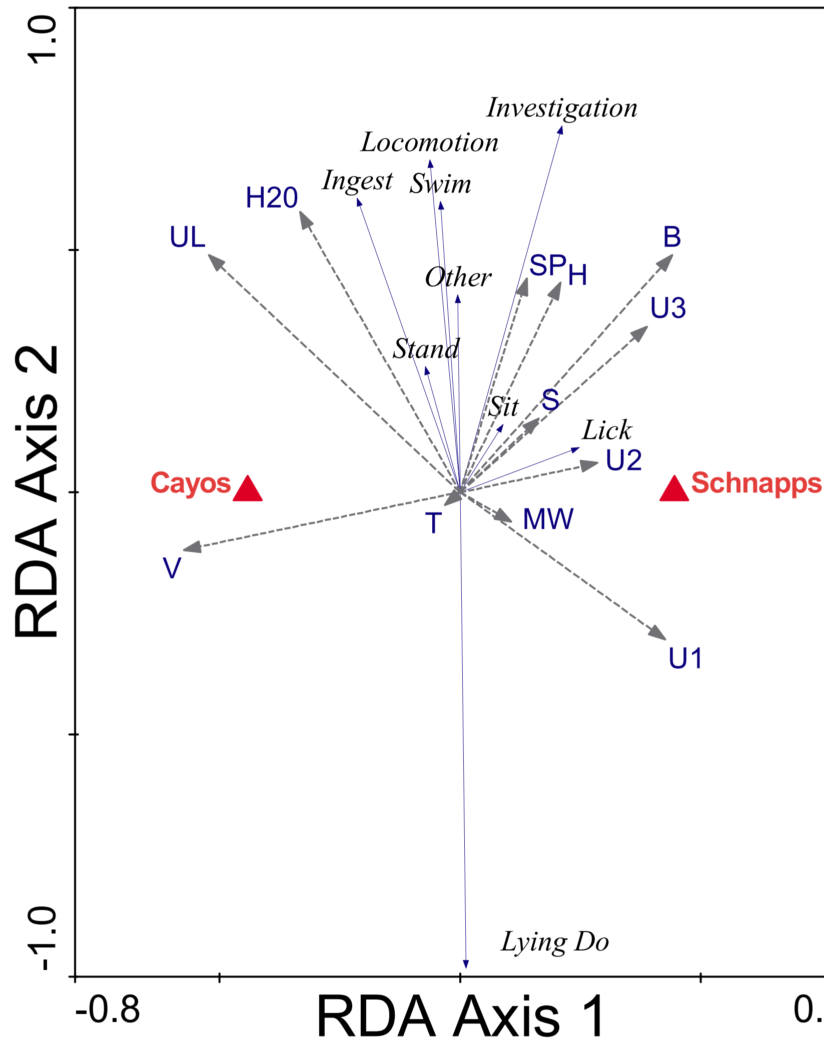

Figure 30. An RDA biplot of the single canonical axis and first unconstrained axis. This figure illustrates the differences between mother and young in terms of behaviors exhibited and the correlations of those behaviors to particular exhibit sections and distance classes. The Cayos / Schnapps dummy variable explained 1.8 % of the variance in behavior and was significant (999 permutations, F-ratio = 4.085, P = 0.0170) and explained 4.4 % of the variance in the behavior-exhibit section relationship.

The partial Redundancy Analysis (pRDA) of behavior abundance found that enclosure type (inside barn vs. outside on exhibit) explained 19.2 % of the variance in Allie's behavior (*F*-ratio = 3.348, *p*-value = 0.0390). Outside was associated with increased swimming; whereas, inside was associated with increased investigation and lying down (Figure 31).

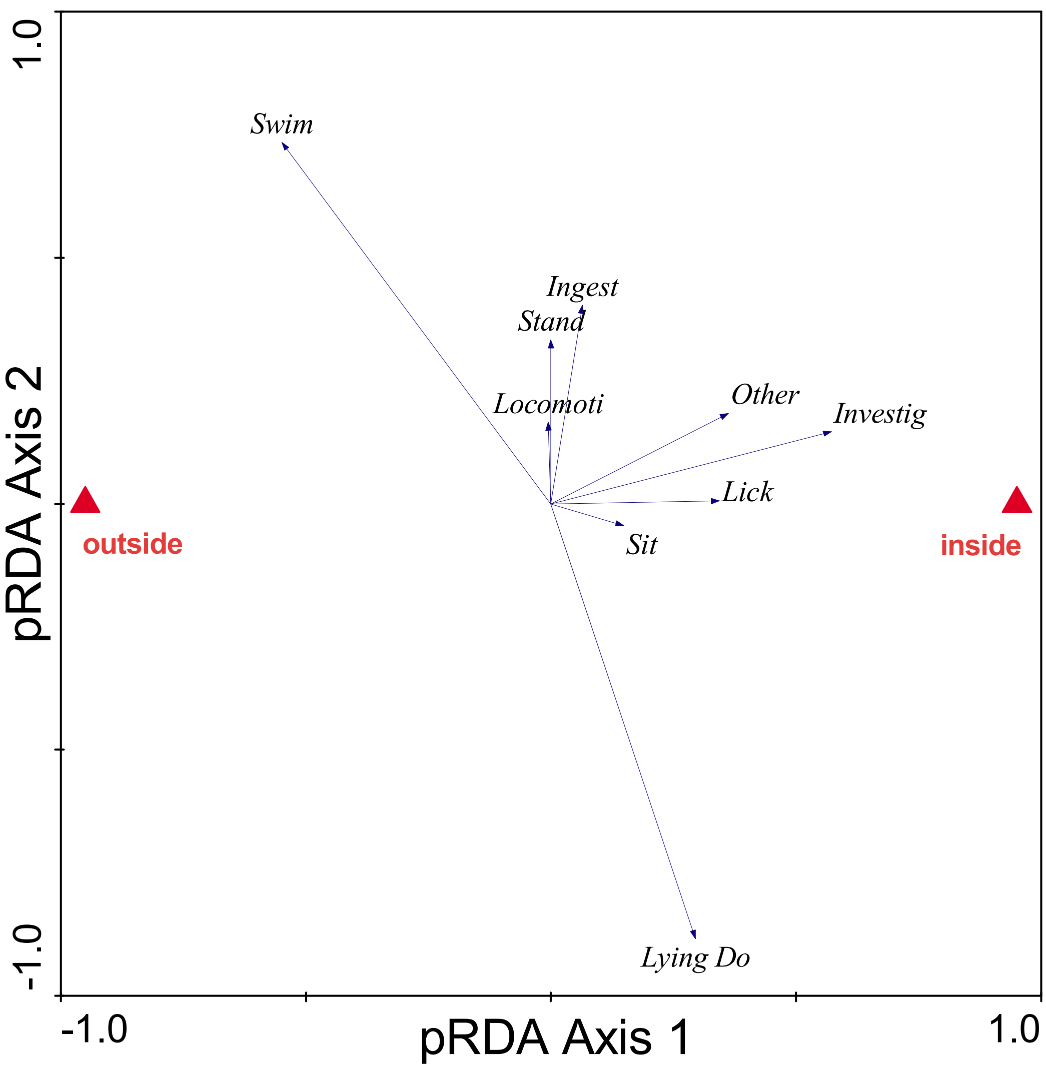

Figure 31. pRDA displaying the relationship of Allie's behaviors relative to enclosure after factoring out the effect of tclass. Outside Allie swam more and inside she investigated more and rested for more observations. Behaviors such as locomotion, stand and ingest seem to occur equally in both enclosures.

The Redundancy Anaylsis (RDA) of behavior abundance found that before and after landscaping explained 0.8 % variance in behavior, and was not significant. The partial RDA of section usage found that before and after landscaping explained 17.3 % of the variance in section abundancy with time class factored out (F-ratio = 17.656, p-value = 0.0010). Before the landscaping, Allie spent more observations in sections SF and B; after the landscaping she was in section S1 more (Figure 32).

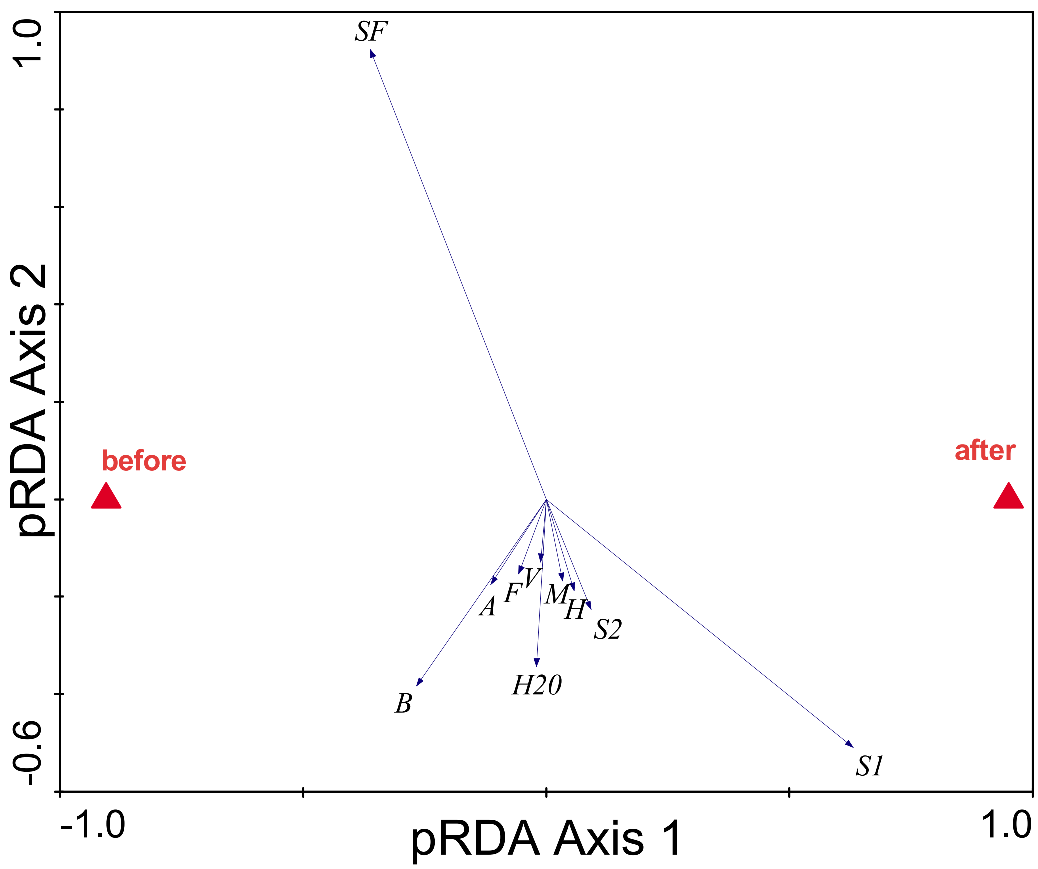

Figure 32. pRDA displaying the relationship of the sections of Allie's exhibits as explained by the landscaping treatment after factoring out the effect of time class.

MOTHER- YOUNG INTERACTIONS

Mother and young behavior is not independent (χ^2 = 4000.78, *p*-value = 0.0005). Lying down, investigation, and swimming were the most frequent behaviors performed simultaneously by Cayos and Schnapps; whereas, lying down while the other tapir was investigating was the most seen non-simultaneous behavior (Table 7). The interaction between Cayos' behavior and distance explained significantly more deviance than the interaction between Schnapps' behavior and distance. All of the models (except the fully saturated model) were significant (Table 8). Model 3 and 4 had the same number of degrees of freedom but model 4 explained more deviance (Table 9).

Cayos and Schnapps demonstrated similar behavior and distance relationships (Figure 33). Lying down occurred when the two were either in close proximity (touching to 1ft) or far apart (>18ft). They were most active when they were between 3 and 18ft apart. Lying down and 3-18ft were negatively associated.

Table 7. This table indicates the number of times Schnapps and Cayos were performing various behaviors simultaneously. The shaded diagonal indicates when the mother and young were performing the same behavior at the same time.

		Cayos behavior								
		Ingest	Investigation	Lick	Locomotion	Lying	Other	Sit	Stand	Swim
Schnapps Behavior	Ingest	65	41	3	8	19	2	0	0	9
	Investigation	143	480	4	37	477	15	5	16	63
	Lick	5	11	0	1	53	0	0	0	1
	Locomotion	15	33	0	33	6	1	0	1	3
	Lying	264	274	8	20	2340	9	5	27	24
	Other	5	8	0	2	11	5	0	2	2
	Sit	2	15	0	3	30	2	1	1	0
	Stand	4	10	1	1	5	2	0	0	0
	Swim	7	20	0	4	0	1	0	3	156

Table 8. The hierarchical log-linear models investigated their deviance (G^2), number of degrees of freedom, and the *P*-value for each model. The models are called hierarchical because each model increases in complexity (i.e. more variables and fewer degrees of freedom).

	Model	G^2	**df**	***P***
1	S.beh + C.beh	5072	388	< 0.001
2	S.beh + C.beh + Dist.Grp	3648	384	< 0.001
3	S.beh + C.beh + Dist.Grp + S.behxDist.Grp	3260	352	< 0.001
4	S.beh + C.beh + Dist.Grp + C.behxDist.Grp	2982	352	< 0.001
5	S.beh + C.beh + Dist.Grp + S.behxC.beh	1454	320	< 0.001
6	S.beh + C.beh + Dist.Grp + S.behxC.beh + C.behxDist.Grp	788	288	< 0.001
7	Saturated (full) model	0	0	

Table 9. ANOVA table indicating the degree of improved fit (ΔG^2) or lack of improved fit of each model and an estimate of the probability that the observed improvement is different from zero. Model 3 and 4 have the same number of degrees of freedom but model 4 explains more deviance.

	G^2	**df**	ΔG^2	**Δdf**	***P*** **(>**ΔG^2**)**
Model 1	5072	388			
Model 2	3648	384	1423.4	4	< 0.001
Model 3	3260	352	388.19	32	< 0.001
Model 4	2982	352	278.22	0	---*
Model 5	1454	320	1527.8	32	< 0.001
Model 6	788	288	666.41	32	< 0.001
Saturated	0	0	787.62	288	< 0.001

* test has zero degrees of freedom

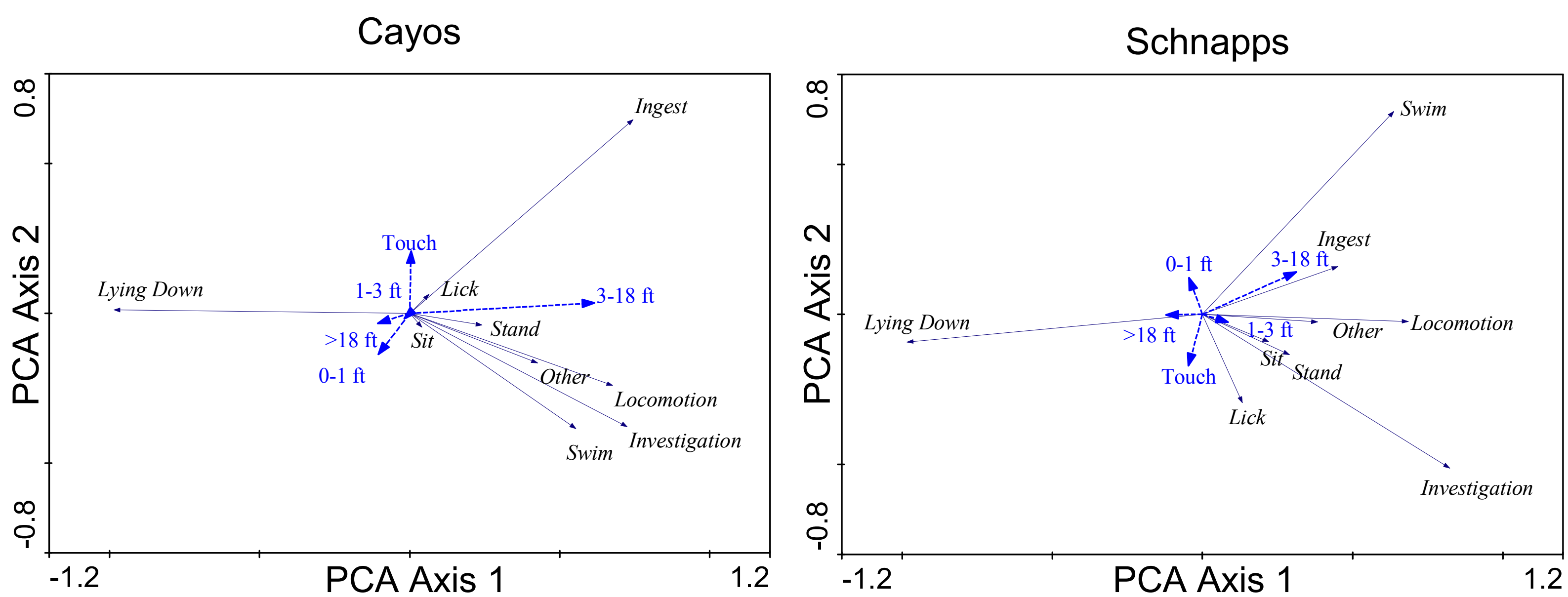

Figure 33. Two PCA biplots on behavior (solid blue arrows) which have distance overlaid in the ordination space as passive variables (dotted arrows, blue). In the PCA for Cayos, Axis 1 explained 63.8 % of the variance in behavior. In the PCA for Schnapps, Axis 1 explained 63.4 % of the variance in behavior.

CHAPTER V

DISCUSSION

ACTIVITY PATTERNS

General Patterns

On average, the tapirs in this study spent 57.99% resting, 18.73% investigating, 11.64% feeding, 5.04% swimming. Other studies have reported similar results, with resting occurring 54.3%-65.2% and feeding 8.2%-24.1% (Mahler, 1984a; Seitz, 2000c; Seitz, 2001). Studies conducted on wild tapirs indicate more activity at night than during the day (80.4% and 20.2% respectively), however, other studies found no patterns (Foerster and Vaughan, 2002; Leal and Foerster, 2004; Williams, 1978). So it is possible that captive tapirs are more active during the day than wild tapirs.

Schnapps investigated and licked the most out of all of the tapirs. This could partially be explained by the presence of her offspring which could make her more alert and responsive. She spent the most observations licking herself (58.90%) or Cayos (34.25%). Construction also began in July near the Baird's tapir enclosure which may explain changes both in her and Cayos' behavior during that month. She may have viewed the disruption as a potential threat or oddity that required more investigation. In the wild, tapirs avoided areas of high human activity (Constantino and Ho, 2002; Naranjo Pinera and Aldan, 1998; Torres et al., 2004b). Recent research on giant pandas

(*Ailuropoda melanoleuca*) found construction noise increased stress behaviors, cortisol levels, and exploratory behaviors (in one of the individuals) (Powell et al., 2006).

Unlike the other individuals, Schnapps was never seen performing any eliminatory behaviors. This is likely explained by a preference for using deep water for elimination. The layout of the exhibit made it very hard to see into the water, possibly leading to no observations. Wild and captive tapirs often use water for eliminatory purposes (Eisenberg et al., 1990; Matola et al., 1997; Seitz, 2001; Williams, 1991).

Melvin ingested, drank, and moved around the most. In contrast to the other tapirs, he was fed at scheduled times during the day, both in the morning and the afternoon. The increased observations of feeding may explain why drinking also increased, since eating was often followed by drinking. The other tapirs, which generally swam more, may have been drinking while swimming under water which would remain undetected. Movement was usually in the form of pacing with some aggression occurring as well, this could be due to the small size of the enclosure and the overall lack of stimulation.

Off-exhibit areas tend to be small and are designed for short-term holding, they are generally considered inadequate for long-term captivity because they do not simulate the animal's natural environment (Forman et al., 2001). Animals in small, sterile enclosures are more prone to stereotyped behavior such as pacing (Mallapur et al., 2002). Pacing was the most common form of stereotypic behavior seen in zoo animals (Swaisgood and Shepherdson, 2005). By enriching the environment, enclosures can seem more complex and become more interesting and dynamic, while significantly decreasing stereotypic behaviors such as pacing (Forman et al., 2001; Jensvold et al., 2001;

Swaisgood and Shepherdson, 2005). Zoos should consider increasing the enrichment regimen for animals kept in small enclosures for extended periods.

Allie both swam and vocalized more than any other individual. The variation in swimming frequency may be a species differences. Other research found that captive Malay tapirs used water facilities more than any other tapir species (Seitz, 2001). Swimming could also indicate either an individual preference or enclosure difference. Her vocalizations usually occurred in the evenings when the zoo was open late. Since she was housed alone, the vocalizations were most often directed at me, other visitors, or zoo staff (i.e. humans). Allie's vocalizations included two different types of squeals (a fluctuating squeal and a sliding squeal) and a hiccup sound. Only the shrill fluctuating squeal has been reported in the Malay tapir, but the all the vocalizations heard have been reported in other tapir species (Ferris, 1905; Hislop, 1950; Hunsaker and Hahn, 1965; Klingel, 1977; Morris, 2005; Terwilliger, 1978). Both the shrill squeal and the hiccup sound indicate agitation (Ferris, 1905; Hislop, 1950; Hunsaker and Hahn, 1965; Klingel, 1977). The sliding squeal is not well understood but is used during exploratory behavior and is possibly a contact call (Hunsaker and Hahn, 1965; Klingel, 1977). Squeals, snorts, and whistles are common among Perissodactyla (Klingel, 1977).

Allie was never observed showing aggression. One explanation could be that no conspecific was present. This it is not likely, because, despite being kept alone, Melvin showed aggression to capybaras, as well as, to inanimate objects. Allie could have behaved aggressively to the Indian munjac or birds in her enclosure but she was not. The range of temperament in tapirs varies from very tame to aggressive, so most likely the difference in Allie's temperament is due to individual variation (Barongi, 1993).

Temporal Patterns

The number of nights the zoo was open late increased as the summer progressed, this may explain why Allie showed an increase in investigation, ingestion, and movement. The change in the zoo's hours affected all of the tapirs out on exhibit, but for Allie the effect was the greatest. For all three, locomotion increased. Allie also had a dramatic drop in stationary behaviors during that period. The disruption of the regular routine likely resulted in these changes. Usually the tapirs were fed after being put in from exhibit, so the additional wait for dinner may have caused stress resulting in the agitation and pacing seen after hours. This could be considered an enrichment technique because of the increase in activity; however, many of these behaviors could be considered stress responses to the situation. Stress should not be considered inherently bad, although there are identifiable negative effects (Wielebnowski, 2003). Enrichment is generally thought to reduce stress not to cause it (Carlstead and Shepherdson, 1994).

The reduction in investigation for Melvin over the summer is most likely explained by observer effect. The only way I could observe him was to stand right in front of the stall because a waist high cinderblock wall obscured the view in any other position. As I spent more time watching him throughout the summer, it is possible that he habituated to my presence.

The peak in resting occurred as the temperature began increasing and dew point was at its lowest point. This is consistent with the findings of the environmental effects analysis. It could also be a reaction to fewer people moving around the zoo at that time.

Swimming peaked around the hottest, driest times of the day but also when the dew point was fairly high. Other research found that bathing is used to regulate body temperature and often occurs during the hottest part of the day (Eisenberg et al., 1990; Seitz, 2001). Melvin did not follow the swimming pattern that the other tapirs exhibited which could be due to the small size of his pool or the slightly different conditions in the barn. Since the other tapirs showed increased swimming due to climatic variables (temperature, humidity, dew point, etc.), it is possible that the partially controlled climate of the barn may have reduced swimming behavior. Inside the barn, the amount of shade was greatly reduced; this difference in light exposure may have reduced swimming behavior. However, the barn was open to the outdoors so when Melvin was in the yard he was exposed to the same conditions as the other tapirs.

Investigation was mostly sporadic over the course of a day. Smelling was the prime form of investigation, likely because wind direction and airborne stimulus vary greatly throughout the day. Ingestion was the most variable behavior amoung tapirs, most of the tapirs were fed after hours (Melvin was the exception to this) and so the behaviors that dominated this study were foraging throughout the exhibit and utilization of enrichment when it was present.

Comparisons

Differences in species, sex, age groups, and number in exhibit could be artifacts of the small sample size and could be individual differences amplified, so conclusions are not definitive. Further research into this area is important.

The variation in the frequencies of bad (i.e. missed) observations is likely due to exhibit bias. The Baird's tapir exhibit had virtually no blind spots, so the tapirs were more likely to be observed. However, in the Malay tapir exhibit, most of section B could not be seen from the front viewing area. In the barns not all of the outside area could be seen so for both exhibits I was likely to have missed observations.

Environmental Effects

The RDA indicated that out of three classes of explanatory variables the individual class explained the most variation. Individual differences in tapirs were also found to be important in other studies on captive behavior research (Seitz, 1998; Seitz, 2000c; Seitz, 2001).

Historical references and hunter accounts state that tapir activity changes based on the phase of the moon (Lizcano and Cavelier, 2000; Thom, 1936). The RDA showed that percent of lunar illumination was weakly correlated with less frequent behaviors such as aggression and vocalization and explained a relatively small amount of variation in behavior overall. This could be partially due to the lack of observations made at night, perhaps had night-time observations been made in this study a greater amount of variation would have been explained by lunar illumination. The lowland tapir has commonly been observed on nights when the moon is full (Padilla and Dowler, 1994). In mountain tapirs, nighttime activity increased on trails and at saltlicks during the full moon (Lizcano and Cavelier, 2000).

Increased dew point, humidity, precipitation were associated with an increase in active behaviors such as locomotion, feeding, swimming, and investigation and a decrease in lying down. Out of all the environmental variables, dew point explained the most variation. Wild tapirs also show variation in activity due to climatic conditions. In the wet season, Baird’s tapirs were more active during the day which is consistent with my findings (Foerster and Vaughan, 2002). During the dry season, tapirs showed increased fruit consumption and rested primarily in mud wallows (Foerster and Vaughan, 2002; Williams, 1991). The weather conditions in Kansas were different from those to which either Malay or Baird's tapirs would naturally be exposed. Temperature was not so different, but dew point and humidity were much lower. This may have some importance to exhibit design and housing considerations for tapirs. Husbandry guidelines and standards for captive tapirs recommend that the temperature of inside facilities be between 18.5 and 29.5ºC (65-85ºF) and if temperatures in outdoor exhibits exceed 35ºC (95ºF) protection in the form of shade and water should be present (Barongi, 1993; Barongi, 1999; Shoemaker et al., 2003). Also recommended was that indoor humidity exceed 50% unless a pool is available. Further investigation into the effects of climate on tapir behavior should be conducted. Perhaps other climatic conditions (such as dew point and precipitation) should be considered in future husbandry guidelines and standards be stricter for tapirs housed in outdoor exhibits.

When animals are housed in conditions that vary too much from the animals' natural environment stereotypical behavior is more frequent (Forman et al., 2001). One way of preventing this may be to house tapirs located in temperate regions within indoor exhibits with a controlled environment. While this may increase the expense of keeping tapirs, it may ultimately improve the well-being of the tapirs and may increase their attractiveness to the public. This would be beneficial in several ways. Currently, tapirs housed in outdoor exhibits are brought indoor for the colder months. This can lead to tapirs being off exhibit for up to half the year. The stalls in which they are housed during this time are small (30.5-55m.^{2}/ 100-180ft.^{2}) and designed for short-term holding (Barongi, 1993; Barongi, 1999; Forman et al., 2001; Shoemaker et al., 2003). Tapirs could be on display year round if housed in indoor exhibits, increasing the overall number of exhibits available at the zoo in inclement weather and slower winter months, while allowing tapirs to be in more suitable large exhibits for the entire year. Secondly, the public is most interested in seeing active animals, and resting tapirs receive 37.3% less attention (Seitz, 2001). By controlling these variables the zoo may increase the activity of tapirs making them a more attractive public display. Finally, the increased interest of the public in tapirs may bring more awareness of tapirs in general, as well as, their endangerment. Public awareness of taxa and conservation problems has been increased by zoos (Gippoliti and Carpaneto, 1997).

SPATIAL USE

Allie, Schnapps, and Cayos all had preferences for resting spots, occasionally switching them. Research on resting site selection has suggested that tapirs prefer areas with shade and other microhabitat components were that primarily facilitate thermoregulation (Alger, 1998). During the day, tapirs primarily rested in dense vegetation often near water; resting spots were often reused (Alger, 1998; Anon., 1834; Eisenberg et al., 1990; Foerster and Vaughan, 2002; Williams, 1978; Williams, 1991). In mammals, choice of sleeping site is a species-specific sleep behavior, influenced by the thermal and predatory environment (Anderson, 1998; Lima et al., 2005; Zepelin et al., 2000). The areas chosen for resting by the tapirs in this study were shaded and usually had some sort of vegetation, often in the back of the exhibit. Leopards were found preferentially resting in the back of their enclosure as well (Mallapur et al., 2002). Suggestions for exhibit design recommend that at least 25% of an exhibit be shaded at any time (Barongi, 1993).

Ingestion was associated with morning and inside for Melvin, he was fed in the morning and afternoon daily and his food was always put inside, therefore, these are reasonable associations. He did forage outside for food and, on occasion, hay or branches were put out there for him, but the bulk of his eating occurred inside. The PCA for Melvin showed a clumping of behaviors such as investigation and locomotion with the pool; however, he did not carry out all of these behaviors while in the pool, only a few of them. This is likely an artifact of the session groupings that were done in the PCA analysis (see methods). Thus during the session in which he used the pool those behaviors also occurred.

For Cayos, sections V and U2 were associated with ingestion, whereas in Schnapps section U3 was associated with ingestion (Figure 11). Both of them actually used sections V and UL for ingestion, so it is likely that the association of sections U2 and U3 with ingestion is an artifact of the statistical test much the same way it was for Melvin.

The differences in section use for Cayos and Schnapps can be explained by the differences in their behavior. Cayos had a higher frequency of ingestive behavior and section V was one of the sections with which ingestion was correlated. Schnapps investigated and rested more, both of which were associated with the two sections she used the most. One explanation is that some territoriality existed but both tapirs were seen in all sections and mother tapirs start displaying territorial behavior only after the next offspring is born (Foerster and Vaughan, 2002; Williams, 1991). Even then, family groups (a monogamous pair and their young) travel and rest together, sharing overlapping home ranges (Foerster, 2002a; Foerster and Vaughan, 2002; Terwilliger, 1978). Sibling tapirs may interact a great amount as well (Foerster and Vaughan, 2002). One aggressive encounter was observed between Schnapps and Cayos during the course of this study. Schnapps chased Cayos around the exhibit biting at his rump while he ran away and vocalized. For the most part, however, Schnapps and Cayos were observed in close proximity, behaving peacefully, even touching noses.

Time of day was significant only for Allie. Allie was a different species, so perhaps this is a difference between species; however, more research needs to be done before that claim could be substantiated. Allie was managed by the large mammal keepers and the Baird’s tapirs were managed by the Australian and South American exhibit keepers. The differences in handling may have resulted in Allie having a routine (resting most of morning and noon, swimming in the afternoon, and locomotion before close). Finally, the difference could be a variation in individual behavior. Some individual animals prefer routine over novelty and excitement (Wielebnowski, 2003).

Allie regularly swam in the afternoon. This was on average the hottest part of the day thus she may have been escaping the heat. It is common for Malay tapirs to spend the hottest time of the day in the water or wallowing in mud holes to cool themselves (Eisenberg et al., 1990).

Allie was much more active the evenings that the zoo was open late. This change might have been disruptive and even stressful, because she was used to having a routine. Usually around 5pm, she would be let into the barn and fed, but she would have to wait for an addition 2 to 3 hours when the zoo was open late. Most of this time was spent pacing the exhibit, vocalizing, and eating whatever vegetation she could find. The zoo might consider varying Allie's routine more regularly so disruptions are not as stressful. This may be done by providing her with food based enrichment. A variety of enrichment techniques have been devised for tapirs including food boxes, sunken buckets covered with straw, produce scattered throughout exhibit, produce or grass added to a pool, and branches or other food items hung from trees (Hobbelink, 2006; Seitz, 2000b; Sharpe, 1997). No only may providing enrichment reduce the stress associated with changes in routine but it may also increase daily activity.

Allie showed a difference in behavior depending on enclosure type. Swimming was correlated with being outside on exhibit; increased investigation and resting were associated with being inside in the barn. It is likely that the some of the variation in investigation can be explained by observer effect. To get a proper view of what she was doing I sat only a few feet from the door to her stall. The sense of smell was the most used form of investigation, in this instance 88% of occurrences of smelling were of the air, so I can not be completely sure of exactly what she was investigating. The reduced amount of swimming may be due to the differences in the two pools. The barn's pool was smaller, shaped differently and not as deep. Another explanation could be that differences in climatic variables (such as temperature, humidity, and shade) were enough to discourage swimming. She regularly swam in the afternoon when out on display. Allie's behavior was greatly influenced by time of day; disrupting her routine by keeping her inside may have been enough to change her behaviors. Also, the temperature was higher at this time of day, perhaps the barn kept the temperature low enough to reduce her swimming. This, however, is less likely because the barn was open to the outdoors. The increased shade in the barn may have had an influence on swimming. The barn was much darker than the exhibit and it is probable that she responded to light cues. Variations in sunlight and the influence on behavior were not examined in this study but further research into this could be useful for exhibit design.

After the landscaping of her exhibit, Allie was in section S1 more and in sections B and SF less (Figure 10). All three of these sections are areas where she primarily rested. Part of the landscaping involved completion of a project started at the beginning of summer in which section B was filled with rocks. This was done to prevent her from sleeping there because it was out of view for zoo visitors. Therefore, it is not surprising that she stopped using section B. The staff also cut down a tree, mowed the exhibit, and added branches/ logs to two areas (sections H and H_2O). Overall, the amount of shade and vegetation was reduced. This reduction which may explain why Allie moved to section S1 and abandoned section SF. Tapirs primarily rested in shaded areas, usually in dense vegetation and near water (Eisenberg et al., 1990; Foerster and Vaughan, 2002; Williams, 1978; Williams, 1991). Section S1 is under several trees and remained well shaded even after the landscaping. In tapir exhibits, zoos should maintain shade, not only is it more like natural tapir habitat, but because excessive light exposure can cause blindness (Barongi, 1993; Barongi, 1999; Powell, 2004; Shoemaker et al., 2003). Another change that occurred at the same time was that an Indian muntjac (Mama) started jumping the fence and moat into Allie's exhibit. Mama was often observed resting in section SF, which may explain why Allie changed resting areas.

Mother-Young Interactions

Of the behaviors observed, three frequently occurred simultaneously in mother and young: resting, investigation, and swimming. Cayos and Schnapps often rested at the same time. This is common, not only in mother young relationships, but with other family members, such as father or siblings (Foerster, 2002a; Foerster and Vaughan, 2002; Terwilliger, 1978). Investigation (which was primarily smelling) likely occurs simultaneously because something of interest is in the air. Swimming together may have been due to climatic conditions or the bond between them.

When behaviors were not simultaneous, typically one tapir was lying down while the other was investigating. This could be for protection. Usually smelling was performed while lying down (38.64% in Cayos and 49.43% in Schnapps) but it was done frequently while standing (36.60% in Cayos and 25.85% in Schnapps) or walking (18.54% in Cayos and 15.00% in Schnapps). Schnapps licked at a greater frequency when Cayos was lying down. She was most often licking herself (58.90%) or Cayos (34.25%).

Cayos' behavior was more influenced by distance than Schnapps' indicating that he was more aware of his mother proximity. Cayos demonstrated a higher diversity of behaviors overall, these various behaviors were associated with an intermediate distance from his mom. Perhaps that distance allowed him the freedom to explore behaviors but also was still comforting and safe.

CONCLUSIONS

In general, tapirs spent the majority of observations resting, investigating, feeding, and swimming. Variation in behavior could be explained by individual, climate, and month. Definitive conclusions could not be drawn on the differences between number of individuals in an enclosure, sex, species, and age. Tapir behavior and section use may be impacted by nearby construction, landscaping the exhibit, type of enclosure, other species, change in daily routine, and time of day. Future research should be conducted to examine these areas.

The percent lunar illumination explained a small amount of the variation in tapir behavior. Increased dew point, humidity, precipitation were associated with more active behaviors such as locomotion, feeding, swimming, and investigation and a decrease in lying down. Further investigation into the effects of climate on tapir behavior should be conducted and include night observations. Zoos in temperate regions should consider housing tapirs in indoor exhibits with a controlled environment.

Tapirs performed different behaviors in different sections of their enclosures. Off-exhibit barn stalls and pools may be inadequate for extended periods. More research should is needed in this area. I recommend that zoos increase the enrichment regimen for animals kept in these enclosures.

Mother and young frequently rested, investigated, and swam simultaneously. The young's behavior was more influenced distance. We know little about the relationship between mothers and older young (>3 months), further investigation is needed.

RECOMMENDATIONS FOR ZOOS

The recommendations I make in this section are based on my research and the current available literature on tapirs.

Varying feeding schedules and providing environmental enrichments is suggested to avoid daily routines. A variety of enrichment techniques have been devised for tapirs (Hobbelink, 2006; Seitz, 2000b; Sharpe, 1997). Some of the food based techniques such as installing food boxes, creating feed stations, adding produce to pools, and hanging branches are simple and inexpensive ways of improving the lives of tapirs (Hobbelink, 2006; Seitz, 2000b; Sharpe, 1997).

Zoos housing tapirs outside should maintain as much shade as possible in exhibits. Not only is it more natural but it is important in preventing corneal cloudiness which leads to blindness (Barongi, 1993; Barongi, 1999; Powell, 2004; Shoemaker et al., 2003). Also, because tapirs spend a significant portion of their time resting providing habitat for resting is important, and tapirs prefer areas with shade, vegetation near water, and in the back of the exhibit (Alger, 1998).

Zoos in temperate regions should consider housing tapirs in indoor exhibits with a controlled environment. Increased dew point, humidity, precipitation were associated with more active behaviors such as locomotion, feeding, swimming, and investigation and a decrease in lying down. Weather conditions in most of the United States are different from those to which tapirs would naturally be exposed. Stereotypical behavior occurs at a greater frequency when animals are housed in conditions that vary too much from their natural environment (Forman et al., 2001). Housing tapirs in indoor exhibits may prevent this. Tapirs could be on display for the full year instead of having to be kept in small off-exhibit enclosures for part of the year. The number of exhibits available during the winter and in bad weather would increase. Additionally, by controlling these variables the zoo may increase the activity of tapirs making them a more attractive public display. Ultimately, this could bring more awareness to tapirs and their conservation needs.

Tapirs may be more active at night than during the day. In indoor exhibits, simulating night and day during operational zoo hours may provide the zoo-going public with a more accurate portrait of the tapir. Additionally, the public is most interested in seeing active animals (Seitz, 2001).

Off-exhibit barn stalls and pools may be inadequate for extended periods. Animals in small, sterile enclosures are more prone to stereotyped behavior such as pacing (Mallapur et al., 2002). Time spent in these enclosures should be minimal. If at all possible the pool size should be increased. I recommend that zoos increase the enrichment regimen for animals kept in these enclosures. By enriching the environment, enclosures can seem more complex and become more interesting and dynamic, while significantly decreasing stereotypic behaviors such as pacing (Forman et al., 2001; Jensvold et al., 2001; Swaisgood and Shepherdson, 2005).

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APPENDIX

Table 10. Literature on tapirs in captivity based on species.

Species of Tapiridae	Scientific Literature	Accounts (such as notes, observations, & other published material)	Total Number of Published Work	Authors
Tapirus bairdii	3	3	6	(Sanchez and Aldan, 2004; Seitz, 2002a; Seitz, 2002c; Soto, 2003; Torres, 2002; Torres et al., 2004a)
Tapirus indicus	10	17	27	(Adachi, 2004; Anon., 1980; Brandstatter, 2004; Chapeau et al., 1993; Ferris, 1905; Fontaine, 1961; Gun, 1988; Hislop, 1950; Holtkotter, 2003; John, 2004; Kasman et al., 1985; Lock, 1991; McClure, 1963; Merilan et al., 1982; Michel et al., 2003; Miller et al., 2000; Murphy et al., 1997; Okamoto, 1997a; Okamoto, 1997b; Ossowski, 2004; Powell, 2004; Read, 1986; Richardson et al., 2004; Seitz, 2002c; White et al., 2003; Zainal-Zahari et al., 2000; Zenzinger, 2003)
Tapirus pinchaque	0	3	3	(Bonney and Crotty, 1979; Gale and Sedgwick, 1968; Richardson et al., 2004)
Tapirus terrestris	9	9	18	(Anon., 1979; Anon., 1997; Bartmann, 1980; Borges and Tortato, 2003; Holbrook, 2002; Hunsaker and Hahn, 1965; Kinahan, 2000; Mahler, 1984b; Mallinson, 1969; Michel et al., 2003; Murphy et al., 1997; Oliveira et al., 2001; Ormrod, 1967; Pollock and Ramsay, 2003; Sharpe, 1997; Smielowski, 1979; Starzynski, 1965; Young, 1961)
Not mentioned	1	2	3	(Baumann et al., 1984; Beer, 2002; Nordstrom, 2002)
All species	12	7	19	(Ashley et al., 1996; Barongi, 1993; Barongi, 2003; Froehlich, 1999; Horan, 1983; Houck et al., 2000; Janssen et al., 1996; Klingel, 1977; Maluf, 1991; Norman and Ashley, 2000; Norton and Ashley, 2004a; Norton and Ashley, 2004b; Ramsay et al., 1994; Schryver et al., 1983; Seitz, 2000a; Seitz, 2002b; Wilson and Wilson, 1973; Witmer et al., 1999)

Table 11. Literature on tapirs in captivity based on subject area

Subject	Scientific Literature	Accounts (such as notes, observations, & other published material)	Total Number of Published Work	Authors
Aggression	0	2	2	(Horan, 1983)
Anatomy & Physiology	10	1	11	(Anon., 1997; Baumann et al., 1984; Holbrook, 2002; Kasman et al., 1985; Maluf, 1991; Merilan et al., 1982; Ramsay et al., 1994; Sanchez and Aldan, 2004; Schryver et al., 1983; Witmer et al., 1999; Zainal-Zahari et al., 2000)
Communication	1	3	4	(Ferris, 1905; Hislop, 1950; Hunsaker and Hahn, 1965; Klingel, 1977)
Comparisons Between Species	1	0	1	(Seitz, 2000a)
Development	0	4	4	(Adachi, 2004; Barongi, 1993; Mallinson, 1969; Young, 1961)
Enrichment	3	0	3	(Seitz, 2000a; Sharpe, 1997; Zenzinger, 2003)
General Behavior	3	2	5	(Barongi, 1993; Mahler, 1984b; Seitz, 2000a; Torres et al., 2004a; White et al., 2003)
Genetics	6	0	6	(Ashley et al., 1996; Froehlich, 1999; Houck et al., 2000; Norman and Ashley, 2000; Norton and Ashley, 2004a; Norton and Ashley, 2004b)
Husbandry	0	12	12	(Barongi, 1993; Bartmann, 1980; Borges and Tortato, 2003; Gale and Sedgwick, 1968; Gun, 1988; Hislop, 1950; Horan, 1983; Nordstrom, 2002; Read, 1986; Richardson et al., 2004; Seitz, 2002a; White et al., 2003)
Longevity	0	3	3	(Fontaine, 1961; Holtkotter, 2003; Seitz, 2002c)
Medical	6	11	17	(Chapeau et al., 1993; Gale and Sedgwick, 1968; Hislop, 1950; Horan, 1983; Janssen et al., 1996; Kasman et al., 1985; Lock, 1991; McClure, 1963; Michel et al., 2003; Miller et al., 2000; Murphy et al., 1997; Oliveira et al., 2001; Ormrod, 1967; Pollock and Ramsay, 2003; Powell, 2004; Ramsay et al., 1994; Starzynski, 1965)
Nutrition	2	8	10	(Barongi, 1993; Beer, 2002; Borges and Tortato, 2003; Gale and Sedgwick, 1968; Gun, 1988; Okamoto, 1997a; Okamoto, 1997b; Ormrod, 1967; Soto, 2003; Wilson and Wilson, 1973)
Preference Testing	1	0	1	(Kinahan, 2000)
Reproduction	1	18	19	(Anon., 1979; Anon., 1980; Barongi, 1993; Bartmann, 1980; Bonney and Crotty, 1979; Brandstatter, 2004; Ferris, 1905; Gun, 1988; John, 2004; Kasman et al., 1985; Mallinson, 1969; Nordstrom, 2002; Ormrod, 1967; Ossowski, 2004; Read, 1986; Smielowski, 1979; Torres, 2002; Torres et al., 2004a; Young, 1961)
Other	1	1	2	(Barongi, 2003; Seitz, 2002b)

Table 12. Known plants consumed by Baird's tapir with seed dispersal information (Estrada, 2004; Foerster and Vaughan, 2002; Galetti et al., 2001; Janzen, 1981; Janzen, 1982; Matola et al., 1997; Naranjo Pinera and Aldan, 1998; Olmos, 1997; Terwilliger, 1978; Tobler, 2002)

Class	Family	Number of Species eaten	Species eaten (common/ local name)	Seeds Dispersed (Number of Species)
Filicopsida		**4+**		
	Polypodiaceae	4	*Cyclopeltis semicordata*	
			Polypodium sp.	
			Tectaria euryloba	
			Tectaria incisa	
	Unknown	+	*unknown sps. of fern*	
Liliopsida		**26+**		**Dispersed (6)**
	Araceae	3+	*Anthurium sp.* (anturio)	
			Dieffenbachia sp.	
			Philodendron inequilaterum	
			Philodendron sp.	
	Arecaceae	12+	*Acrocomia vinifera*	Dispersed- 100%
			Astrocaryum alatum	
			Astrocaryum standleyanum	?
			Bactris balanoidea	Killed
			Bactris gasipaes	Killed
			Bactris sp.	
			Chamaedonea wendlandiana	
			Euterpe edulis	?
			Genoma hoffmanniana (surtuba)	
			Raphia taedigera	Dispersed
			Scheelea rostrata	Dispersed
			Syagrus romanzoffiana	?
			Syagrus oleracea	Dispersed
	Bromeliaceae	2+	*Bromelia penguin*	Dispersed
			Bromelia karatas	Dispersed
			sp. (pinuelas)	
	Commelinaceae	1	*Campelia sp.*	
	Cyclanthaceae	1	*Cyclanthus bipartitus*	
	Cyperaceae	1	*Cyperus hermaphroditus*	
	Gramineae	2	*Chusquea sp.* (canuela)	
	(or Poaceae)		*Panicum sp.*	
	Marantaceae	1+	*Ishnosiphon pruinosus*	
			Ishnosiphon sp.	
	Musaceae	2	*Heliconia mariae*	
			Musa paradisiaca	Killed
	Smilacaceae	1	*Smilax mollis*	
Magnoliopsida		**156+**		**Dispersed (33)**
	Acanthaceae	1	*Mendonicia lindavii*	
	Amaranthaceae	1	*Amaranthus sp.*	
	Anacardiaceae	4	*Anacardium occidentale*	Dispersed
			Spondias mombim	Dispersed- 100%
			Spondias purpurea	Dispersed- 100%
			Spondias radlkoferi	Dispersed- 100%
	Annonaceae	1	*Desmosis panamensis*	
	Apocynaceae	3	*Odontodenia graniflora*	

Magnoliopsida cont.	156+		Dispersed (33)
Apocynaceae cont.		*Prestonia portbellensis*	
		Stemmadenia sp.	
Aquifoliaceae	1	*Ilex pallinda* (azulillo)	
Araliaceae	2	*Dendropanax sp.* (cacho de venado)	
		Oreopanax sp.	
Asclepiadaceae	1	*Matalea sp.*	
Asteraceae	4	*Bidens sp.*	
		Jessea multivenia (quiebracha)	
		Melampodium sp.	
		Wulffia baccata	
Bignoniaceae	4	*Crescentia alata*	Dispersed- 88%
		Jacaranda copaia	
		Pachyptera kerere	
		Pitheoctenium echinatum	
Bixaceae	1	*Cochlospermum vitifolium*	Dispersed
Boraginaceae	1	*Cordia guanacastensis*	Dispersed
Buddlejaceae	1	*Buddleja sp.*	
Burseraceae	3	*Bursera simaruba*	Dispersed
		Protium tenufolium	
		Tetragastris panamensis	
Cactaceae	1	*Epiphyllum sp.*	
Campanulaceae	1	*Burmeistera sp.*	
Capparaceae	1	*Capparis sp.*	
Cecropiaceae	1	*Cecropia polyphleia* (guarumo)	
Chenopodiaceae	1	*Chenopodium sp.*	
Chloranthaceae	1	*Hedyosmum bonplandianum* (aguila)	
Chrysobalanaceae	1	*Licania platypus*	
Combretaceae	2	*Combretum decandrum*	
		Terminalia chiriquensis	
Convolvulaceae	2	*Ipomea phyllomega*	
		Ipomea titliacea	
Cornaceae	1	*Cornus disciflora* (lloro)	
Cucurbitaceae	1	*Gurania seemaniana*	
Cunoniaceae	1	*Weinmannia trianaea* (arrayan)	
Dilleniaceae	2	*Davilla multiflora*	
		Tetracera volubilis	
Ericaceae	2	*Meacleania sp.* (colmillo)	
		Vaccinium consanfuimeum	
Euphorbiaceae	5	*Acalypha diversifolia*	
		Alchornea costaricensis	
		Croton sp.	
		Manihot esculenta	
		Margaritaria nobilis	Dispersed
Fabaceae	19	*Bauhinia ungulata*	Dispersed
		Caesalpina coriari	Killed
		Cassia emarginata	Dispersed- 17.5%
		Cassia grandis	Killed
		Copaifera langsdorffi	?
		Desmodium adscendens	
		Enterolobium contortisiliquum	Dispersed
		Enterolobium cyclocarpum	Dispersed- 22%
		Erythrina sp.	
		Hymenaea courbaril	Killed
		Inga pezizigera	
		Inga quatternata	
		Inga vera	Dispersed

Magnoliopsida cont.	**156+**		**Dispersed (33)**
Fabaceae cont.		*Ormosia isthmensis*	
		Pithecelobium saman	Dispersed- 33-60%
		Platymiscium polystachyum	
		Prosopis juliflora	Dispersed- 100%
		Pterocarpus rohrii	
		Swartzia simplex	
Fagaceae	3	*Quercus copeyensis* (roble)	
		Quercus costaricensis (encino)	
		Quercus oleoides	Killed
Flacourtiaceae	1	*Lacistema aggregatum*	
Gesneriaceae	1	*Columnea sp.* (santurio)	
Grossulariaceae	1	*Escallonia myrtilloides* (carnitora)	
Lauraceae	1	*Phoebe mexicana*	
Loganiaceae	1	*Buddleja sp.* (salvia)	
Malvaceae	2	*Hibiscus rosa-sinensis*	
		Sida rhombifolia	
Melastomataceae	4+	*Bellucia pentamera* (Tilba takaika)	
		Miconia argentea	
		Miconia lacera	
		Miconia sp. (lengua de vaca)	
		Miconia sp. (una de gata)	
		Ossaea diversifolia	
Meliaceae	1	*Guarea sp.*	
Moraceae	7+	*Artocapus incise*	?
		Brosimum alicastrum	Killed
		Cecropia exima	
		Ficus costaricana	Dispersed
		Ficus insipida	Dispersed
		Ficus sp.	Dispersed
		Justicia sp.	
		Sorocea affinis	
Myrsinaceae	3	*Ardisia revolute*	Dispersed
		Myrsine sp. (madurillo)	
		Parathesis sp.	
Myristicaceae	1+	*Virola sebifera*	
		Virola sp.	Dispersed
Myrtaceae	2	*Eugenia sp.*	
		Manguifera indica	?
Onagraceae	1	*Fushsia microphylla* (madroncillo)	
Oxalidaceae	1	*Averrhoa carambola*	?
Phytolaccaceae	1	*Phytolacca sp.*	
Piperaceae	6	*Peperomia sp.* (hoja para escribir)	
		Piper aequale	
		Piper leptocladum	
		Piper marginatum	
		Piper pseudo-gargaranum	
		Piper reticulatum	
Polygonaceae	1	*Polygonum sp.*	
Portulacaceae	1	*?*	
Rhamnaceae	3	*Karwinskia calderoni*	Dispersed
		Rhamnus oreodendron (duraznillo)	
		Ziziphus guatemalensis	Dispersed- 100%
Rhizophoraceae	1	*Cassipourea elliptica*	
Rubiaceae	16	*Alibertia edulis*	Dispersed
		Alseis blackiana	
		Genipa amencana	Dispersed
		Gouania iupuloides	

Magnoliopsida cont.	**156+**		**Dispersed (33)**
Rubiaceae cont.		*Guettarda macrosperma*	Dispersed- 100%
		Hamelia axillaris	
		Hoffmannia sp.	
		Palicourea guianensis	
		Pentagonia macrophylla	
		Psychotria emetica	
		Psychotria limonensis	
		Psychotria microdon	Dispersed
		Psychotria nervosa	Dispersed
		Psychotmria trichotoa	Dispersed
		Randia armata	Dispersed
		Randia echinocarpa	Dispersed
Rutaceae	3	*Citrus aurantium*	Dispersed
		Psidium guajava	Dispersed
		Zanthoxylum sp. (lagartillo)	
Sapindaceae	6	*Allophyllus pilospermus*	
		Cupania costaricensis	
		Paullina bracteosa	
		Serjania atrolineata	
		Serjania cornigera	
		Serjania insignis	
Sapotaceae	3	*Manilkara sapota*	Killed
		Mastichodendron capiri	Killed
		Pouteria sp.	Killed
Solanaceae	3	*Cestrum baenitzii*	
		Physalis sp.	?
		Sollanum umbellatum	
Sterculiaceae	2	*Guazuma ulmifolia*	Dispersed- 20%
		Byttneria aculeata	
Ulmaceae	2	*Celtis iguneus*	
		Trema sp.	?
Urticaceae	2	*Myrisocarpa yzabalensis*	
		Urera elata	
Verbenaceae	2	*Citharexylum sp.*	?
		Petraea volubilis	
Violaceae	2	*Hybanthus prunifolius*	
		Rinorea sylvatica	
Vitaceae	2	*Cissus sicoides*	
		Vittis tiliifolia	
Rospsida	**6**		**1**
Guttiferae	2	*Rheedia madruno*	
		Symponia globulifera	Dispersed
Malpighiaceae	3	*Bunchosia sp.*	
		Mascagnia sp.	
		Stigmaphyllon lindenianum	
Olacaceae	1	*Heisteria concinna*	
TOTAL	**192+**		**40**

Table 13. Known plants consumed by Malay tapir with seed dispersal information (Corlett, 1998; Medway, 1974; Williams, 1978; Williams and Petrides, 1980)

Class / Family	Number of Species eaten	Species eaten (common/ local name)	Seeds Dispersed (Number of Species)
Gnetopsida	**1**		
Gnetaceae	1	*Gnetum gnemon*	
Liliopsida	**13**		
Amaryllidaceae	1	*Curculigo latifolia* (cateng)	
Araceae	7	*Acoris calamus*	
		Aglaonema simplex	
		Ahadendrum montanum	
		Amorphallus sp. (sampah)	
		Homalomena deltoidea (kemoiyang hijau)	
		Homalomena griffithii	
		Homalomena rubra (kemoiyang)	
Arecaceae	2	*Caryota mitis*	
		Pinanga disticha	
Commelinaceae	1	*Forrestia griffithii*	
Liliaceae	2	*Dracaena elliptica* (belakoh)	
		Dracaena pendula	
Lycopodiopsida	**1**		
Selaginellaceae	1	*Selaginella willdenonii* (rumput badak)	
Magnoliopsida	**94+**		**Dispersed (2)**
Acanthaceae	1	*Lepidagathis longifoloia*	
Actinidiaceae	1	*Sauauia leprosa*	
Anacardiaceae	1	*Mangifera indica* (mango)	
Annonaceae	1	*Xylopia ferruginea*	
Ampelidaceae	1+	*Vitis cinnamomea*	
		Vitis sp.	
Bombacaceae	1	*Durio zibethinus* (durian)	Dispersed
Burseraceae	2	*Dacryodes rostrata*	
		Santiria laevigata	
Celastraceae	1	*?*	
Chloranthaceae	1	*Chloranthus officinalis*	
Cucurbitaceae	2	*Citrullus lanatus* (watermelon)	
		Cucumis sativus (cucumber)	
Ebenaceae	3	*Diospyros buxifolia*	
		Diospyros latisepola	
		Diospyros sumatrana (behtne)	
Euphorbiaceae	25+	*Antidesma pendulum*	
		Antidesma tomentosum	
		Aporosa aurita	
		Aporosa nigricans	
		Aporosa praineana (tembasa)	
		Aporosa pseudoficifolia (somkledung)	
		Aporosa sp. (ubat meriam)	

Magnoliopsida cont.	**94+**		**Dispersed (2)**
Euphorbiaceae cont.		*Aporosa stellifera* (metkot)	
		Aporosa symplocoides (metkot)	
		Baccaurea parviflora (kemai)	
		Baccaurea pyriformis (jentek)	
		Baccaurea sp.	
		Blumeodendron subrotundifolium	
		Croton argyratum	
		Elateriospermum tapos (perah)	
		Erismanthus oblique	
		Hevea brasiliensis (rubber tree)	
		Macaranga curtisii variation *glabra* (manga hijau)	
		Macaranga denticulate (mahang hijau)	
		Macaranga gigantean	
		Macaranga hosei	
		Macaranga hypoleuca (mahang puteh)	
		Macaranga laciniata	
		Macaranga sp. (red petioles)	
		Macaranga triloba (mahang merah)	
		Pimeleodendron griffithianum	
Fabaceae	2+	*Millettia atropurpures*	
		Parkia speciosa (petai)	
		Other species	
Gesneriaceae	1	*Boea sp.*	
Lauraceae	1	*?*	
Loganiaceae	1	*Strychnos axillaris*	
Magnoliaceae	1	*Michelia sp.*	
Melastomaceae	5	*Melastoma malabathricum* (kenudok)	
		Memecylon dichotomum (klandis)	
		Memecylon heterophleurum	
		Memecylon oligoneuron (klandis)	
		Memecylon sp. (nipis kulit)	
		Pyllagathis rotundifolia (tanglis)	
Meliacae	2	*Aglaia sp.*	
		Sandoricum koetjape	
Moraceae	4+	*Artocarpus heterophyllus* (jackfruit)	Dispersed
		Ficus ribes (ara)	
		Ficus semicordata (gaboit)	
		Ficus sp.	
		Streblus elongatus	
Myristicaceae	3	*Gymnacranthera forbesii* (pelanyil)	
		Knema malayana (pendarah)	
		Knema stenophylla (pendarah)	
Myrsinaceae	1	*Ardisia colorata*	
Myrtaceae	2+	*Eugenia cerasiformis*	
		Eugenia griffithii	
		Eugenia sp.	
Passifloraceae	1	*?*	
Polygalaceae	1	*Polygala venenosa*	
Proteaceae	1	*Helicia attenuate* (jering tupai)	
Rhamnaceae	1	*Ventilage oblongifolia* (tandok)	
Rosaceae	2	*Prunus arborea* variation *stipulacea*	
		Prunus glisea	
Rubiaceae	18+	*Canthium domesticum*	
		Gardenia sp.	

Magnoliopsida cont.	**94+**		**Dispersed (2)**
		Hedyotis philippenisis	
		Lasianthus attenuatus (jerangil hangus)	
		Lasianthus bracterscens (sarik bateng)	
		Lasianthus griffithii (tenboh)	
		Lasianthus maingayi (kentul tampoi)	
		Lasianthus oblongus (pengkras)	
		Lasianthus pilosus (kentul)	
		Lasianthus sp.	
		Prismatomeris malayana (banran)	
		Psychotria ovoidea	
		Psychotria sp. (pecang)	
		Randia anispohylla	
		Timonius wallichianus	
		Txora pendula	
		Txora sp.	
		Uncaria sp.	
		Urophyllum glabrum (cabal)	
		Urophyllum hirsutum (cabal)	
		Urophyllum sp. (narum)	
		Urophyllum streptopodium (cabal)	
		(pengemang)	
		(camakob)	
Sapindaceae	1	*Xerospermum intermedium* (gigi buntal)	
Sapotaceae	3	*Chrysophyllum lancaolatum*	
		Palaquim hispidum	
		Payena lucida	
Saxifragaceae	1	*Polyosma flavovirens*	
Violaceae	1	*Rinorea anguifera*	
Rospsida	**9+**		
Guttiferae	3	*Garcinia nigrolineata* (asam ketam)	
		Garcinia opaca variation *dumosa*	
		Garcinia rostrata	
Icacinaceae	2+	*Gomphandra capitulata*	
		Gomphandra quadrifida variation *ovalifolia* (ubat kera)	
		Gomphandra quadrifida variation *quadrifida*	
Olacaceae	1	*Strombosia maingayi*	
Styraceae	3+	*Symplocos crassipes* variation *curtisii* (nirat)	
		Symplocos ferruginea (nirat kecil)	
		Symplocos rubiginosa	
		Symplocos sp. (tenboh)	
Unknown	**4**		
Unknown		(cangris)	
Unknown		(perancah)	
Unknown		(kelat)	
Unknown		(jaba)	
TOTAL	**122+**		**Dispersed (2)**

VITA

Maurine Jennifer Gilmore

Candidate for the Degree of

Master of Science

Thesis: TAPIR BEHAVIOR- AN EXAMINATION OF ACTIVITY PATTERNS, MOTHER YOUNG INTERACTIONS, SPATIAL USE, AND ENVIRONMENTAL EFFECTS IN CAPTIVITY ON TWO SPECIES (*Tapirus indicus* & *Tapirus bairdii*)

Major Field: Zoology

Biographical:

Personal Data: Born in Sioux Falls, SD on July 30, 1979 to Rachel and Darrell Gilmore. She found her first love (the tapir) at the age twelve in the Minnesota Zoo in Apple Valley, MN and it has endured ever since. In the winter of 2004-2005, she became the proud dog-mom of two. As of late she has been seen cavorting with a rogue botanist.

Education: She graduated Washington High School, Sioux Falls, SD in May 1997. She attended Northland College in Ashland, WI for two years before transferring to Oregon State University, Corvallis OR, where she ultimately received a Bachelor of Science degree in Zoology. She studied abroad at the University of Ghana in Accra. She completed the requirements for a Master of Science degree in Zoology at the Oklahoma State University, Stillwater, OK in May, 2007.

Experience: Teaching Assistant, Fall 2004 - Spring 2006; Wetland Ecology Field Assistant, Spring 2005 - Fall 2005; Daycamp Director of Life-Tech Ventures, Summer of 2003; Science Teacher at Nature's Classroom, Spring 2002 - Spring 2003; Intern at Chintimini Wildlife Rehabilitation Center, Spring 2001; Animal Behavior Research Project, Oregon Coast Aquarium, Spring 2001; Independent Study in Primatology in Ghana, Fall 2000; Animal Behavior Research on Diana Monkeys at Lake Superior Zoological Gardens, Fall 1998 - Winter 1999.

Name: Maurine Gilmore Date of Degree: May, 2007

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: TAPIR BEHAVIOR- AN EXAMINATION OF ACTIVITY PATTERNS, MOTHER YOUNG INTERACTIONS, SPATIAL USE, AND ENVIRONMENTAL EFFECTS IN CAPTIVITY ON TWO SPECIES (*Tapirus indicus* & *Tapirus bairdii*)

Pages in Study: 129 Candidate for the Degree of Master of Science

Major Field: Zoology

Scope and Method of Study:

Behavioral observations were made of 4 tapirs (2 species) at Sedgwick County Zoological Gardens, Wichita KS. Activity patterns were examined for each individual and all individuals combined. The variation in behavior and exhibit usage was examined in response to environmental variables. The behavioral interaction between a mother and her young was also investigated.

Findings and Conclusions:

The tapirs spent the majority of observations resting (57.99%), investigating (18.73%), feeding (11.64%), and swimming (5.04%). Variation in behavior could be explained by individual, climate, and month.

Definitive conclusions could not be drawn on the differences between number of individual in an enclosure, sex, species, and age. Tapir behavior and section use may be impacted by nearby construction, landscaping the tapir/s exhibit, type of enclosure (barn stalls vs. exhibits), other species, change in daily routine, and time of day.

The percent illumination explained a small amount of the variation in tapir behavior; increased dew point, humidity, precipitation were associated with more active behaviors such as locomotion, feeding, swimming, and investigation and a decrease in lying down.

Tapirs performed different behaviors in different sections of their enclosures. Off-exhibit barn stalls and pools may be inadequate for extended periods of time. Mother and young frequently rested, investigated, and swam simultaneously. The young's behavior was more influenced distance.

Further research into tapir behavior is suggested and specific recommendations for zoos are made.

ADVISER'S APPROVAL: Dr. Tracy Carter