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Semnopithecus entellus
Hanuman langur

Cover Photo: Hanuman langur (*Semnopithecus entellus*) female with quadruplats (four infant) observed for the first time in the history of primatology, at Mandore, Jodhpur, India. (Photo: Dr. A.K. Chhangani).

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Contents

SURVEY ON THE USE OF NONHUMAN PRIMATES IN EUROPE. HAGELIN, J.

Key words: monkeys, Europe, taxonomy, nonhuman primates, experimental procedures, literature survey

Abstract

Research conducted in Europe using nonhuman primates as scientific tools was surveyed. Scientific articles identified from the year of 2001 (n=721) were sampled according to species used, area of research, type of experiment and country. Results showed that nonhuman primates were used in many scientific disciplines and that there was a great diversity between purposes of studies in which they were used in Europe. More than half of all studies were classified as *in vitro*. *C. aethiops* (24 %), *M. mulatta* (13 %), *M. fascicularis* (12 %) and *Callithrix* spp. (6 %) were the most commonly used species in research. The general areas of microbiology (25 %), neuroscience (19 %) and biochemistry (12 %) cumulatively accounted for 57 % of the articles. More than half of the articles were conducted in Germany (19 %), France (18 %) and the UK (20 %).

Introduction

Research with nonhuman primates (NHPs) have been conducted in Europe for many years. There is a wide range of areas where live or some lower biological level of NHP material are used. Some applications aim to increase basic knowledge in an evolutionary perspective (PARKER and MCKINNEY, 1999), and live NHPs also provide unique animal models where their close resemblance to humans are not replicated by other species, e.g. in applications related to neuroscience and infectious diseases (KING et al., 1988; HAU et al., 2000; SCIENTIFIC COMMITTEE ON ANIMAL HEALTH AND ANIMAL WELFARE, 2002). Moral and legal obligations require that live NHPs are used in research only when absolutely necessary and when used, they should be treated as humanely as possible.

Use of different primate species in different areas of research have been described previously (LECORNU and ROWAN, 1978; ERWIN, 1981; FRIDMAN and POPOVA, 1983; FRIDMAN and POPOVA, 1988; HAMPSON et al., 1990; ZUCKER and STACKS, 1996; WEBER, 1997; YAMAMOTO and JARRETA, 1999; BRINKMAN, 2000). Generally, *Macaca* spp. accounted for about half of all NHP used, and neuroscience, microbiology and behaviour were among the most common areas of research. These surveys were however almost exclusively based on samples related to certain species or countries. Also, distribution was primarily based on database searches and the actual content of the articles were, in all but one survey, not investigated in depth. None of these surveys elucidate the use of NHPs in scientific research in Europe. The present survey covers all articles identified from database searches and those articles were scrutinised ensuring that they contained original research that used live or some lower level of biological material of NHPs and was conducted in a European setting. Many articles from the database search was

thereby omitted in the final sample, since they did not meet this criteria (like the present survey would not have done). The aim of the present survey was to describe the use of NHPs in research conducted in Europe in 2001. Taxonomy, area of research, country and type of procedure served as dependant variables.

Materials and Methods

Data collection

The present study was a literature survey of all original articles that could be identified which 1) used live or some lower level of "nonhuman primate biological material" and 2) were published in 2001. Medline was searched for common and generic names, using all levels up to level five of the Taxonomy Browser. Additionally, a search was performed using the key words monkey(s), ape(s), primate(s) and *Vero* (RHIM et al., 1969). PrimateLit was also searched to identify articles not included on Medline. Only those articles derived from publications that had an impact factor in 2000 according to ISI Journal Citation Reports® were included in the final sample for analysis. Overall, 721 NHP articles containing 1074 studies published in 330 different journals were identified and scrutinised.

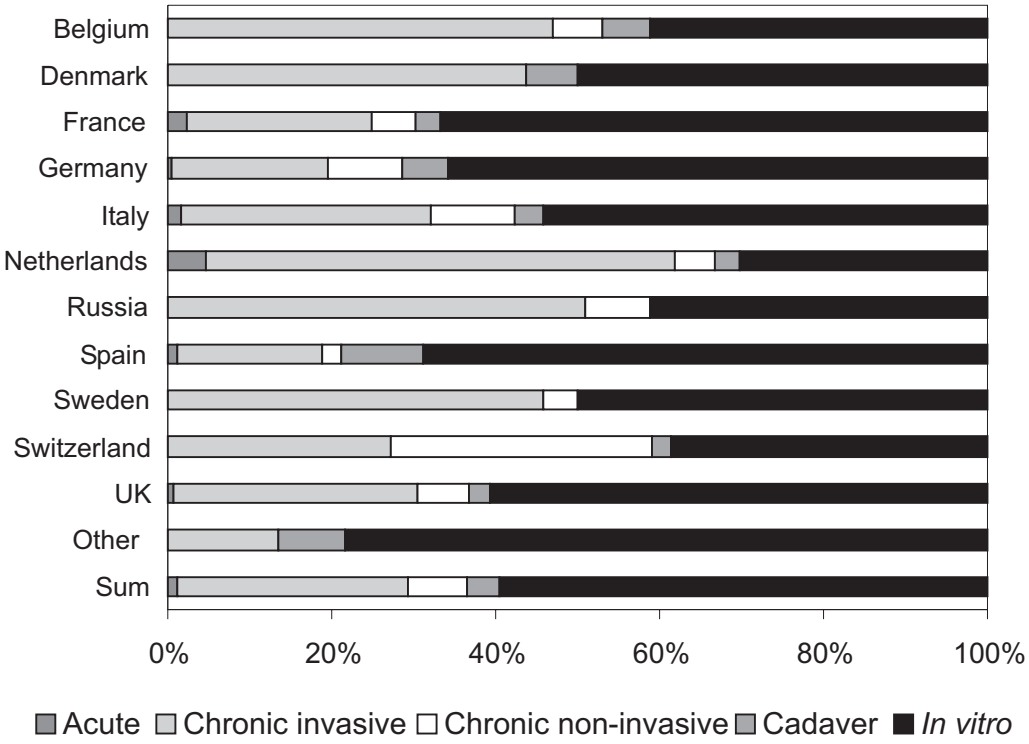

Fig. 1. Research classes and European countries. N=1074.

Articles and studies

An article was considered to contain more than a single study if more than one species was used and/or more than one of the five experimental classes mentioned below were employed. This may be illustrated by the following example: if one animal was first subjected to some chronic procedure and then was euthanised and its cells and tissues were utilised, then it was classified as a chronic study. If cells and tissues was obtained from another animal than the one used in the chronic study, then it was classified as two studies. Anthropology and genetic articles often contained more than one species or subspecies, and several studies may thus have been counted for an individual article.

Area of research

Regarding area of research, classification was primarily done according to the area of the journal. For multidisciplinary journals the articles were scored according to where it fit best. In addition, many articles contained a section devoted to molecular or cellular biology procedures, but unless the primary focus of the article was these procedures, classification was not based on them.

Country

The setting where the project was undertaken was sampled rather than the address of the primary author. In practise, there were only minor differences between the two in the vast majority of articles in most areas of research. However, a number of projects, e.g. related to conservation and ecology, conducted by European scientists were undertaken in the species' natural habitat in Africa, Asia and South and Central America. These articles were excluded.

Research classes

All studies were sorted into five different classes of experimental research:

1) The acute study included investigations that involved the use of a subject once, with the experimental procedures performed under non-recovery anaesthesia.
2) The chronic invasive study was a more heterogeneous group of investigations, but they were characterised by the primate being conscious during at least some part of the experiment. Procedures in studies categorised as chronic invasive may have varied from routine blood sampling to more invasive procedures in which the subjects may have suffered pain, distress and/or lasting harm.
3) The chronic non-invasive study implied that no physiological manipulations were performed on the subjects. Non-invasive studies primarily addressed issues related to the general topics of behaviour, cognition, anthropology, nutrition, and conservation. Some of these studies may have included psychological manipulations induced by the scientists, but not physiological, i.e. their body surface was not penetrated by any needle, e.g. to obtain blood or to anaesthetise them, and the NHPs were not subjected to any surgical procedure.
4) The cadaver study, in which the subjects were euthanised by the authors or some other professional at the same facilities, prior to the actual experiment, comprised the fourth category.

5) The *in vitro* study, in which only primate cells and/or tissues were used, comprised the fifth category. The biological materials for *in vitro* studies were often obtained from commercial companies or museums, and this class of research can be distinguished from cadaver study in that *in vitro* studies did not explicitly state that the authors euthanised the primates.

Statistics

Statistics was done using SAS/STAT® (SAS Institute Inc.: Cary, NC, USA). Chi square analysis was used to measure differences in proportions. $P < 0.05$ was considered significant.

Results

The types of research classes is shown in Figure 1. More than half of all studies was classified as *in vitro* (59 %). A proportion of 28 % was chronic invasive studies, and the remaining 13 % belonged to the other research classes. *In vitro* studies were most frequent in all countries but Denmark, Netherlands, Russia, Sweden and Switzerland. In France and Germany, where cumulatively 41 % of all studies were conducted, *in vitro* studies outnumbered chronic invasive studies by 3:1. In the UK, where 23 % of all studies were conducted, the ratio between *in vitro* studies and chronic invasive studies was 2:1.

Table 1 shows that *C. aethiops*, *M. mulatta*, *M. fascicularis*, and *Callithrix* spp. were the taxonomic groups that were most commonly utilised in NHP research studies published in 2001, accounting cumulatively for almost 55 %. The vast majority of studies of *C. aethiops* were *in vitro* studies utilising *Vero* cells. In the studies where live animals were used, the most frequent species were *M. mulatta*, *M. fascicularis* and *C. jacchus*. Apes, Lower Apes and Prosimians were predominantly used in *in vitro* studies.

The vast majority (88 %) of studies reported the number of animals that were used. There were no significant differences in proportions regarding reporting the number of subjects used between suborder groups of Table 2**.** Among those studies who reported the number of subjects used, 73 % of the animals were Old World monkeys, 20 % were New World monkeys, 6 % were Prosimians and 1 % were Apes (or Lower apes).

The distribution of NHP articles according to research areas and geographical location is shown in Table 3. A higher proportion of articles within the field of neuroscience was conducted in the UK ($P < 0.001$). There were no other significant differences regarding area of research and country.

The research areas where the different species were used varied between species. Apes and Lower apes were predominantly used in genetics. New World monkeys were predominantly used in genetics, microbiology and neuroscience. Old World monkeys were on the other hand relatively more frequent in the other research areas of research. Prosimians were predominantly used in genetics.

Table 1: Species used in original studies and geographic location of study in 2001.[1]n=1065.

	Bel-gium	Den-mark	France	Ger-many	Italy	Nether-lands	Russia	Spain	Swe-den	Switzer-land	UK	Other	Sum	%	Sum	%
Apes															**96**	**9.0**
Gorilla spp.			4	5	1			6	1	2	9		28	2.6		
Pan spp.		1	7	8	1	6		9	2	1	12		47	4.4		
Pongo spp.			3	7				4		1	6		21	2.0		
Lower apes			3	12				4			9		28	2.6	**28**	**2.6**
Old World monkeys															**680**	**63.8**
Cercocebus spp.			1							1	7		9	0.8		
Cercopitehcus spp.																
C. aethiops	8	4	42	48	20	12	14	25	6	14	42	21	256	24.0		
Other *Cercopith.*			6	2						1	2		11	1.0		
Erythrocebus spp.			1				1	1			1		4	0.4		
Lophocebus spp.			2								5		7	0.7		
Macaca spp.																
M. mulatta	4	1	19	25	5	18	15	7	4	5	30	5	138	13.0		
M. fascicularis		6	27	18	10	16	2	9	6	9	25	1	129	12.1		
M nemestrina			1	6	3	1	2	1	1		1		16	1.5		
Other *Macaca*		1	4	1	4		3		2		6		21	2.0		
Unspec *Macaca*	1		1	4		1		1			2		10	0.9		
Mandrillus spp.			1								7		8	0.8		
Miopithecus spp.								1					1	0.1		
Papio spp.	3		18	2	2		8		1		14	4	52	4.9		
Theropithecus spp.											2		2	0.2		
Colobinae spp.			1	4		1	1				9		16	1.5		

	Bel-gium	Den-mark	France	Ger-many	Italy	Nether-lands	Russia	Spain	Swe-den	Switzer-land	UK	Other	Sum	%	Sum	%
New World monkeys															**152**	**14.3**
Callimico spp.										1			1	0.1		
Callithrix spp.		1	10	14	1	4		2	1	3	31		67	6.3		
Leontopithecus spp.			2								6		8	0.8		
Saguinus spp.			4	5		3				2	5		17	1.6		
Alouatta spp.			2										2	0.2		
Aotinae spp.		1	1	3	1					1	1		8	0.8		
Atelinae spp.			6	2				1			2		11	1.0		
Callicebinae spp.			2	1				1					4	0.4		
Cebinae spp.		1	10	7	3						7		28	2.6		
Pitheciinae spp.			5										5	0.5		
Unspecified *Cebidae*				1									1	0.1		
Prosimians															**79**	**7.4**
Cheirogaleidae spp.			12	13									25	2.3		
Daubentoniidae spp.			1	1							1		3	0.3		
Galagonidae spp.				10									10	0.9		
Indridae spp.			1										1	0.1.		
Lemuridae spp.			23	8	3					1	3		38	3.6		
Loridae spp.				1							1		2	0.2		
Tarsiers				4									4	0.4	**4**	**0.4**
Unspec. NHP	2		5	2	2	1	5	1		2	2	4	26	2.6	**26**	**2.4**

[1] Biological material from a number of extinct species were excluded (n=9). These were cells or fossils used in anthropology, genetics and/or palaeontology.

Table 3: Distribution of original articles according to area of research and country. [1]n=715.

	Biochem Chem Hematol	Surgery Transpl Anatomy	Neurosci Brain Eye	Microbiol	HIV	Pharmacol Toxicol	Physiol	Endocrin Reproduct	Genetics	Behaviour	Other	Sum	%
Austria	2			1							1	4	0.6
Belgium	2	1	5	5	1					2		16	2.2
Czech Republic				3								3	0.4
Denmark	3		2	1	2			2			3	13	1.8
Finland	1			2				1	1			5	0.7
France	14	9	25	32	6	8	7	2	11	15	1	130	18.2
Germany	17	3	23	33	7	7	4	7	17	10	9	137	19.2
Greece	1	1	2	3								7	1.0
Hungary	1			1							2	4	0.6
Italy	8	3	7	9	2	4	3		3	8	3	50	7.0
Netherlands	4	4	9	17	7	3	3		3	3	3	56	7.8
Norway					1	4					1	6	0.8
Poland		1						1	1			3	0.4
Portugal								1				1	0.1
Russia	4		8	14		3	3	1	2	2	1	38	5.3
Spain	8		9	17		3	1	2	3	1	2	46	6.4
Sweden	4	1	4	3	4	2			3	1		22	3.1
Switzerland	6	5	4	6	1	2		1	1	4	2	32	4.5
Turkey	1											1	0.1
UK	10	2	39	34	7	4	3	6	18	6	11	140	19.6
Ukraine	1											1	0.1
Sum	87	30	137	181	36	42	24	24	63	52	39	715	100
%	12.2	4.2	19.2	25.3	5.0	5.9	3.4	3.4	8.8	7.3	5.1	100	

[1] Articles conducted in more than one single European country were excluded (n=6).

Table 2: Number of animals used in all types of research classes but *in vitro*. Number of studies specifying number of animals in relation to total number of studies in parenthesis. n=430.

Country	**Prosimians**	**New World**	**Old World**	**Apes**	**Sum**	%
Belgium			66 (8/8)		66	1.3
Denmark		17 (2/2)	43 (5/6)		60	1.2
France	204 (7/10)	22 (4/5)	665 (55/58)		891	17.4
Germany	106 (5/6)	405 (14/19)	309 (37/45)	14 (3/4)	834	16.3
Italy		66 (3/3)	132 (21/23)		198	3.9
Netherlands		67 (6/6)	265 (31/33)	23 (4/4)	355	6.9
Russia[1]			938 (18/29)		938	18.3
Spain		(0/1)	95 (19/21)	2 (2/3)	97	1.9
Sweden		11 (1/1)	131 (10/11)		142	2.8
Switzerland	2 (1/1)	43 (6/6)	386 (15/16)	18 (4/4)	449	8.8
UK		410 (37/39)	643 (51/55)	5 (3/3)	1058	20.6
Other			43 (7/8)		43	0.8
Sum	312 (13/17)	1041 (73/82)	3716 (277/313)	62 (16/18)	5131	100

[1] One large survey conducted in Russia (n=692) accounted for 74 % of the Old World monkeys (YAKOVLEVA et al., 2001).

Discussion

European scientists account for about one fourth of all scientific articles using NHPs in research world-wide (HAU et al., 2000). The present results show that many scientists use live or some lower biological level of NHPs in research and that activity, measured by number of original scientific articles, remain at a high level of quantity. The distribution of research areas where NHPs were used were rather similar to what has been reported for France and the UK previously (HAMPSON et al., 1990; YAMAMOTO and JARRETA, 1999). The present results confirm that neuroscience, HIV and genetics are among the areas that have increased in scale the most over time during the past two decades (BRINKMAN, 2000). This seems to go hand in hand with general trends in biomedical research. Disregarding *in vitro* studies, *Macaca* spp, and in particular *M. mulatta* and *M. fascicularis*, were by far the most frequent species used. The present results further confirmed that *C. jacchus* has replaced *S. sciureus* as the most frequently used New World monkey species (SCIENTIFIC COMMITTEE ON ANIMAL HEALTH AND ANIMAL WELFARE, 2002).

Presently, there is no consensus on how many NHPs that are used in research in Europe, since such statistics do not exist in all countries and where official statistics exist there is no consensus on how these numbers should be collated, although harmonisation is aimed for within the EU. The latest EU statistics from 1999 suggested

that some 726 Prosimians, 1353 New World monkeys, 5199 Old World monkeys and 6 Apes were used for experimental purposes according to their definition (COMMISSION OF THE EUROPEAN COMMUNITIES, 2003). Almost exclusively, the countries that did not report any use of NHPs in the EU statistics, were not included in the present results of Table 2 either. In absolute numbers, the difference between the 1999 EU statistics and the present results primarily concerned Denmark and Sweden. There may be several reasons causing this discrepancy, including: i) the same subjects were used in more than one study sampled, ii) the experimental procedures were not regarded being an experiment according to legislation, iii) there may be numerical differences in use between years in these countries, iv) some protocols may have taken several years to conduct and the subjects may only have been entered in the statistics one year and not again in the following years.

Regarding suborder, the main difference between the numbers reported in the EU statistics and the numbers of Table 2 were studies where Apes (including Lower apes) were used. The 18 identified studies in the present survey where live Apes were used were classified as chronic non-invasive (n=7) or chronic invasive (n=9). The latter were blood sampling for genetics and virology (the subject had not been infected). The other two studies included in Table 2 used tissues from cadavers in protocols related to HIV and virology.

It is likely that species used and the magnitude of research conducted in Europe reflect availability of animals and funding of research, and to some extent the differing public opinion (HAGELIN et al., 2003) and regulatory and ethical institutional review that must be overcome before a project is given approval (DE GREEVE and DE LEEUW, 1999). In addition to the research of the sample covered, NHPs are used by various industries and national or international bodies who often not publish their work, and not all academic research conducted yield any results that get published.

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EVOLUTION IN THE REGULATION OF SPACE AND CARRYING IN THE PARENTAL REARING OF THE CAPTIVE PYGMY MARMOSET (*CEBUELLA PYGMAEA*). QUERALT, A.M. AND VEÁ, J.J.

Key words: *Cebuella pygmaea*, infant care, ontogeny, carrying, proximity, rejections, evolution, emancipation

Abstract

The primate family of Callitrichidae is characterized by the rearing of young within a monogamous mating system with the collaboration of the older offspring. Thus, more than one individual is involved in rearing the young and each has a particular role to fill. The nature of this role is adapted in an interactive way to the relationship between infant and parents and to the rate of growth of the baby. The aim of this paper is to study the evolution in the dynamics of the interactions between the infant and parents in the parental rearing of offspring. Using a variety of indices we determined: who took responsibility for organizing the carrying of the baby (begining and ending) and how this was conducted, the frequency of the infant's refusals to be carried and nursed and, finally, the role of each individual in situations which brought them into close contact with the infant. We observed a singleton pygmy marmoset (*Cebuella pygmaea*) infant and his parents in captivity during the first twenty weeks of life. We used continuous focal animal sampling. Our results showed differences in the behaviour of the father and the mother in carrying the infant, in coming into contact with the infant and in the frequency of rejections. In the first weeks the baby was carried at all times and was able to initiate a change of carrier on his own, but it was the mother who usually initiated the carrying in order to nurse him. When the infant began to spend more time on his own, it was the parents who controlled the commencement of carrying, but with increasing independence the infant himself initiated the carrying and his parents terminated it. In addition, in this period the frequency of the infant's rejections increased while there was a fall in the efforts of the parents to maintain proximity with the infant. Thus, the parents collaborate in the infant's process of independence. The relationship established between the parents and baby evolves as the infant develops so that following weaning the infant's dependence on his parents is not so great. This occurs in a feed-back process between parents and infant which incorporates the behavioural variations of each individual.

Introduction

As the infant dependence period of primates is particularly long, parents provide intensive care for their infants, which includes transport, lactation, grooming, protection and, in some species, food supply. These behavioural patterns can be carried out by individuals other than the mother, although this alloparental infant care varies substantially among the different primate species (NICOLSON, 1987). Such a high variation in the quality of the alloparental care is also observed in other taxonomical groups, such as birds (BROWN, 1987) and carnivores (KLEIMAN and MALCOM, 1981; GITTLEMAN, 1985).

In Old World primates, it is usually the females that provide allomaternal care (MCKENNA, 1981) male-infant interactions being rare (JOHNSON et al., 1980). "These sexual dimorphism in primate caregiving is apparently due to the limited motivation of the male to interact with infants" (PRYCE, 1988, p. 1455). However, the New World primate family Callitrichidae (which comprises marmosets - *Callithrix* and *Cebuella* - tamarins - *Saguinus* and *Leontopithecus* - and *Callimico*) has developed a cooperative breeding system for their twin babies, in which not only the parents but also older brothers, and even other unrelated adult males take part (DAWSON, 1978; NEYMAN, 19878).

In their natural arboreal habitat, marmosets and tamarins live in territories which range in size between 4 and 50 ha, except for the *Cebuella pygmaea* species, whose groups inhabit small home ranges (between 0,2 and 1 ha), located around a few trees (SOINI, 1988). Their social structure consists of groups of between 2 and 15 members. The pygmy marmoset is one of the species with a smaller group size (SOINI, 1988; GARBER, 1994). They have always been considered monogamous, but some recent field studies show the existence of polyandrous groups (GARBER et al., 1984; GOLDIZEN, 1990; SOINI, 1987). Groups are usually composed of an adult male and a female with their infants and some immature individuals which stay in the family group at least until they reach sexual maturity (afterwards they become independent) together with one or two adult males. GARBER (1994) p. 211 argues that, in *Cebuella pygmaea*, "aggression by same sex adults may lead to the early expulsion of young adult and subadult offspring from their natal range". It seems that polyandry is less frequent in pygmy marmosets than in the other species (SONI, 1987,1988; FERRARI and LOPES FERRARI, 1989).

Both at liberty and in captivity, the mother transfers the responsibility of infant care, excluding lactation, to the father. Although this behaviour is observed in all Callithrichids, the question of which parent looks after the babies during the first days, and the moment when the parents exchange functions vary according to species. For instance, in *Saguinus fuscicollis* the father takes charge of the infants from the first or second day onwards (EPPLE, 1975); however, in the case of the *Leontopithecus rosalia* it is not until after two or three weeks that the father takes responsibility for the babies (HOAGE, 1978).

A number of hypotheses involving costs and benefits have been put forward to account for the help that the mother receives. All primate mothers expend energy in gestation and lactation, but in addition these small species of Callitrichids carry twins. At birth the twins weigh, together, between 14 and 25 % of the mother's weight, which becomes 50 % in a short time (LEUTNEGGER, 1973). Bearing in mind the energetic cost of lactation and the fact that females have a post-partum oestrus after three weeks, the mother probably suffers an energetic stress which forces her to adopt this community breeding pattern (KLEIMAN, 1977). For their part, siblings that participate in transport and care acquire parental skills needed to maximize their own parental success and contribute towards the infants' survival (CLEVELAND and SNOWDON, 1984). The unrelated males benefit from sexual access to the female which does not present external signs of ovulation (PRICE, 1992b).

The energetic demands which result from the breeding of two relatively large infants may increase the food needs, due both to lactation and to the energetic and me-

chanical burden that infant carrying represents (GOLDIZEN, 1990). According to PRICE (1992a), the tamarins' behaviour, even in captivity, reveals costs that can probably associated with this activity. When these animals are carrying their infants, they spend less time eating, moving and taking part in social activities than when they are not.

The carrying of babies differs somewhat between species, both in the total transport time and in the task distribution between the mother and the father. Until the fourth week, all species usually carry their infants 90 % of the time, but from then on, according to the published data, tamarins carry their babies longer than marmosets (TARDIFF et al., 1993). Nonetheless, our study in captivity (QUERALT and VEÀ, 1994) showed no differences between the cotton-top tamarin and the pygmy marmoset.

On the other hand, within this cooperative breeding system, each individual performs its function interactively adapted to the infant's rhythm of growth. The interaction among parents, helpers, and infants develops in relation to the changing physiological conditions of the adults, and to the changing stimulating traits of the infants. In his maturative process and behavioural development, the infant will go through stages such as weaning and emancipation, in which his parents probably play an important role.

The aim of this paper is to study the evolution in the dynamics of the interactions between the infant and parents in the parental rearing of offspring. Using a variety of indices we aimed to determine who took responsibility for organizing the carrying of the baby (beginning and ending) and how this was conducted, the frequency of the infant's refusals to be carried and nursed and, finally, the role of each individual in situations in which they were in close contact with the infant.

It would have been very interesting to compare our results with those of other studies, but in our review of the bibliography we were unable to find any studies that used the index we applied with the pygmy marmoset. In consequence, we will compare with the results obtained in a study with *Callithrix argentata melanura* (BUCHANAN-SMITH, 1984).

Method

Subjects

The subjects of this study were a family group of pygmy marmosets. The group was formed by parents and one male infant. The parents had also been born in captivity, and it was their first experience of rearing. The animals belong to Barcelona Zoo. They were placed in cages in which one of the walls was made of wire netting and there was no visual contact with the species in the next cage. Inside these cages humidity was kept at an average of 60 %, temperature between 20° and 30° C and the day-night cycle was monitored as well. Inside the cage, there were natural materials (branches, trunks and reeds), plants and a wooden box, with a frontal hole and a ledge, used as a nest, and a wooden shelf fixed along one of the walls. The subjects were fed twice a day. The first meal about 08:00 AM, consisted of child's pap and vitamin complement, and the second, about 02:00 PM , was composed of natural food (fruit and vegetables). As a complement to this diet, they were supplied with live prey (crickets and grasshoppers). The subjects were habituated to our presence.

Observations

The observations were carried out in Barcelona Zoo. They were recorded with an 8 mm. videocamera, using a continued focal recording. Sessions lasted 60' or 90' and took place between 4 and 7 times a week, depending on the infant's age. The observation sessions were held at different times between 10:00 AM and 07:30 PM, in order to cover the different activity periods of the day. All in all, forty-two hours were taped in the first five months of the baby's life.

The following behaviour categories and their duration were later transcribed on recording sheets:

- *Carrying by Mother / Father* = the infant set on the back of one of his parents, side or front, with no more than one extremity touching the ground. We specify whether it is the mother or the father that carries the infant. Suckling is registered as Mother's Carrying.
- *Infant alone* = when the infant is not carried by any member of the group.
- *Infant Starts Carrying by Mother / Father* = the Infant starts the carrying climbing itself onto the carrier's body without help.
- *Infant Terminates Carrying by Mother / Father* = the infant finishes the carrying by itself.
- *Mother / Father Starts Carrying* = the carrier starts the carrying by taking the Infant and putting it on her/his body; this category includes any action made with the front extremities in order to impulse the Infant onto the carrier.
- *Mother / Father Terminates Carrying* = the carrier finishes the carrying by removing the Infant from her/his body.
- *Rejection by Mother* = Mother's activities to avoid the Infant remaining on her body to be nursed, to be carried or to avoid him climbing back on. She flattens her body against the ground to avoid the Infant reaching her breast.
- *Rejection by Father* = Father's activities to avoid the Infant remaining on his body to be carried, or to avoid him climbing back on.
- *Mother / Father Approaches the Infant* = the Mother or the Father reduces their distance from the Infant to a maximum of 20 cm.
- *Infant Approaches Mother / Father* = the Infant reduces his distance from the Father or the Mother to a maximum of 20 cm.
- *Mother / Father Distances from the Infant* = the Mother or the Father increases the distance between them and the Infant more than 20 cm minimum.
- *Infant Distances from Mother / Father* = the Infant increases his distance from the Mother or the Father more than 20 cm minimum.

Data Analysis

With the information obtained through this behavioural categories system, the time percentages for certain behaviours were calculated; we analyzed three factors involved in the parental care by applying an index for each one of them:

1) Regulation of carrying (HINDE and WHITE, 1974):

$$RC = \frac{MK_1 \times 100}{MK_1 + MK_0} - \frac{BK_1 \times 100}{BK_1 + BK_0}$$

where: MK_1 = number of times the infant initiates carrying. MK_0 = number of times the father or mother initiates carrying. BK_1 = number of times the infant terminates carrying. BK_0 = number of times the father or the mother terminates a carrying bout. If the score is +100 the infant always starts and does not terminate carrying. If the score is -100 the father or the mother always initiates carrying, and does not terminate it.

2) Relative frequency of rejections (HINDE and SPENCER-BOOTH, 1967):

$$RFR = \frac{R}{MK_1 + MK_0 + R}$$

where: R = number of times the father or the mother rejects the infant. MK_1 = number of times the infant initiates a carrying bout with the father or the mother. MK_0 = number of times the father or the mother initiates a carrying bout.

3) Regulation of proximity (HINDE and SPENCER-BOOTH, 1967):

$$RP = \frac{Ap_1 \times 100}{Ap_1 + Ap_0} - \frac{L_1 \times 100}{L_1 + L_0}$$

where: Ap_1 = number of times the infant approaches the father or the mother. Ap_0 = number of times the father or the mother approaches the infant. L_1 = number of times the infant leaves the father or the mother. L_0 = number of times the father or the mother leaves the infant. Negative scores show a greater role of the father or mother in maintaining proximity. Positive scores show a greater role of the infant in maintaining proximity.

Results

Figure 1 shows the time percentages in which the baby is carried by the father, the mother, and the time when the infant is alone. During the first weeks of life, the baby is constantly carried. From the 4th week he begins to be left alone. At the beginning he still, near his parents, and often falls over. His locomotor abilities improve

gradually. The father carries the infant longer than the mother. The baby gradually achieves independence, and in the 19th week, hi is carried by his father for the last time.

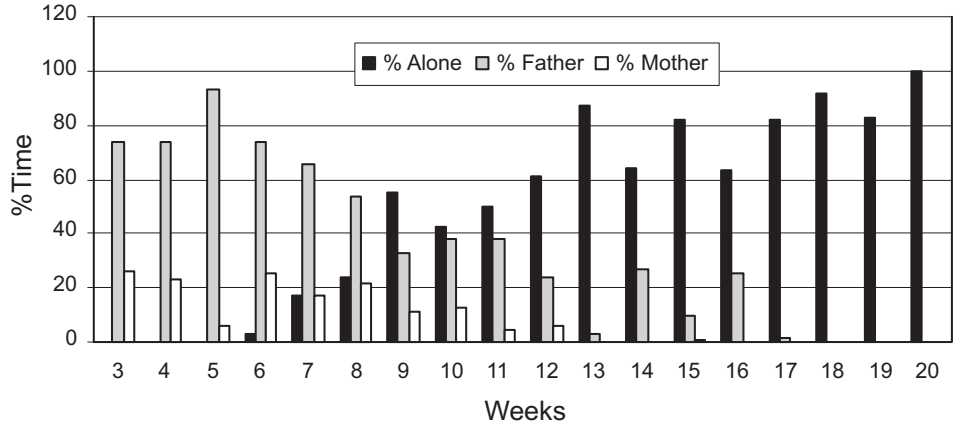

Fig. 1: Time distribution of parental care in *Cebuella pygmaea.*

Regulation of Carrying

From the data analysis, we have identified the different modalities of beginning and ending a carrying bout.

- *The Infant Changes Carrier* = The infant breaks off a carrying bout with a carrier to initiate another, without the intervention of his parents.

With his parents, this behaviour appears in the 5th and 6th week, characteristically, the infant goes to him after nursing.

- *The Carrier Transfers the Infant* = The original carrier transfers the baby to the other individual; this is considered the end of the carrying by the original carrier. We have observed this on a number of occasions, and in each case it was done by the mother.
- *The Infant is Removed from the Carrier* = An individual takes the infant away from the carrier. In this case the remover is recorded as the starter of a carrying bout. This action is characteristic of both parents.
- *The Infant Leaves the Carrier* = The infant terminates the carrying bout and remains on its own

To answer the question of who is the responsible - the parents or the infant - for beginning and ending of the carrying bouts, we apply the Regulation of Carrying index (HINDE and WHITE, 1974).

Figure 2 shows the index results. In weeks 3 and 4, both parents are responsible for all initiations to carry. Week 5, the mother continues to control the carrying bouts herself; the infant takes the initiative as far as carrying by father is concerned. In week 6 there is a slight advantage of the infant in the control of the carryings, especially with the father. Week 7 weaning begins. Probably the father compensates

the mother's rejections of the infant by starting carrying bouts. From this point, the infant takes the initiative starting the carryings and the parents terminate them, especially the mother, because until week 16th the infant was seen suckling. The baby resists weaning, and, at the same time starts eating solid food from his mother's hands.

From here, an equilibrium is achieved in the distribution of responsibilities and many carrying bouts take place as play or in situations of alarm. In the 19th week the infant is no longer carried by the mother, and the father carries him for the last time.

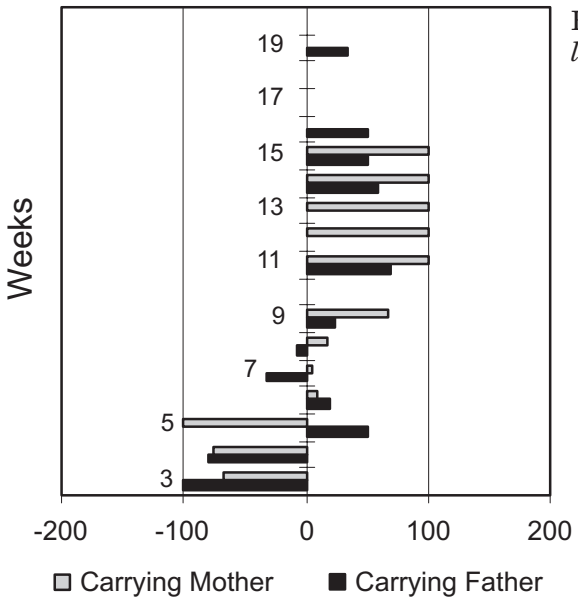

Fig. 2: Regulation of carrying (*Cebuella pygmaea*).

Relative Frequency of Rejections

Figure 3, shows how the mother rejects the infant for the first time in the 4th week.

In the 7th rejections by the father begin. During weaning rejections by the mother become commonplace. Rejections by the mother are more frequent, as the infant often tries to initiate carrying in order to suckle.

Regulation of Proximity

Figure 4, shows the results of this index. The distance and approach behaviours begin when the infant achieves a certain independence of movements and can move with confidence. This takes place at the beginning of the 6th week. During these first movements, the infant cames back to his father after exploring.

From now until the 10th week it is the parents who maintain proximity, controlling the infant's activities; gradually, the infant begins to emancipate. This coincides with the first constant rejections. The parents wants the infant to be near, but not on top of them.

During the 11th, 12th and 13th weeks the infant takes the initiative again and the parents lose it; the infant tries to stay near his parents to initiate carrying.

In the14th and 15th weeks there is a high level of rejections which can be compensated with proximity. From now on, the infant is the one who controls the proximity with his parents, though he does so moconstantly with the father.

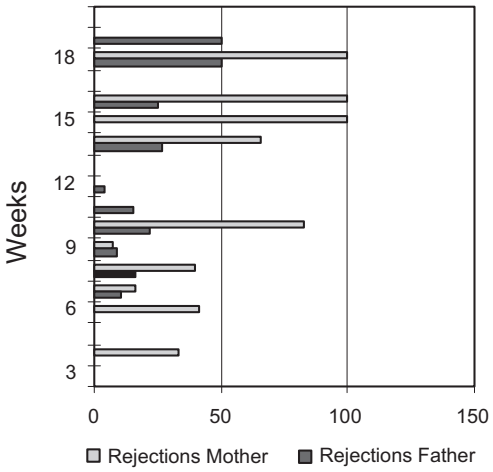

Fig. 3: Frequency of rejections (*Cebuella pygmaea*).

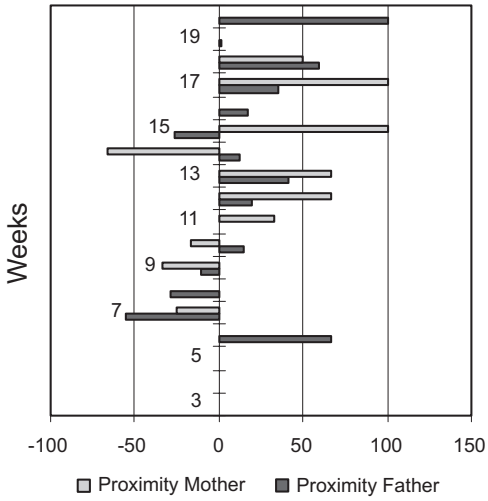

Fig. 4: Regulation of proximity (*Cebuella pygmaea*).

Discussion

During the four first weeks the father takes on responsibility for carrying from the very first days. The mother only assumes responsibility for nursing, as reported by CHRISTEN (1974), POLA and SNOWDON (1975) and MOYNIHAN (1970). In contrast, the studies by SOINI (1988) and WAMBOLDT, et al. (1988) show that paternal care does not increase until the third week of life.

These differences may be due to the different conditions of captivity of the individuals and, according to SOINI'S (1988) study, whether or not the mother is primiparous; when the mother is not a beginner, she herself is the first to take care of the infants. This hypothesis lends support to our results.

In the first days the infant is carried all the time, and the parents initiate the carrying bouts and the nursing, though very soon he is able to initiate carrying by changing carrier.

We take the development stages obtained in QUERALT and VEÀ (1996) as references.

- First days alone (5th week): When the infant begins to be alone, his mother controls the beginning of the carrying; with the father, it is the infant who initiates it
- The infant spends more time alone (6th week): When the infant begins to emancipate, he takes charge of the regulation of carrying, initiating the carrying bouts with the father, but less so with the mother. Refusals only from the mother. Proximity is maintained by the father.

- Beginning of weaning (7^{th} - 8^{th} week): During the first stages of weaning, the father compensates the mother's rejections by initiating more carryings, and maintaining the proximity with the infant. The infant tries to initiate carryings with the mother and receives hir first rejections.
- Beginning of locomotor independence (9^{th} - 13^{th} weeks): The infant initiates carrying with the father, and more with the mother. Rejections from both father and mother. The infant maintains proximity more with the father than with the mother. He resists weaning
- First explorative movements (14^{th} - 15^{th} weeks): When the infant begins his first long movements and explorations, the parents are responsible for maintaining proximity, and controling the infant in his emancipation. The infant initiates carrying bouts with the mother and does not terminates them. Rejections from father and mother, and proximity is maintained by the parents. They want him controlled but not on top of them.
- More independence: With the infant's greater locomotor independence, the parents decrease their tolerance level, and increase their rejections to his carrying and nursing initiatives, and also reduce their efforts to stay near the infant. The infant attempts to maintain proximity with his parents, in order to climb over them.
- From week 16^{th} an equilibrium is achieved in the distribution of responsibilities, and many carryings are performed in a play context or in alarm situations. In this way, father and mother collaborate in the infant's emancipation process, although to varying degrees. On many occasions it seems that the role of the father is influenced by the mother's behaviour, which is directly related with nursing.

We compared our results with pygmy marmosets with BUCHANAN-SMITH'S (1984) study made on *Callithrix argentata melanura* infant twins and their family group for the first eight weeks of life. The infants received little caregiving from the mother after the first two weeks of life, the father and juvenile offspring performing the majority of carrying. Calculations on the regulation of proximity, regulation of carrying and the relative frequency of rejections (using the same indexes as us) all point towards to the following conclusions: adults and older siblings are completely responsible for their care until week 3. The infants were first seen to be independent of carriers on day 19, and their locomotor skills improved rapidly after this point. The tolerance of the group members decreased, and they began to disengage themselves from the infants, leaving them on branches. After this point infants began to seek proximity with carriers, attempting to climb on to them, and as a result they were generally rejected more by carriers.

In general terms, we can see how these conclusions are very similar to ours, though the species are different. Furthermore, in this comparison, two factors must be considered: it is known that there is great individual variation in the rates of development of independence of the infants, which is related to the caretaking activities of the family members; singletons achieve independence later than twins, as the burden on the carriers is less, thus making them more tolerant. The demands of the infant and the care of the parents change drastically during the period of physical and psychological dependence. The long duration of this period compared with other mammals has two important consequences: First, it gives the descendants greater

opportunity in their ontogenetic experiences as we found changes both in their capacities and in their necessities as well. Second, the parents can create effective ways of solving these changing necessities. So, the infants' development forces change in the parents' care activities.

Conclusions

As the infant emancipates, he is the one who initiates carryings and maintains the proximity.

The parents exercise a fundamental role in the emancipation and in the development of the infant's capacities, sometime, controlling and restricting his autonomy,and sometimes supporting them.

The relationships established between the infant and his parents evolve and change as the infant develops so that following weaning the infant's dependence on his parents decreases. This occurs within a parent-infant feed-back process, which adapts the behaviouristical variations of each individual.

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OBSERVATION OF ISOLATED/SOLITARY MALE HANUMAN LANGURS, *SEMNOPITHECUS ENTELLUS* IN SEMI-ARID REGION. RAJPUROHIT, L.S., CHHANGANI, A.K., RAJPUROHIT, R.S. AND RAJPUROHIT, D.S.

Key words: *Semnopithecus entellus*, Solitary males, Semi-arid region

Abstract

There are about 1900 Hanuman langurs, *Semnopithecus entellus* in and around Jodhpur, Rajasthan (India) and the so-called genetically isolated langur population is monitored and well studied since 1967 (when there were about 900 animals). It has always been recorded which is correct up to some extent that there are no other langur groups within a radius of 100 km. However, there are few reports of solitary males observed in the arid and semi-arid region of Jodhpur district.

There are total 11 incidents of solitary or duo langur males during last 30 years observed at 24-175 km from Jodhpur city in different directions. They were observed living in part of semi arid areas not used by the main langur population of Jodhpur. These males are mostly old adults and might be ousted resident males of bisexual troop who had left the site and started living solitary life. In the search of more suitable place, they may cover the long distances like 60 km or even 175 km. These isolated males were salient when alone and gave only grunts and alarm calls when in duo or more in numbers. Local people provision them and depending on the suitability of place their stays is prolonged sometimes till death. The individuals sighted alone may be living as solitary or as duo existence but their status cannot be determined accurately unless they are individually known and can be observed over extended intervals.

Introduction

The Hanuman langur (*Semnopithecus entellus*) a member of South Asian colobinae is most widely distributed (from sea level to about 3600 m altitude in the Himalayas and from evergreen forests to the semi-arid region). Of 19 species of non-human primates found in the Indian subcontinent, it is a highly adaptable species occurring in a wide range of habitats (ROONWAL and MOHNOT, 1977; OPPENHEIMER, 1977). The species is the best studied specially at Jodhpur in the last 35 years.

The species has a variable social organization; the two basic types of social groups are bisexual troops and the all-male bands. Bisexual troops are generally matrilineal groups of adult and sub-adult females, infants and juveniles with an adult male (unimale bisexual troop) or more than one adult male (multi-male bisexual troop). The percentage of uni-male versus multi-male troops and the corresponding number of extra troop band males varies from place to place. Social change is a natural process and the resident male replacement is an important and regular phenomenon of social change. The resident males of troops are replaced usually after 2.5-3.5 years of tenure ships (RAJPUROHIT, 1987; SOMMER and RAJPUROHIT, 1989; MOHNOT et al., 1987). The several possibilities concerning the fate of ousted resi-

dent males have been worked out (RAJPUROHIT, 1987; RAJPUROHIT and MOHNOT, 1988; RAJPUROHIT et al., 1986). They may be killed by invading males; may becomes solitary; may rejoin male bands; may stay with their presumed sons and form a separate male gang; or may disappear from the area. In the second and the last possibilities the ousted resident male leave the site as solitary or along with few more males and move further as and where they get suitable place from safety and food availability point of view. The present paper reports the cases of isolated males sighted in Jodhpur district – the semi-arid region during last 30 years.

A solitary adult male Hanuman langur (*Semnopithecus entellus*) at Mewasa hills.
(Photo: A.K. Chhangani)

Material and Methods

Hanuman langurs are studied in and around city of Jodhpur, which lies at the eastern fringe of the Great Indian Desert in Rajasthan (altitude about 241 m MSL, latitude 26° 18' N and longitude 73° 08' E). There are about 1900 langurs inhabiting in this isolated population in an area of about 150 sq km (MOHNOT, 2001; RAJPUROHIT et al., 2001, 2002). The bisexual troops occupy their own home ranges of about 0.5-1.8 sq km with very few exceptions. Females remain life-long in their natal troops, males emigrate usually as juveniles and join unisexual social unit (i.e., all male band) whose home ranges can be as long as 15 sq km. Bisexual troops contains 9-154 individuals (average 44.5) and all male bands 2-52, average 12.5 (MOHNOT, 2001; RAJPUROHIT et al., 2001).

The current investigations are the part of a long-term field study on langurs of Jodhpur based on ad libitum and scan sampling (ALTMAN, 1974). The climate of Jodhpur is dry with maximum temperature around 48 °C during May/June and minimum around 0 °C during December/January. It receives 90 % of its scanty rainfall (average 360 mm) during monsoon months (i.e., July - September). The habitat used by the langurs includes open scrub forest, fields, farms and orchids (MOHNOT, 1974). Water is available to all groups throughout the year from manmade water holes, which collect rainwater. The diet consists of different parts from approximate 190 plant species. Jodhpur langurs are well habituated, are considered sacred and

are never been hunted. They are easy to observe since animals are not that shy and spend most of the daytime on the ground. The habitat is greatly influenced by human, particularly because the population of Jodhpur city has increased markedly from about 3,50,000 (in 1968) to 9,25,000 (in 2001).

The details about the isolated males sighted time to time over a long period of years together are recorded, the dates, location and the number of individuals if more than one male are summarized in Table 1.

Table 1: Details of the isolated male langurs observed in Jodhpur districts during 1973-2002.

Case No.	Date	Location	Solitary/duo or more isolated male langurs
1.	April, 1973	Osian Town (62 km north to Jodhpur)	Duo (both adult males)
2.	June 30, 1982	Osian Town (62 km north to Jodhpur)	Solitary (1 old adult male)
3.	Sept., 1984	Bap (175 northwest to Jodhpur, near Phalodi)	Solitary (1 old adult male)
4.	Sept., 1985	Mewasa (50 km north to Jodhpur, Tehsil Osian)	Solitary (1 old adult male)
5.	Feb., 1990	Osian Town (62 km north to Jodhpur)	Solitary (1 adult male)
6.	Oct. 11, 1997	Osian Town (62 km north to Jodhpur)	Duo (1 adult and 1 young adult male)
7.	Nov. 26, 1997	Osian Town (62 km north to Jodhpur)	Duo (2 adult males)
8.	Dec. 10, 1997	Osian Town (62 km north to Jodhpur)	Solitary (1 adult male)
9.	May 5, 1998	Osian Town (62 km north to Jodhpur)	Solitary (1 adult male)
10.	Sept 9, 2000	Osian Town (62 km north to Jodhpur)	Solitary (1 old adult male)
11.	March 3, 2002	Kakelao (25 km southeast to Jodhpur)	Duo (1 young and 1 old adult male)
12.	March 12, 2002	Mogra (24 km south to Jodhpur)	Four males (3 adults and 1 old adult)
13.	March 27, 2002	Kakani (30 km south to Jodhpur)	Duo (1 adult and 1 old male)
14.	April 12, 2002	Fitkasni (11 km southeast to Jodhpur)	Solitary (1 old adult male)
15.	May 26, 2002	Near Bhandu (27 km southwest to Jodhpur)	Solitary (1 adult male)

Observation and Results

The sightings of solitary and duo male langurs are presented in Table 1. All isolated individuals observed were either old adults or the adult males. One solitary an

old adult male sighted in September, 1984 at 'Bap' (Case no. 3 in Table 1), 175 km northwest to Jodhpur near Phalodi (35 km north to Phalodi on Bikaner Road) lived there for about 15 years as per the local people reported. First time a duo was sighted at 'Osian' by LSR (Case no. 1) in April 1973 on a big Ficus free near Jain School, as LSR was a student of this school those days of 7th standard. There were two adult males and mostly they stayed in Osian and roamed around for several years. On June 30th 1982, an old male langur sighted in desert 5 km south to Osian (Case no. 2) and this old male might be one of the duo lived in Osian since 1973. Similarly an old male langur was reported at 'Mewasa' valley near a temple (50 km north to Jodhpur and 12 southeast to village Osian) and this individual as reports said lived there for about 8-10 years on the date (i.e., September 1985). One older male sighted at Osian in February 1990 (Case no. 5).

On October 11, 1997, two (1 adult and another young adult) males were seen at 'Osian' (Case no. 6), but after 2 months the young male has disappeared and the another adult male was seen alone there till September 2000.

Recently, there are some cases of isolated male langurs found near Jodhpur where there are no earlier reports stands. As per Table 1 these isolated males observed as solitary, duo or in one case having four males (3 adults and an old adult), sighted at 'Mogra' (24 km south to Jodhpur city) and most probably two males (an adult and an old adult) sighted on March 27, 2002 at 'Kakani' (30 km south to Jodhpur) were the again splitted males from the four males seen at 'Mogra' on March 12, 2002. On May 26, 2002 the latest report in which a solitary male langur sighted at 27 km west to Jodhpur on Barmer road.

The behaviour of solitary male when initially encountered did differ qualitatively from our early encounters with the initially unhabituated bisexual troop members. When approached, solitary males walked steadily away or ran from us, moving through the semi-arid vegetation and ground.

The vocalization given by isolated males observed by us were the characteristic "alarm bark", grunts, and some time "whooping" (loud calls). Only duo or more in number isolated males gave these vocalizations. Solitary males (as alone) were never noted to vocalize.

The solitary males living in Osian town (60 km north to Jodhpur) were occasionally found in the interior desert area as far as 5 km from the place where they live isolated. Thus these males not only occupy home ranges unacceptable to general bisexual troops, they also use the ranges differently making greater use of kinds of food resources or in search of more suitable site.

Discussion

There are several features of our observation of solitary males, which may contribute as such to an understanding of langur troops as they do to the significance of isolated males. Why should some males choose to live as solitary life near or far to the troops present at Jodhpur? Social life presumably convey certain advantages and disadvantages, and the evolutionary or facultative chose to live one way or the other may be based upon an integration of the costs and benefits of both alternatives (WILSON, 1975). For adult male langurs the most probable advantages to troop life (as a resident male) are protection from predators, access to mates, grooming and

other beneficial social interactions. And to live as an individual of all male band chances to get access to females occasionally (at the time of invasion to bisexual troops), grooming, protection and other social interactions. But as RAJPUROHIT and MOHNOT (1988) revealed in their findings that after once discarded/ousted from the residency of bisexual troop, there are least chances to get back any good ranks in the male band and thus there are no possibilities to be resident male of the same or any other troop. Therefore, some (about 20 %) of the ousted resident males isolated themselves from the main population and started living alone nearby. And in due course of time in search of more suitable place, they reach as far as 62 km (Osian) or 175 km (Bap) and then lived there for life-long. BHARGAVA (1984) reported similar cases of existence of solitary langur males reported at 'Sheo' (Barmer district) and 'Bubuali' (Jaisalmer district).

Disadvantages of group life may include competition with other group members for food/social strife, and an increased probability of contacting disease (ALEXANDER, 1974). Solitary males observed by us always appear to be in excellent physical state. During 1999-2000 and through 2001, when our observations reported in Jodhpur langur population that a skin disease resembling mange seriously afflicted all members of both Arna bisexual troops and an all male band (CHHANGANI et al., 2001) and about 70-80 langurs died in two years to this contacting disease.

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CROP RAID BY HANUMAN LANGUR *SEMNOPITHECUS ENTELLUS* IN AND AROUND ARAVALLIS, (INDIA) AND ITS MANAGEMENT. CHHANGANI, A.K. AND MOHNOT, S.M.

Key words: Crop raid, Hanuman langur, Management strategies, Economic loss

Abstract

Survival and reproduction of individuals depend on their ability to locate and harvest sufficient food to meet their nutritional needs. All primate species interact with a variety of food distributed in their home range, which is within their reach. In the present paper crop raid by Hanuman langur is presented. Their ability to learn things very quickly and change in the behaviour accordingly, makes them very successful and potential crop raiders. Crop damage is very common along the immediate periphery of wildlife sanctuaries and national parks, by primates and other wild animals. Cultivated food plants and their seasonality in the diet of Hanuman langur, crop raids and crop loss, etc are the aims of this paper. Langurs are highly adaptive animals and feeding upon variety of food items, which includes, natural, cultivated and artificial food. These animals are capable of damaging most agricultural and horticultural crops. On an average, the langurs of KWS spent 34.6 % of their daily activity time on feeding. Langurs eat about 184 types of foot items, which include natural and cultivated plant parts and artificial food provided by the people. Savika troop, B-2 eats natural and cultivated food but do not receive artificial food from the people. In nature, this troop eats part of 73 natural food plants. Besides these 73 natural plants, it also eats, 13 crops, 22 types of vegetables and 8 types of flowers and fruits grown in vegetable and crop fields, gardens and orchards around. The cultivated plant consumption was 40.8 % in the month of September and 19.25 % in the month of June. The annual economic loss to farmers in the study area is about US $ 1800-2400 from all the 12 farms. In addition to this the cost of crop protection for each farm ranged between US $ 200 to 250 per year, which comes between US $ 2400 to 3000 annually for all the 12 farms. Besides this direct loss, they also cause indirect loss like feeding upon the fruiting trees and their flowers, which reduces the fruit production considerably, which farmers cannot visualize. To protect crop fields and orchards from wildlife and langurs farmers use many methods. These methods include patrolling the fields, throwing stone with "gophan", keeping dogs, fencing with thorny twigs, potash bomb etc.

Introduction

In general, survival and reproduction of individuals depend on their ability to locate and harvest sufficient food to meet their nutritional needs. Timings and selection of food plants are synchronized to meet the requirements of proteins, carbohydrates, fats, vitamins, water, minerals, trace elements, etc. All primates have the same general need to acquire energy. The specific patterns of resource utilisation may however vary according to species, age-sex classes, social group, population and habitat. All primate species interact with a variety of food distributed in their home range, which is within their reach.

Crop raid by different wild animals in particular mammals, like Elephant (*Elephas maximus*), Gaur (*Bos gaurus*), Blue bull (*Boselaphus tragocamelus*), Sambar (*Cervus unicolor*), Barking dear (*Muntiacua muntak*), Black buck (*Antilope cervicapra*), Chinkara (*Gazella gazella bennetti*), Wild boar (*Sus scrofa*) and Porcupine (*Hystrix indica*) has been widely reported from all over the country (PRATER, 1980; SCHULTZ, 1986; SUKUMAR, 1990; BOHRA et al., 1992, BALASUBRAMANIAN et al., 1993; CHHANGANI, 1994; CHHANGANI and MOHNOT, 1997).

Crop raid by many primate species have are also been reported such as Hanuman langur (*Semnopithecus entellus*), Colobus (*Colobus guereza*), Chimpanzees (*Pan troglodytes*), Olive baboons (*Papio hamadryas anubis*), Rhesus macaque (*Macaca mulatta*), Assamese macaque (*M. assamensis*), Vervet monkey (*Chlorocebus aethiops*), Red tailed guenons (*Cercopithecus ascanius*), Blue monkey (*C.mitis*), black and white colobus, etc. (MOHNOT, 1974, 1999; ROONWAL and MOHNOT, 1977; FORTHMAN QUICK, 1986; BOULTON et al., 1996; PIRTA et al., 1997; HILL, 1997; CHHANGANI, 2000). These primates are highly adaptive. Their ability to learn things quickly and change in their behaviour accordingly, makes them very successful and potential crop raiders, when living close to humans (ELSE, 1991).

In India crop damage is very common along the immediate periphery of wildlife sanctuaries and national parks, by primates and other wild animals. But there are several primate species, which leaves in and around human habitations on the out skirts of village, towns and cities where they do considerable damage to crops, vegetable fields and orchards. This man-monkey conflict is mainly due to conversation of forests into large-scale monoculture plantation, shifting cultivation, forest cutting and encroachment in the home range of animals, which reduces the availability of natural food to primates.

Cultivated food plants and their seasonality in the diet of Hanuman langur, crop raids and crop loss, etc are the aims of this paper and to (1) list the total species of crops, vegetables, fruits and flowers (2) estimation of economic loss and threats to livelihood of farmers living in and around Kumbhalgarh Wildlife Sanctuary (3) seasonal ratio of cultivated food and natural food (4) management strategies employed by the people and human-wildlife conflict in conservation and management strategies of primates.

Material and Methods

Study Site: The Kumbhalgarh Wildlife Sanctuary (KWS) lies between 25°0' and 25°40' N and 73°21' and 73°30'E some 200 km south of Jodhpur in west Aravalli hills of Rajasthan, India . The total area of KWS is 585 sq. km. Its altitude vary from 274 to 1155 meters above sea level. Distinct winter, summer and monsoon season are characteristic of KWS. During summer, temperature fluctuates between 30° C, which may rise up to 48° C during May and June. The minimum temperature in winter is 5° C, which may go down to 2° C in December – January. The average annual rainfall is 725 mm, with a minimum of 403 mm and maximum 950 mm. A variety of agricultural and horticultural crops are grown in the study area. These are: Ganwar (*Cyamopsis tetragonaloba*), Genhu (*Triticum eastivum*), Makka (*Zea mays*), Tamatar (*Lycopersicon lycopersicum*), Band gobi (*Brassica oleracea L. Var.* (*Capitatal*),

Fig. 1a: A group of Hanuman langur (*Semnopithecus entellus*) feeding on the vegetable field of Bangan (*Solanum melongena*).
(Photo: A.K. Chahangani)

Fig. 1b: Hanuman langurs (*Semnopithecus entellus*) feeding on standing wheat (*Triticum eastivum*) crop field, while the farmer is sleeping near by in the morning.
(Photo: A.K. Chahangani)

Bhindi (*Abelmoschus esculentus*), Amrood (*Picidium guajava*), Anar (*Punica granatum*), Nimbu (*Citrus medica*), Kaila (*Musa paradisiacal*), Papita (*Carica papaya*), Hajara (*Tagetes erecta*) and (*T. patula*) and Tulsi (*Ocimum canum*). The forest in the home ranges of the langur troops is broadly dry deciduous or woodland type dominated by kala dhawa (*Anogeissus pendula*) gorya dhawa (*Anogeissus latifolia*), salar (*Boswellia serrata*), gol (*Lannea coromandelica*), kherni (*Wrightia tinctoria*), dhawa (*Anogeissus pendula*), kumbat (*Acacia senegal*), khair (*Acacia catechu*), ber (*Zizi-*

phus mauritiana), dhonk (*Butea monosperma*), etc. The undergrowth mainly consists of jharber (*Ziziphus nummularia*), ardusa (*Adhatoda zeylanica*), gangan (*Grewia tenex*), franger (*Grewia flavescens*), kanter (*Capparis separaia*), lantana (*Lantana camara*), etc. Some climbers and grasses are also found.

The main fauna of KWS includes, Leopard (*Panthera pardus*), Hyena (*Hyaena hyaena*), Indian Wolf (*Canis lupus*), Jackal (*Canis aureas*), Sloth Bear (*Melursus ursinus*), Fourhorned antelope (*Tetracerus quadricornis*), Chinkara (*Gazella gazella*), Porcupine (*Hystrix indica*), Sambar (*Cervus unicolor*), Bluebull (*Boselaphus tragocamelus*), Toddy Cat (*Paradoxorus hermaphordiatus*), Jungle Cat (*Felis chaus*), Fox (*Vulpes bengalensis*), Crocodile (*Crocodilus palustris*) and Rock Python (*Python molurus*).

Langur population: In the present study a total of 16 groups of Hanuman langur, including 11 unimale bisexual troops and 5 all-male bands with a population of 540 animals were observed in and around Kumbhalgarh Wildlife Sanctuary (KWS). The mean troop size was 41.7 (range 19 to 113) and the mean band size 15.6 (range 8 to 32). The adult male-female sex ratio was 1.46 in the study area. This population was under observation from 1995 to 2002 during a long-term eco-behavioural study wherein 16 groups were monitored. Of these bisexual troops BS-2, BS-3 and BS-10 were the focal troops, living in three different ecosystems categorized on the basis of biotic and a biotic factors. The details of these three ecosystems are:

Factors	**Ecosystem – I Focal Troop 1 (B-2)**	**Ecosystem – II Focal Troop 2 (B-5)**	**Ecosystem – III Focal Troop 2 (B-5)**
Human interference	Present	Present	Absent
Human settlements	Present	Present	Absent
Grazing	Allowed	Allowed	Not allowed
Tree cutting	Present	Present	Absent
Artificial feeding	Absent	Present	Absent
Agricultural activity	Present	Absent	Absent
Highway traffic	Present	Present	Absent
Predators	Panther, Jackals, Wolf, dog, etc.	Dogs only	Panther, Hyena, Wolf, Jackals, etc.

Methods: Data were collected from January 1996 to December 1996 from focal troop B-2 and three study groups, B-1, AMB-1 and AMB-2 living in ecosystem-I in and around KWS. The group composition of focal troop B-2 was as follows:

Census Year	**Adult**		**Sub adult**		**Juvenile**		**Infants**						**Total**
							WC		**CC**		**BC**		
	M	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	**M**	**F**	
June 1997	1	15	0	0	0	2	7	4	2	2	3	2	38
June 1998	1	15	0	3	6	4	3	3	1	1	2	1	40
June 1999	1	18	0	2	5	4	4	3	2	2	1	1	43

Data on feeding behaviour were collected using focal and scan sampling techniques in which the activity of visible animals is recorded at regular intervals throughout the day from dawn to dusk following Altmann (1974). Data were collected for 72 hours per month for each focal troop, B-2, B-5 and B-10 for six consecutive days in a month. Focal troop individuals were identified with the help of identification marks, such as cuts, scars, tail carriage, facial features, postures, gesture, etc. as well as by pedigree records. Photographic support was also used. One day prior to the commencement of data collection, the roosting tree(s) on which the study group sleeps were located. This strategy facilitated to start observation next day before group leave it's sleeping trees early morning.

Each focal sample sheet covers 20 minutes of observation with five minutes of sample interval. During this sample interval scan sample of five minutes for all animals was attempted. If any animal was eating, the record of plant species and plant part eaten was noted. Observation schedules for all the three focal troops were evenly distributed over the study period so as to achieve statistical compatibility of data.

Vegetation survey was conducted using quadrate method (MRC, 1981). To supplement the field data local farmers were also interviewed.

Results

Langurs are highly adaptive animals and feeding upon variety of food items, which includes, natural, cultivated and artificial food. These animals are capable of damaging most agricultural and horticultural crops. On an average, the langurs of KWS spent 34.6 % of their daily activity time on feeding. The daily activity period for Hanuman langurs ranged from more than 14 hours in the longer daylight period of Summer (May – June) to 11 hours during shorter day light period of winter (December – January). The time spent on feeding activity differ for all the three focal troops. For Savika troop, B-2 it was 35.08 %; for Ranakpur temple troop, B-5, 29.50 % and for forest troop, B-10, 39.30 % (fig. 2). On the basis of data gathered at KWS the Hanuman langurs may be regarded as wholly vegetarian. Langurs eat about 184 types of foot items, which include natural and cultivated plant parts and artificial food provided by the people. Natural food includes leaves, flowers, fruits, seeds, gum, bark and arial roots. Cultivated food in the form of fruits, seeds, grains, vegetables, flowers, and parts of garden bushes are commonly eaten. They receive variety of artificial food from the people in the form of raw, cooked, fried and roasted stuffs. Besides this langurs were observed eating sand, chewing bee-wax and licking plant latex and rocks.

Savika troop, B-2 eats natural and cultivated food but do not receive artificial food from the people. In nature, this troop eats parts of 73 natural food plants. Besides these, it also eats, 13 crops, 22 types of vegetables and 8 types of flowers and fruits grown in vegetable and crop fields, gardens and orchards around (table 1).

This troop consumed maximum number of natural food plants in the month of June, which is about 80.75 %. The minimum consumption was observed in the month of September, which is about 59.20 %. The cultivated plant consumption was 40.8 % in the month of September and 19.25 % in the month of June. The overall an-

nual consumption of natural food was 67.02 % and that of cultivated food 32.98 % (fig. 3).

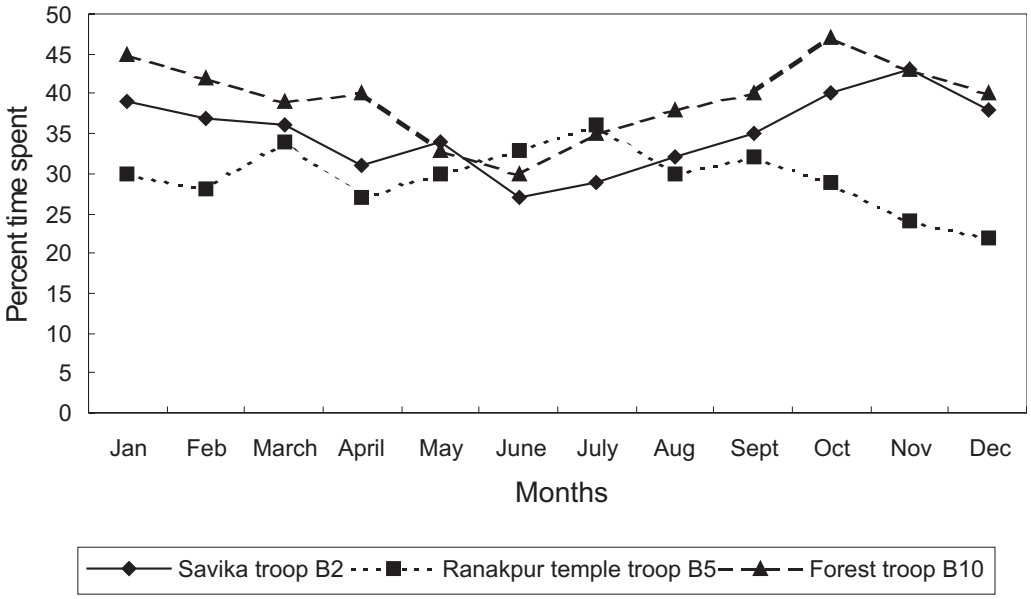

Fig. 2: Percent feeding time spent in a year by three focal troops at KWS.

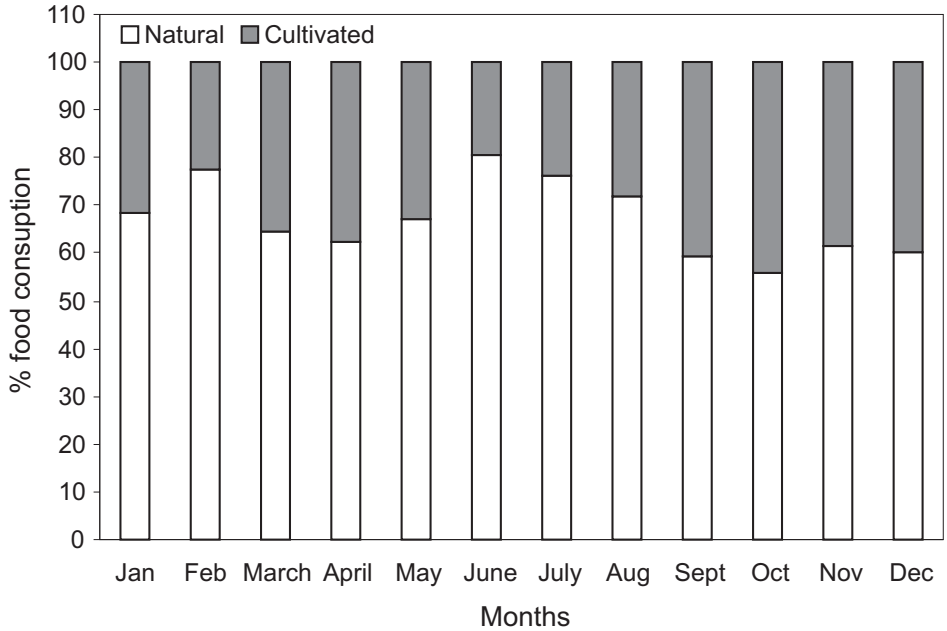

Fig. 3: Percent consumption of natural and Cultivated food by Savika troop, B-2.

Economic loss: In this study the kind of loss, direct or indirect brought about by langur raids were also estimated. It is found that they damage most agricultural crops to a considerable extent. Extent of crop damage depends on the number of troop members and crop protection strategies employed farmers. In the homer range of this troop all the farms orchards are raided and damage affected. We found that langurs spoil more crops then they actually eat, juveniles and infants in particular bring about damage during play on the ground as well as on the fruit trees. The damage is up to 27 % of total yield and rarely up to 5 %. The estimate of damage was assessed on the basis of the information gathered from farmers and through visual observations from 12 farms. The calculated crop damage from two bisexual troops B-1 and B-2 (including one focal troop (B-2)) and two all male bands AMB-1 and AMB-2 comes to about US $ 900 per annum from a total of 102 animals living in the periphery of crop fields and orchards. If we include the costs of crop protection per household it ranges between US $ 150-200 per farm per year, which comes to US $ 1800-2400 for 12 farms. Besides this direct loss, they also cause indirect loss by feeding upon the flowering and fruiting trees, which reduces the fruit production considerably, which farmers cannot workout. Juveniles and infants break branches blooming with flowers and fruits during play.

Crop protection strategies and management: To protect crop fields and orchards from wildlife and langurs farmers use many methods. These methods include patrolling the fields, throwing stone with "gophan", keeping dogs, fencing with thorny twigs, potash bomb etc. The most commonly used crop protection strategy in guarding their fields by constant vigilance during crop reasons. This method is used by 60 % of the farmers in the study area. 20 % of field owners use "gophan", a device to throw stones towards invading langurs to chase them away from the field. Few farmers (about 15 %) using dogs for crop protection to chase the langurs away. Many times these dogs kill the langurs, in particular juveniles and infants. While the remaining 5 % of farmers use dangerous methods like single shot gun, potash bomb and high voltage electric current in which langurs are usually killed or seriously injured.

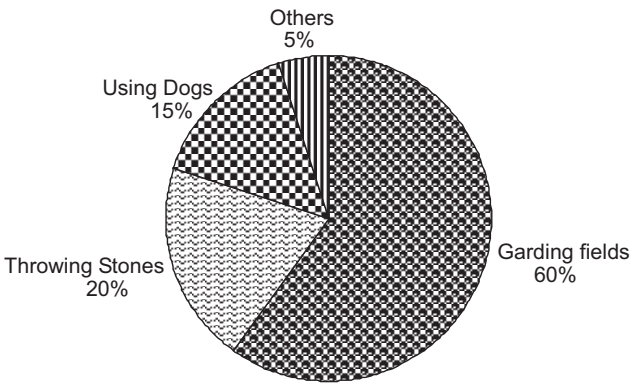

Fig. 4: Different crop protection strategies used by farmers.

On the basis of questionnaires and visual observations the methods for crop protection is calculated in percentage, which is shown in fig. 4. Along with above methods all the farmers commonly use thorny twigs and branches of *Prosopis juliflora*, *Acacia nilotica*, *Ziziphus nummularia*, *Z. mauritiana* and some time naturally grown *Euphorbia caducifolia*. Despite all these measures of crop protection langurs do manage to invade the crops.

Table 1: Food plants consumed by Savika troop, B-2 (January 1996 to December 1996).

Local Name	Botanical Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	*	**
Crops															
1. Ganwar	*Cyamopsis tetra-gonaloba*	-	-	-	-	-	-	YL	ML,FL	UF	RF	RF	SE	6	6
2. Genhu	*Triticum eastivum*	UF	UF	RF	-	-	-	-	-	-	-	YL	FB	5	4
3. Chana	*Cicer arietinum*	UF	RF	RF	-	-	-	-	-	-	-	YL	ML	5	4
4. Moong	*Phaselus radiatus*	-	-	-	-	-	-	YL,ST	ML	UF	MF	-	-	4	4
5. Rizka	*Medicago sativa*	-	-	-	ML	ML	ML	ML	-	-	-	-	-	4	1
6. Makka	*Zea mays*	-	-	-	-	-	-	-	ML	UF	RF	-	-	3	3
7. Moth	*Vigna aconitifolia*	-	-	-	-	-	-	-	ML	UF	MF	-	-	3	3
8. Ganna	*Saccharum officinarum*	-	ST	ST	ST	-	-	-	-	-	-	-	-	3	1
9. Momphali	*Arachis hypogaea*	RF	-	-	-	-	-	-	-	-	-	ML	UF	3	3
10. Sarson	*Brassica campestries*	FL	-	-	-	-	-	-	-	-	-	-	YL	2	2
11. Jawar	*Sorghum bicolor*	-	-	-	-	-	-	-	ML	UF	-	-	-	2	2
12. Til	*Brassica juncea*	-	-	-	-	-	-	-	-	YL	MF	-	-	2	2
13. Kapas	*Gossypium herbaceum*	-	-	-	-	-	-	-	-	YL	UF	-	-	2	2
Vegetables															
1. Gajar	*Daucas carota*	YL,ML	RO	RO	RO	-	-	-	-	-	-	YL	YL,ML	6	3
2. Dhania	*Coriandrum sativum*	ML,ST	ML,ST	-	-	-	-	-	-	-	YL,ML	ML,ST	ML,ST, FL	5	4
3. Chandalia	*Amaranthus hybridus*	-	-	-	-	-	-	-	YL	YL,ST	ML,ST	ML,ST	ML,ST, FL	5	4
4. Kakri	*Cucumis sativys*	YL	FL	RF	RF	RF	-	-	-	-	-	-	-	5	3
5. Muli	*Raphanus sativus*	ML,RO	RO,ML	-	-	-	-	-	-	-	YL	YL,FL	FL,UF	5	5
6. Tamatar	*Lycopersicon lycoper-sicum*	RF	RF	-	-	-	-	-	-	-	YL	YL,FL, UF	YL,UF	5	5
7. Band gobi	*Brassica oleracea L. Var. Capitatal*	ML	ML	-	-	-	-	-	-	-	YL	YL,ML	ML	5	2
8. Bhindi	*Abelmoschus esculentus*	-	YL	FL	RF	RF	-	-	-	-	-	-	-	4	3
9. Baingan	*Solanum melongena*	-	-	FL	RF	RF	RF	-	-	-	-	-	-	4	2
10. Kachar	*Cucumis melo var. culta*	-	-	-	-	-	-	-	-	FL	FL	RF	RF	4	2

Local Name	Botanical Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	*	**
Vegetables															
11. Kanda	*Allium cepa*	YL,FL	-	-	-	-	-	-	-	-	YL	YL	YL,FL	4	2
12. Palak	*Rumex vesicarium*	YL,FL, ST	YL,FL, ST	-	-	-	-	-	-	-	-	YL,ST	YL,ST	4	3
13. Pudina	*Mentha spicata*	-	-	-	-	-	YL,ST	YL,ST	YL,ST	FL,ML, ST	-	-	-	4	4
14. Sakarkand	*Ipomoea batatas*	RO	-	-	-	-	-	-	-	YL,FL	YL	-	RO	4	3
15. Ful gobi	*Brassica oleracea L. Var. botrytis*	FL	-	-	-	-	-	-	-	-	YL	YL	ML,FL	4	3
16. Mirchi	*Capasicum annuum*	-	-	-	-	-	-	-	-	-	YL	FL	RF	3	3
17. Methi	*Trigonella foenum-graecum*	YL,ST	-	-	-	-	-	-	-	-	-	YL,ST, FL	ST,YL	3	3
18. Matira	*Citrullus lanatus*	-	-	-	-	-	-	-	FL	FL	UF	-	-	3	2
19. Tumbi /All	*Lagenaria siceraria*	-	-	-	-	-	-	YL,ML	FL	FL	-	-	-	3	2
20. Kaddu	*Cucurbita moschata*	-	-	-	-	-	FL	FL	-	-	-	-	-	2	1
21. Tori	*Luffa cylindrica*	-	-	-	-	-	-	YL,FL	FL	-	-	-	-	2	2
22. Karala	*Momordica charantia*	-	-	YL,FL	FL	-	-	-	-	-	-	-	-	2	2
Cultivated flowers and fruits															
1. Amrood	*Picidium guajava*	-	-	-	-	-	-	-	YL,ML	ML	FL	UF	-	4	4
2. Anar	*Punica granatum*	-	-	-	-	-	-	-	YL,ML	ML,FL	FL,UF	UF	-	4	4
3. Nimbu	*Citrus medica*	-	YL	FL	-	RF	-	-	-	-	-	-	-	3	3
4. Kaila	*Musa paradisiaca*	-	UF	UF	-	-	-	-	-	-	-	-	FL	3	2
5. Papita	*Carica papaya*	-	-	-	FL	UF	UF	-	-	-	-	-	-	3	2
6. Hajara	*Tagetes erecta*	FB	FB,FL	FL	-	-	-	-	-	-	-	-	YL,FB	3	3
7. Hajara	*Tagetes patula*	FL,FB	FL	-	-	-	-	-	-	-	-	-	FB	3	2
8. Tulsi	*Ocimum canum*	-	ML	-	-	-	-	-	-	-	-	ML	ML,FL	3	1

L = Young leaves; ML = Mature leaves; FB = Flower buds; FL = Mature flower; UF = Unripe fruits; RF = Ripe fruits; SE = Seeds; GU = Gum; BR = Bark; AR = Arial root; ST = Stem; * Consumption in year; ** Parts consumed of a species

Discussion

Hanuman langurs at some places obtain as much as 90 % of food from cultivated plants (YOSHIBA, 1968) and at many places the percentage is low. At places this species is dependent on crops for much of its diet (HRDY, 1977). In addition to food the also cause damage to the orchard plants and fruit trees by breaking the thin branches with flowers and fruits.

In the present study the maximum consumption of cultivated food was found during September to December, which was 35 to 43 %, and the minimum consumption was 19 % in the month of June. This percentage of feeding on crop fields increases and decreases with the availability of cultivated food plants. Langurs were observed eating roots, stem, young and mature leaves, flowers, fruits and occasionally whole plants. The frequency of a plant species eaten depends on the degree of success with which the langurs could invade the fields. In this study all farms were equally vulnerable to crop raids by langurs. Generally, the farms located adjacent to sanctuary's boundary wall and the farms with poor crop protection strategies are at risk most and suffer losses. In a study conducted by Sahoo in Himachal Pradesh where the estimated damage level varied from district to district and from habitat to habitat depending on the distance of a farmland from the fringe of the nearest forest Perso Communication.

The annual economic loss to farmers in the study area is about US $ 1800-2400 from all the 12 farms. In addition to this the cost of crop protection for each farm ranged between US $ 200 to 250 per year, which comes between US $ 2400 to 3000 annually for all the 12 farms. Therefore the monitoring cost to a farmer comes more then the cost of crop damage. Although the indirect damage to the reproductive parts (flowers, unripe fruits) of a fruit tree was not calculated in the present study, but it was observed that this damage during the jumping and play on a fruit tree by whole group is quite high. Such damage can be estimated by comparing the production of reproductive parts in the similar farm, which is not invaded by langurs.

In many parts of Africa farmers have hunted and trapped wildlife coming to their fields, which help to reduce local population of pest species with in their field (VANSINA, 1990). Langurs cause severe damage to crops in many parts of the country and the crop protection strategies and management tactics varies from area to area. In Sri Lanka langurs eats young leaves, shoots, buds of mangoes and other fruits and they some time killed as crop raider (MUCKENHIRN, 1972). But, in India peoples are not killing langurs mainly because of prevalent religious sentiments and because of Wildlife Protection Act, 1972. The langur is regarded as sacred by Hindus, who often feed them, generally every Tuesday, which is the traditional day of the monkey-god- Hanuman (ROONWAL and MOHNOT, 1977). But farmers frequently threaten them, throwing stones, whistle, shout at them and use firecrackers to scare them away from the field. But, langurs are very intelligent and well organized when they raid crop fields. When they attack a field, all the group members do not enter at one time. Few (2-6) enter while others remain on the edge of the field or in trees watching vigilantly. They gave alarm call as and when any person or dogs approach them.

Crop raid by male-bands is more frequent compared to bisexual troops possibly because males are physically strong and batter skilled in running, threatening and fighting. Females have to care for their infants. It was also observed from bisexual

troops that females with infants always enter in the last when all adults, sub-adults, juvenile males and few females without infant have moved in. Male-bands have bigger home ranges as compared to bisexual troops (CHHANGANI, 2000), so they were visiting more number of agricultural and horticultural fields more often compared to bisexual troops.

It was observed that langurs are more fearful of adult man then women and children and a person carrying "gophan" versus one who is without "gophan". About 65 percent of all crop guarding is done by women and children. For successful guarding it is required that people be in the fields during the seasons when the crops were most vulnerable, and this guarding should have to be through out the day. Obviously, this was not possible because people had many other works to do. Other studies have also reported that primates are more fearful of adult man then of women and children (STRUM, 1994; KING and LEE, 1987; HILL, 2000).

It was also found that many times 4-5 farmers hire a person or persons (depend on farmers groups) to guard their crop fields, and share the cost of guarding fields. This practice is the most economic and more successful amongst all crop protection strategies. It was also noticed in the last 6 years, that attitude of peoples towards the conservation of area and wildlife have changed considerably. Earlier there were few demands for gun licenses, but now this demand has increase considerably which is mainly to protect their agricultural and horticultural fields from wildlife attacks. In majority of cases we found farmers depend on their crop/horticulture/produce for survival. Such attitude of peoples is not restricted to KWS only but in many other areas as well. This is a man-wildlife conflict issue related to people's attitude which suggest falling conservation interest of people in India, Africa and United States (SUKUMAR, 1985; INFIELD, 1988; BALASUBRAMANIAN et al, 1993; CONOVER and DECKER, 1991; CHAUHAN and SAWARKAR, 1989).

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KILLING OF HANUMAN LANGUR (*SEMNOPITHECUS ENTELLUS*) IN ROAD ACCIDENTS IN KUMBHALGARH WILDLIFE SANCTUARY, RAJASTHAN, INDIA. CHHANGANI, A.K.

Key words: Killing, Hanuman langur, Road accident, Vehicle, Kumbhalgarh Wildlife Sanctuary (KWS)

Abstract

Vehicles and trains often kill wild animals, even in the protected areas, wildlife sanctuaries and national parks. In the present study at Kumbhalgarh Wildlife Sanctuary (KWS) a total 439 road-kills of wild species recorded. Which includes mammals, birds, reptiles and others of which 47 cases of road accident were recorded in 15 bisexual troops and all male bands of Hanuman langur with 29 killings. These cases of road accidents involves 28 male and 19 female langurs, of which 18 male and 11 female were killed, which suggests that males died significantly more than females in road accidents. The maximum road killings were observed in the month of August and minimum in May and June during the study period. During tourist season about 85 % of the total deaths were recorded at KWS. 25 % of total deaths observed at KWS of Hanuman langur due to road accidents.

Introduction

Kumbhalgarh Wildlife Sanctuary (KWS) is one among several wildlife sanctuaries and national parks in India, which are traversed by public roads and railway tracks. Collision of wild animals with vehicles and trains are common in India. Deaths of elephants (*Elephas maximus*), Asiatic lion (*Panthera leo percica*), tigers (*Panthera tigris*), leopards (*Panthera pardus*), bluebulls (*Boselaphus tragocamelus*), chinkara (*Gazella gazella*), black bucks (*Antilope cervicapra*), hanuman langurs (*Semnopithecus entellus*) jackals (*Canis aureus*), jungle cats (*Falis chaus*) and civets (*Paradoxorus hemaphordiatus*) can be observed occasionally. Such situation indicates that the vehicles and trains often harm wildlife even in protected areas, wildlife sanctuaries and national parks. For example, Rajaji National Park, Gir National Park, Dudhwa National Park, Borivalli National Park, Sariska National Park, Mount Abu Wildlife Sanctuary, Sitamata Sanctuary, Kumbhalgarh Wildlife Sanctuary (KWS) are some such protected areas where accidental deaths of wild animals are common. The range of species affected by vehicular traffic and road kills have not been quantified in India except for few studies carried out elsewhere (e.g. BROEKHUYSEN, 1965; LEWIS, 1989; LOPEZ and ROVIRALTA, 1993; LOPEZ, 1993; DREWS, 1991, 1995). Killing of Hanuman langurs in road accidents have been observed in other studies by MOHNOT (1974), RAJPUROHIT (1987), AGORAMOORTHY (1987), RAJPUROHIT and CHHANGANI (1997) and CHHANGANI (2000, 2001). Some effect on demography by road kills on yellow baboons was also studied in Tanzania by DREWS (1995).

Material and Methods

The Study Site

The Kumbhalgarh Wildlife Sanctuary (KWS) lies between 20°5' and 23°3' N latitude and 73°15' and 73°45'E longitude some 200 km south of Jodhpur in the west Aravalli rangers of Rajasthan, India (fig. 1). The total area of KWS is 585 sq. km. Its altitude vary from 274 to 1155 meter above see level. KWS is characterised by distinct winter, summer and monsoon. During summer, temperature fluctuates between 30 – 35° C, which may raise up to 46° C during May and June. The mean temperature in winter is 5° C, which may go down to 2° C in December – January. The average annual rainfall is 725 mm; with a minimum 403 and maximum 950 mm.

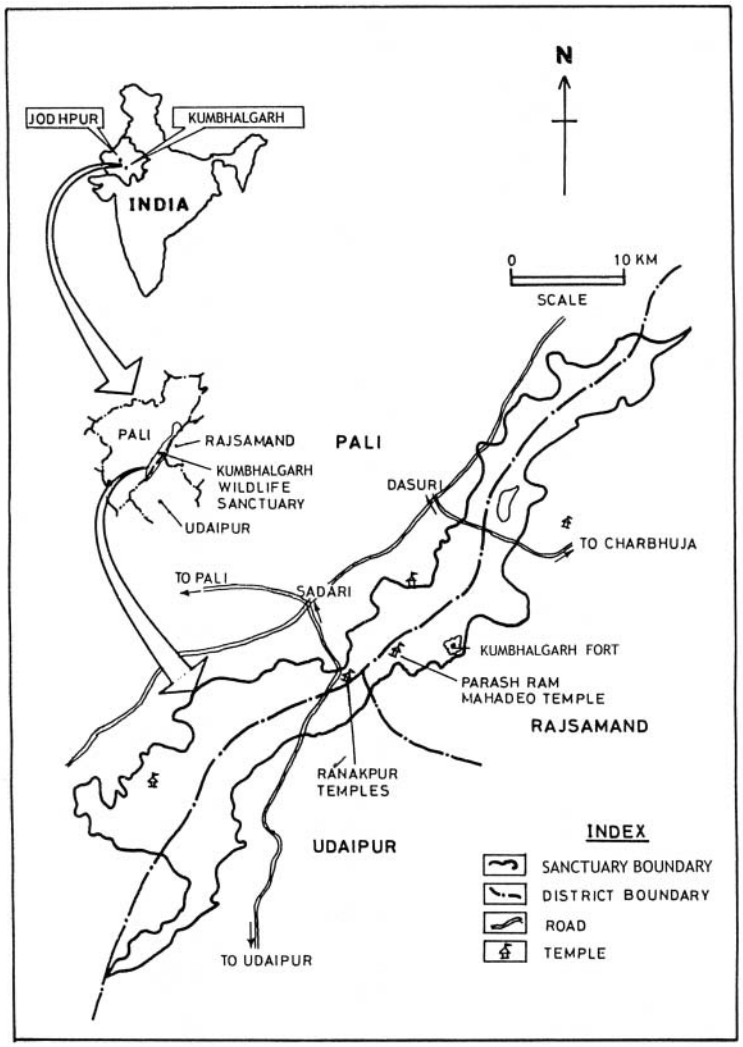

Fig. 1: Location of Kumbhalgarh Wildlife Sanctuary in the Aravalli Hills.

The forest is broadly dry deciduous or woodland type dominated by 'gorya dhawa' (*Anogeissus latifolia*), salar (*Boswellia serrata*), godal (*Lannea coromandelica*), kherni (*Wrightia tinctoria*), dhawa (*Anogeissus pendula*), kumbat (*Acacia senegal*), khair (*Acacia catechu*), ber (*Ziziphus mauritiana*), dhonk (*Butea monosperma*), etc. The undergrowth (shrubs) mainly consists of jharber (*Ziziphus nummeularia*), adusa (*Adhatoda zeylanica*), gangan (*Grewia tenex*), franger (*Grewia flavescens*), kanter (*Capparis separaia*), lantana (*Lantana camara*), etc. Some climbers and grasses are also found.

The main fauna of KWS includes, leopard (*Panthera pardus*), hyaena (*Hyena hyaena*), Indian wolf (*Canis lupus*), jackal (*Canis aureus*), sloth bear (*Melursus ursinus*), four-horned antelope (*Tetracerus quadricornis*), chinkara (*Gazella gazella*), porcupine (*Hystrix indica indica*), samber (*Cervus unicolor*), bluebull (*Boselaphus tragocamelus*), toddy cat (*Paradoxurus hermaphroditus*), jungle cat (*Felis chaus*), fox (*Vulpes bengalensis*), crocodile (*Crocodilus palustris*) and rock python (*Python molurus*).

Methods

Road kill data were collected during a long-term study entitled eco-behavioural diversity of Hanuman langur (*Semnopithecus entellus*) living in three different ecosystems in and around Kumbhalgarh Wildlife Sanctuary. Data presented in this paper were collected from 15 groups and bands which includes 11 (73 %) bisexual troops and 4 (27 %) all male bands with a population density of 67 langurs per square kilometer. The adult male – females sex ratio is 1:5.6 which is female based. Two state highways (about 25 km long) and 3 ancillary roads (30 km long) passes through the sanctuary. Between December 1995 to December 2000 the species and location of each road accident resulting into death of wild taxa were recorded while driving on the highway to and from the study area. Occasionally road kills were also reported by forest officials and drivers. These information were included in this study after verification and confirmation. The recording efforts remained more or less constant throughout the study. Road kills generally disappeared from the road within few hours to a day as a result of scavengers operating in the area. My records are limited to the more striking animal classes like mammals, birds and reptiles. However, frogs and invertebrates were commonly killed by vehicles. During tourist season and monsoon the number of road accidents increases.

Result and Discussion

The Jodhpur – Udaipur highway passes through sanctuary between Sadari and Bokhada villages. Likewsie, Desuri – Charbhuja road crosses the sanctuary through Desuri-ki-Nal. The Kot-Divar road passes through Divar-Ki-Nal. Sadari-Parshuram Mahadave and Sabri- Muchhala Mahaveer temple road also passes through the sanctuary. Out of these roads Sadari-Bokhada and Desuri-Charbhuja are the highways. Both are busy roads with heavy vehicles. The Ranakpur temple is a major tourist attraction on Sabri-Bokhada road. During this study period total of 439 road kills of wild species were observed and recorded in and around Kumbhalgarh Wildlife Sanctuary. Of them 80 % occurred on the highways. Killing are common at the sharp turns, slope and near water holes and small tracks, which cross the roads be-

ing the preferred areas of animals. Taxa found in the road killing are listed, all together 52 species of animals were found killed in this kind of road accidents. Of these 33.7 % were birds, 36.2 % mammals and 17.5 % were reptiles and 12.4 % were domestic animals. In mammals there were18.7 % Hanuman langurs. Which comes to 6.8 % of total road killing. Total 47 cases of road accidents were recorded in 15 bisexual troops and all-male bands of Hanuman langurs. Of them 29 langurs were killed, 13 seriously injured and 5 sustained minor injuries (Table 1). It is basically because of heavy traffic on the roads passing through the sanctuary.

Table 1: Observed cases of road accidents of Hanuman langurs in different bisexual troops and all-male bands (December 1995 to August 2000).

S. No.	Troop/Band No. of cases	Age category of animal	Sex	Vehicle hit	Fate
1.	B – 1 (i)	Juvenile	M	Jeep	Killed
	(ii)	Adult	F	Jeep	Killed
	(iii)	Infant- II	M	Bus	Injured (Seriously)
2.	AMB – 1 (i)	Subadult	M	Car	Killed
	(ii)	Adult	M	Jeep	Killed
3.	B – 2 (i)	Juvenile	M	Car	Killed
	(ii)	Adult	F	Bus	Killed
	(iii)	Whitecoat	M	Truck	Injured (Fractured)
	(iv)	Juvenile	F	Jeep	Killed
4.	AMB – 2 (i)	Old adult	M	Jeep	Killed
	(ii)	Adult	M	Truck	Injured (Fore limb frac.)
	(iii)	Juvenile	M	Bus	Killed
5.	B – 3 (i)	Juvenile	M	Motorbike	Injured
	(ii)	Adult	F	Car	Killed
	(iii)	Juvenile	F	Jeep	Injured (Seriously)
6.	B – 4 (i)	Juvenile	M	Car	Killed
	(ii)	Whitecoat	M	Bus	Injured (Franctured)
	(iii)	Adult	F	Jeep	Injured (Minor)
	(iv)	Adult	F	Mini Bus	Killed
7.	B – 5 (i)	Juvenile	M	Car	Killed
	(ii)	Adult	F	Bus	Injured (Serious)
	(iii)	Juvenile	M	Jeep	Injured (Minor)
	(iv)	Whitecoat	F	Bus	Killed
	(v)	Adult	F	Bus	Injured (Fractured leg)
	(vi)	Whitecoat	M	Jeep	Killed
8.	B – 6 (i)	Juvenile	M	Car	Killed
	(ii)	Adult	F	Jeep	Killed
9.	B – 7 (i)	Juvenile	F	Car	Killed
	(ii)	Juvenile	M	Bus	Injured (Minor)
10.	B – 8 (i)	Juvenile	F	Car	Injured
	(ii)	Juvenile	M	Jeep	Killed
	(iii)	Whitecoat	F	Car	Injured (Seriously)
11.	B – 9 (i)	Juvenile	M	Bus	Killed
	(ii)	Adult	F	Truck	Injured (Minor)
	(iii)	Subadult	F	Jeep	Killed

S. No.	Troop/Band No. of cases	Age category of animal	Sex	Vehicle hit	Fate
12.	B – 10 (i)	Juvenile	F	Car	Killed
	(ii)	Juvenile	M	Jeep	Killed
	(iii)	Adult	F	Bus	Injured (Leg)
13.	AMB – 3 (i)	Juvenile	M	Jeep	Killed
	(ii)	Adult	M	Car	Killed
	(iii)	Adult	M	Bus	Injured (Minor)
14.	B – 11 (i)	Juvenile	F	Jeep	Killed
	(ii)	Adult	F	Car	Injured (Fractured leg)
15.	AMB – 4 (i)	Juvenile	M	Car	Injured
	(ii)	Adult	M	Jeep	Killed
	(iii)	Adult	M	Jeep	Killed
	(iv)	Sub adult	M	Car	Killed

These cases of road accidents involve 28 male and 19 female langurs, of which 18 male and 11 female were killed and in 18 cases langurs get minor and major injuries (see Table 2). This clearly revealed that males died significantly more then females in road accidents. By the road accidents the male female sex ratio is also imbalanced, which may Leeds to a female biased sex ratio (RAJPUROHIT and CHHANGANI, 1997). Similar situation of sex differences in mortality among langurs were also observed at Jodhpur (see RAJPUROHIT and SOMMER, 1991). Due to this inbreeding in the population may take place and genetic hetrozygocity of genes may lose. In such conditions species may loss the health resistance and population may exposed to large numbers of diseases, which may leeds to mass mortality by diseases like in Jodhpur langurs population (CHHANGANI et al., 2001).

Table 2: Overall Scenario of road accidents, killing and injuries sex-wise.

Sex	Accidents	Killings	Injuries
Male	28	18	9
Female	19	11	9
Total	47	29	18

The maximum road killings (i.e. about 17 %) were observed in the month of August during monsoon and minimum in hot summer of May and June i.e. 2.1 % in each month, during December 1995 to December 2000. By and large, winter and summer months show less road accidents in KWS (fig. 2). Because, Parshuram Mahadave, Muchhala Mahaveerji and Ranakpur temple (a world famous tourist place) is visited by large numbers of tourists (both Nationals & International) in tourist seasons in the month of July to February (CHHANGANI, 2000). During the tourist season's the traffic is quit high through the Kumbhalgarh Wildlife Sanctuary, as a result 85 % of deaths were observed during the tourist seasons. According to Govt. of Rajasthan, Dept. of Tourism, on an average 70,000 national and international tourist visited Ranakpur temples (PANWAR, 2001) during tourist season.

The road accident is a major cause of mortality in Hanuman langurs studied at KWS. Here, the home ranges of study troops were found to pass through the high-

way located in the study area. Killings of human and nonhuman primates in road accidents have also been observed in other studies like MOHNOT (1974), MAKWANA (1974), WINKLER (1981), RAJPUROHIT (1987), AGORAMOORTHY (1987), CHHANGANI and MOHNOT (1997) and RAJPUROHIT and CHHANGANI (1997).

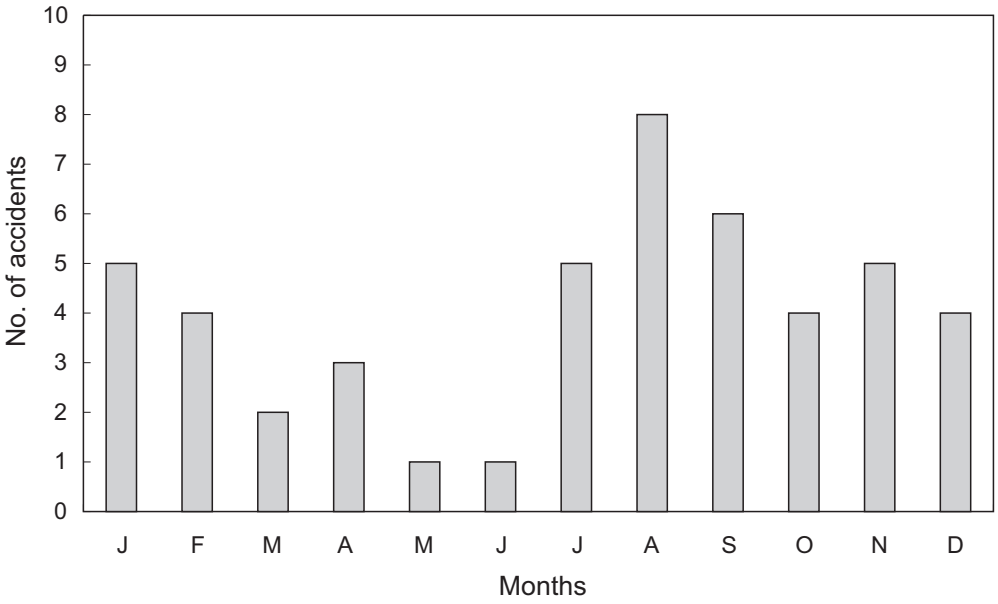

Fig. 2: Cases of road accidents observed in different months of year at KWS study area during study period (i.e. December 1995 to December 2000).

The comparatively higher mortality of Hanuman langurs due to road accidents is because of their diurnal habits. These non-humans primates keep close to temples. The Ranakpur temple (a world famous tourist place) is being visited by large number of tourists. They offer food to langurs seen around. The latter have developed habit of keeping them close to temple (CHHANGANI, 2000). Provisioning of langurs along the roads by people is very common due to religious sentiments and langurs also expect food from every vehicle and do not bother much to speedy vehicles passing through. These vehicles often hit langurs and kill or injure them. Many times during fights and interactions between bisexual troops and all-male bands, animals suddenly and un-knowly come in front of the vehicles while running behind and chasing at an speed of 60-70 km/hr and are thus hit the vehicles. In such cases langurs often die instantaneously.

Langurs also utilize roads for walking, juvenile playing running and foraging on vegetation available along the roadside. This is also an added advantage to langurs to avoid predators. These roads are busy and predators like panther, wolf and jackals usually avoid coming towards roads in the daytime.

The causes of deaths of langurs at KWS are predation, road accident, diseases, electrocutions, etc. were recorded, and about 25 % of total deaths of Hanuman langurs were due to road accidents (CHHANGANI, 2000).

Fig. 3: Adult male killed in road accident near Ranakpur temples in the Kumbhalgarh Wildlife Sancuary.

Recommendations

The one and only best way of reducing the rate of collisions between vehicles and animals especially langurs is to reduce and limit the vehicle speed within the sanctuary area. Adequate signboards on the possible turns, spots of feeding and drinking at regular intervals should remind the drivers to reduce speed and of presence of wild animals on the road. Most effective way of reduce langur mortality, people should not throw and feed langurs on the road from their vehicles passing through wildlife sanctuaries like KWS.

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