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PROSPECTS FOR MANAGEMENT OF PRIMATE PESTS

Shirley C. STRUM*

ABSTRACT

Among the variety of commensal relationships between human and nonhuman primates, those of most concern today center around « conflict ». As part of a long-term study of olive baboons (*Papio anubis*) in Kenya, we had the opportunity to investigate the response of four wild troops to the incursion of agriculture. We also tested a variety of management techniques. The development of crop-raiding was not inevitable. In fact, baboons appeared very reluctant to raid, except for a few who had previously fed on human food. Responses ranged from enlarging home range size, decreasing troop size, shifting home range, to raiding as a secondary strategy and raiding as the main foraging orientation. Crops provided greater digestibility and increased foraging efficiency over natural foods. Eating human food altered activity budgets, increased growth and reproduction, but took its toll in injuries and deaths. Control techniques work through increasing costs and decreasing benefits of raiding. The most promising technique is taste aversion conditioning, although better emetics are needed before this method can be widely used. Shifting cultivars may also be effective, particularly if the new crops are less digestible or less palatable for baboons. The prospects for managing primate pests will vary depending on whether animals have viable alternatives. The future of existing primate commensalism is threatened by increasing human pressure on resources. It is highly unlikely that new commensal relationships will develop given these same constraints. Nevertheless, the framework of primate commensalism may provide insights into the variety of human and nonhuman primate relationships and how these might be manipulated for future primate conservation.

Key words : Kenya, baboon *Papio anubis*, commensalism, food choice, taste aversion conditioning.

INTRODUCTION

Commensalism is a new concept in the study of primate behavior, although it has been used in interpretations of the behavior of other animal species for

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decades (see Marler & Hamilton, 1966 ; Wilson, 1975). Traditionally, commensal relationships are considered symbiotic or mutualistic, with each species deriving advantage from the close association. Gautier and Biquand (this volume) would like to expand the concept for primates to include the range from the « extreme » situations where nonhuman primates are dependent on humans for their survival (wild, provisioned or food-enhanced) through those situations where human modifications to habitats create new niche opportunity for other primate species. This is a useful way to conceive of the variety of relationships that can exist between human and nonhuman primates. It also suggests an evolutionary dimension that has long been ignored.

But in the modern context perhaps the most important practical issue is « conflict » between human and nonhuman primates. This conflict threatens to disrupt previously neutral or positive commensal relationships and offers a serious challenge to the future conservation of many primate species.

Baboons and macaques may be particularly well suited to commensalism with humans because of their dietary opportunism and flexibility. Below, I discuss a particular case of baboon adaptation to recent human modification of their habitat. This is an example of what Gautier and Biquand term « sudden adaptation », and stands in contrast to the case of long-term adaptation by rhesus monkeys discussed by Southwick and Siddiqi (this volume). The comparison provides insight into the future prospects of commensalism as a way of life for some primate species.

THE MAKING OF CROP-RAIDING BABOONS

As human populations expand, particularly in the biologically diverse developing world, the conflict between animals and people over crops poses a major threat to wildlife, in general, and primates, in particular. Figures for the annual loss of primates as a result of attempts to protect crops are difficult to obtain. But anyone who has worked with monkeys or apes knows the seriousness of the problem. Local farmers and governments also appreciate the extent of the conflict and the economic costs of crop damage.

Primates are a particular problem. Because they are so intelligent, control techniques are usually not successful. Some wildlife can be contained by simple fences and barriers, and even elephants are deterred by electric fences. But primates jump over and dig under barriers, they climb on electric insulators and find the dead spots in electric fences. Even killing primate pests is, in fact, relatively ineffective. After the initial deaths, the remaining animals learn extreme caution but continue to raid. Subsequent attempts at extermination are time consuming and expensive. The loss of lives and food are not the only consequences. The antagonism between people and animals over crops makes other wildlife conservation efforts more difficult.

As part of a long-term study of olive baboons in Kenya, we had the opportunity to investigate the response of four wild troops to the incursion of agriculture. We also tested a variety of management techniques ranging from traditional chasing and guarding to innovations like taste aversion conditioning. Together these data offer a framework for understanding primate crop-raiding and for evaluating the prospects of managing not just baboons but other primate pests.

THE SITE

The study site is located in the Great Rift Valley of Kenya near a little town named Gilgil (see Blankenship & Qvortrup, 1974 ; Harding, 1976 ; Strum & Western, 1982 ; and Strum, 1987 for details of the site and the population). The area is high altitude savanna with an annual mean rainfall of 700 mm which falls in two seasons. The climate and bushed grassland make the region a prime wildlife area, despite the presence of cattle ranching. The home ranges of the four study troops (PHG, WBY, EC, CRIP) were within the borders of two large ranches (Kekopey 45 000 acres and Marula 65 000). One of the troops (PHG) has been studied continuously since 1970 while the other three were studied before and after the introduction of subsistence agriculture in the region (see Strum 1987 for a review ; see also Strum, 1984 ; Musau and Strum, 1984 ; Oyaro and Strum, 1984). The crop-raiding research spanned the period from 1980 until 1985.

The region has only marginal agricultural potential but the pressure for land in Kenya has forced many people out of traditional areas to try their luck elsewhere. The baboon's initial reaction to the settlement was curiosity. They investigated the new buildings and fences, but did little else. Each small-hold farm averaged 5-10 acres, only part of which was cultivated. The settlement was low in density and widely dispersed. Crops first appeared in August of 1979. The conflict between baboons and people began in earnest during that harvest, but the level of raiding was erratic over the next 5 years because of vagaries in rainfall.

Contrary to local folklore about baboons, the development of crop-raiding was not inevitable. The other options included increasing home range size (EC), decreasing troop size by fissioning (PHG), and shifting home range (PHG, EC) (see Table I, Fig. 1 and 2). Raiding could be either a supplementary strategy or the main foraging strategy, and individuals or entire troops could become crop-raiders.

The most significant contributing factor to the development of raiding behavior was a dramatic reduction in natural forage available to the baboons because of agricultural settlement. This occurred both through excision of farmland and because of the large number of domestic stock introduced by the farmers. For example, in both 1974 and 1981 the troop averaged 72 individuals. In 1974, before settlement, the natural forage available per baboon at the end of the dry season was 137.9 gr/m² while in 1981, 2 years after settlement began, it was only 31.4 gr/m² (Table II).

Despite this pressure, the baboons appeared very reluctant to raid. Adolescent males were more likely to become raiders than other age-sex classes. Those who had previous experience eating human food (as members of other troops that fed at human refuse pits) seemed predisposed to make the transition to crop-raiding. Different troops experimented with various options. Eventually, EC moved out of the farming area, PHG split into two troops, one which raided (WBY) and the other which did not (PHG). A few males in nonraiding MHG did independently become supplemental raiders. CRIP had shifted from foraging naturally to a reliance on refuse pits by 1978. They also became supplemental crop-raiders.

WHY RAID ?

Everyone assumes that when crops are there, baboons raid. However, crop-raiding is a *foraging strategy* with specific costs and benefits. Our data on

TABLE I

Change in Pumphouse (nonraiders) home range size as a result of agricultural settlement.

Year	Home range size	Troop size
1978	46.5 square km	100
1979	31.3	89
1980	31.3	82
1981	12.5	72 (Troop split in July)
1982	18.5	63
1983	19.5	63
1984	22.23 (Jan.-Sept.)	57
<i>Wabaya home range size (raiders) Wby split from PHG in July 1981</i>		
1981	4.25 (July-Dec.)	23
1982	6.5	25
1983	8.0	27
1984	6.5 (Jan.-Sept.)	32

Home range size represents yearly maximum. Troop size represents yearly average.

TABLE II

*Food availability quotient for Pumphouse troop
(Biomass per baboon available at the end of dry season).*

Year	Rainfall	Troop Size	FAQ (grams/square meter)
1971	638 mm	48	142.5
1972	673	59	109.8
1973	622	63	132.8
1974	684	72	137.9
1975	711	76	136.4
1976	472	90	52.4
1977	791	96	94.2
1978	679	100	52.5 (Settlement begins)
1979	635	89	25.8
1980	565	82	19.8
1981	859	72	31.4 (Troops splits in July)
1982	721	63	14.8
1983	685	63	24.1
1984	365	57	14.3 (Translocation in September)

Rainfall is yearly total while troop size is yearly average. FAQ is calculated by multiplying the vegetative production by the home range size, adjusting for competition by herbivores, and then dividing by troop size. This represents an estimate of the relative availability to a Pumphouse baboon of herb layer biomass at the most critical period during each year.

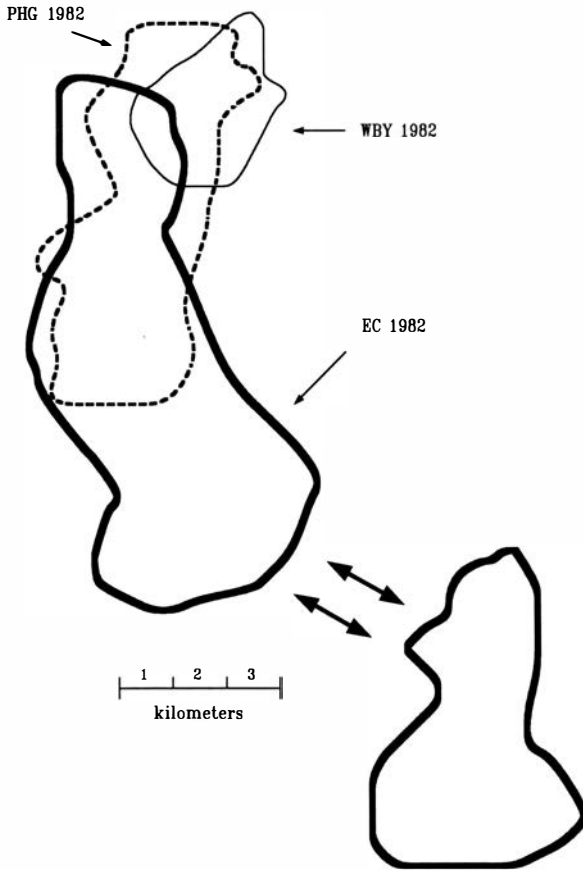


Figure 1. — Changes in home range in 3 troops in response to agricultural settlement.

activity budgets, on growth, condition, reproduction, injury and mortality of raiders and nonraiders provide insights about the consequences of the raiding strategy. They also suggest why some techniques of control succeed while others fail.

The value of crops to Gilgil baboons is both their digestibility and foraging efficiency. Human foods were lower in cell-wall and cellulose than wild foods (see Forthman-Quick & Demment, 1988). They represented a rapidly digestible source of energy. Human foods also had the advantage of « package » size. One ear of maize is equivalent to a large harvesting effort for natural foods. Although human foods had less protein than many natural foods, they yielded more energy per unit of effort. The effect of a « raider » diet can be seen in several parameters. Activity budgets of raiders and nonraiders differ in important dimensions (see Eley *et al.*, 1989 and Table III). Our long-term data show that raiders spend less time feeding, more time resting and slightly more (but significantly so) time socializing. This is

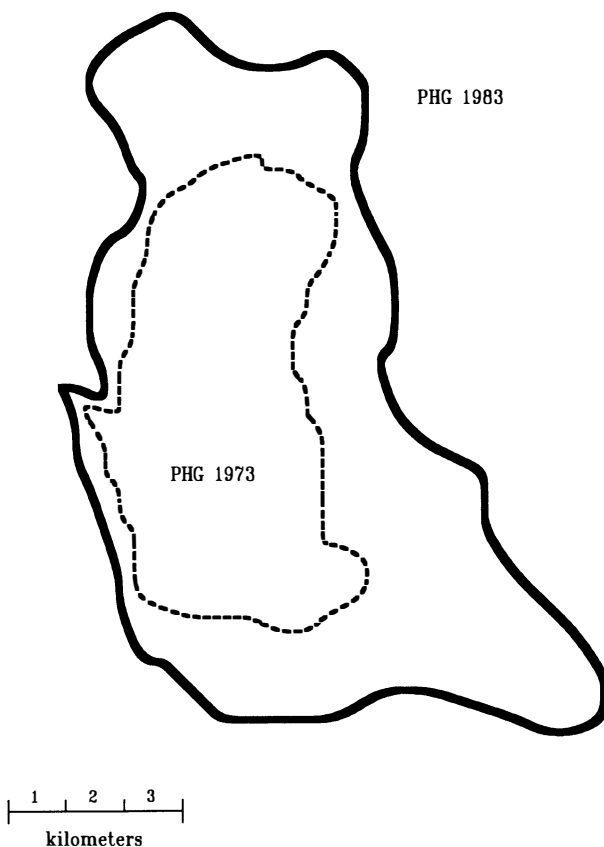


Figure 2. — Reduction in PHG home range as the result of agricultural settlement.

consistent with Forthman's short-term study of raiding (Forthman-Quick, 1984) in this population and with data from food enhanced yellow baboons at Amboseli National Park in Kenya (Altmann & Muruthi, 1988). These differences are greater for females than for males (Table III).

The change in diet and activity pattern has a marked effect on growth, condition and reproduction. Raiders grow faster, reach adulthood earlier and achieve higher final weights than nonraiders (Strum, 1991 and Table IV). Raiders are also in better condition (Table V) with more subcutaneous fat and fewer parasites (Eley *et al.*, 1989). Female raiders have shorter interbirth intervals than female nonraiders (Strum, in prep.), while the heavier raider males have greater consort success as large adolescents and young adult immigrant males than nonraiders of the same classes (Strum, in press).

But there are costs as well. Injury and death resulted from conflict with humans over crops and other sources of human food (Eley *et al.*, 1989).

TABLE III

*Example of activity budget differences between raiders and nonraiders
(Scan samples : 6 months data, 1983/84) (n = 1 361 scans ; 40 215 data points).*

* indicates statistically significant differences.

	Nonraider (PHG)	Raider (WBY)
Adult Male		
Feed	45.7 %	21.2 %*
Travel	32	26.2
Rest	12.5	38.5*
Social	3.2	6.7*
Groom	5.5	7.2*
Adult Female		
Feed	55.7	29.0*
Travel	28.7	31
Rest	6.6	25.7*
Social	2.2	3.5*
Groom	7.7	9.3

TABLE IV

Weights of raiders and nonraiders.

	Raiders	Nonraiders
Males	27.4 kg (n = 40)	24.0 (n = 47)
	31.3 (natal only) (n = 26)	
Females	15.6 (n = 39)	15.2 (n = 52)
	20.4 (natal only) (n = 16)	

These are asymptotic weights for adults (see Strum, 1991). « Natal only » refers to animals who were part of a raiding troop from birth as contrasted to individuals who switched to raiding later.

TECHNIQUES OF CONTROL

If raiding is a foraging strategy with a particular set of benefits and costs, then effective control techniques might be expected to work by manipulating this ratio in a negative fashion. We tested both old and new control methods in attempts to increase costs and decrease benefits by imposing additional risks and decreasing palatability.

TABLE V

*General body condition of raiders and nonraiders
(As examined at Translocation in 1984).*

	Excellent	Good	Fair	Poor
WBY (Raiders)	2	29	5	0
CRIP (Raiders)	3	25	13	0
PHG (Nonraiders)	3**	25	27	2

** « Crop-raiding males » in PHG. See Eley *et al.*, 1989 for details.

The traditional techniques of chasing animals out of the fields, and guarding crops are only successful if they manage to use up all the baboons' extra time. Foraging efficiency is so much greater when feeding on crops that baboons can wait for hours, even most of the day, for an opportunity to raid.

Adding elements that the baboons perceive as life-threatening improves the success of both chasing and guarding by increasing risk. Baboons are more afraid of men than of women or children, and of people with weapons than when they are unarmed. They were most afraid of armed men, and next of women and children with stones or with dogs. However, killing or injuring a raider has little impact on others unless they witness the event. For example, the disappearance of a lone raider male is not perceived as a cost of raiding since males often vanish when they migrate to other troops. Making the costs visible may be the origin of some folk methods like hanging out dead baboons, or capturing and painting a baboon before releasing it back to the group. Selective killing is not a deterrent, then, unless it is properly done.

We tried new ways to artificially enhance the perception of risk. This could be done in a variety of ways, for example, lion and leopard scent strategically placed around the fields, bird-fright explosions, machine simulations of noises like and gunshots, and playback of tape recordings of baboon alarm vocalizations.

We began with playback of baboon alarms. This was partially successful but the long-term effectiveness of even the best response is not likely to be significant. Baboons habituate quickly to « false » alarms. Presumably the same would apply to attempts to simulate the presence of « danger » like lions, leopards, and explosions.

Among the variety of new techniques that we tried were ones aimed at reducing the palatability of the crops. We tested two repellents, oleo capsicum resin (essence of chili pepper) and HATE 4C. Oleo capsicum resin may have some potential as a deterrent. Despite the success of HATE C4 as a deterrent for elephants, deer and pigs, it had no effect on the baboons.

The most promising new control technique appeared to be conditioned taste aversion (Forthman-Quick, 1984). Taste aversion conditioning was developed in the United States to control the killing of domestic stock by wolves and coyotes. As part of our crop-raiding research, Forthman adapted the technique for use with baboons. Her preliminary captive trials suggested that lithium chloride was the only safe emetic available at the time. However, the baboons could detect an illness dose since it made the food taste very salty. In order to assess the feasibility

of taste aversion conditioning in wild baboons, field trials involved capturing individuals using maize as bait in a wire trap, sedating them and injecting the emetic. They were then revived with an antidote. The animals vomited the maize in their stomachs when they regained consciousness (Forthman-Quick, 1984).

Treated wild baboons showed evidence of an aversion to maize but not as strongly as treated captive animals. Many factors contributed to the lowered response in the wild individuals: the lower dosage, the long delay between food consumption and illness, and the lack of repeated food-illness treatments (Forthman-Quick, 1984).

These results suggest that, despite problems of dosage and delivery of lithium chloride, taste aversion conditioning might be an effective way to control crop damage by baboons. But other emetics are needed. These should be undetectable, easy to deliver, with rapid emetic action, rapid metabolism, and negligible side effects. For widespread use they would also have to be inexpensive. Each season, a part of the harvest could be sacrificed as bait. Raiders who eat the treated food would have repeated illnesses and strong aversions, reinforced each harvesting season by additional exposures, as necessary.

Another control technique could involve changing the palatability, digestibility or size of crops. For example, legumes like beans are less palatable than maize, less digestible than many natural foods and take considerable time to harvest. Beans were not as vulnerable to raiding by baboons as maize. Changing cultivars might be the simplest solution under some circumstances, particularly when the switch does not entail either an economic or cultural cost (see also Horrocks and Baulu, this volume).

CONCLUSIONS

The baboon case study has identified a variety of factors that contribute to making primates into agricultural pests. Fortunately, the generally conservative nature of baboons, and other primates, is initially an obstacle to any shifts in foraging strategies, including crop-raiding. This reaction is easily reinforced. However, ecological, biological, social and even cognitive considerations interact to determine the development of crop-raiding.

The baboon data also make it clear that the prospects for managing primate pests will vary depending on the circumstances. Effective *in situ* management requires refuge areas of natural forage large enough to supply sufficient food throughout the year. The animals must have viable alternatives. And control is easier if a raiding tradition has not yet been established. Then, traditional techniques do work but their effectiveness can be improved. Farmers need education about the importance of using up all the raiders' time and about enhancing the animals' perception of risk. Traditional methods are costly in terms of time and energy. For these reasons, new techniques are also needed. Taste aversion conditioning holds great promise. Shifting crops may also be appropriate. Obviously, the best prospects for managing primate crop-raiding are in newly settled areas that are marginal for agriculture.

By contrast, controlling crop-raiding in regions of high agricultural potential or in areas that have traditionally been used for agriculture, is very difficult. Often there is no refuge area and if there is, it may be insufficient for the many groups

of primates now concentrated there. No matter what control method is used, the remaining animals will persist in raiding if they have no alternatives.

Management possibilities are limited. Alternative provisioning could be provided. This may be appropriate to preserve groups of endangered primate species. Eradication is another option but, as already discussed, this technique is fraught with difficulties. A new technique, translocation, may be the most effective and least costly way to manage pest primates provided that suitable vacant habitat is available.

In 1984 we translocated three of the four study troops, two raiding (WBY, CRIP) and one nonraiding group (PHG), to test the potential of this method (see Strum and Southwick, 1986 ; Strum, 1987). Removal of the pest groups combined with education of farmers has prevented further crop-raiding by the baboons left behind. The translocated groups have also thrived. The three troops have adapted to their new homes in habitats without any agricultural potential. All the groups are now foraging naturally.

Conflict between human and nonhuman primates over crops incurs serious costs to both. Strategies to improve the effectiveness of traditional techniques, as well as the development of new control methods increases the chances of coexistence in many areas. The baboon data can be viewed as a first step in developing better management strategies for other primate pests.

Could baboons become commensal macaques ? This is an interesting question. The likely answer is no. True commensalism depends on appropriate cultural attitudes, like those in Asia, which view nonhuman animals as brethren and are if not positive, then at least neutral. There is nothing comparable among the current human cultures sharing the baboons' range in Africa. Even a temporary positive attitude to baboons evinced by tourists and some farmers quickly turns to hostility when smart and dexterous animals decide they want what the humans have (see also Boug *et al.*, this volume). To « eat from the same table » (Southwick & Siddiqi, this volume) also requires that there be enough on that table. Certainly, the evolution of a commensal relationship is highly unlikely in the modern context of increasing human population pressure and decreasing resources.

This raises the general question of the future of primate commensalism. To the extent that human modification of the environment creates new habitats *without* the potential for conflict (e.g. secondary growth in logged forests which become the preferred habitat of gorillas), we might be able to track the co-evolution of human and nonhuman primates. Here, Gautier and Biquand's suggestion that some species may gain a competitive edge could provide us with insights into the past role of human activity in the evolution of the modern primate community and the relative success of certain species over others.

But in most cases today, any competitive edge will be short-lived as the needs of these species come in conflict with the increased human pressure on all resources. The eventual decline of nonhuman primates can result from simply overshooting resources, density related mortality, or enhanced disease from close proximity to humans. The line between neutral commensalism and negative commensalism, where primates become pests, is easily crossed. India offers one of the best examples (see Southwick and Siddiqi, this volume). India also provides another lesson. Often conservation efforts change cultural attitudes in a direction that destroys the possibility of commensal relationships. In India, the cultural/religious milieu provided the basis of tolerance of other primates and allowed the evolution of a variety of commensal situations for monkeys. Shifts to

utilization schemes to provide economic benefits for the country altered attitudes. When utilization was stopped, people's orientation was different. Now commensal monkey « commodities » no longer had value and therefore became « pests » (Jim Moore, pers. comm).

Despite my prediction of the decline in commensal relationships, there is still an advantage to developing this framework for primates. Current primate conservation issues and challenges can only be understood within a perspective that places humans as agents, evolutionarily and historically, in the creation of primate habitats, and of primate opportunities as well as conflicts. It may be that the ultimate fate of all nonhuman primate species will be extinction when in direct competition with humans and commensalism is only a fleeting phase. But understanding how commensal relationships develop and are sustained could offer us better insights into how we might manipulate the future to increase the possibility of primate conservation.

RÉSUMÉ

Parmi les nombreux types de relations commensales entre l'homme et les primates non-humains, les plus problématiques sont aujourd'hui les situations de conflit. Au cours d'une étude de longue durée des babouins olive (*Papio anubis*) au Kenya, nous avons pu étudier la réponse de 4 troupes de babouins sauvages à l'irruption de l'agriculture. Nous avons expérimenté plusieurs techniques pour réduire les conflits ainsi créés. Le développement du comportement de pillage n'était pas inévitable, les babouins se montrant très prudents, à l'exception des individus ayant déjà consommé des aliments d'origine humaine. Nous avons observé diverses formes de réponse à cette perturbation d'origine agricole : accroissement du domaine vital, réduction de la taille des groupes, changement de zone, et enfin pillage comme ressource annexe ou principale. Les cultures sont plus digestes que la nourriture naturelle et de récolte facile. L'apport de nourriture humaine a ainsi modifié les budgets d'activité, accéléré la croissance individuelle et le taux de reproduction, mais aussi prélevé son tribut en blessures et mortalité. Les techniques de contrôle sont basées sur l'accroissement des coûts et la diminution des bénéfices liés au pillage des plantations. Parmi ces techniques, la plus prometteuse est l'aversion alimentaire conditionnée, bien que les émétiques actuels ne se prêtent pas à un usage généralisé de la méthode. Une autre solution serait le remplacement des cultures actuelles par de nouvelles cultures, moins digestes ou moins appréciées des babouins. Le résultat des mesures prises dépendra en tout état de cause de l'existence de solutions de remplacement alimentaires viables pour les babouins. L'avenir de relations commensales stables entre l'homme et les babouins est toutefois compromis par la pression croissante de l'homme sur les ressources naturelles. Il est très peu probable que de nouvelles associations commensales se forment au vu de ces dernières contraintes. Néanmoins, l'étude du commensalisme des primates permet d'éclairer la diversité des relations entre l'homme et les primates non-humains, ces connaissances permettront dans l'avenir d'assurer au mieux la conservation des primates.

Mots-clés : Kenya, babouins, commensalisme, choix alimentaires, aversion alimentaire conditionnée.

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