J. Zool., Lond. (2003) **260**, 203–208 © 2003 The Zoological Society of London Printed in the United Kingdom DOI:10.1017/S0952836903003650

Diet of the maned wolf (*Chrysocyon brachyurus*) and its role in seed dispersal on a cattle ranch in Brazil

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(Accepted 12 November 2002)

Abstract

The maned wolf *Chrysocyon brachyurus* is the largest canid inhabiting South America. Its geographic distribution includes the open fields of Brazil's central area, which is currently undergoing agricultural expansion. The diet of the maned wolf and its seasonal variation was determined on a dairy cattle ranch (São Luís farm, 566 ha) in the State of Minas Gerais, Brazil. From January to December faeces of the maned wolf were collected monthly ($n = 150$ scats; 397 food item occurrences). Twenty-nine taxa were identified from scats, 18 of animal origin (46% or 183 occurrences) and 11 of plants (54% or 214 occurrences). The fruits of *Solanum lycocarpum* were the dominant food item in our study (29%). Mammals contributed 13%, arthropods 12%, birds 11% and reptiles 2% of the food items. Arthropods and fruits were prevalent in the rainy season and mammals in the dry season. As expected for a heavily farmed region, frugivory results were at the lower end of the diversity scale (9–33 species) and included four old garden species. No previous study of the diet of maned wolf has registered as many species of Solanaceae as this one. Although dietary richness was lower, the main food items (wolf fruit, armadillos, rodents, birds) were the same as study sites in 'cerrado' and upland meadows. In this region, the open habitats occupied by the maned wolf were previously covered by Atlantic forest, suggesting that landscape modification such as cattle ranching has opened new frontiers for distribution expansion of the maned wolf. The impact of loss of dietary richness and the increase in Solanaceae on the survival of the maned wolf need to be evaluated.

Key words: *Chrysocyon brachyurus*, dairy cattle ranch, diet, maned wolf, Minas Gerais State, scat, Brazil

INTRODUCTION

Genus *Chrysocyon* consists of a sole species, *Chrysocyon brachyurus* Illiger, 1811. It is the largest canid of South America, being well adapted to meadows and savanna habitats. Its long legs favour locomotion and its large ears detect prey over the dense grasses (Sokolowsky, 1927; Krieg, 1940; Langguth, 1975; Dietz, 1984). Its geographic range includes 'cerrado' and the grasslands of Central Brazil, eastern Bolivia, Paraguay, north Argentina and Uruguay (Cabrera & Yepes, 1960; Langguth, 1975). Although solitary, males and females associate once a year during the reproductive season (Dietz, 1984). They are more active at dawn (*c*. 91% active). By day they rest in a dense habitat, forest, meadows or shrubs (generally in small creek origins; Büeler, 1973 cited in Dietz, 1984), not moving much (Dietz, 1984). The diet of the maned wolf, an omnivore, is typical and diverse, including rodents, arthropods, reptiles, birds, fruits and armadillos either in 'cerrado' (Carvalho, 1976; Dietz, 1984; Jácomo, 1995; Motta-Junior *et al*., 1996; Motta-Junior, 2000) or upland meadows (Aragona & Setz, 2001). The wolf-fruit *Solanum lycocarpum* (Solanaceae) is the staple of its diet, thus its nickname (Carvalho, 1976). It is largely found around Brazil, generally in sandy soils and sunny habitats (Leitão Filho, 1975). Solanaceae fruits are known for having glycoalkaloids (Scavone & Panizza, 1980; Albuquerque, 2001). Silveira (1969) once suggested that these substances could inhibit a kidney infection by *Dioctophyma renale*, prevalent in maned wolves. Maned wolves are persecuted in the belief that they prey on domestic stock (Meritt, 1973; Grzimek, 1980). Other mortality factors are intense fire, road kills, and illegal hunting and trading (Dietz, 1984; Vieira, 1996). The maned wolf has been classified as vulnerable by the IUCN since 1982. With mechanization, much of Brazil's rapid agricultural expansion is taking place in 'cerrado', which was recently added to the hotspots list (Mittermeier, Gil & Mittermeier, 1997). Hotspots are the 25 richest and most threatened reservoirs of plant and animal life on

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Earth (Mittermeier, Gil & Mittermeier, 1997). Studies in modified landscapes will help to evaluate the future survival of the maned wolf.

The objectives of this study were to determine foods from maned wolves in a dairy cattle ranch, to compare the diet in this area with previous work and to examine relationships between the diet and season. Data are also provided on scat deposition sites and the effect that passage through the gut of a maned wolf has on the germination success of seeds of *Solanum lycocarpum*.

STUDY AREA

From January to December 1996, our study was conducted on a private dairy cattle ranch (São Luís Farm; 21°51′53″S, 43°19′35″W), Matias Barbosa County, south-east Minas Gerais State. It is one of the largest (566 ha) and oldest properties in the region. Topography is heterogeneous, ranging from plains to mountains. Climate is type Cwa (mesotermic, after Köppen, 1948), subtropical, rainy in summer (November–April) and a dry winter between May and October (EMBRAPA, 1996). In 1996 it rained l546 mm and average temperature was 2l.2 °C (EMBRAPA, 1996). This region was covered by subtropical semi-deciduous forest, largely converted into coffee in the second half of the 19th century (Dean, 1996) and subsequently into pastureland.

METHODS

Feeding habits of the maned wolf were determined by monthly collection of scats ($n = 150$) on São Luís farm. During 5 days each month all trails and dirt roads, crossing all types of vegetation, were searched by foot. To standardize the sampling effort, the same routes were explored every month, with careful inspection of trail intersections, rocks, earth and termite mounds, preferred sites for maned wolf scat depositions (Dietz, 1984).

The scats were identified as maned wolf by size/diameter, presence of its hair, nearby tracks, deposition place and characteristic odour. Scats were washed in tap water over 2 fine-mesh screens (0.5 and 1 mm) to recover scales, feathers, bones, hair, teeth, claws and seeds among other items, and dried. Seed identification was helped by a seed reference collection from Coordenadoria de Assistência Técnica Integral de Campinas (CATI). The importance of each food item was determined by relative occurrence frequency, or the percentage of the number of scats with the item by the sum of occurrences of all items (Deblase & Martin, 1981). Fruit biomass was determined by the average weight of 2–10 ripe fruits. Except for armadillos, animal biomass was compiled from literature (Emmons, 1990; Motta-Junior *et al*., 1996). The minimum number of prey in a scat was counted from hard parts (Motta-Junior *et al.*, 1996). Relative biomass was calculated by biomass of the item by the sum of biomass from all items in scats (Motta-Junior *et al*., 1996; Juarez, 1997).

Food items were grouped as: grasses, fruits, arthropods, reptiles, birds, mammals. Wolf-fruit was analysed separately because of its importance in the maned wolf diet. For seasonal analysis, months with < 100 mm of rain were considered as dry. A *G*-test for independence with Yates' correction was conducted on presence and absence of indicated items in scats between seasons, using BioEstat 2.0 (Ayres *et al.*, 2000).

Species and morphospecies richness in the wolf diet from Matias Barbosa (present study), Água Limpa (Motta-Junior *et al*., 1996) and Jaborandi (Juarez, 1997) were compared by the rarefaction method of species richness estimation (program Rarefact, version 5.2; Krebs, 2000). Nine species reported by Motta-Junior *et al*. (1996) were grouped with related taxa to correspond to our classification of food items.

To study the effect that passage through the gut of a maned wolf has on the germination success of seeds of *Solanum lycocarpum*, two seed germination trials (September 1997 and March 1998) were conducted. For each trial, 100 seeds (50 in the dry season and 50 in the rainy season) from > 20 scats and 100 seeds from > 10 ripe wolf-fruits gathered during 1996 (control) were used. Seeds were sown in 2 plastic trays in mineral substrate and inspected daily for 30 days to determine germination (when a root appeared). The use of constant samples sizes within studies allowed us to compare germination success using a *G*-test for independence with Yates' correction, on numbers of germinated seeds in each treatment between studies, using BioEstat 2.0 (Ayres *et al.*, 2000).

RESULTS

Three to 19 scats were collected monthly, totalling 68 scats in the wet season and 82 in the dry season. Twenty-nine different food items were identified, 18 animal (46%) and 11 (54%) plant (Table 1). In terms of biomass, animal items were more important (56.9%) than plant (43.1%) items.

Seeds representing at least nine plant species (mean 1.07 ± 0.28 species/sample) were found in 135 (90%) scats. Solanaceae was by far the richest (six species) and most frequent family (126 scats). *Solanum lycocarpum* seeds were present in all months (116 scats), and wolf-fruit was the most frequent food item (29.2%), making up 42.3% of the food biomass (Table 1). Other fruit species in the diet were bell peppers *Capsicum annuum*, *Nicandra physaloides, Solanum aculeatissimum, Solanum erianthum, Solanum pseudocapsicum* (all Solanaceae), coffee *Coffea arabica* (Rubiaceae) and papaya *Carica papaya* (Caricaceae). Except for *S. aculeatissimum* (eight scats in April, May and July) and *S. erianthum* (two scats in January and February), these species were all present in one scat each. Guava *Psidium guajava*, bell peppers, coffee and papaya are relicts of old gardens.

From animal items, 21% were mammals, 12.1% insects, 11% birds and 2% reptiles. By biomass, frequencies

Table 1. Contents of scats of maned wolf *Chrysocyon brachyurus* at São Luís dairy cattle ranch in Matias Barbosa, Minas Gerais, Brazil, in 1996. n.i., not identified

Food item	Occurrence (no. of scats)	Frequency%	Biomass (g)	Biomass%
Grass, Graminae	68	17.1	–	–
Papaya *Carica papaya*, Caricaceae	1	0.3	600	0.49
Guava *Psidium guajava*, Myrtaceae	7	1.8	280	0.23
Joá-bravo *Solanum aculeatissimum*, Solanaceae	8	2.0	80	0.07
Wolf-fruit *Solanum lycocarpum*, Solanaceae	116	29.2	52200	42.29
Other fruits	14	3.5	–	–
Plant sub-total	214	53.9	53160	43.07
Beetles, Coleoptera n.i.	16	4.0	32	0.03
Termites, Isoptera n.i.	11	2.8	1.29	0.001
Cricket, Acrididae	4	1.0	4	0.003
Cricket, Gryllidae	4	1.0	12	0.01
Katydid, Tettigonidae	6	1.5	30	0.02
Other insects	7	1.8		
Tilapia *Tilapia* sp., Cichlidae	1	0.3	550	0.45
Pit viper *Bothrops jararaca*, Viperidae	3	0.8	1950	1.6
Glass lizard *Ophiodes striatus*, Anguidae	1	0.3	110	0.09
Skink *Mabouya* spp., Scincidae	3	0.8	30	0.02
Birds n.i. Small bodied Passeriformes	44	11.0	860	0.7
White-eared opossum *Didelphis albiventris*, Didelphidae	2	0.5	1380	1.12
Grass mouse *Akodon* spp., Muridae	9	2.3	193.5	0.16
Rice rat *Oryzomys* spp., Muridae	12	3.0	540	0.44
Murid mice n.i.	33	8.3	990	0.80
Paca *Agouti paca*, Dasyproctidae	2	0.5	8000	6.50
Long-nosed armadillo *Dasypus* spp., Dasypodidae	22	5.5	41800	33.90
Yellow armadillo *Euphractus sexcinctus*, Dasypodidae	3	0.8	13800	11.18
Animal sub-total	183	46.1	66703.5	56.94
	397	100.0	70282.8	100.00

Table 2. Seasonal variation of food items in scats of maned wolf *Chrysocyon brachyurus* and statistical significance

	No. of scats (%)			
Item	Dry season ($n = 82$)	Rainy season ($n = 68$)	G	P
Wolf-fruit	52 (63)	64 (94)	20.29	0.000***
Mammals	53 (65)	22 (32)	14.47	0.000***
Birds	23 (28)	17 (25)	0.06	0.814
Insects	9 (11)	36 (53)	30.32	0.000***

were: mammals 54%, fruits 43%, reptiles 2% and birds 1%. The pit viper was present in three scats, one in May and two in July. At least two individuals were consumed. All bird remains were of Passeriformes. One egg shell of a *Crotophaga ani* (Cuculidae) was also found in the scats.

Wolf-fruit ($r_s = 0.07$, $P < 0.05$) and insect ($r_s = 0.62$, $P < 0.00$l) presence in scats were positively correlated to rain and were more prevalent in the rainy season (Table 2). Mammals were negatively correlated with rain ($r_s = -0.87$, $P < 0.00$l) and more prevalent in the dry season (Table 2). Birds did not prevail in any season (Table 2).

More wolf-fruit seeds recovered from scats in the study site germinated in March (37%) and in September (39%) and in a shorter time than those collected from ripe fruits (both 4%).

Scats were primarily deposited on high and steep road banks (37%), gravel mounds (20%), dirt road and trails (12%), high and steep kaolin mine banks (11%), kaolin mine ground (8%), top of the mine (3%), rock outcrops (7%) and termite mounds (2%). High deposition places were preferred (80%).

DISCUSSION

Our results from a dairy cattle ranch show some similarities and differences from those reported for 'cerrado' at Serra da Canastra National Park, Minas Gerais State (Dietz, 1984), Emas National Park, Goiás State (Jácomo, 1995), Fazenda Água Limpa in the Federal District (Motta-Junior *et al*., 1996), Fazenda Rio Pratudão in Jaborandi, Bahia State (Juarez, 1997) and upland tropical meadows at Ibitipoca, Minas Gerais State (Aragona & Setz, 2001).

As in Água Limpa (Motta-Junior *et al*., 1996), Emas (Jácomo, 1995) and Jataí (Motta-Junior, 2000), arthropods or insects, including beetles, were not frequent in scats in Matias Barbosa (present study, but see Aragona & Setz, 2001). *Bothrops jararaca* is a new item in the maned wolf diet, although Neuwied lancehead *Bothrops neuwiedii* was already reported for Emas (Jácomo, 1995). Although sparse in the maned wolf diet, reptiles comprised a similar biomass to that found in Jaborandi (Table 3), and a lower biomass than that in Jataí and Água Limpa (Table 3). Bird

Table 3. Major food items in scats of maned wolf *Chrysocyon brachyurus* by frequency (%) at a dairy cattle ranch in Matias Barbosa (present study) compared to 'cerrado' and upland meadow studies. Values in parentheses are biomass (%)

	Matias Barbosa ($n = 150$)	Água Limpa[a] ($n = 105$)	Emas[b] ($n = 645$)	Jataí[c] ($n = 191$)	Canastra[d] ($n = 740$)	Jaborandi[e] ($n = 70$)	Ibitipoca[f] ($n = 141$)
Arthropods	12.1	2.0	1.8	4.9	5.9	3.7	13.8
Lizards	1.1	2.6 (4)	1.1	1.1 (2)	0	0.5 (2)	0.1
Snakes	0.8	0	2.7	1.7 (1)	0.3	1.0 (1)	0.5
Birds	10.9 (1)	13.8 (6)	14.0	6.2 (2)	11.5	8.3 (4)	3.5
Rabbit	0	0	0	2.0	1.1	0	0
Rodents	14	22.0 (7)	23.5	18.3	25.5[g]	32 (22)	38
Armadillos	6.3 (45)	9.2 (30)	3.9	2.8 (27)	3.1	1.5 (13)	13.3
Wolf-fruit	29.3	25.7	19.6	21.5	32.6	31.9	26.2

Sources:
[a] Motta-Junior *et al*., 1996
[b] Jácomo, 1995
[c] Motta-Junior, 2000
[d] Dietz, 1984
[e] Juarez, 1997
[f] Aragona & Setz, 2001
[g] All small mammals

frequency was intermediate, but biomass was lower than in other study sites (Table 3). Avian eggshells were also observed in Canastra (Dietz, 1984) and Ibitipoca (Aragona & Setz, 2001), but none was from domestic stock.

Identification of *Dasypus* species here, as elsewhere (Jácomo, 1995; Motta-Junior *et al*., 1996), shows that the maned wolf hunts either the smaller more open field dweller or the larger forest species (see Emmons, 1990). Although rabbit latrines were common (EFS pers. obs.), no rabbits appeared in the maned wolf diet in Matias Barbosa (present study, but see Dietz, 1984; Motta-Junior, 2000; Aragona & Setz, 2001). In Emas, Água Limpa and Jaborandi, rabbits were not consumed either (Jácomo, 1995; Motta-Junior *et al*., 1996; Juarez, 1997). Among mammals, rodents were also the most frequent item elsewhere, all higher than in Matias Barbosa (Table 3).

Although large, the solitary maned wolf captures prey smaller than other canids that co-operate in hunts (Moehlman, 1989). At Matias Barbosa the largest prey was *Agouti paca* (6–13 kg; 0.5%), smaller than at other sites (collared anteater, Dietz, 1984; full-sized pampas deer, Bestelmeyer & Westbrook, 1998; *Mazama* sp. juvenile, Motta-Junior, 2000). Giant anteater found in scats at Canastra was considered to be from a road kill (Dietz, 1984). Mammals heavier than 5 kg were found infrequently (0.7%, Motta-Junior *et al.*, 1996; 0.5%, Juarez, 1997). By biomass, armadillos were more important in the maned wolf diet in Matias Barbosa and elsewhere, although in Jaborandi rodents continue to be the main item (Table 3).

In Jataí, the maned wolf attacked poultry (two chickens in 191 scats; Motta-Junior, 2000) and in Canastra, poultry was attacked more frequently between September and November, when litters are born in the wild (Dietz, 1984). The tracks of young were observed in March and June in Matias Barbosa, but there was no predation on domestic stock (but see Motta-Junior, 2000). Wolf tracks were never observed approaching domestic animals in the pasture. However, ranchers reported a foraging wolf near the cattle, with no sign of disturbance by the cattle.

The basic diet of the maned wolf in Matias Barbosa comprised wolf-fruit, armadillos and small rodents (murid), together with 49.1% frequency and 88.8% biomass ingested. Similar studies in cerrado (Motta-Junior *et al*., 1996; Juarez, 1997), presented the same dietary basis (Table 3). All items in the diet of the maned wolf which were present at a lower frequency in Água Limpa and Jaborandi were also consumed in Matias Barbosa, or were identified in the fauna and flora from the ranch.

In Matias Barbosa, as in other landscapes, the maned wolf had a generalist diet comprising wolf-fruit, small rodents, armadillos, birds, reptiles and some insects, items that are highly available anywhere. Species or morphospecies richness (28 spp. in 150 scats), however, was lower than in other study sites (e.g. Água Limpa: 34 spp. in 104 scats, Motta-Junior *et al*., 1996; Jaborandi: 30 spp. in 70 scats, Juarez, 1997; Fig. 1).

The seasonality in maned wolf diet documented in the other studies was also observed at Matias Barbosa. Causes of seasonality vary from wolf-fruit (this study only), miscellaneous fruits (Dietz, 1984; Motta-Junior *et al*., 1996) and insects (Dietz, 1984; present study) being more frequent in the rainy season, and rodents (Motta-Junior *et al*., 1996) and mammals (Dietz, 1984; present study) being more frequent in the dry season. Wolf-fruit production can be year round (Dietz, 1984; Aragona, 2001) or more prevalent from April to September (dry season, Motta-Junior, 2000; Queirolo, 2001). Higher consumption of wolf-fruit in the rainy season (when theoretically less abundant) suggests that maned wolves are actively searching for this resource (see Carvalho, 1976; Dietz, 1984; Motta-Junior *et al*., 1996; Aragona & Setz, 2001). However, our impression is that wolf-fruit in Matias Barbosa was more abundant in the rainy season. As in other sites (Motta-Junior, 2000; Queirolo, 2001), in

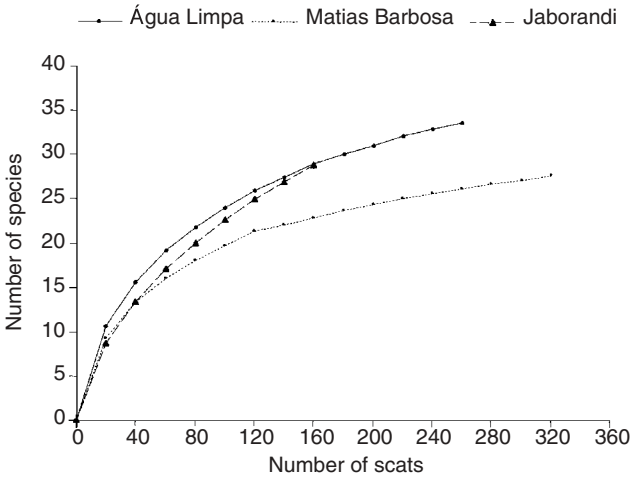

Fig. 1. Rarefaction curves for number of species in scats of the maned wolf *Chrysocyon brachyurus* for Matias Barbosa (present study), Água Limpa (Motta-Junior *et al*., 1996) and Jaborandi (Juarez, 1997).

the ranch other wild fruits seemed more abundant in the rainy season, but this did not lead to a higher consumption by the maned wolf (but see Dietz, 1984; Motta-Junior *et al*., 1996). As for mammals or rodents, the maned wolf could be following abundance variations, because higher rodent abundances are reported for the dry season (Alho & Pereira, 1985; Alho, Pereira & Paula, 1986; Queirolo, 2001).

Our results for wolf-fruit seeds differ from published experiments conducted in open 'cerrado', where 67% of the seeds germinated in each treatment ($G = 23.69$, $P = 0.000$, Lombardi & Motta-Junior, 1993; but see Motta-Junior & Martins, 2002). Both higher and accelerated seed germination qualify the maned wolf as an important disperser of wolf-fruit seeds in Matias Barbosa because they carry a large quantity of seeds (*c*. 300 seeds per scat; E. F. Santos, pers. obs.) and they have highly cursorial life habit, thus transporting the seeds over long distances year round. Although cattle can carry large quantities of seeds they do not take them far. Other frugivores, such as the crab-eating fox *Cerdocyon thous*, are smaller and, although reported as eating wolf-fruit (Albuquerque, 2001), none of their scats at Matias Barbosa contained wolf fruit seeds (EFS pers. obs.).

As in Canastra (Dietz, 1984), but not in Ibitipoca (Aragona & Setz, 2001), scats were deposited in many different places. As in Ibitipoca, termite mounds were rare in Matias Barbosa (present study), but most depositions were on high places (see also Dietz, 1984, 70%). In Matias Barbosa, kaolin mining offered steep grooves, gravel mounds to recover dirt roads, and road banks. In Canastra, Água Limpa and Jaborandi (Dietz, 1984; Motta-Junior *et al*., 1996; Juarez, 1997), highly used substrates for scat deposition differ in quality as germination sites: termitaria are nutrient rich but rocks lack soil, though this bush also grows in poor soils.

Modifications of the landscape by humans in Matias Barbosa make new substrates available (kaolin mines, gravel mounds, road banks), and could have favoured germination and development of *Solanum lycocarpum*, increasing fruit availability in the region. But frequency of wolf-fruit in the diet does not support this (29% *vs* 74–90%, Dietz, 1984; Motta-Junior *et al*, 1996; Juarez, 1997; Aragona & Setz, 2001; but see Jácomo, 1995; Motta-Junior, 2000; Table 3). On the other hand, during the dry season when pasture is scarce, cattle also consume (and disperse) *Solanum lycocarpum*, competing with maned wolves. Much dung was seen containing seeds and seedlings of *S. lycocarpum* (present study; J. C. Motta-Junior, pers. comm.).

As expected for a heavily farmed region, our frugivory results are at the lower end of the diversity scale (nine to 33 species) and include four old garden species. On the other hand, no previous study has registered so many species of Solanaceae. Although dietary richness was lower, the main food items (wolf-fruit, armadillos, rodents, birds) were the same as those found in study sites in 'cerrado' and upland meadows (Dietz, 1984; Motta-Junior *et al*., 1996; Juarez, 1997; Aragona & Setz, 2001). In this region, the open habitats occupied by the maned wolf were previously covered by Atlantic forest, suggesting that landscape modification such as cattle ranching has opened new frontiers for distribution expansion of the maned wolf. The impact of loss of dietary richness and the increase in Solanaceae on the survival of the maned wolf need to be evaluated.

Acknowledgements

We acknowledge the Brazilian National Science Foundation (CNPq) for a fellowship to EFS. We are grateful to Mr Fernando C. Veiga Neto for authorization and encouragement to work on his farm and the use of farm facilities. Staff from the Seed Bank of the Coordenadoria de Assistência Técnica Integral de Campinas (CATI) helped with seed identification. We thank M. DeVivo, M. Galetti and P. Crawshaw for discussions and J. C. Motta-Junior, W. R. Silva and two anonymous reviewers for critically reading the manuscript. W. W. Benson helped with the final English version.

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