RESEARCH ARTICLE

Measuring Success in Primate Translocation: A Baboon Case Study

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Translocation of primates is still a rare event. The translocation in 1984 of two research groups of wild baboons that had been studied for 12 years prior to translocation and observed for 18 years afterwards offers a comprehensive set of data with which to evaluate success. A comparison with indigenous baboon troops at the release site provides an independent control for assessing performance in the release area. Two success criteria are developed with the use of indicator measures that include birth rate, death rate, patterns of mortality and survivorship, body condition, intestinal parasites, and group size. The baboon translocation succeeded according to both criteria: the two troops were saved by the translocation, and they did as well or better than could be expected in their new home. Their performance matched or exceeded that of translocated groups of other primate species. Am. J. Primatol. 65:117–140, 2005. © 2005 Wiley-Liss, Inc.

Key words: baboons; translocation; primate conservation; success criteria

INTRODUCTION

Primates, like biodiversity as a whole [Wilson, 2002], are threatened by habitat loss and fragmentation [Cowlishaw & Dunbar, 2000]. Many primate species are also targets of the bushmeat trade [Kemf & Wilson, 1997; Mittermeier & Konstant, 1996/1997; Peterson, 2003] and human–wildlife conflicts [Hill, 2000; Strum, 1994, 2001]. Few primate populations or habitats are considered secure. Habitat protection within parks and reserves remains the best hope of conserving most species [Mittermeier & Konstant 1996/1997; Oates, 1999; Primack, 1998]. Even in such settings, however, small population sizes pose a threat to survival

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through inbreeding and stochastic processes over time [Gilpin & Soule, 1986]. The translocation of threatened and endangered species between habitats, and the possible restoration of captive populations to the wild [Kleiman & Rylands, 2002], will sometimes be necessary to maintain viable populations. It is advantageous to develop suitable methods of translocation, and measures to determine their relative success, for non-endangered species before we tackle endangered ones. The translocation of well-studied baboons in 1984 offered researchers a particularly good opportunity to examine measures of success, as well as the ecological and behavioral factors that affect translocation.

The Gilgil Baboon Project was witness to the changing primate conservation reality. Observations began in the early 1970s, but the land was sold to an agricultural cooperative, and small-scale farming began in 1979. From 1981 until late 1984, we studied the development of crop-raiding and tested various techniques to control or minimize raiding by the baboons. The results were promising [Forthman, 1986; Strum, 1987, 1994]. However, despite these successes, one troop began to visit a nearby army camp, where they quickly turned from being an amusing diversion for army wives to posing a full-scale threat to gardens and houses. The army began to shoot baboons and promised to continue unless the problem was solved. I made the decision to move three vulnerable troops to a safer location where the rainfall was too low for arable farming and there were no permanent human settlements. Throughout this period we collected information on the reproduction, behavior, and ecology of the three wild baboon troops. In addition, we studied baboons that were indigenous to the release site for comparison.

As of 1984, there had been no well-documented case of primate translocation [Strum & Southwick, 1986]. Here I take translocation to mean the movement of groups from where they are vulnerable in the wild to another location within their historical range [IUCN, 2002; Konstant & Mittermeier, 1982]. Although baboons were not an endangered species, saving these research animals created an opportunity for us to document the technique fully and to evaluate the results with broader primate conservation in mind. If generalists such as baboons could not be moved, then more specialized primates would be unlikely candidates for translocation. However, if the experiment succeeded, it would provide lessons that could help future primate translocations.

Any claim made about primate translocation success must be both verifiable and broadly applicable. This requires 1) the use of measurable indicators of success, and 2) a way to evaluate them relative to an explicit performance target or control, since environmental conditions may affect success indicators independently. For example, changes in food supply or predation may drive the reproductive performance of both indigenous and translocated groups up or down at target locations.

This paper presents data on birth and death rates, mortality and survivorship patterns, group size, body condition, and intestinal parasites as verifiable success indicators. Pre- and post-translocation periods are compared. To fulfill the second condition mentioned above, released troops and groups indigenous to the area are contrasted. Indigenous baboons represent the performance expected in the location during the period of time under consideration.

The baboon experiment is then compared to other primate translocations. I conclude that this baboon translocation has been a success according to verifiable indicators and criteria, and by comparisons with other primate species.
Three troops of wild baboons (Table I) were translocated in 1984 from the Kekopey Ranch near Gilgil in the Central Rift Valley of Kenya to two sites on the Laikipia Plateau (Colcheccio and Chololo) about 200 km to the north. One troop, the Pumphouse Gang (PHG), had been studied since 1970 [e.g., Harding, 1976; Strum, 1975, 1976, 1981]. The second troop, Malaika (MLK), was a daughter group of PHG that fissioned in 1981. The third troop, Cripple (CRIP), was not intensively studied until the year before translocation.

In this paper I report only on the translocation success of PHG and MLK, both of which were observed continuously after they were translocated to Chololo. The CRIP group, which was moved to Colcheccio 80 km to the west, was watched only until 1989, and thus there was insufficient time to measure translocation success. Data are presented on two nontranslocated groups for comparison with the two translocated groups. Eburru Cliffs (EC), another Kekopey troop, was monitored before the translocations began, but was not moved. Thus, it offers a measure of how representative the translocated troops were in the original population. Data on Soitoitashe (STT) are used to compare the success of two translocated groups relative to an indigenous troop at the release site. STT was studied from 1985 onward [e.g., Barton et al., 1992].

### Study Areas

Before they were translocated, PHG and MLK lived in a high-altitude savanna that had been used for ranching domestic stock since 1903 [Blankenship & Qvortrup, 1974]. Large predators were continually removed, and water was piped throughout the 45,000 acres. As a result, the ranch supported a large population of wildlife. There was no conflict with humans. The land was sold to an agricultural cooperative in 1976 and divided into small agricultural plots; however, few of the new owners took up farming until 1979.

From 1981 through 1984, a team of humans guarded the new farming area closest to the troops’ sleeping sites as a way to control conflicts. These “chasers” tried to prevent the study groups from crop-raiding, a strategy that reduced but did not eliminate the problem. The chasers did not injure the baboons or protect them from other humans. Farmers and army personnel caused all human-related baboon deaths and injuries reported during this time.

Selection of the translocation sites followed a 2-year survey that focused on ecological factors such as the availability of baboon foods, permanent water, and appropriate sleeping places. National parks and reserves were excluded. The

<table>
<thead>
<tr>
<th>Troop</th>
<th>Total</th>
<th>Adult</th>
<th>Subadult</th>
<th>Juvenile</th>
<th>Infant</th>
<th>Adult</th>
<th>Subadult</th>
<th>Juvenile</th>
<th>Infant</th>
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</thead>
<tbody>
<tr>
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<td>4</td>
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<td>4</td>
<td>16</td>
<td>5</td>
<td>7</td>
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</tr>
<tr>
<td>MLK</td>
<td>36(^a)</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>10</td>
<td>10</td>
<td>–</td>
<td>2</td>
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<tr>
<td>CRIP</td>
<td>38(^b)</td>
<td>3</td>
<td>2</td>
<td>9</td>
<td>7</td>
<td>9</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

\(^a\)For MLK: adult male AO escaped from traps after capture and was not translocated. Infant female MX was captured but taken to IPR.

\(^b\)Cripple troop was translocated but was not reported on in this article.
attitude of people toward baboons, and the likelihood of future conflict with humans were also considered. As at Kekopey, the new sites were large ranches that had healthy wildlife populations, including baboons, and relatively little livestock. The new sites differed from Kekopey in several respects. Chololo's annual rainfall (350 mm) was half that of Kekopey (750 mm), water was more ephemeral and localized, and droughts were more common. Large predators, including leopards, lions, and cheetahs, were present at Chololo but had been removed from Kekopey. While the two locations had many plant species in common, Chololo's greater aridity made it a more challenging place for baboons.

Since there were indigenous baboons at the release area, I considered the risks involved in introducing the other groups. It was not possible to determine carrying capacity with any precision beforehand (see discussion in Brown and Lomolino [1998]). However, information from wildlife surveys and interviews with local residents indicated that the indigenous baboon population had crashed during the severe drought of the mid-1970s and had not yet fully recovered. This suggested that the translocated and indigenous groups might not create severe competition for each other. To minimize disease risks, the captured animals were carefully screened before they were released. They were found to be healthy [Eley et al., 1989]. In 1984, these measures were deemed an acceptable evaluation of risk to the indigenous baboons, particularly since the baboons were not endangered, and the new site was private land rather than a protected area.

Translocation

The three troops were captured and moved separately (see Strum and Southwick [1986] and Strum [1987, 2001] for detailed procedures). MLK was moved to Chololo on 17 September 1984, and PHG was moved there 10 days later. A total of 132 baboons were captured in the three troops, and 131 were translocated (Table I). The translocation took place during a period of serious drought, when the indigenous baboons were dying. The released troops were lightly provisioned with a commercial cattle feed for 3 weeks after they were released. Two years later, in 1986, they were also provisioned in the same way for 13 weeks because of another severe drought. In addition to this provisioning, in 1986 one PHG female was darted and examined. She was diagnosed as having a nonlethal bacterial infection. She and three of seven other females with a similar infection were given one dose of a broad-spectrum antibiotic. Both treated and untreated animals recovered. There have been no other interventions since 1986.

MATERIALS AND METHODS

The study troops were followed on a daily basis before and after they were translocated. MLK and PHG were watched nearly every day after their release in 1984 until 1995. Since 1995 they have been followed for a minimum of 4 days per week. Thus, from 1985 through 2001, each group was watched on average for 265 days per year. Data on births, deaths, immigration, emigration, group size, and ranging patterns were collected continuously.

Birth rates were calculated from a total of 263 births by means of the standard measure for vertebrates: births per reproductive female per year [Caughley, 1977]. Post-translocation birth rates were compared in three ways: yearly, in 2-year periods (since baboon females that give birth in 1 year normally do not give birth in the next), and as overall averages. PHG birth rates were compared for the entire 12 years before translocation, and matched with data
from 12 years after translocation. MLK birth rates were available for only the 4 years before the move, and were matched with data from the first 4 years after translocation. Data collected from the translocated and indigenous groups since 1985 were compared to assess the divergence of translocated from indigenous female birth rates over time. For this comparison, the 2-year interval measure was chosen because it represents the average interbirth interval for baboons before translocation [Strum & Western, 1982].

Death rates were calculated from 443 deaths recorded in PHG, MLK, and STT (the indigenous group), and expressed as per capita annual mortality to normalize for differences in group size.

Mortality patterns were determined from the classifications of the 443 deaths, which were defined as natural or human-related (see Table II: 1–9). Natural deaths included illness (code 1), accident (code 2), injury (code 4), and predation (code 3). Predation deaths were assigned conservatively in the absence of direct evidence. Thus, predation was inferred by disappearances that coincided with predator signs, or from the condition of animal remains. Human-related deaths (codes 6–9) were scored by direct observation and inference. These included animals killed in reprisal (code 9) for crop raids (Kekopey) and killing of livestock (Chololo), and those killed collaterally by, for example, traveling bands of Masai warriors (code 7). Accidents included baboons killed by power lines (code 6), and delayed deaths from injuries inflicted by people (code 8). No local people killed baboons for food. A death was considered “undetermined” (code 5) if an animal was present and healthy when the group ascended to the sleeping site in the evening but was absent the next morning without evident cause. Sometimes it was not possible to be certain that the animal was dead. This analysis includes such “disappearances” (code 11) but excludes cases of emigration.

Survivorship was calculated from lifetables constructed from annual baboon natality and mortality rates in the study troops. Lifetables have been widely used for wild vertebrates [Caughley, 1977] and nonhuman primates for which there are sufficient data [e.g., Fedigan & Zohar, 1997]. Methods to include both complete (uncensored) and incomplete (censored) data have facilitated the study of survival patterns. These are particularly useful for data from wild primate populations in which the fate of individuals is sometimes unknown. Censored data include animals that disappear and animals that are still alive at the end of the study period. For statistical comparisons of troops, I used the Kaplan-Meier product limit method [Statsoft, 1999], which estimates the survivorship function directly from the continuous survival times using each case, rather than accumulating cases within specific predetermined intervals. Only females of known birth dates were used for analysis of survival. Since survivorship curves are sensitive to the oldest age theoretically attainable, and the study periods were of shorter duration than the maximum lifespan, some truncation of data was necessary. Thus the oldest age attainable in a given period was taken as the upper limit for that period. MLK was studied for too short a period before translocation (4 years) to give a good measure of post-translocation success based on pretranslocation lifetable survivorship.

Group sizes were calculated as yearly averages based on totals at the end of each month. Reliable troop size information was not collected for STT until 1986. Censuses of other resident troops were done seasonally from 1990 onward.

I rated body condition subjectively, on a scale ranging from excellent to very bad, expanding on a system developed in 1985 [Barton, 1989] by adding specifics of affected body parts.
<table>
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<th>PHG M</th>
<th>PHG Total</th>
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<th>MLK M</th>
<th>MLK Total</th>
<th>EC F</th>
<th>EC M</th>
<th>EC Total</th>
<th>Total F</th>
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</table>

TABLE II. Causes of Death by Troop and by Location
Parasite loads were determined from the concentration of intestinal parasites eggs in feces. Samples for parasite analysis were collected at the time of translocation and from 1996 to 2001. Eggs were extracted and counted with the use of the McMaster flotation and the formol-ether concentration techniques [Eley et al., 1989].

I determined the overall success of translocation by comparing all indicators for pre- and post-translocation, and for translocated groups relative to indigenous baboons at the new site. I used the same time periods for all analyses, and compared only periods of similar length (Table III). For example, since good data on PHG had been collected for 12 years before translocation (BT), a matching set of data collected for 12 years after translocation (AT) were used for comparison. When a closer look was potentially instructive—for example, to examine the effects of crop raiding at Kekopey—shorter matched segments were also compared. Thus, the time before translocation was divided into two segments of 6 years each beginning in 1973, (periods A and B), since sample sizes were too small (particularly for the survival analysis) for smaller intervals to be used. The troops were foraging naturally in period A. Period B begins with the first crop-raiding and ends with the translocation. To match this, the first 12 years after translocation were also divided into 6-year periods (C and D) ending in 1996. To take advantage of all of the data, and explore the effect of “time since translocation,” I partitioned time in other ways—for example, into two 8-year periods (S and T) and three periods of 5 years and 4 months (U, V, and W).

All analyses were performed with the statistical software package CSS Statistica [Statsoft, 1999]. Most comparisons used nonparametric statistics because of the small sample sizes. A Kruskal-Wallis analysis of variance (ANOVA) was the nonparametric alternative to a between-groups, one-way ANOVA. The “H” value and its level of significance are given, rather than the secondarily-derived median test based on $\chi^2$ values. Chi-square and parametric t-tests for independent samples and multivariate ANOVA (MANOVA) were used when appropriate. Survival curves were assessed by five independent tests, and the best fit was selected by the software program, Statistica. Gehan’s generalized Wilcoxon test (yielding a $\chi^2$ statistic) was used for two-sample comparisons. The survival curve analysis of more than two groups employed an extension of Gehan’s generalized Wilcoxon’s test [Gehan, 1965a, b; StatSoft, 1999].

### TABLE III. Time Periods Used in the Analysis

<table>
<thead>
<tr>
<th>Time periods</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT A</td>
<td>1973–1978</td>
</tr>
<tr>
<td>BT B</td>
<td>1979–1984</td>
</tr>
<tr>
<td>AT C</td>
<td>1985 (including September 1984 onwards)–1990</td>
</tr>
<tr>
<td>AT D</td>
<td>1991–1996</td>
</tr>
<tr>
<td>AT S</td>
<td>September 1984–1992</td>
</tr>
<tr>
<td>AT T</td>
<td>1993–2001</td>
</tr>
<tr>
<td>AT U</td>
<td>1985–April 1990</td>
</tr>
<tr>
<td>AT V</td>
<td>May 1990–August 1995</td>
</tr>
<tr>
<td>AT W</td>
<td>September 1995–2000</td>
</tr>
</tbody>
</table>

BT, before translocation (1973–August 1984); AT, after translocation (September 1984–2001).
RESULTS

Birth Rate

The mean birth rates per female for PHG during the 12 years before (0.62 ± 0.24) and after (0.45 ± 0.22) translocation were not significantly different (t = 1.57; df = 11; P = 0.13). Thus, despite differences in rainfall and seasonality between Kekopey and Chololo, post-translocation matched pretranslocation average birth rates. The more limited data on MLK suggest the same. Data from the 4 years before (0.71 ± 0.22) and after (0.43 ± 0.21) translocation showed no significant difference (t = 1.89; df = 6; P = 0.11). However, the mean birth rate for PHG for the entire period after translocation was 0.49 (± 0.21), and it went as high as 0.82 in 2000, with a mean birth rate of 0.61 in the most recent period (W). Similarly, the mean birth rate for MLK for the entire period after translocation was 0.55 (± 0.36). MLK’s birth rate was also 0.82 in 2000, with period W having a mean birth rate of 0.63. The birth rate of both troops exceeded that of the indigenous troop for period W (0.49 ± 0.34) and the year 2000 (0.50). After translocation, the released troops’ combined birth rates correlate with the control indigenous troop (from 1987 to 2001 PHG/MLK vs. STT n = 15; r = 0.71; P = 0.00). Post-translocation birth rates for PHG and MLK were also correlated with each other for the entire period 1985 to 2001 (n = 15; r = 0.60; P = 0.02).

Although the birth rates show no significant difference between conditions or between groups, there may be indications of short-term differential responses resulting from translocation. For example, the birth rates of translocated females depart from those of indigenous females when they are considered in 2-year intervals since 1986 (Fig. 1). Initially, MLK did better than PHG relative to STT. From 1988 until 1996, the two released troops displayed similar ups and downs in

![Deviation of female birth rates of translocated groups (PHG and MLK) from those of the indigenous group (STT) from 1986 through 1999.](image-url)
birth rates. Thereafter they diverged in the magnitude of their deviation from indigenous birth rates.

**Death Rate**

The average annual death rate for PHG after translocation (13.12 ± 5.67) did not differ significantly from the pretranslocation rate (10.42 ± 7.86; t = 1.04, df = 26, P = 0.31). The post-translocation death rate for MLK (13.01 ± 8.05) also shows no significant difference from the pretranslocation rate (20.48 ± 21.10) when matched 4-year periods are compared (t = 0.66, df = 6, P = 0.53). PHG and MLK mortality rates for the 4 years before translocation (t = -0.36, df = 6, P = 0.73) and after translocation from 1985 to 2001 (t = -1.48, df = 30, P = 0.15) did not differ, nor were the translocated troops different from the indigenous control group STT in that regard (PHG/STT, t = -1.40, df = 26, P = 0.17; MLK/STT, t = 0.08, df = 26, P = 0.93).

Figure 2 shows the progression of annual mortality rates for all troops, including the control groups (EC at Kekopey, and STT at the release site). PHG mortality rises at Kekopey (r = -0.73, n = 14, P = 0.00), and then falls after translocation (r = -0.50, n = 17, P = 0.04). The MLK death rate does not change until the most recent period (V vs. W = 2.307, t = 2.31, df = 10, P = 0.04). The STT death rate does not change significantly, despite the peak in the death rate from 13.30 (± 8.29) in period V to 28.71 (± 21.11) in period W (t = 1.66, df = 10, P = 0.13). While there are no differences between troops, PHG mortality rates do not correlate with either MLK or STT in this annual progression. By contrast, the MLK and STT death rates are highly correlated (r = 0.86, n = 15, P = 0.00).

**PROGRESSION OF ANNUAL MORTALITY RATES**

Fig. 2. Per capita annual mortality rates among troops are compared before and after translocation. “Before translocation” includes one control group (EC) that was not moved. “After translocation” includes one indigenous control group (STT). See Table III for time periods.
The similarity between death rates pre- and post-translocation, and between translocated and resident groups does not distinguish among the sources of mortality. Table II gives a detailed breakdown of the sources of mortality for all troops. The main patterns of mortality and their changes over time are summarized for all groups in Fig. 3.

PHG shows a large increase in the human-induced mortality rate between the early (0.87 ± 1.21) and late (8.56 ± 4.77) periods at Kekopey (t = 3.83, df = 10, P = 0.00), while natural mortality remains the same throughout. Farmers and army personnel killed crop-raiding baboons after the agricultural subdivisions occurred. All three Kekopey troops (PHG, MLK and EC) were similarly vulnerable (Kruskal-Wallis ANOVA, H = 4.15, df = 2, P = 0.13). After translocation, PHG deaths from human causes dropped from a Kekopey high of 53% of known causes of death in period B to a low of 14% in period C, with a per capita annual rate of 8.56 as compared to 3.65 (t = 1.62, df = 10, P = 0.14). Human-induced mortality rates remained the same in the later period (D), with a per capita rate of 2.33 (t = 0.36, df = 10, P = 0.74). Thus, as the baboons lived longer in the release area, their mortality rate (2.33 ± 2.71) came to resemble that of the early pre-crop period at Kekopey (1.95 ± 2.41; t = 2.00, df = 10, P = 0.07).

Although MLK did not exist before farming came to Kekopey, the same high human-related mortality rate is evident prior to translocation (Fig. 3). The rate fell steeply after translocation to 1.41 (± 2.43), as compared to 15.21 (± 15.85) before translocation. Human-related deaths rose later (6.00 ± 13.26) as a result of stock-raiding and local human politics. The distribution of human-caused deaths...
after translocation is similar between PHG and MLK (Kruskal-Wallis ANOVA, 
$H = 0.65, df = 1, P = 0.42$) and with the indigenous control group STT during the 
release period (Kruskal-Wallis, $H = 1.78, df = 2, P = 0.41$), as well as during 
different shorter periods. Human-related deaths peak at the same time for all 
three troops (Fig. 4) because of conflicts that arose when indigenous and 
translocated baboons preyed on livestock. This was more likely to occur when 
natural foods were scarce.

Natural and human-related mortality rates show an inverse relationship 
before and after translocation for both troops (Fig. 3). As human causes of death 
decline, natural causes of death increase after translocation relative to Kekopey 
for both troops (binomial test; PHG before translocation (BT)/after translocation 
(AT) human deaths $n = 60, df = 1, P = 0.00$; natural deaths $n = 60, df = 1, p = 0.05$; 
MLK BT/AT human deaths, $n = 26, df = 1, P = 1.00$; natural deaths $n = 53, df = 1, 
P = 0.00$). For PHG the mean per capita annual rate of natural causes of deaths 
increases from 2.85 ($\pm 2.04$) before translocation to 8.94 ($\pm 5.20$) in the first 5 
years after release (period B vs. C; $t = 2.67, df = 10, P = 0.02$). MLK’s mortality 
rate from natural causes changes from 1.00 ($\pm 1.72$) to 5.23 ($\pm 2.91$) during the 
same time ($t = 2.28, df = 7, P = 0.06$).

Before translocation, PHG and MLK differed in the specific sources of 
mortality; however, after translocation they did not (Kruskal-Wallis ANOVA, 
Kekopey: $H = 9.01, df = 1, P = 0.00$; Chololo: $H = 0.52, df = 1, P = 0.47$). Thus, 
translocating PHG and MLK changed their vulnerability to specific causes of 
death.

An explanation can be found in the main contributions to natural mortality. 
Disease and predation account for the majority of known natural deaths 
(Table II). Disease is the greatest source of natural mortality for PHG before 
translocation (64%). This does not change markedly in the new location, where 
disease represents 53% of known deaths (mortality rate = 1.30 and 3.25 before 
and after translocation, respectively; $t = 1.60, df = 28, P = 0.12$). The same is not 
true for MLK. Although MLK lost no animals to disease in the 4 years before it 
was moved, disease accounted for 42% of natural mortality in that group after
release, for an average annual rate of 4.46 (t = 2.053, df = 17, P = 0.05). However, when compared to only the first 4 years after release, the difference was not significant. The disease numbers for the translocated troops span the range of the indigenous control group, STT (50%), and the average disease mortality rate is not different for either troop (PHG/STT, t = –1.38, df = 28, P = 0.18; MLK/STT, t = –0.68, df = 28, P = 0.50).

The translocated troops succumbed to two pathogens that were not previously seen. The first, in 1986, was found to be a common soil bacterium that caused extensive tissue erosion around the perineal area in females, and around the penis in the few infected males. The only death, that of a female, was the result of secondary complications (see below). Seven other animals recovered slowly; four were treated once, while the other three got better without help. Similar infections were observed in the indigenous groups, but none were as severe as those in the translocated animals. Nonetheless, this infection did not recur after 1986. The second pathogen appeared in 1987, and four animals died within a few weeks of becoming ill. Postmortem tests carried out by the Institute of Primate Research, Nairobi, indicated a virus. No local baboons were seen with the same symptoms, and this illness has not been observed again in the translocated baboons.

We measured intestinal parasites at the time of translocation [Eley et al., 1989] and again from 1996 to 2001. At the time they were moved, there was a difference between the mean strongyle egg infestations in the two troops. Samples from 1996–2001 also showed troop differences. MLK and the indigenous troop, STT, had similar levels of infestation, while both were different from PHG (n = 552; PHG mean = 821; MLK mean = 1503; STT mean = 1758; MANOVA; F = 33.40; df = 2; P = 0.00). The parasite load recorded from 1996 to 2001 was also correlated with body condition (r = 0.157, n = 239; P = 0.00), where the best body condition was rated zero.

One female may have died as the result of complications from a high intestinal parasite load that caused a rectal prolapse at a time when her perineal tissue had been eroded by a bacterial infection (see above). A veterinary evaluation indicated that she died of dehydration.

Predation risk showed a large shift as a result of the translocation. There were no verified deaths from predation at Kekopey, largely due to predator removal over the years. After translocation, 34% and 43% of all natural deaths in PHG and MLK, respectively, were from predation. The average per capita annual mortality from predation was 2.77 for PHG and 7.94 for MLK. This reflects the troops’ exposure to leopards, lions, and cheetahs at the release site, where there were no predator eradication programs. Predation deaths in the indigenous control troop, STT, accounted for 46% of deaths by natural causes, with an average annual per capita rate of 6.53. The three troops had similar predation mortality rates when per capita rates were compared (PHG/STT; t = 1.01, df = 28, P = 0.32; MLK/STT; t = 0.26, df = 28, P = 0.79).

Changes in Mortality Patterns

Vulnerability to both disease and predation changed during the time after release. This is most apparent when the first 8 years are compared with the subsequent 8 years. The level of disease risk shifted for PHG, which lost 17 animals in the first period (14 of which succumbed just after translocation, from 1986 through 1988), and only three in the second period. The per capita annual disease rate differed significantly from an average of 5.50 to 0.64 during the same
time \( (t = 3.13, \text{df} = 16, P = 0.01) \). The number of animals lost to disease in MLK also declined from 14 to eight over the same intervals, but this was not a significant change in the annual rate \( (t = 0.49, \text{df} = 16, P = 0.63) \). MLK losses, like those of PHG, were highest in the early period; however, unlike PHG, the troop continued to lose animals to illness. As expected from these numbers, the distribution of deaths by illness after translocation was not the same in different years (mortality rate, PHG, \( \chi^2 = 83.00, \text{df} = 15, P = 0.00; \) MLK \( \chi^2 = 45.45, \text{df} = 15, P = 0.00 \)). The disease risk for STT, the indigenous control group, increased during the last 8 years from 3.83 to 5.99, but the difference was not significant. Although the numbers are small, these deaths tended to cluster in time. The translocated troops appear to be out of synchrony with the indigenous troop, even though STT also suffered illness differentially over the years (STT, \( \chi^2 = 51.59, \text{df} = 13, P = 0.00 \)). PHG diverged from both MLK and STT (which resembled each other) in the later period \( (T) \) \( (\text{PHG/MLK}, t = -2.18, \text{df} = 16, P = 0.04; \) PHG/STT, \( t = -2.86, \text{df} = 16, P = 0.01) \). The body condition and level of intestinal parasites of PHG and MLK also are observed to change when data from 1996–2001 (approximately period \( T \)) are compared with those from the time of translocation. Although the inverse relationship between body condition and parasite load remained, PHG body condition improved while MLK body condition declined. During this time, the parasite load of MLK was similar to that of the indigenous group, STT, while both differed from that of PHG (see above).

Vulnerability to predation varied over the period of 1985–2000 for the translocated troops (per capita annual rate: PHG, \( \chi^2 = 100.73, \text{df} = 15, P = 0.00 \); MLK, \( \chi^2 = 415.54, \text{df} = 15, P = 0.00 \)). There were synchronous peaks in predation deaths from 1988 through 2000 (Fig. 5). However, the magnitudes of loss were different for the translocated troops. The rate at which the control indigenous troop, STT, was preyed upon also varied during the period of observation (STT, \( \chi^2 = 396.56, \text{df} = 13, P = 0.00 \)). The distributions of predation deaths in the three troops during the entire period did not differ (PHG vs. MLK vs. STT, Kruskal-Wallis ANOVA, \( H = 1.99, \text{df} = 2, P = 0.37 \)). The indigenous group had exceptionally high rates of predation in 1995 and 1999/2000. The peak in 1999 signified a 50% loss of STT animals, while 24% of the troop was lost the following year. MLK

![DEATHS BY PREDATION AFTER TRANSLOCATION](image)
also suffered higher predation during the same periods (61% of the troop in 1999, and 16% in 2000). PHG stands out as the exception during those times, since it lost only 7% and 3% of its members in 1999 and 2000, respectively.

Fig. 6. Female-based survivorship in PHG group before and after translocation (periods A–D).

Fig. 7. Female-based survivorship in PHG group after translocation (periods U–W).

PHG SURVIVORSHIP: PERIOD A, B, C, D

PHG SURVIVORSHIP: PERIODS U, V, W
Divergent mortality patterns developed in PHG and MLK with time. Initially, the average mortality rates of all three troops resemble each other (period C, \( t = 1.89 \), \( df = 8 \), \( P = 0.09 \); or period S, \( t = 1.08 \), \( df = 12 \), \( P = 0.30 \)). PHG mortality rates later declined relative to MLK (period D, \( t = 2.30 \), \( df = 10 \), \( P = 0.04 \); period T, \( t = 2.33 \), \( df = 14 \), \( P = 0.04 \)). PHG natural mortality drops sharply (period C: \( 8.94 \pm 5.20 \); D: \( 2.33 \pm 2.71 \); t = 2.76, \( df = 10 \), \( P = 0.02 \)), whereas MLK rises (period C: \( 5.23 \pm 2.91 \); D: \( 11.03 \pm 11.08 \); t = 2.03, \( df = 10 \), \( P = 0.07 \)). The
pattern relative to the control resident troop, STT, indicates that PHG divergence began late in 1995 (PHG/STT period T, $t = -2.07, df = 14, P = 0.05$), while MLK and STT appear to converge during the same time (period T: MLK/STT, $t = 0.23, df = 14, P = 0.81$), as can also be seen in Fig. 2.

**Survivorship**

Mortality can be treated as if the animals were born at the same time and died as part of the same cohort. The cumulative probability of surviving to age $x$, $l_x$ in PHG was the same for the 12 years before and after translocation. Survival to 16 years of age was also the same for the released troops and the indigenous troop, STT [Strum, 2002]. However, survivorship differences appear when shorter periods are examined (Gehan’s generalized Wilcoxon test, $\chi^2 = 10.487; df = 3; P = 0.02$; Fig. 6). PHG’s higher survivorship occurred during both period A (before the move) and D (after the move), while lower survival was seen during both period B (before release) and C (after release). This way of looking at mortality suggests that while survival varied over shorter intervals, the differences in survival were not a function of translocation. After release, PHG survival improved with time (periods U, V, and W; Gehan’s generalized Wilcoxon test; $\chi^2 = 8.27; P = 0.02$; Fig. 7). MLK’s survival rate was not statistically different over these periods (Gehan’s generalized Wilcoxon test; $\chi^2 = 3.28; P = 0.20$); however, the trend appears to be declining survivorship that is converging with that of the indigenous troop (period T; Fig. 8).

**Group Size**

Group size is the aggregate outcome of births, deaths, and migrations, and may be another measure of translocation success. Initially, the group size of PHG dropped from 52 to 45 between translocation in 1984 and 1987 (Fig. 9). This group lost animals due to disease and a few human-related deaths. There was a precipitous decrease in numbers in 1988 from 45 to 33, and then a slow decline to 23. In 1994 the troop began to grow again, and reached 29 in 1999. Growth accelerated to 38 in 2000, and has continued. When group size is examined in terms of “time since translocation,” there was a decline in the first 9 years and an increase in the last 9 years ($1985–1993$, $r = -0.95$, $P = 0.00$; $1993–2001$, $r = -0.76$, $P = 0.02$). As a result, there is no overall linear correlation ($n = 17$, $r = -0.40$, $P = 0.12$), but there is a strong curvilinear fit ($P = 0.01$).

In the first 2 years after release, as PHG declined, MLK held steady (Fig. 9). Then MLK received a number of immigrants from STT when the indigenous (control) troop fissioned. Afterward, MLK stayed roughly the same size (about 33–36 animals) until 1996, when there was a major decline. Troop size dropped from 33 to 21 animals, a decline that continued until 2000. For MLK, there is a negative correlation between time since translocation and group size ($1985–2001$, $n = 17$, $r = -0.85$, $P = 0.00$), with the period of 1993–2001 contributing the most to the change ($n = 9$, $r = -0.94$, $P = 0.00$). Here, too, the best fit is curvilinear ($P = 0.01$).

The indigenous troop, STT, was large (more than 100 animals) when observations began in 1985 (Fig. 9). It rapidly declined to 60 after it fissioned in 1987. The larger “mother” troop rebounded over the next 5 years and reached a peak of 86 animals before it too began a steady decline. Although a large number of births in 1998 temporarily increased the group’s size, most of those infants
subsequently died. After that, the group continued to get smaller. This downward trend is significant from 1985 through 2001 \( (n = 17, r = -0.73, P = 0.00) \) when time is measured as years since translocation. Other local troops have been censused on a regular basis since 1990. The mean size of the groups in this population has also declined during this period \( (n = 37 \text{ counts}; r = 0.55; P = 0.00) \).

There is no correlation between group size and the number of deaths that occurred, taking STT, the indigenous group, as the benchmark \( (r = -0.163, n = 15, P = 0.56) \). MLK similarly shows no correlation \( (r = -0.042, n = 17, P = 0.87) \). PHG group size and number of deaths are correlated \( (r = 0.639, n = 17, P = 0.01) \), probably because PHG experienced the highest number of deaths just after translocation, when it was a large group. If this early period is removed, the correlation disappears \( (period \ T: r = -0.088, n = 9, P = 0.82) \).

**DISCUSSION**

Translocation of primates is still a rare event (see below). Ideally, suitable methods should be developed and improved with the use of non-endangered species before one intervenes on behalf of endangered animals. The baboon translocation experiment provided such an opportunity. We were able to investigate the consequences of capturing and releasing wild primates to another location within their historical range.

More translocations have been completed since this one was undertaken in 1984 (see below). However, the information on births, deaths, mortality patterns, survivorship, and group size reported here represents a unique perspective that goes beyond the issue of whether the animals survive the release to how they do for a lifetime afterwards. In addition, the long-term observation of an indigenous troop yielded important comparison or “control” information for evaluating post-release performance.
I consider two criteria for success. The first is whether the baboons are better off than they would have been if they had not been moved. This requires an assessment of both the period leading up to the move and the period after the animals were translocated. The second criterion evaluates how well the released troops have done relative to what was actually possible in the new location.

**Criterion 1**

PHG showed a significantly rising mortality before translocation as a result of conflict with humans created by subdivision of land, and changes in land use. MLK became an independent troop during this time, in response to the incursion of agriculture. Mortality in MLK was also primarily due to conflict with humans. The end point at Kekopey was a fast-declining population headed for extinction. However, on average, mortality rates for PHG before and after translocation did not differ. But this average disguises important variations. The progression of annual mortality rates after translocation shows a falling and then stable death rate for PHG, and a rapidly declining rate for MLK that rose to pretranslocation levels only more than a decade later. Both troops also experienced a major change in what they died from as a result of the translocation. The human-related deaths that threatened PHG and MLK with extermination before translocation have declined to less than 5%, while deaths from natural causes (particularly predation and disease) have become the main risks.

Moving the baboons also increased their vulnerability to new pathogens. Initial immunity may have been related to the baboons’ physical condition, since only one translocated troop (PHG) succumbed. PHG individuals were in relatively poor condition when they were moved. As a natural foraging troop, they experienced the full impact of a severe drought at that time. In contrast to PHG, MLK individuals were in excellent condition when they were captured because their reliance on human food buffered them from the drought and actually enhanced their condition. No further deaths from these pathogens occurred after 1986. This raises the interesting and perhaps important possibility that the PHG survivors developed some immunity after the initial exposure.

Other indicators support the conclusions that the baboons are alive today because they were moved, and that translocation did not adversely affect their survival. The cumulative survival probabilities for PHG females before and after translocation [Strum, 2002] did not differ, but they did diverge over shorter intervals. However, the differences were not the result of translocation, since periods of lower survivorship were observed in both locations. Average birth rates also held constant for both translocated troops despite differences in rainfall and seasonality between Kekopey and the release site. Post-translocation birth rates actually rose to pretranslocation averages and higher in the last period for PHG. MLK’s average birth rate remained lower than its food-enhanced pretranslocation rate, but it did climb to that of PHG before they were moved. Group size both declined and increased for the two troops after they were released. Variations in death rates were higher than those in birth rates, which contributed to the group sizes of the troops. At the end of the period reported here, PHG was growing and MLK was stable after a phase of decline as the result of heavy predation that began 15 years after translocation.

The 30 years reviewed in this analysis involve different environmental, historical, and land-use conditions. The early years at Kekopey, before land subdivision, were followed by a period of conflict resulting in high mortality. The period after release had varying and different risks. For PHG, the later
translocation years appear to match the earlier Kekopey good times as far as mortality, natality, and survival are concerned. Although MLK initially did better than PHG, PHG now appears to be doing better than MLK. In sum, the translocation experiment has succeeded in saving two baboon troops.

Criterion 2

It would be impossible to accurately evaluate how well the released animals did in their new home without indigenous animals for comparison. STT, the indigenous troop, provides the “control” for interpreting changes in indicators for PHG and MLK.

The birth rates of translocated and indigenous females were the same, overall. They also tracked each other through various ecological fluctuations. However, there were short-term patterns that may be instructive. The released females departed from the indigenous females when births were clustered into 2-year periods and the means were compared. In the first 2-year interval, PHG and MLK diverged in different ways, with PHG deviating negatively and MLK deviating positively. PHG may have begun at a disadvantage compared to MLK because of its relatively poorer condition at the time of translocation. Then a drought followed by a period of high biomass in 1988–1989 (unpublished data) appears to have synchronized the two released troops. From then until 1996 they showed similar patterns of divergence compared to the indigenous females in both direction and magnitude. MLK and PHG began to disaggregate again from 1996 onward at a time when PHG made significant shifts in its home range (unpublished data). The details of reproduction, cycle length, interbirth interval, and age at menarche, and their relationship to ecology and resources after translocation certainly warrant further examination. We can conclude, however, that the translocated animals produced young whenever they could, and at much the same rate, which implies that their nutritional condition was adequate [Strum & Western, 1982].

Death rates of translocated troops and the control indigenous group are not different overall, however shorter periods show some interesting patterns. MLK had lower death rates in the early period, and higher ones later on. PHG diverged from both MLK and STT in the later period, from 1995 to 2001. All three troops had synchronized human-caused deaths as well as synchronized deaths from predation, although the peaks for the two types of mortality occurred at different times. The risk of disease in the translocated troops varied but was not significantly different from that in the indigenous group. This suggests that although vulnerability to various types of mortality applies regardless of troop origins, MLK and STT converged (as implied by the survival curves) during the later period, while PHG diverged from both of them.

The birth and survival rates of the released groups were comparable to those of the indigenous control group. The translocated troops also got smaller during some periods (PHG early on, and MLK much later). These fluctuations should not be interpreted as a consequence of the translocation because MLK’s steady fall in group size began in 1996 (not in 1984) and coincided with a similar decrease in mean group size of indigenous baboons. It is likely, however, that PHG’s initial decline was a consequence of the translocation. It happened immediately after the release when death rates, while lower than before translocation, were nonetheless higher than in the later period. PHG’s later growth, at a time when all other troops were getting smaller, needs some explanation. The answer may be found in
a series of home-range shifts to areas where PHG encountered more food and fewer predators (unpublished data).

The baboon translocation has also succeeded according to the second criterion because it is possible to conclude that the released animals did as well as could be expected. PHG’s performance was even better than the norm in the most recent period. The data just presented argue convincingly that the two baboon troops have met the challenges of the move and have “adapted” to their new situation. Given that they have survived for a typical baboon lifetime after their release, the experiment has also met the most robust criterion proposed in the literature [Griffith et al., 1989; IUCN, 1998; Wolf et al., 1996].

Other Lessons for Primate Translocations

Birth rates vs. death rates.

Death rates appear to have a more important role in the success of a translocation than birth rates as long as the released animals are able to reproduce. Mammalian and primate female reproductive physiology sets the constraints on birth rates [Trivers, 1972]. Death rates are much more variable and potentially more devastating for a translocation experiment. In this study, disease contributed to over half of the natural mortality cases in which the cause of death could be established, a risk that appears relatively invariable across troops. However translocation had an impact for at least one of the released troops, PHG. If condition and disease are linked in the way that has been demonstrated for condition and intestinal parasites, then the risk of disease may be minimized if the translocated animals are released in the best condition possible [Strum, 2002].

Predation contributes marginally less to mortality than disease, but is a much more variable risk. Overall, the troops were similarly vulnerable to predation, but this was site-specific and was changed by the translocation. After the animals were released, the risk was linked to where the groups ranged (unpublished data).

The translocated troops could not avoid predation except by moving to another place. PHG exercised this option. This suggests that primate translocation experiments should target areas with low or lower predator pressure when there is a choice.

Adaptation to local circumstances.

Various measures suggest that the translocated animals were adapting to their new circumstances. They were no more vulnerable to disease after the initial period than the indigenous group. Mortality rates for PHG declined overall, while those of MLK declined in the first decade. Later, when MLK death rates rose, they did so in step with the indigenous control group, STT. Body condition and parasite loads followed a similar progression as each of the translocated troops responded to their particular circumstances, and MLK responded in a manner similar to that displayed by the indigenous group.

The changes in group size are in some ways a reflection of overall adaptation. The group size data suggest that the post-release adjustment process had two stages. In the first stage, the costs/risks of the move are visible, particularly in terms of what the animals died from. In the second stage, the translocated troops appeared to respond to extrinsic factors in the same way as indigenous baboons. This indicates that caution should be used in evaluating other primate
translocations. Short-term indicators may not be representative of the long-term outcome for translocated animals.

**Impact on indigenous groups.**

So far I have examined the consequences of the translocation for the released animals. However, there is growing concern about the impact of releases on resident communities [IUCN, 1998, 2002]. One worry is disease [Woodford & Rossiter, 1994]. The baboon data suggest that the risk was greater for the animals who were moved than for the residents, a conclusion that has also been reached by others [Brambell, 1977; Campbell, 1980; Collinson & Anderson, 1984; Wolf et al., 1996]. It may be that better physical condition increases immunity to new pathogens (see deThoisy et al. [2001] for evidence that poor condition decreases immunity). If physical condition and prior exposure are important, realistically assessing disease risks will require more and better data from a variety of circumstances.

The second concern is competition between residents and newcomers. It is notoriously difficult to determine carrying capacity [Brown & Lomolino, 1998]. The population-wide decline in group size might be seen as a result of competition from the translocated troops if it were not for information from the larger region. During this same period, groups of baboons, vervets, and patas monkeys in the adjacent region (comprising approximately 1,800 km$^2$) decreased—some critically. The likely causes include periods of serious drought and higher than normal rates of predation. At this point, after nearly two decades, the consequences of releasing more baboons (whose cumulative home range is about 85 km$^2$ out of 1,800 km$^2$) may be minor compared to the impact of normal ecological factors on the wider primate populations during the same time. However, carrying capacity remains an important if elusive consideration for any future primate translocation.

**Comparison with other translocations.** Primate translocations are still relatively rare, despite the growing number of experiments conducted with New World monkeys [IUCN, 2002]. It is difficult to make direct comparisons between this and other translocations because quantitative information on mortality, survival, or birth rates is seldom presented, and many such experiments have short or limited post-release data. The information currently available in the literature on primate translocations (red howlers (*Alouatta seniculus*) [de Thoisy et al., 2001; Richard-Hansen et al., 2000; Vie & Richard-Hansen, 1997], mantled howlers, (*Alouatta palliata*) [de Vries, 1991; Garcia-Ordonez et al., 1987; Richard-Hansen et al., 2000; Serio-Silva, 1997], black howlers (*Alouatta pigra*) [de Thoisy et al., 2001; Horwich et al., 1993, 2002; Ostro et al., 1999; Richard-Hansen et al., 2000], white faced sakis (*Pithecia pithecia*) [Vie & Richard-Hansen, 1997], golden handed tamarins (*Saguinus midas*) [Vie & Richard-Hansen, 1997], golden lion tamarins (*Leontopithecus rosalia*) [Beck, 2001; Kierulff & de Oliveira, 1994; Kierulff et al., 2002a, b; Kleiman & Rylands, 2002], black lion tamarins (*Leontopithecus chrysopogus*) [Medici et al., 2003], rhesus macaques (*Macaca mulatta*) [Malik & Johnson, 1991, 1994; Morrison & Menzel, 1972; Southwick et al., 1998; Strum & Southwick, 1986], Tibetan macaques (*Macaca thibetana*) [Berman & Li, 2002], Zanzibar red colobus (*Procolobus kirkii*) [Struhsaker & Siex 1998], and orangutans (*Pongo pygmaeus*) [Andau et al., 1994]) suggests that (1) they are able to survive the move and reproduce on a par with undisturbed groups, except when the released units do not consist of intact groups, (2) there
are stages in the adjustment process after release [Berman & Li, 2002; Horwich et al., 2003; Kierulff et al., 2002a, b; Medici et al., 2003], (3) death rate appears to be more critical than birth rate to success, (4) survival may be sensitive to fluctuations....Ostro et al., 1999]. The results of primate translocations imply that the release habitat need not be identical to the original habitat. Primates appear to be able to trace resources after they are moved, but released groups cannot survive if the basic resources are insufficient [Struhsaker & Siex, 1998].

The paucity of long-term data means that only tentative conclusions can be made about the success of the baboon translocation relative to other primate experiments. Given that proviso, the baboons have done as well or better than other wild primates who have been translocated.

CONCLUSIONS

Baboons, unlike some of the primate species involved in recent translocations, are not a conservation priority. Nevertheless, by salvaging two research groups, the baboon translocation was among the first to demonstrate that entire wild nonhuman primate groups can be successfully moved. The 18 years of post-translocation data provide quantitative measures of long-term success. Comparing conditions before the translocation to what happened afterwards offers one success criterion, while a comparison with indigenous groups provides a second criterion for the performance of the released animals. The results of the baboon translocation strengthen earlier claims that translocation should be a conservation and management tool for primates [see also Caldecott & Kavanagh, 1983; Chivers, 1991; Kierulff et al., 2002a; Konstant & Mittermeier, 1982; Medici et al., 2003]. Future translocations can benefit from what we have already learned. Each new experiment will add crucial information to the evolving model for primate translocation, a model that must include ways to weigh potential benefits against possible risks while recognizing that these will vary with the species, circumstances, and human priorities.

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REFERENCES


