IMPACT OF TRANSLOCATION ON THE BEHAVIOR AND HEALTH OF BLACK HOWLERS

Rangel-Negrín A[1], Dias PAD[2] & Canales-Espinosa D[2]

[1] Departamento de Biología, Universidad de Barcelona. Vall Hebrón 171, 08035 Barcelona, España. Email: ari_rangel@hotmail.com

[2] Instituto de Neuroetología, Universidad Veracruzana. Av. Dr. Luis Castelazo Ayala S/N. Col. Industrial Animas. Ap 566, Cp 91190, Xalapa, Veracruz México.

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ABSTRACT. Translocation is a conservation method that has been applied to manage wild populations of several animal species, including howlers (*Alouatta spp*.). The aim of the present study was to compare the behavior and health of a group of the endangered black howlers *Alouatta pigra* between pre- (2006) and post-translocation (2007) in the Mexican state of Campeche. This group was composed of seven individuals, which lived in a highly disturbed habitat where they faced multiple risks. The group was translocated to a protected forest located ca. 45 km from their original location. Our results indicate that after translocation individuals spent less time resting and more time moving, used more trees and tree species as food sources, and daily ranging distances were longer, resulting in a larger home range. Additionally, social interactions, especially affiliation, were more frequent. There were also changes in physical condition and blood parameters, suggesting that after translocation individuals were healthier. We propose that an integrative monitoring of the behavior and physiology of translocated animals may help to assess the short-term success of translocations, and could be used to predict the long-term sustainability of managed populations.

Key Words: *Alouatta pigra*, translocation, Campeche, Mexico, behavior, health

RESUMEN. La translocación es un método conservacionista que ha sido usado para manejar poblaciones silvestres de diversas especies animales, incluyendo a los monos aulladores (*Alouatta spp*.). El objetivo del presente estudio fue comparar el comportamiento y la salud de un grupo de la especie amenazada *Alouatta pigra*, monos aulladores negros, antes (2006) y después (2007) de ser translocados en el estado de Campeche, México. Este grupo estaba compuesto por siete individuos, los cuales vivían en un hábitat altamente perturbado en donde se enfrentaban a diversos riesgos. El grupo fue translocado hacia un bosque protegido localizado ca. 45 km de su ubicación original. Nuestros resultados indican que después de la translocación los individuos pasaron menos tiempo descansando y más tiempo moviéndose, usaron más árboles y más especies de árboles como fuentes de alimento, y que los recorridos diarios fueron mayores, resultando en un mayor ámbito hogareño. Además, las interacciones sociales, y en particular, la afiliación, fueron más frecuentes. También se registraron cambios en la condición física y parámetros sanguíneos que sugieren que después de la translocación los individuos estaban más sanos. Con base en estos resultados, proponemos que el monitoreo integrado del comportamiento y fisiología de animales translocados, puede ayudar a determinar el éxito de las translocaciones en el corto plazo, y podrá ser usado para predecir la sustentabilidad a largo plazo de las poblaciones manejadas.

Palabras clave: *Alouatta pigra*, translocación, Campeche, México, comportamiento, salud

INTRODUCTION

Translocation involves moving wild animals from one part of their distributional range to another, and usually aims at re-establishing self-sustaining populations and maintaining their viability (Griffith et al. 1989, IUCN 1998). To date, several animal translocations have been carried out, for many different reasons, and with various goals, means and success rates (e.g., Griffith et al. 1989, Wolf et al. 1998, Fischer and Lindenmayer 2000). However it is usually logistically and methodologically difficult to gather integrative data on the impact of translocations on animals, so our current knowledge on the short-term responses of animals to translocation is limited.

The Mesoamerican black howlers (*Alouatta pigra*) are currently the most threatened species of howlers, primarily because of their restricted distribution and the high rates of deforestation of their habitat (Marsh et al. 2008). Consequently, it is urgent to implement conservation actions that promote the sustainability of the remaining populations. Translocation is an effective tool to manage populations of black howlers (e.g., Ostro et al. 1999a, Horwich et al. 2002), but we are still lacking an integrative perspective on its effects on groups and individuals, as all studies dealing with translocated howlers have focused on a limited set of variables related to their behavior (e.g., feeding behavior and activity: Silver and Marsh 2003), or demography (e.g., group structure: Ostro et al. 2001).

During our surveys of black howlers in the Mexican state of Campeche, we identified a group that faced low survival probabilities, as it lived on a few trees scattered along a chili-pepper plantation. The group had to go to the ground to move from one tree to another, and in July 2006 it was attacked by dogs; this attack resulted in the death of a juvenile male and injury of a female. Local farmers told us that the area would be burnt, and asked if we could relocate the group.

This relocation presented us the opportunity to assess the impact of translocation on the group. Therefore, the aim of the present study was to investigate if translocation had a short-term impact (up to one year after relocation) on the behavior and health of this group. Specifically, we quantified differences between pre- and post translocation in activity patterns, diet, space-use, social behavior, physical condition, and hematology and blood biochemistry.

METHODS

Study Areas. The translocation was carried out in the Mexican state of Campeche in November 2006. Climate in this region is warm and humid, with a mean annual temperature of 26 °C, and mean annual rainfall of 1300 mm (Vidal-Zepeda 2005). Before translocation, the study group lived in a 30 ha area with trees scattered through agricultural fields in the Nuevo Ontario settlement (18° 57' 01" N, 90° 53' 22" W). Three other groups occupied this area, and occasionally, other individuals that lived in a nearby fragment were observed visiting the area. Population density in this area, considering only resident groups, was 0.63 ind/ha. According to local people, this area (El Chilar) was slashed and burned during the months of March-May 2005 to prepare the soil for chili, maize, and pumpkin cultivation. After deforestation, the only trees left were those that could not be easily cut with ax and chainsaw, mainly mature trees with diameters at breast height (dbh) >80 cm.

The selected release site, Calax, was located ca. 45 km from El Chilar (18° 51' 16" N, 91° 18' 40" W), and complied with several important criteria to assure the long-term survival of individuals. Among these, we emphasize three: large size, adequate vegetation composition and structure, and appropriate conservation status. The release area was large (ca. 3,000 ha) and was composed of original medium semi-evergreen forest interspersed with seasonally flooded areas of low tropical forest and mangroves, with elevation ranges from sea level to 10 m. These types of habitat are suitable for howlers (Crockett and Eisenberg 1987). In our evaluation of composition and vegetation structure in both sites (from a sample of all trees with dbh ≥ 10 cm in 10 randomly located 50 x 2 m plots per site, Keel et al. 1993) we found evidence that the potential food availability was higher in Calax than in El Chilar. Furthermore, in Calax we found several species reported as important for the diet of black howlers, such as *Brosimum alicastrum*, *Manilkara zapota*, *Pouteria campechiana*, *Talisia olivaeformis, Ficus spp.,* and *Spondias spp.* Finally, Calax is located within the 'Área de Protección de Flora y Fauna Laguna de Términos', a federal preserve with >7,000 km^2 (CONANP 2000). Therefore, primates released in this area are protected by this institution.

We never saw or heard any howlers in Calax before translocation, although several groups of spider monkeys (*Ateles geoffroyi yucatanensis*) were observed. Following the translocation of the group from El Chilar, other two groups (totaling 10 individuals) were translocated to Calax. These groups were released >2 km from the area occupied by the animals from El Chilar, and we never observed any interactions (including vocalizations) between the groups. After translocations, the population density at Calax was 0.017 ind/ha.

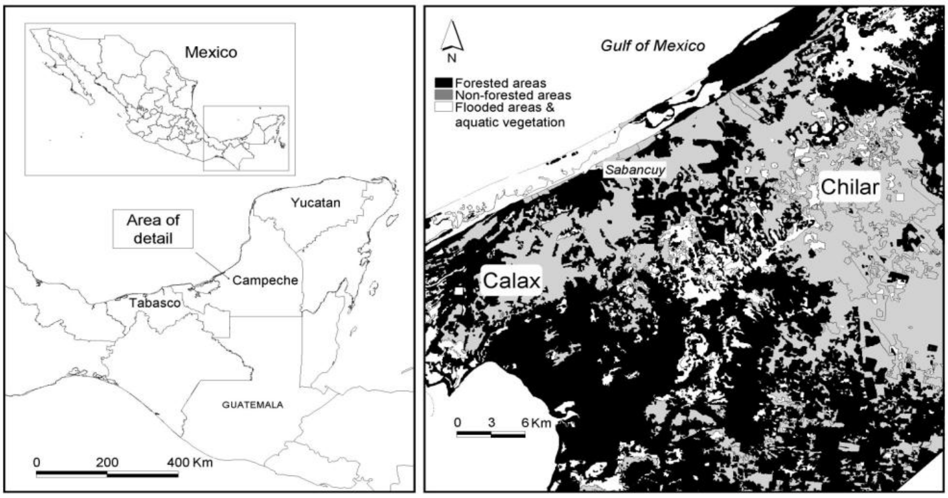

Figure 1. Location of the pre-translocation (Chilar) and post- translocation (Calax) sites of black howlers in Campeche, Mexico, 2006-2007.

Study group. At the beginning of the observations in El Chilar (April 2006), two adult males, three adult females, and three juveniles (ca. 1 year, two females and one male) composed the group. In July 2006, the juvenile male died after being attacked by dogs. After translocation (November 2006), two male infants were born, one in December 2006, and the other in March 2007. In March 2007, one of the adult males left the group. Similarly, in July 2007 one adult female (the one with no dependent infant) and a juvenile female emigrated. Therefore, when the group was recaptured in November 2007, it consisted of one adult male, two adult females, one juvenile female and two male infants.

Behavioral sampling. To study changes in the behavior of the group from pre- to post-translocation, we studied activity patterns, diet, space-use, social interactions and spatial organization in both conditions. Pre-translocation observations were performed from April 6 to July 10, 2006, and post-translocation between April 20 and June 26, 2007. A total of 240 h of observations were collected in each condition. We used focal-animal sampling with continuous recording (1 hr samples; Martin and Bateson 1994) to study activity patterns and diet. During each focal sampling we recorded the duration of the following activities: resting, feeding and moving. Additionally, during feeding we recorded the time dedicated to the consumption of different plant items: tree leaves, tree fruits, other parts. All trees used as food sources were identified to species level. To study the patterns of space-use, each tree used by the focal individuals was located via a handheld global positioning system (GPS). We used the behavioral sampling method with a continuous recording (10 hr sessions; Martin and Bateson 1994) to study social interactions. During observation sessions, we recorded all occurrences of affiliative and agonistic interactions. To study the spatial organization of the group, we used focal-animal sampling (1 hr sessions) with an instantaneous recording at 10 min intervals. During each instantaneous recording, we noted the position of all adults with respect to the focal considering the following categories: contact, <1 m, 1 to 5 m, 6 to 10 m, >10 m.

Capture, morphometric measurements and blood sampling. We captured and translocated the group in November 2006, and recaptured it one year later (November 2007) to assess changes in physical condition and health. The capture and handling techniques applied have been described elsewhere (Rodríguez-Luna et al. 1993, Rodríguez-Luna and Cortés-Ortiz 1995). During translocation, after sampling all individuals we transported the group to Calax, and released all animals simultaneously. During the sampling of captured animals, we took three morphometric measurements in order to compare physical condition and nutritional status between conditions: body weight (Terranova and Coffman 1997), upper arm circumference (a proxy to protein reserves; Frisancho 1974) and abdomen circumference (a proxy to fat reserves; Seidell et al. 1990). We took ca. 5 ml of blood from each animal (from the tail vein) to run hematological and biochemical analysis. We measured the following items: leukocytes, lymphocytes, granulocytes, red blood cells, hemoglobin, hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), red blood cell distribution width (RDW), platelets, glucose, blood urea nitrogen (BUN), creatinine, albumin, and total protein. Our research complied with all laws of the Estados Unidos Mexicanos, and our research protocols were approved by SEMARNAT (SGPA/DGVS/01273/06 & 04949/07).

Analyses. We transformed activity patterns data into percentages of activity (i.e., resting, feeding, moving) per observation day, and time dedicated to the consumption of the different food items (i.e., leaves, fruits, others) into percentages of total feeding time. Data on the number of species and trees used by the group were pooled for each observation day. We performed comparative analysis between pre- and post-translocation values for daily activity patterns, diet, space-use, social interactions, and spatial organization with Mann-Whitney tests (p fixed at 0.05). To study space-use, we digitized all trees used by the group in both conditions as points with ARC VIEW 3.2 (Environmental System Research Institute, Inc., USA). We calculated day ranges as the sum of the lengths of straight lines connecting individual tree points used by the group during each observation day. We calculated home range size following the methods proposed by Ostro et al. (1999b). We calculated rates of social interactions by dividing the daily frequency of interactions by the duration of each observation session. These calculations were performed for total, affiliative and agonistic interactions. We analyzed spatial organization with the index of spatial proximity described by Dias (2007), which gives an estimation of proximity among group members by considering the frequencies of observation of individuals in proximity categories according to different weighing values. This index varies between 0 (all group members were >10 m) and 1 (all group members were in contact).

Our analyses of changes in physical condition, hematology, and biochemistry were limited by two impediments. First, by November 2007 two adults had left the group and could not be located for recapture. Second, due to problems with the handling of samples, we lost the plasma of the adult male that still resided in the group during the recapture. Therefore, our results for physical condition and serum biochemistry were based on data from one male and two females, and results for hematology were only available for two females. For each variable, we averaged among all individuals the values for the capture and recapture. We then calculated the effect size index *d* for repeated measures for each variable (Cohen 1988). As our sample size for these variables was too small to run consistent statistical significance tests, we used this index to examine whether the observed differences were substantively important. As no standard values for physical condition and health indicators were available, and our sample size was small, we used this index to explore the power of the differences between conditions; those variables that had an index ≥ 0.8 were considered to have high effect size (Cohen 1988; i.e., to have changed markedly between conditions).

RESULTS

After translocation there was a ca. 5% decrease in time resting (Mann-Whitney $Z = 3.92$, $P < 0.001$) and ca. 9% increase in time moving (Mann-Whitney $Z = 5.29$, $P < 0.001$). Feeding also increased after translocation but not significantly (Table 1). The number of species (Mann-Whitney $Z = 5.81$, $P < 0.001$) and individual trees used as food sources (Mann-Whitney $Z = 5.70$, $P < 0.001$) per day increased fourfold after translocation. The total number of species (from 10 to 38) and trees (from 17 to 611) also increased notably. The consumption of leaves increased after translocation (ca. 20%; Mann-Whitney $Z = 2.67$, $P < 0.01$), mainly through an important increase in the consumption of young leaves (from 22.37% to 43.19% of total feeding time; Mann-Whitney $Z = 3.27$, $P < 0.001$).

Table 1. Behavior of black howlers before (2006) and after (2007) translocation, Campeche, Mexico

	Pre-translocation		Post-translocation		P [b]
	Mean[a]	Range	Mean	Range	
Activity patterns					
% Resting	85.66	73.8–95.1	75.34	52.2–88.2	***
% Feeding	10.81	3.98–20.8	12.29	3.51–29.1	n.s.
% Moving	3.54	0.2–12.5	12.37	2.29–24.7	***
Diet					
N° of consumed species	1	1–4	5	2–9	***
N° of individual trees	1	1–4	7	2–17	***
% Leaves	30.05	0–100	50.79	5.43–96.8	***
% Fruits	55.79	0–100	40.00	3.2–85.6	n.s.
% Others	14.16	0–100	9.21	0–84.5	n.s.
Space-use					
Home range (ha)	3.49		13.88		
Mean day range (m)	145.19	0–705	505.71	61.66–1057.7	***
Social behavior					
Rate of interactions (int/hr)	1.09	0–3.8	1.86	0.25–4.33	*
Rate of affiliation (int/hr)	0.61	0–2.6	1.50	0.25–3.67	**
Rate of agonism (int/hr)	0.31	0–1.8	0.34	0–1.22	n.s.
Spatial index	0.19	0.07–0.25	0.24	0.18–0.37	***

[a] Mean values for each full-day follow, with the exception of home range size. Home range was calculated as the cumulative space used by the group during 24 days in each condition.
[b] * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; n.s. non-significant

After translocation, there was a tenfold increase in the home range of the group (Table 1) and daily ranging distances increased by over threefold (Mann-Whitney $Z = 4.80$, $P < 0.001$). There was an increase in total social interactions (Mann-Whitney $Z = 1.95$, $P = 0.05$) and affiliation (Mann-Whitney $Z = 3.36$, $P < 0.01$) after translocation (Table 1). These changes in social interactions were more remarkable for some behaviors, such as playing (+666.7%, from 0.015 int/hr to 0.093 int/hr), supplantation (+650%, from 0.008 int/hr to 0.06 int/hr), or sitting in contact (+290%, from 0.208 int/hr to 0.813 int/hr). The spatial index was higher after translocation (Mann-Whitney $Z = 4.34$, $P < 0.001$), suggesting that group cohesion increased.

Table 2. Mean (±SD) black howler physical condition, serum biochemistry, and hematology before (November 2006) and after (November 2007) translocation, Campeche, Mexico

	Pre-translocation		Post-translocation		*d* [a]
	Mean	SD	Mean	SD	
Physical condition					
Body weight (kg)	5.8	1.22	6.5	1.82	**–1.07**
Arm circumference (cm)	12.67	1.26	15	2.55	**–1.79**
Abdomen circumference (cm)	40	5.57	37.67	4.73	**2.02**
Serum biochemical values					
Glucose (mmol/L)	7.37	4.76	4.03	1.06	0.65
BUN (mmol/L)	6.42	2.23	4.88	1.96	**1.04**
Creatinine (μmol/L)	79.56	26.52	61.88	31.82	0.64
Albumin (g/L)	30.3	5.7	39.3	11.9	–0.58
Total protein (g/L)	60	6.9	62.3	11.2	–0.14
Hematologic values					
Leukocytes (10^3/μl)	12.10	0.71	10.05	4.45	0.40
Lymphocytes (%)	3.70	0.99	2.90	0.57	**1.89**
Granulocytes (%)	4.85	0.78	4.95	3.18	–0.03
Red blood cells (10^6/μl)	2.94	0.4	3.04	0.28	**–0.79**
Hemoglobin (g/dl)	8.10	0.85	8.70	0.28	**–1.06**
Hematocrit (%)	24.80	2.4	26.35	1.34	**–1.46**
MCV (fl)	84.75	3.46	87.05	3.61	**–16.26**
MCH (pg)	27.65	0.92	28.75	1.63	**–1.56**
MCHC (g/dl)	32.65	0.21	33.05	0.64	–0.47
RDW (%)	14.70	0.14	16.40	1.98	**–0.80**
Platelets (10^3/μl)	101.00	67.88	123.50	64.35	**–6.36**

[a] Effect size index: variables with high effect sizes are marked in bold.

We found high effect size values in the comparison of the three morphometric variables between conditions: body weight, upper arm circumference and abdomen circumference. The first two increased after translocation, whereas the last decreased (Table 2). Concerning serum biochemical analysis, only BUN concentrations had a high effect size, having decreased during post-translocation. Hematologic analyses revealed high effect size for several variables: lymphocytes, red blood cells, hemoglobin, hematocrit, MCV, MCH, RDW, and platelets; lymphocyte counts decreased after translocation, whereas all other parameters increased.

DISCUSSION

We found several changes in the behavior and health of howlers after translocation, suggesting that translocation had a strong short-term impact on the group. Based on our results, as well as in the observation that the translocated individuals survived and reproduced in their new environment, we hypothesize that this relocation had a positive effect on individuals.

First, the significant increases in both the number of species and trees used as food sources indicate that the group maintained a more diverse diet after translocation. As the nutritional balance of howlers depends on the mixture of different plant items (Milton 1979, Nagy and Milton 1979), dietary quality was probably higher after translocation. This would explain the observed changes towards more energy-intensive activity patterns, longer daily ranges, larger home range, more social interactions and closer proximity between individuals. Similar trends have been found in other studies of translocated *A. pigra* and *A. seniculus* (Ostro et al. 1999a, Richard-Hansen et al. 2000, Silver and Marsh 2003).

Interestingly, serum glucose levels were higher before translocation, suggesting an elevated ingestion of sugars, which could relate with more time spent feeding on fruits during this period. In conjunction with a low-protein diet and sedentarism, this raises the susceptibility of individuals to diabetes in other non-human primates (Ange-van Heugten et al. 2007). In addition to changes in other health indicators, which we discuss below, the increase in body weight and protein reserves, and decrease in fat reserves, suggest that post-translocation changes in diet and an increase in exercise (suggested by longer day ranges), contributed to an overall improvement of the health of individuals.

Second, the group's pre-translocation daily ranging lengths are amongst the lower reported for *Alouatta*. In ca. 20% of the pre-translocation observation days the group occupied a single tree, and in 62.5% of the days the group moved less than 100 meters. These trends reflect the limitations faced by the group to move from one tree to another, and were probably the result of a tradeoff between the necessity to move through the ground to reach another food source, and the danger of being attacked and depredated during such movements. In contrast, the lengths of post-translocation day ranges are within the average values reported for *Alouatta* (Di Fiore and Campbell 2007).

Third, there is evidence that the health of individuals improved after translocation. For instance, low levels of red blood cells (and RDW), hemoglobin, hematocrit, MCV, and MCH are indicative of anemia; after translocation we registered increases in all these parameters. Anemia has been previously reported for howlers by de Thoisy et al. (2001) in individuals that faced food constraints comparable to those we observed in our study group. Such constraints may also explain the low pre-translocation arm circumference, concentrations of albumin (which may reflect inadequate protein intake in both cases; Crissey et al. 2003) and body weight. Finally, after translocation leukocytes and lymphocytes were lower, whereas platelet counts were higher, suggesting that before translocation individuals could present some infection. We therefore conclude that overall physical condition and health of animals improved after translocation.

Information on health parameters of howlers is currently scarce. Vié et al. (1998) and de Thoisy et al. (2001) reported hematological and biochemical values for free-ranging *Alouatta seniculus*, and Crissey et al. (2003) studied the serum biochemistry of *A. palliata*. Overall, our findings are within the normal ranges reported by these authors, although some discrepancies (e.g., serum glucose and creatinine) are probably due to species-specific differences, variation in diet, latitude, among others. Alternatively, these and other differences between our results and those of previous studies could be an artifact of small sample size. We studied a single group, and for some of the variables analyzed (e.g., hematology), our sample size was two, challenging any attempts of deriving generalizations from the present study. Nonetheless, this exploratory analysis offers researchers the opportunity to consider the importance of integrating different kinds of data in order to obtain a better understanding of the responses of animals to translocation.

Management implications. The two main measures of success of translocations are individual survival and reproduction after release (Griffith et al. 1989). However, for some species several years may be required before translocated animals reproduce, so the study of the acclimation of individuals to their new local circumstances may provide intermediate indicators for long-term sustainability. Although the results of this case study are limited, we propose that a monitoring of changes in behavior and health of translocated animals similar to the one presented here could assist in that direction. For instance, the observation of changes in activity budgets associated with variation in food supply could help predicting short-term variation in the health of individuals, which in turn influences fertility and survival. Based on such indicators, wildlife managers may plan initiatives to support the managed populations, such as artificial provisioning of food or supplementations (Fischer and Lindenmayer 2000).

Additionally, we propose that other indicators should also be considered for the monitoring of translocated howlers, such as parasitism or stress. Overall, this knowledge, in conjunction with data on the biology of well-established groups, will improve our understanding of the short and medium-term consequences of translocation. Therefore, it could enhance the long-term probabilities of success of translocations of this endangered primate.

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