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# Socialization of Adult Owl Monkeys (*Aotus* sp.) in Captivity

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## Abstract

Social housing has often been recommended as one-way to address the psychological well-being of captive non-human primates. Published reports have examined methods to socialize compatible animals by forming pairs or groups. Successful socialization rates vary depending on the species, gender, and environment. This study presents a retrospective look at pairing attempts in two species of owl monkeys, *Aotus nancymaae* and *A. azarae*, which live in monogamous pairs in the wild. The results of 477 pairing attempt conducted with captive, laboratory housed owl monkeys and 61 hr of behavioral observations are reported here. The greatest success pairing these owl monkeys occurred with opposite sex pairs, with an 82% success rate. Opposite sex pairs were more successful when females were older than males. Female–female pairs were more successful than male–male (MM) pairs (62% vs 40%). Successful pairs stayed together between 3 and 7 years before the animals were separated due to social incompatibility. Vigilance, eating, and sleeping during introductions significantly predicted success, as did the performance of the same behavior in both animals. The results of this analysis show that it is possible to give captive owl monkeys a social alternative even if species appropriate social partners (i.e., opposite sex partners) are not available. The focus of this report is a description of one potential way to enhance the welfare of a specific new world primate, the owl monkey, under laboratory conditions. More important is how the species typical social structure of owl monkeys in nature affects the captive management of this genus.

### Keywords

*Aotus*; behavioral management; pair housing; psychological well-being; socializations; owl monkey

## INTRODUCTION

Observations of animals living in their natural habitat have reported that owl monkeys live as monogamous pairs with associated juvenile or infants comprising the typical social group [Cornejo et al., 2008; Fernandez-Duque et al., 2011; Wright, 1994]. Owl monkeys are

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generally found in groups consisting of a mated male–female pair and up to two juveniles. Young animals migrate out of their natal group around 3 years of age [Fernandez-Duque, 2009]. Fernandez-Duque & Huck [2013] found that owl monkeys do not mate for life but that either sex may be replaced by "floaters," young animals that have left their natal group. They report that pairs, that had at least one successful reproductive outcome, stayed together for a median of 9.1 years. Factors leading to the breakup of pairs tended to come from outside the group, animals expelled through agonistic interactions with outsiders, rather than from inside the group, lack of reproductive success or one mate driving off the other. Owl monkeys are generally held as singly housed individuals for research purposes or as monogamous pairs in captivity [Fernandez-Duque, 2012; Moynihan, 1964; Wright et al., 1989]. Recommendations for captive primates have promoted the use of socialization opportunities [National Research Council, 1998, 2011; Rennie & Buchanan-Smith, 2006; Roder and Timmermans, 2002]. Published reports describe various methodologies for implementing social housing but only for primates with social systems that are very different from owl monkeys, and typically involving isosexual pairs, that is Baker et al. [2012, 2014]; Couch et al. [2013]; DiVincenti&Wyatt [2011]; and Novak [2004]. However, success rates vary depending on the species, gender, and environment.

This is a retrospective study comparing the success rates of pairing owl monkeys in captivity. Specifically, we tested the hypothesis that non-species typical pairs, that is male–male and female–female are possible in a captive environment and represent a positive alternative when species-typical male–female pairs are not option. We expected the male-female pairs would be successful at a higher rate than the other types of pairings.

## METHODS

All research presented complied with protocols approved by the UT MD Anderson Cancer Center Institutional Animal Care and Use Committee, it adhered to all legal requirements and to the Principles for Ethical Treatment of Non-Human Primates established by the American Society of Primatologists.

### Subjects

The owl monkeys were housed in the Owl Monkey Breeding and Research Resource (OMBRR) originally part of the Department of Comparative Medicine at the University of South Alabama (UoSA). The OMBRR relocated, in early 2008, to the Michale E. Keeling Center for Comparative Medicine and Research (KCCMR), part of the UT MD Anderson Cancer Center. During this time the colony has ranged from 200 to 350 animals. Data used in this analysis were collected at both the UoSA and KCCMR facilities between the years 2002 and 2014. All animals were captive born adults with a mean age of 4.2 ± SD 3.7 years. The 477 pairing attempts presented in this paper, 435 from *Aotus nancymaae* pairs and 42 from *A. azarae* pairs, were collected at both locations and represent a subset of the 619 pair attempts catalogued. In order to reduce dependencies, only data from unique animal pairs were used in this analysis. Table I shows the breakdown of pair formations by species and pair type; Female–Male (FM), Female–Female (FF) and Male–Male (MM).

## Housing

Pairs, at both facilities, were housed in primate cages measuring 3′ wide by 3′ deep by 5′ tall ($0.9 \times 0.9 \times 1.5$ $m^3$). All animals had nest boxes located within their cages. Cages were equipped with either metal or PVC perches, as well as floor and hanging toys. All monkeys had *ad libitum* access to food and water. Supplemental treats of fruits and vegetables were provided on a regular schedule. Lighting was on a reverse 12–12 cycle with lights on at 0300 hr and off at 1500 hr while the animals were housed at UoSA. This shifted to on at 0000 hr and off at 1200 hr at KCCMR. Overhead louvers provided dim light until after end of day animal checks and were closed between 1430 and 1500 hr. Colony rooms had red light illumination during the dark phase at both facilities.

## Procedure

All monkeys were observed in their home cage prior to selection for pair housing. Care staff were consulted regarding the behavior and medical status of each monkey, that is whether animals were overly aggressive to handling; demonstrated either positive or negative interactions with other monkeys in the past or exhibited any significant weight changes, prior to any pairing attempts. In all social group movements animal records were screened for signs of hyper-aggressiveness and medical issues that might preclude their movement. In addition, FM pairs were screened for possible inbreeding concerns.

## Pairing method

Monkeys at the OMBRR were single housed in cages ($0.56$ $m^2$) with a sliding, protected contact panels, integral to the cage. The panels consisted of a course mesh that allowed olfactory and finger-to-finger contact. On the first day of a planned introduction, the panels separating adjacent cages were removed and monkeys were allowed to interact for at least 1 hr. Pairs that entered the same nest box during the first day were allowed to stay together. Pairs that did not enter the same nest box after the first hour were separated by the protected contact panel. This procedure was repeated for 3 days. After the third day, if the animals did not engage in agonistic interactions, the protected contact was permanently removed and the pairs were allowed to stay together. Animals were separated if at any time during the pairing protocol they demonstrated excessive agonistic interactions, defined as increased frequency of chases, bites, and overt fighting between potential partners. A pair was considered to be a success if the two animals stayed together for at least 1 week.

## Data collection and analysis

Two sources of data were assessed for this study. First, pairing records were generated from a husbandry database that has been in use since the establishment of the owl monkey colony. Pairings were considered successful if they lasted for more than 7 days.

Pairing success was analyzed using a logistic regression analysis with pair type and species in the model. The statistics reported here are log likelihood goodness of fit (*G*-test) tests on the main effects of the logistic regression model as reported by SPSS software (v.22, SPSS, Inc, Chicago, IL) [Norris et al., 2014]. *Post-hoc* analyses were conducted when appropriate using an alpha level corrected for the number of comparisons (Bonferroni correction) [MacDonald & Gardner, 2000].

In addition, 61 hr of behavioral data were collected using instantaneous scan sampling every 3 min of the first hour following the introduction. During each scan the behavioral state, location within the cage, and proximity to its partner were recorded. Location within the cage was documented by recording which of six equal perching sites the owl monkey was using during the scan. The pair's behavior and location were considered synchronous when they were recorded in the same behavioral state or in the same location. To ensure the quality of the data, inter-observer reliability tests were conducted prior to behavioral observation until an 85% rating (Cohen's Kappa) was reached. The behavioral states recorded consisted of Agonistic, Eating, Drinking, Sleep, Vigilance, or Object Manipulation (see Table II for ethogram). Raw scores were converted to percent of time estimates by dividing the number of recorded occurrences of each response by the total number of scans made. Differences between successful and unsuccessful pairs were analyzed used *t*-tests with corrections for unequal variances applied with necessary.

Kaplan–Meier survival functions were calculated for each pair type. Comparisons of survival between groups were performed using log-rank tests. Pairs separated for research, husbandry, or the death of one of the animals were considered censored data in the Kaplan–Meier survival analysis.

Other behavioral comments were recorded *ad libitum* throughout the introductions as notes to the animal's file for use in discussions about future pairing attempts. These notes were not used in the current analysis.

## RESULTS

### Pairing Success

**Species differences—**The model tested did not show a statistical interaction between species and pair-type, ($G = 0.45$, df = 2, $P = 0.8$) indicating there are no differences between the two species in the success rate of heterosexual vs iso-sexual pair types.

**Pair-type difference—**An analysis of pairing type found a significant effect of pair type ($G = 48.54$, df = 2, $P < 0.05$). FM pairings were 4.37 times more likely to be successful compared to same sex pairs. FF pairs were 2.4 times more likely to be successful compared to MM pairs.

**Partner age effects—**When the female was older than the male, paring attempts were significantly more likely to succeed ($G = 13.75$, df = 1, $P < 0.05$). Pairs where the female was older than the male where 3.23 times more likely to succeed compared to pairs where the male was older.

### Kaplan-Meier Survival Analysis

A Kaplan–Meier Survival Analysis of the number of days a successful *Aotus nancymaae* pair stayed together showed that there was a significant difference between the three pairing types (log-rank $\chi^2 = 4.78$, $P < 0.05$). Table III lists the median time to failure for each pair type. Female–Male pairs had a median longevity of 2.95 (+0.58 SEM) years, compared to 2.18 (+0.71) years for FF pairs, and 1.50 (+0.31) years for MM pairs. *Aotus azarae* pairs

also differed significantly between pair types (log-rank $\chi 2 = 4.36$, $P < 0.05$) with FM pairs remaining together for a median of 7.74 (+2.96) years, FF pairs 2.81 (+2.59) years, and the one successful MM pair together for 22 days. Figure 1 illustrates the survival functions for the pair types of *Aotus nancymaae*.

### Interactions During the First Hour of Pairing

Instantaneous scan data from the first day pairing attempts were analyzed. Statistical analysis showed no difference between *A. nancymaae* and *A. azarae* so the data were collapsed for further testing. Table IV shows the percent of time each response was recorded across both animals in the pair.

Pairs that were ultimately successful (n = 54) displayed significantly more time in behavioral synchrony (exhibiting the same behavior at the same time) ($t = 3.4$, df = 12, $P = 0.006$) and shared the same nest box ($t = 3.4$, df = 21, $P = 0.003$) significantly more than unsuccessful pairs (n = 12). No significant differences were found for the amount of time that the pairs shared the same location (t = 1.8, df = 15, $P = 0.09$) or were in proximity to each other (t = 1.5, df = 13, $P = 0.16$).

Individuals that were successfully paired (n = −108) displayed significantly more vigilant ($t$=3.96, df = 25, $P = 0.0005$) and eating (t=−3.1, df=57, $P = 0.002$) behavior and significantly less time engaged in agonistic behavior (t= −4.39, df= 23, $P = 0.0002$) than individuals who were unsuccessful in pairing (n = 24). There were no significant differences between the groups when comparing time spent sleeping ($t = 0.32$, df= 44, $P = 0.74$) or drinking ($t = 1.9$, df = 107, $P = 0.058$), and no subjects were observed manipulating objects.

## DISCUSSION

Housing owl monkeys presents a specific set of challenges for research laboratories. Opportunities to engage in normal social behavior, i.e., formation of opposite-sex pairs, may not be possible given the requirements of protocol restrictions, housing limitations, or population demographics. Even when opposite-sex pairs are available for socializations, there is no guarantee of success and caution is recommended when forming new pairs [Baer, 1994]. Socializing adult *Aotus* monkeys can be a viable element of an enrichment program and an alternative solution to individually housing these primates in the laboratory.

Our results demonstrate that the most successful pairing of adult owl monkeys occurs when mixed-sex pairs are socialized. Eighty-two percent of opposite sex pairs were successful, while iso-sexual pairings of either females or males resulted in lower successful pairings (62% FF pairs and 40% for MM). As Capitanio et al. [2015] point out most pairings in other commonly used laboratory primates are within-sex, as most mixed sex pairs do not form pair bonds. Within *Aotus*, however, the primary bond is between male and female adults, and these pairs may be preferred and are easier to form.

In the field adult owl monkeys are expelled from a social group by intruding adults [Fernandez-Duque, 2004; Fernandez-Fernandez-Duque, 2007]. While this generally does not happen in captivity, pairs do have a finite life span. It is possible that the average 7.7

years is due to the small number of *A. azarae* FM pairs. Pairing owl monkeys is not a “once and done” thing. With an overall length between 2 and 3 years, facilities with owl monkeys should be prepared to separate animals that become overly aggressive to one another and form new pairs as needed.

Our study indicates that it was possible to house owl monkeys in same-sex pairs for extended periods of time. Given the benefits documented for socializing same-sex pairs in primates (e.g. Baker et al., [2012]; Becker et al. [2013]; DiVincenti et al. [2012]; Duarte et al. [2012]; Lee et al. [2012]; and Xie et al. [2014]) these results suggest that giving the owl monkeys the opportunity to live with another conspecific is a viable option when developing a housing plan for owl monkeys. Though there is some risk in forming non-species typical pairs, the animals are under constant observation during the pairing process, and provides a potentially high benefit to the animals. As Truelove et al. [2015] and the Guide [National Research Council, 2011] suggest, pairs should be monitored before, during, and after pair formations. Observations should be conducted prior to any pairing attempts to discern overt behavioral propensities, i.e., aggressiveness or submissiveness, in individuals. Knowing the behavioral propensities of your animals will help you judge their interactions within the context of their individual normal behavior [Capitanio et al., 2015]. Our results suggest that behavioral technicians should look for vigilance, eating, and sleeping as signals of success. Also, coordinated responses are an indication that the animals are pairing. Similarly, Truelove et al. [2015] reported increasing amounts of enlisting and co-threatening in their rhesus pairs process and the joint signaling described by Hannibal et al. [2015]. During the pairing process coordinated vigilance, usually directed at the observer, was the best predictor of pairing success.

Ultimately, individuals responsible for the behavioral management of large non-human primate colonies must address questions regarding the socializations of animals under their care. Socializations are just one part of a comprehensive behavioral management program. Truelove et al. [2015] suggest a cost–benefit analysis needs to be completed before considering a pair formation. Each socialization brings with it inherent difficulties and dangers. Successful socialization rates for all nonhuman primates vary depending on the species, gender, developmental history, individual differences, and environment [Bernstein, 1991; Crockett, 1998; Eaton et al., 1994; National Research Council, 1998]. Opposite sex owl monkey pairs have been compatible up to 3 years before demonstrating aggression sufficient to require separation [Baer, 1994; Fernandez-Fernandez-Duque, 2007]. One of the biggest challenges associated with managing a socialization program for nonhuman primates in the laboratory is accurately assessing the cost-benefit ratio associated with formation of any new groups or pairs [Truelove et al., 2015]. Worlein et al. [2015] correctly point out that these costs include pre-screening animals for behavior characteristics by both behavioral and care staff, as well as time moving the animals, and dealing with the consequences of unsuccessful pairing attempts. This is especially true when socializing adult males of the species typically seen in laboratory research [Baer, 1994; Baker, 2007], and as reported here for owl monkeys. Initial costs include the time and effort needed to form compatible social groups or pairs. Moreover, the potential for wounding, interruption of a protocol, and the possibility of affecting the outcome of the planned research, should be figured in as part of the analysis as well. The benefits accrued from successful socializations may be difficult to

measure directly. The NRC report on the psychological well-being of nonhuman primates [National Research Council, 1998] recommends further assessment of behavior which deviates from species typical patterns. The research of Fernandez-Duque & Huck [2013] provides some insight into at least one kind of behavioral plasticity among wild owl monkeys which has some potential in influence compatible parings in captivity. Housing social primates in non-species typical social structures, in this case compatible iso-sexual pairs of adult owl monkeys, even to a limited extent, should be explored as an alternative to single cages. While not all socializations are successful, and this is true for any primate socializations, our data would suggest that some laboratory housed owl monkeys can be socialized in same sex pairs given the caveats and cautions described above. We suggest that species typical social groupings is always preferred and should be a priority if appropriate social partners are available. However, if suitable partners are not available the animals should be given a choice to live socially, even if not in a species typical group.

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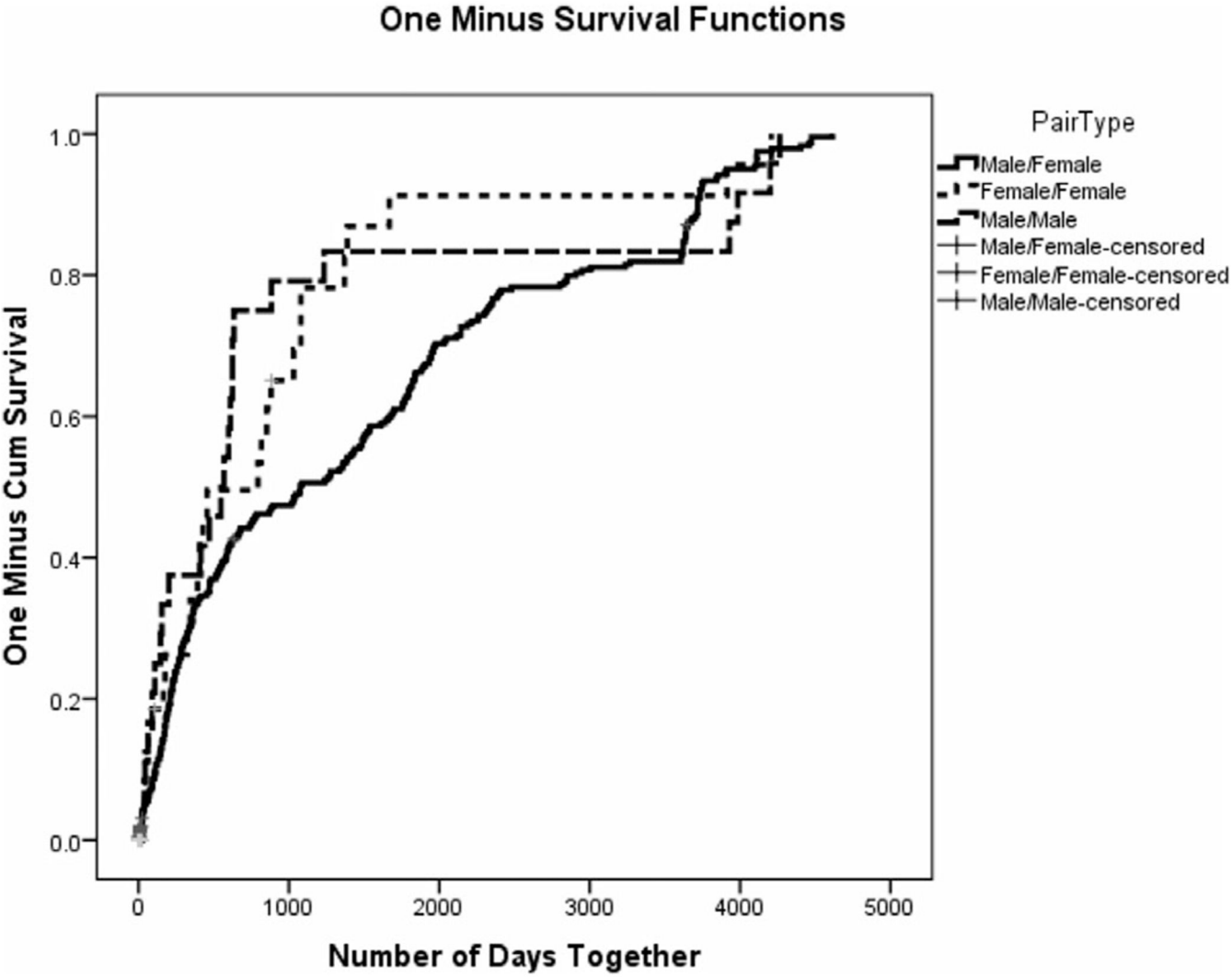


**Fig. 1.**

Kaplan–Meier survival curves for *Aotus nancymaae* pair formations between 2002 and 2014 for each pair type (Female/Male, solid line; Male/Male, dashed line; Female/Female, dotted line). The survival distributions for the three groups were compared using a log-rank test (SPSS v22). There was an overall statistical difference in mean pair survival time ($P<0.05$). Female/Male pairs the mean survival time was 2.95 years, compared to 2.18 years for the Female/Female pairs and 1.5 years for the Male/Male pairs.

**TABLE I.**

Number Pairing Attempts by Species and Pair Type

| Species | Pairing result | Male/female | Female/female | Male/male | Total |
|---|---|---|---|---|---|
| *A. nancymaae* | Total | 329 | 48 | 58 | 435 |
| | Successful | 274 | 31 | 24 | 329 |
| | Unsuccessful | 55 | 17 | 34 | 106 |
| | Success Rate | 83.3% | 64.6% | 41.4% | |
| *A. azarae* | Total | 23 | 15 | 4 | 42 |
| | Successful | 15 | 8 | 1 | 24 |
| | Unsuccessful | 8 | 7 | 3 | 18 |
| | Success Rate | 65.2% | 53.3% | 25% | |
| Overall success rate | | 82.1% | 61.9% | 40.3% | |

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**TABLE II.**

Ethogram of Responses Recorded During Instantaneous Scans Collected During the First Hour Post Introduction

| Response | Definition |
|---|---|
| Agonistic | Included all instances of contact and on-contact aggression; including grabs, pulls, biting, arched back display |
| Eating | Sitting ingesting bits of chow or fruit |
| Drinking | Ingesting water from the lixit valves |
| Object manipulation | Moving or touching any inanimate object in the cage |
| Sleep | Siting, not moving, eyes closed and head down |
| Vigilance | Sitting, head up, eyes fixed on an object outside the cage |

**TABLE III.**

Mean Survival Time (in Years) for *Aotus nancymaae* and *Aotus azarae Pairs*

| | | | | 95% Confidence interval | | |
|---|---|---|---|---|---|---|
| ***Aotus* species** | **Pair type** | **Mean** | **Std. error** | **Lower bound** | **Upper bound** | **Longest time to failure (years)** |
| *nancymaae* | Male/female | 2.95 | 0.58 | 1.80 | 4.09 | 12.64 |
| | Female/female | 2.18 | 0.71 | 0.79 | 3.56 | 11.53 |
| | Male/male | 1.50 | 0.31 | 0.89 | 2.11 | 11.68 |
| | Overall | 2.38 | 0.35 | 1.71 | 3.06 | |
| *azarae* | Male/female | 7.74 | 2.96 | 1.93 | 13.55 | 10.82 |
| | Female/female | 2.81 | 2.60 | 0 | 7.89 | 10.79 |
| | Male/male | 22 days[a] | – | – | – | 0.06 |
| | Overall | 4.59 | 2.48 | 0 | 9.45 | |

[a]Only one Male/Male *A. azarae* pairing was attempted and it lasted 22 days.

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**TABLE IV.**

Percentage of Instantaneous Scans Recorded for Each of the Responses

| Successful pair | Agonistic (%) | Eat (%) | Sleep (%) | Vigilant (%) | Drink (%) | Object manipulate (%) |
|---|---|---|---|---|---|---|
| No | 1.5 | 0.1 | 0.8 | 9.8 | 0.0 | 0.0 |
| Yes | 0.6 | 4.2 | 9.1 | 73.9 | 0.0 | 0.0 |

Scans were taken at 3 min intervals, across the first hour after the pair was introduced to a common cage.