obtained during interviews with the ex-inhabitants of an abandoned village near the Igarapé do Urucú (a left affluent of the Rio Sucunduri, along the Serra do Sucunduri) indicates that *M. acariensis* and another species of marmoset with blackish hairs occur in the area. As *M. melanurus* has been confirmed as occurring in the Sucunduri Mountains (Noronha, unpubl. data), it is possible that these species are sympatric in this region.

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Sleep Parameters in Captive Female Owl Monkey (*Aotus*) Hybrids

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Introduction

In the 1970s and 1980s, captive breeding of owl monkeys began in countries such as the United States of America (Cicmanec and Campbell, 1977; Weller *et al.*, 1991; Malaga *et al.*, 1997), Peru (Gozalo and Montoya, 1990) and Germany (Rappold and Erkert, 1994). In 1977, a comparatively smaller owl monkey colony was established in Japan, at the Primate Research Institute facility of Kyoto University, with founding members originating from Bolivia. Unfortunately, at that time, the production of hybrids occurred due to inadvertent pairing of different owl monkey species before the existence of multiple *Aotus* species had been determined (Hershkovitz, 1983; Ford, 1994; Groves, 2001). Extreme chromosomal diversity with diploid counts ranging from 46 to 56 is one distinguishing feature of owl monkeys, apart from their nocturnality (Ma *et al.*, 1977; Yunis *et al.*, 1977; Reumer and de Boer, 1980; Simpson and Jones, 1982). Previous studies on owl monkey hybrids suggest that while the adult female hybrid monkeys may sometimes conceive — although at lower rates compared to normal individuals — adult male hybrid owl monkeys are most probably sterile (Ma *et al.*, 1977; Yunis *et al.*, 1977; Reumer and de Boer, 1980; Simpson and Jones, 1982).

Rigorous sleep quantification data exist for less than 10% of extant primate species (Campbell and Tobler, 1984). Since owl monkeys (1) are unique among platyrrhines for their nocturnal behavior, (2) are notable for their strictly arboreal habitat, and (3) use holes and platforms in lodge trees as their sleep sites, sleep quantification in the wild has remained a virtually impossible challenge. Under captive conditions owl monkey sleep has been recorded previously for *A. trivirgatus* (Perachio, 1971) and *A. azarae* (Sri Kantha and Suzuki, 2006; Suzuki and Sri Kantha, 2006). The objective of this study was to quantify the parameters for sleeping behavior activity among captive-born owl monkey hybrids.

Methods

Four female owl monkey hybrid siblings (age range 11–16 yrs; weight range 1.016–1.163 kg) and three female owl monkey purebreds, including a mother and two of her progeny (age range 6–16 years; weight range 1.050–1.079 kg) reared at Kyoto University's Primate Research Institute (PRI), were the subjects of this study. The founding members of the owl monkey colony, born in the mid-1970s, originated from Bolivia. These seven

monkeys were housed in individual stainless steel cages (100 × 70 × 60 cm). The *Aotus* colony room was maintained on a shifted, alternating 12 hr light (2300–1100 hrs: 200 lux): 12 hr dark (1100–2300 hrs: 0.01–0.5 lux) cycle. Lighting conditions of the room were routinely checked by an illuminance meter (TopCon IM-5, Tokyo). Food and water were available to the monkeys *ad libitum*, and the commercial pellet diet for New World monkeys (25.1 g protein and 10.6 g lipid/100 g diet) was supplemented daily with fresh fruits and twice-weekly with mealworms. All experiments were carried out with approval from the Research Committee of the Institute, and according to the Primate Research Institute's Guidelines for the Care and Use of Laboratory Primates.

Quantification of the monkeys' sleep behavior activity was carried out by actigraphy (Actiwatch AW-64, Mini Mitter Co., Bend, Oregon, USA) for 12 consecutive days, as described previously (Sri Kantha and Suzuki, 2006; Suzuki and Sri Kantha, 2006). In brief, the following definitions were applied as per the Actiwatch manufacturer's instructions: (1) Activity count: an instrument-specific arbitrary unit (AU) quantifying primate activity, computed from any omni-directional motion made by the caged monkey. Though this count is not suitable for determining the absolute activity of the monkey in concrete terms, it is helpful in evaluating comparative activity patterns among the monkeys wearing the Actiwatches from the same commercial supplier. (2) Total sleep time (TST): the cumulative count of time, as measured in minutes in a continuous 24-hour circadian cycle, that was recorded as sleep. As per the algorithm used in the instrument, based on a one-minute sampling epoch, activity counts of 0.40 were recorded as a wake epoch, and activity counts below this threshold were recorded as a sleep epoch. (3) Sleep episode length (SEL): the mean length of blocks of continuous sleep, measured in minutes, falling between two waking bouts, in a 12 h light phase of the 24 h circadian cycle.

The weight of the Actiwatch was only 17 g (approximately one-sixtieth of an owl monkey's body weight) and there were few if any signs of discomfort due to its presence around the monkey's neck. Karyotype analysis was performed as previously reported by Hirai and colleagues (1998). Data were analyzed by a two-tailed Student's *t*-test for independent means for any significant differences. Statistical computations were performed using STATISTICA software (StatSoft, Inc., Oklahoma, USA).

Results

The female parent of these sibling monkeys belonged to *A. azarae* type (2n = 50), and the male parent was of unknown lineage (2n = 53). The karyotype maps of the now-deceased male parent A14 (2n = 53) have already been published (Nagao *et al.*, 2005). Based on the varying karyotype profiles (with diploid numbers 51, 52 and 53) in four of the monkeys in our study and the affiliated taxon data available for owl monkeys (Ford, 1994), these first-generation captive-bred females were confirmed as *Aotus* hybrids. Among these four hybrid females, A40 was an outlier, since karyotype analysis demonstrated that this monkey carried a trisomic condition for its X-chromosomes (data not shown). Though this monkey remains healthy, certain behavioral and physiological differences from the other group members were observed, such as excessive tear formation in the eyes and agitated vocalizations.

Quantified sleep behavior activity data for each of the four *Aotus* hybrids, for 12 consecutive days, are presented in Table 1. Due to its trisomic condition for X-chromosomes, the *Aotus* hybrid 40 monkey's activity-behavioral sleep parameters are of some interest. We recorded the lowest daily activity amount in this trisomic monkey (103 ± 34 AU) and the shortest SEL/12 h light phase (13 ± 5 min) compared to the other three non-trisomic hybrid monkeys, indicating that it may be partially suffering from lethargy and discontinuous sleep phases. The mean SEL of the trisomic hybrid monkey significantly differs from the mean SEL (27 ± 13 min) of non-trisomic hybrid monkeys ($p < 0.01$). Table 2 provides a statistical comparison of group mean variation in behavioral sleep parameters for non-trisomic hybrid and purebred monkeys. Both the TST/24 h and SEL/12 h light phase differed significantly ($p < 0.01$)

Table 1. Measured behavioral sleep-activity parameters in the hybrid owl monkey subjects[1].

Owl Monkey	Behavioral Sleep		Activity
ID number[1] and sex	TST/24 h[2] (min)	SEL/12 h light phase[3] (min)	Mean Activity Counts (arbitrary units)
Non-trisomic			
37 ♀	618 ± 187	23 ± 8	159 ± 108
39 ♀	829 ± 92	40 ± 12	133 ± 49
41 ♀	734 ± 64	18 ± 5	121 ± 49
Trisomic			
40 ♀	730 ± 196	13 ± 5	103 ± 34

[1] Owl monkeys 37, 39, 40 and 41 are siblings, born to wild-born parents of the founder colony.
[2] Total Sleep Time; based on 12 consecutive days of data acquisition.
[3] Sleep Episode Length, determined during the monkey's quiescent (light) phase.

Table 2. Comparison of group mean variation in behavioral sleep parameters for owl monkey non-trisomic hybrids and purebreds.

Parameter	Owl Monkeys[b]		*t*-test (p)
	Non-trisomic Hybrids	Purebreds	
n	3	3	
age range (yr)	11–16	6–16	
TST/24 h (min)[a]	727 ± 150	591 ± 82	< 0.01, df = 70
SEL/12 h light phase (min)[a]	27 ± 13	51 ± 36	< 0.01, df = 70

[a] Mean ± SD.
[b] All monkeys are females.

between the two groups, with the hybrid individuals registering a higher TST/24 h and a shorter SEL compared to the pure breds.

Discussion

One of the females in our study (ID number 40) carries an X chromosome trisomy, detected from karyotype analysis. In the absence of published information on the sleep profiles of *Aotus* hybrids, or trisomic *Aotus*, the marked variation in SEL obtained for the trisomic *Aotus* hybrid monkey is a novel finding. Studies on trisomy among nonhuman primates have been understandably meager, partly due to a very low survival rate of individuals with chromosomal anomalies (Ruppenthal *et al.*, 2004). Nevertheless, the prevalence of significant sleep disturbances among humans suffering from autosomal trisomic conditions (Ellingson and Peters, 1980; Shaffer *et al.*, 1996; Ruppenthal *et al.*, 2004; Segel *et al.*, 2006) provide some clue to the unusually varied behavioral sleep profile recorded for this trisomic *Aotus* hybrid monkey. To conclude, we report significant differences in the TST and SEL parameters between the purebred owl monkeys and the non-trisomic hybrid owl monkeys. In addition, similar to trisomic humans who suffer from sleep irregularities, the SEL and activity data obtained in a trisomic hybrid owl monkey provide indirect evidence to its behavioral irregularity in comparison to non-trisomic hybrid owl monkeys.

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Further Information on Neotropical Monkeys Reported in the XVI[th] Century: Part 2

Bernardo Urbani

This article presents new evidence on the manner in which Neotropical primates were perceived in the 16[th] century (after Urbani, 1999, 2004). It includes several aesthetic and artistic views of New World primates from the early Contact period. The *Florentine Codex* contains the first illustration of human / non-human primate interactions from the New World. Between 1540 and 1585, Friar Bernardino de Sahagún wrote a compendium of 12 books in Nahuatl, Latin and Spanish and illustrated these volumes with the cooperation of local assistants of Aztec descent. This work was the result of interviews with people of Tlatecolco, Tenochtitlán and Texcoco (today, the greater Mexico City metropolitan area). This text is considered one of the major illustrated treatises of the contact period in the New World. A drawing in Book 11 depicts a scene entitled *Captura de monos* ("capturing monkeys"; see Fig. 1). It is a representation of monkeys being lured and captured (Sahagún, 1963). The physical appearance of the primates illustrated suggests they might be spider monkeys (*Ateles geoffroyi*). As described in a previous report (Urbani, 1999), Sahagún indicated in 1555 that the Mexican Amerindians would use monkeys' hands as omens for deciding when to sell their merchandise.

The other representations include early European paintings in which monkeys occupy a principal position posing with nobles. These suggest that Neotropical primates played an interesting role as preferred and "exotic" pets even during the early Contact period. The earliest painting is of Prince Edward of Wales with a marmoset, possibly *Callithrix jacchus* (Fig. 2a; Zuckerman, 1998). It was painted by the German Renaissance artist Hans Holbein (1497–1543), living at that time in Basel, Switzerland. The monkey might have been obtained by some of the English travelers that visited the northeastern part of South America during the 16[th] century (see Ribeiro and Araujo Moreira Neto, 1992). In Fig. 2b, the painting depicts the *Infanta* Isabela Clara Eugenia (1566–1633), daughter of Felipe II and Isabel de Valois, with a common marmoset (*Callithrix jacchus*) (Zuckerman, 1998). This painting by the Spanish Renaissance painter Alonso Sánchez Coello (1531–1588) is the most realistic pictorial representation of any Neotropical primate during the 16[th] century (see other figures in Urbani 1999, 2004, this study). These early European paintings (Figs. 2a and 2b) suggest the existence of an early international network of primate trade; the geographical distribution of these marmosets was a Portuguese territory in the New World (today northeastern Brazil), out of the colonial range of Spain and England.

Finally, Lucas Hombolte (1494–1544) painted a portrait of Catarina de Aragón y Castilla (1509–1533) of Spain with a capuchin monkey (Fig. 2c; Zuckerman, 1998; Fragaszy *et al.*, 2004). It is neither a tufted capuchin nor a white-faced capuchin, but may be either *Cebus albifrons* or *Cebus olivaceus*. Venezuela was the first Spanish territory to be

Figure 1. Obtaining monkeys by the Mexican Amerindians.

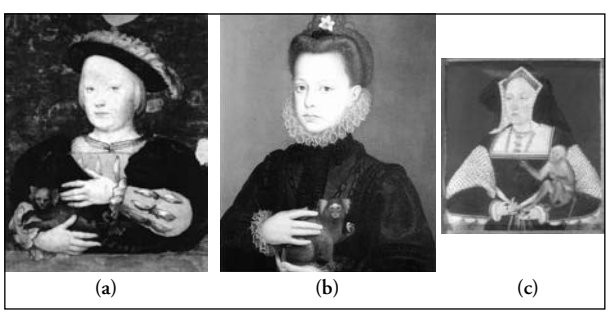

Figure 2. (**a**) Prince Edward of Wales with a marmoset; (**b**) The *Infanta* Isabela Clara Eugenia and a common marmoset; (**c**) Catalina de Aragón y Castilla with a capuchin monkey.