Callimico Species Survival Plan Husbandry Manual

Vince Sodaro, Editor
Chicago Zoological Park

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Brookfield Zoo, 3300 Golf Road, Brookfield, Illinois 60513
U.S.A.

Cover photograph: *Callimico goeldii* in Pando, Bolivia. Photograph by Vince Sodaro

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Preface

Ask a keeper in the Primate Department at Brookfield Zoo to describe a favorite primate to work with, and you might hear guinea baboon or orangutan, gorilla or golden lion tamarin, pygmy slow loris or mandrill. But ask Vince Sodaro and you will most certainly hear callimico. Vince, who has worked at Brookfield Zoo since 1980, has been keenly interested in callimico for most of his professional career and has contributed significantly to our knowledge about their captive care and husbandry.

The publication of this husbandry manual fulfills a personal and professional goal Vince set for himself many years ago. It represents a wealth of knowledge and husbandry expertise that Vince and other animal-care specialists, veterinarians, nutritionists, and researchers have accumulated over the more than 25 years of working with these "enigmatic" neotropical primates in captivity.

Vince's professional focus on improving the health, well-being, and reproductive success of the callimico population in zoological institutions well reflects Brookfield Zoo's commitment to our conservation program for the species. Since the first group of callimico that were confiscated by USFWS and brought to Brookfield Zoo in 1977, we have devoted considerable resources to the species–from determining how to meet their basic needs to managing a conservation breeding program, from supporting field research to developing a conservation education curriculum that has been adopted by a few of the species' range countries in South America.

In the late 1970s, Ben Beck directed the early research at Brookfield Zoo to understand the basic husbandry needs of callimico. In the 1980s, Anne Baker began managing the growing callimico population in North America and established the Callimico SSP at Brookfield Zoo in 1992. I took over the species coordinator role for the SSP in 1996, a position that would seem to be part of the job description for curator of primates at Brookfield Zoo.

The international studbook for callimico came to Brookfield Zoo in 1983, and Mark Warneke, who worked alongside Vince when callimico were still new to our collection, has been its studbook keeper since 1985. Vince is the husbandry advisor for callimico and has not ceased in his pursuit of knowledge pertaining to the species.

The late Sue Crissey was the nutrition advisor for callimico and conducted much of the early research on renal disease in callimico in collaboration with veterinarian Tom Meehan at Brookfield Zoo. Barbara Lintzenich has followed as nutrition advisor with a special interest in health issues related to Vitamin D. Veterinarians at Brookfield Zoo amassed a wealth of medical information and established normal values for callimico, and Jackie Zdziarski served as the first veterinarian advisor for the callimico program.

Keith Winsten, as education advisor to the program, developed the model education curriculum "Monkeys in the Middle," which presents callimico as the primate ambassador of the Amazonian rain forest.

This substantial institutional commitment to *Callimico goeldii* was fostered by and flourished under director George Rabb, who retired from Brookfield Zoo last year.

By 1994, the callimico conservation breeding program became a biregional collaboration between the Callimico SSP, managed at Brookfield Zoo, and the Callimico EEP, coordinated by Gustl Anzenberger at the University of Zurich. This productive cross-pollination of husbandry expertise and population management between Europe and the United States has served to boost our husbandry knowledge and ensure a genetically and demographically healthy population of callimico for both regions.

You will find a wealth of information on callimico in these pages. The format follows the outline for AZA husbandry manuals. In reading this publication, you will undoubtedly come to appreciate why callimico remain an enigma to us all and to better understand why we continue to endeavor to learn about these unusual primates and to strive to improve our ability to meet their specialized needs.

Melinda Pruett-Jones
Species Coordinator, Callimico Species Survival Plan
Curator of Primates
Chicago Zoological Society

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I would like to thank the following people for their support of this manual: Melinda Pruett-Jones, Andrew Baker, the Chicago Zoological Society, and the AZA Neotropical Primate Taxon Advisory Group. Special thanks go to Carol Sodaro for her advice about the trials and tribulations of organizing a husbandry manual. I would also like to thank the following people, who have generously shared their knowledge of callimico with me, both in captivity and in the wild: Gustl Anzenberger, Benjamin Beck, Anita Christen, Beatte Rettberg-Beck, Amy Hanson, Jan Ramer, Carol Sodaro, Mark Warneke, Leila Porter, and Edilio Nacimento.

Contributors

Amy Hanson, Wildlife Conservation Society; Jennifer Langan, D.V.M., Chicago Zoological Park; Maureen Leahy, Chicago Zoological Park; Barbara Lintzenich, Chicago Zoological Park; Vince Sodaro, Chicago Zoological Park; Kristina Vasarhelyi, University of British Columbia; Mark Warneke, Chicago Zoological Park; Jackie Zdziarski, former, D.V.M., Chicago Zoological Park.

The Callimico Species Survival Plan Husbandry Manual contains the best information available from authors who are widely acknowledged for their familiarity with the needs of managed, captive callimicos and the design of faciclities for their care. However the authors make no claim that the recommendations made here apply to all circumstances or are more than generally applicable. The full responsibility for the safe, humane management of callimicos rests entirely with the institutions and individuals charged with their care.

Introduction

Krisztina Vasarhelyi

Callimico goeldii is a South American primate found in the tropical rain forests of the upper Amazon region. *Callimico,* meaning "beautiful little monkey," was first described in 1904 by Oldfield Thomas and named after the Swiss zoologist Emil Goeldi (Hershkovitz, 1977). Morphologically, *Callimico* is a small-bodied species, with wild adults having a mean body mass of 366 grams (n=3) for males and 355 grams (n=5) for females (Encarnación and Heymann, 1998). Martin (1990) reported weights of about 500 grams in captive adult animals, although weights in excess of 800 grams have been attained by adult individuals at Brookfield Zoo (V. Sodaro, pers. comm.). The silky pelage is generally black or blackish-brown (Hershkovitz, 1977). Average body length is about 222 mm, and the length of the tail is about 130% of the length of the body (Rowe, 1996). Goeldi's monkey is generally regarded as monogamous, although the observations from the wild and captivity that are accumulating suggest that more than one breeding female can exist in a group, and group size tends to be slightly greater than that expected for true family units (Martin, 1990). In recent field surveys, groups ranging in size from three to 10 animals and sometimes containing more than one infant were observed, suggesting that *Callimico* may engage in both monogamous and polygynous mating (Christen and Porter, 1999).

Callimico occupies an intermediate position between the two families of New World monkeys (platyrrhines). It shares some features with the true New World monkeys (family Cebidae), such as having three molars instead of two in each tooth row and giving birth to single offspring, and others with the marmosets and tamarins (family Callitrichidae), such as small body size and claws on all digits except the big toe (Martin, 1990). The intermediate position of *Callimico* has led to disagreement regarding their phylogenetic position, and it has been variously assigned to the Cebidae (Simpson, 1945; Simons, 1972; Martin, 1990), the Callitrichidae (Napier and Napier, 1967; Szalay and Delson, 1979; Rosenberger, 1981; Ford 1986; Martin, 1992) or even its own family, Callimiconidae (Hershkovitz, 1977). The incorporation of more recent molecular data tends to support a grouping of *Callimico* within the Callitrichidae as it forms a clade with the marmosets, *Callithrix* and *Cebuella*, to the exclusion of the tamarins *Leontopithecus* and *Saguinus* (Seuanez et al., 1989; Horovitz and Meyer, 1995; Pastorini et al., 1998).

Although some individual variation within the species has been noted, no geographic variation has been reported, and *Callimico goeldii* is generally considered to be the sole species within the genus. Deviations from the regular black and blackish-brown color of the pelage have occasionally been documented. Patches of reddish, gray, or white fur on the head, back, and basal third of the tail have been observed (Hershkovitz, 1977). Several explanations have been proposed for these color variations, such as unseasonal molting, or response to disease, injury, or changed conditions in captivity (Hershkovitz, 1977). So far, there has been no attempt to link these incidental observations to differences in geographic origins of the animals. The results of a recent genetic analysis challenge the view that *Callimico goeldii* is monotypic within the genus. The study of the genetic structure of the founder stock and breeding success within the captive population suggests that the population suffers from significant outbreeding depression (Vasarhelyi, 2000), as well as from the already recognized inbreeding depression (Lacy, et al., 1993).

Geographically, *Callimico* is distributed in the upper Amazon region spanning southern Colombia, northern Bolivia, eastern Peru and Ecuador, and western Brazil (Herskovitz, 1977). By nature, *Callimico* is quieter and tend to exhibits more cryptic behavior than other platyrrhines (Christen and Porter, 1999). While these characteristics contribute to difficulties in locating the animals, there are strong indications that the species is vulnerable and may be disappearing. Several field surveys have been carried out in the Pando Department of Bolivia (Buchanan, 1991; Izawa, 1979; Masataka, 1981a; Masataka, 1981b; Pook and Pook, 1981; Pook and Pook, 1982; Christen and Geissmann, 1994; Christen, 1998). Animals could not reliably be located in the same regions in successive surveys. The home range of *Callimico* has recently been estimated to be 150 ha, which is substantially larger than previously thought and also considerably larger than home ranges of sympatric tamarin species (Christen and Porter, 1999). The large range may be a factor in the apparently sparse distribution of the species. Nonetheless, *Callimico* is known to be hunted, and they are also a species favored as pets. These activities can subject the population to pressures that it may not be able to withstand. Based on available information, *Callimico* are considered in need of protection according to the IUCN categories for endangered species (Baille and Groombridge, 1996).

In captivity, *Callimico* is maintained within the framework of an international breeding program. The captive population of *Callimico* is similar in its origins to a number of other captive populations (Lacy et al., 1993) in that it stems primarily from confiscated animals that were intended for illegal trade. Consequently, little information is available about the wild-caught founders. The first known wild-caught *Callimico* to be acquired by a zoo in Europe was an individual received by the London Zoo in 1915, while the first to reach a North American zoo was one that was acquired by the National Zoo in 1938. Both of these individuals were short-lived and thereafter it was not until about 1954 that additional specimens began to arrive in zoos. A studbook for the captive population was established in 1970, but it was not actively maintained prior to 1983. It is presently located at the Chicago Zoological Society. There are 103 wild-caught animals listed in the studbook. Of these, 57 animals bred successfully in captivity.

References

Baille, J., and B. Groombridge. 1996. IUCN Red List of Threatened Animals. IUCN, Gland, Switzerland.

Buchanan-Smith, H. 1991. Field observations of Goeldi's monkey, *Callimico goeldii,* in northern Bolivia. *Folia primatalogica,* 57:102-105.

Christen, A. 1998. The most enigmatic monkey in the Bolivian rain forest- *Callimico goeldii. Neotropical Primates* 6(2):35-37.

Christen, A., and T. Geissmann. 1994. A primate survey in Northern Bolivia, with special reference to Goeldi's monkey, *(Callimico goeldii). International Journal of Primatology,* 15:239-274.

Christen, A. and L. Porter. 1999. Field surveys of Goeldi's monkey in northern Bolivia. Primatology and Anthropology Into the Third Millenium: Abstracts of the Centenary Congress of the Anthropological Institute and Museum in Zurich. University of Zurich, Zurich.

Encarnación, F., and E. Heymann. Body mass of wild *Callimico goeldii. Folia primatologica,* 1998;69:368-371.

Ford, S.M. 1986. Systematics of the New World Monkeys. In: *Comparative Primate Biology: Systematics, Evolution and Anatomy,* eds.: D.R. Swindler and J. Erwin, volume 1, pp. 73-135, Alan R. Liss, New York.

Hershkovitz, P. 1977. *Living New World Monkeys (Platyrrhini).* The University of Chicago Press, Chicago.

Horovitz, I., and A. Meyer. 1995. Systematics of New World monkeys (Platyrrhini. Primates) based on 16S mitochondrial DNA sequences: a comparative analysis of different weighting methods in cladistic analysis. *Molecular Phylogenetics and Evolution,* 4:448-456.

Izawa, K. 1979. Studies on peculiar distribution of *Callimico. Kyoto Overseas Research Reports of New World Monkeys,* 1:1-19.

Lacy, R.C., A. Petric, and M. Warneke. 1993. Inbreeding and outbreeding in captive populations of wild animal species. In: *The Natural History of Inbreeding and Outbreeding,* ed. Nancy Wilmsen Thornhill, pp. 352-374, The University of Chicago Press, Chicago and London.

Martin, R.D. 1990. *Primate Origins and Evolution: A Phylogenetic Reconstruction.* Princeton University Press, Princeton, New Jersey.

-------. 1992. Goeldi and the dwarfs: the evolutionary biology of the small new world primates. *Journal of Human Evolution,* 22:367-393.

Masatak, N. 1981a. A field study of the social behavior of Goeldis' monkey (*Callimico goeldii*) in north Bolivia I. Group composition, breeding cycle, and infant development. *Kyoto Overseas Research Reports of New World Monkeys* 2:23-32.

-------. 1981b. A field study of the vocalizations of Goeldi's monkey (*Callimico goeldii*) in north Bolivia II. Grouping pattern and intragroup relationship. *Kyoto Overseas Research Reports of New World Monkeys* 2:33-41

Napier, J.R., and P. H. Napier. 1967. *A Handbook of Living Primates.* Academic Press, London.

Pastorini, J., M.R. Forstner, R. Martin, and D. Melnick. 1998. A reexamination of the phylogenetic position of *Callimico* (Primates) incorporating new mitochondrial DNA sequence data. *Journal of Molecular Evolution,* 19:175-208.

Pook, A.G., and G. Pook. 1981. A field study of the socio-ecology of the Goeldi's monkey *(Callimico goeldii)* in northern Bolivia. *Folia primatologica,* 35:288-312.

-------. 1982. Polyspecific association between *Saguinus fuscicollis, Saguinus labiatus, Callimico goeldii* and other primates in north-western Bolivia. *Folia primatologica,* 30:196-216.

Rosenberger, A.L. 1981. Systematics: the Higher Taxa. In: *Ecology and Behavior of Neotropical Primates I,* eds. A.F. Coimbra-Filho, and R.A. Mittermeier, Vol. 1, Academia Brasileira da Ciencias, Rio de Janeiro, pp. 9-27.

Rowe, N. 1996. *The Pictorial Guide to the Living Primates.* Pogonias Press, East Hampton, New York.

Seuanez, H.N., L. Forman, T. Matayoshi, and T. G. Fanning. 1989. The Callimico goeldii (Primates, Platyrrhini) genome: karology and middle repetitive {(Line-1) DNA} sequences}. *Chromosoma.* 98:389-395.

Simons, E.L. 1972. *Primate Evolution: An Introduction to Man's Place in Nature.* Macmillan, New York.

Simpson, G.G. 1945. The principles of classification and a classification of mammals. *Bulletin of the American Museum of Natural History* 85:1-350.

Szalay, F.S., and E. Delson. 1979. *Evolutionary History of the Primates.* Academic Press, New York.

Vasarhely, K. 2000. Genetic variation and its correlates in the captive population of Goeldi's Monkey (*Callimico goeldii*). Ph.D. Thesis. University of Zurich, Switzerland.

The History of Goeldi's Monkeys *(Callimico goeldii)* in Captivity

Mark Warneke

The first record of a captive callimico is at the Para (Goeldi) Museum in 1912. The United States' National Zoo held a callimico in 1938, which is the first recorded instance of a captive animal outside of its native South America. A few additional specimens trickled into North American collections in the 1950s at the Wildlife Conservation Society, in New York, United States, and again at the National Zoo, but there was no reproduction. The Frankfurt Zoo in Germany was the first European zoo documented to exhibit callimico. Frankfurt and Oak Ridge Associated Universities in Tennessee, United States, both recorded births in 1965 and 1966. Oak Ridge and the San Diego Zoo had the first studbook-recorded births that survived more than a year. It should be noted here that animals held in both Germany and in the United States by Rainer Lorenz, a pioneer in studying callimico behavior and reproduction in captivity, have largely eluded our efforts to document them well enough to register them in the studbook. The origin of twin callimicos described by Hill (1966) is also obscure.

In 1973, Oak Ridge recorded a full second generation, but prior to 1975, only the Frankfurt Zoo was able to sustain a reproductive colony, and that was mainly due to the contributions of wild-caught animals. Between 1975 and 1977, five European institutions--the Durrell Wildlife Preservation Trust and the Bristol Zoo in the United Kingdom, the Stuttgart and Cologne Zoos in Germany, and Apenheul Nature Park in the Netherlands--imported callimicos, and all were able to establish successful longer-term breeding programs (Carroll, 1982). About the same time--July 1977-- the United States Fish & Wildlife Service confiscated five pairs of callimico illegally brought to the United States through Miami, Florida. These animals were all placed on indefinite loan to the Chicago Zoological Society, United States (Beck et al., 1982).

Brookfield Zoo had held the species as early as 1968 but did not record a birth until receiving these confiscated animals. All 10 founding individuals, as well as a male obtained on breeding loan from Oklahoma City Zoo, went on to produce offspring, and the Chicago Zoological Park's role in callimico conservation was started. The Japan Monkey Center in Inuyama, Japan, obtained callimico in 1975, and there is now a healthy population becoming established in a few Japanese institutions. By the 1980s, second and higher captive generation births were relatively common in captivity.

The international studbook was originally proposed in 1969 by Dr. Rainer Lorenz, then at the Delta Regional Primate Center in Covington, Louisiana, and he was named studbook keeper in 1970. Dr. Lorenz left the Delta Regional Primate Center in 1976, and the studbook remained inactive until 1983, when it was transferred to the Chicago Zoological Park with Beate Rettberg as studbook keeper. When Ms. Rettberg left the Chicago Zoological Park in 1985, the studbook was transferred to Mark Warneke at the same institution. The SSP was established at Brookfield Zoo with Anne Baker, then at Brookfield Zoo, as the first coordinator in 1992. In 1995, Melinda Pruett-Jones took over the coordinator role. An EEP was established by Bryan Carroll, then at the Durrell Wildlife Trust, in 1990. Leadership of the Callimico EEP was transferred to Gustl Anzenberger at the University of Zurich in 1993. The European and North American populations of callimico are now managed in a joint effort. In 2001, the Japanese Association of Zoos appointed Kazuhito Matsumoto, of the Chiba Zoological Park, as regional studbook keeper for callimico in Japan.

References

Beck, B., D. Anderson, J. Ogden, B. Rettberg, C. Brejla, R. Scola, and M. Warneke. 1982. Breeding the Goeldi's monkey *Callimico goeldii* at Brookfield Zoo. *International Zoo Yearbook* 22:106-114.

Carroll, B., 1982. Maintenance of the Goeldi's monkey, *Callimico goeldii* at Jersey Wildlife Preservation Trust. *International Zoo Yearbook*, 22: 101-105.

Hill, W.C.O., 1966. On the neonatus of *Callimico goeldii* (Thomas), *Proc. Royal Soc. Edinburgh*, Sec. B, Vol 69.

Housing of Callimico in Zoological Parks

Vince Sodaro

The housing, management, and husbandry techniques that have been used for callimicos in zoological institutions have traditionally been quite similar to those that have been used for successfully maintaining marmosets and tamarins (Mallinson, 1976; Carroll, 1982; Beck et al., 1982; Price et al., 1999). In general, the similarities in size, social structure, and space requirements of callimico to those of other callitrichid species make callimico well-suited to the methods of care that were originally developed for *Callithrix, Leontopithecus,* and *Saguinus.*

Materials

A variety of materials suitable for construction of cages for callitrichids have been described (Mallinson, 1975; Xanten, 1990; Gengozian et al., 1978). In off-exhibit areas where aesthetics are not a consideration, enclosures are frequently constructed of wooden framing with steel or wire mesh (Beck et al., 1982; Snowden, et al., 1985). Wire mesh cage fronts can facilitate sexing of young animals, diagnosing of pregnancy, and easy observation of animals (Rettbeg-Beck, 1990). Cages constructed of wood should be sealed. USDA regulations require that interior building surfaces of nonhuman primate facilities be impervious to moisture so that they may be readily sanitized (USDA, 1992). In general, porous materials of all features of the enclosure and other than replaceable features such as tree branches should be avoided.

Many modern zoological exhibits are constructed of textured rockwork (concrete or epoxy) to create a naturalistic appearance. Trees, vines, and other features of these exhibits may also be constructed of epoxy or concrete. These exhibits are often glass- or wire-fronted with fine semi-transparent mesh.

Enclosures

Hampton et al. (1965) provided the first description of housing provided for callimico (as well as *Saguinus* species) housed in a biomedical facility at Tulane University, New Orleans, Louisiana. Other detailed descriptions of enclosures for callimico were later provided by Lorenz (1969, 1972), Arentsen (1977), Carroll (1982), and Beck et al. (1982). The space requirements needed to maintain socially well-adjusted breeding groups of callimico are relatively modest and are similar to the minimum cage size of 3 x 2 x 2.5m recommended by both the Golden Lion Tamarin Management Committee (Rettberg-Beck, 1990) and the Cotton-Top Tamarin SSP© (Savage, 1995). Breeding pairs with as many as five offspring at Brookfield Zoo have been housed together for extended periods of time in enclosures measuring 8’8” x 4’3” x 8’10” high, but the chances of successfully housing larger groups together can be considerably enhanced by providing larger enclosures.

Wherever possible, the primary furnishings in callimico enclosures should consist of natural tree branches arranged to create a variety of arboreal pathways leading to all of the principle features within the enclosure, including nestboxes or sleeping sites, shelving, and food and water bowls. Furnishings should include both rigid and flexible, vertical and horizontal supports of varying diameters placed at varying angles. Avoid placing branches directly above food or water sources to minimize the chance of contamination from urine and feces. Callimico are adept at climbing or locomoting on diagonal or vertical branches, but they prefer level furnishings for resting and social activities. Horizontal branches should be a minimum of 1.5” in diameter but preferably 3-4” to allow the animals to sit or rest comfortably and to engage in normal social interactions, such as grooming.

In addition to branches provided as cage furniture, shelving on the sides, front, or back of the enclosure may also be provided. Shelves increase the usable surface area within the enclosure and provide places where food and water bowls and behavioral enrichment items may be offered.

Managers wishing to provide optimal enclosures or exhibits might wish to design such exhibits based on aspects of behavioral ecology and patterns of locomotion that have been observed in studies of callimico in their natural habitat. The species is confined to areas of rain forest in the upper Amazon region in Colombia, Ecuador, Peru, Brazil, and northern Bolivia and seems to have a preference for areas in which dense undergrowth and stands of bamboo occur (Buchanan-Smith, 1991). Pook and Pook (1981) found that callimico in northern Bolivia showed a strong preference for traveling, foraging, and resting in the understory of the forest and were observed traveling at heights of less than 5m off the ground during 72 of 82 observations. Izawa (1979) also reported a tendency for callimico to remain in the lower layers of the forest. Nevertheless, the species is not averse to ascending to greater heights within their forest habitat and has been observed at heights of approximately 12m while feeding on fruit (Buchanan-Smith, 1991).

Field observations have revealed that callimico show a tendency to travel and locomote in the understory by vertical clinging and leaping between the trunks of trees (Moynihan, 1976). Pook and Pook (1981) also noted this mode of locomotion during travel and reported that the species is capable of leaps of up to 4m from one vertical support to another without losing height.

A naturalistic exhibit designed to replicate the natural habitat of callimico might therefore contain a variety of vertical tree trunks; low-growing, shrub-like vegetation; and suitable horizontal supports on which animals can rest and groom. Heights of 5m or less are sufficient.

Although Lorenz (1972) stressed the importance of providing nestboxes for callimico to sleep in, and as a place of security, Beck (1982) and Carroll (1982) noted that callimico rarely slept in nestboxes. Pook (1975) concurred with these observations and noted that callimico at the Jersey Zoological Park tended to sleep on top of their nestboxes. In a questionnaire pertaining to callimico husbandry sent to 33 European zoological parks in 2001 (Appendix I), 25 respondents reported that they provided their callimico with nestboxes. Of these, eight reported that their callimico did not use them, while two other institutions did not provide nestboxes because they had found that the animals did not use them. Nevertheless, callimico will use nestboxes to hide in when stressed or startled, and it is recommended that at least one nestbox per pair or family group be provided. The entrance should be large enough to allow an adult carrying offspring to easily enter or exit. The nestbox should be located in the upper third of the enclosure.

A variety of substrates may be used in enclosures. Both the Golden Lion Tamarin Management Committee (Rettberg-Beck, 1990) and the Cotton-Top Tamarin SSP© recommend the use of soil or other natural absorbent materials, such as bark or mulch, that can be removed for appropriate hygiene. In the previously mentioned callimico husbandry questionnaire (Appendix I), several institutions reported the use of various substrates, such as bark chips, wood chips, and a 50/50 mixture of pulped coconut husks and bark chips. Chamove et al. (1982) found that the use of deep woodchip litter in enclosures used to house *Macaca arctoides* at the Edinburgh Zoological Gardens inhibited the growth of disease-producing bacteria, such as salmonella, when the litter was allowed to compost and break down over the a period of several weeks.

Protocols for cleaning and disinfecting nonhuman primate enclosures, including those of callimico, vary greatly between institutions in North America and may be dictated by tradition, practicality, time constraints, veterinary staff recommendations, the presence of various pathogens, whether the enclosure is indoor or outdoor, etc. Cleaning regimens in European institutions that house callimico are likewise extremely varied, with the frequency of cleaning ranging from daily to as long as six to eight months between cleanings. The frequency with which enclosures are disinfected is similarly varied and ranges from daily to once per year or never (Appendix I). There is therefore no strict rule of thumb as to the optimal method for cleaning and disinfecting callimico enclosures. Many institutions that maintain callitrichid species clean and replace branches, perches, and other features of enclosures infrequently to retain scent-mark secretions (DuMond, 1972; Stevenson, 1975; Beck et al., 1982; Young and Carroll, 1993). Rettberg-Beck (1990) recommend “spot” cleaning feces and food remains for *Leontopithecus rosalia* as opposed to major cleaning. Still, it is important to integrate such practices with effective cleaning and disinfecting protocols to minimize the risk of pathogenic infections.

Temperature and Humidity Requirements

During a field study of callimico conducted by Porter (2000) in northern Bolivia from April 1998 to March 1999, temperatures ranged from an average maximum of 29.9°C (85.82°F) to an average minimum of 21.2° (70.1°F). Occasional cold fronts lowered the minimum temperature to 13°C (55°F) or lower for several days. The species' geographical range in the wild lies entirely within the humid tropics. Nevertheless, observations on captive animals given access to outdoor enclosures have shown that callimico have a remarkable tolerance for temperatures considerably lower than the minimum of 13°C recorded by Porter when provided with supplemental heating and protection from drafts. Lorenz (1972) reported that callimico that were not provided with nestboxes slept alone or in clusters on a board at temperatures as low as 0°C (32°F) and remained in excellent health. Animals at the Jersey Wildlife Preservation Trust, where temperature varies between about 32°C in summer and –5°C in winter, were given outdoor access during the day unless there was ice or snow on their perches. During summer months, groups were given constant access (Carroll 1982). Despite these cases, prolonged exposure to temperatures below 70°F is not recommended. Lorenz (1969) recommended a range of 70° to 77°, while animals housed in a colony at Brookfield Zoo were maintained at a temperature of 77° (Beck et al., 1982).

Lorenz (1972) also reported decreased activity in callimico at temperatures above 28°C (82°F) and found that they become lethargic at temperatures above 35°C (95°F). The sparsely furred chest, abdomen, and inner thighs of callimico may serve as a thermo-regulatory adaptation for the species to aid in dissipation of heat. Animals in captivity and in the wild will often sprawl on horizontal branches with the chest and abdomen in contact with the branch during times of extreme heat (pers. obs.).

The species is fairly tolerant of extremes in humidity but seems to exhibit noticeably dry, whitish, and sometimes flaky skin at humidity levels below approximately 40%. Beck et al. (1982) found that humidity levels below 60% caused callimico to wipe their faces on cage surfaces and to sneeze excessively, while higher humidity levels resulted in saturated pelage and swollen eyes.

Photoperiod

The distribution of Callitrichids in the Neotropics, where little variation in day length occurs, has led several authors to recommend a 12L:12D photoperiod (Snowden et al., 1985; Stevenson, 1975; Savage, 1995; DuMond, 1972). Beck et al. (1982) preferred a photoperiod of 14L:10D and found that during the early years of the Brookfield Zoo colony, animals were prevented from adequate food consumption if given less than fourteen hours of "daylight." However, changes in feeding times for callimico at Brookfield Zoo over the years from 1990 to the present have allowed a shift to 12L:12D, which is sufficient for adequate consumption of diet.

Feeding

The nutritional aspects and management guidelines for callimico diets are addressed in a separate chapter of this manual (see Nutrition and Diet) and will not be addressed here.

Callimico should be fed at least twice daily. A morning meal should be offered as early in the day as possible, and animals should be given adequate time to eat undisturbed prior to keeper activities such as cleaning of enclosures. Family groups of four or more animals should be provided at least two food bowls at widely spaced locations within an enclosure to ensure that subordinate animals can feed without interference from dominant group members. Fresh water should be offered daily.

Callimico are, in general, rather finicky eaters. They tend to have a preference for fruits and insects and to poorly consume green vegetables such as green peppers, green beans, brussels sprouts, okra, celery, and parsley. It is often difficult to transition adult animals to new diets or unfamiliar food items. Commercially raised hairless mouse pups ("pinkies") should not be offered due to the potential risk of infection with viral callitrichid hepatitis.

General Housing Considerations

Callimico in the wild are shy and cryptic and occur at low densities per square kilometer, often more than a kilometer away from the nearest neighboring group. Their behavior in a captive setting also reflects these characteristics. They thrive on strict routine and are easily stressed by changes in keeper staff, loud noises, transfers to new enclosures, and visual access to other callimico groups or individuals.

Institutions that hold more than one group of callimico should prevent groups from having visual access to each other. Animals that are allowed to see each other will direct intense territorial displays at each other, which, in turn, creates a stressful situation for all animals involved. Auditory contact between groups that cannot see each other does not seem to be stressful to callimico, although individuals will often respond to each others' long calls.

Wherever possible, keepers caring for callimico should attempt to get as close of a visual inspection of the animals as possible on a daily basis. In enclosures with wire meshing, this is easily accomplished by encouraging individuals to cling to the mesh to accept raisins, mealworms, or other small treats at the first a.m. check of the animals. A close-up frontal view of individuals will allow keepers to check for signs of pregnancy in females, weight loss or weight gain, injuries, or signs of illness.

References

Arentsen, D. 1977. *Callimico goeldii* at Bristol Zoo. *Ratel,* 4(2-3): 13-15.

Beck, B.B., D. Anderson, J. Ogden, B. Rettberg, C. Brejla, R. Scola, M. Warneke. 1982. Breeding the Goeldi's monkey *Callimico goeldii* at Brookfield Zoo, Chicago. *International Zoo Yearbook,* 22:106-114.

Buchanan-Smith, H.M. 1991. Field observations of Goeldi's monkey, *Callimico goeldii* in northern Bolivia. *Folia primatologica,* 57:102-105.

Chamove, A.S., J.R. Anderson, S.C. Morgan-Jones, and S.P. Jones. 1982. Deep woodchip litter: hygiene, feeding, and behavioral enhancement in eight primate species. *International Journal for the Study of Animal Problems,* 3:308-318.

Cotton-top Tamarin SSP ©1995. In: *Cotton-top Tamarin SSP© Husbandry Manual,* ed. A. Savage, pp. (V) 1-15. Providence, Roger Williams Park Zoo.

DuMond, F. 1972. Recommendations for a basic husbandry program for lion marmosets. In: *Saving the Lion Marmoset,* ed. D. Bridgewater. Wheeling, WV:WAPT.

Gengozian, N., J.S. Baston, and T.A. Smith. 1978. Breeding of marmosets in a colony environment. In: *Primates in Medicine Volume 10,* eds. E.I. Goldsmith and J. Moor-Jankowski, pp. 71-78. Karger: Basel.

Hampton, J.K., Jr., S.H. Hampton, and B.T. Landwehr. 1965. A special breeding cage for small primates such as marmosets. *Laboratory Animal Care* 15:178-183.

Izawa, K. 1979. Studies on peculiar distribution of Callimico. *Kyoto Overseas Research Reports of New World Monkeys,* 1:1-19.

Lorenz, R. 1969. Notes on the care, diet and feeding habits of Goeldi's monkey *Callimico goeldii. International Zoo Yearbook,* 9:150-155.

---------. 1972. Management and reproduction of the Goeldi's monkey, *Callimico goeldii* (Thomas, 1904), Callimiconidae, Primates. In: *Saving the Lion Marmoset,* ed. D.D. Bridgewater, pp. 92-109. Wheeling, WV:WAPT.

Mallinson, J. 1975. The design of two marmoset complexes at the Jersey Zoological Park. *Jersey Wildlife Preservation Trust Annual Report,* 12:21-26.

Moynihan, M. 1976. *The New World Primates*. Princeton University Press, Princeton, New Jersey.

Pook, A.G. Breeding Goeldi's monkey, *(Callimico goeldii)* at the Jersey Zoological Park. *Jersey Wildlife Preservation Trust Annual Report,* pp.17-20.

Pook, A., and G. Pook. 1981. A field study of the socio-ecology of the Goeldi's Monkey *(Callimico goeldii)* in northern Bolivia. *Folia primatologica,* 35:288-312.

Porter, L.M. 2000a. *Callimico* and *Saguinus:* Dietary differences between sympatric callithricines in northern Bolivia. *.American Journal of Primatology,* 51, Supplement 30, page 252.

Price, E.C., S. Herron, D. Wormell, and M. Brayshaw. 1999. Getting primates to eat pellets: The nutrition of New World monkeys at Jersey Zoo. *Dodo*, 35:57-66.

Rettberg-Beck, ed. 1990. *Husbandry protocol for golden lion tamarins (Leontopithecus rosalia rosalia)*. Washington, D.C.: National Zoo.

Snowden, C.T., A. Savage, and P.B. McConnell. 1985. A breeding colony of cotton-top tamarins *(Saguinus oedipus)*. *Laboratory Animal Science*, 35(5):477-480.

Stevenson, M. 1975. Maintenance and breeding of the Common Marmoset *Callithrix jacchus* with notes on hand-rearing. *International Zoo Yearbook*, 16:110-116.

United States Department of Agriculture (USDA). Animal and Plant Inspection Service *Subchapter A—Animal Welfare; Subpart D—Specifications for the Humane Handling, Care, Treatment and Transportation of Nonhuman Primates*, October 1992.

Young, J.A., and B. Carroll. 1993. The genus *Leontopithecus* in captivity at the Jersey Wildlife Preservation Trust. In: *Marmosets and Tamarins in Captivity (Proceedings of Sympsium 17 of Association of British Wild Animal Keepers)*, ed. R. Colley, pp. 23-30. Bristol: Association of British Wild Animal Keepers.

Xanten, W.A. 1990. Marmoset behavior in mixed-species exhibits at the National Zoological Park, Washington. *International Zoo Yearbook*, 29:143-148.

Appendix I: A Survey of Husbandry Practices for Callimico in European Zoological Institutions

Respondents to Callimico Husbandry Survey

Aalborg Zoo, Denmark
Allwetter Zoo, Germany
Barcelona Zoo, Spain
Colchester Zoo, England
Combe Martin Wildlife Park, England
Cricket St. Thomas Wildlife Park, England
Dierenpark Wissel, Netherlands
Dortmund Zoo, Germany
Dresden Zoo, Germany
Drusilla Park Zoo, England
Dublin Zoo, Ireland
Gotlands Djurpark, Sweden
Helsinki Zoo, Finland
Karlsruhe Zoologischer Garten, Germany
Lisbon Zoo, Portugal
London Zoo, England
Marwell Zoological Park, England
Olands Djurpark, Sweden
Olomouc Zoo, Czech Republic
Paignton Zoo, England
Parc Zoologique de Lille, France
Santillana del Mar Zoo, Spain
Shaldon Wildlife Trust, England
Skansen Zoo, Sweden
Szedeg Zoo, Czech Republic
Tierpark Dählhölzli, Switzerland
Walter Zoo, Switzerland
Welsh Mountain Zoo, Wales
Wilhelma Zoo, (Stuttgart) Germany
Zoo D'Asson, France
Zooparc de Beauval, France
Zoologicka Zahrada Jihlava, Hungary
Zurich Zoo, Switzerland

Responses to Questions Asked in the Survey

1. Are your animals housed in a colony-type facility? If so, please describe.

Most of the respondents to the survey seemed to not understand what was meant by the expression "colony-type facility," although the responses to the question suggested that few, if any, of the institutions house their animals in such a facility. The Anthropological Institute at Zurich, Switzerland, is the only other institution that definitely houses multiple groups of *Callimico*, along with *Callithrix jacchus* and *Cebuella pygmaea*, in a colony-type facility. In October of 2000, the facility held 39 animals housed in nine groups. Responses to the question were as follows:

Aalborg Zoo: "We house five species/families of callitrichidae."
Allwetter Zoo: A group of 4.2 and a group of 0.3 housed in the same facility.
Dierenpark Wissel: One group of 2.1.1 housed in same building with a group of *Calllithrix penicillata.*
London Zoo: Two *Callimico* groups housed in a Small Mammal section that also houses other small monkeys.
Marwell Zoo: Two *Callimico* pairs, one of which has a baby, that can't see each other and probably can't hear each other.
Paignton Zoo: One group with golden lion tamarins in next enclosure.
Parc Zoologique de Lille: One group housed in a "Tropical House" that also houses other Callitrichid species.
Shaldon Wildlife Trust: One group (pair plus offspring) in a building with other Callitrichid species.

2. How many groups do you house in such a facility?

Allwetter Zoo, London Zoo, and Marwell Zoo were the only institutions that reported having more than one pair of *Callimico.* The Anthropological Institute at Zurich, Switzerland, houses nine groups of *Callimico* within a single building.

3. Do you house multiple groups of *Callimico* within visual contact with each other? If so, do these groups successfully reproduce?

Only Allwetter Zoo responded that it has separate groups that are within visual contact of each other, with a distance of 5 meters between the two groups. The one group consists of 0.3 animals, but the other group of 4.2 successfully reproduced in the presence of the other group.

4. Do you house multiple groups of *Callimico* within auditory contact of each other?

None of the institutions reported housing multiple groups within auditory contact of each other, but the groups at the Anthropological Institute at Zurich, Switzerland, are within auditory contact of each other.

5. Do you have *Callimico* groups that you feel should be breeding and reproducing but don't? If so, do you have an explanation for why they failed to reproduce?

Allwetter Zoo, Cricket St. Thomas, and Lisbon Zoo reported that they have pairs that failed to reproduce. Allwetter stated that its pair of 1.1 "stopped reproduction at the age of 10 yrs. (male) and 8 yrs. (female) – too young." Cricket St. Thomas stated that its breeding female "becomes pregnant but loses the infants pre-parturition." Lisbon offered no explanation of the circumstances of its pair that failed to reproduce.

6. Are your *Callimico* on display in public areas of your institution?

Dortmund and Santillana were the only institutions that don't have their *Callimico* on display in public areas.

7. If they are on display, do they have access to an off-exhibit area or are they kept on exhibit at all times?

Of 28 total responses to this question, 11 institutions stated that their *Callimico* are on exhibit at all times, and six stated that their animals have access to off-exhibit areas. Six responses were ambiguously answered "yes" or "no." Three institutions responded that the enclosures offered areas in which the animals could hide from public view.

Aalborg	On exhibit at all times.
Allwetter	On exhibit at all times.
Barcelona	On exhibit at all times.
Colchester	On exhibit at all times.
Combe Martin	On exhibit at all times.
Cricket St. Thomas	Off exhibit area available.
Dierenpark Wissel	Yes.
Dresden	Off exhibit area available.
Drusilla Park	Off exhibit area available.
Dublin	On exhibit at all times.
Gotlands	"Possibility of hiding."
Helsinki	"Have inside enclosures; when the offspring are young, the group has access there at all times."
Karlsruhe	Yes.
Lisbon	Yes.
London	Yes.
Marwell	One pair has off-exhibit area, one pair has dense plantings to hide in.
Olands	No.
Olomouc	Yes.
Paignton	On show 10:00-18:00 hrs.
Parc Zoologique de Lille	Have access to off-exhibit area.
Shaldon	Have access to off-exhibit area.
Skansen	On exhibit at all times.
Szedeg Zoo	On exhibit at all times.
Tierpark Dählhölzli	"They may go up to the roof where they are alone."
Walter Zoo	On exhibit at all times.
Wilhelma	On exhibit at all times.
Zoo D'Asson	"Indoor facilities are out of public view."
Zoo Beauval	On exhibit at all times.
Zurich Zoo	Have access to an off-exhibit area.

8. Have you ever attempted to house your *Callimico* in mixed-species situations with other species of primates or other animals (mammals, birds, reptiles, other)? Please list species that you have successfully housed with *Callimico.*

Allwetter Zoo	*Bufo marinus, myoprocta pratti, Testudo carbonaria.*
Cricket St. Thomas	Oriental white-eyes, white-cheeked touraco, red-rumped caciques, peacock pheasant sp.
Dierenpark Wissel	*Callithrix penicillata.*
Dortmund Zoo	*Myoprocta pratti, Pithecia pithecia, Dasypus novemcinctus.*
Dublin Zoo	Bare-faced curassow *(Crax fasicolata), Leontopithecus rosalia,* Green iguana *(Iguana iguana).*
Helsinki Zoo	Wild cavy.
Karlsruhe	Wild cavy.
London Zoo	Green acouchi *(Myoprocta pratti).*
Marwell Zoo	One pair with pair of *Leontopithecus chrysomelas,* one pair with female *Leontopithecus rosalia,* and a pair of agoutis *Dasyprocta.*
Parc Zoologique de Lille	*Callithrix pygmaea, Testudo graeca, Testudo hermanni.*
Shaldon Zoo	Acouchi *(Myoprocta pratti)*; handreared male *Callimico* has been successfully mixed at various times with *Saimiri* sp.; lion tamarins.
Skansen	*Callithrix pygmaea,* iguanas, were previously mixed with tortoises.
Walter Zoo	Kinkajou *(Poto flavus), Aotus griseimembra,* American alligator *(Alligator mississippiensis),* green iguana *(Iguana iguana),* several species of turtles and tortoises, ducks, perching birds, touracos.
Welsh Mountain Zoo	Single male *Callimico* with a male *Saguinus oedipus* and a male *Callithrix argentata.*
Wilhelma	Two-toed sloths, mountain paca.

9. What are the approximate dimensions of the enclosures in which your *Callimico* are housed?

Aalborg Zoo	Inside: 5.8m^2 / 18.4m^3.	Outside: 20m^2 / 28m^3.
Allwetter Zoo	Two separate enclosures: L 7m x W 3m x H 3.5m, 5m x 5m x 4m.	
Barcelona Zoo	Two enclosures of 2m x 2m x 1.40m (high 2m). The enclosure is 90 cm above ground level.	
Colchester Zoo	Outside enclosure: L 5m x W 5m x H 3.5m. Indoor enclosure: L 3m x W 2m x H 2m.	
Combe Martin	Indoor: 8' x 6'.	Outdoor: 10' x 10'.
Cricket St. Thomas	100 ft x 40 ft x 15-20 ft.	
Dierenpark Wissel	Inside: 2m x 15m^2.	Outside: 50m^2.
Dortmund Zoo	Two separate groups of *Callimico,* each of which have indoor and outdoor enclosures. Indoor: 4m x 3.3m x 2.8.	Outdoor: 4.5m x 4.5m x 2m. Indoor: 2.3 x 0.8m x 7m,
Dresden Zoo	2m^2 x 2.5m high.	
Dublin Zoo	Inside: 5m x 3m.	Outside: 5m x 2m.
Drusilla Park	Inside: L 3m x W 1m x H 2m.	Outside: L 3.1m x W 2.2m x H 2m.
Helsinki Zoo	12m^2 x 4m high.	
Karlsruhe	Inside: 20m^2 x 3m high.	Outside: 50m^2 x 5m high.
London Zoo	L 14’ x W 7’ x H 6’.	
Lisbon Zoo	Approx. 3m x 5m x 3m.	
Marwell	Two separate groups/enclosures: 5m x 20m x 3m high, 3m x 3m x 3m.	
Olands Djurpark	Inside: 10m^2.	Outside: 15m^2. Night area: 3m.
Oloumouc Zoo	2m x 3m x 3m.	
Paignton Zoo	Inside: L 2m x W 2.5m x H 2.5m.	
Parc Zoologique de Lille	L 3m x W 2.5m x H 2.8m.	

Santillana	Inside: $8m^2$.	Outside: $64m^2$.
Shaldon	Inside: 2m x 2m x 1m.	Outside: 3m x 3m x 3m.
Skansen	L 15' x W 12' x H 12'.	
Szedeg	Inside: L 3.3m x W 2.2m x H 2.2m. Outside: L 5.1m x W 3.2m x H 6m.	
Tierpark Dählhölzli	7m x 3m x 3m.	
Walter Zoo	L 12m x W 10m x H 10m.	
Wilhelma	Two separate groups. Two indoor enclosures: each 3m x $3m^2$. One outdoor enclosure: 4.8m x $2.7m^2$ (2.8m high).	
Zoo D'Asson	Inside: 150 x 150 x 150 (meters?). Outside: 300 x 300 x 200 (meters?).	
Zoologicka Zahrada	Inside: 4m x 2m x 5m.	Outside: 3m x 2m x 5m.
Zurich Zoo	Group has an exhibit area as well as an off-exhibit area. Dimensions given: $8.5m^2$ ($26.5m^3$).	

10. How many different members of your staff regularly care for your *Callimico?*

One keeper (with three to four occasional relief keepers)	1 of 33 responses.
One keeper	1 of 33 responses.
Two keepers	13 of 33 responses.
Three keepers	10 of 33 responses.
Three to four keepers	1 of 33 responses.
Four keepers	3 of 33 responses.
Five keepers	1 of 33 responses.
Six keepers	1 of 33 responses.
"Many" keepers	1 of 33 responses.
"Several"	1 of 33 responses.

11. What photoperiod do you provide for your *Callimico?*

Eleven institutions responded that they offer 12 hours of daylight. One institution offers 13.5 hours of daylight. The responses given by all of the other institutions suggested that their animals are housed in such a way as to allow natural lighting and photoperiods via skylights or by allowing the animals outdoor access during favorable weather.

12. What temperature and humidity parameters do you consider to be optimum for housing your *Callimico?*

Aalborg	23-26°C, 50-80%.
Allwetter	20-28°C, best about 24°, 80-90%.
Barcelona	20-30°C, 40-60%.
Colchester	20-25°C, "humidity is variable but high end of the scale seems best."
Combe Martin	75°F, 60%.
Cricket St. Thomas	15-25°.
Dierenpark Wissel	Inside 20°C.
Dortmund	25°C/90%. 22°C/60%.
Dresden	22-25°C, 50-60%.
Drusilla Park	18-20°C, humidity not controlled.
Gotlands	20°C.
Helsinki	26°C, 75%.
Karlsruhe	22°C.

Lisbon	"Natural conditions for Portugal: 10-35°C, 80%."
London	70-78°F, 21-25°C, 60-85%.
Marwell	22°C.
Olands	25°C, about 90%.
Olomouc	25-30°C, 85-95%.
Parc Zoologique de Lille	23-25°C, 50-60%.
Santillana	23°C, 80%.
Shaldon	22°C in winter with heated shelving.
Skansen	25-30°C, 70%.
Szedeg	20-25°C, 50-60%.
Tierpark Dählhölzli	21°C minimum, 60-90%.
Walter Zoo	25°C, 80%.
Welsh Mountain	18-30°C.
Wilhelma	25-30°C, 70-80%.
Zoo D'Asson	20°C, 80%.
Zooparc Beauval	"Kept in a tropical area (20°C) and high degree of humidity."
	Zoologicka Zahrada:27° in day, 22° at night, 75%.
Zurich Zoo	Minimum 18ºC, optimum 24-26º

13. Do you provide your *Callimico* with outdoor access? If so, for how many months of the year?

Twenty-seven of the 33 institutions provide their *Callimico* with some outdoor access. Of these, 13 (Aalborg, Colchester, Combe Martin, Dresden, Drusilla Park, Lisbon, Marwell, Paignton, Santillana del Mar, Shaldon, Tierpark Dählhölzli, Wilhelma, and Zoo D'Asson) allow the animals year-round access to outdoor enclosures. The other 14 allow their animals outdoor access for periods ranging from two to three months (Parc Zoologique de Lille) to nine months (Olomouc).

14. What is the lowest temperature for which you allow your animals outdoor access?

Responses to this question varied considerably. Wilhelma Zoo allows its animals year-round outdoor access and locks them indoors only if temperatures fall below-3°C. Parc Zoologique de Lille (France) allows its animals access to the outdoors only for two to three months of the year, with 17-18°C being the minimum temperature for which animals are allowed to go out. Karlsruhe Zoo allows its animals outdoor access from May through November but also lets them out on warm days in April and December. The Helsinki Zoo waits until spring temperatures reach 15° to let animals outside. It reported that its *Callimico* adjusted to the changing temperatures during the summer and would still be given access to their outdoor enclosure in the autumn when night temperatures were as low as 0°C.

15. Do the animals that have no access to outdoor enclosures receive sunlight from windows or skylights?

Only six institutions (Barcelona Zoo, Cricket St. Thomas, London Zoo, Skansen Aquarium, Walter Zoo, and Zurich Zoo) do not exhibit their animals in outdoor enclosures. Animals at all of these institutions receive sunlight from either windows or skylights.

16. Do you provide your callimico with nestboxes? If so, do they use them? Please give the dimensions of the nestbox and its opening.

Twenty-five institutions responded that they give their callimico nestboxes. Of these, eight responded that their callimico do not use the nestboxes that are provided. Two other institutions responded that they don't provide their callimico with nestboxes because they had found that the animals don't use them. Three respondents did not answer the question. Three institutions responded that they don't provide callimico with nestboxes.

17. Do you provide your callimico with natural cage furniture (tree branches)?

All 33 institutions responded that they provide their callimico with natural tree branches for cage furniture. Several of the respondents also described other cage furniture provided in addition to tree branches.

Aalborg	"Living and dead, apple trees very good."
Colchester	"Bamboo and natural tree branches. Live fruit trees are also grown in the outside enclosure."
Dublin	"Also fiber rope."
Lisbon	"Ropes, chains, perches, and many other items."

18. Do you provide mulch as a substrate in the enclosure in which your callimico are housed?

This question was really meant to refer to indoor enclosures, and I unfortunately did not word the question as such in the questionnaire. Because so many of the institutions exhibit their callimico outdoors for varying lengths of the year, those that responded that they provide mulch substrates did not always indicate whether or not these substrates are in the indoor enclosures as well as outdoor enclosures. Nevertheless, several of the institutions that don't provide their callimico with outdoor access provided information about the use of mulch substrates in their indoor enclosures. Some of the institutions that provide their animals with outdoor access also provided information about the use of substrates in their indoor enclosures.

Five of the six institutions that house their callimico indoors provide various substrates in the enclosures. These include wooden chips (Barcelona), a 50/50 mixture of pulped coconut husks and bark chips (London), and bark chips (Zurich).

Of particular interest was the response from the Skansen Aquarium in Stockholm, Sweden, which houses its callimico in an enclosure that was described as "an ecological cage, i.e., it takes care of itself. The ground is 1½ meter thick (1 meter drainage, ½ meter with decoration bark). This is decomposing all biologic matters that come down (food, urine, feces, leaves and more). This is also producing an additional temperature regulation through the decomposing process. For six years this has not been changed and only positive results have evolved, such as production of insects and invertebrates for the monkeys to be able to search for and eat (makes the cage self enriching). No urine and feces smell is present in this cage, only a good natural smell equal to what you feel when you enter a green house. Natural plants and branches (even live ones) gives a natural feeling."

The Walter Zoo in Switzerland exhibits its callimico in a naturalistic conservatory-style building that was described as a "tropical rainforest hall, a community of different animals in a small piece of environment. There are no cages or fences and all animals have access to the entire hall, while visitors are only allowed to use one path through it." The substrate was described as "natural forest floor."

Four institutions that provide their callimico with outdoor access provide mulch substrates for the animals when they are housed indoors. The Dublin Zoo reportedly provides a mulch substrate "with planted areas inside and outside of the house." Gotlands Zoo provides a substrate of tree fibers in its callimico's indoor enclosure, while Karlsruhe provides a bark substrate, and Szedeg "wood chips from pine trees."

19. How frequently do you clean and disinfect the enclosure in which your callimico are housed?

The cleaning regimens of the various institutions are extremely varied, with the frequency of cleaning ranging from daily to as long as six to eight months between cleanings. The frequency with which enclosures are disinfected is similarly varied and ranges from daily to once per year or never (Table 1).

20. How frequently do you replace natural features such as tree branches?

Aalborg Zoo	"Some replanted every spring."
Allwetter Zoo	"Only when they break or get rotten."
Barcelona Zoo	Every three months.
Colchester Zoo	"Regular changes."
Combe Martin Wildlife Park	Twice a year.
Cricket St. Thomas Wildlife Park	?
Dierenpark Wissel	Once a week.
Dortmund Zoo	All every two years.
Dresden Zoo	When they break.
Drusilla Park Zoo	Two to three times yearly.
Dublin Zoo	Six months.
Gotlands Djurpark	"When dirty."
Helsinki Zoo	Add new monthly, change all twice a year.
Karlsruhe Zoologischer Garten	Only if necessary.
Lisbon Zoo	Once a year.
London Zoo	Six to eight months.
Marwell Zoological Park	"Every two years, most branching is growing."
Olands Djurpark	Weekly.
Olomouc Zoo	Four times per year.
Paignton Zoo	Monthly.
Parc Zoologique de Lille	Twice a year.
Santillana del Mar Zoo	When necessary as they break (approx. yearly).
Shaldon Wildlife Trust	Two to three times per year.
Skansen Zoo	Some have still not been changed after 6 years, some every one to two years due to destruction.
Szedeg Zoo	"Removed and changed twice a year.""
Tierpark Dählhölzli	± monthly.
Walter Zoo	"Most never replaced because they are live plants (trees and large bushes)."
Welsh Mountain Zoo	Every two months.
Wilhelma Zoo	If necessary every three to four years.
Zoo D'Asson	When necessary.
Zooparc de Beauval	"Natural plants always."
Zoologicka Zahrada Jihlava	Once or twice per year.
Zurich Zoo	?

21. Have you successfully housed polyandrous or polygamous groups? If so, what were the sex ratios of the groups?

Polygamous groups consisting of single males and multiple breeding females were created at two institutions (Altwetter Zoo and Santillana Del Mar).

22. Have you had mothers and daughters, or sisters within the same family become pregnant and give birth following the introduction of a new male to the group (i.e., after the mother's original mate died or was removed)? Did the group remain stable and for how long? If not, what happened?

Two institutions (Allwetter Zoo and Dortmund Zoo reportedly had multiple females within the same group give birth:

Allwetter

"When the breeding pair was removed together with their son, all three daughters reproduced after the introduction of a new male. This was stable for the two parent-reared daughters from January 1998 until April 2000. Then the group started to break."

Dortmund

"Yes. Two females gave birth (May, July) but only one survived (born in July). A few weeks later the whole group went down because animals died from callitrichid hepatitis."

23. Have you ever attempted to create same-sex pairs or groups of adult callimico? If so, please specify the sex and numbers of animals involved and whether they have been kin or not. What was the outcome?

This question was asked because of the poor rate of success in attempting to introduce unrelated adult males to each other, unrelated adult females to each other, or related adults that had been separated from each other for long periods of time at Brookfield Zoo. Five institutions (London, Parc Zoologique De Lille, Walter Zoo, Wilhelmina, and Zoo D'Asson) described their experiences with same-sex pairs or groups:

London Zoo

"Females, mother and daughters (0.3). Males, father and son. All animals stable until they were split for re-pairing." (Not clear from the response if they were already together.)

Parc Zoologique De Lille

"We started with 1.1 but the female had big problems and died early. We welcomed 2 other males."

Walter Zoo

"For about one year we had two unrelated males together. They both did fine, we never had any problem with them."

Wilhelmina

"Three unrelated males, but the first male had to be separated (after fighting occurred) after some days, and the other two had to be separated after eight weeks."

Zoo D'Asson

"Two males housed peacefully together for one year."

24. What has been the largest group maintained at your institution?

Allwetter Zoo and Zooparc Beauval reported that they have maintained groups of up to 10 individuals. Combe Martin, Paignton Zoo, and Skansen Aquarium have had groups of nine individuals. Tierpark Dählhölzli has had a group of eight (6.2). Groups of six or seven animals are common and were reported by several institutions.

25. What has been the shortest period between the time of creating a new breeding pair until the birth of a full-term offspring?

Eighteen institutions responded to this question. For these institutions, the average time between the creation of the new pair until the birth of a full-term offspring was 8.2 months, with a range of 5.75 months to 14 months. The time of 22 weeks and 2 days (156 days) given by the Dresden Zoo suggests that the dam was ovulating and that breeding and conception probably took place almost immediately upon introduction of the male and female.

Aalborg Zoo	14 months.
Allwetter Zoo	6 months.
Barcelona Zoo	7.5 months.
Colchester Zoo	-----
Combe Martin Wildlife Park	12 months.
Cricket St. Thomas Wildlife Park	12 months.
Dierenpark Wissel	-----
Dortmund Zoo	8.5 months.
Dresden Zoo	22 weeks and two days.
Drusilla Park Zoo	7 months.
Dublin Zoo	-----
Gotlands Djurpark	~1 year.
Helsinki Zoo	8 months.
Karlsruhe Zoologischer Garten	-----
Lisbon Zoo	-----
London Zoo	8 months.
Marwell Zoological Park	-----
Olands Djurpark	-----
Olomouc Zoo	6 months.
Paignton Zoo	-----
Parc Zoologique de Lille	-----
Santillana del Mar Zoo	-----
Shaldon Wildlife Trust	6 months.
Skansen Zoo	-----
Szedeg Zoo	5 months and three weeks.
Tierpark Dählhölzli	10 months.
Walter Zoo	-----
Welsh Mountain Zoo	-----
Wilhelma Zoo	7 months.
Zoo D'Asson	6 months.
Zooparc de Beauval	-----
Zoologicka Zahrada Jihlava	7 months.
Zurich Zoo	-----

26. Have you had parentreared females that had no experience with younger siblings reproduce? Please give the international studbook numbers of these individuals. If you have only a local ID, give it in addition to the birth date of the animal. Indicate whether or not they successfully cared for their offspring.

The purpose of this question was to gather information pertaining to the importance of prior infant carrying experience to the successful rearing of a female's own offspring. Several females in the North American population have successfully reared infants without prior infant experience. In some cases, the institutions that responded were uncertain of the infant carrying experience of females that had come to them from other institutions. For some of these females, prior infant experience (or lack of) could be inferred, although not necessarily confirmed, through the reproductive records of the parents of these females as documented in the international studbook.

Aalborg Zoo:

Female #1424 reportedly "did not take care of her first two born but raised her third, fourth, and fifth." This female was born at the Anthropological Institute of the University of Zurich, and the studbook does not list any subsequent births for her parents, so it is unlikely that she had prior infant experience. It is unclear if her first two infants died or were handreared, but none of her offspring are listed in the studbook as having been handreared.

Olomouc Zoo:

Oloumouc responded that "for the first young she hasn't cared and for the second she has cared." No studbook number was given for this female, but it is most likely #1314, born 26 October 1992 at Bekesbourne and sent to Olomouc 15 April 1998. If so, she most likely did have at least one infant experience with a male sibling #1315 born 10 April 1993. This female apparently gave birth to female #1734 on 2 October 1998. This infant was handreared.

Tierpark:

"This is possible for Dolores (#1399), she came to us 27 Sept 95 from Dortmund and reproduced successfully. [It is likely that this female had at least one infant experience with a younger sibling (#1400) born to her parents when she was six months old.] As well as Juanita, born here (#1550) on 13 July '96 and went to Szeged, Hungary." Female #1550 is the daughter of #1399 and was born 13 July 1996. #1399 gave birth to a male offspring #1726 on 6 March 1997 when #1550 was only eight months old. Although this infant had a different sire than the father of #1550, I'm guessing that she was still with her mother at the time and received infant experience with this sibling.

27. Have you had handreared callimico reproduce? If female, did they care for their offspring? If male, did they carry their offspring?

Seven institutions (Allwetter, Dresden, Gotlands, London, Olomouc, Wilhelmina, and Zurich Zoo) reported that they have had handreared female callimico that reproduced and successfully raised offspring. Allwetter reported that a handreared female there gave birth to a premature infant. It was not clear whether or not this infant survived. At Wilhelmina, a pair of handreared callimico (male studbook #108 and female studbook #904) have successfully raised three offspring, and the male reportedly began to carry following the birth of the third infant. A handreared female at the Zurich Zoo (studbook #1275) successfully raised female offspring studbook #1639.

Table 1. Cleaning Practices for Callimico Enclosures at 33 European Institutions

Institution	Cleaning Schedule	Disinfection Schedule	Disinfectant Used
Aalborg	"Rarely."	"Loose furniture regularly."	Quaternary-ammonia-based product.
Altwetter	Daily.	Never.	None.
Barcelona	Every two weeks.	"Hard cleaning once every three months."	Bleach.
Colchester	Daily.	?	?
Combe Martin	Daily.	Daily.	"Non-smelling."
Cricket St. Thomas	Weekly/daily for feed areas.	Weekly/daily for feed areas.	Detergents.
Dierenpark Wissel	Twice weekly.	Once per year.	?
Dortmund	Daily/new mulch monthly.	Never.	"Hot water only."
Dresden	Daily.	Never.	None.
Drusilla Park	Twice weekly.	"No disinfectant used."	None.
Dublin	Six months.	Six months.	Detergents.
Gotlands Djurpark	Every week.	Every week.	Detergents.
Helsinki	Daily/new trees – two per year.	"Disinfectant only when needed."	Quaternary-ammonia-based product.
Karlsruhe	Daily.	Clean daily without disinfection.	None.
Lille	Two to three times per year.	Twice to three times per year.	Detergents.
Lisbon	Once per month.	No disinfection.	None.
London	Six to eight months.	Six to eight months.	Detergents.
Marwell	Floors every other day, shelves daily.	Floors ever other day, shelves daily.	Detergents.
Olands	Daily.	Weekly/daily for feed areas.	Detergents.
Olomouc	Once per week.	Once per week.	Detergents.
Paignton	Daily.	Monthly.	Quaternary-ammonia-based product.
Santillana	Daily.	Every two weeks.	?
Shaldon	Daily.	No regular use of disinfectants.	Detergents.
Skansen	Some surfaces two times a week or more	Never?	None.
Szedeg	Mulch cleaned daily.	Glass walls disinfected weekly.	"Virocid."
Tierpark Dählhölzi	Daily.	Never.	None.
Walter	Daily.	Never.	None.
Welsh Mountain	Every two months.	Once annually.	Quaternary-ammonia-based product.
Wilhelmina	Daily – not logs or branches.	Never.	None.
Zoo D'Asson	Daily.	Weekly/daily for feed areas.	Detergents.
Zoologicka Zahrada	Daily.	?	Detergents.
Zooparc Beauval	Daily.	Daily.	Detergents.
Zurich	Daily.	Never.	None.

Callimico in Mixed-Species Exhibits in Zoological Parks

Vince Sodaro

Goeldi's monkeys, *Callimico goeldii*, are sympatric with many other species of primate throughout their range and have been observed in polyspecific association with *Saguinus fuscicollis* and *Saguinus labiatus* by several field researchers (Masataka, 1981; Pook and Pook, 1981, 1982; Buchanan-Smith, 1991; Christen, 1998; Porter, 2000). The species also lends itself well to mixed-species exhibition in zoological parks and has been successfully housed and exhibited with a variety of primate species, as well as other mammals. Mixing callimico with other species, whether the combinations are zoogeographically correct or not, can have several benefits. Such combinations can create more interesting exhibits and alleviate cage space problems, as well as provide social enrichment for the animals involved. Published accounts of attempts to mix callimico with other species, successfully as well as unsuccessfully, can provide useful guidelines for institutions considering the exhibition of callimico with other species (Xanten, 1990; Averill, 1999; Sodaro, 1999; Ritchie et al., 1999; Dalton and Buchanan-Smith, in press). As with all mixed-species introductions, the success or failure of such attempts can be influenced by a variety of factors, including exhibit size, method of introduction, group composition, age and sex ratio of the animals, and personality differences of individuals. There is no rule of thumb to predict which species combinations are likely to be successful, and combinations that may be successful in some situations may be unsuccessful in others.

Group Composition

Callimico have been successfully mixed with *Aotus nancymai* (Averill, 1999), *Callithrix melanura* (Xanten, 1990), *Cebuella pygmaea* (Dalton and Buchanan-Smith, in press), *Leontopithecus rosalia* (Xanten, 1990; Sodaro, 1999), *Leontopithecus chrysomelas* (Sodaro, 1999; Ritchie et al., 1999), *Pithecia pithecia* (Averill, 1999), and *Saguinus oedipus* (Rafert, pers. comm.). Most of these cases involved same-sexed combinations of individuals of two or more species, pairings of single opposite-sexed individuals of two species, or the addition of individuals or same-sexed pairs of a species to a breeding pair or group of another species. Relatively few of these cases involved combinations of heterosexual pairs or breeding groups of callimico with those of other callitrichid species, and the stability of such combinations is therefore more difficult to predict. Dalton and Buchanan-Smith (1999) successfully integrated a breeding pair of callimico and a single offspring with a family group of six *Cebuella pygmaea* at the Edinburgh Zoo in Scotland. A pair of callimico at the St. Louis Zoological Park have been successfully housed with a pair of *Leontopithecus chrysomelas*, while an attempt to introduce a heterosexual pair of callimico to a heterosexual pair of *Leontopithecus chrysomelas* at Brookfield Zoo was unsuccessful (Sodaro, 1999). In this case, the female callimico exhibited prosexual behaviors and directed a pilo-solicit display toward the male tamarin on the first day of the introduction. On the following day, the female callimico and female tamarin fought and the tamarin sustained a severe bite wound.

The possibility of successfully combining heterosexual breeding groups of callimico with those of other callitrichid species may be enhanced by the exhibition of such combinations in large conservatory-type exhibits with ample vertical space and natural vegetation. Such exhibits are better able to allow for the natural separation of callimico and other species into the vertical niches in which they have been observed during polyspecific associations in the wild. Buchanan-Smith (1991) found that although callimico are often seen in association with *Saguinus labiatus* and *Saguinus fuscicollis*, the three species exhibit pronounced differences in their preferred heights in the forest. Callimicos were usually observed at heights of less than 5m, whereas *S. fuscicollis* spent most time at heights of 10-15m and *S. labiatus* at heights of 15-20m.

Nonprimate Species

Callitrichids have been successfully exhibited with a variety of nonprimate mammal species, including *Dinomys brannickii* (Averill, 1999), *Abrocoma* sp., *Choelopus didactylus, Choelopus hoffmanni, Coendu prehensilis, Dasyprocta agouti, Kerodon rupestris, Myoprocta pratti, Temandua tetradactyla,* and *Tolypeutes matacus* (Sodaro, 1999). These and many other species may be considered for mixed-species housing with callimico provided that the space requirements and nutritional, environmental, and general husbandry needs of the species involved can be managed. A female callimico exhibited with *Dinomys brannickii* at the San Diego Zoo developed a close bond with this species and groomed and slept with them (Averill, 1999). Similarly, Xanten (1990) reported that a Goeldi's monkey at the National Zoological Park frequently groomed a juvenile *Kerodon rupestris.* However, while acouchis, agoutis, and rock cavies are commonly exhibited with small primates in small-mammal exhibits, all are prone to aggression toward primates and have been responsible for the injuries or deaths of various callitrichid species. They have been found to be similarly aggressive to *Callicebus* and *Pithecia* in mixed-species exhibits (Sodaro, 1999). Although many institutions have housed these species with small primates without incident, managers considering housing these species with callimico or other small primates should approach such combinations with caution.

Methods of Introduction

A variety of methods have been used to introduce callimico to other species. Most of these methods are the same as those that are typically used to introduce unfamiliar conspecifics to each other. Several institutions that combined callimico with other species provided visual, auditory, and olfactory contact between the species by means of howdy cages or mesh dividers that separated species in adjacent enclosures (Ritchie et al., 1999; Xanten, 1990; Dalton and Buchanan-Smith, in press). A male callimico at Brookfield Zoo was introduced to a male *Leontopithecus chrysomelas* in a “neutral” enclosure that neither species had had prior exposure to to offset any possible dominance advantage that might have resulted from the introduction occurring in the home territory of either species (Sodaro, 1999).

Many institutions that have attempted mixed-species introductions involving Neotropical primates allowed each species to become familiar with the exhibit without the other species present. If the introduction occurred in an enclosure in which one of the species was already living, the new species was given time alone to become familiar with the enclosure. Giving each species time to become familiar with an enclosure prior to an introduction allows animals to learn the layout and physical features of the exhibit and increases the likelihood that they will be comfortable with their surroundings when the introduction actually occurs.

Appendix 1: Enclosure Dimensions for Mixed-Species Exhibits of Callimicos

Edinburgh, Scotland

1.1.1 Callimico/1.1.4 Cebuella exhibit (both were breeding groups)
Indoor area 4.9m x 2.6m x 3.0m high
Outdoor area 4.9m x 3.7m x 4.0m high

National Zoological Park

Callimico/Kerodon exhibit
4.8m x 2m x 3m high

1.0 Callimico/1.0 GLT/1.0 C. melanura exhibit
5.7m x 6.1m x 4.2m high

St. Louis Zoo

Callimico/GHLT exhibit
14.5' high, 13'10”long, 14' deep
Case I: 2.0 GHLT sibs with 1.3 breeding group of callimico: successful
Case II: 0.1 GHLT (5 yrs old) & 3 yr old son with 2.1 family group of callimico: unsuccessful due to aggression by callimico
Case III: 0.1 sterilized GHLT (8 yrs old) and 5 yr. old mate with 1.2 family group of c.g. successful. Initially the female c.g. chased the female GHLT, but through repeated intros with behavioral enrichment as a distraction, the chasing eventually ceased and the combination worked.

San Diego Zoo

3.4 Pacarana/0.1Callimico/0.2 Aotus/1.0 Pithecia pithecia
Exhibit is 15’ x 22’. “Bedrooms” are 4’ x 4’ or 3’ x 8’.

Milwaukee Zoo

0.1 Callimico/0.1 GLT/ 0.1 Cotton-top/ 0.1 Cebuella/0.0.1 acouchi
20’ x 30’ x 22’ high with live plants throughout all the way to skylight

Brookfield Zoo

11.1 callimico/1.1 GHLT (unsuccessful introduction)
10’ x 10’ x 8’ high

1.0 callimico/0.1 GLT
4’ x 10’ x 8’

0.1 callimico/0.1 cotton-top
4’ x 10’ x 8’

0.2 GLT/0.1 callimico
8’6” x 8’6” x 8’10” high

References

Averill, S. 1999. Every monkey needs a pacarana: Husbandry tips for a primate/rodent mixed species exhibit. In: *1999 Primate Mixed Species Symposium*, pp. 1-7. Dallas Zoo, Dallas, TX.

Buchanan-Smith, H. 1991. Field observations of Goeldi's monkey, *Callimico goeldii* in northern Bolivia. *Folia primatologica*, 57:102-105.

Christen, A. 1998. The most enigmatic monkey in the Bolivian rain forest- *Callimico goeldii*. *Neotropical Primates*, 6(2): 35-37.

Dalton, R., and H. M. Buchanan-Smith. In press. A Mixed-species exhibit of Goeldi's monkeys and pygmy marmosets *Callimico goeldii* and *Cebuella pygmaea* at Edinburgh Zoo, Scotland.

Masataka, N. 1981b. A field study of the behavior of Goeldi's monkeys *(Callimico goeldi)* in north Bolivia II. Grouping pattern and intragroup relationship. *Kyoto Overseas Research Reports of New World Primates* 2:33-41.

Pook., A., and G. Pook. 1981. A field study of the socio-ecology of the Goeldi' Monkey *(Callimico goeldii)* in northern Bolivia. *Folia primatologica*, 35:288-312.

Pook, A., and G. Pook. 1982. Polyspecific associations between *Saguinus fuscicollis*, *Saguinus labiatus*, and *Callimico goeldii* and other primates in north-western Bolivia. *Folia primatologica*, 30:196-216.

Ritchie, L., L. Hartung, and I. Porton. 1999. Case Studies: mixing golden-headed lion tamarins with other new world monkeys. In: *1999 Primate Mixed Species Symposium.* Dallas Zoo, Dallas, TX.

Sodaro, V. 1999. Housing and exhibiting mixed species of Neotropical primates. In: *Callitrichid Husbandry Manual*, eds. V. Sodaro and N. Saunders, pp. 7-34. Neotropical Primate Taxon Advisory Group.

Xanten, W.A. 1990. Marmoset behavior in mixed-species exhibits at the National Zoological Park, Washington. *International Zoo Yearbook*, 29:143-148.

Social Organization and Housing of Captive Goeldi's Monkeys

Vince Sodaro and Amy Hanson

Little is known about the formation of social groups of wild Goeldi's monkeys, *Callimico goeldii*, or the familial relationships of the individuals within them. The species has been known to occur in groups of two to 12 individuals (Porter, 2001; Christen, 1999; Encarnación and Heymann, 1998, Masataka, 1981). Each of these authors documented groups in which there appeared to be two breeding females.

Despite these observations, *Callimico* in captivity are most successfully managed as male/female pairs and their offspring, hereafter to be referred to as family groups (Table 1). Family groups of up to 10 individuals have been maintained at various European institutions. Groups maintained in North American institutions rarely attain this size but have been composed of as many as seven individuals. Factors such as enclosure size, sex ratios within groups, and individual animals' temperaments likely play a role in how long such groups may remain intact. Family groups generally remain stable for long periods of time (years), but offspring may be aggressively driven from the group by one or both of the parents at ages beyond two years (pers. obs.). This timeline agrees with the one documented observation of dispersal in wild Goeldi's monkeys in which a roughly two-year-old male dispersed from his family group and immigrated into a group composed of at least two adult females (Porter et al., 2001).

Social Grouping	**Stability**	**Duration of Stability**	**Comments**
Male/female pair.	High.	Several years.	Breeding or nonbreeding.
Entire family group (male/female pair and offspring)or any subgroup (e.g., father/daughter, mother/daughter, siblings, etc.).	High.	Several years.	Generally remain stable as longas adult animals are not separated for more than a few days, though aggression toward offspring over two years of age can force them out of the group.
Same-sex pairs/trios of unrelated animals.	Low.	Days to months.	Stability may be increased by isolating group from conspecifics or other callitrichids.
Multifemale breeding group.	Low.	Days to months to two years.	Groups have a tendency to remain stable until births occur, after which aggression between females occurs.
Multimale breeding group.	Variable?	Months to years?	Only four documented groups (this report).

Table 1. Summary of stability of various social housing conditions for Goeldi's monkeys.
See text for details and references.

The care of infants in family groups of *Callimico* is similar to that of *Callithrix* (Stevenson and Rylands, 1988), *Cebuella* (Soini, 1988), *Leontopithecus* (Kleiman et al., 1988) and *Saguinus* (Snowdon and Soini, 1988) with fathers and older offspring assisting with the care and carrying of offspring. For a detailed description of infant care and development, see Infant Development (Sodaro, this volume).

Multifemale Breeding Groups

The relatively few reports of groups of Goeldi's monkeys containing more than one breeding female in captive settings suggest that, while sometimes successful initially, such groupings do not exhibit long-term stability and rarely lead to sustained successful breeding (Appendix III).

In a study at the Jersey Wildlife Preservation Trust designed to test the stability of multifemale groups in a captive setting, three groups comprised of single males housed with two unrelated females remained stable for periods ranging from 46 to 326 days (Carroll, 1988). All three groups were disbanded following severe fighting between the two females, and in only one of the trios did both females succeed in rearing infants. In the second group, both females gave birth but neither infant survived, while in the third group neither female became pregnant.

A trio that was formed at the Belfast Zoological Gardens by introducing an adult male to two adult female siblings remained stable for more than 15 months until both females became pregnant (Hardie, 1995). These two females gave birth two days apart. On the morning that the younger female gave birth, both she and the male attacked the other female. The younger female's infant died the next day, but she continued to attack her sister, who gave birth one day later. Following the removal of the younger female, the remaining pair successfully reared the other infant.

At the Allwetter Zoo in Germany, a group of three sibling females, one of which was handreared, all became pregnant following the introduction of a new male (Encke, pers. comm.). All three females reproduced, although the handreared female did not raise her infants. The group reportedly remained stable from January of 1998 until the spring of 2000 and grew to 1.7 individuals. Thereafter, the subdominant breeding female, the handreared female, and one of the female offspring that had been born into the group in 1999 were forced out of the group.

A group at Brookfield Zoo, in which a mother and daughter became pregnant following the introduction of a new male, resulted in both females giving birth on the same day. In this case, the mother succeeded in raising her own infant but was observed displacing and intimidating her daughter on the day of births. The daughter's infant was found on the floor of the enclosure. This infant died despite attempts to handrear it.

At the St. Louis Zoo, an adult male was introduced to an adult female and her 17-month-old daughter and a 10-month-old daughter. The group remained stable, and approximately 10 months after the introduction of the new male, the oldest daughter was removed from the group. Thirteen months after the introduction of the male, the mother gave birth to a male infant. Five weeks later, her remaining daughter also gave birth to an infant. Although the infant was initially observed being carried and cared for by the daughter on the morning on which it was born, it was found dead in the enclosure later the same day, apparently having been killed by another group member.

In one of the only cases in which a group with two sexually mature females remained stable at Brookfield Zoo, an adult male was introduced to a female, her six-month-old male offspring, and threemonthsold female offspring . This female offspring remained in this group for over two years without conflict, during which time her mother gave birth to three additional offspring. Of interest in this case was the fact that the female never became pregnant during the time that she remained in this group with a stepfather.

Multimale Breeding Groups

The stability of multimale breeding groups of callimico in captivity has not been previously documented. However, sexually mature female individuals were introduced to multimale groupings at Brookfield Zoo four times, producing variable results. In the first case, a wild-caught adult female was introduced to a group consisting of a wild-caught adult male, along with three of his captive-born offspring. These offspring were a 16-month-old male, a 10 and one half-month-old male, and a five-month-old female. The youngest male in the group was observed copulating with the female on the day of the introduction, as well as the following day. The oldest male was removed from this group exactly two weeks after the introduction of the female to the group, during which time relationships among all three males remained amicable. The youngest male remained in the group for approximately 2 and one half months, during which time relationships between he and his father were also amicable. Throughout the time that all three males coexisted in this group, the youngest male was the only individual observed copulating with the female. The female gave birth to a full-term infant 154 days after the final time that she was observed copulating with the youngest male.

In a second case at Brookfield Zoo, a two-year-old female was introduced to a pair of unrelated handreared males that had been raised together in the natal group of the older male. The two males were removed from this group when the older male was one year and seven months of age and the younger male was eight months old. The males were housed alone for eight days prior to the introduction of the female. The grouping remained stable for approximately six months, with the female seeming to show a preference for the younger of the two males. The female gave birth 194 days following the introduction to the males.

Thereafter, the younger male began to show mild aggression toward the other male, and two weeks after the birth of the infant, the two males engaged in a brief but intense fight. The older male was removed from the group approximately one month later and was found to have several bite wounds that had not been previously observed.

The remaining two cases at Brookfield Zoo involved the same two male siblings having single females introduced to them. The first case occurred when the males were 19 months of age and 14 months of age. A 1 and one half-year-old female was introduced to these males, resulting in a trio that was compatible for two months, until the female died.

Twenty-five days after the death of the first female, a 1 and one half-year-old female was introduced to the same two males. This grouping remained compatible from January of 1987 until October of 1989, during which time the female gave birth and successfully raised four offspring. The female at times seemed to show a stronger preference for the older male, but tension was never observed between the two males. This grouping was eventually disbanded when the female and the older male were removed from the group to be sent as a breeding pair to another institution.

Same-Sex Pairs

Same-sex pairs (or even trios) of callimico are most likely to be managed successfully in cases in which the animals are related and have lived together continuously within their family groups. Mothers and daughters or female siblings, as well as fathers and sons or male siblings, can be housed together without problems as long as they are not separated from each other for significant lengths of time.

Same-sex pairs of unrelated adult individuals or related animals that have been separated from each other for long periods of time are generally unstable. Although introductions of same-sex animals to each other may initially be uneventful, such pairings usually result in unpredictable aggression between individuals, in periods of time ranging from days to months after pairing. This may be especially true of same-sex pairs that are housed in close proximity to conspecifics in other enclosures. Some same-sex pairings initially result in intense affiliative (e.g., grooming) and prosexual behaviors (e.g., scent marking and mutual sniffing) between the individuals, but these relationships are also unstable (see Appendix I).

A limited amount of data suggest that same-sex pairings are more likely to be successful when housed in isolation from conspecifics or other callitrichids. In Carroll's study of three multifemale groups (1988), the females in each group were first paired with each other and were stable for periods ranging from one to five months prior to the introduction of males. No other callitrichids or callimico groups were in visual, auditory, or olfactory contact with these groups. A pair of male callimico housed in isolation from conspecifics and other callitrichids at Brookfield Zoo was stable for eight months until fighting occurred 24 days after a female *Saguinus oedipus* was moved into the room and housed in an adjacent enclosure. Of 12 other same-sex groupings of callimico at Brookfield Zoo (five male pairs, two male trios, and five female pairs) in which the pairs were housed in visual and auditory contact with conspecifics, only two were compatible. Neither of the two attempts to create male trios was successful, and the remaining eight same-sex pairing attempts resulted in fights or extreme displays of fear by a subordinate individual that necessitated separation in periods of time ranging from less than two hours to 22 days (Appendix I).

Other Housing Options

Family groups in which one of the parents has died or has been removed will usually remain stable. An incest taboo inhibits members of the same family from breeding with each other as long as all group members remain together and are not separated for significant lengths of time. Therefore, parents will rarely breed with their own offspring and siblings will not breed with each other.

Introductions of Stepparents

The death or removal of a parent from a family group may create a situation in which it is desirable to introduce a new mate to the remaining parent or to an adult and an immature sibling. However, the length of time for which groups with stepparents are likely to remain socially stable is variable and may be of shorter duration than groups composed of a breeding pair and their own offspring.

In seven of 13 cases in which stepparents were introduced to single parents with offspring at Brookfield Zoo and elsewhere, stepparents became intolerant of stepoffspring that were significantly younger than the ages at which offspring are typically peripheralized from family groups when housed with their own parents (Appendix II).

In these cases, stepparents became aggressive to stepoffspring that were ages ranging from six to 17 and a half months. In three cases, stepparents also were observed to attempt to prevent stepoffspring from carrying subsequent offspring that were born in their groups. These cases raise interesting questions regarding the relationships of individual members of callimico groups in the wild, as well as the manner in which individuals immigrate and emigrate between groups.

Attempts to introduce stepparents to single parents with offspring should be limited to groupings in which offspring have not reached sexual maturity. Offspring that are sexually mature are likely to be incompatible with stepparents of the same sex. Two attempts to introduce stepfathers to females with male offspring that were 14 months old or older at Brookfield Zoo failed due to immediate aggression by the male offspring toward the newly introduced males (Appendix II). In a more unusual case at Brookfield Zoo, an attempt to introduce an adult male to an adult female, her 16-month-old daughter, and her 10-month-old daughter failed when the two daughters intimidated the newly introduced male. Tension between sexually immature offspring and the stepparent of either sex may also sometimes occur. At the Anthropological Institute at the University of Zurich, Switzerland, a male that was less than six months of age exhibited fear of an unrelated adult male that was introduced to his mother (Anzenberger, pers. comm.). The adult male in this group did not exhibit aggression and the group remained stable. In another case, a stepfather that was introduced to a pregnant adult female and her three-month-old daughter at Brookfield Zoo began to exhibit aggression to the stepdaughter when she was six months of age, as well as to attempt to prevent her from carrying an infant that the adult female had given birth to. The stepfather's aggression toward the stepdaughter intensified when the stepdaughter was eight months of age, necessitating the stepfather's removal from the group.

Mature offspring and stepparents that are of the opposite sex are likely to perceive each other as potential mates. Mothers and sexually mature daughters may continue to have stable relationships for some time following the introduction of a stepfather but may ultimately prove to be problematic, as in the previously mentioned cases at Brookfield Zoo and St. Louis Zoo.

Introductions

The creation of new male/female pairs of Goeldi's monkeys is usually uneventful. Copulations frequently occur on the first day, and often within minutes, of an introduction. Nevertheless, in a small number of introductions, individuals may initially show fear or wariness of newly introduced cagemates. The likelihood of successfully introducing unfamiliar individuals to each other can be improved by providing them with visual, auditory, and olfactory contact with each other prior to the introduction by housing them in close proximity to each other in adjoining enclosures or through the use of "howdy" cages.

Signs of compatibility within a newly formed pair include active sharing of food, frequent bouts of allogrooming, individuals sitting in close proximity to each other, and sleeping together in or on the nestbox. Note that similar behaviors can occur (sometimes intensively) in same-sex pairings, but that is not an indication of stability (see Appendix I). For a detailed listing of affiliative and other behaviors, see Callimico Ethogram (Hanson and Sodaro, this volume).

References

Carroll, J.B. 1988. The stability of multifemale groups of Goeldi's monkeys *Callimico goeldii* in captivity. *Dodo*, 25:37-43.

Christen, A. 1999. Survey of Goeldi's monkeys *(Callimico goeldii)* in northern Bolivia. *Folia primatologica*, 70:107-111.

Encarnación, F., and E.W. Heymann. 1998. Body mass of wild *Callimico goeldii. Folia primatologica*, 69:368-371.

Hardie, H.M. 1995. Do subordinate female *Callimico* disperse from their social groups? *Folia primatologica*, 64:192-195.

Kleiman, D.G., R.T. Hoage, and K.M. Green. 1988. The lion tamarins, genus *Leontopithecus.* In: *Ecology and Behavior of Neotropical Primates II.*, es. A.F. Coimbra-Filho, and R.A. Mittermeier, pp. 299-347. Rio de Janeiro, Brazil: Academia Brasileira de Ciencias.

Masataka, N. 1981a. A field study of the social behavior of Goeldi's monkeys *Callimico goeldii* in north Bolivia I. Group composition, breeding cycle, and infant development. *Kyoto University Overseas Research Reports of New World Monkeys* 2:33-41.

Porter, L. 2001. Social organization, reproduction, and rearing strategies of *Callimico goeldii:* new clues from the wild. *Folia primatologica*, 72:69

Porter, L., A. Hanson,., and E. N. Becerra. 2001. Group demographics and dispersal in a wild group of Goeldi's monkeys *(Callimico goeldii). Folia primatologica*, 72:108-110.

Snowdon, C.T., and P. Soini. 1988. The tamarins, genus Saguinus. In: *Ecology and Behavior of Neotropical Primates II.*, eds. A.F. Coimbra-Filho, and R.A. Mittermeier, pp. 223-298. Rio de Janeiro, Brazil: Academia Brasileira de Ciencias.

Soini, P. 1988. The pygmy marmoset, genus *Cebuella.* In: *Ecology and Behavior of Neotropical Primates II.*, es. A.F. Coimbra-Filho and R.A. Mittermeier, pp. 79-129. Rio de Janeiro, Brazil: Academia Brasileira de Ciencias.

Stevenson, M.F., and A.B. Rylands. 1988. The marmosets, genus *Callithrix.* In: *Ecology and Behavior of Neotropical Primates II.*, es. A.F. Coimbra-Filho, and R.A. Mittermeier, pp. 131-222. Rio de Janeiro, Brazil: Academia Brasileira de Ciencias.

Appendix I. Same-Sex Pairings of Callimicos at Brookfield Zoo

Animal	Std#1218	Std#1312
Sex	Male	Male
Age at Pairing	2 years, 2 months	1 year, 5 months
Date of Pairing	14 March 1995	
Length of Time Together	8 months	
Reason Pair/Trio Separated	Fighting during the day, both receiving nonfatal injuries. The fight occurred 24 days after a female cotton-top tamarin was moved into the room (not the same enclosure) where this pair was housed.	
Comments	Std#1218 was reared in his family group. At three months of age his sire died and was replaced with an unrelated male. The new male began to be aggressive toward Std#1218 when he was 8 months old. Std#1218 was removed from his group at 1 year, 5 months of age.	

Animal	Std#1468	Std#1413
Sex	Male	Male
Age at Pairing	1 year, 9 months	2 years, 3 months
Date of Pairing	6 April 1996	
Length of Time Together	2 hours	
Reason Pair/Trio Separated	Std#1468 immediately fearful of Std#1413, submissive vocalizations when near him.	
Comments	Std#s 1468 and 1413 were full siblings. Both were handreared and integrated into their family groups (both were being carried by family members by 44 days of age). Std#1413 was observed carrying Std#1468 when they lived in their family group together. The two had been separated from each other for 14 months prior to their pairing.	

Animal	Std#665	Std#828	Std#749
Sex	Male	Male	Male
Age at Pairing	3 years	1 year, 8 months	2 years, 5 months
Date of Pairing	27 April 1990		
Length of Time Together	Group of three was together for approx. 1½ hr after which Std#665 was removed. Std#s 749 and 828 remained together until separated due to fighting on 30 April 1990.		
Reason Pair/Trio Separated	Std#665 was intimidated, chased, and jumped on by Std#749. Std#s 749 and 828 fought.		
Comments	Trio was formed by first putting Std#s 749 and 828 together. Both were handreared. This pair seemed compatible and Std#665 was added the same day. Std#665 was removed after approx. 1½ hr. On 30 April 1990 Std#749 sustained several bite wounds after he chased and attacked Std#828. Pair was then separated.		

Animal	Std#200	Std#212
Sex	Male	Male
Age at Pairing	1 year	1 year, 3 months
Date of Pairing	13 July 1982	
Length of Time Together	4 months	
Reason Pair/Trio Separated	Std#212 removed and sent to another institution 9 November 1982.	
Comments	Pair was apparently compatible.	

Animal	Std#200	Std#212	Std#201
Sex	Male	Male	Male
Age at Pairing	1 year, 1 month	1 year, 4 months	1 year, 4 months
Date of Pairing	7 August, 1982		
Length of Time Together	1 day.		
Reason Pair/Trio Separated	Std#s 200 and 212 were aggressive to Std#201 and chased and intimidated him.		
Comments	Std#201 was added to the previously compatible pair of males. Std#s 200 and 212 continued to be compatible following the removal of Std#201.		

Animal	Std#473	Std#591
Sex	Male	Male
Age at Pairing	11 years	9 years
Date of Pairing	3 April 1995	
Length of Time Together	24 hours	
Reason Pair/Trio Separated	Pair fought the day after the introduction.	
Comments	The first day of the introduction Std#473 showed intense interest in Std#591 by following and sniffing him, grooming him, begging food from him, and putting his arm over his shoulder. Std#473 ventral tail curled and scent-marked more frequently.	

Animal	Std#495	Std#553
Sex	Male	Male
Age at Pairing	3 years, 5 months	2 years, 4 months
Date of Pairing	19 August, 1988	
Length of Time Together	13 days	
Reason Pair/Trio Separated	Pair fought on 31 August 1988.	
Comments		

Animal	Std#665	Std#828
Sex	Male	Male
Age at Pairing	3 years	1 year, 8 months
Date of Pairing	3 May 1990	
Length of Time Together	3 days	
Reason Pair/Trio Separated	Std#665 attacked Std#828 and inflicted several wounds.	
Comments	On first day of introduction Std#665 nonaggressively pursued Std#828 for about 15 minutes. Seemed to get along well throughout first day and were observed sitting together. On 6 May 1990 Std#828 was found on floor of enclosure in a.m. fear-grimacing at Std#665. Std#828 had bite wounds on rt. Leg, and rt. thumb was bitten off.	

Animal	Std#134	Std#164
Sex	Female	Female
Age at Pairing	6 years, 6 months	5 years, 4 months
Date of Pairing	22 August 1985	
Length of Time Together	2 months, 3 weeks	
Reason Pair/Trio Separated	Pair fought on 20 September 1985. Tension between pair observed throughout October 1985. Pair fought again on 11 November 1985 and were then separated.	
Comments	Both females had previously been housed with males as breeding pairs. Female Std#164 was handreared.	

Animal	Std#824	Std#655
Sex	Female	Female
Age at Pairing	8 years	8 years
Date of Pairing	5 April 1995	
Length of Time Together	11 days	
Reason Pair/Trio Separated	Pair fought overnight on 13 and 15 April, causing nonfatal injuries.	
Comments	First day of introduction animals noted to groom each other intensively, food share, pectoral sniff and hug, genital sniff, scent mark, and ventral tail curl. On the day after the first overnight fight, no aggression was noted between this pair; they were observed sitting together and grooming one another.	

Animal	Std#1269	Std#1213
Sex	Female	Female
Age at Pairing	2 years, 5 months	2 years, 4 months
Date of Pairing	21 March 1995	
Length of Time Together	12 months	
Reason Pair/Trio Separated	Chronic poor health of Std#1269 (anemia, weight loss)	
Comments	First day of introduction Std#1269 noted to genital sniff and approach Std#1213. Both animals scent marked and ventral tail curled. Observed touching and sniffing each other and slept together overnight. During the first week it was noted that Std#1269 dominated Std#1213 at the food bowl. After two weeks it was noted that both animals ate without problems from the same bowl, even when two were offered. Std#1269's adult weight ranged from 570g-624g prior to pairing. From 21 March 1995-December 1995 it ranged from 580g-680g. From 13 February 1996 to 12 March 1996 it ranged from 396g-454g. On 15 March 1996 her weight was 370g at which time she was separated from her companion for medical management.	

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Animal	Std#978	Std#787
Sex	Female	Female
Age at Pairing	8 years, 9 months	11 years
Date of Pairing	21 March 1999	
Length of Time Together	21 days	
Reason Pair/Trio Separated	Fighting during day of 11 April 1999. Std#787 sustained nonfatal injuries.	
Comments	Std#787 was the mother of Std#978. Pair had not been together for 5 months, 3 weeks prior to attempt to reintroduce. During the first two days of the introduction the pair were observed to share food, groom each other, and slept together overnight. Std#978 was the aggressor during fight.	

Animal	Std#978	Std#638
Sex	Female	Female
Age at Pairing	11 years	15 years
Date of Pairing	25 April 2001	
Length of Time Together	Two consecutive days of housing together during the day and separated at night. Together continuously for 7 days thereafter.	
Reason Pair/Trio Separated	Fighting during day of 3 May 2001. Minor injuries but pair separated permanently thereafter.	
Comments	Pair had had visual, auditory, and olfactory access to each other through wire mesh for one month prior to introductions and affiliative behaviors had been observed. For first two days of introduction pair was separated at night. Pair was together continuously from 27 April 2001 until 3 May 2001 when fighting occurred.	

Appendix II. Summary of Successful and Unsuccessful "Stepparent" Cases for Callimico at Brookfield Zoo

Unsuccessful Cases

1. Stepfather Ramon Std#388 introduced to adult female Kris Std#117 and her four-month-old daughter Catarina Std#199. Fighting first observed between the stepfather and daughter when daughter was 10½ months old and again when she was just under 13 months old. Daughter removed from group when she was 14 months old due to wound received from stepfather.

2. Stepfather Manuel Std#238 introduced to adult female Cherie Std#128 and her 7½-month-old daughter Roberta Std#324. Injuries to daughter first noted when she was about 8½ months old, although no overt aggression was observed. Other injuries noted when she was 10½ months of age and again at 11½ months old. Stepfather observed to attack her when she was exactly one year old. Stepfather removed from group thereafter.

3. Stepfather Julio Std#336 introduced to adult female Magdalena Std#208 and her 5½-month-old daughter Lady Madonna Std#491. Daughter sustained significant injuries when she was six months old and wounded several other times over the next several months. Stepfather removed from the group when daughter was just under 10 months old.

4. Adult male Julio Std#336 introduced to adult female Leigh Std#444 and her nine-month-old male sibling Grant Std#495. Sporadic tension and fear behaviors by Std#495 directed at Std#336 were noted over a period of four months following the introduction of Std#336 to the group. An infant that was sired by Std#336 was born to Std#44 five and one-half months after the introduction and thereafter hostile encounters between the two males in the group began to increase. Std#336 was noted to have prevented Std#495 from carrying the infant. Seven months after the introduction, a fight occurred between the two males and Std#495 was then removed from the group at the age of 14 months.

5. Stepfather Rodriguez Std#564 introduced to adult female Minnie Std#134 and her 14-month-old son Pook Std#656. The son began to aggressively chase Std#564, which resulted in the removal of Std#564 from the group.

6. Adult male Adan Std#194 introduced to adult female Bea Std#143 and her 16-month-old daughter Winnifred Std#443 and 10-month-old daughter Leticia Std#475. Both daughters aggressively intimidated the newly introduced male, necessitating his removal.

7. Stepfather J.C. Std#913 introduced to adult female Laurie Std#825 and her two-month-and three-week-old son Quarantino Std#1218. Tension noted between the stepfather and son when the son was about eight months old. Group remained intact until aggression by the stepfather necessitated the removal of the son at the age of one year and 5½ months.

8. Adult male Don Alejandro Std#446 introduced to adult female Madeira Std#424, her 16-month-old son Alfie Std#665, and her infant Madeline Std#817. The newly introduced male was removed after the son attacked him.

9. Stepfather Pinto Std#1876 introduced to adult female Deanna Std#1877 and her approximately 3½-month-old daughter Elsie Std#2121. Mother pregnant from previous mate at time of introduction. Female infant Std#2202 born approximately eight weeks after introduction. Daughter Std#2121 was frequently chased away by stepfather during her attempts to approach and/or carry the infant. Four months after the introduction of the stepfather to the group, when the stepdaughter was just under eight months old, aggressive chasing of her by the stepfather escalated dramatically and necessitated his removal from the group.

10. Stepfather Larry Std#784 introduced to adult female Mary Std#928, who was already pregnant at the time of the introduction from a stepfather that had been introduced into her mother while she was still in her family group (see number 8 under Successful Cases). She gave birth to a male offspring Mooki Std#1059 seven weeks after the introduction to Std#784. The group was sent to Woodland Park Zoo in Seattle when the son was 14 months old. The stepfather attacked and injured the son a week after the group arrived in Seattle, necessitating the removal of the son from the group.

Successful Cases

1. Stepfather Pepe Std#89 introduced to adult female Eunice Std#92 and her two daughters Judy Std#104 (seven months old) and Vickie Std#116 (seven weeks old). The adult female was removed from the group approximately seven weeks later due to illness. The group had remained stable until her removal. The male remained with the two younger females until the younger of the two was removed six months later.

2. Stepfather Pepe Std#89 introduced to adult female Marie Std#96 and her two male offspring Adan Std#194 (seven months old) and Mario Std#212 (six weeks old). The older male offspring was removed from the group four months later at the age of 10½ months. The younger male offspring remained in the group until the stepfather was removed 8½ months after being introduced to the group due to the incompatibility of the adult pair. No problems were ever observed between the stepfather and either of his two stepsons.

3. Stepfather Marcos Std#198 introduced to adult female Spring Std#337, her 10-month-old brother Cristobal Std#482, and her one-month-old daughter Gail Std#542. The group remained stable until the stepfather was removed from the group due to illness four months and 18 days after the introduction.

4. Stepfather Don Diego Std#160 introduced to adult female Tango Std#90 and her 10-month-old daughter Anna Std#180 and her four-month-old son Marcos Std#198. The daughter was removed two days later when it became apparent that Std#160 was more interested in her than in her mother. The son remained in the group for 11 months until his removal to pair with another female. He was 15 months old at the time of his removal.

5. Stepfather Don Diego Std#160 introduced to adult female Cherie Std#128, her 1½-year-old daughter Roberta Std#324, and her 4½-month-old daughter Felina Std#469. Female Std#128 gave birth to twins, one of which is removed for hand-rearing, 161 days after the introduction of Std# 160 to the group. Three weeks later, female Std#324 gave birth to a female infant. Brief aggressive interactions were observed between Std#324 and Std#128 on the fourth and fifth day after Std#324's infant was born. This infant died of a fractured skull at the age of 18 days. Std#324 was then removed from the group to attempt to introduce an unrelated infant to her for cross-fostering. Two days later, after the cross-fostering attempt failed, Std#324 was returned to her group but was immediately and aggressively chased by several group members. She was then permanently removed from the group. Female Std#469 remained in the group for 14 months and was then removed to send to another institution. She was 18½ months old at the time of her removal.

6. Stepmother Priscilla Std#187 introduced to adult male Don Diego Std#160 and his 10-month-old daughter Marcella Std#233. A female infant sired by Std#160 was born to Std#187 approximately 6½ months after the introduction. The daughter remained in the group for about 10 months until her removal to pair with a male. She was one year and eight months old at the time of her removal from the group.

7. Stepfather Bryan Std#126 introduced to adult female Magdalena Std#208, her six-month-old male offspring Dwarf Std#521 and four-week-old daughter Gloria Std#557. The male Std#521 died two months after the introduction of the stepfather to the group, but female Std#557 remained in this group for two years and two months without conflict before her removal at the age of almost 2½ years. Her mother Std#208 produced several offspring during the time that the group was together.

8. Stepfather Bryan Std#126 introduced to adult female Madeira Std#424, her one-year-old daughter Mary Std# 928 and six-week-old daughter Margarita Std#986. The group remained stable for over five months until the daughter Std#928 was removed after it was determined that she had become pregnant from the stepfather. The younger daughter Std#986 remained in the group for one year and eight months when she was aggressively driven from the group by her mother, the stepfather, and a younger 16-month-old female sibling offspring Std# 995. Std#986 was 21 months old at the time of her removal from the group.

9. Stepfather Cristobal Std#482 introduced to adult female Amazonia Std#326 and her five-month-old son Jimmy Std#553. The group remained stable for 16 months until the stepfather and Std#553 sustained injuries in a fight with each other. The stepson was approximately one year, 10 months old at the time. Despite the final outcome of this case, it is listed here as successful due to the fact that the age of the stepson at the time of the fight was close to the age at which individuals may be peripheralized from their family groups by their own parents.

10. Adult female Maya Std#223 introduced to adult male Arturo Std#561 and his seven-month-old sister Pandora Std#755. Std#223 was pregnant from her previous mate at the time of this introduction. Despite occasional tension, the group remained intact for one year and five months.

Other

Stepmother Maya Std#223 introduced to adult male José Std#93 and his three offspring: 16-month-old male Tomas Std# 201, 10½-month-old male Samson Std# 219, and five-month-old female Tina-Marie Std#240. Both male offspring were removed from the group within nine weeks of the introduction of the stepmother. The stepmother gave birth to a female offspring approximately six months later. The stepmother and the stepdaughter continued to be compatible, although the stepmother would not tolerate the stepdaughter's attempts to carry the infant. She was observed to aggressively chase the stepdaughter to recover the infant on several occasions when the stepdaughter carried the infant. This stepdaughter was approximately one year of age at the time of her first attempt at infant carriage. She was removed from the group six days after the stepmother's next birth, one year after the stepmother's introduction to the group.

Appendix III. Multifemale Breeding Groups of Callimicos in Captivity

Brookfield Zoo

1. Feb. 3, 1985: Stepfather Don Diego Std#160 introduced to adult female Cherie Std#128, her 1½-year-old daughter Roberta Std#324, and her 4½-month-old daughter Felina Std#469. On July 14, 1985, 161 days after the introduction of Std#160 to the group, female Std#128 gave birth to twins, one of which was removed for handrearing. Three weeks later, on August 4, 1985, female Std#324 gave birth to a female infant. Brief aggressive interactions where observed between Std#324 and Std#128 on the fourth and fifth day after Std#324's infant was born. This infant died of a fractured skull at the age of 18 days. Std#324 was then removed from the group to attempt to introduce an unrelated infant to her for cross-fostering. Two days later, after the cross-fostering attempt failed, Std#324 was returned to her group but was immediately and aggressively chased by several group members. She was then permanently removed from the group. Female Std#469 remained in the group for 14 months and was then removed to send to another institution. She was 18½ months old at the time of her removal.

2. October 1, 1985: Bea Std#143 housed with her 16-month-old daughter Winnifred Std#443 and 10-month-old daughter Leticia Std#475. On October 15, 1985, both daughters were separated from Bea and male Don Pedro Std#173 was introduced to Bea. On October 16, 1985, Leticia was reintroduced to the pair. On October 23, 1985, Winnifred was reintroduced to the pair. On March 30, 1986, both Bea and Winnifred gave birth to infants. At the first a.m. check, Bea was found to be carrying her infant while Winnifred's infant was found laying in the wood shavings on the floor of the enclosure. Bea was observed trying to pick this infant up. Winnifred and her infant were removed from the enclosure in an attempt to induce her to care for her infant. The infant died four days later and Winnifred was not reintroduced to this group. Bea was removed from the group on August 20, 1986, leaving Don Pedro, Leticia, and Bea's infant Beatisimo Std#571 together. Don Pedro and Leticia then became a breeding pair.

3. February 25, 1986: Bryan Std#126 introduced to adult female Magdalena Std#208, her six-month-old male offspring Dwarf Std#521 and four-week-old daughter Gloria Std#557. The male Std#521 died two months after the introduction of the stepfather to the group, but female Std#557 remained in this group for two years and two months without conflict before her removal on May 1, 1988, at the age of almost 2½ years. She did not become pregnant during her time in the group although, she would have been sexually mature at one year of age. Her mother Std#208 produced three offspring during the time that the group was together.

4. October 29, 1986: Chris Std#179 introduced to female siblings Oreja Std#461 (two years old) and Jana Std#541 (1 years old). The trio was compatible until Chris Std#179 died on March 24, 1987.

5. December 10, 1987: Ignacio Std#538 introduced to female siblings Oreja Std#461 and Jana Std#541. The trio was together until May 28, 1988, when Oreja Std#461 died during labor.

6. July 13, 1990: Bryan Std#126 introduced to adult female Madeira Std#424, her one-year-old daughter Mary Std# 928 and six-week-old daughter Margarita Std#986. The group remained stable for over five months until the daughter Mary Std#928 was removed after it was determined that she had become pregnant from the stepfather. The younger daughter Margarita Std#986 remained in the group for one year and eight months when she was aggressively driven from the group by her mother, the stepfather, and a younger 16-month-old female sibling, offspring Std# 995. Std#986 was 21 months old at the time of her removal from the group.

Other Known Multifemale Breeding Groups

1. At the Allwetter Zoo in Germany, a group of three sibling females, one of which was handreared, all became pregnant following the introduction of a new male (Encke, pers. comm.). All three females reproduced, although the handreared female did not raise her infants. The group reportedly remained stable from January of 1998 until the spring of 2000 and grew to 1.7 individuals. Thereafter, the subdominant breeding female, the handreared female, and one of the female offspring that had been born into the group in 1999 were forced out of the group.

2. March 3, 2001: At the St. Louis Zoo, adult male Dashiel Std#987 was introduced to adult female Cappuchino Std#1334, her 17-month-old daughter Dana Std#1877, and 10-month-old daughter Friday Std#1783. The adult female gave birth to a male infant on September 15, 2001. The group remained stable, and approximately 10 months after the introduction of the new male, the oldest daughter was removed from the group. Cappuchino Std#1334 gave birth to another male infant on April 12, 2002. Her daughter Friday Std#1783 gave birth to an infant on May 19, 2002. The infant was being carried and cared for by Friday Std#1783 when it was discovered during the morning but was found dead in the enclosure later the same day, apparently having been killed by another group member.

Previously Published Cases

In: Carroll, J.B. 1988. The stability of multi-female groups of Goeldi's monkey, *Callimico goeldii,* in captivity. *Dodo, J Hersey Wildl Preserv Trust* 1988;25: 37-43.

Three study groups were set up between 1984 and 1987, each consisting of a male and two unrelated females. All three trios were eventually disbanded following aggression between the females. In one case, both females raised one infant. In the second group, both females reproduced but both infants died three days after birth, one of which was killed during fighting between the females. In trio #3 of Carroll's study, neither female became pregnant and the trio was disbanded after 46 days due to fighting between the females.

In: Hardie, S.M. 1995. Do Subordinate Female *Callimico* Disperse from Their Social Groups? *Folia Primatol* 1995;64:192-195.

A trio that was formed at the Belfast Zoological Gardens by introducing an adult male to two adult female siblings remained stable for more than 15 months, until both females became pregnant. These two females gave birth two days apart. On the morning that the younger female gave birth, both she and the male attacked the other female. The younger female's infant died the next day, but she continued to attack her sister, who gave birth one day later. Following the removal of the younger female, the remaining pair successfully reared the other infant.

Reproduction

Vince Sodaro

Introduction

Callimico typically give birth to single offspring, a characteristic that distinguishes them from all other taxa of the Callitrichidae (Pook, 1975). Twinning is a rare occurrence, with only 10 documented cases in captive animals (Warneke, 2003), and it has not been documented for the species in the wild. The ovarian cycle is approximately 23 to 24 days, with a reported range of 20 to 35 days (Christen et al., 1989; Pryce et al., 1993). The gestation is estimated to range from 144 to 159 days (Lorenz, 1972; Carroll et al., 1989; Ziegler et al., 1989; Jurke et al., 1994), with a postpartum estrus occurring from 10 to approximately 22 days after parturition (Carroll, 1982; Jurke et al., 1994). As a result, established pairs may breed prolifically, with interbirth intervals of approximately 165 days (Carroll, 1982; Beck et al., 1982). The predictability of the 165-day interbirth interval can serve as a valuable guide for managers anticipating parturition in multiparous females. The species has recently been shown to have biannual birth seasons in the wild, with births occurring in northern Bolivia toward the end of the dry season and during the second half of the rainy season (Porter, 2000). Nevertheless, there is no pattern of seasonality for births in a captive environment, and infants may be born during all months of the year (Carroll, 1982).

Both sexes may reach sexual maturity at less than a year of age. Using hormonal assays, Dettling and Pryce (1999) determined that a 48-week-old female attained sexual maturity while still housed in her family group. A male at Brookfield Zoo impregnated a female when he was approximately 11½ months of age. Lorenz (1972) reported a female of the same age becoming pregnant and giving birth to a full-term viable infant at the age of 16½ months. Despite these cases, callimico of this age are typically maintained and housed within their family groups and are not put into breeding situations until ages of 1½ to two years of age. An incest taboo normally inhibits breeding between siblings, as well as between parents and offspring, in groups in which all members are continuously housed together.

An 18-year-old female at the Durrell Conservation Trust is the oldest known female to have given birth to a viable offspring. A male that was 19 years, seven months old is the oldest known male to have sired a viable offspring. This same male also sired a stillborn infant at the age of 20 years, two months (Warneke, 2003).

Breeding Behaviors

It is not unusual for previously unfamiliar adult male and female callimico to copulate almost immediately following introduction, frequently on the first day of pairing (Lorenz, 1972; Beck et al., 1982) and often within the first hour. Sexual receptivity of females to males and solicitation to copulate is signaled by a stationary quadrupedal stance by the female, with the back slightly arched and the elbows and knees partially extended. This stance is accompanied by piloerection. A female in estrus may also be observed approaching and sitting next to or in front of the male and reaching back to touch or tap the male to solicit copulation. Tongue flicking may accompany such encounters by either the male or the female (Lorenz, 1972; Beck et al., 1982). A male will usually respond to these behaviors by mounting the female dorso-ventrally to begin copulation. In established breeding pairs, copulations and estrus behaviors cease during the pregnancy of the female and will normally be observed only during the postpartum estrus phase of the female. A male of an established breeding pair may be observed regularly checking the female's state of receptivity by following and sniffing her genitalia. These behaviors are typically not followed by attempts to mount the female unless she is in estrus.

Pregnancy

Pregnancy is usually readily apparent about six weeks prepartum, when the female's abdomen becomes noticeably enlarged and distended. However, there is a great deal of variability to the appearance of individual females in the third trimester of pregnancy, depending on the size of the fetus and the amount of weight that the female gains. A comparison of the nonpregnant weights of six females at Brookfield Zoo at the approximate time of conception with their weights within a week of parturition showed an average increase of 12.5% (range 5% to 21%)of their nonpregnant weights during pregnancy. For these females, as well as for several others at Brookfield Zoo whose weights had been monitored throughout pregnancy, weights did not always increase progressively and were, in some cases, marked by periods of decrease at various points in the pregnancies.

Females frequently urinate more frequently during the final month of pregnancy (Beck et al., 1982), and the base of the tail may appear to be continually wet. During late pregnancy, some females may appear to move more slowly and, in extreme cases, may appear to be stiff in the hindquarters and have difficulty locomoting normally. In such cases, a crouching, waddling gait may be seen as the female moves along horizontal substrates. Other signs of impending birth may be a change in the female's resting location. Although most callimico that are provided with a nestbox prefer to sleep on top of it rather than inside of it, some females nearing parturition may spend more time resting inside of their nestboxes during the day.

Although Pook (1975) witnessed a birth that occurred early in the evening shortly before the lights were switched off in a colony at the Jersey Wildlife PreservationTrust, the vast majority of births occur at night and are rarely observed by keepers (Heltne et al., 1981). Despite over 200 viable births having occurred over a 20-year period in a breeding colony at Brookfield Zoo, none occurred during daylight hours while keepers were present. Signs of labor in a pregnant female during the day may therefore be viewed as an unusual event , are cause for concern, and should be monitored closely.

References

Beck, B., D. Anderson, J. Ogden, B. Rettberg, C. Brejla, R. Scola, and M. Warneke. 1982. Breeding the Goeldi's monkey *Callimico goeldii* at Brookfield Zoo. *International Zoo Yearbook,* 22:106-114.

Carroll, B. 1982. Maintenance of the Goeldi's monkey *Callimico goeldii* at Jersey Wildlife Preservation Trust. *International Zoo Yearbook,* 22:101-105.

Carroll, J.B., D.H. Abbott, L.M. George, R.D. Martin, 1989. Aspects of urinary oestrogen excretion during the ovarian cycle and pregnancy in Goeldi's monkey, *Callimico goeldii. Folia primatologica,* 52: 201-205.

Christen, A., M. Döbeli,B. Kempken, M. Zachmann, and R. D. Martin. 1989. Urinary excretion of oestradiol-17ß in the female cycle of Goeldi's monkeys *(Callimico goeldii). Folia primatologica,* 52:191-200.

Dettling, A., and C. R. Pryce. 1999. Hormonal monitoring of age of sexual maturation in female Goeldi's monkeys *(Callimico goeldii)* in their family groups. *American Journal of Primatology,* 48:77-83.

Heltne, P.G., J. F. Wojcik, and A. G. Pook. 1981. Goeldi's monkey, Genus *Callimico*. In: *Ecology and Behavior of Neotropical Primates I,* eds. A.F. Coimbra-Filho and R.A. Mittermeier, pp. 169-209. Rio de Janeiro, Brazil: Academia Brasileira de Ciencias.

Jurke, M.H., C.R. Pryce, M. Döbeli, and R.D. Martin. 1994. Non-invasive detection and monitoring of pregnancy and the postpartum period in Goeldi's monkey *(Callimico goeldii)* using urinary pregnanediol-3-glucuronide. *American Journal of Primatology,* 34:319-331

Lorenz, R. 1977: Management and reproduction of the Goeldi's monkey *Callimico goeldii* (Thomas 1904). Callimiconidae, Primates. In: *Saving the Lion Marmoset:* 92-109. Bridgwater, D.D. (Ed.). Wheeling, WV: Wild Animal Propagation Trust.

Pook, A.G. 1975. Breeding Goeldi's monkey, *(Callimico goeldii)* at Jersey Zoological Park. *Annual Report of the Jersey Wildlife Preservation Trust,* pp. 17-20.

Porter, L.M. 2001. Social organization, reproduction and rearing strategies of *Callimico goeldii:* New clues from the wild. *Folia primatologica,* 72:69-79.

Pryce, C.R., M. H. Jurke,, H. J. Shaw, H.J, I. G. Sandermeier,M. Döbeli. 1993.Determination of the ovarian cycle in Goeldi's monkey via the measurement of steroids and peptides in plasma and urine. *Journal of Reproduction and Fertility*, 99:427-435.

Warneke, M. 2003. *International Studbook* ***Callimico goeldii.*** Brookfield, Il: Chicago Zoological Society.

Ziegler, T.E., C.T. Snowden, and M. Warneke, 1989. Postpartum Ovulation and Conception in Goeldi's Monkey, *Callimico goeldii. Folia primatologica,* 52: 206-210.

Infant Development of Goeldi's Monkey *Callimico goeldii*

Vince Sodaro

Introduction

The physical and behavioral development of Goeldi's monkey *Callimico goeldii* infants is well documented. Heltne et al. (1973, 1981), Pook (1975, 1978), Beck et al. (1982, 1990), Carroll (1982), Jurke and Pryce (1994), Anderson (1996), and Sodaro (2000) provide detailed descriptions of the physical and behavioral ontogeny of captive infants, while Masataka's description (1981) remains the most detailed to date of the development of wild callimico infants. This chapter will therefore not attempt to provide an exhaustive overview of infant development for the species. Rather, it will serve as an abbreviated yet practical guide to the normal developmental parameters that zoological park personnel may expect to observe in captive-born callimico infants.

Births

Callimico typically give birth to single offspring. Twinning is extremely rare for the species and is known from only 10 cases (Warneke, 2003). In only two of these cases were both infants born alive, and in neither case was the dam successful in raising both offspring. In one of the cases, a multiparous female appeared to be unable to handle the carrying and nursing of both infants, and one of the infants died on day three. In the second case, one of the infants was removed for handrearing on day one after the dam appeared to be experiencing similar difficulties. The occurrence of twinning in this species should therefore be cause for concern to managers, even in cases in which the dam has previously shown competent maternal skills.

Although Pook (1975) witnessed a birth that occurred early in the evening shortly before the lights were switched off in a colony at the Jersey Wildlife Preservation Trust, the vast majority of births occur at night and are rarely observed by keepers (Heltne et al., 1981; Sodaro, 1999). Despite over 200 viable births having occurred over a 20-year period in a breeding colony at Brookfield Zoo, none occurred during daylight hours while keepers were present. Signs of labor in a pregnant female during the day may therefore be viewed as an unusual event and are cause for concern. Such a situation should be monitored closely.

Newborn infants are typically discovered by keepers during the first morning check of the animals. Competent, experienced females exhibiting good maternal care will appear to be comfortable carrying a newborn infant, which is normally carried dorsally across the upper back and back of the neck when not nursing. Unlike *Callithrix* (Pook, 1978), *Leontopithecus* (Hoage, 1977), and *Saguinus* (Cleveland et al., 1984) infants, which may be carried by other group members in the first week of life, callimico infants are normally carried exclusively by the dam until at least two to three weeks of age (Heltne et al., 1973; Pook , 1975, 1978; Carroll, 1982). A newborn callimico infant carried by group members other than the dam signals maternal rejection or others problems and requires an immediate response from keepers.

The pelage of newborn infants is typically predominantly black, although various other shades may be present. The hands and feet are sparsely haired and may have a whitish or golden color (Heltne et al., 1981; Hill, 1966). The tail of an infant described by Hill (1966) was white. An infant born at the Jersey Wildlife Preservation Trust in 1978 was born with extensive areas of white pelage, with only the crown and face being black, and a mid-dorsal gray line (Carroll, 1982). The remaining pelage was white. Several infants born at Brookfield Zoo have also exhibited varying amounts of white pelage, including infants that were entirely white except for the crown, which was black. Others were born white from approximately the middle of the back down, including the legs and tail, while several others exhibited white cheeks. As in the case of the Jersey animal, these individuals lost these unusual colorations as they matured and exhibited the normal black pelage as adults. Such pelage variations have not been documented in wild infants, and it is not known if their occurrence in captive populations represents natural pelage variations or is the result of factors within the captive environment.

Early Development

Newborn infants are normally carried exclusively by the mother for the first two to three weeks of life. During the first week, infants may be seen clinging in a variety of positions on the mother's body. While carried dorsally, infants usually cling diagonally across the mother's shoulders with one forearm clinging to the shoulder and with the other clinging to the fur on the opposite side of the neck (Heltne et al., 1981). Heltne et al. also describe infants being carried ventrally on the mother's belly or side during the first week. Weak infants may be seen clinging low on the mother's thigh, lower back, or tail, or they may show an inability to climb from a ventral position to the mother's back. While clinging ventrally, such infants may be observed with their heads hanging back and with limbs extended away from the mother's ventrum rather than clinging in close contact with the ventrum. The tails of weak infants may appear to be limp rather than coiled close to the body, as is frequently seen in strong infants.

Newborn infants may be seen with their eyes open on the very first day of life (Beck et al., 1982; Heinemann, 1970) and by day two or three may be seen looking around (Heltne et al., 1981). Beck et al. (1982) also report that newborn infants should nurse within eight hours of birth but that in most cases it probably occurs sooner. At Brookfield Zoo, infants were usually observed to nurse at least once during hour-long formal observations conducted on day one. Infants moving from the dorsal position to a nursing position may climb headfirst over the mother's shoulder to the opposite breast to begin nursing. Competent mothers will facilitate nursing by raising their arm away from their body to allow a rooting newborn to find the nipple, which is close to the armpit. Once the infant is in nursing position, the female will appear to hold her upper arm close enough to the infant's head to block it from straying from the nipple (Sodaro, 1998). Throughout the first two weeks of life, infants do little more than nurse and sleep, although while in the dorsal position they may be seen looking at their surroundings or other group members.

Paternal and Sibling Care

When an infant is two to three weeks of age, an abrupt change in its developmental progress is initiated by the mother's vigorous attempts to force the infant to dismount from her. If the infant is in the dorsal position during such episodes, the mother may stand bipedally and rub the infant against a wall or other vertical substrate, or she may lie on her back and role back and forth to rid herself of the infant. This behavior may be accompanied by mild attempts to bite at the infant, as well as pull at the infant with her hands (Masataka, 1981). If the infant is in the ventral position when such attempts occur, the mother may be seen pushing at the infant and holding it away from her body with her arms fully extended. The mother's attempts to rid herself of the infant will invariably cause the infant to piloerect and to emit distress cries. These attempts lead to the first participation in the carrying and care of the infant by the father and older siblings. Carrying by the father occurs first, followed by carrying by older siblings (Beck et al., 1982; Carroll, 1982; Pook, 1978). The distress cries of the infant being pushed off of the mother typically result in the father's immediate approach to the mother and infant. The father does not manually pull the infant from the mother, but leans over the infant and allows it to climb onto him. Thereafter, carrying by the mother decreases dramatically and usually occurs only during nursing bouts (Heltne, 1978). Older siblings usually begin to carry when the infant is in its fifth week (Beck et al., 1982; Carroll, 1982). Although Moynihan (1976) and Christen (1998) reported that adults in the wild abandoned their infants when suddenly startled by human observers, group members in the Brookfield colony immediately ran to retrieve infants when startled by perceived threats in the captive environment. Fathers, in particular, were often fiercely protective of infants and other group members in such situations, directing elaborate threat displays at keepers, which included piloerection, tail wagging, baring of teeth, and forcible pushing of other group members away from the front of their enclosures.

Independence

Infants are first seen alone at ages ranging from 24 days to six weeks of age (Beck et al., 1982; Jurke and Pryce, 1994; Masataka, 1981), although independent locomotion is not usually seen until the infant is five to six weeks of age. The infant's first experience with contact with a substrate may be voluntary or involuntary. Carriers may force the infant to dismount, or it may voluntarily dismount from a stationary carrier onto the substrate. The earliest occurrences of independence from carriers are usually quite brief and may be accompanied by piloerection and distress vocalizations, especially in cases in which the infant has been pushed off of a carrier. This often results in an immediate "rescue" by other group members. Infants are not adept at climbing during the first weeks of independent locomotion and frequently fall. Managers should therefore bed the enclosure with a soft substrate such as wood shavings or hay to cushion infants from falls for the first month of independent locomotion. Exploratory behavior and time spent off of other group members gradually increase after week six, although infants may still be carried at three months old (Pook, 1978). Infants beyond three months of age are largely independent but may still momentarily jump onto other group members when frightened.

Solid food is first eaten by infants at about four weeks of age (Carroll, 1982). Infants at this age may be seen leaning over the shoulder of the mother or father from the dorsal position to taste food items being held by the adult. Group members may passively share food with infants, allowing infants to take a food item that they have themselves begun to eat. Active sharing may also be seen, which occurs when an adult picks up a food item, holds the item in front of itself, assumes a stationary sitting position, and allows the infant to take the item. As infants become more adept at independent locomotion, they begin to find their way to the food bowl and pick up food items on their own. Nevertheless, food sharing continues to be an integral part of the social interactions between group members for all age and sex classes for the species. Weaning occurs at about 16 weeks (Carroll, 1982).

Callimico may be sexually mature at less than one year of age. A male at Brookfield Zoo (studbook #219) sired an offspring at the age of 11½ months, while the earliest documented age of sexual maturation for a female is 48 weeks (Dettling and Pryce, 1999). Dettling and Pryce (1999) found that females still housed within their family groups became sexually mature at a median age of 57 weeks.

Offspring may remain in their family groups well beyond the age of sexual maturity, and families of up to six or seven individuals may remain stable for relatively long periods of time. Given the short average interbirth interval of 165 days for established pairs (Beck et al., 1982), juveniles receive their first exposure to newborn siblings at the age of 5½ months of age and begin to carry them at the age of about seven months. By the age of two, such individuals may have gained the experience of caring for and carrying three younger siblings. Although for some Callitrichid species prior infant care experience is considered to be essential for individuals to successfully raise their own offspring (Tardiff et al., 1994), callimico raised in family groups and receiving proper socialization may successfully raise offspring without prior infant experience (Sodaro et al., 1994). Seven of nine females at Brookfield Zoo that happened to be the last offspring born into their family groups and consequently had no opportunities to receive infant carrying experience were later successful in raising their own offspring. The socialization process that occurs through parental rearing of callimico infants within natal groups, rather than infant carrying experience, may be the most critical requirement for the future success of individuals as parents.

Weight Gain

Keepers rarely handle newborn infants that receive competent maternal care, and because such individuals are not weighed, the range of birth weights of parent-reared infants is not known. The lowest documented birth weight of an infant that was successfully parent-reared is 43.5 grams (Sodaro, 2000). The birth weights of 15 infants that were handreared at Brookfield Zoo beginning on day one ranged from 48 to 70 grams, with a mean of 57.85 grams. Of 18 handreared infants, birth weight doubled between five and eight weeks of age and tripled between eight and 10 weeks of age. At 10 weeks of age, weights ranged from 160 to 219.3 grams, with a mean of 188 grams. Many individuals, whether handreared or parent-reared, continue to gain weight up to two years of age. However, the age at which weight gain ceases to be representative of typical patterns of growth and development for callimico is unknown. Factors related to a captive environment, such as inactivity or diet, may contribute to weight gain in individuals beyond two years of age.

References

Anderson, D. 1996. *Rapid physical development and maturation, delayed behavioral maturation, and single birth in young adult Callimico: A reproductive strategy.* Ph.d. diss. Ohio State University.

Beck, B., D. Anderson, J.Ogden, B. Rettberg, C. Brejla, R. Scola, and M. Warneke. 1982. Breeding the Goeldi's monkey *Callimico goeldii* at Brookfield Zoo. *International Zoo Yearbook,* 22:106-114.

Beck, B., D. Anderson, E. Derrickson, B. Rettberg, V. Sodaro, R. Scola, and M. Warneke. 1990. The development of body weight and behavior in captive callimicos. Unpublished.

Carroll, B., 1982. Maintenance of the Goeldi's monkey *Callimico goeldii* at Jersey Wildlife Preservation Trust. *International Zoo Yearbook,* 22:101-105.

Christen, A. 1998. The most enigmatic monkey in the Bolivian rain forest- *Callimico goeldii. Neotropical Primates,* 6(2):35-37.

Cleveland, J., and C. T. Snowdon. 1984. Social development during the first twenty weeks in the cotton-top tamarin *(Saguinus oedipus). Animal Behavior,* 32:432-444.

Dettling, A., and C. R. Pryce. 1999. Hormonal monitoring of age at sexual maturation in female Goeldi's monkeys *(Callimico goeldii)* in their family groups. *American Journal of Primatology,* 48:77-83.

Heinemann, H. 1970. The breeding and maintenance of captive Goeldi's monkey, *Callimico goeldii. International Zoo Yearbook,* 10:72-78.

Heltne, P.G., D. C. Turner, and J. Wolhandler. 1973. Maternal and paternal periods in the development of infant *Callimico goeldii. American Journal of Physical Anthropology,* 38:555-560.

Heltne, P.G., J. F. Wojcik, and A. G. Pook. 1981. Goeldi's monkey, Genus *Callimico.* In:*Ecology and Behavior of Neotropical Primates I.,* eds. A.F. Coimbra-Filho and R.A. Mittermeier, pp. 169-209. Rio de Janeiro, Brazil: Academia Brasileira de Ciencias.

Hill, W.C.O. 1966. On the neonatus of *Callimico goeldii* (Thomas). *Proc. Royal Soc. Edinburgh,* Sec. B, Vol.69.

Hoage, R.J. 1977. Parental care in *Leontopithecus rosalia:* sex and age differences in carrying behavior and the role of prior experience. In: *The Biology and Behavior of Callitrichidae,* ed., D. Kleiman, pp. 293-305. Washington, D.C.: Smithsonian Press.

Jurke, M.H., and C. R. Pryce. 1994. Parental and infant behaviour during early periods of infant care in Goeldi's monkey, *(Callimico goeldii). Animal Behavior,* 48:1095-1112.

Masataka, N. 1981a. A field study of the social behavior of Goeldi's monkeys *(Callimico goeldii)* in north Bolivia I. Group composition, breeding cycle, and infant development. *Kyoto University Overseas Research Reports of New World Monkeys,* 2:23-32.

Moynihan, M. 1976. *The New World Primates.* Princeton University Press, Princeton, N.J.

Pook, A.G. 1975. Breeding Goeldi's monkey, *(Callimico goeldii)* at the Jersey Zoological Park. *Annual Report of the Jersey Wildlife Preservation Trust,* pp. 17-20.

--------. 1978. A comparison between the reproduction and parental behaviour of the Goeldi's monkey *(Callimico goeldii)* and true marmosets (Callitrichidae). In: *Biology and Behavior of Marmosets,* eds. H. Rothe, H.I. Wolters, and J.P. Hearn, pp. 1-14. Gottingen,Germany: Eigenverlag Rothe.

Sodaro, V., K. Pingry, and K. Snyder. 1994. Changes in handrearing procedures for *Callimico goeldii* at Brookfield Zoo. In: *1994 AZA Regional Conference Proceedings,* Oglebay Park, Wheeling, West Virginia.

Sodaro, V. 1999. Handrearing *Callimico goeldii* in zoological parks. In: *Callitrichid Husbandry Manual,* eds. V. Sodaro and N. Saunders, pp. 88-92. Neotropical Primate Taxon Advisory Group.

--------. 2000. A review of handreared Goeldi's monkey *Callimico goeldii* at Brookfield Zoo 1977-1997. *International Zoo Yearbook,* 37:360-366.

Tardif, S.D., C. B. Richter, and R. L. Carson. 1984. Effects of sibling rearing experience on future reproductive success of two species of Callitrichidae. *American Journal of Primatology,* 6:377-380.

Warneke, M. 2003. *International Studbook* ***Callimico goeldi.*** Brookfield, Il: Chicago Zoological Society.

Handrearing Callimico in Zoological Parks

Vince Sodaro and Barbara Lintzenich

Introduction

Attempts to handrear callimico infants are most frequently necessitated by poor maternal care or actual rejection or abandonment. The vast majority of callimico births occur at night and are seldom observed by keepers. At the first morning check of the animals, keepers typically discover abandoned infants. Such infants may be found lying on the floor or shelves of the cage, or being carried by another member of the female's group. Unlike *Leontopithecus* (Hoage, 1977) and *Saguinus* (Price, 1992) infants, which may be carried by other members of a female's group in the first week of life, captive-born callimico infants are normally carried exclusively by the dam until at least three weeks of age. A newborn callimico being carried by group members other than the dam signals maternal rejection or other problems and requires an immediate response.

Competent, experienced females exhibiting good maternal care will appear to be comfortable carrying a newborn infant, which is normally carried dorsally across the upper back and back of the neck when not being nursed. Such females will facilitate nursing for the infant by raising their arm away from their body to allow a rooting newborn to easily find the nipple, which is close to the armpit. Once the infant is in nursing position, a female will appear to hold her upper arm close enough to the infant's head to block it from straying from the nipple.

Poor maternal care or signs of rejection of an infant may not always be immediately apparent in situations in which a female is found to be actually carrying a newborn infant but should be noticeable within two to three hours of continuous observation.

Early indications of problems may include:

1) attempts by a female to dislodge an infant from her back by rubbing it against walls or substrates within the cage;
2) a female pulling or holding the infant's head away from her breast during nursing attempts;
3) aggressive or defensive behaviors or obvious stress triggered by the approach of other group members; or
4) constant “fidgeting” with an infant.

If stress triggered by the presence or approaches of another group member seems to be the only factor affecting the female’s care of the infant, the immediate removal of that group member is recommended to avoid the necessity to handrear.

Infants should be removed for evaluation and possible handrearing if poor maternal behaviors continue during continuous observations on day one and no nursing has been seen.

An infant observed clinging low on a female's back or hindquarters or carried ventrally for prolonged periods of time is usually an indication of the infant's weakness due to lack of nursing or that the infant has other physical problems. This situation requires immediate removal of the infant for evaluation and, most likely, handrearing. Infants that have sustained bite wounds do not usually survive.

Twinning is a rare occurrence in *Callimico* (Altmann et al., 1988), with only 10 documented cases (Warneke, 2003). Five of these cases occurred at Brookfield Zoo, and in only two of these were both offspring born alive. In one of these cases, a multiparous female appeared to be unable to handle the carrying and nursing of both infants, and one of the infants died on day three. In the second case, one of the infants was removed for handrearing on day one after the dam appeared to be experiencing similar difficulties. The occurrence of twinning in this species should therefore be cause for concern to managers, even in cases in which the dam has previously shown competent maternal skills. Removal of one of the infants for handrearing should be seriously considered if observations suggest that the dam is having problems carrying or positioning the infants for nursing.

Handrearing Procedure

Twenty callimico infants have been handreared at the Chicago Zoological Park using a protocol that has evolved from one that was first developed at the Departments of Microbiology at Rush-Presbyterian St. Luke's and University of Illinois Medical Centers in Chicago, Illinois (Wolfe et al., 1972). This protocol was first successfully applied to callimico in 1979 (Beck et al., 1982). The handrearing process at the Chicago Zoological Park has undergone many changes over the course of handrearing these infants and differs in certain aspects from the protocol as described by Beck et al. (Sodaro et al., 1994). Every infant, and consequently every handrearing effort, is unique. The protocol described here should therefore be viewed as a set of guidelines that can be modified to suit the individual needs of each infant being handreared.

Incubation and Thermoregulation

If an infant is discovered abandoned or is removed from the dam or other group members and appears to be strong and warm to the touch, place it in an incubator with the temperature set at between 89° to 90° F. If the infant appears to be weak and is cold to the touch, the temperature of the incubator should be gradually increased to 89° to 90° F over a period of several hours. This temperature range should be maintained for the infant through day nine and decreased to 87° F on day 10. The temperature should be decreased to 85° F on day 14 and to 82° F on day 18.

Callimico have been found to be able to thermoregulate at ages ranging from 23 to 25 days and can then be removed from incubators. Thereafter, they should be placed in an interim cage within the enclosure of the group to which the infant will be introduced. A supplemental heat lamp must be provided for warmth, and the temperature of the enclosure or room in which they are housed must be maintained at 78° to 80° F.

Surrogates

Infants should be provided with a surrogate that approximates as closely as possible the size, shape, and color of an adult animal. Ideally, a surrogate made from the preserved skin and fur of a callimico specimen would be the best possible surrogate that could be provided, but if this is not possible, a small, black “stuffed animal” made of soft artificial material can be used.

Milk Composition

Milk output and composition will change over time. Thus, one sample is not necessarily a good indication of true milk composition throughout the lactation period (Ausman, 1995). There is no information on *Callimico goeldii* milk, although there is information for a few other species of Callitrichids. *Saguinus oedipus* (cotton-top tamarin) milk was reported to contain 3.8% protein, 3.2% fat, 5.8% carbohydrate (lactose), and 0.4% ash, on a fresh weight basis (Hafes, 1971). From the tamarin milk data, the milk can be calculated to be approximately 86.9% water and contain 0.66 kcal/gram. It was reported that milk composition of common marmosets was more dilute (Ausman, 1995; Oftedal & Iverson, 1995). From these observations, a formula has been tried and is outlined in the next section.

Diet and Feeding Procedure

Nipples are made following a method developed by Dr. James Ogden (Ogden, 1979). A compilation of published data and the holding institutions that performed handrearing successfully shows that a combination of a human infant milk replacer and a high-protein nutritional supplement is an effective formula for Callitrichid handrearing (Beck et al., 1982; Crissey, 1993). The ingredients SMA (Wyeth Laboratories Inc.) and Sustagen (Mead Johnson & Co.) formerly used in making formula (Beck et al., 1982) are no longer manufactured. A combination of liquid Similac® with Iron and powdered Boost® High Protein Supplement is now recommended. This formula should be offered at a ratio of 94.5% Similac® and 5.5% Boost® High Protein powder. Since the Boost powder can be difficult to obtain in the small quantities needed, a combination of liquid Similac® with Iron and liquid Boost® High Protein Supplement is compared to the previous suggested formula. This liquid formula has not been tested. Also available is a high-protein primate formula (Primilac) manufactured by Bio-Serve. Table 1 outlines the formulas as fed, and Table 2 compares the formulas on a dry matter basis as compared to the Nutrient Requirements of Nonhuman Primates (2003).

Table 1. *Callimico goeldii* handrearing formulas as fed

Nutrient	Similac®/Powered Boost®a	Similac®/Liquid Boost®b	Primilac
Water, %	86.9	92.57	87.5
Energy, ME kcal.g	0.65	0.56	-
Protein, %	2.69	2.57	2.40
Carbohydrate (lactose), %	6.90	6.02	6.30
Fat, %	3.54	3.55	3.51
Linoleic Acid, %	0.85	0.73	-
Vitamin A, IU/g	3.25	2.79	6.08
Vitamin D3, IU/g	0.42	0.47	0.32
Vitamin E, mg/kg	28.7	40.9	7.36
Thiamin, mg/kg	2.1	0.90	0.65
Riboflavin, mg/kg	1.19	1.22	1.3
Niacin, mg/kg	13.7	10.3	6.48
Pyridoxine, mg/kg	0.94	0.96	0.65
Folic Acid, mg/kg	0.27	0.21	0.97
Vitamin B12, mg/kg	0.003	0.003	0.03
Pantothenic Acid, mg/kg	5.64	4.73	4.05
Choline, mg/kg	105.9	134.1	324
Biotin, mg/kg	0.11	0.09	0.03
Vitamin C, mg/kg	78.9	103.5	97.2
Calcium, %	0.078	0.071	0.05
Phosphorus, %	0.063	0.060	0.03
Magnesium, %	0.014	0.013	0.01
Potassium, %	0,13	0.10	0.07
Sodium, %	0.17	0.14	0.03
Iron, mg/kg	17.8	14.1	22.9
Zinc, mg/kg	5.9	8.2	2.7
Copper, mg/kg	1.29	0.95	0.55
Manganese, mg/kg	1.02	0.65	2.7
Iodine, mg/kg	0.13	0.12	0.28

[a]Similac® + powdered Boost® = 94.5% Similac® liquid with iron to 5.5% Boost ® high-protein powder.
[b]Similac® + liquid Boost® = 80% Similac® liquid with iron to 20% Boost ® high-protein liquid.

Table 2. Nutrient analysis of *Callimico goeldii* handrearing formulas on a dry matter basis

Nutrient	Similac®/ Powered Boost®[a]	Similac®/ Liquid Boost®[b]	Primilac	NRC*
Protein, %	23.7	34.6	19.3	15-22
Fat, %	31.1	47.8	28.3	-
Vitamin A, IU/g	28.6	37.5	48.9	8
Vitamin D3, IU/g	3.7	6.3	2.6	2.5
Vitamin E, mg/kg	252	550	59.2	50-100
Thiamin, mg/kg	18.8	12	5.2	3
Riboflavin, mg/kg	10.5	16	10.4	4
Niacin, mg/kg	121	138	52.2	25
Pyridoxine, mg/kg	8.2	12.8	5.2	4
Folic Acid, mg/kg	2.3	2.8	7.8	4
Vitamin B12, mg/kg	0.023	0.04	0.26	0.03
Pantothenic Acid, mg/kg	49.6	63.7	32.6	12
Choline, mg/kg	931	1805	2608	750
Biotin, mg/kg	1.03	1.1	0.26	0.2
Vitamin C, mg/kg	694	1393	782.6	200
Calcium, %	0.68	0.9	0.37	0.5-0.8
Phosphorus, %	0.68	0.8	0.28	0.4-0.6
Magnesium, %	0.5	0.17	0.11	0.08
Potassium, %	1.1	1.3	0.54	0.4
Sodium, %	1.4	1.9	0.25	0.2
Iron, mg/kg	157	189	185	100
Zinc, mg/kg	52	110	21.7	100
Copper, mg/kg	11.4	12.7	-	12-20
Manganese, mg/kg	9.0	8.7	21.7	20
Iodine, mg/kg	1.2	1.5	2.2	0.35

[a]Similac® + powdered Boost® = 94.5% Similac® liquid with iron to 5.5% Boost ® high-protein powder.
[b]Similac® + liquid Boost® = 80% Similac® liquid with iron to 20% Boost ® high-protein liquid.
*NRC is National Research Council's nutrient requirements of nonhuman primates 2003.

Newborn infants should initially be offered formula at a rate of at least 20% of their body weight per 24 hours (i.e., a 50g infant should be offered a total of 10cc's of formula per day divided between the total number of feedings offered per day). This rate may be increased if a steady progression of weight gain does not occur during the first seven to 10 days. Weak infants are first offered Pedialyte® Oral Electrolyte Maintenance Solution. As an infant begins to gain strength over the course of the first day, formula should be offered.

Strong, healthy infants are fed five times daily, with additional night feedings offered at two- to three-hour intervals for the first eight to 10 days. Newborn infants weighing less than 50g should be at two-hour intervals. Night feedings can gradually be eliminated and, in most cases, stopped completely at about one month of age. A schedule of five formula feedings daily should be continued through day 13, increasing the amount fed as the infant's demand increases. The initial amount fed should increase to about 2cc per feeding at one week of age and to 3cc at two weeks of age.

Day 14: Decrease the number of feedings per day to five, offering Gerber® Mixed Baby Cereal (Gerber Products Company) at the second and the fourth feedings. The cereal is prepared by adding 1cc of formula to ½ teaspoon of dry cereal. Mashed banana is added to the cereal on day 18 and is gradually followed by other mashed fruits.

Day 25: Add a small amount of Zupreem® Marmoset Diet (Premium Nutritional Products, Inc.) to the cereal. Initial consumption of the Zupreem® Marmoset Diet is usually poor but gradually improves as the infant becomes more experienced with eating solids and approaches weaning.

Day 28: Decrease the number of feedings per day to four, with the second and fourth being cereal feedings. Small pieces of fruit, steamed sweet potato, and Zupreem® Marmoset Diet are offered in addition to that mixed with the cereal. Infants at this age typically consume between 5cc and 7cc of formula at each of their three formula feedings.

Day 46: Decrease the number of feedings to three, combining the first two and last two feedings such that formula and cereal are fed simultaneously at these feedings. The midday feeding is formula. Infants at this age consume between 8cc and 11cc of formula at each of the three feedings offered.

Day 70: The process of weaning the infant to the adult diet should begin by decreasing the amount of cereal offered. This usually encourages the infant to begin to eat the fruits, steamed sweet potato, and Zupreem® Marmoset Diet more readily, although many infants at this age already do so.

Day 77: Discontinue the cereal. Begin to gradually decrease the amount of formula offered per meal. Some infants at this age may be consuming a maximum of 15cc of formula per feeding, but many begin to show a preference for solids before weaning has begun and will begin to refuse part of their formula ration. Infants should be totally on the adult diet by day 84.

Birthweights and Weight Gain

Only four of 20 infants that have been successfully handreared at the Chicago Zoological Park had birth weights of less than 53g, the smallest of which was 42g. Thirteen infants with birth weights ranging from 37.5g to 50g died at ages ranging from one to seven days despite handrearing efforts. Eleven of these weighed less than 50g. Two other infants with weights of less than 50g when handrearing attempts began at ages of four days and six days also died. While infants in this weight range can be regarded as being of compromised and poor candidates for survival of handrearing attempts, it is likely that a certain number of infants that are successfully reared by female callimicos with good maternal skills fall within this weight range.

The majority of healthy handreared infants double their birth weight between weeks five and six, although the smallest infant handreared at Brookfield doubled her birth weight at 26 days of age. This same infant tripled her birth weight at 51 days of age, while infants typically triple their birth weight at ages ranging from eight to 10 weeks.

Weeks of Age	**Range**	**Mean**
Birth	42-72.7g	57.56g
1	44-68g	58.2g
2	52-79.2g	65.12g
3	61-94g	77.01g
4	68-108.3g	89.87g
5	76-126g	104.96g (N = 19)
6	94-145g	120.56g (N = 20)
7	96-153.6g	132.42g (N = 20)
8	118-177.5g	152.5g (N = 17)
9	146-200.9g	170.59g (N = 16)
10	160-219.3g	186.98g (N = 15)
Male birth weight range	(N=8): 52.7-59g	Mean = 57.47g
Female birth weigh range	(N=12): 42-72.7g	Mean = 57.62g

Table 1. Birth Weights and Weekly Weights of Callimico Handreared at the Chicago Zoological park. (N=18 unless otherwise noted)

Socialization Problems

Handreared callimico, like handreared marmosets and tamarins, frequently exhibit an array of socialization problems, including imprinting on humans, poor parental skills and rejection of offspring, premature peripheralization from foster groups, and incompatibility with conspecifics. The socialization process that occurs through parental rearing of callimico infants within natal groups is a critical requirement for the social and parental success of the individual upon reaching adulthood. After long periods of isolation from conspecifics prior to reintroduction, most handreared callimico infants do not recognize conspecifics as something to cling to or by which they might be carried. Adults in the groups to which they are reintroduced, whether the infants' family or a foster family, seldom show solicitous parental behavior toward them.

It is therefore critical that all aspects of any handrearing endeavor focus on minimizing the social isolation from conspecifics that often characterizes traditional “nursery” handrearing efforts, as well as on promoting as close contact between an infant and its family as is possible as early as possible.

Reintroduction

While reintroduction to foster families rather than to natal groups has proven to work well for *Saguinus oedipus* infants (Dronzek et al., 1986), nine callimico infants that were introduced to foster families at the Chicago Zoological Park failed to become well-integrated into these groups (Sodaro et al., 1994). Although they were accepted and tolerated as group members while infants, all were harassed and peripheralized by one or both foster parents at ages ranging from 3½ to 13 months.

Contact between the infant and the other members of its family can be maximized from day one by handrearing the infant within the enclosure of the family. The following is a summary of the steps that can be taken to accomplish this:

1. The incubator in which the infant is kept can be put inside of the family's enclosure. This allows extensive, visual, auditory, and olfactory contact between the infant and the family from day one. The electrical cord can be protected from possible chewing or biting by the group by a PVC pipe used as a conduit.

2. All feedings of the infant should take place in the group’s cage. Family members of five infants handreared at the Chicago Zoological Park using this method seemed to maintain a high level of interest in the infants and frequently directed protective or defensive behaviors at keepers who handled the infants. This method also facilitated direct contact between the infants and group members as they crowded around the infant. Keepers allowed infants and group members to touch and sniff each other during these feedings. These five infants were provided with separate surrogates to which they were encouraged to transfer for all feedings. The purpose of these surrogates was to establish a “bridge” that the infants eventually learned to associate with food and which were used to lure them out of their interim cage into the vicinity of the adults' food bowl. This, in turn, accelerated the process whereby the infants learned to locomote independently, as well as feed themselves from the families' bowl.

3. At the age of 35 days, infants should be removed from the interim cage during the day and allowed to have direct contact with the group by attaching the surrogate to the top of the interim cage. A small branch should be attached from the top of the interim cage to allow the infant a route to the food bowl or to return to the inside of the interim cage.

If no negative interactions are observed between the infant and family members during two to three days of observations of this situation, it is no longer necessary to return the infant to the interim cage at night. Continued isolation of the infant in the interim cage at this stage would only serve as a further barrier to socialization. If, and when, the infant begins to be carried by family members, the feeding surrogate can be used to retrieve the infant for feedings. Once the infant has begun to sleep with family members, it can be regarded as well-integrated into the family and the use of surrogates can be discontinued.

Products Mentioned in the Text

Boost® High-Protein Supplement
Mead Johnson Nutritionals
Evansville, IN 47721 USA
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Gerber® Mixed Baby Cereal
Gerber Products Company
Fremont, MI 49413, USA

Pedialyte® Oral Electrolyte Maintenance Solution
Ross Products Division
Abbott Laboratories
Columbus, OH 43215-1724 USA

Primilac®
Bio-Serve, Inc.
P.O. 450
Frenchtown, NJ 08825

Similac® with Iron Infant Formula
Ross Products Division
Abbott Laboratories
Columbus, OH 43215-1724 USA

Zupreem® Marmoset Diet
Premium Nutritional Products, Inc.
P.O. Box 2094
Mission, KS 66202 USA

References

Altmann, J., M. Warneke, and J. Ramer. 1988. Twinning among *Callimico goeldii. International Journal of Primatology,* 9:165-168.

Ausman, L.M. 1995. Nutritional needs of the neonate and growing young monkey. *Symposium on Health and Nutrition of New World Primates*. March 12, 1995.

Beck, B.B., D. Anderson, J. Ogden, B. Rettberg, C. Brejla, R. Scola, and M. Warneke. 1982. Breeding the Goeldi's Monkey *Callimico goeldii* at Brookfield Zoo, Chicago. *International Zoo Yearbook,* 22:106-114.

Dronzek, L., A. Savage, C. T. Snowden, C. S. Whaling, and T. E. Zeigler. 1986. Technique for Handrearing and Reintroducing Rejected Cotton-Top Tamarin Infants. *Laboratory Animal Science,* 36:243-247.

Hafes, E.S.E. (ed.). 1971. Comparative Reproduction of Non-Human Primates. Charles C. Thomas Publishing, Springfield, IL.

Hoage, R.J. 1977. Parental care in *Leontopithicus rosalia:* sex and age differences in carrying behavior and the role of prior experience. In: *The Biology and Behavior of Callitrichidae,* ed., D. Kleiman, pp. 293-305. Washington, D.C.: Smithsonian Press.

Ogden, J.D. 1979. Hand-rearing Saguinus and Callithrix genera of marmosets. In: *Nursery Care of Nonhuman Primates,* ed., G.C. Ruppenthal, pp. 313-319. New York: Plenum Press.

Price, E.C. 1992. Contributions to infant care in captive cotton-top tamarins *Saguinus oedipus:* the influence of age, sex, and reproductive strategy. *International Journal of Primatology,* 13:2.

Sodaro, V., K. Pingry, and K. Snyder. 1994. Changes in Handrearing Procedures for Callimico goeldii at Brookfield Zoo. In: *1994 AZA Regional Conference Proceedings,* pp. 404-407. Wheeling, WV: AZA.

Warneke, M. 2003. *International Studbook* ***Callimico goeldii.*** Brookfield, Il: Chicago Zoological Society.

Wolfe, L.G., J.D. Ogden, J.B. Deinhardt, L. Fisher, and F. Deinhardt. 1972. Breeding and handrearing marmosets for viral oncogenesis studies. In: *Primate Breeding,* ed. W.I.B. Beveridge, Basel: Karger.

Management, Training, and Behavioral Enrichment

Maureen Leahy

Identification of Individuals

Permanent identification of animals is strongly recommended. Tattooing an animal's inner thigh with its international studbook number is preferred. Typically, females are tattooed on their right inner thigh and males on their left inner thigh. The use of a transponder chip for secure identification is also recommended. Brookfield Zoo uses microchip implants manufactured by the Trovan, Infopet Identification System, Burnsville, MN. Individual callimico housed within a group setting may be difficult to identify quickly for research purposes. For these instances, shaving a 2" segment on the animal's tail or using hair dye are temporary means of identifying individuals. Callimico can also be fitted with an ear tag or a stainless-steel neck chain that supports a small, colored, lightweight plastic identification tag.

Capture Methods

Callimico may need to be periodically captured for medical reasons, transportation, or relocation. Depending on the design of the enclosure, most callimico can easily be caught with a net. Using a finely meshed net is recommended to prevent claws or teeth from becoming entangled.

Callimico can easily become stressed during a netting procedure and potentially injure themselves or cage mates. Using less stressful methods of capture are recommended whenever possible. If an animal is accustomed to sleeping in its nestbox, lock it in at night or early in the morning before lights are turned on. Nestboxes can be constructed with nontoxic treated wood or plastic, measuring approximately 11" wide X 10" deep X 12" tall, and have a front-side opening that is 4" wide X 5" tall located approximately 3" from the nestbox bottom. Several 0.5 cm holes can be drilled into the sides and front of the nestbox to provide ventilation. A sliding door can also be affixed to the front of the nestbox to close off the opening and potentially be used to secure a callimico inside. Callimico can also be desensitized to a transport crate, as discussed in this manual's training chapter.

Manual Restraint Techniques

Callimico can be easily handrestrained by one person for minor procedures such as physical examination, blood sample collection, vaccination, and tuberculin testing. This is most effectively done by securing the animal's head with a thumb and forefinger of one hand around the neck, while the other hand restrains the animal's torso and legs. Once the animal is secure within a net or crate, the handler must gain control of the animal's head by placing his or her thumb and forefinger firmly and supportively around the animal's neck. The second hand can either gain control of the torso or, if necessary, slip underneath the net and replace the first hand. The free hand should then be used to grasp and secure the animal's waist, or alternatively, to extend the animal's legs and tail. Handlers should wear leather gloves during a restraint procedure to prevent potential bite wounds.

Shipment and Preshipment Preparations

Animal shipment guidelines have been established by CITES (Convention on International Trade in Endangered species), IATA (International Air Transport Association), and USFSW (United States Fish & Wildlife Service). The United States Department of Agriculture (USDA) also regulates specific requirements for the shipment of nonhuman primates (Subpart D, sections 3.87-3.92). The process of shipping a callimico from one institution to another should also include the following preparatory steps to ensure a successful transfer:

1. Perform a preshipment exam of the animal.
2. Provide pertinent information about the animal's history to the receiving institution.
3. Construct or acquire a suitable shipping crate.
4. Make appropriate travel arrangements for shipment.

Preshipment Exam

The preshipment physical exam is needed to obtain baseline information on the animal's health prior to shipment. A suggested preshipment exam (J. Zdziarski, pers. comm.) should include:

- Fecal analysis for parasites and ova
- Fecal culture for bacterial pathogens
- Tuberculin test
- Complete blood count
- Serum chemical panel
- Administration of vaccinations, as needed
- Urinalysis
- Thoracic radiographs
- Permanent identification (transponder and tattoo studbook number on inner thigh)

Animal History

Provide the receiving institution with any pertinent details about the animal's past and present medical and social histories. This should include, but is not limited to, the American Association of Zookeepers (AAZK) Animal Data Transfer (ADT) form; ARKS (Animal Record Keeping System) and MedARKs (Medical Animal Record Keeping System) individual specimen reports; nutritionist-approved dietary specifications; and other related individual records such as training, enrichment use, or behavioral data. When shipping an animal for breeding purposes, it is important to provide specific information on the individual's own rearing history, as well as its previous breeding experience, care of offspring, infant carrying experience, etc.

Shipping Container Specifications

An appropriate shipping container should measure at least 18” long X 12” wide X 12” high and be constructed of either nontoxic treated wood or plastic, and it must provide good ventilation. Containers should have several 0.5 cm holes on the sides and front of the box or a wire mesh door and wire 5-mesh “windows” on the sides. IATA-approved rigid plastic dog containers such as Vari Kennel® or similar containers measuring 21” long X 16” wide X 15” high are recommended. Cover any open mesh with an additional layer of fine mesh or burlap to prevent callimico from probing their hands through the holes. Burlap is also recommended to ensure the animal’s privacy.

The inside of the container floor can either be covered with an absorbent substrate layer, such as wood wool, pine shavings, or hay, or be fitted with a secured wire grate that will allow urine and feces to collect on the bottom. Allow a maximum of 0.5 cm between the grate slats to decrease the chance of the animal getting its hand or foot caught. Food and water bowls can be secured to the inside of the crate with supportive rings to prevent movement during shipment. Place the bowls close to the crate door so that provisions can be replaced during shipment, if necessary.

The outside of the container should have a carrying handle, and “Live Animals/This Side Up” labels should be affixed to three sides of the container. Label the container with pertinent information, including the addresses and phone numbers of the sending and receiving institutions. Immediately prior to shipment, secure the container door closed by looping a wire or Teflon cable tie through the door and a previously drilled hole in the crate front.

Multi-animal Shipments

The following recommendations should be considered if more than one callimico needs to be shipped. A young infant less than eight months of age should always be shipped in the same crate as its dam. Two to four animals can also be sent in the same container, but only if they have been an established pair or living together in a stable family group prior to shipment. However, the crate size should be increased to properly accommodate the number of animals being shipped. When shipping a large family group in which individuals may need personal attention, a single large container can be divided into several compartments. The interior walls between compartments should allow cross-ventilation and auditory/olfactory contact.

Travel Arrangements, Timing, and Regulations

Air-transport shipments should be as direct as possible and should be avoided on weekends or holidays. Callimico can become easily chilled or overheated, so it is best to ship during the spring or fall to avoid extreme temperatures and weather conditions. Also, take into account the possible weather at any scheduled stop and plan accordingly. The USDA Animal Welfare Act regulations for mammals prohibit shipment of animals if the temperature is below 7.2OC (45OF) for more than 45 minutes during handling unless accompanied by a certificate of acclimation to lower temperatures. Shipments of animals are also prohibited when temperatures exceed 29.5°C (85°F) in any animal-holding facility at the terminal, over 32.9°C (75°F) for more than four hours at the terminal, or over 29.5°C (85°F) for more than 45 minutes during handling.

Training

Basic Training Recommendations

Proactive management of animal behavior has become a growing priority in the larger zoological community (Sullivan, 2000). Training in a zoological setting can make several tasks easier and help provide a higher level of care. Keeper time is always limited, but small adaptations to the usual callimico husbandry routine allow for simple training opportunities, such as:

Body Examination

Training an animal to come up to the cage front for a handfed treat provides a daily opportunity for a keeper to visually examine the animal's body for any physical changes. For example, tooth abscesses are a common medical problem for callimico but are usually detected only through close observation of an animal's face for swelling beneath the eyes or around the muzzle. The small size and dark color of callimico make injuries or physical abnormalities difficult to see unless the animal remains still by clinging to the cage front in close view of the keeper. Further steps can be made to desensitize the animal to a flashlight or a cotton swab that can aid in a visual body examination.

Weighing

Routine monthly weighing of callimico is recommended and may also be necessary on a weekly basis if there is an individual medical concern. Using a small portable scale is recommended with a platform cover that measures approximately 10" X 10". Brookfield Zoo uses a portable scale (model 7000XL) manufactured by Doran Scales, Inc., Batavia, IL. The scale has a six-digit LED display and weighs in gram amounts with a capacity of 4500 grams X 1 gram. Some callimico are bold enough to jump onto a scale placed in their enclosure to retrieve a favorite food item without any prior desensitization. However, preparatory steps can be taken to desensitize those individuals that are reluctant to do so. For example, keep the scale cover accessible in the animal's cage and place a daily food treat on it or the animal's food bowl, until the animal is comfortable with its presence. A common problem in obtaining an accurate weight on callimico is that their long tail has a tendency to hang off of the scale platform onto other surfaces, rendering weights that are less than the true weight of an animal. This can be avoided by placing a foraging container with 4" to 6" sides on the scale platform so that the callimico must either sit completely inside of it to retrieve the food item. If a callimico rests on the container's outer edge, its tail will hang freely and an accurate weight can be obtained. Individual callimico weights can fluctuate as much as 10g to 30g depending on the time of day and whether or not the animal's stomach is full. It is recommended to note the time of day the weight was obtained to maintain meaningful weight records.

Urine and Fecal Collection

The collection of biological samples from callimico may be necessary for medical analyses or research purposes. Fortunately, collection is fairly easy because callimico typically urinate and defecate immediately after lights are turned on. Preparatory steps should be taken to acclimate an animal to sample collection. This can be done gradually by entering the enclosure to offer a handfed treat and eventually incorporating the collection tub once the animal is comfortable. Ultimately, a food reinforcer should be given to the individual after it has remained still to urinate and defecate into a container that is held one to two feet below it. Using a collection container allows a clean, "free-catch" biological sample to be obtained.

Crate Training

Callimico may need to be periodically captured for medical reasons, transportation, or relocation. Using the least stressful methods of capture are recommended whenever possible. This can be accomplished by desensitizing animals to transport crates. A crate can be slowly introduced to an animal's environment by associating it with a primary reinforcer, such as food. The animal's food bowl can regularly be placed inside the crate. Gradually, the animal should begin to accept the crate as a neutral or even partially rewarding part of its environment (Sullivan, 2000). If the holding area is equipped with a cage fronted area and a small, 10'' X 10'' access door, a portable wire mesh extension box (10'' wide X 10'' tall X 20'' long) can be temporarily attached with clips to the outside of the open access door for trapping purposes. This extension "balcony" should be given on a frequent basis so that a callimico can comfortably enter by choice and spend a significant amount of time inside of the balcony without actually being trapped. At Brookfield Zoo, callimico seem highly motivated to enter the balcony, probably because it allows an individual to essentially come outside of its enclosure to view another component of its surrounding environment. When necessary, a keeper can lure the animal into the end of the balcony with handfed favorite foods while using his or her other hand to close a guillotine-style shift door to trap the animal (see Figure 1). The capture process can also be formalized by incorporating operant conditioning training techniques such as cuing the animal to touch or station on a target placed inside the transport crate or balcony.

Figure 1. A callimico has been lured to the end of the "balcony" for handfed grapes. The keeper is closing the guillotine-style shift door behind the animal for trapping purposes.

Formalized Training Programs

Although structured operant conditioning training programs have already been successfully incorporated into the husbandry of several different primate species, the concept of a Callitrichid training program is relatively new. Refer to Farmerie et al. (1999) for suggestions on how to establish and structure a formalized callimico training program.

Behavioral Enrichment

The United States Department of Agriculture (USDA) requires zoological institutions to follow appropriate plans for environmental enhancement that are adequate to promote the psychological well-being of nonhuman primates. When designing an enclosure or enrichment program for callimico, their natural environment and behavior should be considered. Enrichment opportunities can be created by increased enclosure complexities, providing objects to manipulate or enhance the senses, providing varied food items, and using foraging or task-oriented feeding methods (Husband et al., 1997).

Enclosure Enrichment

Enclosure design should provide a physical environment for callimico that is as similar to their natural one as possible. In the wild, *Callimico* have a limited distribution in the western Amazon and have been documented in disturbed, dense forest habitat containing significant amounts of bamboo (Izawa, 1979; Heltne et al., 1981), as well as in primary forest habitat (Moynihan, 1976; Hershkovitz, 1977), including undisturbed riverine forest (Christen, 1999). *Callimico* in the wild have also been observed in polyspecific associations with *Saguinus fuscicollis* and *Saguinus labiatus* (Pook and Pook, 1982; Christen and Geissman, 1994; Porter, 2000).

When traveling alone, callimico tend to occupy the dense forest understory at low heights of 0 to 5m. *Callimico* will also occupy the forest floor, open understory, or mid-canopy levels, but more often when associated with *Saguinus* (Porter, 2000). Therefore, all dimensions of a captive enclosure should be utilized to give callimico the opportunity to maintain natural behavior, as well as an element of control over their environment. The ground surface of an enclosure can be covered with a thick bedding of substrate, such as peat moss, pine shavings, or pine bark mulch, to mimic forest floor habitat. Floor bedding can also provide foraging opportunities that are consistent with observations of callimico in the wild retrieving insects from beneath leaf litter on the ground (Porter, 2000).

Natural plantings (Farmerie et al., 1999) can be added to the lower and mid levels in an enclosure to mimic dense forest undergrowth. Wild callimico have proven to be a cryptic species that is extremely wary of people and often retreat into the dense undergrowth when approached (Hanson, 2000). Natural plantings in a captive enclosure can act as privacy barriers for an individual to use to retreat from either a cage mate or zoo visitor.

The mid and upper levels of an enclosure should provide opportunities for callimico to vertically cling and quadrupedally locomote. A variety of branch widths (1” to 5” in diameter) both vertically and horizontally placed, and varying in flexibility, should construct a densely furnished framework. Pook and Pook (1981) observed callimico sleeping in dense tangles of vegetation. Small shelves or platforms installed at varying heights in a captive enclosure can provide comparable space for callimico to rest next to one another.

Wild callimico have also been observed basking in the sunlight during resting bouts (V. Sodaro, 2001, personal communication.). Providing a heat lamp (using a 250 watt red bulb with an approximate temperature of 35°C) at a safe distance from the enclosure can mimic the light and heat intensity of the sun for basking opportunities. Care should be taken to avoid placing the lamp too close to the front of the enclosure to avoid the possibility of animals receiving burns. A survey by Farmerie et al. (1999) also lists the use of nestboxes, rock ledges, ropes, vines (artificial and real), window ledges, sand, river rock, and grass as potential substrates and furniture to enhance the physical environment.

Sensory Enrichment

Enrichment should be dynamic in order to mimic the abundance of stimuli that wild callimico would encounter on a daily basis. Auditory stimulation can be created by repeating a CD or tape of native rain-forest sounds. Callimico also have a repertoire of olfactory communication behaviors. For example, callimico scent mark by depressing their hindquarters and rubbing either their genital or anal area on a substrate. Callimico also crouch low to rub their sternal glands along horizontal substrates. Another scenting behavior unique to callimico is the tail mark, characterized by an animal coiling its tail to sweep over the anogenital region or sternal area (Heltne et. al, 1981). In captivity, simply adding a new individual branch or plant will encourage olfactory investigation and scent marking. Extracts, dry or fresh herbs, and spices can also be given to stimulate the olfactory senses. Providing visual stimulation is another important component of enrichment. Plastic crib toys with brightly colored parts or small mirrors can encourage visual investigation (see Appendix A). However, mirrors should initially be presented with caution as some individuals may not recognize their own reflection and perceive it as territorial encounters with other individuals. There are many other simple, low-cost physical objects that can be placed in a callimico enclosure to encourage visual or olfactory investigation. A survey from the Callitrichid Husbandry Manual (Farmerie et al., 1999) suggests the use of balls, bells, blankets, burlap, children's toys, feathers, hammocks, keys, mobiles, PVC pipes, squeak toys, stuffed animals, and videos.

Dietary Enrichment

According to Porter's (2000) study of callimico in northern Bolivia, their average annual consumption included a diet of 31% arthropods, 29% fruits, 29% fungus, 3% vertebrates, 1% exudates, and 7% unknown items. However, these percentages often increased or decreased significantly depending on the seasonal availability of the food resource. In captivity, providing a monotonous diet is unnatural. Although flexibility in a captive diet is somewhat limited to ensure nutritional completeness, substitution (nutritionist- or veterinarian-approved) of diet items, such as fruits, given a couple of times throughout the course of a week can add complexity to an animal's meal. For example, in Porter's (2000) study, wild callimico consumed at least 21 different species of fruits during the month of greatest fruit abundance. In captivity, some dietary variety can be achieved by offering a different fruit each day on a rotational basis, along with a weekly "exotic" seasonal fruit substitution such as mango or papaya. Alternating between whole and chopped fruit is another simple way to add dietary variety. Whole fruit can be affixed to a skewer and hung below a branch for an additional foraging challenge (see Appendix A).

Dexterity Enrichment

As previously mentioned, Porter (2000) documented polyspecific associations between callimico, *Saguinus fuscicollis*, and *Saguinus labiatus.* Hand morphology differs among the three species and likely reflects different foraging strategies (Bicca-Marques, 1999). *S. fuscicollis* has long, narrow hands that appear to be best for manipulative prey foraging, while *S. labiatus* has shorter fingers like those of nonmanipulative foragers, and callimicos have an intermediate hand shape. Porter (2000) never observed callimico foraging for insects in holes or crevices like S. fuscicollis. However, callimico at Brookfield Zoo readily use enrichment devices that replicate *S. fuscicollis* foraging techniques. Callimico retrieve food items that are placed inside PVC piping with several small openings or inside a plastic-coated wire mesh box (see Appendix A). The openings of both devices are at least ½" wide to take into account callimico hand size. Callimico are further challenged with task-oriented enrichment devices such as puzzle feeders and plastic bird toys (see Appendix A) that also require dexterity. Skillful manipulation of the hands and fingers is consistent with natural callimico foraging behaviors. For example, wild callimico hunt for insects using pounce-and-capture techniques or by grabbing their prey with a two-handed grasp with their feet anchored to a support (Porter, 2000).

Live Prey Enrichment

The presentation and variety of insects offered in captivity can also be an important source of enrichment. Callimico in the wild have been observed hunting for insects on thin, flexible branches or under leaves (Porter, 2000). These foraging behaviors can be replicated in captivity by challenging callimico to manipulate paper boxes and bags or in between the pages of a thin phone book to retrieve hidden insects. Wild callimico have also been observed retrieving insects from beneath leaf litter on the forest floor (Porter, 2000). To mimic this in captivity, provide different foraging containers filled with substrate, such as pine shavings or bark mulch, and hidden insects (see Appendix A). Captive callimico can also refine their hunting skills when live crickets are scattered throughout their enclosure at unpredictable times.

Exudate Enrichment

Wild callimico only opportunistically forage on plant exudates as they do not have incumbent incisors with which they can actively stimulate exudate flow (Porter, 2000). According to Porter (2000), exudates they encounter may be produced as a result of natural or animal damage or from trees, such as *Parkia pendula*, that produce exudates around their fruit pods. Captive callimico can be challenged to use their tegulae to probe out simulated exudates, such as honey or mashed banana, from predrilled holes in plastic wood or hanging log devices (see Appendix A).

Enrichment Use and Scheduling

A study was undertaken at Brookfield Zoo to determine how much callimico utilize enrichment items and how frequently enrichment items should be changed (Wojciechowski, 2001). Because callimico do not destroy or soil many of the enrichment items provided, these items can usually be left in their enclosure for more than one day. However, callimico should not be expected to spend a significant amount of time utilizing an enrichment device the second day, unless more food items are added to the device or it is relocated to a different location in the same group's enclosure. The study determined that during the first 25 minutes, callimico utilize newly provided enrichment devices 10% to 36% of their time and utilize refilled or relocated enrichment devices 8% to 28%. While novel enrichment devices get more use than refilled enrichment devices overall, some individual enrichment devices showed greater use after being refilled than when provided new, and some enrichment devices showed the same amount of use.

To ensure the greatest variety of environmental enrichment, it is suggested that enrichment items be divided into different categories and that different categories be scheduled for different days of the week or month. For example, the preceding paragraphs discuss five different types of enrichment (dietary, sensory, dexterity, live-prey, and exudate). To encourage a variety of naturalistic behaviors, these five categories (or further breakdown, depending what is available at your institution) could be put on a rotation so the animals receive a variety of different enrichment types.

References

Bicca-Marques, J. 1999. Hand specialization, sympatry, and mixed-species associations in callitrichines. *Journal of Human Evolution*, 36:349-378.

Christen, A. 1999. Survey of Goeldi's monkeys *(Callimico goeldii)* in northern Bolivia. *Folia primatologica*, 70:107-111.

Christen, A., and T. Geissmann, 1994. A primate survey in northern Bolivia with special reference to Goeldi's monkey *(Callimico goeldii). International Journal of Primatology,* 15(2):239-273.

Farmerie, M., D. Neiffer, and K. Vacco, 1999. Enrichment and operant conditioning of *Callitrichids.* In: *Callitrichid Husbandry Manual,* eds. V. Sodaro and N. Saunders, pp.52-77.

Hanson, A.M. 2000. Habitat use in relation to diet, with particular emphasis on mycophagy, by *Callimico goeldii* in Pando, Bolivia. Master's thesis, State University of New York at Stony Brook, Stony Brook.

Heltne, P.G., F.J. Wojcik, and A.G. Pook, 1981. Goeldi's monkey, Genus *Callimico*. In: *Ecology and Behavior of Neotropical Primates Volume I,* eds. A.F. Coimbra-Filho and R.A. Mittermeier, Academia Brasileira de Ciencias, Rio de Janeiro, pp. 169-209.

Hershkovitz, P. 1977. *Living New World Primates (Platyrrhini) Volume I.* University of Chicago Press, Chicago.

Husband, S., L.K. Mayo, and C. Sodaro, 1997. Behavioral enrichment. In: *Orangutan Husbandry Manual,* ed. C. Sodaro, pp. 103-107.

Izawa, K. 1979. Studies on peculiar distribution patterns of *Callimico. Kyoto University Overseas Research, Reports of New World Monkeys:* 1-19.

Moynihan, M. 1976. *The New World Primates.* Princeton University Press, Princeton, NJ.

Pook, A.G. and G. Pook, 1982. Polyspecific association between *Saguinus fuscicollis, Saguinus labiatus, Callimico goeldii* and other primates in north-western Bolivia. *Folia primatologica,* 38:196-216.

Porter, L.M. 2000. Benefits of polyspecific associations for the Goeldi's monkey, *Callimico Goeldii.* Ph.D., State University of New York at Stony Brook, Stony Brook.

Porter, L.M. 2000. *Callimico goeldii* and *Saguinus:* Dietary differences between sympatric callitichines in northern Bolivia. In press.

Sullivan, T. 2000. *Animal Training Manual.* Chicago Zoological Society, Brookfield Zoo, Brookfield, IL.

Wojciechowski, S. 2003. Is enrichment still good the next day?: Overcoming the challenges of providing daily enrichment to multiple animal groups in a colony-type situation. In: Hare, V.J., Worley, K.E., and Hammond, B. 2003. *Proceedings of the Fifth International Conference on Environmental Enrichment.* San Diego: The Shape of Enrichment, Inc. Pp. 211-220.

Appendix A.

Sensory Enrichment

Crib Toy with Mirror

6” X 12” plastic toy with numerous moveable small plastic pieces. A 2” X 2” mirror is in the center.

Crib Toy Without Mirror

Similar to above, but no mirror.

Food as Enrichment

Fruit Skewer with Grapes

Skewer with two grapes per animal suspended below a substrate.

Fruit Skewer with Apple

Same as above, but contains a small apple piece.

Dexterity Enrichment

Pink/Purple

Plastic bird toy. Circular cage, 3” tall and 2” in diameter. End opens to place two grapes per animal inside but then is closed to the animal.

Dice

Plastic toy 3” tall and 2” in diameter. There is a 1”-diameter opening near the bottom of the side. Two dice are stuck inside as an obstacle to removing the five raisins per animal.

Ferris Wheel

3” circular plastic toy. A wheel is located inside. The animals must turn the wheel to get out the two grapes per animal.

Mesh Box

2” X 4” X 4” completely enclosed mesh box. (mesh = _” X 1”)
Contains two grapes per animal.

PVC Tube

12” long, 2”- diameter PVC tube, with seven _” holes in the side.

Insect Enrichment

Small Forage Pile

Container (12” diameter, 4” deep) filled with shavings or bark chips and five raisins per animal. Placed on upper shelf of enclosure.

Large Forage Pile

Container (20” diameter, 10” deep) filled with a foraging substrate and five raisins per animal. Placed on floor of enclosure.

Egg Crate

12”-square cardboard egg crate filled with foraging substrate and five raisins per animal.

Hanging Forage Tray

12” X 20” X 3” deep plastic tray covered in 1” mesh. Suspended by chain below a branch. Filled with foraging substrate and five raisins per animal.

Blue Box

Plastic box ~4” X 4” X 8” with 3” X 4” opening n the side.
Filled with foraging substrate and five raisins per animal,

Ferret Log

12”= long plastic log (3” in diameter) with both ends open and two 3” holes in the center. Filled with foraging substrate and five raisins per animal.

Exudate Enrichment

Forage Board

4” X 6” piece of plastic wood attached to cage front with ~15 holes big enough to fit a raisin inside.

Hanging Forage Log

12” long X 3”-diameter piece of natural branch. Suspended vertically below a branch. Contains ~15 holes big enough for raisins.

Health and Medical Management of *Callimico Goeldii*

Jennifer Langan, DVM, Dipl. ACZM, and Jacqueline M. Zdziarski, DVM

Introduction

Many of the general health and medical management considerations that apply to caring for nonhuman primates in captivity are directly applicable to *Callimico goeldii*. As with other marmosets and tamarins, *Callimico* develop a wide variety of clinical symptoms for which identifying an etiology can often be challenging due to their small size. In the following chapter, we highlight preventive medicine, quarantine and preshipment recommendations, restraint and anesthesia, hematology, and clinical chemistry. We also provide an overview of diseases and a sample necropsy protocol. This chapter aims to serve as a supplemental reference for *Callimico* and is by no means inclusive of all primate medicine. Much of the information covered here is described in greater detail in the Callitrichid Husbandry Manual.

Preventive Medicine

The best captive-animal management programs adopt multidisciplinary approaches. Management programs that eliminate or minimize chronic stress through thoughtful enclosure design, behavioral enrichment, population control, appropriate social groupings and breeding pairs, and balanced diets contribute to the health and well-being of the animals. Preventive health care is an essential part of any medical management program. A preventive medicine program should include: quarantine, routine examinations, parasite detection and control, immunizations, enteric pathogen screening, tuberculin testing, good nutrition, a pest control program, and thorough postmortem examination, including gross and histological evaluation. In order to be successful, a preventive medicine plan should: 1.) be written, 2.) include education and training of zoo personnel responsible for carrying out the plan, and 3.) require a staff that is dedicated to fulfilling the plan's goals.

Annual physical examinations, radiographs, tuberculin testing (0.1 ml mammalian tuberculin, human isolate intradermal in an upper eyelid), parasitology examination (fecal sedimentation preferred to float techniques due to increased sensitivity), cytological evaluation for *Gongylonema* sp. ova via tongue scrapings, rectal cultures for pathogen screening (*Salmonella* sp., *Campylobacter* sp., *Shigella* sp., *Yersinia* sp.), and routine hematological and serum biochemical evaluation are all helpful in detecting changes in the health of an individual or a colony of *Callimico*. Dental prophylaxis should be done on an as-needed basis, and additional serum should be collected for banking purposes. A less stressful and more thorough examination of these Callitrichids is possible when the animals are sedated with the use of inhalation anesthetics. Immobilization facilitates physical examination and allows for faster, safer diagnostic sample collection.

Currently, there are no specific recommendations for immunizations for *Callimico*. Tetanus toxoid and rabies vaccination are used by some institutions based on risk. Administration of these vaccinations is at the discretion of the individual institutions.

Preshipment Evaluation

Preshipment evaluation is typically requested by the receiving institution when animals are transferred from one institution to another. However, a heath evaluation may even be appropriate when animals are transferred from one area to another at the same institution.

Preshipment evaluation should include a minimum database consisting of: signalment, medical history (individual and group health concerns, contraception), complete physical examination, radiographs, hematology and serum biochemical evaluation, three negative fecal examinations, tongue scrapings for *Gongylonema* sp., TB testing, enteric pathogen screening (*Salmonella* sp., *Campylobacter* sp., *Shigella* sp., *Yersinia* sp.), body weight, and individual identification (tattoo/transponder) information. Results of the preshipment evaluation should be forwarded to the receiving institution for review, allowing sufficient time to arrange for or change shipping arrangements for the animals.

Quarantine

Quarantine helps prevent the introduction of disease into a collection and the transmission of zoonotic diseases to zoo personnel or visitors. Zoonotic diseases are those agents that may be transmitted from animals to man. Taxonomically, nonhuman primates are closely related to humans, and many diseases are transmissible between them, including parasites, bacterial agents, and viruses. Transmission may occur via aerosol (coughing or sneezing), saliva (spitting), feces, or bodily fluids (blood, urine, or wound exudates). Exposure to zoonoses may occur while handling animals, through a bite or scratch, or with contact to bodily fluids. Cleaning and hosing in animal enclosures may also expose animal-care staff. High-pressure water hoses may cause infectious agents to become aerosolized, where they may be inhaled or swallowed. To minimize the potential for disease transmission, animals should be held in a separate facility upon arrival for at least 30 days and until the health status of each individual is determined.

Animals stressed by recent shipment are more likely to shed virus particles, bacterial agents, or intestinal parasites. These pathogens may be latent or newly contracted during shipment. Animals held in quarantine should be accessible only to the personnel providing routine maintenance and medical care. All other staff should not have access to these animals. Employees working in primate facilities should be required to wear protective clothing while working with quarantined nonhuman primates. Protective clothing should prevent exposure to body fluids and restrict their spread. When entering nonhuman primate quarantine areas, employees are recommended to wear long-sleeved coveralls, boots, protective rubber gloves, and a surgical mask with an eye shield, goggles, or a clear plastic full-face shield.

Protective clothing should be removed when employees leave the quarantine area, preferably in an anteroom. Any biological samples (i.e., feces, blood) gathered for testing should be placed in sealed containers, double-bagged in plastic, and labeled before being removed from the quarantine area. All cage debris, such as food, bedding, and excrement, should be double-bagged in plastic and disposed of appropriately.

Protective clothing should be discarded or decontaminated by chemical disinfecting prior to machine washing, and the enclosure housing the animal should be disinfected with appropriate agents.

Quarantine protects the health of the animal collection, the veterinary staff, animal caretakers, and the public. An ongoing, documented training program for the staff should be implemented to address methods of husbandry and care, infectious disease hazards, and health precautions that prevent the spread of infectious agents. Training should address protocols for reporting injury (bites, scratches) and unusual illnesses. Good animal husbandry and management practices can reduce the risk of transmission of zoonotic diseases. Employees with colds or cold sores should not work directly with nonhuman primates. If they must work in the area, they should wear gloves and face masks at all times. Employees with more serious illnesses (diarrhea, fever, etc.) should seek medical attention, and they should inform their physician that they work with nonhuman primates.

Table 1. Hematology (Mean ± SD (N))

WBC	*10^3/UL	6.028 ± 2.894	(403)
RBC	*10^6/UL	6.54 ± 0.70	(379)
HGB	GM/DL	14.1 ± 1.6	(389)
HCT	%	43.2 ± 4.7	(426)
MCH	MG/DL	21.6 ± 1.8	(379)
MCHC	Uug	32.6 ± 2.2	(387)
MCV	fL	66.1 ± 5.0	(378)
SEGS	*10^3/UL	3.195 ± 1.981	(393)
BANDS	*10^3/UL	0.187 ± 0.392	(77)
LYMPHOCYTES	*10^3/UL	2.544 ± 1.718	(397)
MONOCYTES	*10^3/UL	0.184 ± 0.179	(351)
EOSINOPHILS	*10^3/UL	0.189 ± 0.224	(252)
BASOPHILS	*10^3/UL	0.062 ± 0.040	(25)
NRBC	/100 WBC	3 ± 6	(58)
PLATELET CNT.	*10^3/UL	838 ± 225	(207)
RETICS	%	0.3 ± 0.6	(7)

Table 2. Serum Chemistry Values (Mean ± SD (N))

GLUCOSE	MG/DL	130 ± 41	(353)
BUN	MG/DL	23 ± 8	(342)
CREAT.	MG/DL	0.7 ± 0.3	(282)
URIC ACID	MG/DL	0.6 ± 0.3	(220)
CA	MG/DL	9.9 ± 0.8	(299)
PHOS	MG/DL	5.1 ± 2.2	(282)
NA	MEQ/L	152 ± 7	(283)
K	MEQ/L	4.6 ± 1.1	(286)
CL	MEQ/L	110 ± 5	(275)
IRON	MCG/L	100 ± 27	(6)
MG	MG/DL	2.48 ± 0.27	(8)
HCO3	MMOL/L	19.0 ± 2.2	(5)
CHOL	MG/DL	112 ± 29	(278)
TRIG	MG/DL	83 ± 31	(232)
TOT. PROTEIN	GM/DL	6.8 ± 0.8	(338)
ALBUMIN	GM/DL	4.3 ± 0.7	(240)
GLOBULIN	GM/DL	2.6 ± 0.5	(240)
AST (SGOT)	IU/L	118 ± 39	(341)
ALT (SGPT)	IU/L	62 ± 47	(343)
TOT. BILI	MG/DL	0.4 ± 0.2	(323)
D. BILI	MG/DL	0.1 ± 0.1	(14)
I. BILI	MG/DL	0.2 ± 0.1	(14)
AMYLASE	U/L	314 ± 167	(21)
LIPASE	U/L	81 ± 173	(11)
ALK PHOS	IU/L	154 ± 78	(266)
LDH	IU/L	252 ± 120	(218)
CPK	IU/L	526 ± 899	(212)
OSMOLARITY	MOSMOL/L	324 ± 0	(1)
CO2	MMOL/L	18.5 ± 6.6	(215)
FIBRINOGEN	MG/DL	267 ± 121	(6)
GGT	IU/L	52 ± 79	(226)

Restraint and Anesthesia

Callimico can be caught within a net and handrestrained for minor procedures. Animal-care staff should wear protective clothing, including latex and leather gloves, as well as face masks when working in close proximity to these primates. Once *Callimico* are in the net, the handler wearing leather restraint gloves can gain control of the head and then the hind legs. Handlers must remember that these animals are extremely dexterous and prone to escape. Another alternative to netting is training the animals to shift into a small carrying case from which they can be caught or anesthetized via chamber induction.

Due to their small size, Goeldi's monkeys can be restrained for hand injections with an anesthetic. Simple procedures such as physical examinations, tuberculin testing, and blood sample collection can be accomplished by using 5-10 mg/kg of intramuscular ketamine hydrochloride (Fort Dodge Laboratories, Fort Dodge, IA) with or without medetomidine (Domitor, manufactured for Pfizer Animal Health, Exton, PA). The dose for medetomidine is 0.03-0.04 mg/kg, which is used in conjunction with the low-end dose of ketamine. Ketamine has a relatively quick onset of action, wide margin of safety, and lack of respiratory and cardiovascular depression, and animals experience a fairly rapid recovery. Some of the advantages of using medetomidine in combination with ketamine are that it allows for lower doses of ketamine, improved muscle relaxation, and quicker recoveries since medetomidine is reversible with atipamezole (150-200 µg/kg IM). For prolonged or painful procedures, supplemental anesthesia is necessary and may be achieved using an inhalation anesthetic agent.

Callimico can also be manually restrained and induced with inhalation anesthetics including isoflurane (Aeranne, manufactured for Fort Dodge Animal Health, Fort Dodge, IA) and sevoflurane (SevoFlo, Abbot Laboratories, North Chicago, IL). These agents have a wide margin of safety, as well as quick induction and recovery times. Gas anesthetics may be supplied via an induction chamber, face mask, or endotracheal tube. Although primates are relatively easy to intubate, *Callimico,* due to their small size, can present more of a challenge. A headlamp, laryngoscope, cotton-tipped applicator, or piece of gauze to move the tongue forward to expose the glottis and stylet are all useful when intubating this species. Small-gauge endotracheal tubes (size 2), intravenous catheters, rubber feeding tubes, or shortened tom-cat catheters can all be used as endotracheal tubes.

It is important to monitor depth of anesthesia, cardiopulmonary function, and temperature during an immobilization. Trends in heart and respiratory rate, blood pressure, and reflexes should all be recorded during an anesthetic procedure. To help maintain adequate core body temperatures, animals can be placed on heated water blankets and covered with a towel to reduce exposure to the ambient environmental temperature. Alcohol and sterile preparation solutions should be used judiciously to maximize antibacterial properties and minimize heat loss. For longer procedures, intravenous catheters to maintain intravenous access and deliver fluids are recommended. The lateral saphenous vein, located superficially on the posterior leg just distal to the stifle, is most convenient for catheter placement.

Hematological and Serum Biochemical Analysis

Normal hematologic and serum biochemical values for *Callimico goeldii* are summarized in the following tables. These values were taken from the International Species Identification System (ISIS) Reference Ranges for Physiological Values in Captive Wildlife 2002 Edition CD. Table 1 summarizes the hematological data and Table 2 the clinical biochemical analyses for *Callimico.* The results appear as mean values ± standard deviation, with the number of samples analyzed (N) in parenthesis. Most of these samples were collected under general anesthesia.

Blood collection in *Callimico* is best achieved from the femoral vein at the femoral triangle. However, the saphenous vein on the posterior aspect of the lower hind limb and the jugular vein can also be used. Although blood can be collected under manual restraint, chemical immobilization decreases stress and struggling significantly.

In addition to blood sampling for routine testing, collection of a small quantity of extra serum for banking purposes is recommended. Building a serum bank can provide samples for future diagnostic testing and may facilitate retrospective disease investigations. Samples should be aliquotted, frozen, and preferably stored at -70°C. In addition, it can be helpful to prepare additional stained, fixed blood smears for future references.

Diseases of *Callimico Goeldii*

Diseases of the *Callimico goeldii* are similar to those of other New World primates. Below, several of the more common or pathologic bacterial, viral, parasitic, and neoplastic diseases are discussed.

Bacterial

Shigella sp., *Salmonella* sp., and *Campylobacter jejuni* can all cause significant enteric disease, resulting in marked morbidity and mortality. Shigellosis is more commonly diagnosed in Old World primates but can occur in New World species. The major clinical sign with these bacterial infections is diarrhea. However, asymptomatic carriers are common. Acutely affected animals have liquid, sometimes hemorrhagic, diarrhea and can quickly become dehydrated and may experience abortion. Diagnosis is made by rectal swab cultures, and treatment includes supportive care, fluid therapy, intestinal protectants (kaolin or barium sulfate), and antibiotics based on sensitivity patterns. The treatment of choice for campylobacteriosis is erythromycin, but enrofloxicillin and ampicillin can also be used. Testing for these pathogens during routine examinations, quarantine, and preshipment testing is recommended.

Pseudotuberculosis is caused by *Yersinia pseudotuberculosis,* and clinical signs can include cachexia, diarrhea, dehydration, abortion, and sudden death without other symptoms. *Yersinia* sp. cause more mortalities during cold and wet weather since the organism prefers these conditions. Pseudotuberculosis is of importance because of its zoonotic potential and possible adverse effects on captive breeding. Diagnosis is difficult due to sporadic shedding and because it can often be overlooked on routine culture due to its specific need for a cold-temperature culture environment. Vaccination has been attempted but requires further investigation due its questionable efficacy in preventing disease (Bielli et al., 1999). *Yersinia enterocolitica* is also considered a pathogen and, like *Y. pseudotuberculosis,* can result in suppurative enteric and hepatic lesions that contain massive numbers of organisms. The best way to prevent infection is to control risk factors. This can be achieved by quarantining new arrivals, avoiding overcrowding and stress (immunosuppression), providing appropriate temperature and humidity, and controlling pests such as rodents, wild birds, and insects, which can harbor and transmit the disease to primates.

Pasteurellosis is caused by *Pastuerella multocida* and is rarely reported in *Callimico.* It has been reported in association with gongylonemesis (Duncan et al., 1995) from at least one zoological institution. The inflammation and tissue damaged caused by *Gongylonema* larvae migrating through oral tissues may predispose animals to septicemia and subsequent pneumonia, hepatitis, and death. Other predisposing factors may include tooth root abscesses and surgery. Treatment includes supportive care, fluid therapy, and antibiotics.

Streptococcus zooepidemicus septicemia can occur if Goeldi's monkeys are fed undercooked meat or cross-contamination occurs during food preparation (Montali et al., 1999). Suppurative cervical lyphmadenitis, splenitis, and enteritis may develop and often result in fatal sepsis without sufficient time to begin treatment. Infection can be prevented by adequately cooking meat and by using proper sanitation procedures during food processing.

Other bacterial infections that have been noted in Callitrichidae but may not necessarily be specific to *Callimico* are *Bordetella bronchiseptica, Klebsiella* sp., leptospirosis, and listeriosis. Mycobacterial infections are uncommon in this species.

Viral

Callitrichid hepatitis is caused by lymphocytic choriomeningitis virus (LCM) and has caused significant mortality in some collections. The disease onset is usually acute and the clinical course is rapid. Clinical signs include lethargy, collapse, dyspnea, anorexia, and sudden death, but animals can also die without signs. Gross lesions include congested lungs, jaundice, effusions, splenomegaly, pale liver, and intramuscular hemorrhage. Histologically, hepatitis with disorganized swelling and necrosis of the hepatocytes is typical. The virus is carried by rodents, and *Callimico* have acquired LCM from consuming pinkie mice. Therefore, not offering pinkies as part of the diet of captive *Callimico* is recommended. Prevention is by eliminating rodents from where the animals are housed.

Herpesvirus tamarinus (herpesvirus T, *herpesvirus platyrrhinae*) produces latent infections in *Saimiri, Cebus,* and *Ateles.* Occasionally, oral, labial, or lingual ulcers may be seen in these species. However, this alphaherpesvirus causes pantropic epizootic infections in Callitrichids and owl monkeys. Clinical signs include lethargy; depression; anorexia; rhinitis; oral, labial or cutaneous vesicles; and ulcers . The disease usually has a short course, with animals dying in several days (Montali et al., 1999). Lesions occur in most organs and tissues and consist of hemorrhage and focal necrosis. The risk of infection can be decreased by not housing *Callimico* near *Saimiri, Cebus,* or *Ateles* sp.

Human Herpesvirus simplex-1 (HSV-1) also causes acute, disseminated disease with signs similar to Herpesvirus T. Deaths due to Herpesvirus simplex have been associated with owners or keepers with open herpetic sores on the lip or mouth (Montali et al., 1999). The risk of infection can be decreased by prohibiting contact with people symptomatic for HSV and by wearing masks and face shields.

Measles infections produce severe conjunctivitis, lethargy, dyspnea, serous nasal discharge, facial edema, and maculopapular exanthema on lips and skin. Severe pneumonia and gastroenteritis may also develop. Callitrichids are usually more severely affected than other New World primates and may develop a maculopapular rash over most of their body. Epizootic outbreaks have been observed where gross lesions may consist only of a skin rash and pulmonary edema. Preventive measures include vaccination with a modified live human measles vaccine for nonhuman primates and animal caretakers, as well as wearing appropriate protective gear when working in primate areas.

Yellow fever, Hepatits A, encephalomyelitis virus, and parainfluenza virus have also been documented in *Callimico* and other Callitrichids (Montali et al., 1999) but occur infrequently.

Parasitic

Naturally occurring toxoplasmosis infections have occurred in many New World primates that appear to be very susceptible to *Toxoplasma gondii.* The disease has been diagnosed sporadically in Callitrichids in which most cases seem to have been associated with feeding raw meat in their diets. However, transmission can also occur by ingestion of oocysts shed in cat feces or by eating infected feral mice. Clinical signs of infection include acute respiratory distress, neurologic signs, anorexia, lethargy, progressive weakness, and sudden death (Montali et al., 1999). The disease generally has a rapid course, and gross lesions include primarily pulmonary edema and hemorrhage. Histologically, there is focal necrosis in many organs and central nervous system associated with this coccidian organism. Treatment is rarely possible due to the rapid progression of the disease. Disease is controlled by eliminating raw meat from primate diets and preventing feral rodents and felids access to *Callimico* exhibits.

Two species of coccidia, *Isospora endocallimici* and *Isospora callimico,* have been identified in *Callimico.* Infection may be asymptomatic or in some cases may cause diarrhea and dehydration. Diagnosis is made by identification of oocyst by fecal flotation. Since oocysts take several days to become infective in the environment, proper sanitation can reduce the incidence of coccidiosis.

Giardia lamblia is a protozoan that can infect the upper intestinal tract of *Callimico*, in addition to many other mammalian species. This organism is zoonotic, and clinical signs in all animals can include diarrhea, dehydration, and severe debilitation. Giardiasis can be diagnosed by direct cytological evaluation of fecal smears or by zinc sulfate fecal flotation. The trophozoites and cysts can be difficult to identify, and a drop of iodine can be used to help visualize these protozoans on cytological preparations. Shedding can be sporadic, so multiple fecal samples over several consecutive days should be examined when giardiasis is a differential diagnosis. Metronidazole is the treatment of choice, but due to the poor acceptability of the drug and the persistent nature of the infection, chronic carriers are common.

Gongylonema pulchrum is a nematode that burrows through the tongue, esophageal, and oral tissues in *Callimico*, as well as many other mammals. The clinical signs of lingual gongylonemesis include increased salivation, decreased appetite, depression, lethargy, hyperemia and thickening of lips, and swelling of the face and tongue. As mentioned previously, death has occurred as a result of secondary infection with *Pasteurella multocida*. The intermediate hosts are cockroaches and coprophagous beetles. Diagnosis can be difficult but is possible by performing tongue scrapings and visualizing the characteristic thick-shelled eggs or rare larva. Gongylonemesis has been successfully treated using ivermectin and menbendazole once a month for three to four months. Infection can be controlled by eliminating contact with intermediate hosts by instigating vigilant pest-control measures.

Ptergodermatites nycticebi (Rictularia nycticebi) is a spiruid nematode found in the lumen of the small intestine with their anterior ends embedded in the mucosa. Heavy infections can produce profound weakness, anemia, and hypoproteinemia. Cockroaches and crickets have been incriminated as their intermediate hosts. Prevention is by maintaining good pest-control measures. Treatment with menbendazole or fenbendazole has eliminated eggs being shed in the feces.

Anatrichosoma cutaneum is a trichuroid nematode that has been known to affect a variety of nonhuman primates, including *Callimico.* An acute outbreak involving this parasite in a colony of *Callimico* at Brookfield Zoo in the mid-1980s was characterized by creeping cutaneous eruptions on the palms and soles of the hands and feet. The infection was successfully treated with ivermectin. As with many parasitic nematodes, cockroaches are intermediate hosts for *Anatrichosoma* sp.

Ingestion and aberrant migration of *Balisascaris procyonis* larvae can cause neurologic signs, including ataxia, head tilt, circling, and blindness. Confirming a diagnosis is difficult, and treatment is usually unrewarding. Preventing contact with raccoon feces is the most important preventive measure.

Neoplastic

Myelolipomas are benign mesenchymal tumors that have been identified in numerous *Callimico.* These tumors arise from the liver, and clinical signs typically occur only when the tumors become very large and impinge on other organs. Clinical signs include hepatomegaly and cachexia despite a normal appetite. As the disease progresses, lethargy and anorexia may develop. Myelolipomas are usually an incidental finding found on routine physical examination or necropsy. A confirmed antemortem diagnosis is rarely indicated but can be accomplished with a liver biopsy or needle aspirate. Increased incidence of myelolipomas within a group of *Callimico* may be attributed to inbreeding (Heard et al., 1996).

Other neoplasms found in *Callimico* include intestinal adenocarcinoma, pancreatic adenocarcinoma, osteosarcoma, adenoma, and a melanotic ependymoma in a neonate.

Other Diseases

Subcutaneous melengestrol acetate (MGA) implants have been used as a contraceptive in many primates without adverse affects. However, in *Callimico,* as well as other New World primates, MGA has caused exuberant endometrial decidualization, resulting in cystic uterine tissue, infertility, and morbidity. Decidualization is a normal progesterone-driven process in the endometrial stroma of pregnant primates (Murnane et al., 1996). but the process continues with the subcutaneous implants in place. and the uterus goes on to develop significant gross pathologic changes. Clinical signs include depression, persistent vaginal discharge. and an enlarged, firm uterus. Clinical signs resolve after ovariohysterectomy. The use of MGA in *Callimico* is contraindicated due to its marked adverse effects.

A review of the *Callimico* necropsy reports from institutions in the United States from 1977 to 2002 revealed that the most common category of pathologic findings was renal disease (40.8%). Gastrointestinal disease was identified in 17.6% of the pathology reports submitted to the *Callimico* SSP pathology advisor. Clinical low-grade kidney and gastrointestinal disease are very common in *Callimico.* Histologic renal pathology, such as glomerulonephritis and progressive nephropathy, has been found on many postmortem examinations. Lesions in both the renal parenchyma and gastrointestinal tissues usually appear chronic, and rarely can an inciting etiology be identified. Long-term or recurrent intestinal parasitism, bacterial overgrowth, or dietary antigen exposure inciting chronic immunologic stimulation and systemic inflammation have been hypothesized as possible etiologies, but more investigation is needed. Further data compilation from the pathology records mentioned above showed that pulmonary, liver, and heart disease was identified in 18.8%, 17.6%, and 17.6% of Callimico necropsies, respectively. Myelolipomas were present in approximately 10% of animals necropsied. Possible signs of gongylonemiasis were found in 3.5% of animals necropsied.

Callimico Necropsy Procedure

1. *Refrigerate* the body if there will be a delay before necropsy. (Delays should be avoided since autolysis proceeds rapidly). *Do not freeze the body.*
2. *Record* all relevant historical information.
3. *Weigh* the animal.
4. *Perform an external exam.* Note any musculoskeletal abnormalities, ectoparasites, evidence of trauma, skin lesions, etc.
5. *Examine body orifices* for patency, exudates, fecal staining around anus and tail, etc.
6. Evaluate *nutritional condition* based on fat stores and relative muscle mass.
7. Make a ventral midline incision from the mandible to the pelvis with a sharp scalpel or scissors. Note any accumulations of fluid or exudate in the abdomen and obtain a swab for bacterial and/or fungal culture and cytology if appropriate.
8. *Note if the diaphragm is intact* and if there is negative pressure. Open the diaphragm with a scalpel blade. Cut the ribs and open the thorax. Note any accumulations of fluid or exudate in the thorax and obtain a swab for bacterial and/or fungal culture and cytology if appropriate.
9. Obtain a sterile blood sample for bacterial culture by direct heart puncture using a 1-3 cc syringe with a 25-22 gauge needle.
10. Remove the internal organs and examine each systematically. Note the quantity and nature of ingesta throughout the gastrointestinal tract.
11. Obtain samples for histopathology using the tissue list provided as a guide. *Save samples of all lesions.*

Tissue Check List

All of the following tissues may be placed together in a single container of 10% neutral buffered formalin. *The volume of formalin should be 10 times the volume of all tissues collected.* The tissues should be no thicker than 0.5cm to ensure proper fixation.

Skin
Muscle (thigh)
Sciatic nerve (with thigh muscle)
Tongue
Esophagus
Stomach
Duodenum
Jejunum
Ileum
Cecum
Colon
Liver with gallbladder
Pancreas
Spleen
Kidney
Urinary bladder
Ovary or testis
Uterus
Lymphnode
Adrenal gland
Thyroid and parathyroid
Thymus (if present)
Trachea and lung
Heart (atrium & ventricular wall with great vessels)
Pituitary
Brain
Eye
Femoral bone marrow

Neonatal Necropsy Procedure

The follow procedures are in addition to the general necropsy protocol for this species.

1. Examine and fix placenta and any fetal membranes that are available.
2. Determine degree of maturity/immaturity of fetus.
3. Determine crown-rump measurement.
4. Examine umbilicus (fix section of umbilical stump and surrounding skin in formalin).
5. Note any skeletal abnormalities (cleft palate, hare lip, facial/limb/trunk abnormality).
6. Note internal malformations (anomalies, diaphragmatic hernia).
7. Determine if the animal was stillborn. Place a section of lung tissue in 10% buffered formalin. If the lung sinks, the animal probably did not breathe. If the lung floated, the animal probably breathed.
8. Examine stomach contents (milk, meconium, etc.).
9. Proceed with remainder of necropsy protocol for *Callimico.*

Freeze portions of the following tissues: liver, spleen, lung, brain, heart, kidney. Freeze each tissue separately (at least 10g of each tissue if large enough). Store tissues in an ultra-low freezer (-70oC). If an ultra-low freezer is not available, conventional freezing is acceptable. These tissues may be discarded after a definitive diagnosis is established, but if possible, should be saved for future research purposes.

Necropsy Report Form

Institution:

Address:

Date of Death: ID# Studbook #

Birth Date/Age: Sex: Weight (Kg):

Necropsy Date: Necropsy Location:

History

Enclosure mates:

Indoor enclosure: Outdoor enclosure:

Weather/Indoor climate (approx. temp., windy, rainy, etc.):

Movements or relocations:

Diet:

Contraceptive implant type Implant# Implant wt.

Clinical history (include clinical signs, lab work, treatment, and circumstances of death):

Gross Examination

General external exam (nutritional condition, skin, body orifices, superficial lymph nodes)

Musculoskeletal system (bones, bone marrow, joints, skeletal muscle)

Respiratory system (nasal passages, trachea, bronchi, lungs, diaphragm, regional lymph nodes)

Cardiovascular system (heart, pericardial sac, great vessels, valves)

Digestive system (mouth, teeth, tongue, esophagus, stomach, intestines, regional lymph nodes)

Liver, gall bladder, pancreas, spleen (size, color, consistency)

Urinary system (kidneys, ureters, bladder, urethra)

Reproductive system (ovaries/testes, uterus, cervix, penis/vagina, accessory sex glands, mammary glands, placenta)

Endocrine system (thyroid, parathyroid, adrenal and pituitary glands)

Central nervous system (brain, meninges, spinal cord)

Sensory organs (eyes, ears)

Laboratory results (microbiology, cytology, fluid analysis, etc.)

Prosector Date

References

Bielli, M., S. Lauzi, A. Pratelli, M. Martini, P. Dall'Ara, and L. Bonizzi. 1999. Pseudotuberculosis in marmosets, tamarins, and Goeldi's monkeys *(Callitrichidae/Callimiconidae)* housed at a European Zoo. *Journal of Zoo and Wildlife Medicine.* 30 (4), 532-536.

Duncan, M., L. Tell, C. Gardiner and R. Montali. 1995. Lingual gongylonemiasis and pasteurellosis in Goeldi's monkeys (Callimico Goeldii). *Journal of Zoo and Wildlife Medicine* 26(1):102-108.

Harwell, G., D. Dalgard. 1979. Clinical *Anatrichosoma cutaneum dermatitis* in nonhuman primates. *Proceedings of the American Association of Zoo Veterinarians,* pp. 83-86.

Heard, D.J., L.E. Fox, J. Fox, L. Neuwirth, and R. Raskin. 1996. Antemortem diagnosis of myelolipoma-associated hepatomegaly in a Goeldi's Monkey *(Callimico goeldii). Journal of Zoo and Wildlife Medicine.* 27 (2), 266-270.

Kalaitsidis, F., H. Lutz, C.R. Pryce. 1999. Hematology and serum chemistry values in captive Goeldi's monkey *(Callimico goeldii). Journal of Zoo and Wildlife Medicine.* 30 (3), 372-376.

Montali, R.J., and M. Bush. 1999. Diseases of the Callitrichidae, Zoo and Wildlife Medicine: Current Therapy, 4th edition. Fowler, M.E., and R.E. Miller, editors, W.B. Saunders, Philadelphia, U.S.A., 369-376.

Murnane, R.D., J.M. Zdziarski, T.F. Walsh, M.J. Kinsel, T.P. Meehan, P. Kovarik, M. Briggs, S.A. Raverty, and L.G., Jr. Phillips. 1996. Melengestrol acetate-induced exuberant endometrial decidualization in Goeldi's marmosets *(Callimico goeldii)* and Squirrel monkeys *(Saimiri sciureus). Journal of Zoo and Wildlife Medicine.* 27 (3), 315-324.

Ott-Joslin, J.E. 1993. Zoonotic Diseases of Nonhuman Primates. In: Fowler, M. E. (ed.). Zoo and Wild Animal Medicine. Current Therapy 3. W.B. Saunders Co., Philadelphia, Pennsylvania, Pp. 358-373.

Richardson, J.H. 1987. Basic Considerations in Assessing and Preventing Occupational Infections in Personnel Working With Nonhuman Primates. *Journal of Medical Primatology,* 16:83-89.

Zdziarski, J.M. 1999. Preventive Medicine. In: *Callitrichid Husbandry Manual,* eds. V. Sodaro, and N. Saunders; pp. 105-123.

Nutrition and Diet

Barbara Lintzenich, Brookfield Zoo, and Amy Hanson, WCS/Bronx Zoo

Introduction

Goeldi's monkeys *(Callimico goeldii)* have an expected body mass range of 393-680 grams in the wild (NRC, 2003; Hershkovitz, 1977). Probable gross energy requirement is estimated to be 160-335 kcal $GE \cdot BW_{kg}^{-1} \cdot day^{-1}$ (Bernard et al., 1988; Clapp and Tardif, 1985; Wirth and Buselmaier, 1982; Escajadillo et al., 1981).

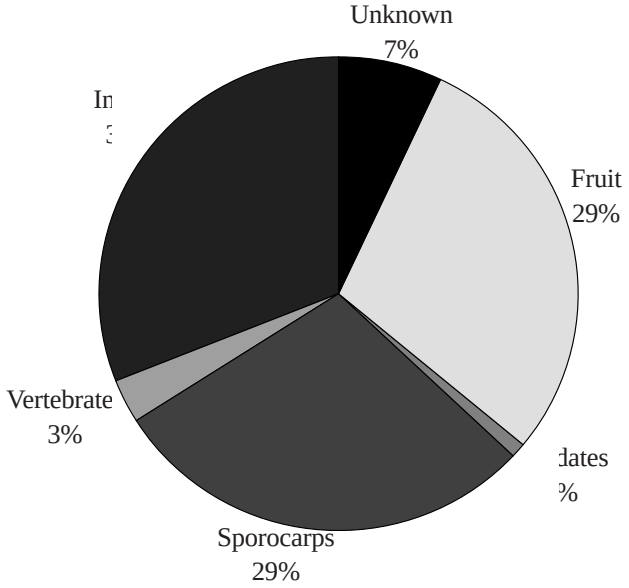
Free-ranging Goeldi's monkeys were documented to consume 31% insects (mostly orthoptera), 29% fruit, 29% sporocarps of fungi, 3% vertebrates, 1% tree exudates, and 7% occasional bird eggs and soil (Porter, 2001). As they consume such a wide variety of food items, they can be considered generalist omnivores.

When formulating diets for captive Goeldi's monkeys, as with all species, flexibility is needed to account for animal preferences, weight, exercise, physical condition, reproductive status, growth phase, environment, and behavioral considerations, as well as food availability. An average active adult animal will consume a total of approximately 5% of body weight per day (dry matter basis) or between 16% and 24% of body weight on an as-fed basis (depending on the moisture content of the diet). Diets in captivity typically contain 30% to 80% commercial marmoset diet (dry/canned or a combination), 10% to 60% fruit, 10% to 30% vegetable/starch, 2% other (usually hard-boiled egg), and 2% to 15% insects with very few supplements added (see Appendix A).

Feeding and Ecology Foraging Patterns

Although few detailed studies of Goeldi's monkeys *(Callimico goeldii)* have been conducted in their natural habitat, an in-depth study of one habituated group of wild Goeldi's monkeys provides important insight into their feeding ecology. Goeldi's monkeys were documented to consume insects (mostly orthoptera), fruit, the sporocarps of fungi, vertebrates, tree exudates, and occasional bird eggs and soil (Figure 1) (Porter, 2001).

Figure 1. Proportions of feeding time free-ranging Goeldi's monkeys spend consuming food types (Porter, 2001).



The components of the Goeldi's monkey diet are not substantially different from those of other Callitrichids. What is unusual about Goeldi's monkeys is the proportion of their feeding time that they spend consuming sporocarps, the fruiting bodies of fungi. During a one-year study, Goeldi's monkeys spent 29% of their feeding time consuming sporocarps (Porter, 2001). In comparison, other Callitrichids that consume fungi generally spend 1% to 5% of their feeding time consuming fungi (Hanson, 2000; Hanson et al., 2003). The proportion of feeding time Goeldi's monkeys spent consuming sporocarps varied throughout the year, ranging from 0% during some wet season months to 60% during the dry season (Porter, 2001). By relying on sporocarps more heavily during the dry season, when fruit is less available, Goeldi's monkeys appear to use sporocarps as a fallback resource. The relevance, if any, of Goeldi's monkeys' reliance on sporocarps in the wild to the species' captive dietary and nutritional needs is as yet unclear but warrants investigation.

As with most primates, the Goeldi's monkey diet in the wild is varied. In addition to the many types of food they consume, there is great diversity within each food category. For example, Goeldi's monkeys consume products from 56 plant species (Porter, 2000).

The foraging patterns of Goeldi's monkeys, like those of other Callitrichids, are also diverse. They have a small body size and clawlike nails on all of their digits except the hallux of their feet, which provide for efficient foraging from tree trunks (Garber, 1992). Goeldi's monkeys do not reach deeply into cracks and crevices in search of insects, as do some tamarins, nor do they gauge holes in tree trunks to simulate gum flow, like many marmosets. However, they are active predators of arthropods and small vertebrates. They search tree leaves and forage on the ground through leaf litter for insects. They also navigate on thin branches and hang from their back legs to retrieve items. As with all primates, it is important to provide captive Goeldi's monkeys with opportunities for dietary diversity, as well as foraging challenges (refer to the Enrichment Chapter in this manual), while at the same time ensuring proper nutrition.

Role of Gut Morphology in Feeding Strategy

Although the digestive tract of a Goeldi's monkey has been described and appears to be comparable to that of other Callitrichids (Hill, 1959), the species' digestive physiology has not yet been studied in detail. Several marmoset species are known to have relatively large caecums and colons that, by increasing an animal's ability to ferment ingested items, aid in the digestion of gums (Power, 1996, Power and Oftedal, 1996, Ferrari et al., 1993). The fungi consumed by Goeldi's monkeys, like gums, are largely composed of complex carbohydrates that are likely to be difficult to digest (Hanson, unpubl. data). Although the digestibility of fungi by primates has not been studied, studies of rodents and marsupials have shown that fungi are hard to digest and that fermentation aids in their digestion (Claridge et al., 1999; Cork et al., 1998; McIlwee and Johnson, 1998; Claridge and Cork, 1994). Thus, it would likely be beneficial for Goeldi's monkeys to have an enlarged caecum and colon to aid in the digestion of fungi. Whether or not Goeldi's monkeys have this adaptation has yet to be determined. The fact that Goeldi's monkeys have recently been phylogenetically aligned with the marmosets (Canavez et al., 1999; Pastorini et al., 1998) further supports the idea that they may have similar digestive adaptations to aid in the processing of difficult-to-digest carbohydrates. While the question of whether Goeldi's monkeys have adaptations to aid in the digestion of fungi is interesting, however, there is as of yet no indication that such adaptations would have any implication for their captive dietary needs. As for marmosets, this subject requires further investigation.

Infant Animals

Infant Animals: Handrearing/Infant Diet Guidelines (please refer to the handrearing chapter in this manual).

Physiological Status

Reproducing Females and Growing Young

Energy

Infant nonhuman primates require more energy per unit of BW than do adults of their species (NRC, 2003). It has been proposed that energy requirements for infant New World monkeys are 300-500 kcal $GE \cdot BW_{kg}^{-1} \cdot day^{-1}$ compared with 200-300 kcal $GE \cdot BW_{kg}^{-1} \cdot day^{-1}$ for infants of the larger Old World species (NRC, 1978; Nicolosi and Hunt, 1979). Nicolosi and Hunt (1978) reported that both Old World and New World monkeys have adult energy requirements that were lower by 30% to 50% on a $kcal \cdot BW_{kg}^{-1} \cdot day^{-1}$ basis than for growth. This is similar to humans.

Energy requirements for pregnancy and lactation remain undefined for nonhuman primates. With humans, recommended dietary allowances for energy for healthy, active women in their first trimester are not different from those for nonpregnant women (NRC, 1989). However, some say an increase is necessary due to increase in energy needs associated with the developing mass of fetal, placental, and maternal tissue, plus additional energy needs for new tissue synthesis (NRC, 1989). For Callitrichidae, Kirkwood and Underwood (1984) found that for cotton-top tamarins *(Saguinus oedipus oedipus),* females gained weight toward the end of pregnancy but it was not significant. For lactation, however, energy intake appeared to double. Also, Nievergelt and Martin (1999) found that females increased their energy intake by up to 100% and lost weight during lactation.

Protein

Protein requirements for pregnancy and lactation have not been studied. However, Tardif (1998) found that common marmoset females and infants had similar growth on diets that were 15% and 25% protein. Additionally, Power (2002) found that the composition of the marmoset milk was independent of the protein levels (15% and 25%) in the diets. Power found that protein at ~19% of the estimated energy in common and pygmy marmoset milk was constant among females.

Recommendations

Nutrient Requirements

Very few studies have been conducted with Goeldi's monkeys from which nutrient requirements could be established. The National Research Council (NRC, 2003) has attempted to describe the nutrient requirements of all nonhuman primates generally.

Energy

An animal requires energy for basal metabolic functions, for muscular activity, and for tissue accretion, reproduction, or lactation. Not all the total energy in food is available to the animal due to losses during digestion and metabolism. Gross energy (GE) is the energy released when organic substances are completely oxidized to carbon dioxide and water. Digestible energy (DE) is the GE minus the GE of feces, and metabolizable energy (ME) is GE minus the GE lost in the feces, urine, transpiration, and combustible gases. Energy expenditure requirement generally decrease with age due to a decrease in basal metabolic rate (also referred to as basal energy expenditure) (NRC, 2003). The basic equation

used for many animals is Kleiber's equation of $70BW_{kg}^{0.75}$. This equation has been used as a model for larger primates (macaques and chimpanzees) but not in smaller primates as in Goeldi's monkeys. There have been no direct studies of energy requirements for Goeldi's monkeys. However, commercial diets offered to marmosets and tamarins, formulated to contain 3.5-4.2 kcal $ME \cdot g^{-1}$, have helped to prevent "marmoset wasting syndrome" (a protein-calorie deficiency characterized by weight loss, alopecia, chronic diarrhea, muscle atrophy, chronic colitis, and often anemia) among *Callithrix jaccus, C. jaccus jaccus, C. jaccus penicillata, Saguinus oedipus,* and *S. fuscicollis illigeri* (Wirth and Buselmaier, 1982; Clapp and Tardif, 1985). Additionally, purified diets fed to adult cotton-top tamarins *(Saguinus oedipus)* providing 160 kcal $GE \cdot BW_{kg}^{-1} \cdot day^{-1}$ alleviated signs of wasting syndrome (Escajadillo et al., 1981). And finally, an open-formula diet, natural-ingredient diet providing 335 kcal $GE \cdot BW_{kg}^{-1} \cdot day^{-1}$ alleviated signs of wasting syndrome in mustached cotton-top tamarins *(Saguinus mystax)* (Bernard et al., 1988). There is evidence that in Callitrichids certain proteins may play a role in how individuals absorb nutrients (Gore et al., 2001). While these studies were not performed on Goeldi's monkeys directly, the information from these studies is the best information to apply to the probable requirement of the Goeldi's monkey. As shown in the studies listed, the quantity of energy needed seems to be directly related to the digestibility of the foods consumed. The range of gross energy would be 160-335 kcal $GE \cdot BW_{kg}^{-1} \cdot day^{-1}$ (Bernard et al., 1988; Clapp and Tardif, 1985; Wirth and Buselmaier, 1982; Escajadillo et al., 1981). At the time of this publication, there were two papers that were submitted for publication that measured energy in Goeldi's monkeys specifically. Once published, this information will be of good use.

Protein

It must be noted that actual protein requirement is linked to the array and quantity of essential amino acids and the quality of the protein (NRC, 2003). The amino acid associated with taurine is needed for proper development of young primates, but its requirement as a dietary essential is unknown (Sturman, 1993).

In all animals, protein and many amino acids are required for maintenance of body tissue, for growth, and for nonprotein N-containing bioactive compounds (NRC, 2003). Dietary requirements are increased during pregnancy and lactation, stress, and illness. The requirements also are influenced by the quality and digestibility consumed. Protein requirements of primates do not appear markedly different form those predicted from studies of other mammals (NRC, 2003). Goeldi's monkeys have not been studied specifically. Requirements for juvenile to adult primates, expressed as grams of protein per kilogram of body weight (BW) per day, ranged from 0.59 $g \cdot BWW_{kg}^{-1} \cdot day^{-1}$ for adult humans to 4.3 $g \cdot BW_{kg}^{-1} \cdot day^{-1}$ for juvenile squirrel monkeys. Most adult primates (when there were sufficient data) required less than 3 $g \cdot BW_{kg}^{-1} \cdot day^{-1}$. When energy was considered, protein concentrations needed to support requirements were 4.6-7.5% of ME calories, or 6.4% to 8% of dietary dry matter. Five primate species (a squirrel monkey, a cebus monkey, two species of macaques, and humans) were studied. Flurer and Zucker (1985) proposed protein requirements for *Saguinus fuscollis* to be 7.3% of dietary dry matter. Ausman et al. (1979) proposed protein requirements for *Saimiri sciureus* to be 20.8% of dietary dry matter at two to three weeks, 10% of dietary dry matter at two to three months, and 8.1% of dietary dry matter at nine months. Estimated protein requirement is 15% to 20% of the diet on a dry matter basis in diets containing conventional feed ingredients for all post-weaning nonhuman primates (NRC, 2003). It was noted in the NRC 2003 that lactation and growth of young in smaller primates, such as Callitrichids, can be more satisfactory when the higher percentages in the range are used without explanation (NRC, 2003).

Vitamin D

For primate species that have been investigated, Holick (1994) indicated that vitamin D is not essential in the diet if they have adequate exposure to sunlight. Vitamin D appears to be essential in the tissue metabolism for maintenance of calcium and phosphorus homeostasis and for normal bone mineralization (Holick, 1996). If no sunlight is provided, then the primates must be exposed to artificial light of appropriate wavelengths or diet items that contain sufficient vitamin D. Vitamin D also can be provided in the diet. Few primate species have been studied, and published research proves inadequate to determine differences between the two sources of dietary vitamin D, D_2 vs. D_3. However, some convincing evidence suggests that D_2 is less active than D_3 in New World primates (NRC, 2003).

Power et al. (1997) analyzed blood samples from wild free-ranging *Saguinus oedipus* in Colombia to establish a baseline for assessing vitamin D status of captive Callitrichids. They found serum 25(OH)D concentrations to be 25.5-120 $ng \cdot ml^{-1}$ with a mean of 76.4 $ng \cdot ml^{-1}$. Assuming animals in captivity have serum levels falling in or near this range are adequately nourished with vitamin D , the minimal dietary concentration of vitamin D to support these serum levels with no exposure to sun nor the appropriate ultraviolet light (UVB, an adequate substitute to sun) could be used to estimate minimal dietary requirements. Ullrey et al. (1999) tested a diet containing vitamin D_3 at 2,500 $IU \cdot kg^{-1}$ of dry matter with no exposure to sun of UVB for two years in captive *Saguinus oedipus.* This diet supported growth, reproduction, and serum 25(OH)D concentrations of 48-236 $ng \cdot ml^{-1}$ with a mean of 143.5 $ng \cdot ml^{-1}$ and no evidence of pathologic changes. It should be noted that in Goeldi's monkeys, vitamin D metabolites have been found to be lower than in other New World monkeys (Crissey et al., 1999). However, it was reported that renal dysfunction in this study colony of Goeldi's monkeys probably affected the vitamin D metabolite values (Crissey et al., 1996).

Commercial diets for Callitrichids can contain very high levels of vitamin D_3, to combat potential rickets and osteomalacia. To investigate suitable levels of vitamin D_3, Ullrey et al. (1999) compared health status in *Saguinus oedipus* fed high versus control levels of vitamin D_3. The levels consumed were 2500 IU by a zoo colony and 26000 IU vitamin $D3 \cdot kg^{-1}$ dry matter by a laboratory colony, respectively. The results suggested that 2500 IU supported serum 25(OH)D concentrations that were similar to a sample of wild-caught animals. Levels of 26000 IU appeared to result in health problems, mainly severe colitis. Estimated adequate concentrations of vitamin D_3 in diets containing conventional feed ingredients for postweaning nonhuman primates are 2500 $IU \cdot kg^{-1}$ (NRC 2003). In the NRC 2003, there are anecdotal reports of higher vitamin D_3 requirements under some circumstances, perhaps related to impaired absorption in individuals with colitis.

Vitamin C

Vitamin C has not been studied in Goeldi's monkeys but was proven a dietary essential in common marmosets, and it was determined that no less than 15 to 20 mg ascorbic acid/kg body mass was required (Flurer et al., 1987; Flurer and Zucker, 1989). In those studies, the animals were fed 500 ppm concentration in the diet. The authors concluded that the requirement is higher than human requirements (Flurer et al., 1987). However, when compared to common marmosets on the same diet, saddle-back tamarins had significantly lower circulating levels than the common marmosets, intimating that there is a species difference in need (Flurer and Zucker, 1987) and possibly a higher requirement in some Callitrichid species (Flurer and Zucker, 1989). Estimated adequate nutrient concentrations for vitamin C in diets containing conventional feed ingredients for postweaning nonhuman primates 200 $mg \cdot kg^{-1}$ taking into consideration the form ascorbyl-2-polyphosphate is a source of vitamin C that is biologically active and relatively stable during diet extrusion and storage.

Iron

Iron requirements for nonhuman primates has not been well-established (NRC, 2003). Diets very high in iron, however, can lead to hepatic hemosiderosis in common marmosets (Miller et al. 1997). A study involved young adults that were given diets that were nutritionally balanced, with natural ingredients, but the diets contained either 100 or 500 ppm of iron. After seven months, the 500 ppm was lowered to 350 ppm, due to the death of one individual due to an unrelated cause. However, upon necropsy there was an accumulation of iron in the liver of that individual that died. The mean increase in liver iron content in the high iron diet marmosets was 6545 mg/g DM, while the low iron diet produced a mean of 621.5 mg/g DM. Estimated adequate nutrient concentrations for iron in diets containing conventional feed ingredients for postweaning nonhuman primates 100 $mg \cdot kg^{-1}$. It was noted that due to the possibility of iron-storage disease, especially in the absence of iron binding polyphenols and when large quantities of fruit are offered, it might be better to limit the dietary concentrations to near or slightly below this value.

As mentioned previously, few studies exist that define the nutrient requirements of Goeldi's monkeys. Therefore, other than the nutrients discussed above, the guidelines for nonhuman primates must be used for feeding captive Goeldi's monkeys. See Table 1 for Goeldi's monkeys' estimated requirements adapted from NRC 2003.

Table 1. Goeldi's monkey estimated nutrient requirements on a dry matter basis.

Nutrient	Concentration in Diet[a]
Crude Protein, %	15-22[b]
Fat, %	-
Fiber, %	-
Vitamin A, IU/g	8
Vitamin D, IU/g	2.5[c]
Vitamin E, mg/kg	100
Thiamin, mg/kg	3.0
Riboflavin, mg/kg	4.0
Niacin, mg/kg	25.0
Pyridoxine, mg/kg	4.0
Folacin, mg/kg	4.0
Vitamin B12, mg/kg	0.03
Pantothenic acid, mg/kg	12.0
Choline, mg/kg	750
Biotin, mg/kg	0.2
Vitamin C, mg/kg	200
Calcium, %	0.8
Phosphorus, %	0.6
Magnesium, %	0.08
Potassium, %	0.4
Sodium, %	0.2
Iron, mg/kg	100
Zinc, mg/kg	100
Copper, mg/kg	20
Manganese, mg/kg	20
Selenium, mg/kg	0.3
Iodine, mg/kg	0.35

See explanations on previous pages for justification of nutrient levels.

[a]Probable requirements for nonhuman primates 2003.

[b]Lactation and growth can be more satisfactory when the higher protein concentrations in the range are used. Required concentrations are greatly affected by protein quality. This is a range for all nonhuman primates based on recommendations from the NRC 2003. Since Goeldi's monkeys specifically have not been studied and there is a wide range for Callitrichids in general, the NRC value is recommended.

[c]There are anecdotal reports of higher vitamin D_3 requirements under some circumstances, perhaps related to impaired absorption in individuals with colitis.

Feeding Guidelines and Practical Applications

Food Availability to Zoos

Of primary importance is knowledge of the quantity of nutrients and their quantity consumed in the wild. For the most part, these data are not available. All of the zoos listed in the zoo diet chart fed some type of commercial diet supplemented with some other foods, including insects, fruit, vegetables, and miscellaneous other items (see Appendix A). Based on the feeding ecology, ~30% of the diet is insects. However, in zoos, insects are not offered in that quantity. Of course, there would be differences in the insects foraged in the wild versus those commercially available to zoos.

Consideration should be made for comparing categories of foods consumed in the wild with the same categories of foods available to institutions. However, a botanical classification may not necessarily reflect nutritional content of a cultivated item. Studies of the nutrient content of food items consumed by free-ranging primates indicate that they may be considerably different from those same categories of items available in captivity. Generally, fruits consumed in the wild are higher in fiber and lower in sugars than those items cultivated for human use (Calvert, 1985). Also, fruits consumed in the wild *may be* primarily unripe, while those available in zoos are usually very ripe due to force ripening for humans. Ripening increases the sugar level in the item. This may be one reason why fresh fruit fed in zoos sometimes causes loose stool. Additionally, free-ranging Goeldi's monkeys (like other Callitrichids) consume insects as well as exudates. This variety of food item is not always commercially available to institutions. Thus, it must be acknowledged that, in captivity, animals are limited in dietary intake to the foods that are offered (and consumed) and must meet the animals' nutritional requirements.

Food Preference

The food most consumed by free-ranging animals may not be that most sought but, in fact, that most available. There may be differences in food choice based on physiological condition, and day-to-day fluctuations in food consumed may vary dramatically within and among animals.

Captive Goeldi's monkey diets are artificially limited by types and variety of food items offered. Studies with a variety of laboratory species have shown that an animal does not necessarily select food items based on the item's nutrient content. Instead, an animal may select items based on sugar content, fat content, and even novelty (Price, 1992). Thus, it is important to offer foods that compliment each other nutritionally.

There are a number of publications that list the nutrient content of commonly fed food items, such as produce (Pennington, 1993). Additional publications are available for information about items such as insects (Allen, 1989). The package label of manufactured products presents the guaranteed analyses of the packaged product, but this information *may not* show levels of vitamins and minerals. Many times, the manufacturers will provide these upon request or the product can be chemically analyzed.

Using published research on requirements, the NRC (2003) guidelines, along with data on wild Goeldi's monkey feeding ecology and nutrient content of food items available in zoos, it is possible to formulate appropriate diets for captive Goeldi's monkeys.

Formulation of Appropriate Diets

When formulating diets for captive Goeldi's monkeys, flexibility is needed to account for animal preferences, weight, exercise, physical condition, environment, and behavioral considerations, as well as food availability. Thus, guidelines for nutrient content and food categories, rather than recommending specific food items in set quantities, are appropriate. The guidelines allow for flexibility in diet formulation while that assuring a nutritious diet is consumed.

The entire diet (as well as the enclosure) should be viewed as enrichment, and as long as the target nutrient levels are met with respect to consumption of the diet, the presentation can be altered to fit behavioral and enrichment needs. Care must be taken to account for all ingested food items as diet contributors.

Dietary Recommendations

Schedule

Animals should be fed at least twice per day. The interval between morning and afternoon feeding should be between 4½ and 6½ hours. Since Goeldi's monkeys spend much time foraging, further feeding times also can be scattered throughout the day.

The morning (or activity period) feed should consist of more food than the afternoon (inactivity period) feed, though the same categories of foods should be offered. If possible, food should be available throughout the day and scattered to allow foraging.

Daily Diet

The quantity of food required per day may vary from animal to animal. This may be quite difficult to determine and should be based on accurate measurements of an animal's body mass (or body weight). Charting an animal's body mass over time will provide an indication of optimal weight and normal fluctuations for that animal. This can be extremely valuable as a predictor of possible problems associated with weight changes, including disease. An average active adult animal will consume a total of approximately 5% of body weight per day (dry matter basis) or somewhere near 16% to 24% of body weight on an as-fed basis (depending on the moisture content of the diet). However, this depends on exercise and physiological state. If the animal is lactating, intake may increase up to two times than usual (Kirkwood and Underwood, 1984; Nievergelt and Martin, 1999). If the animal is in a period of decreased activity, it will consume less or gain body mass. In the event there is a large colony of animals, high competition among animals, animals of differing age/sex groupings, or possible pest infestation, the animals should be fed so that there is a small quantity of food remaining after the feeding period. However, there should not be so much food remaining as to allow sorting and rejection of food items to occur. The challenge for the animal care-giver is to ensure that each animal receives its prescribed diet, especially the nutritionally complete manufactured portion. If too much food is offered in a cafeteria-style feeding, the animal is allowed to choose what it will eat and may not consume a nutritionally complete diet.

The food items should be of a size appropriate for easy handling for an individual. Sizes and shapes should be varied for behavioral enrichment.

Food sharing and stealing is common within family groups and serves to teach the young about important food items. However, feeding quantities should be modified to avoid the problem of an individual in a group not receiving enough food because of competition. Adding two or more food dishes per feeding can help eliminate problems with food competition between animals.

It is very important to have fresh water available at all times. Food and water dishes should be disinfected daily to prevent bacterial build-up, especially of *Pseudomonas.*

The importance of the inclusion of the nutritionally complete primate diet cannot be over-emphasized, and its consumption is crucial to proper dietary management of these animals. The diet should be reassessed for nutrient content if one nutritionally complete food item is substituted for another. A drop or increase in food intake must be carefully watched, and body weight should be maintained. Oral medication may be handfed to individuals in favorite items.

Ultimately, it is the diet (food items) actually consumed by each animal that will determine its nutrient status. Thus, the diet offered will allow the animal to consume the nutrients needed. If it does not consume the diet or certain portions of the diet, the animal may not be receiving the nutrients it requires. Thus, it may be important to assess diet consumption, at least periodically.

Reported Health Problems Linked to Diet

It is not clear if renal dysfunction is related to diet fed Goeldi's monkeys in captivity (Crissey et al., 1999). It is not clear if vitamin D and iron are problematic in Goeldi's monkeys. More research is needed in these areas.

Future Research Needs

Basic research of the nutrient requirements of Goeldi's monkeys is lacking and would be beneficial to their captive management.

The digestive system of Goeldi's monkeys should be studied to ascertain whether they have any digestive adaptations to process fungi. If so, whether these adaptations have any bearing on their captive dietary requirements should be considered.

References

Allen, M.E. 1989. Nutritional aspects of insectivory. Ph.D. Thesis. Michigan State University, E. Lansing, MI.

Ausman, L.M., D.L. Gallina, K.W. Samonds, and D.M. Hegsted. 1979. Assessment of the efficiency of protein utilization in young squirrel and macaque monkeys. *American Journal of Clinical Nutrition,* 32:1813-1823.

AZA American Zoo and Aquarium Association. 1993. *Infant Diet/Care Notebook.* AZA, Wheeling, WV.

Barnard, D., J. Knapka, and D. Renquist. 1988. The apparent reversal of a wasting syndrome by nutritional intervention in *Saguinus mystax. Laboratory Animal Science,* 38:282-288.

Calvert, J.J. 1985. Food selection by western gorillas *(G. gorilla gorilla)* in relation to food chemistry. *Oecologia,* 65:236-246.

Canavez, F.C., M.A.M. Moreira, F. Simon, P. Parham, and H.N. Seuanez. 1999. Phylogenetic relationships of the Callitrichinae (Platyrrhini, Primates) based on beta-two-microglobulin DNA sequences. *American Journal of Primatology,* 48:225-236.

Clapp, N.K., and D.S. Tardif. 1985. Marmoset husbandry and nutrition. *Dig Dis Sci* 30:17S-23S.

Claridge, A.W., and S.J. Cork. 1994. Nutritional value of hypogeal fungal sporocarps for the long-nosed potoroo *(Potorous tridactylus),* a forest-dwelling mycophagous marsupial. *Australian Journal of Zoology,* 42: 701-710.

Claridge, A.W., J.M. Trappe, S.J. Cork, and D.L. Claridge. 1999. Mycophagy by small mammals in the coniferous forests of North America: nutritional value of sporocarps of *Rhizopogon vinicolor,* a common hypogeous fungus. *Journal of Comparitive Physiology - B, Biochemical, Systemic, and Environmental Physiology,* 169: 172-178.

Cork, S.J., A.W. Claridge, and J.M. Trappe. 1998. The comparative nutrition of mycophagy among mammals. *Proceedings of the Comparative Nutrition Society.*

Crissey, S.D., T. Meehan, M.A. Pruett-Jones, A. Baker, and L. Phillips. 1996. Vitamin D metabolites 1,25 dihydroxy D and 25 hydroxy D) in Goeldi monkeys *(Callimico goeldii)* and the incidence of renal disease. *Symposium of the Comparative Nutrition Society,*1:33-36.

Crissey, S.D., T.P. Meehan, C. Langman, and M.A. Pruett-Jones. 1999. Vitamin D metabolites 25(OH)D and 1,25(OH)(2)D and kidney function indices and the relationship to diet in Goeldi's monkeys *(Callimico goeldii). Zoo Biology,* 18: 565-574.

Escajadillo, A., R.T. Bronson, P. Sehgal, and K.C. Hayes. 1981. Nutritional evaluation in cotton-top tamarins *(Saguinus oedipus). Laboratory Animal Science,* 31:161-165.

Ferrari, S.F., and E.S. Martins. 1992. Gummivory and gut morphology in two sympatric Callitrichids *(Callithrix emiliae* and *Saguinus fuscicollis weddelli)* from Western Brazilian Amazonia. *American Journal of Physical Anthropology,* 88:97-103.

Flurer, C.I., M. Kern, W.A. Rambeck, and H. Zucker. 1987. Ascorbic acid requirement and assessment of ascorbate status in the common marmoset *(Callithrix jaccus). Annals of Nutrition and Metabolism,* 31:245-252.

Flurer, C.I., and H. Zucker. 1989. Ascorbic acid in a New World monkey family: Species difference and influence of stressors on ascorbic acid metabolism. *Z Emahungswiss,* 28:49-55.

Flurer, C., and H. Zucker. 1985. Long-term experiments with low dietary protein levels in *Callithricidae. Primates,* 26:479-490.

Flurer, C.I., and H. Zucker. 1987. Difference in serum ascorbate in two species of Callithricidae. *International Journal for Vitamin and Nutrition Research,* 57:297-298.

Garber, P.A. 1992. Vertical clinging, small body size, and the evolution of feeding adaptations in the Callitrichinae. *American Journal of Physical Anthropology,* 88:469-482.

Gore, M.A., F. Brandes, F.J. Kaup, R. Lenzner, T. Mothes, and A.A. Osman. 2001. Callitrichid nutrition and food sensitivity. *Journal of Medical Primatology,* 30:1-6.

Hanson, A.H. 2000. Habitat Use in Relation to Diet, with Particular Emphasis on Mycophagy, by *Callimico goeldii* in Pando, Bolivia. Master's thesis, Stony Brook: SUNY-Stony Brook.

Hanson, A.H., K.T. Hodge, and L.M. Porter. 2003. Mycophagy among primates. *Mycologist.* 17(1). In Press.

Hershkovitz, P. 1977. *Living New World monkeys, (Platyrrhini). Vol. 1.* University of Chicago Press, xiv Pp. 1117.

Hill, O. 1959. The Anatomy of *Callimico goeldii* (Thomas). *Transactions of the American Philosophical Society,* 49(5).

Holick, M.F. 1994. McCollum Award Lecture: Vitamin D: new horizons for the 21st century. *American Journal of Clinical Nutrition,* 60:619-630.

Holick, M.F. 1996. Vitamon D: photobiology, metabolism, mechanism of action, and clinical application. Pp. 74-81 in: *Primer on the Metabolic Bone Diseases and Disorders of Mineral Metabolism,* 3rd Ed., M.J. Favus, ed. Philadelphia: Lippincott-Raven.

Kirkwood, J.K., and S.J. Underwood. 1984. Energy requirements of captive cotton-top tamarins *(Saguinus oedipus oedipus). Folia primatologica,* 42:180-187.

McIlwee, A.P., and C.N. Johnson. 1998. The contribution of fungus to the diets of three mycophagous marsupials in *Eucalyptus* forests, revealed by stable isotope analysis. *Functional Ecology,* 12:223-231.

Miller, G.F., D.E. Barnard, R.A. Woodward, B.M. Flynn, and J.W. Bulte. 1997. Hepatic hemosiderosis in common marmosets, *Callithrix jacchus:* effect of diet on incidence and severity. *Laboratory Animal Science,* 47:2, 138-42.

Nicolosi, R.J., and R.D. Hunt. 1979. Dietary allowances for nutrients in nonhuman primates. Pp. 11-37. In: *Primates in Nutritional Research,* K.C. Hayes, Ed. London. Academc Press, Inc.

Nievergelt, C.M., and R.D. Martin. 1999. Energy intake during reproduction in captive common marmosets *(Callithrix jacchus). Physiology and Behavior,* 65:849-854.

NRC, National Research Council. 1978. Nutrient requirements of nonhuman primates. Washington, D. C. *National Academy of Sciences,* p. 83.

NRC, National Research Council. 2003. Nutrient requirements of nonhuman primates, 2nd revised edition. Washington, D.C. *National Academy of Sciences,* p. 286.

Pastorini, J., M.R.C. Forstner, R.D. Martin, and D.J. Melnick. 1998. A reexamination of the phylogenetic position of *Callimico* (Primates) incorporating new mitochondrial DNA sequences. *Journal of Molecular Evolution* 47(1):32-41.

Pennington, J.A.T. 1993. Bowes and Church's Food Values of Portions Commonly Used. 16th ed. Perennial Library, Harper & Roe Publ.

Porter, L.M. 2000. The Behavior and Ecology of the Goeldi's Monkey *(Callimico goeldii)* in Northern Bolivia. PhD thesis, Stony Brook: SUNY-Stony Brook.

Porter, L.M. 2001. Dietary differences among sympatric Callitrichinae in Northern Bolivia: *Callimico goeldii, Saquinus fuscicollis* and *S. labiatus*. *International Journal of Primatology,* 22(6):961-992.

Power, M.L. 1996. The other side of Callitrichine gummivory. In: *Adaptive radiations of Neotropical Primates*. Plenum Press, NY.

Power, M.L., and O.T. Oftedal. 1996. Differences among captive callitrichids in the digestive responses to dietary gum. *American Journal of Primatology,* 40: 131-144.

Power, M.L.,O.T. Oftedal, A. Savage, E.S. Blumer, L.H. Soto, T.C.Chen, and M.F. Holick. 1997. Assessing vitamin D status of callitrichids: baseline data from wild cotton-top tamarins *(Saguinus oedipus)* in Columbia. *Zoo Biology,* 16: 39-46.

Power, M.L., O.T. Oftedal, and S.D. Tardif. 2002. Does the milk of callitrichid monkeys differ from that of larger anthropoids? *American Journal of Primatology,* 56:117-127.

Price, E.C. 1992. The nutrition of Geoffroy's marmoset *Callithrix geoffroyi* at the Jersey Wildlife Preservation Trust. Dodo J. *Wildlife Preservation Trusts,* 28:58-69.

Sturman, J.A. 1993. Taurine in development. *Physiological Reviews,* 73:119-147.

Tardif, S., C. Jaquish, D. Layne, K. Bales, M. Power, R. Power, and O. Oftedal. 1998. Growth variation in common marmoset monkeys *(Callithrix jacchus)* fed a purified diet: relation to care-giving and weaning behaviors. *Laboratory Animal Science,* 48:264-269.

Ullrey, D.E., J.B. Bernard,G.K. Peter, Z.R. Lu, T.C. Chen, J.G. Sikarskie, and M.F. Holick. 1999. Vitamin D intakes by cotton-top tamarins *(Saguinus oedipus)* and associated serum 25-hydroxyvitamin D concentrations. *Zoo Biology,* 18: 473-480.

Wirth, H., and W. Buselmaier. 1982. Long-term experiments with a newly-developed standardized diet for the New World primates *Callithrix jaccus jaccus* and *Callithrix jaccus pencillata* (marmosets). *Laboratory Animal Science,* 16:175-181.

Appendix A

Grams Per Day Per Animal	Brookfield Zoo	WCS[4]	St. Louis	National Zoo	Woodland Park Zoo	Virginia	Palm Beach @ Dreher Park	Sedgwick County	San Antonio	Milwaukee County Zoo	Zoo World	Louisiana Purchase Gardens & Zoo	Zurich
Manufactured Foods													
ZuPreem Marmoset	88g	75g	-	43.5g	100g	60g	20g	50g	-	2- 1" slices	1/8 can	4 pieces	-
ZuPreem Primate	-	-	-	-	-	-	-	-	-	-	-	-	-
St. Louis Mix[1]	-	-	105g	-	-	-	-	-	-	-	-	-	-
Purina 5045 high protein biscuit	-	-	-	1.5g	-	2 pos crushed	-	-	-	-	-	-	-
Mazuri Monkey Biscuit Powder	-	-	-	-	-	-	-	2 T	-	-	-	-	-
New World Monkey Chow	-	-	-	-	-	-	-	-	1 cup	-	-	2 pieces	-
Purina Leafeater Pellet – soaked	-	-	-	-	-	-	-	-	-	1 ea.	-	-	-
Porridge[2]	-	-	-	-	-	-	-	-	-	-	-	-	varies
Commercial primate pellet	-	-	-	-	-	-	-	-	-	-	-	-	no amt. given
Mazuri Marmoset Jelly	-	-	-	-	1/8 cup	-	-	-	-	-	-	-	-
Vegetables													
Sweet Potato	14g	-	-	20g	14g	4g	31g	-	-	-	1/8 cup	1/8 cup	-
Green Pepper	3g	-	-	-	-	-	-	-	-	-	-	-	-
Carrot	5g	-	-	9g	-	4g	31g	9g	-	-	-	1/8 cup	-
Green Bean	6g	-	-	6g	-	-	-	-	-	-	-	-	-
Cucumber	7g	-	-	-	-	-	-	-	-	-	-	-	-
Kale	-	10g	-	2.5	-	-	-	-	-	-	-	-	-
Mixture	-	-	12.5g	-	-	-	-	-	-	-	-	-	-
Romaine/Spinach	-	-	-	2.5g	1 tsp. chopped	-	-	-	-	1 leaf	-	-	-
Lettuce	-	-	-	-	-	-	-	35g	-	-	-	-	-
Fruit/Veggie Mix – MWZ[3]	-	-	-	-	-	-	-	-	-	_ cup	-	-	-
Broccoli - cooked	-	-	-	-	-	-	-	-	-	-	1 floret	-	-
Fruit													
Apple	7g	25g	-	25g	-	8g	62g	37.5g	-	-	1/8 ea.	1/8 cup	10g
Papaya	7g	-	-	-	-	-	-	-	-	-	-	-	-
Banana	8g	10g	-	40g	-	6g	-	-	-	20g	_ ea.	_ cup	10g
Grape	1.1g	-	-	6.5g	1 small	1.5 ea.	-	-	-	-	-	no amt. given	10g
Orange	-	-	-	12.5g	1 T. 2x/wk	10g	52g	44g	-	-	1/8 ea.	1/4 cup	-
Mixture	-	-	12.5g	-	2 T. p.m.	-	-	-	1 cup	-	-	-	-
Seasonal/Treat	-	-	-	-	-	-	24g	-	-	-	-	-	-
Raisins	-	-	-	-	-	-	-	3g	-	-	-	-	-
Other													
Hard-boiled Egg	1.7g	-	-	-	1/8 per wk	5g	-	-	-	_ egg	-	-	0.9g
Peanut	1.3g	-	-	-	-	-	-	-	-	-	-	-	-
Wheat Bread soaked w/ Kayro	-	-	-	-	-	-	-	-	-	-	_ slice	-	-
Marshmallows	-	-	-	-	-	-	-	-	-	-	4 mini	-	-
Strawberry Yogurt	-	-	-	-	-	-	-	-	-	-	-	1 tsp.	-
Edam Cheese	-	-	-	-	-	-	-	-	-	-	-	-	1.7g
Cashews/chestnuts	-	-	-	-	-	-	-	-	-	-	-	-	1 nut/wk
Zwieback crackers	-	-	-	-	-	-	-	-	-	-	-	-	_ ea./wk
Insects													
Mealworm	0.43g	-	-	4g	5 ea./day	25-30 ea. 3x/wk	8-9 ea.	-	-	5	-	-	5-10
Cricket	2.14g	-	-	14g	8 ea. 4x/wk	20 ea. 2x/wk	8-9 ea.	-	-	-	-	-	5-10
WCS Insect Mix[4]	-	2g	-	-	-	-	-	-	-	-	-	-	-
Supplements													
BZ MPS[5]	0.5g	-	-	-	-	-	-	-	-	-	-	-	-
Poly-vi-sol	-	-	-	-	-	-	-	4 drops	-	-	-	-	-
Ferrous Sulfate	-	-	-	-	-	-	-	4 drops	-	-	-	-	-

[1]St. Louis mix is a combination of 30% ground Mazuri Primate Maintenance (5MA2), 18.43% ZuPreem Primate canned, 13% ZuPreem Marmoset canned, 11.13% applesauce, 0.01% ascorbic acid, 0.06% Fer-n-Sol iron drops, 11.52% frozen orange juice concentrate, and 15.85% water.

[2]Zurich porridge is a mixture of baby cereal, calcium carbonate, and a vitamin product.

[3]Milwaukee County Zoo fruit/veggie mixture comprises 115 g frozen corn, 58 g frozen beans, 227 g California Veggie Mix frozen, 115 g boiled sweet potato, 1 apple, 1 pear, 50 g grapes, and _ cup orange juice.

[4]WCS insect mix is a combination of equal portions of crickets, mealworms, and waxworms gut-loaded and dusted with $CaCO_3$. A number of fruits, vegetables, grains, and other items are used as management foods for enrichment and training in the amount of 10% of the daily caloric requirement needs for Gaeldi's monkeys. Contact WCS for more information.

[5]BZ MPS is a combination of 48.8% soybean protein, 24.48% high nitrogen casein, 16.32% spray-dried egg white, 16% magnesium oxide, 2% ferrous sulfate, and 0.4% manganese sulfate.

Ethogram for *Callimico goeldii*

Amy Hansen and Vince Sodaro

This ethogram borrows substantially from behavioral patterns defined in "Goeldi's Monkey, Genus Callimico" by P. Heltne, J. Wojcik, and A.G. Pook in *Ecology and Behavior of Neotropical Primates Volume I*, edited by Adelmar Coimbra-Filho and Russell Mittermeier, Academia Brasileira de Ciencias, Rio de Janiero, 1981. Definitions from an ethogram established by Primate Department staff at Brookfield Zoo from 1977 and 1978 were also utilized.

( ) = function believed to be associated with the behavior is included when known and not obvious.

Visual Behaviors

Stare

Eyes open looking directly at object. (Mild threat.)

Brow lowering

Brows drawn down, nose furrowed, crown hairs may be erect. (Mild threat.)

Grimace

Teeth closed, lips drawn back exposing teeth, tips of canines exposed. (Appeasement.)

Open mouth teeth exposed

Mouth wide, all teeth exposed, may include scream vocalization. (Intense threat mixed with appeasement.)

Quadrupedal display

Animal stands quadrupedally on toes and fingers, back arched, elbows and knees almost fully extended, piloerection, brows may be lowered. Behavior can be stationary or performed between short spurts of running or jumping. (Threat.)

Groom solicit

Animal lays on side or ventrum, in a sprawled or stretched posture, or in a crouched position with head lower than rump. Gaze is usually directed away from potential groomer.

Pilosolicit

Female stands quadrupedally with back slightly arched, elbows and knees partially extended, piloerect. A rigid, largely stationary and unanimated behavior compared to quadrupedal display. (Solicit copulation.)

Present

Female crouches on ventrum in front of male, pelvis lowered, tail may be deflected; female may look or reach back with one hand to male. (Solicit copulation.)

Tail wag

Animal wags or waves entire length of tail from side to side with undulating movement during "quadrupedal display," usually accompanied by piloerection. (Threat.)

Jump over

Animal jumps over the back of another, from stationary position to a stationary position, not in the context of locomotion.

Tongue flick

Protrusion and retraction of tongue several times in rapid succession, mouth slightly open. (Agonistic or prosexual.)

Lateral display

Animal's feet are mostly stationary; head, shoulders, and sometimes hands move from side to side laterally, usually accompanied by "tchuck" vocalizations at end of each movement. (Threat, animal disturbed by something in the environment.)

Uncoil tail

Uncoil and recoil tail from between legs in a seated position; bout ends when tail does not coil or uncoil for 10 sec. (Solicit grooming of tail.)

Self pull

Animal grabs onto some fur on the top or side of its head and pulls gently for one or more seconds; animal is generally sitting or laying at rest when this occurs.

Approach

Animal moves toward another to within 0.5m.

Leave

Animal moves away from another animal, which it had been within 0.5m of, to a distance of at least 1m.

Olfactory Behaviors

Sniff

Direct olfactory attention to conspecific in areas other than genital region or tail.

Genital inspect

Direct focused sensory attention to other's genital area.

Urine taste

Male licks one or more drops of urine emitted by a female.

Tail inspect

Direct focused sensory attention to other's tail.

Genital mark

Chest off substrate, hindquarters depressed, anogenital area rubbed on substrate.

Anal mark

Rubbing of the anus on a substrate from a sitting position.

Sternal rub

Low crouch, rub sternal glands along horizontal substrate. (Note: This behavior was defined by Heltne et al., 1981, but has not been observed to occur in the Brookfield Zoo Callimico collection).

Tail mark

Half: Quadrupedal stance, coiled tail swept over anogenital region.

Full: as above, tail coil also sweeps over the sternal area. Bout ends when tail has not been coiled or uncoiled for 10 sec. (Scent-mark self and area, solicit grooming, also frequently occurs prior to an animal beginning to groom another.)

Sneeze

Rapid exhalation from the nostrils.

Rub muzzle

Animal rubs its nose and/or mouth on substrate.

Scent lick

Quick, single tongue flicks, mouth slightly open. (Sense chemical signals.)

Tactile Behaviors

Allogroom

Manual parting and picking through the pelage of another animal; often involves hairs of groomed animal being pulled between groomer's teeth as well as licking of hairs and skin. A bout ends if an animal moves >0.5m away from the other and grooming is stopped for 60 seconds.

Autogroom

Same as Allogroom, except individual grooms self. A bout ends if the animal stops grooming for 60 seconds.

Touch

Directed contact of one or both hands on a conspecific, except for genital area or tail.

Mount

Individual approaches other from rear, places both arms on other's upper back, with most of mounter's ventrum on other's back.

Copulation

Mount with penetration and thrusting.

Extricate

Walk away, roll on back or side, or otherwise move away so as to disallow attempted mount or copulation.

Waist clasp

Approach partner from rear and place both arms around waist.

Arm over

Individual sits next to another and puts arm over other's shoulder or back.

Contact sitting

Two or more animals sit side by side, parallel head to head or rump to head, or angled, with bodies touching.

Other threat

Push, bite, chase, lunge toward, slap.

Other Social Behaviors and Behaviors Related to Infants

Offered share

An object is proffered by one animal to another. Item can be accepted or refused.

Allowed share

An animal allows a conspecific to take an object with no resistance.

Steal

An animal attempts to take an object from a conspecific who withholds the object by moving it away or holding on the object. Steal can be successful or unsuccessful.

Infant carry

Animal supports at least one half the weight of an infant.

Infant rid attempt

Carrier attempts to dislodge infant by rubbing it against cage or substrate, pulling on its limbs, hanging upside down, biting at it, etc.

Infant transfer

Infant moves from one animal to another, either directly, or after a period of less than 5 seconds during which time it is unattended.

Nursing

Infant carried in a ventral position by dam, enabling it to potentially have access to the nipple.

Rest Positions

Sit

Animal sits on hind quarters, elbows slightly curved, hands on substrate, ventrum not resting on substrate, head is upright; tail may be hanging down or pulled between the legs and curled ventrally.

Lay

Animal lays with knees and elbows fully bent, torso parallel with substrate if hands and feet are on the same substrate, ventrum may or may not be in contact with substrate, head upright; tail may be resting behind animal or pulled between legs with animal's body resting on it.

Head down

Animal "sits" or "lies" with head drooping downward, face toward the ground or substrate. (Usually an indication of extreme fatigue or illness.)

Ventral lay

Animal lays on substrate with most of ventrum in contact with substrate, one or more appendages hanging down over the edge of the substrate.

Callimico Selected Bibliography

Ah-King, M., and B. S. Tullberg, B.S.2000. Phylogenetic analysis of twinning in Callithricinae, *American Journal of Primatology,* 51 (2), 135-146.

Allchurch, A.F. 1986. The nutritional handbook of the Jersey Wildlife Preservation Trust: A collection of all the diets in current use, Jersey Wildlife Preservation Trust, Trinity, Jersey, 1986, 80.

Altmann, J., M. Warneke, and J. Ramer. 1988. Twinning in *Callimico goeldii. International Journal of Primatology,* 9, 165-168.

Anderson, D. 1998. Rapid physical but delayed behavioral maturation and single births in Callimico: A reproductive strategy, *American Journal of Primatology,* 45 (2), 164.

Anzenberger, G. 1992. Monogamous social system and paternity in primates. In: *Paternity in Primates: Genetic Tests and Theories*, editors, R. D. Martin, A.F. Dixson, and E.J. Wickings, Karger, Basal, Switzerland, 203-224.

Anzenberger, G. 1999. On the Flexibility of primate social structures with special reference to monogamy. *Primatology and Anthropology into the Millenium: Centenary Congress of the Anthropological Institute and Museum in Zurich, 1899-1999*. Abstracts, University of Zurich, Zurich, Switzerland.

Arentsen, D. 1977.*Callimico goeldii* at Bristol Zoo. *Ratel,* 4 (2-3), 13-15.

Barton, R. 1983. A comparative study of grooming interactions in primates. *Dodo,* 20, 26-36.

Barton, R. 1985. Grooming site preference in primates and their functional implications. *International Journal of Primatology,* 6 (5), 519-532.

Beck, B. 1978. Goeldi's rescue at Brookfield. *Brookfield Bison* June/July 6-7.

Beck, B., D. Anderson, J. Ogden, B. Rettberg,C. Brejla, R. Scola, and M. Warneke, M. 1982. Breeding the Goeldi's monkey *Callimico goeldii* at Brookfield Zoo. *International Zoo Yearbook,* 22:106-114.

Beck, B., B. Rettberg,D. Anderson, M. Warnek, E.M. Derrickson, J. Ramer, and V. Sodaro. The development of body weight and behavior in captive callimicos. Unpublished.

Bender, M. and L. Mettler. 1960. Chromosomal studies in primates II, *Callithrix, Leontocebus,* and *Callimico. Cytologia,* 25:400-404.

Bielli, M., S. Lauzi, A. Pratelli, M. Martini,P. Dall'Ara, and L. Bonizzi. 1999. Pseudotuberculosis in marmosets, tamarins, and Goeldi's Monkeys (Callithrichidae/Callimiconidae) housed at a European Zoo. *Journal of Zoo and Wildlife Medicine,* 30 (4), 532-536.

Brice, S. 1995. Screening a New World monkey colony for *Yersinia* and investigations of *Y. pseudotuberculosis* and soil. *Dodo,* 31, 139-147.

Bridges, W. 1955. How to tempt the appetite of a *Callimico. Animal Kingdom* 58:91-92.

Buchanan-Smith, H.M. 1991. Field observations of Goeldi's monkey, *Callimico goeldii* in northern Bolivia. *Folia primatologica,* 57:102-105.

Buchanan-Smith, H.M. 1999. Tamarin polyspecific associations: Forest utilization and stability of mixed-species groups, *Primates,* 40 (1), 233-247.

Buchanan-Smith, H., M. Hardie, C. Caceres, and M. Prescott. 2000. Distribution and forest utilization of *Saguinus* and other primates of the Pando Department, northern Bolivia. *International Journal of Primatology,* 21 (3), 353-379.

Cameron, R., C. Wiltshire, C. Foley, N. Dougherty, X. Aramayo, L. and Ria. 1989. Goeldi's monkey and other primates in northern Bolivia. *Primate Conservation,* 10:62-70.

Cameron, R., and H. M. Buchanan-Smith. 1991. Primates of the Pando, Bolivia, *Primate Conservation,* (13-13), 7-10.

Carroll, B., 1982. Maintenance of the Goeldi's monkey *Callimico goeldii* at Jersey Wildlife Preservation Trust. *International Zoo Yearbook,* 22:101-105.

Carroll, J.B. 1985. Pair bonding behaviour in Goeldi's monkey, *Callimico goeldii. Dodo,* 22:57-71.

Carroll, J. B. 1986. Social correlates of reproductive suppression in captive callithricid family groups. *Dodo,* 23, 80-85.

Carroll, J.B. 1987. Caregiver behaviour and the infant rearing strategy of captive *Callimico goeldii. International Journal of Primatology,* 8(5), 521.

Carroll, J.B. 1987. A behavioural study of captive *Callimico goeldii,* housed in polygonous social groups. *International Journal of Primatology,* 8 (5), 522.

Carroll, J.B. 1988. The stability of multifemale groups of Goeldi's monkey, *Callimico goeldii,* in captivity. *Dodo* 25:37-43.

Carroll, J.B., D. Abbott, L. George, J. Hindle, and R. Martin, R.1990. Urinary endocrine monitoring of the ovarian cycle and pregnancy in Goeldi's monkey *(Callimico goeldii). Journal of Reproduction and Fertility,* 89:149-161.

Carroll, J.B. 1991. An investigation into multifemale breeding groups among captive Goeldi's monkeys, *Callimico goeldii,* at Jersey Wildlife Preservation Trust. *Primatalogico No Brasil,* 207-208.

Carroll, J.B. 1993. The captive behavior and reproduction of Goeldi's monkey *Callimico goeldii. Dodo,* 29, 171-172.

Carroll, J.B. 1997. A comparative summary of the nutritional adaptations and needs of callithrichids and application to captive management. In: *Handbook: Marmosets and tamarins in Biological and Biomedical Research*, Pryce, C., Scott, L., and Schnell, C., editors, DSSD Imagery, Salisbury, United Kingdom, 70-77.

Carroll, J.B., D. Abbott, L. George, and R. Martin, R. 1989. Aspects of urinary oestrogen excretion during the ovarian cycle and pregnancy in Goeldi's monkey, *Callimico goeldii. Folia primatologica,* 52:201-205.

Castenholz, A., R. Lorenz, and E. Castenholz. 1978. Morphometry and histology of the eye of *Callimico goeldii* (Thomas, 1904, Callimiconidae, Primates). *Folia primatologica,* 29, 161-177.

Chaves, R., I. Sampaio, M. P. Schneider, H. Schneider, S. L. Page, and M. Goodman. 1999. The place of *(Callimico goeldii)* in the callithricine phylogenetic tree: Evidence from von Willebrand gene intron II sequences. *Molecular Phylogenetics and Evolution,* 13 (2), 392-404.

Christen, A., M. Doebeli, B. Kempken, M. Zachmann, and R. D. Martin. 1989. Urinary excretion of oestradiol-17 beta in the female cycle of Goeldi's monkeys *(Callimico goeldii). Journal of Human Evolution,* 22 (4-5), 367-393.

Christen, A., and T. Geissmann. 1994. A primate survey in northern Bolivia with special reference to Goeldi's monkey, *Callimico goeldii. International Journal of Primatology,* 15:239-274.

Christen, A. 1994. Goeldi's monkey, *Callimico goeldii,* in northern Bolivia. In: *Current Primatology, Volume 1, Ecology and Evolution*, editors B. Thierry, A.J.R. Anderson, J.J. Roeder, and N. Herrenschmidt, University Louis Pasteur, Strasbourg, Austria, 73-78.

Christen, A. 1998. The most enigmatic monkey in the Bolivian rain forest - *Callimico goeldii. Neotropical Primates,* 6 (2), 35-37.

Christen, A. 1999. Survey of Goeldi's Monkey *(Callimico goeldii)* in northern Bolivia. *Folia primatalogica,* 70 (2), 107-111.

Christen, A., andL. M. Porter. 1999. Field Surveys of Goeldi's Monkey in northern Bolivia In: *Primatology and Anthropology into the Millenium: Centenary Congress of the Anthropological Institute and Museum in Zurich, 1899-1999*, Abstracts, University of Zurich, Zurich, Switzerland.

Crissey, S.D., and L. S. Pribyl, L.S. 1997. Utilizing foraging information to provide captive primates with an appropriate diet, *Proceedings of the Nutrition Society,* 56 (3) 1083-1094.

Crissey, S.D., T. P. Meehan, C. Langman, and M. A. Pruett-Jones. 1999. Vitamin D metabolites 25 (OH)D and 1,25(OH)2D and kidney function indices and the relationship to diet in Goeldi's Monkey *(Callimico goeldii), Zoo Biology,* 18 (6), 565-574.

Davis, L.C. 1994. Locomotor and postural adaptations of an unusual platyrrhine, *Callimico goedii. American Journal of Physical Anthropology*, Supplement 18, 76-77.

Davis, L.C.1996. Functional and Phylogenetic implications of ankle morphology in Goeldi's Monkey *(Callimico goeldii).* In: *Adaptive Radiations of Neotropical Primates*, Norconk, M.A., Rosenberger, P.A., and Garber, P.A., editors, Plenum Press, New York, New York, U. S. A., 133-156 and 536-538.

DeMatteo, K.E., I. J. Porton, and C. S. Asa. 2002. Comments from the AZA contraception advisory group on evaluating the suitability of contraceptive methods in golden-headed lion tamarins *(Leontopithecus chrysomelas). Animal Welfare,* 11 (3): 343-348.

DeVleeschouwer, K., K. Leus, and L. VanElsacker. 2000. An evaluation of the suitability of contraceptive methods in golden-headed lion tamarins *(Leontopithecus rosalia chrysomelas)* with emphasis on melengestrol acetate (MGA) implants: I Effectiveness, reversibility and medical side-effects. *Animal Welfare,* 93 (3), 251-271.

Dettling, A., C.R. Pryce, R.D. Martin, and M. Dobeli. 1998. Physiological responses to parental separation and a strange situation are related to parental care received in juvenile Goeldi's monkeys *(Callimico goeldii), Developmental Psychology,* 33 (1), 21-31.

Dettling, A. 1999. Parental care received is associated with subsequent stress response in juvenile Goeldi's monkey *(Callimico goeldii)*. In: *Primatology and Anthropology into the Millenium: Centenary Congress of the Anthropological Institute and Museum in Zurich, 1899-1999*, Abstracts, University of Zurich, Zurich, Switzerland.

Dettling, A., and C.R. Pryce. 1999. Hormonal monitoring of age at sexual maturation in female Goeldi's monkey *(Callimico goeldii)* in their family groups. *American Journal of Primatology,* 48(1), 77-83

Dettling, A.C. 2002. Reproduction and development in Goeldi's monkey *(Callimico goeldii). Evolutionary Anthropology,* 11 (supplement 1), 207-210

Dixson, A.L., and M. J. Anderson. 2002. Sexual selection, seminal coagulation and copulatory plug formation in primates. *Folia primatologica,* 73 (2-3), 63-69.

Duncan, M., L. Tell, and R.J. Montali. 1993. Linguinal spirurids and pasteurellosis in Goeldi's monkey *(Callimico goeldii). 1993 American Association of Zoo Veterinarians Annual Proceedings*, 220-221.

Duncan, M., L. Tell, C.H. Gardiner, and R.J. Montali. 1995. Linguinal gongylonemiasis and pasteurellosis in Goeldi's monkeys *(Callimico goeldii). Journal of Zoo and Wildlife Medicine,* 26 (1), 102-108.

Dutrillaux, B. 1988. New interpretations of the presumed common ancestral karyotype of platyrrhine monkeys. *Folia primatologica,* 50:226-229.

Dutrillaux, B., M. Lombard,J. B. Carroll, and R. Martin. 1988. Chromosomal affinities of *Callimico goeldii* (platyrrhini) and characterization of a Y-autosome translocation in the male. *Folia primatologica,* 50:230-236.

Dutton, C.J., and A.F. Allchurch. 1998. A review of birth control methods in mammals at Jersey Wildlife Preservation Trust. *Dodo,* 34, 134-144.

Encarnacion, F., and E. W. Heymann. 1998. Body mass of wild *Callimico goeldii. Folia primatologica,* 69 (6), 368-371.

Epple, G., and R. Lorenz. 1967. Appearance, morphology and function of sternal glands in the Platyrrhini. *Folia primatologica,* 7, 98-126. (German)

Feistner, A.T.C.and E. C. Price. 1990.Food offering in cotton-top tamarins *(Saguinus oedipus). Folia primatologica,* 54 (1-2), 34-45.

Feistner, A.T. C., and E. C. Price. 1991. Food offering in New World primates: Two species added. *Folia primatalogica,* 57 (3), 165-168.

Ferrari, S.F., S. Iwanaga, E. M. Ramos, M. R. Messias, P. C. S. Ramos, and E.H. da Cruz Neto. 1999. Expansion of the known distribution of Goeldi's monkey *(Callimico goeldii)* in southwestern Brazilian Amazonia. *Folia. primatalogica,* 70 (2), 112-116.

Fidgett, A.L, and A. T. C. Feistner. 1997. Non-invasive methods of nutritional research at the Jersey Wildlife Preservation Trust. In: *Proceedings of the Second Conference of the Nutrition Advisory Group / American Zoo and Aquarium Association on Zoo and Wildlife Nutrition*.

Ford, S.M. 1980. Callithrichids as phyletic dwarfs, and the place of the Callithrichidae in Platyrrhini. *Primates,* 21, 31-43.

Ford, S.M., and K. L. C. Davis. 1995. Callithrichid systematics: The postcranial evidence. *American Journal of Physical Anthropology,* Supplement 20, 92.

Garber, P.A. 1989. Vertical clinging, small body size and the evolution of feeding adaptations in the Callitrichinae. *American Journal of Physical Anthropology,* 78 (2), 224-225.

Garber, P.A. 1992. Vertical clinging, small body size, and the evolution of feeding adaptations in the Callithrichinae. *American Journal of Physical Anthropology,* 88 (4), 469-482.

Garber, P.A. 1996. Marmoset Misconceptions. In: *Adaptive Radiations of Neotropical Primates*, Norconk, M.A., Rosenberger, P.A., and Garber, P.A., editors, Plenum Press, New York, New York, U.S.A., 87-95.

Garber, P.A., and J. A. Rehg. 1998. Preliminary field study of positional behavior and habitat preference in *Callimico goeldii. American Journal of Physical Anthropology,* Supplement 26, 85-86.

Garber, P.A. 2000. The behavioral ecology of mixed species troops of *Callimico goeldii, Saguinus labiatus* and *S. fuscicollis* in northwestern Brazil. *American Journal of. Physical Anthropology,* Supplement 30, page 155.

Garber, P.A., and S. R. Leigh. 2001. Patterns of positional behavior in mixed-species troops of *Callimico goeldii, Saguinus labiatus,* and *Saguinus fuscicollis* in northwestern Brazil. *American Journal of Primatology,* 54 (1), 17-31.

Garber, P.A., and J.J. Bicca-Marques. 2002. Evidence of predator sensitive foraging and traveling in single- and mixed-species tamarin troops. In: *Eat or be Eaten: Predator Sensitive Foraging Among Primates,* L.E. Miller, editor, Cambridge University Press, New York, pages 138-153.

Genoud, M. 2002. Comparative studies of basal rate of metabolism in primates. *Evolutionary Anthropology,* 11 (supplement 1), 108-111.

Goeldi, E., and G. Hagmann. 1904. Prodomo de un catalogo critico commentado da colleccoa de mammiferos no museu do Para (1894-1903). *Bol Mus Goeldi Hist Nat Ethn,* 4:35-106.

Groves, C.P. 2001. *Primate Taxonomy,* Smithsonian Press, Washington, D.C., U.S.A., 350 pages.

Hampton, S.H., M. J. Gross, and J. K. Jr. Hampton. 1978. A comparison of breeding performance and offspring survival in the family Callithricidae. *Primates in Medicine,* 10, 88-95.

Hanson, A.M., and L. M. Porter. 2000.Nutritional composition and distribution of fungal sporocarps consumed by Goeldi's monkeys *(Callimico goeldii)* in northern Bolivia. *American Journal of Primatology,* 51, Supplement 1, page 60.

Hardie, H.M. 1995. Do subordinate female *Callimico* disperse from their social groups? *Folia primatologica,* 64:192-195.

Hardie, S.M., R. T. Day, and H. M. Buchananan-Smith. 1993. Mixed species *Saguinus* groups at Belfast Zoological Gardens. *Neotropical Primates,* 1 (4) 20-21.

Hauser, B., and R. Baumgartner, R. 1991. Colonic adenocarcinoma and hepatic myelolipomas in a Goeldi's monkey *(Callimico goeldii). Folia primatologica,* 57 (1), 52-56.

Heard, D.J., L. E. Fox, J. Fox, L. Neuwirth, and R. Raskin. 1996. Antemortem diagnosis of myelolipoma-associated hepatomegaly in a Goeldi's Monkey *(Callimico goeldii). Journal of Zoo Animal and Wildlife Medicine,* 27 (2), 266-270.

Heisterman, M., E. Moestl, and J. K. Hodges. 1995. Non-invasive endocrine monitoring of female reproductive status: Methods and applications to captive breeding and conservation of exotic species. In: *Research and Captive Propagation,* U. Ganslosser and J.K. Hodges, editors, Filander Verlag, Fuerth, Germany, 36-48.

Heltne, P.G., D. C. Turner, and J. Wolhandler. 1973. Maternal and paternal periods in the development of infant *Callimico goeldii. American Journal of Physical Anthropology,* 38:555-560.

Heltne, P.G., J. F. Wojcik, andA. G. Pook. 1981. Goeldi's monkey, Genus *Callimico*. In: *Ecology and Behavior of Neotropical Primates I,* eds. A.F. Coimbra-Filho, and R.A. Mittermeier, pp. 169-209. Rio de Janeiro, Brazil: Academia Brasileira de Ciencias.

Heinemann, H. 1970. The breeding and maintenance of captive Goeldi's monkeys, *Callimico goeldii. International Zoo Yearbook,*10:72-78.

Hershkovitz, P. 1977. *Living New World Primates, Vol. 1*., Chicago: University of Chicago Press.

Heymann, E.W., U. Zeller, and M. H. Schwibbe. 1989. Muzzle rubbing in the moustached tamarin, *Saguinus mystax,* (Primates: Callitrichidae) - behavior and histological aspects. *Zeitschrift fuer Saeugetierkunde,* 54 (5), 265-275.

Heymann, E.W. 2000. The number of adult males in callithricine groups and its implications for callithricinae social evolution. In: *Primate Males: Causes and Consequences of Variation in Group Composition,* Kappeler, P. M., editor, Cambridge University Press, Cambridge, England, 64-71.

Heymann, E.W., and H. M. Buchanan-Smith. 2000. The behavioral ecology of mixed-species troops of callithricine primates. *Biological Reviews of the Cambridge Philosophical Society,* 75 (2), 169-190.

Hill, C.A. 1966. A *Callimico* is born. *Zoonooz* 34:14-16. (San Diego Zoo).

Hill, W.C.O. 1959. The anatomy of *Callimico goeldii* (Thomas). *Transactions of the American Philosophical Society,* 49(5):1-116.

Hill, W.C.O. 1966. On the neonatus of *Callimico goeldii* (Thomas). *Proc. Royal Soc. Edinburgh,* Sec. B, Vol.69.

Hsu, T.C., and S. H. Hampton. 1970. Chromosomes of Callitrichidae with special reference to an XX/'XO' sex chromosome system in Goeldi's marmoset *(Callimico goeldii* Thomas 1904). *Folia primatologica,* 13:183-195.

Izawa, K. 1977. Problems of distribution of Goeldi's monkey. *Monkey,* 21 (1-2), 48-51 (Japanese)

Izawa, K. 1978a. A preliminary survey of uacari and Goeldi's monkey in Rio Tapiche, Peru. *Monkey,* 22 (2-3), 6-13. (Japanese).

Izawa, K. 1978b. Problems of distribution of Goeldi's monkey, *Monkey,* 22 (2-3) 56-59. (Japanese)

Izawa, K. 1979a. Ecology of Goeldi's monkey. A preliminary survey of Rio Acre, Bolivia. *Monkey,* 22 (5), 6-13. (Japanese)

Izawa, K. 1979b. Studies on peculiar distribution of *Callimico. Kyoto University Overseas Research Reports of New World Monkeys,* 1:1-19.

Jurke, M.H., and C. R. Pryce. 1994. Parental and infant behaviour during early period of infant care in Goeldi's monkey, *(Callimico goeldii). Animal Behavior,* 48-1095-1112.

Jurke, M.H., C. R. Pryce, M. Dobeli, and R. D. Martin. 1994. Non-invasive detection and monitoring of pregnancy and the postpartum period in Goeldi's monkey *(Callimico goeldii)* using urinary pregnanediol-3a glucuronide. *American Journal of Primatology,* 34:319-331.

Jurke, M.H., C. R. Pryce, and M. Dobeli. 1995. Sexual motivation and behavior in female Goeldi's monkey *(Callimico goeldii):* Effect of ovarian state, mate familiarity and mate choice. *American Journal of Primatology,* 36 (2), 131.

Jurke, M.H., C. R. Pryce, and M. Dobeli. 1995. An investigation into sexual motivation and behaviour in female Goeldi's monkey *(Callimico goeldii):* effects of ovarian state, mate familiarity and mate choice. *Hormones and Behavior,* 29: 531-553.

Jurke, M.H., C. R. Pryce, A. Hug-Hodel, and M. Dobeli. 1995. An investigation into the socioendocrinology of infant care and postpartum fertility in Goeldi's monkey *(Callimico goeldii). International Journal of Primatology,* 16:453-474.

Jurke, M.H. 1996. Behavioural and hormonal aspects of reproduction in captive Goeldi's monkeys *(Callimico goeldii)* in a comparative and evolutionary context. *Primates,* 37:109-119.

Jurke, M.H. 2002. Reproductive biology of nonhuman primates. *Evolutionary Anthropology,* 11 (supplement 1), 186-189.

Kalaitsidis, F., H. Lutz, and C. R. Pryce. 1999. Hematology and serum chemistry values in captive Goeldi's monkey *(Callimico goeldii). Journal of Zoo and Wildlife Medicine,* 30 (3), 372-376.

Kimura, T. 2002. Primate limb bones and locomotor types in arboreal or terrestrial environments. *Zeitschrift fuer Morphologie und Anthropologie,* 83 (2-3), 201-219

Kinzey, W.G. 1997. Distribution maps of South and Central American by genus. In: *New World Primates: Ecology, Evolution and Behavior,* Kinzey, W. G., editor, Aldine de Gruyter, New York, New York, U. S. A., 307-324

Kleiman, D.G. 1985. Paternal care in New World primates. *American Zoologist,* 25 (3), 857-859.

Kohlhaas, A.K. 1988. Primate populations in northern Bolivia. *Primate Conservation,* 9, 93-97.

Küenzi, W. 1958. Ein lebender Springtamarin *Callimico goeldii* Thos. In der Schweiz. *Mitt. Naturf. Gessellsch.,* Bern, n.f., 16:38-40.

Lacy, R., A. Petric, and M. Warneke, 1993. Inbreeding and outbreeding in captive populations of wild animal species. In: *The Natural History of Inbreeding and Outbreeding,* ed. N. Wilmsen-Thornhill, pp. 352-374. Chicago: University of Chicago Press.

Laurin, D., C. Ferron, and J. Dancosse. 1994. Social and individual behavior of a family of *Callimico goeldii* in a recreated habitat. *1994 AZA Regional Conference Proceedings,* 371-376.

Lorenz, R 1966. Zur haltung des springtamarins, *Callimico goeldii* (Thomas 1904), in *Deutschland. Zoological Garten.* 32:248-256.

Lorenz, R., and H. Heinemann, 1967. Beitrag zur morphologie und korperlichen jugendentwicklung des springtamarin, *Callimico goeldii* (Thomas 1904). *Folia primatologica,* 6:1-27.

Lorenz, R. 1970. Second generation bred in Goeldi's monkey, *Callimico goeldii,* Callimiconidae, Primates. *International Zoo News,* 17, 79-80.

Lorenz, R. 1971. Goeldi's monkey *Callimico goeldii* Thomas 1904 preying on snakes. *Folia primatologica,* 15:133-142.

Lorenz, R. 1972. Management and reproduction of the Goeldi's monkey, *Callimico goeldii* (Thomas, 1904), Callimiconidae, Primates. In: *Saving the Lion Marmoset,* ed. D. Bridgewater, pp. 92-109. Wheeling, West Virginia: Wild Animal Propagation Trust.

Lyon, M., L. Goldman, and R. Hoage. 1985. Parent-offspring conflict following a birth in the primate *Callimico goeldii. Animal Behavior,* 33:1364-1365.

Mangold, B.J., P. P. Calle, B. L. Raphael, M. D. Stetter,and R. A. Cook. 1994. The presence of enteric coronavirus-like particles in captive callihtrichids. *1994 AZA Regional Conference Proceedings,* 391-393.

Martin, R.D. 1992.Goeldi and the dwarfs: The evolutionary biology of the small New World monkeys. *Journal of Human Evolution,* 22 (4-5) 367-393

Margulis, S.W., J. Chin, M. Warneke, J. Dubach, and V. Lindgren, 1993. The Y-autosome translocation of *Callimico goeldii. International Journal of Primatology,* 16: 1:145-155.

Masataka, N. 1981a. A field study of the social behavior of Goeldi's monkeys *(Callimico goeldii)* in north Bolivia I. Group composition, breeding cycle, and infant development. *Kyoto University Overseas Research Reports of New World Monkeys,* 2:23-32.

Masataka, N. 1981b. A field study of the behavior of Goeldi's monkeys *(Callimico goeldii)* in north Bolivia II. Grouping pattern and intragroup relationship. *Kyoto University Overseas Research Reports of New World Monkeys,* 2:33-41.

Masataka, N. 1982. A field study of the vocalizations of Goeldi's monkey *(Callimico goeldii). Primates,* 23:206-219.

Masataka, N., 1982b. Categorical responses to natural and synthesized alarm calls in Goeldi's monkey *(Callimico goeldii). Primates,* 24:40-51.

Matern, B., and N. Fiege. 1989. Infestation of tamarins with *Ptergodermatites sp.* (Nematoda: Spiruida) in Frankfurt Zoo. *Erkrankungen der Zootiere,* 31, 23-27.

Matsumoto, K., and Y. Mizukami. 2000. Handrearing the Goeldi's Monkey *(Callimico goeldii). Journal of Japanese Association of Zoological Gardens and Aquariums,* 41 (3), 88-95.

McClung, R.M. 1955. We have a *Callimico,* but is it a marmoset or a monkey? *Animal Kingdom,* 58:29-30.

Mitani, J.C., and D. Watts. 1997, The evolution of non-maternal caretaking among anthropoid primates: Do helpers help? *Behavioral Ecology and Sociobiology,* 40 (4), 213-220

Moehle, U., M. Heistermann, A. Einspanier, and J. K. Hodges. 1999. Efficacy and effects of short- and medium-term contraception in the common marmoset *(Callithrix jacchus)* using melengestrol acetate implants. *Journal of Medical Primatology,* 28 (1), 36-47.

Montali, R.J. 1994. Diseases of zoo marmosets, tamarins, and Goeldi's monkeys. *American Association of Zoo Veterinarians Annual Proceedings,* 237-240.

Montali, R.J., M. and Bush. 1999. Diseases of the Callithricidae, Zoo and Wildlife Medicine: Current Therapy, 4th edition, Fowler, M.E., and Miller, R.E., editors, W.B. Saunders, Philadelphia, U.S.A., 369-376.

Morgan, E. 2001. A year in the life of a mixed species exhibit: Keeping Goeldi's Monkeys *(Callimico goeldii)* and pygmy marmosets (*Cebuella pygmaea*) together at Edinburgh Zoo, *Ratel,* 28 (2), 47-53.

Moynihan, M. 1976. *The New World Primates.* Princeton University Press, Princeton, New Jersey, U.S.A.

Murnane, R.F. D., J. M. Zdziarski, T. F. Walsh, M. J. Kinsel, T. P. Meehan, P. Kovarik, M. Briggs, S. A. Raverty, and L. G. Jr. Phillips. 1996. Melengestrol acetate-induced exuberant endometrial decidualization in Goeldi's marmosets *(Callimico goeldii)* and squirrel monkeys *(Saimiri sciureus). Journal of Zoo and Wildlife Medicine,* 27 (3), 315-324.

Narama, I., M. Nagatani, M. Tsuchitani, and H. Inagaki. 1985. Myelolipomas in adult Goeldi's monkeys *(Callimico goeldii). Japanese Journal of Veterinary Science,* 47 (4), 549-555.

Neusser, M., R. Stanyon, F. Bigoni, J. Wienberg, and S. Mueller S. 2001. Molecular cytotaxonomy of New World monkeys (Platyrrhini) – Comparative analysis of five species by multi-color chromosome painting gives evidence for a classification of *Callimico goeldii* within the family of Callithricidae. *Cytogenetics and Cell Genetics,* 94, 206-215.

Oerke, A.K., R. Martin, and J. Hodges. 2000. Ultrasonography in Goeldi's monkey *(Callimico goeldii):* Reproductive data with evolutionary significance. In: *Kongree der Gesellschaft fur Primatologie,* 43.

Omedes, A., and J. B. Carroll. 1980. A comparative study of pair behavior of four callitrichid species and the Goeldi's monkey: *Callimico goeldii* at Jersey Wildlife Preservation Trust. *Dodo,* 17, 51-62.

Pastorini, J.,M. R. J. Forstner, R. D. Martin, and D. J. Melnick. 1998. Morphology and molecules in conflict: The phylogenetic relationships of Callimico within the Callithrichidae. *Folia primatologica,* 69 (4), 237.

Peres, C.A. 1997. Primate community structure at twenty western Amazonian flooded and unflooded forests. *Journal of Tropical Ecology,* 13 (3), 381-405.

Pook, A.G. 1975. Breeding Goeldi's monkey, (Callimico goeldii) at the Jersey Zoological Park. *Annual Report of the Jersey Wildlife Preservation Trust,* pp.17-20.

Pook, A.G. 1978. A comparison between the reproduction and parental behaviour of the Goeldi's monkey *(Callimico goeldii)* and the true marmosets (Callitrichidae). In: *Biology and Behavior of Marmosets,* Rothe, H., Wolters, H.I., and Hearn, J.P., editors, Eigenverlag Rothe, Gottingen, Germany ,1-14.

Pook, A., and G. Pook. 1979. The conservation status of the Goeldi's monkey, *Callimico goeldii,* in Bolivia. *Annual Report of the Jersey Wildlife Preservation Trust,* 16:40-45.

Pook, A., and G. Pook. 1981. A field study of the socio-ecology of the Goeldi's Monkey *(Callimico goeldii)* in northern Bolivia. *Folia primatologica,* 35:288-312.

Pook, A., and G. Pook. 1982. Polyspecific associations between *Saguinus fuscicollis, Saguinus labiatus, Callimico goeldii* and other primates in north-western Bolivia. *Folia primatologica,* 30:196-216.

Porter, L.M. 2000a. *Callimico goeldii* and *Saguinus:* Dietary differences between sympatric callithricines in northern Bolivia. *American Journal of Primatology*, 51, Supplement 30, page 252.

Porter, L.M. 2000b. *Callimico goeldii:* Understory monkeys of northern Bolivia. *American Journal of Primatology,* 51, Supplement 1, page 82.

Porter, L.M. 2001a. Benefits of polyspecific associations for the Goeldi's monkey *(Callimico goeldii). American Journal of Primatology,* 54 (3), 143-158.

Porter, L.M. 2001b. Social organization, reproduction and rearing strategies of *Callimico goeldii:* New clues from the wild. *Folia primatologica,* 72 (2), 69-79.

Porter, L.M. 2001c. The behavior and ecology of Goeldi's Monkey *(Callimico goeldii)* in northern Bolivia. Dissertation, 229 pages.

Porter, L.M. 2001d. Dietary differences among sympatric Callithricinae in northern Bolivia: *Callimico goeldii, Saguinus fuscicollis,* and *S. labiatus. International Journal of Primatology,* 22 (6), 961-992.

Porter, L.M., A. M. Hanson, and E. N. Becerra. 2001. Group demographics and dispersal in a wild group of Goeldi's Monkeys *(Callimico goeldii). Folia primatologica,* 72 (2), 108-110.

Porter, L.M. 2002. Fungus and *Callimico goeldii:* New insights into *Callimico goeldii* behavior and ecology. *Evolutionary Anthropology,* 11 (supplement 1), 87-90.

Porter, L.M. 2002. Habituation of wild Goeldi's monkey *(Callimico goeldii)* at San Sebastian, Departamento Pando, Bolivia. *American Journal of Primatology,* 57 Supplement 1, 80-81.

Price, E.C., and A. T. C. Feistner.1994. Studies of food sharing in small New World monkeys. *Congress of the International Primatological Society*, 15, 352.

Price, E., S. Herron, D. Wormell, M. Brayshaw, and A. T. C. Feistner.2000. Nutrition research on New World monkeys at Jersey Zoo: In: *Zoo Animal Nutrition*, Nijboer, J., Hatt, J.M., Kaumanns, W., Beijnen, A., and Ganslosser, U., editors, Fuerth:Filander Verlag, pages 131-137.

Pryce, C.R., M. H. Jurke, H. J. Shaw, I. G. Sandmeier, and M. Dobeli. 1993. Determination of the ovarian cycle in Goeldi's monkey via the measurement of steroids and peptides in plasma and urine. *Journal of Reproduction and Fertility,* 99:427-435.

Pryce, C.R., F. Schwarzenberger, and M. Dobeli. 1994. Monitoring fecal samples for estrogen excretion across the ovarian cycle in Goeldi's monkey *(Callimico goeldii). Zoo Biology,* 13:219-230.

Pryce, C. 1995. Goeldi's monkey and captive evidence for a monogamous social organisation: A psychobiological experiment in phylogenetic context. *Primate Eye,* 57, 5.

Pryce, C., and A. Dettling. 1995. Fundamental and applied research into Goeldi's monkey breeding: An integration of behavioral, endocrine and life-history techniques. In: *Research and Captive Propagation*, Ganslosser, U., and Hodges, J.K., editors, Filander Verlag, Fuerth, Germany, 285-291.

Pryce, C., F. Schwarzenberger, M. Dobeli, and K. Etter. 1995. Comparative study of oestrogen excretion in female New World monkeys: An overview of non-invasive ovarian monitoring and a new application in evolutionary biology. *Folia primatologica,* 64 (3), 107-123.

Pryce, C. 1996. Evidence for a monogamous social organisation in Goeldi's monkey in captivity: A Psychobiological experiment in a phylogenetic context. *Folia primatologica,* 67 (2), 107-108.

Pryce, C.R., and A. Christen. 1999. Behavioral biology of Goeldi's monkey in captivity: Relevance to the study of their evolution and wild populations. In: *Primatology and Anthropology into the Millenium: Centenary Congress of the Anthropological Institute and Museum in Zurich, 1899-1999.* Abstracts, University of Zurich, Zurich, Switzerland.

Pryce, C.R., J. Pastorini, K. Vasarhelyi, and A. Christen. 2002. *Evolutionary Anthropology,* 11 (supplement 1), 190-194.

Ramsay, E., and R. J. Montali. 1993. Viral hepatitis in New World primates. In: *Zoo and Wild Animal Medicine: Current Therapy 3,* editor M.E. Fowler, W.P. Saunders, Philadelphia, Pennsylvania, U.S.A., 355-358.

Raverty, S.A., M. Briggs, L. G. Jr. Phillips, T. P. Meehan, P. Gattuso, and R. Murnane. 1994. *1994 American Association of Zoo Veterinarians Annual Proceedings,* 244-245.

Rosenberger, A.L. 1981. Systematics: The Higher Taxa. In: *Ecology and Behavior of Neotropical Primates I,* eds. A.F. Coimbra-Filho, and R.A. Mittermeier, pp. 9-27. Rio de Janeiro, Brazil: Academia Brasileria de Ciencias.

Rosenberger, A.L. 1992. Evolution of feeding niches in New World Monkeys. *American Journal of Physical Anthropology,* 88 (4), 525-562.

Rosenberger, A.L., and B. J. Stafford. 1994. Locomotion in captive *Leontopithecus* and *Callimico:* A multimedia study. *American Journal of Physical Anthropology,* 94 (3), 379-394.

Ross, C., and A. MacLarnon. 1995. Ecological and social correlates of maternal expenditure on infant growth in haplorhine primates. In: *Motherhood in Human and Nonhuman Primates,* Editors C.R. Pryce, R.D. Martin, D. Skuse, Kargar, Basel, Switzerland, 37-46.

Rylands, A.B., R. A. Mittermeier, and E. Rodriguez Luna. 1995. A species list for the New World primates (Platyrrhinii): Distribution by country, endemism, and conservation status according to the Mace-Land system. *Neotropical Primates,* 3, Supplement, 113-160.

Rylands, A.B., H. Schneider, A. Luggnuth, R. A. Mittermeier, C. P. Groves, and E. Rodriguez-Luna. 2001. An Assessment of the diversity of New World primates. *Neotropical Primates,* 8 (2), 61-93.

Rylands, A.B. 2002. Two taxonomies of the New World primates – A comparison of Rylands et al. (2000) and Groves (2001). *Australasian Primatology,* 15 (4), 4-9.

Schradin, C., and G. Anzenberger. 1999. Paternal care in Goeldi's monkey: Its endocrinology and motivational development. *Advances in Ethology,* 34, 145.

Schradin, C., and G. Anzenberger. 2001. Infant carrying in family groups of Goeldi's Monkeys *(Callimico goeldii). American Journal of Primatology,* 53 (2), 57-67.

Schradin, C., and G. Anzenberger. 2002. Why do New World monkey fathers have enhanced prolactin levels? *Evolutionary Anthropology,* 11 (Supplement 1), 122-125.

Slifka, K.A., P. E. Bowen, M. Stacewicz-Sapuntzakis, and S. D. Crissey. 1999. A survey of serum and dietary carotenoids in captive wild animals. *Journal of Nutrition,* 129 (2), 380-390.

Sodaro, V., K. Pingry, and K. Snyder. 1994. Changes in handrearing procedures for *Callimico goeldii* at Brookfield Zoo. In: *1994 AZA Regional Conference Proceedings,* Oglebay Park, Wheeling, West Virginia.

Sodaro, V. 1999. Handrearing *Callimico goeldii* in zoological parks. In: *Callitrichid Husbandry Manual,* eds. V. Sodaro and N. Saunders, pp. 88-92. Neotropical Primate Taxon Advisory Group.

Sodaro, V. 2000, A review of hand-reared Goeldi's Monkey *(Callimico goeldii)* at Brookfield Zoo 1977-1997. *International Zoo Yearbook,* 37, 36-0366.

Soma, H., and H. Kada. 1989. Placentation of the Goeldi's monkey, *Callimico, Erkrankungen der Zootiere,* 31, 93-98.

Stevenson, M. 1984. The captive breeding of marmosets and tamarins. In: *Proceedings of Symposium of the Association of British Wild Animal Keepers,* 8, 49-67.

Stevenson, M.F. 1986. Captive breeding of callitrichids: A comparison of reproduction and propagation in different species. In: *Primate Ecology and Conservation,* Else, J.P., and Lee, P.C., editors, Cambridge University Press, 301-313.

Stafford, B., A. L. Rosenberger, and D. C. Broadfield. 1992. Locomotor behavior in captive *Leontopithecus* and *Callimico. American Journal of Physical Anthropology,* Supplement 14, 154-155.

Surridge, A.K., and N. I. Mundy. 2002. Trans-specific evolution of opsin alleles and the maintenanace of trichromatic colour vision in callithricine primates. *Molecular Ecology,* 11 (10), 2157-2169.

Tardif, S.D. 1994. Relative energetic cost of infant care in small-bodied neotropical primates and its relation to infant-care patterns. *American Journal of Primatology,* 34 (2), 133-143.

Terborg, J. 1983. *Five New World Primates.* Princeton University Press, Princeton, New Jersey.

Treves, A. 1996. A preliminary analysis of the timing of infant exploration in relation to social structure in 17 primate species. *Folia primatologica,* 67 (3), 152-156.

Treves, A.1997. Primate natal coats: A preliminary analysis and distribution of function. *American Journal of Physical Anthropology,* 104 (1) 47-70.

Van Roosmalen, M.G.M., and O. M. C. G. Garcia. 2000. Fruits of the Amazonian forest: Part II. Sapotacae. *Acta Amazonica,* 30 (2) 187-290.

Vasarhelyi, K. 2000. Is Callimico monotypic? A reassessment in the light of new data. *Dodo,* 36, 20-29.

Vasarhelyi, K. 2002. The nature of relationships among founders in the captive population of Goeldi's monkey *(Callimico goeldii). Evolutionary Anthropology,* 11 (Supplement 1), 155-158.

Welker, C., and A. Klaiber. 1996. The Goeldi's monkey *(Callimico goeldii)* colony of Kassel University. Demographic and reproductive data from 1978 to 1995. *Primate Report,* 44, 53.

Wich, S.A., and C. L. Nunn. 2002. Do male "long-distance" calls function in mate defense? A comparative study of long-distance calls in primates. *Behavioral Ecology and Sociobiology,* 52 (6), 474-484.

Xanten, W.A. 1990. Marmoset behavior in mixed-species exhibits at the National Zoological Park, Washington. *International Zoo Yearbook,* 29, 143-148.

Ziegler, T.E., C. T. Snowdon, and M. Warneke. 1989. Postpartum ovulation and conception in Goeldi's monkey *Callimico goeldii. Folia primatologica,* 52:206-210.

Ziegler, T.E., C. T. Snowdon, M. Warneke, and W. E. Brisdon. 1990. Urinary excretion of oestrone conjugates and gonadotrophins during pregnancy in the Goeldi's monkey, *(Callimico goeldii). Journal of Reproduction and Fertility,* 89:163-168.