Articles

CALLITRICHIDS AT BELFAST ZOOLOGICAL GARDENS, NORTHERN IRELAND

Belfast Zoological Gardens has an excellent callitrichid collection that includes representatives from all five genera (see Table 1). Although the zoo has been at the picturesque Cave Hill site since 1934, the development of a new zoo began in 1977. Rather than modifying and upgrading existing enclosures, the new zoo was started from scratch higher up the hill. Careful research ensured that the designs of the new enclosures met the behavioural needs of the animals. Great emphasis has also been placed on allowing optimum viewing for the public. As a result, Belfast has excellent exhibits, and this has been recognised by outside organisations, for instance the gorilla house recently received an award from the Universities Federation for Animal Welfare (UFAW). The purpose of this article is to describe the housing and husbandry of the callitrichid collection at Belfast and to examine their breeding records over the past 10 years.

Enclosure Design

Each group of callitrichids occupies its own indoor and outdoor enclosure. The minimum sizes are 3.8 m^3 and 7.9 m^3 for indoor and outdoor respectively, although most groups live in much larger enclosures, with some outdoor enclosures exceeding 200m^3, and one being over 900m^3. The housing varies between different exhibits in the zoo but most indoor enclosures are off exhibit to the public. They are furnished with branches, shelves, a nest box and a heat lamp. Wood shavings cover the floor. In situations where both indoor and outdoor enclosures can be viewed by the public, there is dense vegetation in both, which allows the monkeys to take cover should they wish to. In all cases, the monkeys have constant access between indoor and outdoor areas except during routine cleaning and husbandry and for observational research. Outdoor areas have a lot of vegetation, with a great variety of diameters, orientations and springiness of branches, providing as such ample environmental complexity. Most enclosures have a large central pole, or other vertical support, allowing the callitrichids opportunities for vertical-clinging, a posture used frequently in the wild and for which their claw-like nails are adapted (Garber, 1991). By virtue of the amount of flowering vegetation in the outside areas, numerous insects are attracted, and the monkeys spend a large proportion of the day foraging for them as they would in the wild. The existence of natural branching is especially important for *Cebuella* and *Callithrix* which have a specialised dentition for gnawing holes to stimulate the flow of gum (Coimbra-Filho, 1972; Coimbra-Filho and Mitttermeier, 1978). Despite several generations of being housed in captivity, this behaviour continues in the absence of any food reward, although artificial gum trees (see McGrew *et al.*, 1986) have been introduced recently to encourage the occurrence of this natural activity. Although good enclosure design is the most important form of "enrichment" for the callitrichids, a number of specific enrichment devices are given. These include novel objects and extractive foraging devices such as boards, pineapple tops and other objects in which mealworms and other "treat" foods are hidden. The *Cebuella pygmaea* enclosure is situated opposite the western lowland gorilla indoor area. The contrast between the largest higher primate and the smallest makes an interesting exhibit, and the gorillas spend a considerable amount of time watching the pygmy marmosets.

Eighteen groups of callitrichids are housed off exhibit to the public. These are mainly of *Saguinus labiatus* and *S. fuscicollis,* a large number of which are kept at Belfast forming as they do part of a research programme examining the costs and benefits of mixed-species groups

Table 1. Callitrichid species currently kept at Belfast Zoo (1st October, 1996).

Species	No. of groups	Sex			Conservation Status*
		Males	Females	Unknown	
Cebuella pygmaea	1	5	1	0	LR
Callithrix argentata	1	1	1	0	LR
Callithrix melanura	1	2	1	1	LR
Callithrix geoffroyi	3	6	3	4	VU
Saguinus oedipus	2	4	5	0	EN
Saguinus imperator subgrisescens	2	2	4	0	LR
Saguinus labiatus labiatus	8	10	10	6	LR
Saguinus fuscicollis weddelli	8	10	10	7	LR
Saguinus bicolor bicolor	2	2	2	0	EN
Leontopithecus rosalia	2	2	3	0	CR
Leontopithecus chrysomelas	2	3	6	0	EN
Callimico goeldii	2	1	4	1	VU

*The IUCN Mace-Lande categories (from Rylands *et al.*, 1995): LR = Lower Risk, VU = Vulnerable, EN = Endangered, CR = Critically endangered.

Cover photograph by Russell A. Mittermeier: Goeldi's monkey, *Callimico goeldii.*

(Buchanan-Smith and Hardie, in press; Hardie, 1995a; Hardie *et al.*, 1993). A number of mixed groups have been established that involve species which naturally form associations in the wild. Currently, there is one tri-specific group of *S. labiatus*, *S. fuscicollis* and *Callimico goeldii* and five mixed groups of the two tamarin species, the largest of which consists of five *S. labiatus* individuals and six *S. fuscicollis*. Details of how the mixed-species groups are established can be found in Hardie (1995a, in press). The key to the success of such housing appears to be the provision of large enclosures (mixed-species groups occupy at least double the area occupied by single-species groups) along with resources such as food, water and sleeping sites being provided at multiple locations to reduce the potential for competition between species.

There are two free ranging groups of callitrichids; one of *Leontopithecus chrysomelas* on exhibit in the zoo and one mixed-species group of *S. fuscicollis* and *S. labiatus* off exhibit. The *L. chrysomelas* group regularly go to the ground to forage and play, and are often seen going down prairie dog burrows!

Diet

Most of the callitrichid groups are fed twice daily. They have a small feed in the early morning consisting of a baby food ("Milupa"), peanuts in their shells, and raisins or primate pellets. Their main feed is given around midday and consists of fruit and vegetables. A high protein food such as marmoset jelly, eggs, chicken, mealworms or crickets is included in each main feed and is varied each day. Vitamin supplements are given regularly. Water is constantly available.

Husbandry

The majority of callitrichid groups consist of an unrelated male/female pair and their offspring. Once offspring are at least 18 months old and have had experience with at least two episodes of infant care-giving, they may be removed to establish new groups or be sent to another collection. There have been two exceptions to this husbandry practice. The first was a *Callimico goeldii* group documented by Hardie (1995b) in which two full sisters were housed with an unrelated male. Both sisters became pregnant and gave birth within 3 days of each other. Due to aggression between the sisters, the infants of the younger sister (who gave birth first) died and due to continued aggression the younger sister had to be removed.

The other case was of a *Callithrix melanura* group. It was sent to Belfast from another zoo on 20 July 1993 and consisted of a father and a son (ages differed by nearly six years) and an unrelated female. The older of the two males was the presumed sire of twin female infants born on 5 August 1993 which were raised successfully. The next birth on 25 May 1994 was of a singleton male, and on the day of birth the older male (aged 9 years 1 month and presumed sire of the infant), was attacked by the younger male. The older male died from the injuries. The newborn infant was unharmed and was reared successfully. The female was impregnated by this younger male and gave birth to triplets on 23 October 1994 (151 days later). They were premature and none survived. This younger male died

Table 2. Data extracted from the breeding records of the callitrichid collection at Belfast Zoo.

Species	No. of births	Triplets: twins: singletons	Sex ratio (male:female: unknown)	Sex ratio surviving to weaning	% surviving	Mean inter-birth interval (days) ± s.e.m.(N)	Median inter-birth interval	Shortest inter-birth interval
Cebuella pygmaea	20	2:10:8	17:13:4	15:10:1	76%	2-47 ± 27 (N = 14)	216	138
Callithrix argentata	3	0:2:1	3:0:2	1:0:0	20%	-	-	-
Callithrix melanura	7	1:5:1	3:3:8	3:2:1	43%	191 ± 34 (N = 4)	160.5	160
Callithrix geoffroyi	15	3:11:1	11:13:8	8:11:4	72%	208 ± 26 (N = 11)	162	149
Saguinus oedipus	16	0:13:3	13:7:9	7:6:3	55%	308 ± 50 (N = 14)	245	160
Saguinus i. subgrisescens	10	0:8:2	3:5:10	1:3:0	22%	351 ± 54 (N = 5)	346	182
Saguinus l. labiatus	15	2:11:2	6:4:20	4:1:7	40%	279 ± 62 (N = 9)	182	176
Saguinus f. weddelli	32	1:20:11	16:20:18	11:16:9	67%	296 ± 45 (N = 19)	220	145
Leontopithecus rosalia	10	3:5:2	15:6:0	10:5:0	71%	243 ± 25 (N = 8)	252	139
Leontopithecus chrysomelas	11	0:8:3	8:8:3	8:8:0	84%	203 ± 26 (N = 9)	162	127
Callimico goeldii	18	0:0:18	7:8:3	2:7:1	56%	295 ± 47 (N = 8)	262	171

on 4 December 1994, and a new male was introduced on 31 January 1995, such that the group then consisted of the new unrelated breeding male, a mother, her twin daughters and her son. The mother gave birth on 9 July 1995 to mixed-sex twins, one of whom (the male) survived. She had another twin birth on 17 December 1995. One of the infants died at 2 months 24 days, but the other male twin survived. One of the twin daughters was removed from the group on 23 December 1995 because she was not well integrated and there were signs of aggression towards her. The unrelated male impregnated both the mother and the remaining daughter in the group. The occurrence of two breeding females in captive callitrichid groups is unusual unless, as is the case here, the breeding male is unrelated to both females. The daughter, aged 2 years and 9 months at the time, was the first to give birth on 19 May 1996, but neither of the twins survived. They were found to be partially eaten. The mother gave birth a week later on 26 May 1996, but both infants were found dead on the second day after birth. They were unmarked at death. Both their mother and the daughter who had given birth a week earlier were seen to carry them on the first day. The daughter was removed on 3 July 1996 to avoid competition for the breeding position. On 27 July 1996, the breeding male (five years old) was found dead as a result of injuries. It appeared he had fought with the oldest son in the group, aged 2 years 2 months at the time, who was also injured but recovered. Despite the increasing number of examples of polygynous and polyandrous matings reported for wild *Callithrix* groups (e.g., Digby and Ferrari, 1994; Ferrari and Lopes Ferrari, 1989), this description of aggression and the inability of two related females or males to live peacefully together in captivity with an unrelated opposite-sexed mate once again suggests that the most compatible grouping in the confines of captivity is that of a monogamous family.

Breeding records

The extent of successful breeding among the callitrichids varies enormously both between species, and between individuals (Table 2). The most successful breeding has been with *L. chrysomelas*, who have raised 84% of 19 infants to weaning (2 months). Belfast also has extremely good breeding records for *C. pygmaea*, *C. geoffroyi* and *L. rosalia*. The records for *S. labiatus* are improving. Belfast has recently acquired several new individuals in its collection, whose rearing histories are unknown. Compared to *S. fuscicollis*, this species has taken a considerable period to settle down, and only recently have several groups started to breed and rear successfully. In *S. labiatus* and those other species where infant survivorship is low, analysis of the records shows that it is generally the case of one pairing continuously failing to rear infants despite regular births. The role of prior infant caregiving is known to be extremely important for all callitrichids (although it may be more important for *Saguinus* sp. than *Callithrix* sp., see Tardif *et al.*, 1984) and the lack of such experience is the most probable cause of failure in these groups. In some pairs, the breeding success has improved over consecutive births, while in others, the husbandry practice of pairing a female who fails to rear with a male who is a proven breeder and caretaker has been more successful.

For marmosets and tamarins, twinning is the norm, and in cases where triplets have been born on no occasion have all three infants survived. There is no clear sex ratio bias at birth for any of the species except for *S. oedipus*, with a ratio of 13 males to 7 females. Interestingly, the males were less likely to survive to weaning resulting in a nearly identical sex ratio at this age (7:6).

It is impossible to determine gestation periods for callitrichids in the Belfast collection, but data on interbirth intervals (with live births) are of interest in this respect (Table 2). The shortest IBI of 138 days for *Cebuella pygmaea* is consistent with gestation periods of 133-140 days given by Christen (1968) and Soini (1988). The shortest IBI for *C. melanura* is 160 days and for *C. geoffroyi* it is 149 days. *C. jacchus* is reported to have a gestation of 148 ± 4.3 days (Hearn and Lunn, 1975). The IBI for *C. geoffroyi* suggests that the gestation may be as short or shorter than *C. jacchus*.

The shortest IBI of 145 days for *Saguinus fuscicollis* is as low as previous estimates of gestation (145-152 days: Wolfe *et al.*, 1975). As with the *Cebuella* and *C. geoffroyi* described above it appears that the females must have become pregnant very shortly after birth. The shortest IBI's for the other *Saguinus* sp. are longer, and may be in line with observations from the wild reported by Soini and Soini (1982), that the smaller bodied *S. fuscicollis* have a shorter gestation, IBI and weaning length than the larger-bodied members of the *S. mystax* group. It is interesting to note that the shortest IBI recorded for *L. chrysomelas* of 127 days is in line with the gestation of *L. rosalia* which is around 125-132 days (Kleiman, 1977) and again this shows that the female became pregnant very shortly after birth assuming gestation is of similar duration in this species. The shortest IBI for *Callimico* was 171 days. Gestation is estimated at 149 days (Ziegler *et al.*, 1989). There are insufficient data to analyse birth seasonality in any of the species as yet, but birth clusters are apparent for *C. geoffroyi*: 47% of the 15 births occurred from September to December. There was also a spring peak for *S. oedipus*, with 44% of the 16 births occurring in April and May.

Zoological collections have the potential to play four

main roles: in conservation, in education, in recreation and in research. Belfast fulfils these four roles. A great many of the animals in the Belfast collection are part of National, European or Global Breeding Programmes. For example 86% of the 59 mammal species kept at Belfast are part of breeding programmes. In terms of education, the combination of excellent signs informing visitors about the animals on exhibit, the activities of the education centre, particularly with school children, and the regular special events concerned with education and conservation issues ensures that Belfast plays a strong role. Recreationally, many local people and visitors to Belfast enjoy a day out at the Zoo. Finally, the commitment of Belfast Zoo to research is exceptional. Not only is there a large enough sample size of monkeys of the same species for experimental studies of behaviour but, in addition, these monkeys are housed off exhibit to the public which minimises disturbance during data collection. Should anyone wish to study callitrichids, or any other animal at Belfast Zoo, they should, in the first instance, contact John Stronge, Director, at the address below.

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References

Buchanan-Smith, H. M. and Hardie, S. M. In press. Tamarin mixed-species groups: An evaluation of a combined captive and field approach. *Folia Primatol.*

Christen, A. 1968. Haltung und Brutbiologie von *Cebuella. Folia Primatol.* 8:41-49.

Coimbra-Filho, A. F. 1972. Aspectos inéditos do comportamento de sagüis do gênero *Callithrix* (Callithricidae, Primates). *Rev. Brasil. Biol.* 32(4): 505-512.

Coimbra-Filho, A. F. and Mittermeier, R. A. 1978. Tree-gouging, exudate-eating, and the "short-tusked" condition in *Callithrix* and *Cebuella*. In: *The Biology and Conservation of the Callitrichidae*, D. G. Kleiman (ed.), pp.105-115. Smithsonian Institution Press, Washington, D. C.

Digby, L. J. and Ferrari, S. F. 1994. Multiple breeding females in free-ranging groups of *Callithrix jacchus. Int. J. Primatol.* 15:389-397.

Ferrari, S. F. and Lopes Ferrari, M. A. 1989. A re-evaluation of the social organisation of the Callitrichidae, with special reference to the ecological differences between genera. *Folia Primatol.* 52:132-147.

Garber, P. A. 1991. A comparative study of positional behaviour in three species of tamarin monkeys. *Primates* 32:219-230.

Hardie, S. M. 1995a. The behaviour of mixed-species tamarins groups (*Saguinus labiatus* and *Saguinus fuscicollis*). Unpubl. Ph.D. thesis, University of Stirling, Stirling.

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

Hardie, S. M. In press. Mixed-species groups of sympatric tamarins as a way of exhibiting tamarins. *Int. Zoo Yearbook.*

Hardie, S. M., Day, R. T. and Buchanan-Smith, H. M. 1993. Mixed species *Saguinus* groups at Belfast Zoological Gardens. *Neotropical Primates* 1(4):19-21.

Hearn, J. P. and Lunn, S. F..1975. The reproductive biology of the marmoset monkey, *Callithrix jacchus*. In: *Breeding Simians for Developmental Biology, Laboratory Animal Handbook*, No. 6, F. T. Perkins and P. N. O' Donoghue (eds.), pp.191-202. Laboratory Animals Ltd., London.

Kleiman, D. G. 1977. Monogamy in mammals. *Q. Rev. Biol.* 52: 36-69.

McGrew, W. C., Brennan, J. A. and Russell, J. 1986. An artificial "gum-tree" for marmosets (*Callithrix j. jacchus*). *Zoo Biol.* 5: 45-50.

Rylands, A. B., Mittermeier, R. A. and Rodríguez-Luna, E. 1995. A species list for the New World primates (Platyrrhini): Distribution by country, endemism, and conservation status according to the Mace-Lande system. *Neotropical Primates*, 3 (suppl.): 113-160.

Soini, P. 1988. The pygmy marmoset, genus *Cebuella*. In: *Ecology and Behavior of Neotropical Primates, Vol. 2*, R. A. Mittermeier, A. B. Rylands, A. F. Coimbra-Filho and G. A. B. Fonseca (eds.), pp 79-129. World Wildlife Fund, Washington, D.C.

Soini, P. and Soini, M. 1982. Distribución geográfica y ecología poblacional de *Saguinus mystax* (Primates, Callitrichidae). Informe de Pacaya No. 6, Ordeloreto, DRA/DFF, Iquitos, Peru.

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

Wolfe, L. G., Deinhardt, F., Ogden, J. D., Adams, M. R. and Fisher, L. E. 1975. Reproduction of wild-caught and laboratory-born marmoset species used in biomedical research (*Saguinus* sp., *Callithrix jacchus*). *Lab. Anim. Sci.* 25:802-813.

Zeigler, T. E., Snowdon, C. T and Warneke, M. 1989. Postpartum ovulation and conception in Goeldi's monkey, *Callimico goeldii. Folia Primatol.* 52:206-210.