Laboratory Animals (1982) 16, 88-97

Reproduction, infant survival and productivity of a colony of common marmosets (*Callithrix jacchus jacchus*)

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Summary

Starting with 4 pairs of marmosets, 204 young were successfully reared during 6 years. They were kept in family groups of 2-10. Litter size varied from 1-4; singletons (2%), twins (35%), triplets (55%), and quadruplets (8%). The mean annual increase of weaned young was 3·24 per pair.

The median interbirth interval was 154 days. Of 46 pairs of marmosets, 8 failed to produce young.

Approximately 11% of young born were stillborn and a further 32% of all young born died within 3 weeks; perinatal mortality is largely a result of the failure of parents to rear more than 2 young. In only 2 of 68 triplet births did the parents rear the young unaided.

53% of young born were males but differential mortality reduced the final sex ratio for live young to 50·5% males. Females did not accept and rear the young after caesarian sections.

The linear regression of the growth curve from 5-17 months (where y = weight in grams and x = months) could be expressed as $y = 16{\cdot}6x + 163{\cdot}6$.

The data from 4 marmoset colonies are compared and the relative efficiency of breeding methods discussed.

The common marmoset (*Callithrix jacchus jacchus*) is now well established as a laboratory animal which can be bred in sufficient numbers to supply specimens to meet research requirements or pharmaceutical screening procedures. It is one of the most rapidly breeding species of monkey known, reaching maturity at 13 months and rearing twins at 5 month intervals. It also has the advantage of being small (400-600 g in our colony) and economical to maintain.

A number of papers describe methods which have been developed to breed marmosets successfully in the laboratory (Abbott & Hearn, 1978; Epple, 1978; Hearn, Abbott, Chambers, Hodges & Lunn, 1978; Hiddleston, 1978; Ingram, 1975; Phillips, 1976; Poswillo & Richards, 1972; Stevenson, 1976). In this study marmosets were kept in family groups. Full details are provided of the first 6 years of the colony of *Callithrix jacchus jacchus* established in Aberystwyth in 1973 and ways in which efficiency may be improved are considered.

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Received 4 December 1980. Accepted 8 September 1981.

Materials and methods

4 founder pairs of common marmosets were acquired in the spring of 1973; 3 males and 1 female were wild caught, the others laboratory reared. The wild female was paired with a wild-caught male. The monkeys were housed in large cages to provide as much freedom of movement as possible and to allow the group to increase by breeding to 10-12 individuals without overcrowding. Apart from cases of illness and the abdominal palpation of females 4 months after pairing, the animals were not handled or manipulated in any way. In 1974, 2 more pairs of marmosets were acquired from the University of Bristol, but only 1 of these pairs bred. By the end of 1977 (Table 2) the colony numbered 110, and as this was the maximum which could be accommodated it was not expanded further.

Initially the colony was housed in a single cedarwood building. As it expanded 2 further huts were taken over, one of prefabricated concrete and the other of wood. They were maintained within a temperature range of 20-30°C (optimum 24°C) using electric storage heaters kept on permanently to ensure that, in the event of power failure, the units would still be heated for several hours. These heaters were supplemented by thermostatically-controlled fan heaters set at 24°C. All units had external windows for fresh air. Extractor fans controlled by time switches maintained ventilation, which was varied with the time of year.

Relative humidity was maintained at 40-60% (mean 50%) by domestic humidifiers, each effective for a volume of 70-80 m^3. In addition to natural daylight, fluorescent lighting was provided from 0900 to 2100. Comparisons of the breeding success of the 3 main units did not show marked differences.

3 main types of cage were employed.

Large walk-in observation cage. 2 × 1 × 2 m high, with 26 mm^2 welded wire-mesh sides and top, and a 6 mm thick rigid clear plastic front. Some cages had mesh backs, others built against the wall were backed by plastic shields ('Dorvic'; ICI Plastics Division,

Fig. 1. Cages used for Aberystwyth marmoset colony. A large walk-in type. **B** mobile cage. **C** all-metal cage.

Table 1. Diet Sheet for *Callithrix jacchus jacchus*

When fed	*What fed*	*No. animals*	*Quantity*
Daily	apple	pair	½
	banana	pair	½
	orange	25–30	1
	pear	25–30	1
	carrot/parsnip	25–30	1
	tomato	25–30	1
	dates	25–30	½ block (60 g)
Alternate days	hard-boiled egg	pair	½
	+ monkey pellets*	pair	40 g
	or		
	peanuts in shells +	25–30	40 g
	frozen broad beans (boiled 2 min)	25–30	120 g
Alternate days	Milk mix†	pair	90 ml
	or		
	high-protein porridge‡		
2 × week	multivitamin supplement§ on half grape	given individually	1·5 ml
Weekly	Vitamin D_3 in arachis oil on half grape	given individually	1000 iu

* 'Mazuri'; BP Nutrition (UK) Ltd, Stepfield, UK.

† Milk 450 ml, 'Protein Baby Food' (Robinson's Baby Foods, Coleman Foods, Norwich, UK) 12 g
'Delrosa' syrup (Sterling Health Products, Surbiton, UK) 15 ml. The syrup was added to encourage consumption of the milk.

‡ 'Complan' 36 g; 'Casilan' 25 g; 'Farex' 30 g; 'Cytacon' vitamin B_{12} supplement 20 ml (all from Farley Health Products Ltd, Plymouth, UK).

§ 'Abidec' (Parke, Davis & Co., Pontypool, UK).

Welwyn Garden City, UK). Sawdust was used as a substrate to facilitate cleaning (Fig. 1a).

Mobile cages on casters. 1·2 × 0·75 × 1·8 m high, made of 26 mm² welded mesh with a plastic floor ('Dorvic'; ICI Plastics Division), some with 6 mm thick rigid clear plastic fronts (Fig. 1b).

All-metal cages. 0·8 × 0·82 × 1·24 m high, of 14 swg aluminium with a 25 mm square aluminium tube frame, and a tray of 1·6 mm anodized aluminium. Front, top, and floor grid were of 25 × 12 × 2 mm electropolished stainless-steel welded mesh (Fig. 1c).

Cage furniture consisted of a wooden nestbox approximately 0·26 × 0·22 × 0·28 m with an entrance hole of 0·1 m diameter, perches of 26 mm softwood dowelling, and a wooden or plastic-covered shelf. The 2 larger types of cage contained substantial branches of oak and beech and wooden swings. Marmosets usually slept overnight in the nest box.

Food (Table 1) was given daily at 1100-1200, slightly in excess of consumption so that the marmosets were never totally without. Families in which females were lactating or in the later stages of pregnancy were also given about 30 g of fruit yoghurt when checked in the evening at 1730-1800.

The cages were cleaned daily. Once every 2 months the cage and its furnishings were thoroughly scrubbed with hot water, domestic detergent and bleach. Clean nest boxes were provided monthly.

Access to the colony was restricted and visitors were provided with clean laboratory coats, but no other precautions were taken. No visitor under the age of 16 was allowed in order to minimize the risk of exposing the marmosets to common childhood viral infections. If one of the staff had a mild infection such as a cold, a protective face mask was worn, but any one suffering from a herpesvirus infection was not allowed into the colony until fully recovered, as these viruses generally prove fatal to marmosets (Hunt, Anderson & Chalifoux, 1978).

Results

Pairing and the pair bond

As marmosets are monogamous (Poole, 1978), family groups were founded by placing a pair of 15-18 month old unrelated individuals together in an unfamiliar cage. If after 4 months the female was not pregnant

Table 2. Demographic data for the Aberystwyth marmoset colony 1 May 1973-30 April 1979

	Each 'year' 1 May-30 April					
Raw data	*73-4*	*74-5*	*75-6*	*76-7*	*77-8*	*78-9*
Marmoset on 1 May (N)	8*	20	37†	67§	110§	104§
Adult pairs on 1 May (P)	4	4	6	12	18	20
Live young (L)	15	18	45	67	83	79
Stillborn young	4	1	6	8	13	7
Perinatal deaths (D_1)	2	5	13	23	26	33
Other deaths (>3w) (D_2)	1	0	1	0	3	1
Hand-reared young (H)‡	0	3	3	1	2	0
Nett Increase $L - (D_1 + D_2)$	12	13	31	44	54	45
Derived data						
% Infant mortality $\left(\frac{D_1 + H}{L} \times 100\right)$	13	44	36	36	34	42
% other mortality $\left(\frac{D_2}{(N + L - D_1)} \times 100\right)$	4·8	0	1·4	0	1·8	0·7
% productivity $\left(\frac{L - (D_1 + D_2)}{N} \times 100\right)$	150	65	84	66	49	43
Surviving young/pair/annum# $\left(\frac{L - (D_1 + H)}{P}\right)$	3·25	2·50	4·83	3·58	3·00	2·30

*All breeding adults. †4 adults acquired. ‡Abandoned by parents. §Animals were issued from the colony during 1975-6, 1976-7 and 1977-8. #Ignoring hand-rearing.

she was usually paired with another male. Excluding 9 hand-reared marmosets (although some of them succeeded in breeding), of 46 pairs kept together for 4 months only 8 pairs (17%) failed to breed. 4 of these 8 pairs were in close proximity to dominant relatives, and this may well have been a contributing factor to their failure. 1 male was common to 2 of these pairs and failed to breed with other females as well.

Growth of the colony

Demographic data are presented in Table 2. 'Perinatal deaths' were those which occurred within 3 weeks of birth, most of them occurring within the 1st 10 days. In some calculations of derived data, hand-reared individuals have been eliminated because they were weak, usually 1 of triplets or rejected after caesarian section. As the colony increased in size a smaller proportion of hand-rearing was undertaken, so that this factor was not constant.

Table 2 indicates that infant postnatal mortality remained fairly constant at about 1/3 of all young born alive. The high value (150%) for productivity for the 1st year reflects the fact that, initially, the colony consisted solely of breeding pairs. The productivity of an established colony of around 100 animals, with the offspring kept in family groups until the age of 15 months, can be estimated to approximate 45%. The steady decline in productivity per capita over the 6 years resulted from increasing numbers of non-breeding marmosets within the 20 family groups.

The figures for surviving young per pair per annum vary because colony history was measured in years whereas marmosets breed roughly every 5 months, so that a varying proportion of pairs bred 3 times within the year. This contributed to the high 1975-76 figure. The mean value for increase per pair per annum is $3{\cdot}246 \pm 0{\cdot}91$ (se; $n = 6$) so that the 95% confidence estimate for current production would probably be 3 surviving young per pair per annum.

Excluding perinatal mortality, mortality per head was very low. However, only 5 animals were older than 6 years at the end of the study period.

Parturition

Litter size ranged from 1-4 (Table 3). Most births produced twins or triplets, with the mode at 3. In view of the fact that marmosets seldom rear more than 2 young at a time it might be thought practicable to select for females producing twins. Table 4 shows the births to females with 5 or more parturitions: none produced only twins. The only wild-caught female in the sample (Isolde) produced litters of 1-4 in number.

Of 333 young born whose sex could be determined, 177 (53%) were males. This proportion did not differ significantly from the expected 50:50 ratio (binomial test, $z = 1{\cdot}096$, $P = 0{\cdot}27$). The slightly higher perinatal mortality rate for males (Table 5) reduced

Table 3. Litter size in Aberystwyth marmoset colony

Years		*Litters*	*Number in litter*			
			1	*2*	*3*	*4*
1 + 2	1973-1975	15	0	7	8	0
3	1975-1976	19	0	7	11	1
4	1976-1977	26	0	6	17	3
5	1977-1978	38	2	15	20	1
6	1978-1979	31	1	10	15	5
Total		129	3	45	71	10
%		...	2	35	55	8

Table 4. Litter size among females with 5 or more parturitions

Female	*Litters*	*Number in litter*			
		1	2	3	4
Isolde	14	1	8	3	2
Sandra	8	0	3	4	1
Dum	8	0	0	7	1
Dee	8	0	4	4	0
Circe	8	0	0	5	3
Zama	8	0	7	1	0
Amber	8	0	2	6	0
Tia	8	0	2	4	2
Victoria	5	0	1	4	0
Ochre	5	0	0	5	0

Table 5. Infant birth and perinatal mortality

Young born by caesarian section or hand-reared not included

	Male infants		*Female infants*		*Total*	
	total	*% born*	*total*	*% born*	*total*	*% born*
Born	177	100	156	100	333	100
Live	156	88	139	89	295	89
Stillborn	21	12	17	11	38	11
Perinatal mortality	51	29	36	23	87	26
Surviving	105	59	103	66	208	62

Table 6. Sex ratios of young born in litters of different sizes

Litters		*Male infants*		*Female infants*	
		no.	%	*no.*	%
Singleton	3	2	...	1	...
Twins	45	46	51	44	49
Triplets	68*	111	54	93	46
Quadruplets	10	20	50	20	50

*Sex could not be determined in 3 of the 71 sets of triplets.

Table 7. Expected and recorded ratios of sexes in multiple births based on a 50:50 sex ratio

	Recorded (x)	($\delta = \varphi = 0{\cdot}5$) ($p$)	*Expected* (np)	*Difference* ($x - np$)
Twins ($n = 45$)				
♂♂	10	0·25	11·25	−1·25
♀♀	9	0·25	11·25	−2·25
♂♀	26	0·5	22·5	+3·5
Triplets ($n = 68$)				
♂♂♂	11	0·125	8·5	+2·5
♀♀♀	7	0·125	8·5	−1·5
♂♀♀	22	0·375	25·5	−3·5
♀♂♂	28	0·375	25·5	+2·5

the final figures for 208 surviving young to 50·5% males, which gave a value of $Z = 0{\cdot}069$, $P = 0{\cdot}94$.

Table 6 shows the sex ratios recorded from litters of different sizes: in no case did the sex ratio differ from 50:50. If the frequency of the different combinations is examined for twins and triplets and a 50:50 sex ratio assumed, observed values can be compared with calculated expected values (Table 7). For twins, $\chi^2 = 0{\cdot}86$, $P = 0{\cdot}6$, 2 degrees of freedom; for triplets, $\chi^2 = 1{\cdot}73$, $P = 0{\cdot}6$, 3 degrees of freedom. The number of quadruplets was too small for statistical analysis—there were 6 sets of 2 males and 2 females, and 1 example of each of the other 4 possible combinations of sexes.

The sex ratio of marmosets is therefore compatible with an independent assortment of sex chromosomes in the zygotes, making it improbable that any of the twins or triplets were monozygotic as this would have increased the proportion of same-sex individuals. There was, in fact, a preponderance of opposite-sex twins (Table 7).

Birth complications and mortality

As normal births in common marmosets usually occur at night at 2100-2300 (Stevenson, 1976), females having contractions at other times, particularly in the morning, were given a caesarian section. In all cases it was judged that the mothers would otherwise have died. Of the 13 caesarian sections, 12 were successful. The unsuccessful operation was the 1st, in which the female died under anaesthetic ('Vallergan'; May & Baker Ltd, Dagenham, UK). In all subsequent operations halothane was used, delivered by a dispenser ('Fluotec'; Cyprane Ltd, Keighley, UK) no further problems were encountered (Stevenson & Sutcliffe, 1978). In 6 of the 13 caesarian births the same father was involved, so that it is possible that problems of the 4 females were associated with his genetic contribution to the offspring.

Over half of the females with birth complications were primiparous, but there is no evidence that litter size was correlated with birth problems, as the proportion of twin to triplet births in the caesarian sample resembled that in the population as a whole. The mortality of infants associated with caesarian births was high; 71% were stillborn and the only infant which survived the postnatal period was hand-reared; live young were usually rejected by their parents, or the mother failed to lactate.

There was a high perinatal death rate for the colony as a whole (Table 2), and although it was not always possible to determine the precise cause of death the factors most commonly associated were: prenatally—transverse presentation, pressure by embryos on the mothers' obturator nerve, hydrocephalus or a dead embryo blocking the cervix; postnatally—infanticide,

Table 8. Prenatal and perinatal mortality in litters of different sizes. Data from 23 mothers and 95 litters. Only normal individuals considered (see text).

Number in litter (N)	*Number of litters* (F)	*Stillborn* (S)	*Death within 3 weeks* (P)	*Hand-reared* (H)	*Partially hand-reared*	% *stillborn* $\left(\frac{100S}{NF}\right)$	% *postnatal mortality* $\left(\frac{100\,(P+H)}{NF}\right)$	% *perinatal mortality* $\left(\frac{100\,(P+H+S)}{NF}\right)$
1	3	1	0	0	0	...*	...*	...*
2	33	2	4	0	0	3	6	9
3	51	4	47	4	3	3	33	36
4	8	2	15	3	1	6	56	63

*Numbers too low for realistic percentage.

rejection of young, lactation failure or general weakness of the neonate.

An estimation of the exact mortality rates associated with the rearing of different-sized litters can be made on the basis of the data provided in Table 8. Only normal births were considered—all caesarian sections, an infanticidal mother and 3 others who failed to lactate were eliminated—because the object of the analysis was to determine the success of normal mothers in rearing litters of different sizes.

Perinatal mortality was greater after triplet births than twins as a result of the failure (in all but 2 instances) of the mother to rear more than 2 young. However, 33% mortality must be regarded as a minimum as, in 3 instances, partial hand-rearing was used to supplement maternal care, and all young survived. As in previous cases, fully hand-reared infants were included in the perinatal mortality figures, because without experimental interference these infants would have died. As expected, the mortality rate for quadruplets was even higher than that for triplets.

None of the colony members was known to be older than 8 years and adult mortality was low. There were 6 deaths, from peritonitis, enteritis, pneumonia, acute degeneration of the liver, anaesthesia, and a fractured skull.

Hand-rearing

Where infants seemed likely to have little chance of survival, hand-rearing was undertaken (Stevenson, 1976). The first 2 males reared together, but out of direct contact with older marmosets, failed to breed as adults: one was imprinted on a female member of staff whilst the other attacked females and attempted to mount males. 7 hand-reared young, however, were placed in a cage from the age of 2 weeks with older hand-reared marmosets. Initially their exposure to adults was for only 30 min per day, but this was gradually increased until the animals were 37 days old when they were capable of feeding themselves; all proved capable of breeding.

Partial hand-rearing was developed as a technique for rearing triplets. 1 of the 3 infants was removed from a carrier (i.e. not its mother) during the day and bottle fed every 2 h; the success of this method depended on the vigour of the young and the ease with which a carrier could be captured. Details have been published by Stevenson & Sutcliffe (1978) and Hearn & Burden (1979).

Interbirth intervals

Interbirth intervals were recorded for all females in the colony (Fig. 2). The median and mode interbirth interval is 154 days. If these data are compared with copulation data (Stevenson & Poole 1976) which showed a peak in frequency 10 days post partum, this yields a median gestation period of approximately 144 days—the figure estimated by Hearn (1978) from hormonal data.

3 interbirth intervals followed a caesarian operation, but there was no evidence that this affected their durations (153, 156 and 159 days) which lie well within the distribution of other interbirth intervals, so that the operation does not seem to have affected the date of onset of the immediately post-partum oestrus.

The interbirth intervals preceding twin and triplet litters were compared: data for twins were median 153, mean 152·9, 95% confidence limits 151·8-154·0, $n = 23$; for triplets median 154, mean 154·9, 95% confidence limits 152·9-156·9, $n = 33$. It is apparent that no significant differences in duration existed. Data for 8 females each with more than 7 interbirth intervals showed that individual variation was considerable for both twin and triplet litters.

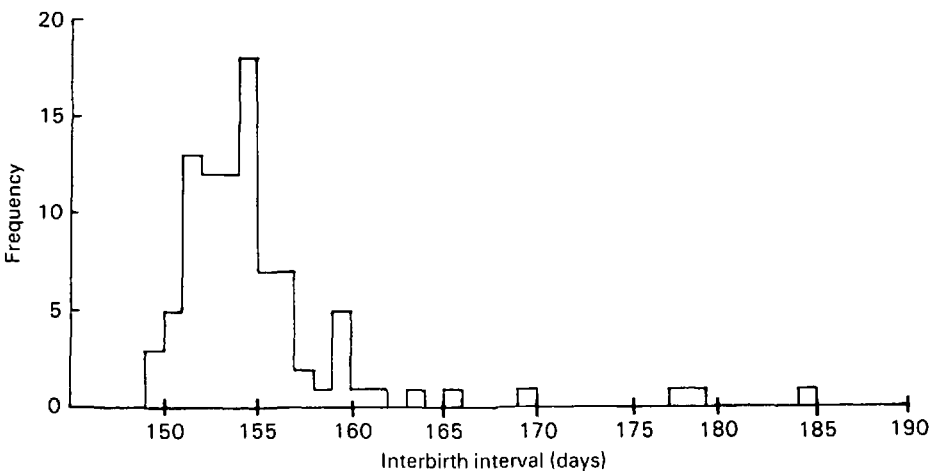

Fig. 2. Histogram of interbirth intervals from 145 to 190 days.

Physical condition and hygiene

The physical condition of the animals was good, adults weighed 400-600 g and the young developed normally without rickets or other developmental malformations. Careful monitoring of the animals' condition and the judicious use of antibiotics were adequate to maintain the general health of the colony.

For routine problems in adults that required the administration of an antibiotic (e.g. vulval bruising during parturition, injury from fighting), 'Panmycin' (Upjohn Ltd, Crawley, UK) was used at 3 × 0·25 ml per day for 3-5 days given orally on a half grape. Failing this the animal was caught twice daily and force fed about 0·4 ml. If there was no improvement in 24 h or a subsequent relapse, 'Penbritin' (Beecham Research Laboratories, Brentford, UK) particularly effective in cases of mastitis, or some other antibiotic was used. For infants, 3 × 0·1 ml per day of 'Panmycin' was given, at 0800, 1500 and 0000 (up to 0·5 ml per day can be given without ill effects): if ineffective, the antibiotic was changed. Marmosets may be sensitive to streptomycin—in one case a female showed loss of balance—so its use was discontinued.

Size of family groups and aggression

Apart from special experiments to determine the maximum possible group size, the social groups were normally allowed to increase until they contained 6-8 individuals. Young adults were removed from the family groups and paired at 12-15 months of age. Inbreeding was avoided by exchanging males with those from other colonies.

Adult marmosets are highly aggressive to strangers of their own sex, so that it is important to avoid such contacts. Marmosets are generally peaceable animals, although twin marmosets commonly fight when just over 5 months of age (Poole, Stevenson & Sutcliffe, 1978). These encounters appear to be a normal part of development, and although fights may be of considerable duration (up to 1 h) little damage is inflicted on the opponent, probably because the combatants still retain their milk dentition. Twin fights rapidly establish a dominance relationship between twins which persists so that further challenges rarely occur.

Aggression may also occur within family groups as siblings reach the age of sexual maturity, when the eldest pairs of twins may attack other group members, so that it is usually advisable to remove them (Rothe, 1975; Poole *et al.*, 1978).

Discussion

A survey of the physical conditions in different common marmoset colonies is provided by Bruhin (1979). They were generally similar, with temperatures 24-30°C and relative humidity 50-60%. All authors

Table 9. Demographic data for 4 colonies of *Callithrix jacchus jacchus*

Colonies listed by authors and colony dates reported

		Hampton et al. (1978) 1966-1974*	*Hiddleston (1976) 1972-1975*	*Abbot & Hearn (1978) unspecified*	*Poole & Evans (1982) 1973-1979*
Interbirth interval (days)	median	...	158	...	154
	mean	265	178·4 ± 3·7	...	154·2 ± 0·6
Gestation (days, median)		145	...	144‡ (141-146)	144
Prenatal mortality (%)		30	4	...	11
Preweaning deaths (as % live born)		58†	27	...	36
Postweaning deaths (18 wks-2 yrs)		35†	...	...	0·6
% live born surviving at 2 yrs		7	...	...	71
Litter size (% of litters)	1	29	5	5	2
	2	56	67	80	35
	3	15	26	15	55
	4	0	1	0	8

*Included *C. j. penicillata* and *C. argentata argentata*.
†Estimated from data given (total = 93%).
‡From Hearn (1978). Abbott & Hearn (1978) give 148 ± 3 days.

cited provided a diet of pelleted monkey food, milk substitute, mixed fruit and supplementary vitamin D_3 (usually 1000-1250 iu per week). Most colonies included a general vitamin supplement and 2 (Ingram, 1975; Stevenson, 1976) provided hard-boiled eggs. In our colony we also fed a high-protein porridge.

One major variable was cage size, ranging from 0·16 m^3 (Hiddleston, 1976; Hearn, Lunn, Burden & Pilcher, 1975) to 4·00 m^3 (Stevenson, 1977). This determines the number of sets of offspring which can be kept with the parents in the same cage. In the case of small cages, the 1st litter is removed before the next one is born, so that the young have no experience of assisting in caring for infants until they themselves become parents. This situation is unnatural and although data are not available for *C. j. jacchus*, Epple (1978) has shown that *Saguinus fuscicollis* reared on this system showed a much lower level of success with their 1st litters. Young which have been separated from their parents at this early age (4-5 m) are generally placed in large 'gang cages' with others of the same age. Such a transfer seems likely to be stressful, but no mortality data are available.

There may be considerable advantages to be gained from keeping the young with the parents until 1 or 2 further sets of siblings have been born. In nature, social groups of common marmosets seem to contain, in addition to the breeding pair and their juvenile offspring a number of individuals estimated to be 15 months of age or older (Stevenson, in press). It seems preferable, therefore, to simulate in the laboratory the natural group structure by retaining young in the parental group at least until they are old enough to be paired (15-18 months). Even the smallest cages used in the Aberystwyth colony (0·8 m^3) were designed to house up to 8 individuals.

Table 9 summarizes data from 4 colonies of common marmosets, although Hampton, Gross & Hampton (1978) include *C. argentata argentata* and *C. penicillata*, which may have influenced their results.

Mean interbirth intervals range from 154 to 265 days, and while the lower value is compatible with mating at an immediate post-partum oestrus followed by a pregnancy of 144 days, the higher values may result from failure to conceive at post-partum oestrus or a high incidence of early abortion. Perinatal and post-weaning mortality were high in the colony of Hampton *et al.* (1978), and the long interbirth intervals and high value for singleton births indicate that conditions may have been suboptimal although, apart from high levels of vitamin D_3, they appear to resemble those of other colonies. Particularly surprising is the high mortality reported after the infants reached 4 weeks, as in the Aberystwyth colony there was no infant mortality after 3 weeks and only 2 juveniles died, 1 from an accident.

Average litter size differs between colonies, and the Aberystwyth colony shows the highest proportion (63%) of births in excess of 2. Recently, however, Hiddleston (cited by Bruhin, 1979) has reported a higher figure (41%) for triplet births in his colony. In captivity, at least, there is no advantage in females producing young in excess of 2 because in the vast majority of cases they fail to rear them.

The weight of adult common marmosets is given by Bruhin (1979) as 350-400 g and by Hearn *et al.* (1978) as 300-310 g. Aberystwyth-reared breeding adults were heavier, males weighing 386-493 g (median 434 g) and females 382-600 g (median 530 g). Their growth from 5-17 months (Fig. 3) follows a linear regression $y = 16{\cdot}6x + 163{\cdot}6$; where y = weight, x = age in months. The mean weight of 247 g

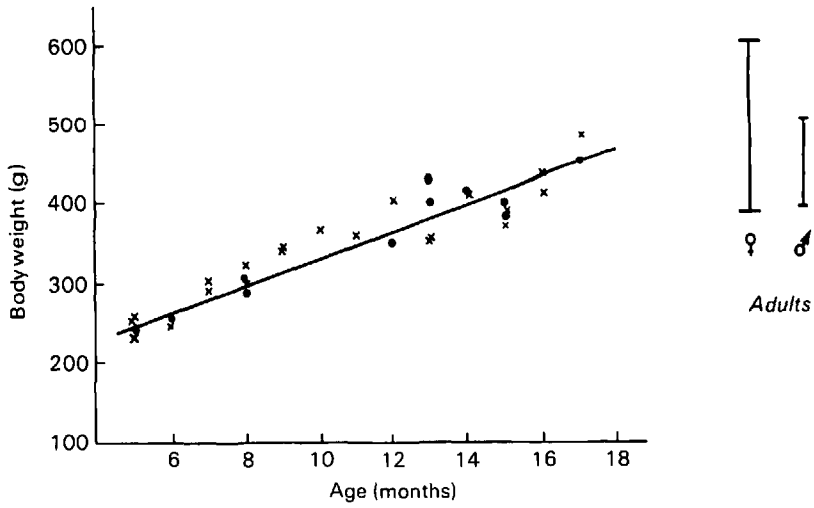

Fig. 3. Growth (g) of *Callithrix jacchus jacchus* from 5-17 months of age. Data from the Aberystwyth colony. × males. • females. Adult male and (multiparous) female weight ranges are also indicated.

at 5 months is higher than the 157 g given by Hiddleston (1976) and the 170 g by Abbott & Hearn (1978), and the slope of the regression is steeper. The regression line for Abbott & Hearn's data is approximately $y = 10x + 133$. The intercept value is in all cases unrealistic (birth weight is approximately 25-35 g) because the 0-5 month segment of the curve has a much steeper slope (Abbott & Hearn, 1978).

As in our data there were no consistent differences in weight between the sexes for 5-17 months, male and female weights could be pooled. However, when the marmosets became adults there was a degree of sexual dimorphism. Adult females, all of which were multiparous, showed upper spread in their weights, independent of the state of pregnancy. It would seem that some females put on 100 g extra weight after they have become adults (i.e. after 17 months of age).

The fact that the Aberystwyth marmosets were heavier than those in other colonies and the higher growth rate between 5-17 months may be attributable to the high animal protein porridge (Table 1) in their diet. In the wild common marmosets eat a considerable proportion of animal food (Stevenson, in press). The wild animals are lighter (adult 350-425, 5 months old 150 g, 10 months 225 g, 16 months 300-350 g) than the Aberystwyth marmosets, but the regression line for 8 data points from developing wild individuals aged 5-17 months yields the formula $y = 16x + 88$, giving a similar growth rate. The intercept is lower for wild marmosets but captive animals are often heavier than their wild counterparts.

The Aberystwyth data may be compared with an ideal situation for a colony both during its growth phase and when it had achieved a stable situation (20 breeding groups). However, as the growth phase is dependent upon the origin, parental experience and ages of the founder stock, it is more satisfactory to consider only the steady state.

The theoretical maximum productivity of marmosets, assuming that a pair rear 2 young every 5 months, is 4·80 young per annum as compared with 3·24 per annum achieved over the 6 year period, representing 67·5% efficiency. Possible methods of improving this figure would be supplementary (bottle) feeding of young in the event of lactation failure (for example after caesarian section), earlier reassortment of incompatible partners (not later than 4 months after pairing), and full hand-rearing of infants rejected by parents. However, these options are labour intensive and may not be economically feasible.

As much of the perinatal mortality results from births in excess of 2, further research would be helpful on the causes of the production of supernumerary young; which may indeed be a laboratory-induced phenomenon.

To conclude, the common marmoset can be kept in relatively unspecialized accommodation but skilled personnel and a complex mixed diet are essential. It is a primate of high fecundity which can be bred in self-maintaining colonies and can provide a surplus for research. This situation is highly satisfactory, both for conservation of the wild stock in Brazil, and because laboratory-reared animals are of known history and free from tropical parasites or diseases.

Acknowledgements

We wish to record our gratitude to a number of colleagues whose enthusiasm and conscientious dedication ensured the success of the marmoset colony, they are Miranda Stevenson, Jean Francis, Kenneth Howells, Linda Bowes, Alistair Sutcliffe, Angela Coates, Sian Evans and Anna Omedes. Also Mr I. I. Jones, the veterinary surgeon who skilfully carried out the caesarian sections as well as providing advice and support.

We thank the Science Research Council and the Medical Research Council for their financial support, and the University College of Wales for the helpful way in which facilities for the development of a marmoset colony have been made available.

We are especially indebted to Miranda Stevenson for making her data about wild marmosets available prior to publication elsewhere.

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Reproduction, Kindersterblichkeit und Produktivität einer Wessbüscheläffchen-Kolonie (*Callithrix jacchus jacchus*)

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Zusammenfassung

Nachdem mit 4 Marmosetten-Paaren begonnen wurde, konnten im Verlauf von 6 Jahren 204 Jungtiere erfolgreich aufgezogen werden. Sie wurden in Familien von 2–10 Tieren gehalten. Die Wurfgrößen variierten von 1–4 Tieren, dabei waren Einlinge mit 2%, Zwillinge mit 35%, Drillinge mit 55% und Vierlinge mit 8% vertreten.

Der durchschnittliche jährliche Zuwachs an abgesetzten Jungen betrug 3,24 pro Paar. Die mediane Zwischenwurfzeit betrug 154 Tage. Von 46 Marmosettenpaaren bekamen 8 keine Junge.

Annähernd 11% der geborenen Jungen waren Totgeburten, weitere 32% starben innerhalb von 3 Wochen, die perinatale Sterblichkeit ist weitgehend auf das Unvermögen der Eltern zurückzuführen, mehr als 2 Junge aufzuziehen. Nur in 2 von 68 Drillingsgeburten konnten die Eltern die Jungen ohne Hilfe aufziehen.

53% der geborenen Jungen waren männlich, die unterschiedliche Sterblichkeit reduzierte das endgültige Geschlechtsverhältnis für lebende Junge jedoch auf 50·5% männliche Tiere. Nach Kaiserschnitten nahmen die Mütter die Jungen nicht zur Aufzucht an.

Die lineare Regression der Wachstumskurve vom 5. bis zum 17. Monat (y = Gewicht in Gramm, x = Monate) kann durch die Formel $y = 16{,}6\,x + 163{,}6$ ausgedrückt werden.

Die Daten von 4 Marmosetten-Kolonien werden zum Vergleich herangezogen, die relative Effizienz der Zuchtmethoden wird diskutiert. (G)