THE HUMANE CONTROL OF CAPTIVE MARMOSET AND TAMARIN POPULATIONS

A W Sainsbury

Veterinary Science Group, The Institute of Zoology, Zoological Society of London, Regents Park, London NW1 4RY, UK

Final acceptance: 13 December 1996

Abstract *Animal Welfare 1997, 6:* 231-242

In zoo and laboratory colonies of marmosets and tamarins (Callitrichidae) there has been an increasing need to adopt breeding control methods. In zoos, this need has been driven by a growth in populations. In laboratories, increased interest in control options has followed from the requirement to improve welfare by housing potential breeding animals together. Progestagen-containing contraceptive implants or depot-injections, prostaglandin injection regimes, vasectomy and various group-management methods have been used to control reproduction in marmoset and tamarin colonies. There is a need for advances in control techniques suitable for use in zoos. In the meantime, a policy of selective euthanasia or the use of vasectomy are recommended as control methods. In laboratories, although improved control methods are required, a number of techniques have been found to be satisfactory. When there are surplus marmosets and tamarins, the alternatives for their utilization include movement to other colonies, use for studies within zoos or in laboratories, sale to private keepers or euthanasia. Selling these animals privately is not recommended, except in exceptional circumstances. The preferred control option will differ in each circumstance and guidance is given in this paper.

Keywords: *animal welfare, Callitrichidae, contraception, control of reproduction, management, marmoset, primate, tamarin*

Introduction

Within the last three decades the management and breeding of captive non-human primate populations has improved to the extent that there is now difficulty finding sufficient space in zoos and similar institutions to house these populations. Many laboratory primate-colony managers who house primates for research are also facing the dilemma of how to deal with surplus individuals and prevent a further increase in their numbers. Dealing with surplus primates and the prevention of a further increase in their numbers are contentious issues, but population control methods have become a necessity in captive primate management to ensure that overcrowding and poor housing conditions do not occur and that the welfare of the population as a whole is guaranteed. The preferred methods of control vary between species due to differences in reproductive physiology or behaviour, ease of physical or chemical restraint, body size and conservation status. Recently, the Primate Society of Great Britain (PSGB) considered the problem of surplus individuals of endangered primate species (PSGB 1988). Regarding options for surplus primates when reintroduction is not possible, as is usually the case for most species, the PSGB made the following recommendations:

a) 'Every effort should be made to ensure that the global population in captivity forms a viable base for further reintroduction or continued captive breeding.

b) If the captive global population is adequate, the following actions should be taken to deal with surpluses in the population:
   - i) The animals may be used for humane research which increases our knowledge of the biology of the species.
   - ii) Fertility control should be applied to a portion of the population.
   - iii) Euthanasia should only be used as a final resort. Where this is practised, due consideration must be given to the genetic and demographic character of the population. Maximum use should be made of the carcase of the animal in appropriate research laboratories.

c) Individuals of an endangered species bred in colonies or zoos, as part of a conservation programme, which are surplus, should not be used as a model for humans in any form of biomedical research or for any other purpose which might create a demand for wild-caught specimens' (PSGB 1988).

In practice, it has been the policy of most zoos and some laboratories to introduce methods to control reproduction in an attempt to prevent surpluses from occurring. In laboratory colonies, the utilization of animals for research may effectively control population size but control of breeding remains important. It is not entirely clear how surplus individuals from zoos or laboratories have been dealt with in the past but if movement between institutions has been impossible then either euthanasia or sales to private keepers may have been undertaken.

The purpose of this paper is to assess the methods available to, 1) control the size of zoo and laboratory populations of primates of the family Callitrichidae (marmosets and tamarins) and, 2) deal with a surplus if one occurs and indicate which methods of control in each case are most humane. Population control of callitrichids presents a particular problem because of their large litter sizes, short gestation periods and short intervals between gestations, compared with the majority of other primate families. Five areas will be tackled in this paper: methods available for the control of reproduction, group-management methods to prevent or deal with surpluses, the use of surplus zoo callitrichids for scientific studies, the integration of surplus laboratory marmosets and tamarins into the zoo population and finally, the sale of surplus zoo or laboratory callitrichids to private keepers. Recommendations are given on those methods of control which are preferable for an individual or a population's welfare, while at the same time being practical. Control methods which warrant further study or scrutiny are also discussed. In zoos, control methods are required to prevent or deal with a surplus of callitrichids. In laboratories, control methods allow non-breeding, mixed-sex pairs to be kept thus avoiding single housing and ensuring both welfare and research requirements are met. In both zoos and laboratories control of populations is required to prevent overcrowding, which may lead to physical and psychological health problems in animals, and to avoid the production of unwanted individuals.

Control of reproduction in callitrichids

The methods that have been used for the control of reproduction in callitrichids can be discussed under the following headings: contraception, termination of early pregnancy, surgical methods producing sterility, and control of reproduction by management. These are considered in turn below.

Contraception

Progestagen-containing contraceptive implants

The use of implants in zoos has arisen from the perceived need to use a reversible method of contraception in individuals whose genes are over-represented in the zoo population (Ballou & Kleiman 1989). Cylindrical implants with a mass of 0.3-0.5g, measuring approximately 10x5mm, containing 10mg melengestrol acetate (MGA) and inserted subcutaneously, have been used frequently in callitrichids (Asa & Porton 1990). More recently, implants containing levonorgestrel ('Norplant', Wyeth, Maidenhead, UK) have been tried in marmosets and other primate species (Asa 1993; Greenwood 1993). The objectives behind the use of MGA implants in golden lion tamarin (*Leontopithecus rosalia*) captive breeding programmes were as follows (adapted from Ballou 1985):

1) The maintenance of a normal family group during control. The generally accepted method of keeping marmosets and tamarins in captivity is in family groups (Richter 1984) although this is not necessarily an exact replica of the situation in the wild (Stevenson & Rylands 1988).
2) A decrease in reproductive rate but, with intermittent usage, allowance for some breeding and therefore, the availability of youngsters to increase the educational value of zoo exhibits.
3) By decreasing the reproductive rate there is a greater opportunity to house genetically important pairs which may then breed. By increasing the interval between gestations the generation time is increased. Both these factors help to maintain genetic diversity.

There have been problems associated with the use of MGA implants in callitrichids (Price & Evans 1991) which can be summarized as follows:

1) implanting procedure difficulties, for example: removal of sutures by the recipient or cagemates (Colley 1993), migration of the implant, wound breakdown and loss of the implant (Price & Evans 1991), failure to find the implant on attempted removal
2) abortion when pregnant females were implanted (Porton *et al* 1992)
3) failure to breed following removal of the implant (Cooper cited by Colley 1991)
4) unplanned pregnancies (Porton *et al* 1992)

The implanting procedure has been improved over time but it is still not a simple operation; it usually necessitates the removal of the animal from the group for at least five days (but cases of 20 days or more have occurred (Buchanan-Smith cited in Colley 1991)) and involves careful post-operative monitoring. Asa (personal communication) found that the use of stainless steel sutures allowed the female to be placed back into the group immediately. The loss of an implant is not usually apparent on visual inspection and so regular handling is required to check the site. There are no behavioural signs in callitrichids which indicate whether the MGA implant is working or in place. Porton *et al* (1992) recognized that a reliable method to monitor implants was needed in order to facilitate the use of these implants in zoo animals.

In golden lion tamarins it appears to be unnecessary to implant subordinate females (Cooper cited by Colley 1991). There is no reason to suspect that the situation will differ in other species of callitrichids because many of these species exhibit behavioural as well as physiological suppression of reproduction (Barrett *et al* 1993).

MGA implants were inserted during pregnancy in ten golden lion tamarins (Porton *et al* 1992). Four females aborted during the first trimester of pregnancy; the others gave birth even though in two cases the implant had been inserted in the first trimester. Timing implant insertion to avoid pregnancy may be difficult in callitrichids which have a post-partum oestrus and therefore, potential to become pregnant shortly after parturition. In a study by Cooper (cited by Colley 1991), it was reported that one golden lion tamarin did not breed following implant removal. However, the majority of tamarins have shown the ability to breed again after implant removal (Porton *et al* 1992).

Porton *et al* (1992) reviewed the use of MGA implants in all primate species. It was found that 2.9 per cent of implanted primates conceived, although a large proportion of these were of one species and none were callitrichids. In these cases (termed birth control failures) the implant was definitely in place at the time of conception. Unplanned pregnancies, where the implant was not in action at the time of conception, were more frequent. Pregnancy occurred due to the loss of an implant or the reliance on an implant which had passed its effective period of activity (16% of MGA implants were known to have been lost).

Munson (1993) reviewed the adverse effects of progestagen-containing contraceptives on animals in American zoos. While it has been shown that the use of progestagen-containing implants in exotic felids has increased the prevalence of endometrial hyperplasia and neoplasia (Munson & Mason 1991), limited data have been available for primates. Munson (1993) reported that one case of retained placenta and endometritis was found in a tamarin with a MGA implant and an orangutan with the same implant type had endometrial atrophy. However, Munson (1993) noted that progestagen-containing contraceptives have been extensively tested in laboratory primates and are also approved for use in women. Adverse effects in women include amenorrhoea and weight gain but some investigators are concerned that there may be an increased risk of breast cancer when these contraceptives are used in young women.

Levonorgestrel implants, which can be injected subcutaneously through a 12-gauge needle, are more easily administered than MGA implants (Greenwood personal communication). However, little is known of their duration of action or of any effects on health in non-human primates.

Progestagen-containing depot-injections

The active ingredient in depot-injections is formulated to prolong the action of contraceptives by slowing the rate of absorption from the injection site. A depot-injection of medroxyprogesterone acetate ('Depo Provera', Coopers-Pitman-Moore, Crewe, UK) has been used in a number of primate species (Porton *et al* 1992), however, only one incidence of its use in callitrichids was reported, but the success or otherwise was not stated. The contraceptive action is likely to last for 30 to 90 days (Porton *et al* 1992).

Termination of early pregnancy

Regular prostaglandin injections

Prostaglandins, specifically cloprostenol, are commonly used in laboratory callitrichids for terminating early pregnancy and act through a luteolytic effect (Summers *et al* 1985). An injection is required approximately every month, so for callitrichids that are regularly and easily handled this technique is relatively simple to administer. In some species there is large individual variation between females in the required dose of prostaglandin but once this has been established the technique is reliable and flexible (Pryce *et al* 1993). Summers *et al*

(1985) found that although prostaglandins act by terminating pregnancy, the low dose required in common marmosets did not appear to cause nausea or pain.

Surgical methods producing sterility

Sterilization by vasectomy

Vasectomy has been recommended for the management of the UK population of cotton-top tamarins (*Saguinus oedipus*) (Colley 1990). It has also been used in golden lion tamarins (Carroll personal communication) and is used regularly in some laboratory colonies of callitrichids (Kuderling cited by Colley 1991; Morris & David 1993). A novel, easy and successful technique for vasectomy has been developed for common marmosets by Morris and David (1993). Some vas deferentia re-cannulated after the initial operations but this difficulty has subsequently been prevented by ligation using non-absorbable suture material. The simple surgical technique allows immediate return to the group (although viable sperm may still be present in the vas deferens for an unknown period). Importantly in laboratories, sterilization of the dominant male in family groups, or the only male in mixed-sex pairs, allows research to continue without breeding while the maintenance of the social group ensures the animal's welfare is not compromised.

Other methods of sterilization such as castration, ovariectomy and ovariohysterectomy could be employed but their use has not been recorded.

Control of reproduction by management

The natural avoidance of inbreeding and suppression of fertility of subordinate animals by the dominant male and female (Abbott 1984) are of great value in captive callitrichids as a way to reduce reproduction. In many cases, groups of ten or more animals can be housed together, comprising the parents and four or five litters. A maximum of 19 animals housed together has been noted in common marmosets (*Callithrix jacchus*) (Rothe 1978). Instances of subordinates being housed with their parents for up to eight years have been recorded (Colley personal communication). The provision of large enclosures to house groups of animals may delay the expulsion of offspring, reduce the need to set up new groups and effectively curtail reproduction.

Splitting heterosexual pairs of callitrichids and creating single-sex groups by splitting family groups have been reported as possible methods to prevent breeding. Colley (1993) noted that the creation of single-sex groups is usually successful if closely related animals have been involved. The establishment of single-sex groups from unrelated animals is not recommended because aggressive interactions are usually persistent and severe injuries result (Richter 1984), although it is possible to achieve the formation of single-sex groups with animals under 12 months of age (Burt & Plant 1983).

Other methods of reproductive control

There are no records of the use of human birth-control pills in callitrichids and only a few cases of their use in New World monkeys in general (Porton *et al* 1992). The use of intra-uterine devices has been reported in chimpanzees (Porteous *et al* in press) but the body size of callitrichids is likely to preclude this form of contraception.

Immunocontraception is a new development which may soon supercede surgical methods of sterilization. Two approaches are of note: stimulating the production of antibodies (in females) which bind to sperm and thus render the sperm inactive, and secondly, the inhibition of fertilization by the induction of antibodies which bind the receptor for sperm on the zona pellucida (Sacco 1987; Kirkpatrick & Turner 1991). The zona pellucida vaccine is undergoing a trial in a laboratory colony of common marmosets in the UK (Morris personal communication). The porcine zona pellucida vaccine (PZP) has recently been used on a number of New World monkeys in the USA (Asa 1993). It has been injected with an adjuvant and some problems have been reported with the injection technique due to the viscosity of the product. It was also noted that the effect of PZP did not appear to be reversible (Asa 1993). However, Munson (1993) noted that in zona pellucida vaccine trials in laboratory mice, dogs and primates the ovarian effects depended on the species, the origin and purity of the immunogen, the dose and the type of adjuvant used. Munson (1993) concluded that there was a need for carefully controlled clinical trials of PZP.

A luteinizing hormone releasing hormone (LHRH) superagonist implant has been investigated in common marmosets but requires further study before its usefulness can be interpreted (Wadsworth personal communication).

Asa and Porton (1990) report that three other methods of reproductive control are under consideration for zoo primates in general: implants containing both oestrogens and progestogens, agonists or antagonists to gonadotrophin releasing hormone (GnRH) and bisdiamines for reversible chemical blockage of spermatogenesis without effect on testosterone.

Options for the management of surplus callitrichids

Euthanasia

Two management techniques involving euthanasia which reduce population growth but maintain social groups have been used. In both cases, breeding in family groups is allowed to continue unabated but individuals are euthanased either as neonates or as juveniles/ subordinate adults (Colley 1990). Juveniles or subordinate adults could be euthanased when expelled from a family group and several zoos now carry out this policy (Colley 1993). The problem of housing animals after expulsion is obviated and it enables the group to breed unabated and the young to experience a 'normal' social environment. One large laboratory-colony has adopted the policy of euthanasing one neonate from each twin birth (Colley 1993).

Use of surplus zoo callitrichids for studies

The PSGB (1988) suggested that surplus endangered primates could be used for 'humane research' but the extent to which this occurs is unclear. Non-invasive studies (such as behavioural research) take place within zoos on a small-scale and there has been a recent call to develop and expand this role (Feistner & Evans 1992). It is unlikely that animals are, or will be held for this purpose alone. Colley (1993) reported that the use of surplus cotton-top tamarins from UK zoos for medical research in laboratories was considered but rejected on the grounds of both negative publicity and the opinions of those involved in the tamarins' care, this despite the potential advantage of increased revenue for conservation.

Integration of surplus laboratory callitrichids into the zoo population
Colley (1993) reported that some laboratory cotton-top tamarins had been dispersed throughout zoological collections in the UK. However, the carrying capacity of zoos is generally considered to be at its limit, so there is little scope for non-endangered species to be dispersed in this manner and only small numbers of endangered callitrichids are kept for research.

Sale of surplus zoo and laboratory callitrichids to private keepers
Although private keepers of callitrichids undoubtedly obtain some of their stock from zoo and laboratory colonies (see Colley 1993) there is no information on the numbers of animals which are involved.

Discussion

Contraceptives
None of the currently used contraceptives have been shown to be ideal for use in zoos. MGA implants have been associated with some reproductive and post-operative complications and involve repeated procedures and disruption of the 'natural family group'. Social development of marmosets and tamarins requires the presence of family groups (Cleveland & Snowdon 1984; Tardif *et al* 1984) in which, among other things, older siblings learn how to rear young by contributing to the rearing of younger siblings. In zoos, the proposal is that implants can be either continuously replaced to maintain the female in a barren state, or the activity of the contraceptive in the implant is allowed to wane so that breeding can occur and another implant is inserted after pregnancy is confirmed (the expected lifespan of MGA implants is approximately two years). Intermittent breeding can be achieved either by allowing the effect of the implant to wane or by removal of the implant. If intermittent breeding is timed correctly older siblings may gain some social experience with younger siblings. In practice, timing pregnancies to ensure that young animals obtain experience of rearing siblings may be difficult because, for example, older juveniles may have been removed in order to establish new pairs by the time the adult female breeds again. Further data on the results of implant programmes are required before the problem can be adequately assessed.

Some other methods of contraception offer improvements in administration but require further investigation. Levonorgestrel implants are more easily administered than MGA implants but trials are required to assess their effectiveness and practicality. Depot-injections and prostaglandin injections may have a more predictable period of action than MGA implants but their use may be more applicable to laboratory rather than zoo colonies because of the frequency of administration. Contraceptives which require a single procedure such as irreversible immunocontraception may be more practical and humane.

Sterilization by vasectomy
Vasectomy is preferable to castration for sterilizing males because it is less likely to alter male behaviour and thus the stability of a social group. Of the methods available to sterilize females, ligation of the oviducts is preferable to ovariectomy or ovariohysterectomy for similar reasons to vasectomy in males. It is probably easier to perform a vasectomy than to ligate the oviducts and so vasectomy is likely to be the preferred method for sterilizing a breeding pair.

There are few reports of the use of vasectomy to control callitrichid populations in zoos. One possibility, which would allow genetically important pairs to breed, provide for the exhibition of family groups for educational purposes and protect the population's welfare, would be to allow a pair to breed several sets of offspring and then for the male to be sterilized. It would be for the managers of each breeding programme to decide on the number of sets of offspring, if any, that should be allowed. This strategy may have two main disadvantages: the irreversibility of the procedure and the need to exhibit non-breeding pairs, once their young have dispersed. Irreversibility could be a problem if, for example, the offspring do not go on to breed. The development of semen banking and artificial reproductive techniques may solve this problem. Ballou (1985) noted that some zoos would not house golden lion tamarins if they were not permitted to breed them. However, efforts could be made to educate the public about the importance of controlling breeding to prevent the problem of unwanted surplus primates. Vasectomy has advantages over the use of the current steroidal contraceptives: the practical problems of the surgical technique are arguably lower than with MGA implantation, reproductive problems in the female are avoided, there are no known side-effects, and only one surgical procedure is required.

Control of reproduction by management

Splitting breeding pairs of callitrichids is not to be recommended if the result is single housing. The isolation of social animals such as callitrichids can lead to abnormal behaviour (Snowdon & Savage 1989; Sainsbury 1994). Single-sex groups created from the splitting of family groups may be stable but an abnormal social group may not be beneficial to behavioural development. In zoos it may be difficult to house split groups, given the limited space available and the fact that a split group is of poorer educational value to the public. In laboratories the establishment of single-sex peer groups of juveniles is not recommended because it creates an abnormal social environment. The housing of family groups is a practical and successful method for raising young to breeding age.

Options for the management of surplus callitrichids

A policy of control by euthanasia is difficult to initiate because personnel build up a rapport with individual animals, particularly in zoos where animal management staff may have close contact with relatively few animals. A policy of euthanasia may also lead to poor public relations and is an ethical dilemma. However, as Lacy (1991) argued, euthanasia may be in the best interests of the welfare of the group and consequently the population, for example, by allowing resources for environmental enrichment to be placed into a limited number of houses.

Hand-rearing of callitrichid neonates has been advocated by some (see review by Sainsbury 1987). However, the labour required to carry out this task is enormous and many hand-reared animals subsequently show abnormal behaviour and thus may be unsuitable for educational or conservation purposes, and poor models for research in laboratories. Therefore, euthanasia of those animals which would have otherwise had to be hand-reared would be a useful method of population control and may help to prevent the rearing of animals with abnormal behaviour.

Few zoos are likely to entertain the idea of using their animals for any type of invasive research in laboratories because of the potential for negative publicity and resistance from within the zoo. If laboratory colonies were to derive animals from zoos they would probably find it difficult to deal with small numbers of irregularly supplied, imprecisely defined animals which do not show standard responses to experimental manipulation. Laboratories can house large colonies of captive-bred marmosets and tamarins relatively easily and cheaply. It is possible that there is an opportunity for zoos to use the surpluses for certain types of research. Although there are advantages in undertaking research on primates in zoos (Feistner & Evans 1992) this work is often constrained because of inadequate numbers of each species.

Although sale to private keepers may be a viable alternative in some cases where there is good husbandry, record keeping (including studbooks), veterinary involvement and cooperation with zoos, this has potential welfare implications. Callitrichids have specific husbandry, behavioural and nutritional needs requiring specialist stockmanship, housing and equipment which cannot easily be met by most members of the public. Colley (1990) pointed out that sale to private keepers probably only delays the production of a surplus number of animals. It may also encourage a market in these animals as pets, which could have a knock-on effect on the trade of wild animals. Harcourt (1987) expressed concern for the implications of any practice which might encourage trade in primates. Colley (1993) found that many zoological collections preferred to place surplus animals with private dealers or keepers than operate a reproductive control programme. However, many private keepers were not interested in cooperating with a national management programme for cotton-top tamarins which included population control.

Conclusion

No single control technique is applicable in all zoo and laboratory situations. The optimal control methods should enhance the welfare of callitrichid populations, should not compromise health and should ensure a social environment as close to the natural situation as possible. At the same time it should be practical. The use of natural suppression of fertility by housing large family groups together meets these needs in most cases and should be used to the full. This method is relatively easy to implement and requires no chemical or surgical intervention. The provision of large enclosures to decrease the likelihood of expulsion of family group members should be encouraged. The use of natural suppression of fertility to control reproduction in callitrichid colonies is, however, a commonly used technique and by itself is unlikely to address the population problem.

In laboratory colonies the requirements of research must be met in conjunction with welfare and practical considerations, therefore, a wide variety of control techniques are likely to be employed. The use of vasectomy to maintain non-breeding social groups is arguably the most humane method but where a reversible method is required and callitrichids are handled regularly, repeated use of contraceptives, such as progestagen depot-injections, are useful. Where possible, workers should be encouraged to base their research on animals in breeding family groups because this is the natural social grouping.

In zoos, animals should be kept in family groups which mimic the wild situation both for welfare reasons and because they provide an exhibit which is of good educational value for the public. Animals kept in these social groups in captivity are better suited for reintroduction to the wild should this be required (Box 1991). For zoos, the population control method which meets these requirements (ie which ensures that breeding groups can be maintained for years without increasing the population, is relatively easy to manage and requires no surgical or chemical intervention) is the policy of euthanasing juveniles or subordinate adults expelled from family groups. The family group provides a pool of animals which can be used to form new breeding pairs if a species is at risk of extinction from, for example, a disease outbreak. This is an important consideration for an endangered species. By euthanasing animals expelled from family groups it is possible to comply with the objectives of the MGA implant programme noted earlier (Ballou 1985) by, in particular, ensuring the availability of youngsters to increase the educational value of zoo exhibits and secondly, by allowing genetically important pairs to breed. The PSGB (1988) recommended euthanasia only as a final resort, but in many situations culling is probably more humane than other control techniques because the welfare of the whole population is optimized. It may be beneficial if the PSGB (1988) statement were to be reassessed. Some zoo managers may consider that a policy of euthanasia is dubious on ethical grounds and may not be prepared to attempt to gain public support for it. In this situation a vasectomy programme may be preferred. Contraceptive techniques require further improvements before they can be recommended in zoos and it is debatable whether reversible methods of contraception are practical in a short-lived primate species. It may be best to conduct the research required on contraceptive techniques in the laboratory situation, where large numbers of animals are available on one site.

Whilst it is hoped that further improvements in control methods will help prevent surpluses of captive primates in the future, occasional surpluses are probably unavoidable. For this reason, non-invasive studies on callitrichids should be encouraged but use of animals for this purpose cannot be expected to solve a surplus problem. Where non-endangered zoo species are involved, their use in humane, invasive medical research should not be discouraged. Sale to private keepers is not recommended, except in exceptional circumstances and colony managers should be discouraged from hand-rearing neonates. Euthanasia is considered the most humane alternative for dealing with surpluses if the options discussed in this paper are not possible.

Animal welfare implications

Surplus primates present a contentious and difficult problem for the managers of these animals. A policy for the control of a marmoset or tamarin population should not be initiated before consideration is given to the welfare and practical issues of the available options. New developments which may improve welfare and ease of management require continual appraisal. This paper addresses the alternatives for breeding control of callitrichids, assesses their effects on health and other aspects of callitrichid welfare and considers their practicality.

Acknowledgements

This paper was prepared with the support of the Captive Care Working Party of the Primate Society of Great Britain. I am very grateful for the additions and comments provided by C S Asa, S Bearder, P M Bennett, J B Carroll, R B Colley, A Glatston, A G Greenwood, J K Kirkwood, K Morris, T H Morris, N Mundy, T B Poole, I S Porteous, E Price, C R Pryce, D Richardson, L Scott, M Wadsworth and G E Webley. Ms Maureen Thompson helped with word processing.

References

Abbott D H 1984 Behavioural and physiological suppression of fertility in subordinate marmoset monkeys. *American Journal of Primatology 6:* 169-186

Asa C S 1993 Minutes of the American Association of Zoological Parks and Aquaria Contraceptive Committee Mid-Year Meeting, St Louis, USA

Asa C S and Porton I 1990 Primate contraception methods in use and in development. *Proceedings of the American Association of Zoo Veterinarians* pp 263-264. American Association of Zoo Veterinarians: Philadelphia, USA

Ballou J 1985 *Golden lion tamarin contraceptive implant program - general information.* National Zoological Park: Washington DC, USA

Ballou J and Kleiman D G 1989 Species survival plan report: Golden lion tamarin. *American Association of Zoological Parks and Aquaria Newsletter 30(2):* 6-7

Barrett J, Abbott D H and George L M 1993 Sensory cues and the suppression of reproduction in subordinate female marmoset monkeys, *Callithrix jacchus. Journal of Reproduction and Fertility 97:* 301-310

Box H O 1991 Training for life after release: simian primates as examples. In: Gipps J H W (ed) *Beyond Captive Breeding. Symposium of Zoological Society of London (62)* pp 111-123. Clarendon Press: Oxford, UK

Burt D A and Plant M 1983 Observations on marmoset breeding at Fisons. *Animal Technology 34:* 29-36

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

Colley R 1990 Cotton-top tamarin. *Proceedings of a Joint Management of Species Group Meeting*, Edinburgh Zoo, UK

Colley R 1991 *British Isles and Ireland: Regional Studbook Cotton-Top Tamarin (Saguinus oedipus)* 5. Federation of Zoological Gardens of Great Britain and Ireland: London, UK

Colley R 1993 Cotton-top tamarins (*Saguinus oedipus*) - conservation and captivity. In: Colley R (ed) *Marmosets and Tamarins in Captivity: Proceedings of the Seventeenth Annual Symposium of the Association of British Wild Animal Keepers.* Association of British Wild Animal Keepers: Bristol, UK

Feistner A T C and Evans S 1992 Research in zoos: prospects for primatology. *Proceedings of the Fourteenth Congress of the International Primatological Society* p202. International Primatology Society: Strasbourg, France

Greenwood A G 1993 Contraception in zoo animals. *Zoo Federation News 65:* 30-36

Harcourt A H 1987 Options for unwanted or confiscated primates. *Primate Conservation 8:* 111-113

Kirkpatrick J F and Turner J W 1991 Reversible contraception in nondomestic animals. *Journal of Zoo and Wildlife Medicine 22:* 392-408

Lacy R C 1991 Zoos and the surplus problem: an alternative solution. *Zoo Biology 10:* 293-297

Morris T H and David C L 1993 Illustrated guide to surgical technique for vasectomy of the common marmoset. *Laboratory Animals 27:* 381-384

Munson L 1993 Adverse effects of contraceptives in carnivores, primates and ungulates. In: Junge R E (ed) *Proceedings of the American Association of Zoo Veterinarians* pp 284-288. St Louis, USA

Munson L and Mason R J 1991 Pathological findings in the uteri of progestogen-implanted exotic felids. *Proceedings of the American Association of Zoo Veterinarians* pp 311-312. American Association of Zoo Veterinarians: Philadelphia, USA

Porteous I, Mundy N I and Grall C In press. Use of intra-uterine devices as a means of contraception in a colony of chimpanzees (*Pan troglodytes*). *Journal of Medical Primatology*

Price E C and Evans S 1991 Contraceptive implants in callitrichids: a call for information. *Laboratory Primate Newsletter 30:* 19

Primate Society of Great Britain 1988 Surplus individuals of endangered species of primates in captivity. *Primate Eye 36:* 17-18

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

Porton I, Asa C and Baker A 1992 Survey results on the use of birth control methods in primates and carnivores in North American zoos. *American Association of Zoological Parks and Aquaria, Contraceptive Task Force*, St Louis Zoological Park, USA

Richter C B 1984 Biology and diseases of Callitrichidae. In: Fox J G, Cohen B J and Loew F M (eds) *Laboratory Animal Medicine* pp 353-383. Academic Press: Orlando, USA

Rothe H 1978 Sub-grouping behaviour in captive *Callithrix jacchus* families: a preliminary investigation. In: Rothe H, Wolters H J and Hearn J P (eds) *Biology and Behaviour of Marmosets* pp 233-257. Eigenverlag H Rothe: Gottingen, Germany

Sainsbury A W 1987 Reducing infant mortality in marmosets. In: Scott P W and Kirkwood J K (eds) *Rearing Young Wild Animals in Captivity - Proceedings of a British Veterinary Zoological Society* pp 55-65. Vetark Publications: Winchester, UK

Sainsbury A W 1994 The relationship between husbandry, behavioural monitoring and disease prevention: examples from a colony of marmosets. Proceedings of the Fifth Symposium of the Federation of European Laboratory Animal Science Association pp 57-60. Royal Society of Medicine Press: London, UK

Sacco A G 1987 Zona pellucida - candidate antigen for contraceptive vaccine development. *American Journal of Reproductive Immunology and Microbiology 15:* 122-130

Snowdon C T and Savage A 1989 Psychological well-being of captive primates: general considerations and examples from callitrichids In: Segal E F (ed) *Housing, Care and Psychological Well-Being of Captive and Laboratory Primates* pp 75-88. Noyes Publications: New Jersey, USA

Stevenson M F and Rylands A B 1988 The marmosets, genus *Callithrix*. In: Mittermeier R A, Rylands A B, Coimbra-Filho A F and da Fonseca G A B (eds) *Ecology and Behaviour of Neotropical Primates, Volume 2* pp 131-222. World Wildlife Fund: Washington DC, USA

Summers P M, Wennick C J and Hodges J K 1985 Cloprostenol-induced luteolysis in marmoset monkeys (*Callithrix jacchus*). *Journal of Reproduction and Fertility 73:* 133-138

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