TECHNICAL CONTRIBUTION

MEASURING GUT PASSAGE TIMES IN SMALL NEW WORLD MONKEYS

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A simple technique for investigating gut passage times in small New World primates was developed, which produced good results without any need for special housing or diet, or for the separation of monkeys from their groups. This technique, which allowed the administration of a faecal marker, chromium oxide, to specific individuals, was used to investigate gut passage times in five species of the genera Callithrix, Saguinus, Leontopithecus *and* Callimico. *Overall, average gut passage time was 4.5 hours, and there were no species differences. Such nondisruptive methods could help in assessing the effects of dietary changes in captive monkeys, and therefore be of considerable value in improving captive diets and hence welfare and breeding success.*

Keywords: *animal welfare, diet, faecal marker, Goeldi's monkeys, gut passage time, marmosets, tamarins*

Introduction

Captive breeding programmes may be important to the survival of many endangered species. Appropriate diets are obviously crucial to the successful breeding of any species in captivity, and it is important to assess diets to ensure that captive animals receive all the nutrients they require. In conjunction with other aspects of nutrition such as digestibility, the measurement of gut passage time, ie the time taken for food to pass through the digestive tract, could be an important tool in pinpointing possible problems in captive animals' diets and in assessing the effects of dietary changes, as well as in monitoring health (eg Price 1992b). Gut passage time is influenced by the composition of an animal's diet, its health and medical treatment, and in turn may affect the absorption of nutrients from food (Crissey *et al* 1990).

In captive collections, particularly those concerned with breeding endangered species, it is important to use techniques which minimize the adverse effects of stressful invasive manipulations. Gut passage times are typically measured using an inert marker which is mixed with the food and passes unaltered through the gut (eg Ruggiero & Whelan 1977, Ganzhorn 1986). The time taken for this marker to appear in the faeces provides an estimate of passage time. If the marker were mixed with the food for an entire group, to obtain measurements from individuals it would be necessary to house them singly. This is clearly undesirable in the case of social species, and this paper describes the

measurement of gut passage times in small New World monkeys, using an inert marker and a method which avoided any disruption to the animals' routine.

Methods

Subjects and housing

The subjects were 16 adult monkeys from five species (see Table 1): Geoffroy's marmosets *(Callithrix geoffroyi)*, silvery marmosets *(Callithrix argentata argentata)*, cotton-top tamarins *(Saguinus oedipus)*, golden lion tamarins *(Leontopithecus rosalia)* and Goeldi's monkeys *(Callimico goeldii)*. All were maintained in the collection of the Jersey Wildlife Preservation Trust (JWPT), and had a good health record prior to the start of the study. Data from Geoffroy's marmosets have also been presented elsewhere (Price 1992a,b).

Table 1 Details of subjects and median gut passage times.

Species	Subject[1]	Housing conditions	No of trials	Median gut passage time (h)
C. geoffroyi	M1529f	With mate	3	4.50
	M1466m	With family	3	5.25
	M1368m	With mate	4	4.50
	M1011m	With family	3	4.50
C. argentata	M870f	With family	3	3.50
	M962m	With family	1	6.50
	M1607f	With family	3	4.75
	M943m	With family	3	4.25
L. rosalia	M1399m	With brother	3	4.50
	M1066m	With brother	4	3.00
C. goeldii	M814m	Alone	3	4.50
	M1255f	Alone	3	5.50
	M1706m	Alone	3	3.75
S. oedipus	M489m	Alone	7	4.42
	M1161m	With sister	4	5.00
	M1461f	With brother	3	4.25

[1] JWPT identification no; m = male, f = female

Some subjects were housed singly, others in pairs or families (see Table 1). Monkeys living alone had been removed from their groups for management reasons; no monkey was separated from its usual cagemates solely for the purposes of this study. All the monkeys could be individually identified using variation in pelage.

The monkeys were housed in indoor-outdoor cages in the marmoset complexes described by Mallinson (1975). Indoor cages measured from 122 x 91 x 152cm high to

183 x 91 x 152cm high; outdoor cages ranged in height from 210 to 261cm, with a floor area of 6.7-8.9m^2.

Diet

The monkeys' diet consisted of a variety of foods given in three meals daily. The morning feed consisting of soaked commercial monkey pellets mixed with either syrup or a vitamin supplement, brown bread and human baby cereal (Boots Co), was given at about 1000h. At about 1200h, a mixture of chopped fruit and vegetables together with a protein item such as pet food or cheese was fed, and at about 1630h, the monkeys were given a small feed of, for example, dried fruit or mealworms. The diet was supplemented regularly with vitamins B12, D3 and E. Further details are given by Allchurch (1986) and Price (1992a,b).

Faecal marker

Chromium oxide (Cr_2O_3), an inert green powder, was chosen as a faecal marker as it had been successfully used in a wide range of species, including marmosets and tamarins (Ruggiero & Whelan 1977, Krombach *et al* 1984, S Evans pers comm).

Small cubes of brown bread (approximate weight 3g) were soaked in about 2.5ml of approximately four per cent Cr_2O_3 solution, and then sweetened with about 1.5g of condensed milk to which a little extra chromium oxide (about 0.0025g per g milk) was added. Each piece of bread therefore contained on average about 0.13g of chromium oxide.

Bread was chosen as a substrate as it formed part of the morning feed, and was also often used to administer medication to the collection. Pilot trials demonstrated that the monkeys would readily take chromium oxide in this form, and that the green colour was easily detectable in faeces. A further advantage of this method was that the marker could be administered to known individuals even if they were part of a group, and there was no need to separate monkeys from their usual cagemates.

Procedure

Trials were conducted from May to August 1991 and from February to March 1992. The marker was administered shortly before or after the morning feed was presented. No training was necessary; typically the whole group came to the front of the cage when the experimenter approached with the bread. The marked bread was hand-fed to an adult selected prior to the trial; if necessary, plain bread was given first to the other animals in the group so that they would not steal marked bread from the subject. The time of administration was recorded, and the chosen monkey was watched until it had eaten most or all of its bread; any small pieces remaining were then removed from the cage.

Cages were searched carefully at hourly intervals after administration of chromium oxide, and the time at which the green colouration first appeared in the faeces was noted. Gut passage times were therefore recorded as falling into one-hour classes: for example, if the first observation of green dye in faeces was made 4 hours after presentation of

marked food, then a gut passage time of 3-4 hours was recorded. To avoid disturbing the animals, they were usually not confined to their inside areas. It was more time-consuming to search the planted outside runs but I am confident that the green colouration was detected when it first appeared.

As the diet varied somewhat from day to day, an attempt was made to carry out several trials on different days for a given monkey, though this was subject to husbandry and other constraints. Between one and seven trials (mean 3.3; see Table 1) were conducted on each monkey. A minimum of two days' time was allowed to elapse between consecutive presentations of the marker to individuals in any given group to ensure that all the chromium oxide from the previous trial had been egested.

Analysis

As occasional outlying values were obtained, medians rather than mean values were calculated for each subject, using the method described by Sokal and Rohlf (1981) for data grouped in classes. These medians were then used as individual data points for further statistical analyses. A Kruskal-Wallis one-way analysis of variance (Siegel 1956) was used to look for interspecific differences in gut passage times.

Results

The median gut passage time for each subject is given in Table 1. Medians ranged from 3.0 to 6.5h, with individual values ranging from 1-2h to 21-22h. Overall, median passage time was 4.5h, with 10 of the 16 subjects' times falling on or between 4 and 5h. There were no significant differences between species in gut passage time ($H = 6.09$, $df = 4$, non-significant).

Discussion

Gut passage times of closely related species of New World monkeys at the Jersey Wildlife Preservation Trust did not differ significantly amongst each other, healthy individuals of five different species all having average gut passage times of 4-5 hours. The technique was simple to use, and would probably be easier and even more accurate in collections with less naturalistic housing.

The values obtained fell within the range of previous reports from other tamarins and marmosets (wild saddle-backed tamarins, *Saguinus fuscicollis*, and moustached tamarins, *S. mystax*; Garber 1986; and captive common marmosets, *Callithrix jacchus*; Krombach *et al* 1984). Garber (1986) found that seeds typically passed through the gut of tamarins in 1-5 hours, with more than half appearing in less than three hours. This appears to be somewhat quicker than the results reported here. One possible explanation is that different food types pass through the gut at different rates; Garber's data were from fruit, while the results of the present study probably mostly reflect the passage time of a high protein commercial food. This issue deserves further investigation.

Comparative data from other primate taxa show a wide range of passage times that depend to a great extent on the species' normal diet. More folivorous species such as

howler monkeys *(Alouatta* spp*)* tend to have longer passage times, howlers averaging around 20-36 hours (Milton *et al* 1980, Crissey *et al* 1990). Ring-tailed lemurs *(Lemur catta)*, which eat less fruit and more woody plant parts than brown lemurs *(L. fulvus)*, have longer passage times (Ganzhorn 1986). As the animals in the present study all received the same diet, the fact that they had essentially identical gut passage times is perhaps not surprising. However, in the wild there are considerable differences in diet even amongst members of the same marmoset or tamarin genus (Ferrari & Lopes Ferrari 1989). Some species of *Callithrix*, for example, use plant gums more than do others (Stevenson & Rylands 1988, Rylands 1989). Adding gum to the diet of these species may increase gut passage time, as it does in other gum-eating primates such as galagos (Nash 1989). Baseline data such as those presented here therefore provide a basis for investigating species differences in response to dietary manipulations. It would also be of considerable interest to extend studies of gut passage time in a particular species to include the effects of other factors such as reproductive phase, disease and medical treatment. Passage times of Geoffroy's marmosets, for example, have been shown to be influenced by health and antibiotic treatment (Price 1992a,b).

Animal welfare implications

This method of measuring the gut passage times of individual captive monkeys housed in groups proved simple to use, producing data that form a basis for interspecific comparisons and for investigating the effects of dietary changes, and could therefore be of much further use in the development of appropriate diets for primates. The technique involved no stressful manipulations such as the separation of monkeys from their usual cagemates, nor any great change to the animals' normal routine - an important factor in developing nutritional research methods for use with endangered species. Used in conjunction with information on diet in the wild, such techniques could be used to assess and refine diets and ensure that captive animals receive all the nutrients they require. This in turn should lead to improvements in the health and well-being of captive primates, and as a result, increase breeding success.

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