REPORT ON STEREOTYPIES SHOWN BY FOUR ELEPHANTS IN LONG-TERM HOLDING FACILITIES

An analysis of stereotypies in four elephants housed at Mary Chipperfield Promotions/Chipperfield Organisation during November and December 1997.

DEFINITION OF STEREOTYPY

Stereotypy is defined as *"a repeated, relatively invariate sequence of movements which has no obvious function"* (Broom & Johnson 1993). Despite this widely accepted definition, it is in fact unclear whether or not stereotypies are functional: they may or may not help animals to cope with their environments (Dantzer 1986; Mason 1991b; Rushen 1993). Stereotypies are most often observed when animals are confined and when there are constraints on their ability to perform certain behaviour patterns (Mason 1991a). They are believed to result from the frustration of specific motivations. In restrictive environments, strongly motivated behaviours gradually become modified or "channelled" into a few simple behavioural elements, which exhibit very little variability (Lawrence & Terlouw 1993; Rushen et al. 1993).

Stereotypies sometimes arise from the redirection of an appetitive behaviour pattern, such as foraging. An appetitive behaviour is one which is concerned with the procurement of a resource, rather than with its consumption. Animals are sometimes strongly motivated to perform such activities for their own sake, even when the resource in question is freely available (eg. Inglis & Ferguson 1986; Hughes et al. 1989; Fraser et al. 1991), but this is not always possible in a captive environment. Examples of such stereotypies include spot-picking in caged canaries, which is a redirected foraging activity (Keiper 1969) and belly-nosing in weaner pigs, which is a redirection of the motivation to suckle (van Putten & Dammers 1976). Other stereotypies are a consequence of feed restriction and probably have more to do with hunger than with a need to perform foraging behaviour. For example, postprandial stereotypies in sows, including chain manipulation, sham chewing, drinker manipulation and excessive drinking (Terlouw et al. 1991; Lawrence & Terlouw 1993). A third group of stereotypies develop from frustrated escape attempts, such as the stereotypic pacing observed before laying in caged hens with no access to a nest-box (Mills & Wood-Gush 1985).

Whether stereotypic behaviour is a coping attempt or a functionless behavioural pathology, its occurrence indicates that an animal has some difficulty coping with its environment and it is therefore an indicator of poor welfare. The more time an animal spends stereotyping, the poorer its welfare is said to be (Broom & Johnson 1993). In some cases, where a stereotypy has been carried out for a long time and the animal is no longer in the environment in which the stereotypy developed, the stereotypy may reveal more about the animal's welfare in its previous environment than about its present condition (Mason 1991b). Long-established stereotypies may become habits, unresponsive to improvements in the quality of the environment (Berkson et al. 1963; Keiper 1970; Stevenson 1983). However, in many cases a stereotypy is responsive to such changes and its incidence reflects the animal's current welfare.

OBJECTIVES

1) To describe the subjects' stereotypies and to ascertain how much of the day they spent performing them.

2) To establish whether the incidence of stereotypy was influenced by various management practices, including shackling, confinement in a small pen, the frequency of hay provision and the level of human activity in the elephant shed.

3) To investigate whether ongoing stereotypy was interrupted by specific events in the elephants' environment, including the provision of grain, hay and discrete food items, people entering the shed and the subjects' pens and the receipt of social contact from other elephants. Also, whether stereotypy was interrupted more frequently and for longer by some events than by others.

4) To investigate whether ongoing stereotypy reduced responsiveness to specific events. Also, whether responsiveness was reduced more to some events than to others.

MARY CHIPPERFIELD PROMOTIONS/CHIPPERFIELD ORGANISATION

Mary Chipperfield Promotions Ltd. was a permanent holding facility which trained and supplied animal acts to circuses and to the film and television industries. The Chipperfield Organisation Ltd., located at the same site, was an international animal supplier and transporter business. One of its clients was a safari park. Two Field Officers of the charity Animal Defenders gained employment with Mary Chipperfield Promotions/Chipperfield Organisation, between 7.10.97 and 26.1.98, and made undercover video recordings in the elephant shed. Cambridge University Animal Welfare and Human-Animal Interactions Group became aware of the undercover operation and video recordings at the time of a prosecution for cruelty. The analysis of video recordings occurred in 2001.

SUBJECTS

Four elephants were housed in the elephant shed during the observation period. At the start of the period, on 5.11.97, only three elephants, Opal, Rosa and Tembo, were present in the shed. They had been there from sometime before 7.10.97. The fourth elephant, Rhanee, was introduced later, on 22.11.97.

Rosa and Opal were female African elephants, 14 and 15 years of age respectively. Their recent history was not known (?). Tembo was a male African elephant, 12 years old. He had been been transferred from a safari park, earlier in the year. Rhanee was a 27 year old female Asian elephant. She had been supplied by Mary Chipperfield Promotions to a circus, for the touring season, before her arrival at the elephant shed. CITES certificates dated 1992 indicated that Rosa, Opal and Tembo had all originally been removed from the wild.

HOUSING AND MANAGEMENT

The four elephants were housed in two adjacent pens, measuring 10.0 x 7.8 m and 5.1 x 4.7 m. They were shackled at night by one front and one back leg. During the day, they were usually unshackled. The elephants were unshackled for about 7 hours a day on average, during the days on which observations were made. The two pens were separated by bars, which permitted physical contact between all individuals when unshackled.

Rosa and Opal were housed together in the larger of the two pens, throughout the observation period. Tembo was shackled in the larger pen at night, but moved to the smaller pen during the day, until 23.11.97. From 23.11.97 onwards, he was housed continually in the larger pen. When Rhanee was introduced, she was initially placed in the larger pen. However, from 23.11.97 onwards, she was housed continually in the smaller pen. Rosa, Opal and Tembo did not leave the elephant shed at any time during the observation period. Rhanee was occasionally taken outside for a training session, which would last approximately 10 minutes.

Apart from the elephants, several other animals were housed in the elephant shed during the observation period. Two horses were accommodated in pens opposite the elephants during the day, being taken outside for the night. A giraffe was housed continually in a pen opposite the elephants.

Mucking out, feeding, watering and shackling were carried out mainly by a single beastman (SG). Other members of staff (RC, MC), with whom the elephants were familiar, sometimes assisted with feeding and shackling. The daily routine began soon after 7.30 am, or 8.30 am on Sundays. If Tembo was to be moved to the smaller pen, this would be done first. There he would have access to water and fresh hay. Between an hour and an hour and a half would be spent mucking out. During this time, all

the elephants would be fed a bucket of grain and sometimes items from the supermarket wastebin, such as bread or vegetables. Once mucking out was complete, the occupants of the larger pen would be unshackled, allowing them to reach water and fresh hay. If Rhanee was present in the smaller pen, she would be unshackled either at or before this time. During the course of the day, the elephants would generally be provided with water and fresh hay at intervals. From around 3.30 to 4.00 pm, the elephants would be mucked out again, shackled and fed grain and sometimes supermarket items. Finally, they would be given a large quantity of hay for the night. If Tembo had been in the small pen for the day, he would not be moved to the larger pen and shackled until Rosa and Opal had been provided with hay. The lights in the shed would typically be turned out between 4.30 and 5.00 pm.

During the days on which observations were made, the elephants received water about 3.5 times a day on average and supermarket items about 1.5 times a day. Additionally, toward the end of the observation period, one member of staff began to hand-feed the elephants one or two small treats several times a day. Before 10.12.97, the elephants received hay about 6 times a day on average, but from this date onwards hay was provided only about 3 times a day.

The beastman frequently behaved in a threatening and violent manner toward the elephants. During the days on which observations were made, the number of violent incidents increased from about 2.5 a day, when there were three elephants in the shed, to about 8 a day when there were four. Violence was precipitated particularly by certain behaviours: when elephants attempted to consume hay before the bale had been distributed; and when they attempted to drink before the water barrel was full. It mostly took the form of punching, kicking and beating with implements including a shovel, a broom, a scraper and an iron bar. The elephants generally responded by moving away and sometimes by fleeing and hiding their heads in a corner of the pen.

During the course of the day, other members of staff would sporadically come and go, engaged in tasks unrelated to the elephants. These included RC, MC and the two Animal Defenders field officers, RW and TS. Occasionally there would be visitors, coming to see the elephants.

VIDEO DATA

Undercover video recordings were made in the elephant shed by Animal Defenders field officers between 4.11.97 and 2.1.98. A video camera was positioned under the roof, in one corner of the shed, so that the whole of the smaller pen and much of the larger pen was visible. On 11.11.97, the angle of the camera was altered, to make more of the larger pen visible. On most days, video recording began at 7.30 am (8.30 am on Sundays), shortly before the lights were turned on in the elephant shed. Recording usually ended after the lights were turned off at the end of the day, typically around 4.30 pm. On many days, the video recordings therefore captured the entire period during which there was light in the elephant shed, whether natural or artificial. The duration of this period, on the days selected for sampling, was about 9 hours on average.

SAMPLING

Days were selected for sampling on the basis of three criteria. First, no sampling day should have more than 40 minutes of missing data. Secondly, no two sampling days should be consecutive. Thirdly, days on which unusual and potentially disruptive events occurred should be avoided. This included occasional days on which the elephants were not unchained and days on which Rhanee was taken outside for training. The observation period, defined as the range of days on which sampling occurred, was from 5.11.97 to 17.12.97. This period was subdivided into three shorter periods, according to the identity of the elephants in the shed at the time and the management practices. During the first period (5, 7, 10, 12, 16 and 18.11), only Rosa, Opal and Tembo were present in the shed. Tembo was housed in the small pen during the day and the elephants were given hay about 6 times per day on average. Owing to the position of the camera before 11.11.97, Opal was not visible whilst shackled on 5, 7 or 10.11, so observations of Opal on these days were not analysed. During the second period (29.11 and 1, 3, 5 and 7.12), Rhanee was also present in the shed. Tembo was housed in the large pen and hay was provided about 6 times per day on average. Rhanee was introduced to the shed a week before this

period began, but observations made on the 23, 24 and 27.11 indicated that the disruptive effect which this had had upon the elephants' behaviour persisted until 27.11 or 28.11 (see Results section, Determination of when period 2 should begin). Rhanee was taken outside for three and a half minutes on 7.11, to show to some visitors, but this did not have a noticeable effect on her subsequent behaviour. During the third period (10, 12, 15 and 17.12), Rhanee was present, Tembo was housed in the large pen and hay was provided about 3 times per day on average.

Two sampling methods were employed. The first was an instantaneous sampling technique (Martin & Bateson 1993), in which the behaviour of all elephants in the shed was recorded at 5 minute intervals throughout the day. The number of occasions on which a given behaviour was recorded, divided by the number of times behaviour was sampled, yielded an estimate of the proportion of the day spent performing that behaviour. These data were used to address objectives (1) and (2), as well as to determine the date on which period 2 should begin.

The second sampling method consisted in observing the behaviour of the elephants before and after specific events. The chosen events were those listed above, plus the provision of water. On every occasion that one of these events occurred, a record was made of what each elephant was doing beforehand, whether its behaviour changed and, if so, what the new behaviour was. If a subject was stereotyping before the event and the stereotypy stopped, then a record was also made of how long it was before stereotypy resumed.

All events except social contact were regarded as being instantaneous, but a change in behaviour was recorded if it occurred within a period of about 10 seconds before the event, or 5 seconds afterwards. The use of a 10 second period before the event allowed for the fact that the elephants were sometimes able to anticipate events. For example they might hear a person approaching the shed, or see them entering the pen where hay was stored. The use of a 5 second period after the event was necessary because the exact moment at which an event occurred was sometimes difficult to pinpoint. For example, it took several seconds to carry hay from the hay pen to the elephants. There was also a delay between entering the larger pen and passing close to the elephants and this delay differed systematically between elephants when they were shackled. Tembo was shackled close to the pen gate, which meant that a person entering the pen by this route was immediately close to him. Rosa was shackled further away, so allowing a 5 second period for responding after pen entry was a means to standardise the nature of the event between these two subjects. Opal was shackled furthest from the pen gate and on many occasions a person entering the pen by this route would not pass close to her until much later, if at all. The implementation of a 5 second period following the event was not sufficient to deal with this eventuality. In fact, it was not possible to completely standardise the nature of the pen entry event between Opal and the other elephants. However, the discrepancy was minimised by recording any change in Opal's behaviour when the person in the pen first came close to her, in addition to changes in behaviour observed within 5 seconds of pen entry.

Social contact was not regarded as being instantaneous. A change in behaviour was recorded if it occurred at any time during the receipt of social contact, but not if it occurred before social contact began or after it had stopped.

In order to control for the possibility that a given behaviour change was spontaneous and not a consequence of the event in question, behaviour was also observed before and after a virtual "dummy" event. This involved making observations at 15 minute intervals throughout the day, as if an event had occurred at these times. A change in behaviour was recorded if it occurred within a period of 10 seconds before the "dummy" event, or 5 seconds afterwards. This time window was more than long enough to permit the "dummy" to act as a control for the social contact event. Observations made on 17.11.97 indicated that the receipt of social contact persisted for a median duration of 1 second (lower quartile = 0 s; upper quartile = 3 s), before there was either a response or a spontaneous cessation of contact. Whenever a change in behaviour could be attributed to an actual event, that instance of the "dummy" event was discarded for the subject in question. The samples which remained revealed how often a given subject's behaviour changed spontaneously during the time window used to observe responses to events. The data describing behavioural changes associated with events, real or virtual, were used to address objectives (3) and (4).

DETERMINATION OF WHEN PERIOD 2 SHOULD BEGIN

In order to determine the date on which period 2 should begin, it was necessary to monitor the time course of the effect which Rhanee's introduction to the elephant shed had upon the incidence of stereotypy. An initial reduction in time spent performing stereotypy was expected, followed by an increase to some stable level. Period 2 should not begin until the incidence of stereotypy had stabilised for all subjects. Because Opal did not exhibit a measurable incidence of stereotypy (see Results section, Objective 1) and in view of the fact that it was decided to analyse the effects of management practices and events upon the incidence of standing inactive in Opal instead (see Results section, Objective 2), the time course of the effect which Rhanee's introduction had upon standing inactive was monitored for Opal.

Figure 1 tracks how the proportion of the day spent performing these behaviours changed during the course of the observation period, for the four subjects. It can be seen that, for Tembo, the incidence of stereotypy was much lower on 23.11 (sampling day 7 in the figure, the calendar day after Rhanee's introduction) than on 18.11 (day 6) and that it remained low on 24.11 and 27.11 (days 8 and 9). It was not until 29.11 (day 10) that the incidence of stereotypy was observed to reach a level consistent with subsequent days. For Rhanee, the level of stereotypy was lower on 23.11 and 24.11 (days 7 and 8) than it was on subsequent days, but appeared to have stabilised by 27.11 (day 9). For Rosa, the incidence of stereotypy was slightly lower on 23.11 (day 7) than on most subsequent days, but by 24.11 (day 8) this was no longer the case. For Opal, the incidence of standing inactive was lower on 23.11, 24.11 and 27.11 (days 7, 8 and 9) than on subsequent days, but had stabilised by 29.11 (day 10).

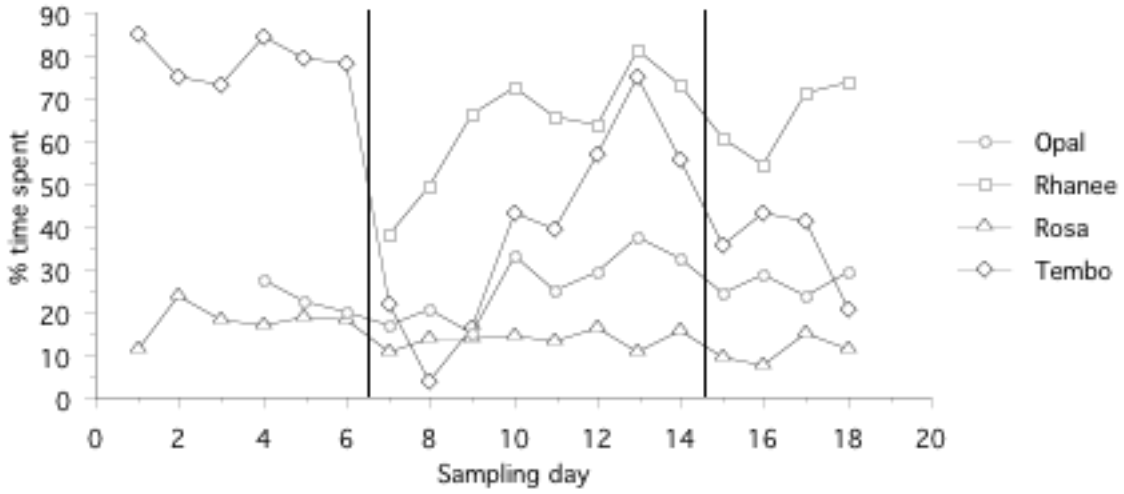

Figure 1. *Time course of the proportion of the day spent performing stereotypy (Tembo, Rhanee and Rosa), or standing inactive (Opal), throughout the observation period. The vertical lines represent the ends of periods 1 and 2.*

Since the proportion of the day spent performing the behaviours in question appeared to have reached a stable level in all subjects by 29.11, it was concluded that this should be the start date for period 2. Thus, period 2 began one week after Rhanee's introduction on 22.11.

OBJECTIVE 1

The first objective was to describe the subjects' stereotypies and to ascertain how much of the day they spent performing them.

Tembo's stereotypy was a head-bobbing movement. Relatively long periods of head-bobbing were interspersed with a short routine in which the head was raised and the trunk lifted, then both head and trunk were lowered. The morphology and rate of the stereotypy exhibited very little variability and Tembo had a preferred spot in both pens where he stood to perform it when unshackled. He frequently consumed hay whilst stereotyping, often carrying a trunkful of hay over to his spot so as to be able to do this. When not eating hay, his trunk was sometimes active, exploring the floor or bars, and sometimes inactive.

Table 1 shows the median percentage of the day which Tembo spent performing stereotypy and a number of other behaviours. The percentage of time spent performing a given behaviour was obtained from the scan data on each of the 15 sampling days and the median of these percentage times was calculated. The lower (25%) and upper (75%) quartiles of the range are also presented, to give an idea of the level of variability between days. It can be seen that Tembo typically spent 56.6% of the day performing stereotypy. He spent only 20.4% of his time eating hay and searching the floor for hay, which was substantially less than Rosa or Opal.

Table 1. *Median percentage of the day spent by Tembo performing various behaviours, including stereotypy*

BEHAVIOUR	MEDIAN % OF DAY SPENT	LOWER QUARTILE	UPPER QUARTILE
Stereotypy only	51.0%	38.9%	63.6%
Stereotypy plus eat hay or grain	8.0%	3.1%	14.6%
Stereotypy total	56.6%	41.6%	77.6%
Eat grain/discrete food items	1.9%	1.2%	3.3%
Eat hay and search floor	20.4%	10.7%	24.6%
Make social contact with elephant	1.9%	0.2%	3.9%
Locomotion only	3.1%	2.8%	5.0%
Stand inactive	5.8%	2.7%	11.2%
Out of sight	0.0%	0.0%	2.2%

Rhanee's stereotypy was a combination of head-bobbing and weaving. Weaving consists of a sideways swaying motion, in which the feet do not move, but the body pivots at pelvis, the amplitude of the swing being greatest at the head. As with Tembo, the morphology and rate of Rhanee's stereotypy exhibited very little variability and she had a preferred spot in which to perform it when unshackled. She also frequently consumed hay whilst stereotyping, sometimes carrying a trunkful of hay over to her spot. When not eating hay, her trunk was sometimes active, exploring the floor or bars.

Table 2 shows the median percentage of the day which Rhanee spent performing stereotypy and other behaviours. The median was taken across 9 sampling days. She typically spent 71.0% of the day stereotyping. She also spent 6.5% of the day making social contact with other elephants, which is high for a behaviour with a short bout length. She spent only 13.2% of her time eating hay and searching the floor for hay.

Table 2. *Median percentage of the day spent by Rhanee performing various behaviours, including stereotypy*

BEHAVIOUR	MEDIAN % OF DAY SPENT	LOWER QUARTILE	UPPER QUARTILE
Stereotypy only	57.1%	48.8%	60.6%
Stereotypy plus eat hay	12.3%	10.4%	15.1%
Stereotypy total	71.0%	62.8%	73.0%
Eat grain/discrete food items	2.3%	1.9%	3.1%
Eat hay and search floor	13.2%	10.8%	16.2%
Make social contact with elephant	6.5%	6.0%	9.2%
Locomotion only	0.0%	0.0%	0.9%
Stand inactive	4.4%	2.5%	4.8%
Out of sight	0.0%	0.0%	0.0%

Rosa's stereotypy was much more variable, in terms of morphology and rate, than Tembo's or Rhanee's. Also, it occurred mainly when she was shackled. Usually, it took the form of weaving, but occasionally she exhibited a forwards stepping motion, in which one step was taken forward, then one back. The frequency and amplitude of the weaving stereotypy was variable, but it tended to take two forms. One was rapid, with a large amplitude, and was seen only when Rosa was shackled. The other was slow, with a small amplitude. This form was easiest to spot when the video tape was played in fast-forward mode. When shackled, relatively long periods of weaving were often interspersed with a routine in which Rosa took several steps to the side, then turned and stepped back. Whilst stereotyping, her trunk was sometimes active, exploring the floor or bars. She was occasionally observed to consume hay whilst stereotyping.

Table 3 shows the median percentage of the day, taken across 15 sampling days, which Rosa spent performing stereotypy and other behaviours. It can be seen that Rosa typically spent 15.1% of the day performing stereotypy. This is a substantial investment of time, but considerably less than that spent by Tembo or Rhanee. She spent 8.0% of her time walking, suggesting that she was often restless. However, she also spent 14.5% of her time standing inactive. The bout length of standing inactive was often in the order of tens of minutes, which was very rarely the case for Tembo or Rhanee.

Table 3. *Median percentage of the day spent by Rosa performing various behaviours, including stereotypy*

BEHAVIOUR	MEDIAN % OF DAY SPENT	LOWER QUARTILE	UPPER QUARTILE
Stereotypy plus eat hay or grain	0.0%	0.0%	1.0%
Stereotypy (fast) total	3.8%	0.9%	6.8%
Stereotypy (slow) total	8.5%	7.1%	11.1%
Stereotypy total	15.1%	11.1%	17.6%
Eat grain/discrete food items	2.9%	1.9%	3.7%
Eat hay and search floor	48.4%	44.6%	51.9%
Make social contact with elephant	1.1%	0.0%	2.8%
Locomotion only	8.0%	5.4%	11.2%
Stand inactive	14.5%	4.6%	19.2%
Out of sight	5.7%	1.9%	8.8%

Opal did not exhibit any stereotypy, except sometimes very briefly when about to receive grain. This took the form of weaving.

Table 4 shows the median percentage of the day, taken across 12 sampling days, which Opal spent performing stereotypy and other behaviours. Opal typically spent 28.0% of the day standing inactive. This was much higher than the other elephants. The bout length of standing inactive was often in the order of tens of minutes and periods of 30 minutes or more were not unusual.

***Table 4**. Median percentage of the day spent by Opal performing various behaviours, including stereotypy*

BEHAVIOUR	MEDIAN % OF DAY SPENT	LOWER QUARTILE	UPPER QUARTILE
Stereotypy total	0.0%	0.0%	0.0%
Eat grain/discrete food items	2.8%	2.1%	3.9%
Eat hay and search floor	51.1%	43.8%	57.1%
Make social contact with elephant	0.9%	0.0%	2.2%
Locomotion only	6.1%	3.7%	7.6%
Stand inactive	28.0%	24.0%	30.9%
Out of sight	6.1%	3.9%	10.7%

OBJECTIVE 2

The second objective was to establish whether the incidence of stereotypy was influenced by various management practices. Certain management practices varied during the observation period, either within or between days, making it possible to analyse their effects upon stereotypy. Because Opal did not exhibit a measurable incidence of stereotypy, but instead spent a great deal of time standing inactive, the effects which management practices had upon the incidence of standing inactive were analysed for this subject. It was hoped that this might shed some light upon the motivational basis of this behaviour in Opal.

Two management practices differed between days. These were confinement in a small pen and the frequency of hay provision. The observation period was divided into three shorter periods on the basis of differences in these practices, as has already been indicated. Tembo was housed for much of the day in the smaller pen during period 1, but was housed with Rosa and Opal in the larger pen during periods 2 and 3. The elephants received hay about 6 times a day on average during periods 1 and 2, but only about 3 times a day during period 3. The effects which these two management practices had upon the incidence of stereotypy or standing inactive were analysed simultaneously, by comparing the three periods using a one-way ANOVA. In the case of Rhanee, who was only present in the shed during periods 2 and 3, a t test was employed instead. The four subjects were tested individually, with one ANOVA or t test per subject. An arcsine squareroot transformation rendered the data homogeneous with respect to variance, as indicated by Levene's test (Howell 1997). The data sets were too small to test for normality. Because the same statistical procedure was being repeated for four subjects, the ANOVAs and the t test would have exhibited a familywise error rate (FW) of $1 - (1 - 0.05)^4 = 0.185$, when the significance criterion was 0.05. To hold FW at 0.05, it was necessary to reduce the significance criterion of these tests to 0.0127. Likewise, to hold FW at 0.01 and 0.001, the significance criterion was reduced to 0.00251 and 0.00025 respectively. Where an ANOVA indicated that a significant difference existed between the three periods, Fisher's least significant difference (LSD) procedure was used to make pairwise comparisons (Howell 1997). The results are shown in Figure 2.

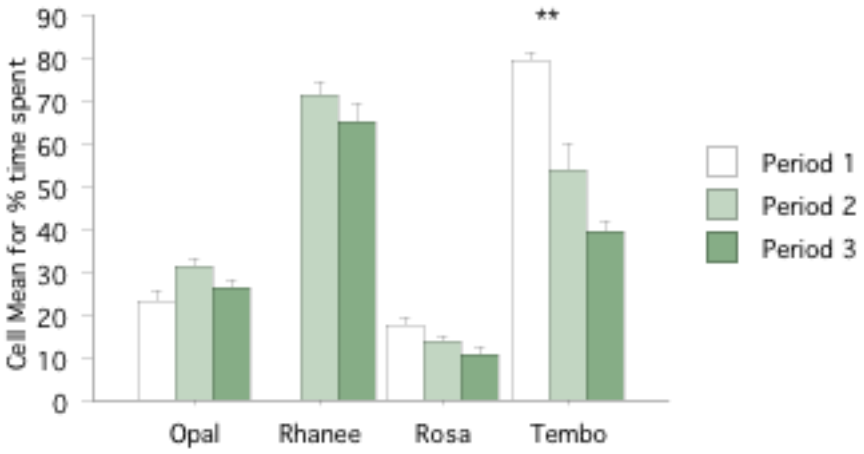

Figure 2. *Means and 95% confidence intervals for the percentage time spent performing stereotypy (Tembo, Rhanee and Rosa), or standing inactive (Opal), during periods 1, 2 and 3. For Tembo, the last day of period 3 was omitted, due to an outlying data value. Asterisks indicate a significant difference between a given pair of periods, for a given subject (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

For Tembo, the ANOVA showed a difference amongst the three periods, which satisfied the FW = 0.001 significance criterion ($F_{2,12}$ = 23.9; p <= 0.0001***). Fisher's LSD indicated that Tembo spent a greater proportion of the day stereotyping during period 1, when housed alone in a small pen for much of the day, than during period 2, when housed continually in a larger pen with other elephants (LSD = 0.143; mean diff. = 0.273; p < 0.01). However, it also indicated that he spent more time stereotyping during period 2, when receiving hay 6 times per day on average, than during period 3, when receiving hay only 3 times per day (LSD = 0.159; mean diff. = 0.200; p < 0.05). The latter result may have been an artefact of the unusually low incidence of stereotypy observed on the last day of period 3, 17.11.97 (qv. Figure 1). When the analysis was repeated with this day omitted, the difference between periods 2 and 3 was rendered non-significant (LSD = 0.156; mean diff. = 0.144; NS).

For Rhanee, the t test revealed no difference between periods 2 and 3 (t_7 = 1.19; NS), indicating that the proportion of the day spent stereotyping was unaffected by the frequency of hay provision. For Rosa, there was no difference between the three periods ($F_{2,12}$ = 5.05; NS), indicating that neither Tembo's movement to the larger pen, nor a reduced frequency of hay provision influenced the incidence of stereotypy. For Opal, there was also no difference between the three periods ($F_{2,9}$ = 4.22; NS), demonstrating that these changes in management had no effect on the proportion of the day spent standing inactive.

There were also two management practices which differed within days. These were shackling and the level of human activity in the elephant shed. It has already been noted that the elephants were unshackled in the morning and shackled again towards the end of the afternoon. It has also been indicated that the level of human activity in the shed varied during the day. There was a lot of activity in the first hour or two of the morning and in the last hour of the afternoon, which included mucking out, feeding and watering. However, between these times, people entered the shed only occasionally, usually either to give the elephants hay or water, or to carry out tasks unrelated to the elephants. Because high levels of human activity tended to coincide with periods spent shackled, it was inevitable that the effects of these management factors would be entangled to some extent. This was bourne in mind when interpreting the results of the analysis. A two-way repeated measures ANOVA was

envisaged for each subject, with shackled/not shackled and the presence/absence of humans in the shed as independent variables and day number as the repeated measure. (The frequency of stereotypy or standing inactive on one sampling day was expected to be independent of the frequency on the next, because consecutive calendar days were never sampled.) However, because there were no between-subjects variables (ie. all subjects received both levels of both independent variables) it was in fact necessary to carry out the analysis as if the design had been factorial, treating day number as an independent variable. The resulting three-way ANOVA had just one score per cell, leaving no residual for estimating the error term. However, in this model the error mean square is not required to calculate F ratios for the management factors, because the interaction mean squares are used instead (Howell 1997). An arcsine squareroot transformation rendered the data homogeneous with respect to variance, as indicated by Levene's test. The data sets were too small to test for normality. As in the previous analysis, it was necessary to reduce the significance criteria of the ANOVAs from 0.05 to 0.0127, from 0.01 to 0.00251 and from 0.001 to 0.00025, so as to hold FW at 0.05, 0.01 and 0.001 respectively. The results are shown in Figures 3 and 4.

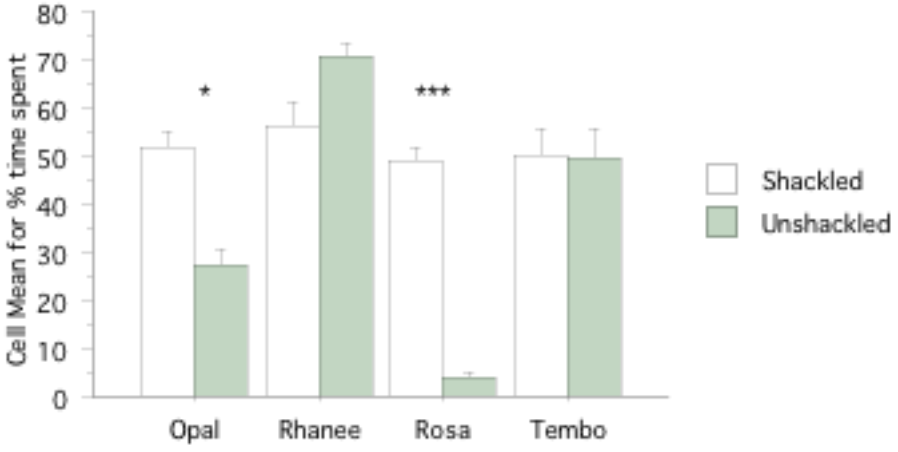

Figure 3. *Means and 95% confidence intervals for the percentage time spent performing stereotypy (Tembo, Rhanee and Rosa), or standing inactive (Opal), whilst shackled and whilst unshackled (1 day omitted, due to missing values). Asterisks indicate a significant difference between these conditions, for a given subject (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

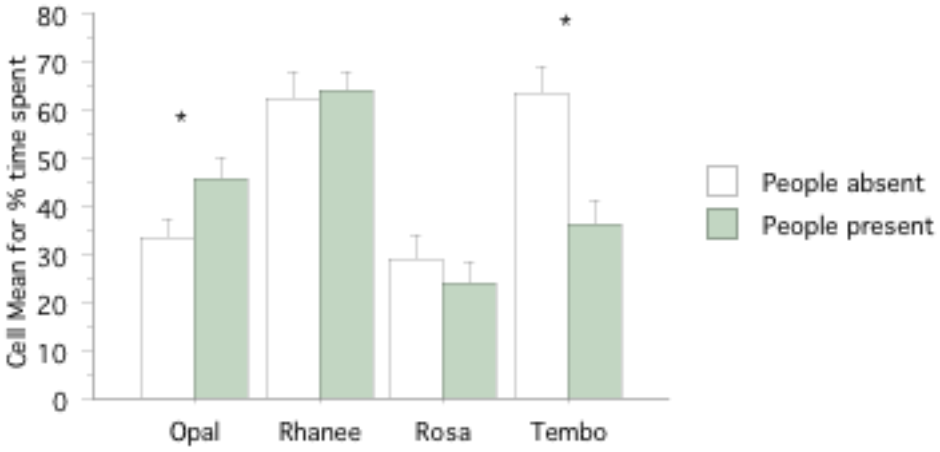

Figure 4. *Means and 95% confidence intervals for the percentage time spent performing stereotypy (Tembo, Rhanee and Rosa), or standing inactive (Opal), whilst people were present in the shed and whilst people were absent (1 day omitted, due to missing values). Asterisks indicate a significant difference between these conditions, for a given subject (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

For Tembo, unshackling had no effect upon the time spent stereotyping ($F_{1,13}$ = 0.02; NS), but less time was spent stereotyping when people were present in the shed ($F_{1,13}$ = 13.5; p = 0.0028*). There was no interaction between these two variables ($F_{1,13}$ = 0.36; NS). For Rhanee, neither unshackling ($F_{1,7}$ = 2.39; NS) nor the presence of people in the shed ($F_{1,7}$ = 0.00; NS) influenced the incidence of stereotypy. For Rosa, unshackling reduced the time spent stereotyping ($F_{1,13}$ = 236.0; p <= 0.0001***), but the presence of people in the shed had no effect ($F_{1,13}$ = 5.06; NS). There was no interaction between these variables ($F_{1,13}$ = 0.36; NS). For Opal, unshackling reduced the time spent standing inactive ($F_{1,10}$ = 14.39; p = 0.0035*), whilst the presence of people in the shed increased the time spent standing inactive ($F_{1,10}$ = 13.16; p = 0.0046*). No interaction was found ($F_{1,10}$ = 3.14; NS). For all four subjects, one day (10.12.97) was omitted from the analysis, because of a missing data value.

OBJECTIVE 3

The third objective was to investigate whether ongoing stereotypy was interrupted by specific events in the elephants' environment. Also, whether stereotypy was interrupted more frequently and for longer by some events than by others. In the case of Opal, the tendency of events to interrupt an ongoing bout of standing inactive was investigated instead.

The events which were analysed were: the receipt of grain, hay and discrete food items; hay being fetched, but not given to the subject; people entering the shed; people entering the subject's pen; and the receipt of social contact from other elephants. In cases where hay was fetched from the hay pen, but not given to the subject, it was either given to an elephant or a horse in another pen, or carried outside. The provision of grain, hay and discrete food items were merged into a single event, partly because these resources were all food items and thus motivationally related and partly because the frequencies with which these events interrupted ongoing stereotypy or standing inactive were very similar. However, when it came to ascertaining whether some events interrupted stereotypy for longer than others, the receipt of grain, hay and discrete food items were analysed individually. Various people entered the elephant shed over the course of the observation period, but most entries were made by the beastman and other members of staff (RC, MC, RW, TS), with whom the elephants were familiar. In order to make the event easier to interpret, only entries by these individuals were included in the analysis. Almost all entries to the elephant pens were by the beastman and two members of staff (RC, MC). For the same reason, entries by other individuals were excluded from the analysis. The receipt of water was not analysed because the responsiveness of subjects to this event was highly variable, depending on the beastman's location and behaviour. Drinking water too soon sometimes precipitated violence.

In order to ensure that a subject's response to one event was reasonably independent of its response to a previous event of the same kind, events which tended to elicit protracted responses (the provision of hay and water) were omitted from the analysis when they occurred less than 10 minutes after a similar event. The figure of 10 minutes was obtained from preliminary observations of the elephants' behaviour. Additionally, incidents of hay being fetched, but not given to the subject, were omitted from the analysis when the subject had received hay less than 10 minutes beforehand.

The analysis was carried out in three stages, corresponding to the three components of the objective. The first stage was to ascertain whether stereotypy or standing inactive were interrupted by any of these events. This meant establishing whether stereotypy (say) stopped more frequently at the time of the event than it did when no event was occurring. The frequency with which stereotypy stopped at the

time of each event was therefore compared with the frequency with which it stopped in the time window ascribed to the "dummy" event. To ensure that the frequencies with which stereotypy stopped were comparable between different events, some of which occurred more often whilst stereotypy was ongoing than others, it was necessary to work with percentage frequencies. The percentage frequency with which stereotypy stopped was calculated by dividing number of times it stopped when a given event occurred by the number of times stereotypy was ongoing before the event.

Because stereotypy and standing inactive were almost always interrupted by the receipt of grain, hay and discrete food items, this variable exhibited very little variance and it was not possible to obtain homogeneity of variance in the data set. Therefore, a non-parametric analysis was required. The Friedman two-way ANOVA by ranks (Siegel & Castellan 1988) was used to ascertain whether there were any significant differences amongst the events, including the "dummy" event. The four subjects were tested individually, with one Friedman test per subject, day number being a repeated measure. It was necessary to reduce the significance criteria of the Friedman tests from 0.05 to 0.0127, from 0.01 to 0.00251 and from 0.001 to 0.00025, in order to hold FW at 0.05, 0.01 and 0.001 respectively. Where a Friedman test indicated that a significant difference existed between the events, Siegel & Castellan's (1988) *post hoc* procedure for making comparisons with a control was used, to make pairwise comparisons between each real event and the "dummy". Because the objective was to ascertain whether stereotypy or standing inactive stopped more often at the time of a real event than during the "dummy" event window, the *post hoc* tests were one-tailed.

It was not possible to analyse all of the events for all subjects. On some days, stereotypy in a given subject was never ongoing before a particular event. When this was the case, the subject's percentage frequency of stopping could not be calculated for that event on those days. Because a repeated measures design does not tolerate missing values, inclusion of such events in the analysis usually meant omitting one or more days from the analysis, with a consequent loss of power. An exception was made for the receipt of grain, hay and discrete food items. Because ongoing stereotypy and standing inactive were almost always interrupted by this composite event, it was decided to insert a percentage frequency of 1.00 in the few cases where a missing value occurred. Owing to a large number of missing values, the receipt of social contact was not analysed for Rosa or Opal. People entering the pen was analysed for Tembo, despite six missing values. In this case, the analysis was repeated with this event omitted, to investigate whether increasing the power of the analysis would reveal differences between other events. The missing values occurred on the six days of period 1, when Tembo was housed mainly in the smaller pen. Hence, when this event was analysed, it represented people entering the larger pen during periods 2 and 3. The results are shown in Figures 5 to 8.

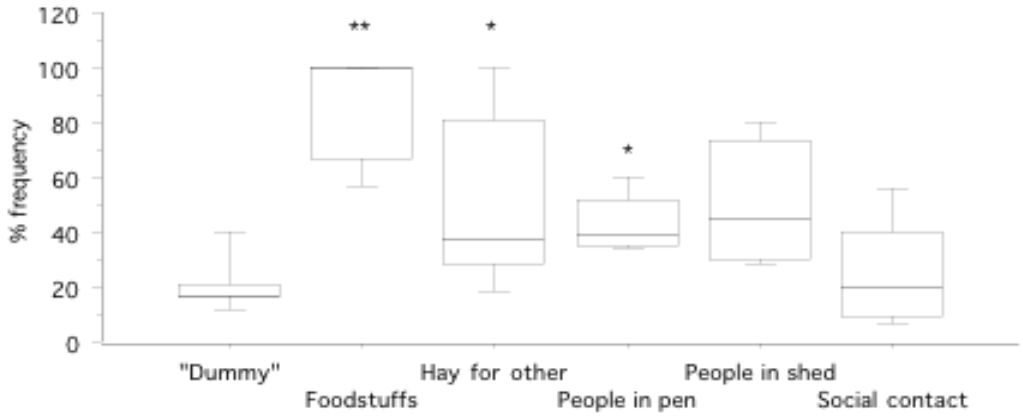

Figure 5A*. Tembo (people in pen included): box plot, showing medians, interquartile ranges and inner fences for the percentage frequency with which various events interrupted ongoing stereotypy during the course of the observation period (all 6 days of period 1 were omitted, due to missing values). Asterisks indicate a significant difference between a given event and the "dummy" variable (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

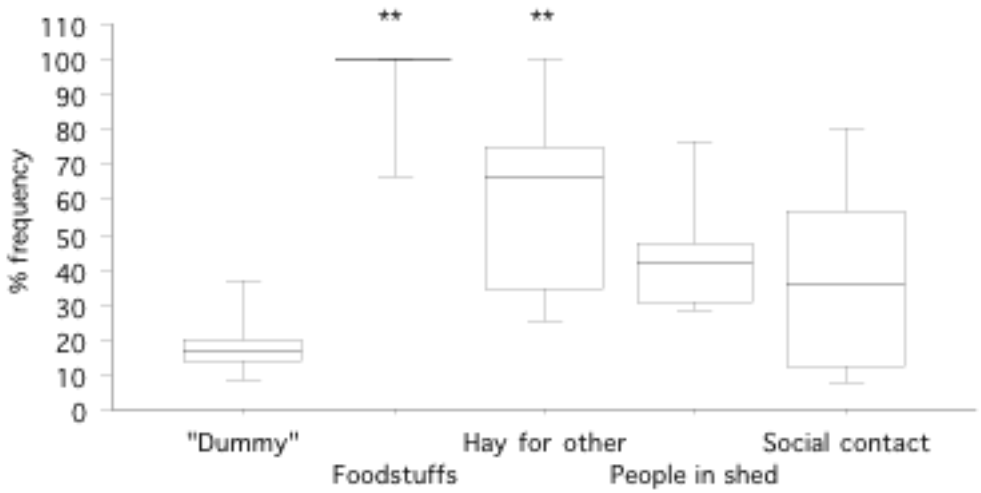

***Figure 5B**. Tembo (people in pen excluded): box plot, showing medians, interquartile ranges and inner fences for the percentage frequency with which various events interrupted ongoing stereotypy during the course of the observation period (no days were omitted). Asterisks indicate a significant difference between a given event and the "dummy" variable (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

For Tembo (Figure 5A), the Friedman test revealed a significant difference amongst the events, including the "dummy" (F_r = 25.7; k = 6; N = 9; p <= 0.0001***). The *post hoc* tests indicated that the receipt of grain, hay and discrete food items (critical diff. = 17.8; rank diff. = 34.0; p < 0.01), hay being fetched, but not given to the subject (critical diff. = 17.8; rank diff. = 19.5; p < 0.05) and people entering the subject's pen (critical diff. = 17.8; rank diff. = 18.5; p < 0.05) all interrupted ongoing stereotypy. People entering the shed (critical diff. = 17.8; rank diff. = 16.5; NS) and the receipt of social contact from other elephants (critical diff. = 17.8; rank diff. = 1.5; NS) did not. Repetition of the analysis, with people entering the pen omitted (k = 5; N = 15), made no difference to the results (Figure 5B).

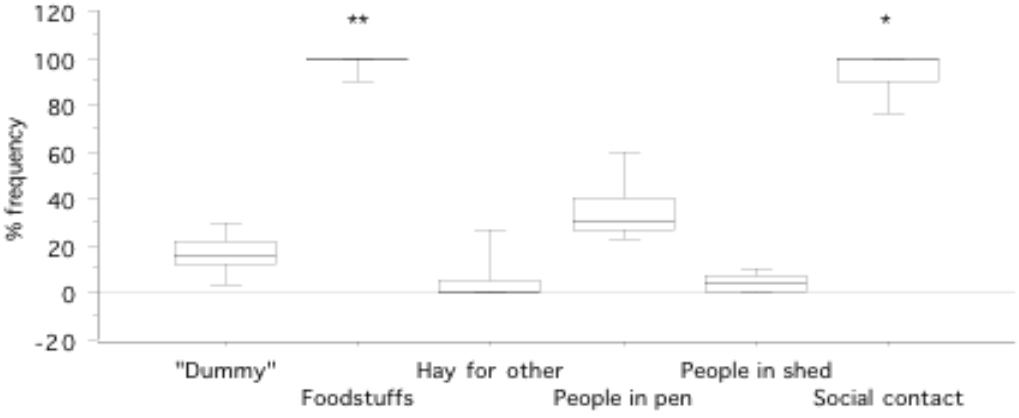

***Figure 6**. Rhanee: box plot, showing medians, interquartile ranges and inner fences for the percentage frequency with which various events interrupted ongoing stereotypy during the course of the observation period (1 day was omitted, due to missing values). Asterisks indicate a significant difference between a given event and the "dummy" variable (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

For Rhanee (Figure 6), there were also significant differences amongst the events (F_r = 37.8; k = 6; N = 8; p <= 0.0001***). *Post hoc* tests indicated that the receipt of grain, hay and discrete food items (critical diff. = 16.8; rank diff. = 23.0; p < 0.01) and the receipt of social contact from other elephants (critical diff. = 16.8; rank diff. = 21.0; p < 0.05) both interrupted ongoing stereotypy, whilst hay being fetched, but not given to the subject (critical diff. = 16.8; rank diff. = -9.5; NS), people entering the shed (critical diff. = 16.8; rank diff. = -8.5; NS) and people entering the subject's pen (critical diff. = 16.8; rank diff. = 10.0; NS) did not.

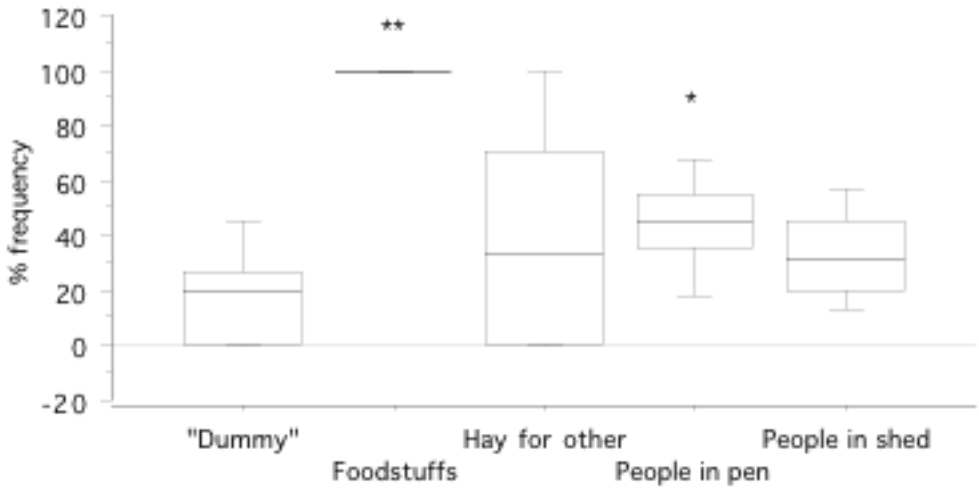

***Figure 7**. Rosa: box plot, showing medians, interquartile ranges and inner fences for the percentage frequency with which various events interrupted ongoing stereotypy during the course of the observation period (2 days were omitted, due to missing values). Asterisks indicate a significant difference between a given event and the "dummy" variable (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

For Rosa (Figure 7), there were significant differences amongst the events (F_r = 30.7; k = 5; N = 13; p <= 0.0001***). *Post hoc* tests revealed that the receipt of grain, hay and discrete food items (critical diff. = 17.4; rank diff. = 42.5; p < 0.01) and people entering the subject's pen (critical diff. = 17.4; rank diff. = 20.0; p < 0.05) interrupted ongoing stereotypy. Hay being fetched, but not given to the subject (critical diff. = 17.4; rank diff. = 15.5; NS) and people entering the shed (critical diff. = 17.4; rank diff. = 12.0; NS) did not.

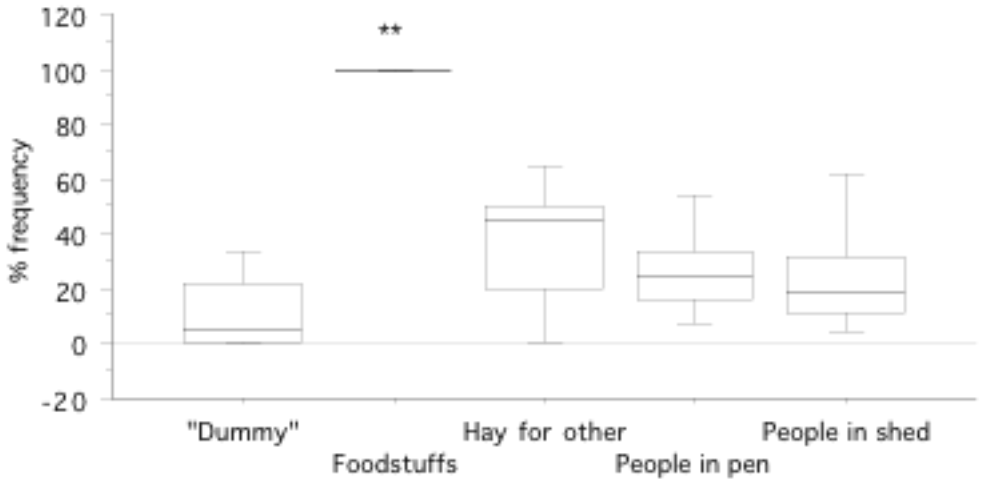

Figure 8. *Opal: box plot, showing medians, interquartile ranges and inner fences for the percentage frequency with which various events interrupted ongoing bouts of standing inactive during the course of the observation period (no days were omitted). Asterisks indicate a significant difference between a given event and the "dummy" variable (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

For Opal (Figure 8), there were again significant differences amongst the events (F_r = 29.0; k = 5; N = 12; p <= 0.0001***). Only the receipt of grain, hay and discrete food items (critical diff. = 16.7; rank diff. = 38.0; p < 0.01) interrupted ongoing bouts of standing inactive. Hay being fetched, but not given to the subject (critical diff. = 16.7; rank diff. = 15.5; NS), people entering the shed (critical diff. = 16.7; rank diff. = 5.0; NS) and people entering the subject's pen (critical diff. = 16.7; rank diff. = 14.0; NS) did not.

The second stage of the analysis was to ascertain whether stereotypy or standing inactive was interrupted more frequently by some real events than by others. This analysis was confined to those events which had already been shown to interrupt the behaviour in question. Because only one event had interrupted ongoing bouts of standing inactive in Opal, only Tembo, Rhanee and Rosa were included in the analysis. Where three or more behaviours had interrupted stereotypy, they were compared using the Friedman test, followed by Siegel & Castellan's (1988) *post hoc* procedure for multiple comparisons between groups, to test all pairwise comparisons. Where only two behaviours had done so, they were instead compared using the Wilcoxon signed ranks test (Siegel & Castellan 1988). With three subjects, the Friedman and Wilcoxon tests would have exhibited a familywise error rate of $1 - (1 - 0.05)^3 = 0.143$, when the significance criterion was 0.05. To hold FW at 0.05, the significance criterion of these tests was reduced to 0.0169. Likewise, to hold FW at 0.01 and 0.001, the significance criterion was reduced to 0.00334 and 0.00033 respectively.

For Tembo (Figure 5A), the Friedman test indicated that there were no significant differences amongst the receipt of grain, hay and discrete food items, hay being fetched, but not given to the subject and people entering the subject's pen (F_r = 6.59; k = 3; N = 9; NS). However, when the analysis was repeated, with people entering the pen omitted (Figure 5B), a Wilcoxon test revealed that stereotypy was interrupted more often by the receipt of grain, hay and discrete food items than it was by people entering the subject's pen (z = -2.94; N = 15; p = 0.0032**). Because the sum of ranks assigned in the Friedman test to hay being fetched, but not given to the subject, was lower than the sum of ranks assigned to people entering the subject's pen, it is likely that a significant difference would also have been found between the receipt of grain, hay and discrete food items and hay being fetched, but not given to the subject, if the power of this test had been greater.

For Rhanee (Figure 6), the Wilcoxon test revealed no significant difference between the frequencies with which stereotypy was interrupted by the receipt of grain, hay and discrete food items and by the receipt of social contact from other elephants ($z = -1.34$; $N = 8$; NS). For Rosa (Figure 7), it was found that stereotypy was interrupted more frequently by the receipt of grain, hay and discrete food items than it was by people entering the subject's pen ($z = -3.18$; $N = 13$; $p < 0.01$).

The third stage of the analysis was to ascertain whether stereotypy was interrupted for longer by some events than by others. The corresponding analysis of standing inactive was not carried out for Opal, because of the difficulty in distinguishing a short bout of this behaviour, which could have been a response to a subsequent event, or simply a pause between activities, from an extended bout, which may have been motivationally distinct. Once again, the comparison was confined to those events which had already been shown to interrupt stereotypy. Unlike in the previous analyses, a repeated measures design was not employed. The use of frequencies presupposes a fixed period of time over which they are to be measured, such as a day, but the use of durations does not. In fact, the clustering of duration scores by day would have been inappropriate. It would have meant entering median durations into the analysis, with a consequent loss of information. Furthermore, because the duration scores on a given day were typically few in number and highly variable in magnitude, the loss of information would have been substantial. Therefore, a factorial design was employed instead, treating individual events as independent. The assumption that successive events on a given day were independent was reasonable, because a period of time, often bringing other events, invariably elapsed between them. The decision to omit hay-related events from the analysis when they occurred less than 10 minutes after the receipt of hay also helped to make this assumption reasonable.

The receipt of grain, hay and discrete food items, which as a composite event had been shown to interrupt stereotypy or standing inactive in all subjects, was decomposed into three discrete events for the present analysis. In the case of Rosa, the receipt of hay was omitted from the analysis, owing to a large number of missing values. The duration scores for these events and for any others which had been shown to interrupt the behaviour in question were compared using the Kruskall-Wallis one-way ANOVA by ranks (Siegel & Castellan 1988), followed by Siegel & Castellan's (1988) *post hoc* procedure for multiple comparisons between groups, which tested all pairwise comparisons. The three subjects were tested individually, with one Kruskall-Wallis per subject. As in the previous analysis, it was necessary to reduce the significance criteria of the Kruskall-Wallis tests from 0.05 to 0.0169, from 0.01 to 0.00334 and from 0.001 to 0.00033, in order to hold FW at 0.05, 0.01 and 0.001 respectively. The results are shown in Figures 9 to 11.

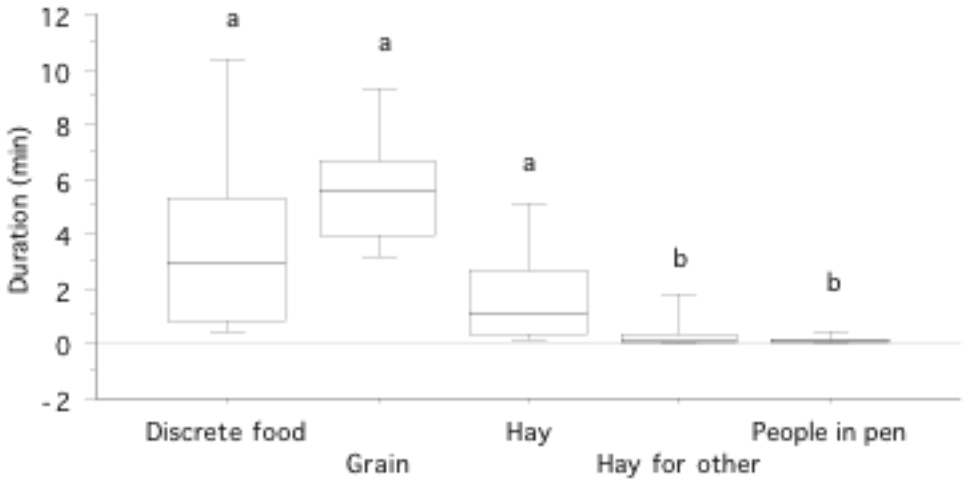

Figure 9*. Tembo: box plot, showing medians, interquartile ranges and inner fences for the duration for which various events interrupted ongoing stereotypy during the course of the observation period. Events which share the same superscript letter do not differ significantly from one another.*

For Tembo, the Kruskall-Wallis test indicated that there were significant differences amongst the events (KW_4 = 76.0; p <= 0.0001***). The *post hoc* tests showed that the events fell into two groups: (1) the receipt of grain, the receipt of hay and the receipt of discrete food items; and (2) hay being fetched, but not given to the subject, and people entering the subject's pen. Events within a given group interrupted stereotypy for similar durations, whilst the events in group (1) interrupted stereotypy for longer than those in group (2). (Grain received vs. hay fetched: crit. diff. = 38.8; rank diff. = 73.1; p < 0.001. Grain received vs. people in pen: crit. diff. = 35.3; rank diff. = 85.5; p < 0.001. Hay received vs. hay fetched: crit. diff. = 35.6; rank diff. = 45.9; p < 0.01. Hay received vs. people in pen: crit. diff. = 31.9; rank diff. = 58.2; p < 0.001. Discrete food items received vs. hay fetched: crit. diff. = 45.4; rank diff. = 62.4; p < 0.01. Discrete food items received vs. people in pen: crit. diff. = 42.5; rank diff. = 74.7; p < 0.001.)

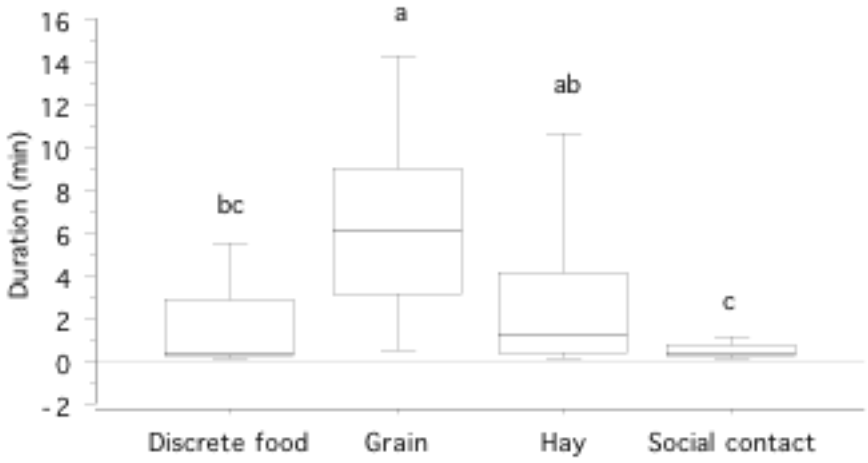

Figure 10*. Rhanee: box plot, showing medians, interquartile ranges and inner fences for the duration for which various events interrupted ongoing stereotypy during the course of the observation period. Events which share the same superscript letter do not differ significantly from one another.*

For Rhanee, there were also significant differences amongst the events (KW_3 = 24.0; p <= 0.0001***). *Post hoc* tests revealed that the receipt of grain interrupted stereotypy for longer than either the receipt of discrete food items (crit. diff. = 27.8; rank diff. = 34.2; p < 0.01), or the receipt of social contact from other elephants (crit. diff. = 23.8; rank diff. = 44.9; p < 0.001). The receipt of discrete food items and the receipt of social contact interrupted stereotypy for similar durations (crit. diff. = 23.3; rank diff. = 10.7; NS). The receipt of hay interrupted stereotypy for a duration which was intermediate between the receipt of grain and the receipt of discrete food items. It exhibited a very high level of variability in its duration scores and differed significantly from neither of these events. It interrupted stereotypy for longer than the receipt of social contact (crit. diff. = 18.5; rank diff. = 23.5; p < 0.01).

Figure 11. *Rosa: box plot, showing medians, interquartile ranges and inner fences for the duration for which various events interrupted ongoing stereotypy during the course of the observation period. Events which share the same superscript letter do not differ significantly from one another.*

For Rosa, there were again significant differences amongst the events ($KW_2 = 57.8$; $p <= 0.0001$***). The receipt of grain (crit. diff. = 19.0; rank diff. = 57.9; $p < 0.001$) and the receipt of discrete food items (crit. diff. = 30.6; rank diff. = 38.0; $p < 0.01$) both interrupted stereotypy for longer than people entering the subject's pen. The receipt of discrete food items exhibited a very high level of variability in its duration scores and sid not differ significantly from the receipt of grain (crit. diff. = 33.9; rank diff. = 19.9; NS).

OBJECTIVE 4

The fourth objective was to investigate whether ongoing stereotypy reduced responsiveness to specific events. Also, whether responsiveness was reduced more to some events than to others. In the case of Opal, the effect of an ongoing bout of standing inactive was investigated instead.

The events which were analysed were the same as those in the previous objective: the receipt of grain, hay and discrete food items; hay being fetched, but not given to the subject; people entering the shed; people entering the subject's pen; and the receipt of social contact from other elephants. As in the previous analysis, entries to the shed or pen were included only when made by individuals who frequently did so and hay-related events were included only when they occurred more than 10 minutes after the previous receipt of hay.

It was necessary at the outset to decide what kinds of behaviour changes, occurring at the time of an event, might unambiguously be interpreted as responses. It was reasoned that behaviours which oriented the subject toward or away from the event, as well as behaviours which brought the subject into contact with a person, elephant or substrate involved in the event, should be classed as responses. Thus, turning toward, approaching, reaching for, touching, or moving away from a person who had entered the shed or pen was called a response. Also: reaching for, touching, or eating hay, grain and discrete food items; turning toward, approaching, or reaching for a person who was carrying hay elsewhere; and touching or moving away from an elephant who was making social contact. Two other behaviours were classed as responses to events: head shaking and trunk lifting. These behaviours mostly occurred when a person was approaching or entering the pen and usually when they were carrying grain or discrete food items. Behaviours which oriented the subject toward or away from, or brought it into contact with, a person, elephant or substrate *not* involved in the event were not classed

as responses. Nor were changes of behaviour to standing inactive or stereotypy. Some cases of standing inactive and stereotypy *might* have been responses to the event, but their lack of directionality made this unclear. It is worth noting that behaviour rarely changed to stereotypy at the time of an event, or when an event was imminent.

The analysis was carried out in two stages, corresponding to the two components of the objective. The first stage was to ascertain whether ongoing stereotypy or standing inactive reduced the subjects' responsiveness to any of these events. This meant establishing whether a subject's responsiveness to a given event was less when stereotypy (say) was ongoing than it was when some other behaviour was ongoing. In fact, it was decided to exclude eating grain and discrete food items from the category of "other behaviour", because preliminary observations had indicated that these activities were very rarely interrupted by events and that they were distinct from all other behaviours in this respect. The frequency with which a subject responded to a given event when stereotypy was ongoing was divided by the frequency with which the event occurred when stereotypy was ongoing, to yield the percentage frequency with which the subject responded. The percentage frequency with which the subject responded when some other behaviour was ongoing was calculated in the same way. Finally, the percentage frequency of responding when stereotypy was ongoing was subtracted from the percentage frequency of responding when some other behaviour was ongoing, to yield a measure of how much the subject's responsiveness to the event was reduced by ongoing stereotypy.

The use of a "dummy" variable, representing the tendency of the subject to exhibit behaviours classified as responses in the absence of an event, was deemed unnecessary. It was felt that the directionality of these behaviours was sufficient to confirm their nature as responses to events. In any case, there was no way to identify behaviours classified as responses in the absence of an event, because their classification depended on the ascription of an appropriate directionality. Instead, the measures of how much responsiveness was reduced by ongoing stereotypy were simply compared with a set of zeros, representing a virtual event to which responsiveness was not reduced by stereotypy.

Because the "zeros", as well as the measure of how much responsiveness to the receipt of grain, hay and discrete food items was reduced by stereotypy or standing inactive, exhibited little or no variance, a non-parametric analysis was required. Four Friedman tests, one for each subject, ascertained whether there were differences amongst the events, including the "zeros". As before, the significance criteria of these tests were reduced from 0.05 to 0.0127, from 0.01 to 0.00251 and from 0.001 to 0.00025, in order to hold FW at 0.05, 0.01 and 0.001 respectively. Where a significant difference existed, the Friedman test was followed by Siegel & Castellan's (1988) *post hoc* procedure for making comparisons with a control, to make pairwise comparisons between real events and the "zeros". These *post hoc* tests were one-tailed.

As was the case in the previous analysis, it was not possible to analyse all of the events for all subjects. The receipt of social contact from other elephants was not analysed for Rosa or Opal. Neither hay being fetched, but not given to the subject, nor people entering the subject's pen was analysed for Rhanee. In the case of Tembo, people entering the subject's pen was analysed, despite six missing values, which all occurred during period 1. As before, the analysis was repeated with this event omitted, to investigate whether increasing the power of the analysis would reveal differences between other events.

The results are shown in Figures 12 to 15. Instead of depicting comparisons between difference values and “zeros”, the figures compare the pairs of percentage frequency scores from which difference values were obtained, ie. the percentage frequency with which stereotypy, or standing inactive, was interrupted by a given event and the percentage frequency with which other behaviours were interrupted. The two types of comparison are equivalent. Whilst the former is statistically more convenient, the latter preserves the data in its original form. In the discussion, reference will be made to the frequency with which other behaviours were interrupted, without which the results cannot be fully interpreted.

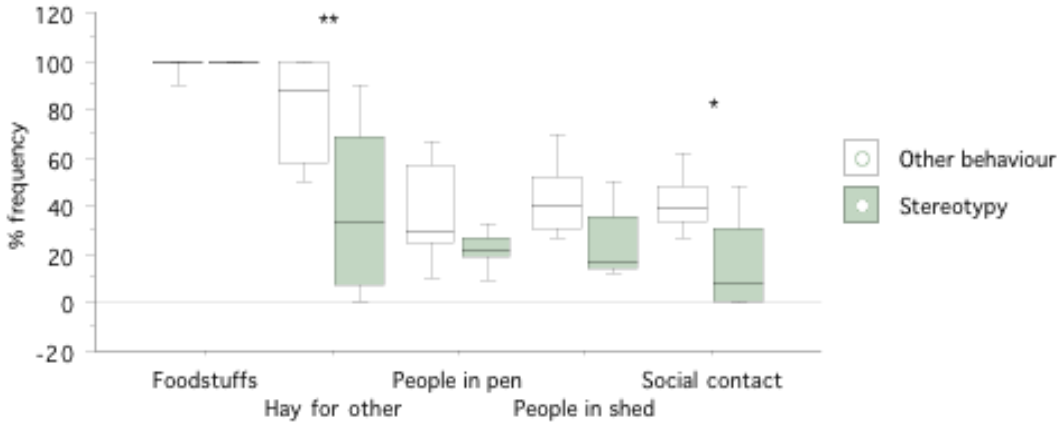

***Figure 12A**. Tembo (people in pen included): box plot, showing medians, interquartile ranges and inner fences for the percentage frequency with which various events interrupted (i) ongoing stereotypy and (ii) other behaviours, during the course of the observation period (all 6 days of period 1 were omitted, due to missing values). Asterisks indicate a significant difference between (i) and (ii), for a given subject (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

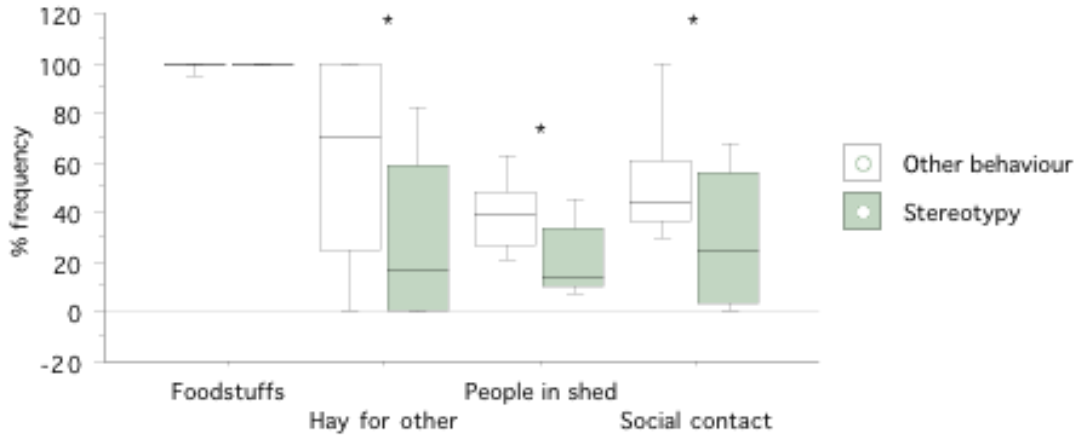

***Figure 12B**. Tembo (people in pen excluded): box plot, showing medians, interquartile ranges and inner fences for the percentage frequency with which various events interrupted (i) ongoing stereotypy and (ii) other behaviours, during the course of the observation period (3 days were omitted, due to missing values). Asterisks indicate a significant difference between (i) and (ii), for a given subject (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

For Tembo (Figure 12A), the Friedman test indicated a significant difference amongst the events, including the "zeros" (F_r = 19.1; k = 6; N = 9; p = 0.0018**). The *post hoc* tests showed that ongoing stereotypy reduced his responsiveness to hay being fetched, but not given to the subject (crit. diff. = 17.8; rank diff. = 25.0; p < 0.01) and to social contact from other elephants (crit. diff. = 17.8; rank diff. = 21.0; p < 0.05). Stereotypy did not reduce his responsiveness to the receipt of grain, hay and discrete food items (crit. diff. = 17.8; rank diff. = -1.00; NS), people entering the subject's pen (crit. diff. = 17.8; rank diff. = 13.0; NS), or people entering the shed (crit. diff. = 17.8; rank diff. = 17.0; NS), although the last event was only marginally nonsignificant. Repetition of the analysis, with people entering the

pen omitted (Figure 12B), again indicated a significant difference amongst the events (F_r = 19.0; k = 5; N = 12; p = 0.0008**). However, the *post hoc* tests revealed that stereotypy reduced Tembo's responsiveness not only to hay being fetched, but not given to the subject (crit. diff. = 16.7; rank diff. = 20.0; $p < 0.05$) and to social contact from other elephants (crit. diff. = 16.7; rank diff. = 21.0; $p < 0.05$), but also to people entering the shed (crit. diff. = 16.7; rank diff. = 20.0; $p < 0.05$). As before, stereotypy did not reduce his responsiveness to the receipt of grain, hay and discrete food items (crit. diff. = 16.7; rank diff. = -1.00; NS).

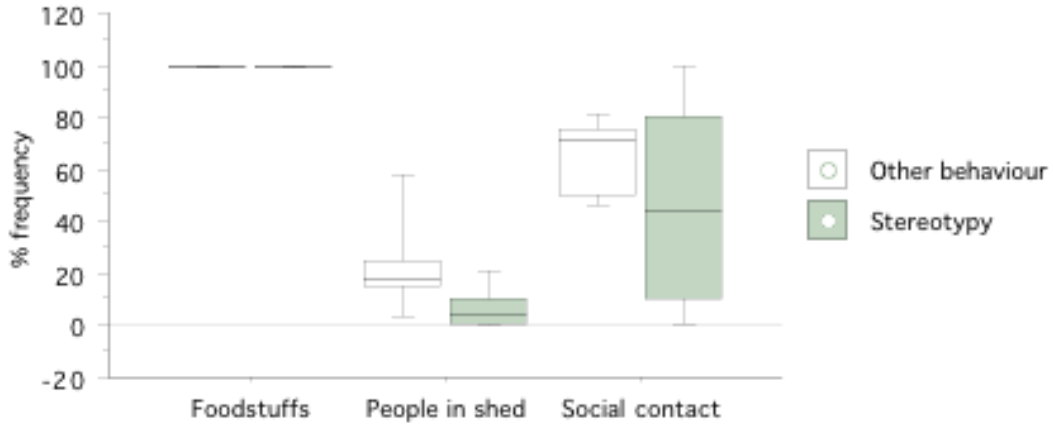

Figure 13. *Rhanee: box plot, showing medians, interquartile ranges and inner fences for the percentage frequency with which various events interrupted (i) ongoing stereotypy and (ii) other behaviours, during the course of the observation period (1 day was omitted, due to missing values). Asterisks indicate a significant difference between (i) and (ii) (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

For Rhanee (Figure 13), the Friedman test showed no differences amongst the events (F_r = 3.17; k = 4; N = 8; NS), indicating that ongoing stereotypy did not reduce her responsiveness to the receipt of grain, hay and discrete food items, social contact from other elephants, or people entering the shed.

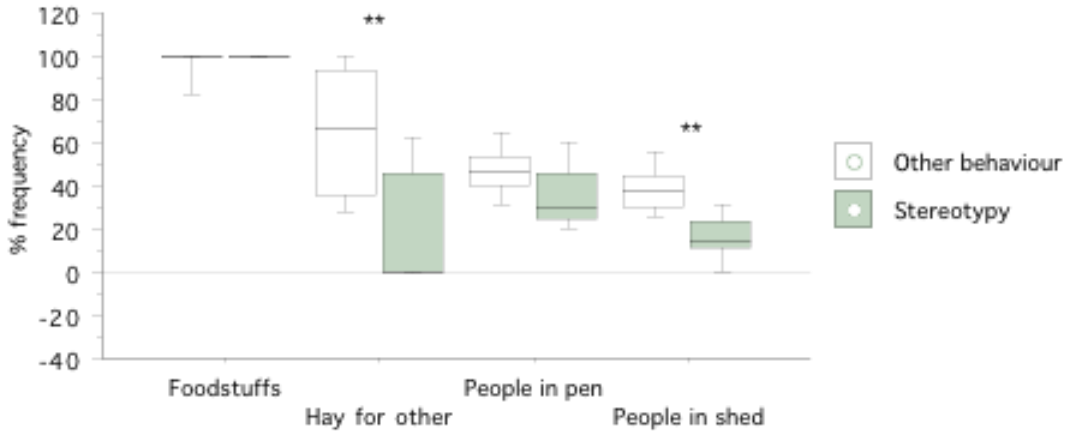

Figure 14. *Rosa: box plot, showing medians, interquartile ranges and inner fences for the percentage frequency with which various events interrupted (i) ongoing stereotypy and (ii) other behaviours, during the course of the observation period (4 days were omitted, due to missing values). Asterisks indicate a significant difference between (i) and (ii) (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

For Rosa (Figure 14), significant differences did exist amongst the events (F_r = 21.5; k = 5; N = 11; p = 0.0002***). *Post hoc* tests showed that ongoing stereotypy reduced her responsiveness to hay being fetched, but not given to the subject (crit. diff. = 16.0; rank diff. = 24.0; p < 0.01) and to people entering the shed (crit. diff. = 16.0; rank diff. = 21.0; p < 0.01), but did not reduce her responsiveness to the receipt of grain, hay and discrete food items (crit. diff. = 16.0; rank diff. = -2.00; NS), or to people entering the subject's pen (crit. diff. = 16.0; rank diff. = 12.0; NS).

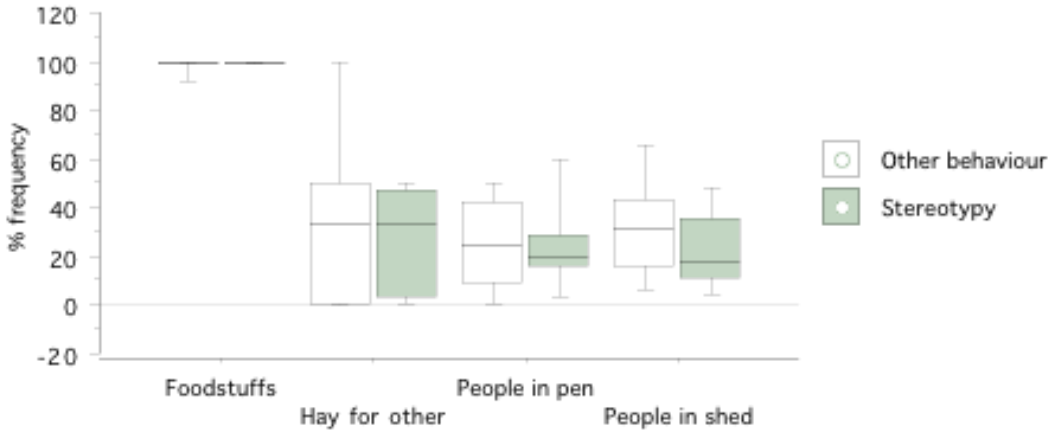

Figure 15. *Opal: box plot, showing medians, interquartile ranges and inner fences for the percentage frequency with which various events interrupted (i) ongoing bouts of standing inactive and (ii) other behaviours, during the course of the observation period (1 day was omitted, due to missing values). Asterisks indicate a significant difference between (i) and (ii) (* = p < 0.05; ** = p < 0.01; *** = p < 0.001).*

For Opal (Figure 15), there were no differences amongst the events (F_r = 0.38; k = 5; N = 11; NS), indicating that an ongoing bout of standing inactive did not reduce her responsiveness to the receipt of grain, hay and other food items, hay being fetched, but not given to the subject, people entering the shed, or people entering the subject's pen.

The second stage of the analysis was to ascertain whether ongoing stereotypy or standing inactive reduced the subjects' responsiveness to some events more than to others. This stage focused upon those events to which stereotypy or standing inactive had already been shown to reduce responsiveness. Because these ongoing activities had not reduced Rhanee's or Opal's responsiveness to any events, only Tembo and Rosa were included in the analysis. Where stereotypy had reduced responsiveness to three or more events, they were compared using the Friedman test. Where responsiveness to only two events had been reduced, they were instead compared using the Wilcoxon signed ranks test. With two subjects, the Friedman and Wilcoxon tests would have exhibited a familywise error rate of $1 - (1 - 0.05)^2 = 0.098$, when the significance criterion was 0.05. To hold FW at 0.05, the significance criterion

of these tests was reduced to 0.0253. Likewise, to hold FW at 0.01 and 0.001, the significance criterion was reduced to 0.00501 and 0.00050 respectively.

For Tembo (Figure 12B), the Friedman test indicated that there were no differences amongst the three events, hay being fetched, but not given to the subject, social contact from other elephants and people entering the shed (F_r = 1.17; k = 3; N = 12; NS). For Rosa (Figure 14), the Wilcoxon test showed no difference between the extent to which ongoing stereotypy reduced responsiveness to hay being fetched, but not given to the subject and people entering the shed (z = -1.42; N = 11; NS).

DISCUSSION

Tembo

Tembo performed stereotypy throughout the light period of the day, typically spending 56.6% of his time in this activity. It made no difference whether or not he was shackled. This is a very substantial investment of time. The fact that Tembo responded to a change in his environment, at the end of period 1, by greatly reducing the amount of time he spent stereotyping (Figure 1), indicates that his stereotypy had not become a habit, insensitive to the quality of his environment. The large amount of time which he was observed to spend stereotyping therefore reflected his current welfare, not merely his condition when the stereotypy first developed. His welfare at the time of the observations was undoubtedly very poor.

Tembo spent relatively little time searching for and consuming hay (20.4% of the light period), but would sometimes combine this activity with stereotypy, so as to be able to carry out both behaviours at once (8% of the light period).

Whilst stereotyping, Tembo's responsiveness to some events in his environment was reduced. He was less responsive than normal to social contact from other elephants, to people entering the shed and to people fetching hay for other animals. However, his responsiveness to most events affecting him directly was not reduced. These included the receipt of grain, hay and discrete food items and people entering his pen. When not stereotyping, it can be seen from Figure 12B that Tembo was highly responsive to the receipt of foodstuffs (median = 100%; LQ = 100%; UQ = 100%) and to people fetching hay for other animals (median = 70%; LQ = 25%; UQ = 100%). He was also moderately responsive to social contact (median = 44%; LQ = 36%; UQ = 61%), to people entering the shed (median = 39%; LQ = 27%; UQ = 48%) and to people entering his pen (Figure 12A: median = 29%; LQ = 25%; UQ = 56%). In no case could it be argued that responsiveness had failed to decline significantly when stereotyping because the normal level of responsiveness had been too low for a significant reduction to occur. Therefore, it was possible to conclude that Tembo remained alert, whilst stereotyping, to the receipt of grain, hay and discrete food items and to people entering his pen.

An analysis of which events were capable of interrupting Tembo's stereotypy included not only the the receipt of grain, hay and discrete food items and people entering his pen, as would have been expected from the findings on responsiveness, but also people fetching hay for other animals. This indicated that although his responsiveness to this event was lower than normal whilst stereotyping, he remained quite responsive to hay being fetched. Further analysis of the events which interrupted stereotypy indicated that the receipt of grain, hay and discrete food items interrupted Tembo's stereotypy more frequently than people entering his pen or fetching hay for other animals. The receipt of grain, hay and discrete food items also interrupted stereotypy for longer than these other events, although this may merely have reflected the fact that it takes some time to consume foodstuffs.

Tembo's sensitivity, not only to the provision of foodstuffs, but also to hay being fetched for other animals, suggests that the frequent provision of hay or other food items might be an effective way to reduce his stereotypy. However, when foodstuffs were provided, they interrupted ongoing stereotypy for only a short period. Figure 9 indicates that the provision of grain interrupted stereotypy for a median duration of 5 minutes and 36 seconds (LQ: 3 min, 54 s; UQ: 6 min, 41 s), the provision of discrete food items interrupted stereotypy for 2 minutes and 56 seconds (LQ: 49 s; UQ: 5 min, 20 s) and the provision of hay interrupted stereotypy for only 1 minute and 4 seconds (LQ: 20 s; UQ: 2 min, 40 s). Tembo would soon drift back into stereotypy, initially combining stereotypy with the consumption of hay or grain in many cases. This may explain the finding that Tembo spent no less time

stereotypying when hay was provided about 6 times per day than he did when it was provided about 3 times per day.

Another finding was that Tembo spent less time stereotyping when people were present in the shed than when they were absent. This finding might be broadly interpreted as indicating that he stereotyped less when "things were going on". However, it leaves open the question of which precisely which things he was responding to or anticipating at these times. It might be the case that a greater frequency of events *per se.* in the environment would be sufficient to reduce Tembo's stereotypy, but this hypothesis could not be tested in the present study.

Additionally, it was found that Tembo spent less time stereotyping when housed with Rosa and Opal in the larger pen, during periods 2 and 3, than he did when housed alone in the smaller pen, during period 1. Another difference between the periods was the presence of Rhanee in the small pen, during periods 2 and 3. It is not clear from this study whether it was the pen dimensions or the social environment which was primarily responsible for the reduction in stereotypy. It has already been noted that Tembo was relatively unresponsive to social contact whilst stereotyping, so it is unlikely that the receipt of social contact whilst stereotyping, which occurred slightly more frequently during periods 2 and 3 (period 1: median = 10.0 times per day, LQ = 11.5, UQ = 21.8; periods 2 and 3: median = 15.0 times per day, LQ = 6.0, UQ = 26.0), was the key factor. However, Tembo was observed to initiate social contact much more often during periods 2 and 3 (period 1: median = 1.5 times per day, LQ = 1.0, UQ = 2.0; periods 2 and 3: median = 8.0 times per day, LQ = 4.5, UQ = 19.0), as well as eliciting social contact, by facing another elephant with his trunk raised (period 1: median = 0.0 times per day, LQ = 0.0, UQ = 0.0; periods 2 and 3: median = 21.0 times per day, LQ = 16.0, UQ = 27.0). This indicates that he did take advantage of the greater opportunities for social contact after period 1, albeit on his own terms.

Rhanee

Rhanee, like Tembo, performed stereotypy throughout the light period of the day, typically spending 71.0% of her time doing so. It made no difference whether or not he was shackled. This is a very substantial investment of time. The relatively low incidence of stereotypy which Rhanee exhibited on the first two days after her introduction to the shed (Figure 1) indicated that her stereotypy was not insensitive to the quality of her environment. Therefore, the amount of time which she was observed to spend stereotyping reflected her current welfare. Rhanee's welfare, like Tembo's, was undoubtedly very poor.

Rhanee spent comparatively little time searching for and consuming hay (13.2% of the light period), but would just as often combine this activity with stereotypy (12.3% of the light period). She spent a considerable amount of time making social contact with other elephants (6.5% of the light period), far more than any of the other subjects. The frequency with which she made social contact was extremely high (median = 150 times per day; LQ = 135; UQ = 161).

Stereotypy did not reduce Rhanee's responsiveness to the receipt of grain, hay and discrete food items, to the receipt of social contact from other elephants, or to people entering the shed. When not stereotyping, it can be seen from Figure 13 that she was highly responsive to the receipt of both foodstuffs (median = 100%; LQ = 100%; UQ = 100%) and social contact (median = 71%; LQ = 50%; UQ = 75%). It was concluded that she remained alert to these events whilst stereotyping. However, the lack of a reduction in responsiveness to people entering the shed did not have such a clear interpretation. Rhanee was normally quite unresponsive to this event (median = 18%; LQ = 15%; UQ = 25%), with the consequence that almost any reduction in responsiveness might have failed to show up as significant. The reduction which was observed was in fact quite substantial, to a median of 4.8%. In view of this, no conclusion was drawn concerning the effect of Rhanee's stereotypy upon her responsiveness to people entering the shed. The effects of ongoing stereotypy upon Rhanee's responsiveness to people entering her pen and fetching hay for another animal could not be ascertained, owing to missing values in the data set.

More complete information was available on the range of events which interrupted ongoing stereotypy. Both the receipt of grain, hay and discrete food items and the receipt of social contact interrupted Rhanee's stereotypy, whilst people entering the shed, people entering her pen and hay being fetched for other animals did not. The frequency with which stereotypy was interrupted by social contact was similar to the frequency with which it was interrupted by the receipt of foodstuffs. Both the receipt of grain and the receipt of hay interrupted stereotypy for longer than the social contact, but this may reflect nothing more than the fact that it takes some time to consume these foodstuffs. Figure 10

indicates that the receipt of social contact interrupted stereotypy for a median duration of 23 seconds (LQ = 14 s; UQ = 46 s).

The fact that people fetching hay for other animals did not interrupt Rhanee's stereotypy suggests that she may be less alert, whilst stereotyping, to hay-related events than Tembo. This hypothesis is supported by the observation that Rhanee rarely responded to people approaching with hay or other foodstuffs until they were about to put them down in front of her. Tembo, in contrast, usually stopped stereotyping much sooner, typically when a person approached, entered or emerged from the hay pen. In fact, Rhanee was comparatively unresponsive, whilst stereotyping, to many of the things which people did in her environment. Thus, her stereotypy was not interrupted by people entering her pen, despite the fact that its small dimensions meant they were always in close proximity to her. Furthermore, in contrast to Tembo, it was found that the amount of time which Rhanee spent stereotyping was no less when people were present in the shed than it was when people were absent.

In striking contrast to her apparent insensitivity to human activity was her high level of responsiveness to social contact from other elephants and her readiness to initiate social contact with them. When Tembo, Rosa or Opal wandered close to the bars of Rhanee's pen during the course of the day, Rhanee was frequently observed to stop stereotyping and attempt to make contact. She sometimes pulled repeatedly on one of Tembo's tusks, to induce him to lift his head. Moreover, when Tembo stood facing her with his trunk up, she usually stopped stereotyping and initiated social contact with him. While most bouts of social contact lasted only a few seconds and stereotypy resumed shortly afterward, a minority of bouts, or series of bouts, lasted substantially longer. For example, on 17.12.97, the median duration of bouts initiated by Rhanee, not necessarily reciprocated, was 3 s (LQ = 1 s; UQ = 7 s). Of these, the longest individual bout lasted more than two minutes and the longest series of bouts, during which social contact did not stop for more than a few seconds at a time, lasted nearly six minutes. Rhanee would appear to be highly motivated to engage in social contact with other elephants and, whether or not the provision of more social opportunities would significantly reduce the time spent stereotyping, it would almost certainly improve her welfare.

As was the case for Tembo, Rhanee spent no less time stereotyping when hay was provided 6 times per day than she did when it was provided 3 times per day. The explanation is similar: although the receipt of foodstuffs invariably interrupted ongoing stereotypy, it did so for only a short period. It can be seen from Figure 10 that the provision of grain interrupted stereotypy for a median duration of 6 minutes and 4 seconds (LQ: 3 min, 4 s; UQ: 8 min, 59 s), the provision of discrete food items interrupted stereotypy for 26 seconds (LQ: 12 s; UQ: 2 min, 52 s) and the provision of hay interrupted stereotypy for 1 minute and 12 seconds (LQ: 21 s; UQ: 4 min, 8 s).

Rosa

In contrast to Tembo and Rhanee, Rosa performed stereotypy mostly when shackled. This observation was confirmed by the finding that the percentage of her time spent stereotyping was significantly higher whilst shackled than whilst unshackled. Because she performed relatively little stereotypy when unshackled, she spent substantially less of the light period stereotyping than Tembo or Rhanee (15.1% of the light period). However, whilst shackled, the percentage of her time spent stereotyping (median = 46%; LQ = 41%; UQ = 54%) was similar to Tembo (median = 43%; LQ = 32%; UQ = 58%), albeit still less than Rhanee (63%; LQ = 47%; UQ = 71%). This suggests that Rosa's welfare was very poor whilst shackled. Her stereotypy was clearly responsive to husbandry procedures and therefore reflected her current welfare.

During the course of the light period, Rosa spent much more time than Tembo or Rhanee time searching for and consuming hay (48.4% of the light period). She also spent 8.0% of her time walking, suggesting that she may often have been restless. However, 14.5% of her time was spent standing inactive. The bout length of standing inactive was often in the order of tens of minutes and she may have been dozing at these times. Extended periods of standing inactive were rarely observed in Tembo or Rhanee.

Whilst stereotyping, Rosa was less responsive than normal to people entering the shed and to people fetching hay for other animals. However, like Tembo, her responsiveness to most events affecting her directly was not reduced. These included the receipt of grain, hay and discrete food items and people entering her pen. The effect that stereotypy had upon her responsiveness to social contact could not be assessed, owing to a large number of missing values. When not stereotyping, Figure 14 indicates that Rosa was highly responsive to the receipt of foodstuffs (median = 100%; LQ = 100%; UQ = 100%) and to people fetching hay for other animals (median = 67%; LQ = 36%; UQ = 94%). She was also

moderately responsive to people entering the shed (median = 38%; LQ = 30%; UQ = 45%) and to people entering her pen (median = 47%; LQ = 40%; UQ = 53%). In no case could it be argued that responsiveness had failed to decline significantly when stereotyping because the normal level of responsiveness had been too low for a significant reduction to occur. It was therefore concluded that Rosa remained alert, whilst stereotyping, to the receipt of grain, hay and discrete food items and to people entering her pen.

An analysis of which events were capable of interrupting Rosa's stereotypy was consistent with this picture. Stereotypy was interrupted by the receipt of grain, hay and discrete food items and by people entering her pen, but not by people entering the shed or fetching hay for other animals. It was also found that stereotypy was interrupted more frequently by the receipt of grain, hay and discrete food items than it was by people entering her pen. The receipt of grain, hay and discrete food items interrupted Rosa's stereotypy for longer than people entering her pen, but this may simply have been because it takes some time to consume these foodstuffs.

The fact that Rosa's stereotypy was not interrupted by people fetching hay for other animals suggests that she was less alert to hay-related events than Tembo whilst stereotyping. Nevertheless, her stereotypy always stopped when she received hay and other foodstuffs. Like Tembo and Rhanee, the duration of this interruption was quite short. Figure 11 shows that the provision of grain interrupted stereotypy for a median duration of 6 minutes and 36 seconds (LQ: 5 min, 31 s; UQ: 9 min, 28 s), the provision of discrete food items interrupted stereotypy for 44 seconds (LQ: 23 s; UQ: 3 min, 36 s) and the provision of hay interrupted stereotypy for 1 minute and 4 seconds (LQ: 27 s; UQ: 3 min, 41 s). Because of this, the percentage of the light period that Rosa spent stereotyping was no less when hay was provided 6 times per day than it was when hay was provided 3 times per day.

An additional finding was that Rosa spent no less time stereotyping when people were present in the shed than she did when they were absent. Furthermore, the absence of an interaction between the effects of shackling and of the presence of people rejects the possibility that the presence of people had had an effect which was confined to the period in which she was shackled. Like Rhanee, the time which Rosa spent stereotyping was simply unaffected by the level of human activity in the shed. The fact that Rosa's stereotypy was interrupted by people entering her pen suggests that she was in fact more alert to human activity than Rhanee. Nevertheless, the findings that time spent stereotyping was unaffected by the presence of people and that stereotypy was not interrupted by people fetching hay for other animals indicate that she was probably less alert to human activity than Tembo.

One thing which is clear from Rosa's behaviour is that she finds shackling aversive. Her welfare would be improved if she could be safely left unshackled for the night.

Opal

Opal was hardly ever observed to perform stereotypy, but spent a considerable amount of time standing inactive (28.0% of the light period), far more than the other elephants. The bout length of this behaviour was often in the order of tens of minutes and periods of 30 minutes or more were not unusual. She may have been dozing at these times, a perfectly normal response to being confined in an unstimulating environment. However, it was also possible that these long periods of inactivity constituted a pathological or coping response to frustration, an alternative behavioural strategy to stereotypy. Some stall-housed sows spend long periods inactive, becoming unresponsive to many events in their environment (van Putten 1980; Wiepkema et al. 1983; Broom 1987). This condition is known as apathy. It develops in environments similar to those which precipitate stereotypy. It has been compared to an experimentally produced phenomenon known as learned helplessness, in which the animal learns that there is nothing it can do to get what it wants and therefore stops trying (Wemelsfelder 1993). A diagnosis of the level of Rhanee's welfare depended upon identifying the motivational basis of her periods of inactivity.

Apart from standing inactive, Opal spent a lot of time searching for and consuming hay (51.1% of the light period), about the same as Rosa. She also spent 6.1% of her time walking, suggesting that, like Rosa, she may often have been restless.

An ongoing bout of standing inactive did not reduce Opal's responsiveness to the receipt of grain, hay and discrete food items, to people fetching hay for another animal, to people entering the building, or to people entering her pen. When not standing inactive, Figure 15 indicates that Opal was highly responsive to the receipt of foodstuffs (median = 100%; LQ = 100%; UQ = 100%), but exhibited a moderate to low level of responsiveness to people fetching hay for another animal (median = 33%; LQ

= 0.0%; UQ = 50%), to people entering the shed (median = 31%; LQ = 16%; UQ = 43%) and to people entering her pen (median = 25%; LQ = 9.4%; UQ = 42%). It is possible that Opal's normal level of responsiveness to events other than the receipt of foodstuffs was sufficiently low and variable that almost no reduction in responsiveness would have shown up as significant. However, it can be seen from Figure 15 that the observed reductions in responsiveness were in fact rather small, with median values of 33% (people fetching hay for another animal), 18% (people entering the shed) and 20% (people entering the pen). Therefore, it is reasonable to conclude that Opal was no less alert and responsive to events when standing inactive than she was normally. There is no evidence to suggest that the protracted bouts of standing inactive which were observed were abnormal, or indicative of poor welfare.

The analysis of which events were capable of interrupting a bout of standing inactive indicated that stereotypy was interrupted by the receipt of grain, hay and discrete food items, but not by people fetching hay for another animal, entering the shed, or entering Opal's pen. The failure of the latter events to interrupt bouts of standing inactive could be attributed to the fact that she was normally quite unresponsive to these events.

An additional finding was that both shackling and the presence of people influenced the amount of time that Opal spent standing inactive. She spent a greater proportion of her time standing inactive when shackled than she did when unshackled. This was probably because her behavioural options were restricted whilst shackled, particularly in the morning when hay was not available. It was also found that she spent more time standing inactive when people were present in the shed than she did when people were absent. This is likely to have been a consequence of the fact that high levels of human activity tended to coincide with periods spent shackled. To some extent, it may also have reflected the fact that there was more than one context in which standing inactive occurred. At least five contexts could be distinguished: in response to an event; in anticipation of an event; as a pause between activities; at times when the subject's behaviour was restricted due to shackling; and at times when nothing was happening. The first two contexts pertained particularly to times when people were present in the shed and were unrelated to shackling. However, they normally elicited only short bouts of inactivity.

General

The four subjects differed greatly in the amount of time they spent performing stereotypy. The management factors which influenced time spent stereotyping also differed, some subjects being sensitive to shackling or to the presence of people in the shed, whilst others were not. Additionally, ongoing stereotypy reduced responsiveness to different events in different subjects and many of the events which were capable of interrupting stereotypy also differed. In fact, there were only three things which the three elephants who performed a measurable level of stereotypy had in common.

1) Ongoing stereotypy did not reduce responsiveness to the receipt of grain, hay and discrete food items.

2) The receipt of grain, hay and discrete food items, whether treated as a composite event or as discrete events, interrupted stereotypy on almost all occasions.

3) However, because the receipt of foodstuffs did not interrupt stereotypy for very long, the amount of time spent stereotyping was not influenced by the frequency with which hay was provided during the day.

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Tembo

More time SW in small pen

Frequency of hay probably makes no diff

Shackling makes no diff

More time SW when people absent

GRPRHAY, HAYO and INPN interrupt SW, not SGRWIN or SOC

GRPRHAY interrupts more frequently than HAYO and possibly INPN

GR, PR and HAY interrupt for longer than HAYO and INPN

SW reduces responsiveness to HAYO, SOC and SGRWIN, not GRPRHAY or INPN

No diff in responsiveness reduction between HAYO, SOC and SGRWIN

Rhanee

Frequency of hay makes no diff

Shackling makes no diff

People present makes no diff

GRPRHAY and SOC interrupt SW, not HAYO, SGRWIN or INPN

No diff in frequency between GRPRHAY and SOC

GR interrupts longer than PR and SOC; HAY interrupts longer than SOC

SW doesn't reduce responsiveness to GRPRHAY, SOC or SGRWIN

Rosa

Frequency of hay makes no diff

More time SW when shackled

People present makes no diff

GRPRHAY and INPN interrupt SW, not HAYO or SGRWIN

GRPRHAY interrupts more frequently than INPN

GR and PR interrupt for longer than INPN

SW reduces responsiveness to HAYO and SGRWIN, not GRPRHAY or INPN

No diff in responsiveness reduction between HAYO and SGRWIN

Opal

Frequency of hay makes no diff

RS more when shackled

RS more when people absent

GRPRHAY interrupts RS, not HAYO, SGRWIN or INPNCL

RS doesn't reduce responsiveness to GRPRHAY, HAYO, SGRWIN or INPNCL