

PART-TIME FOSTERING BY A PAIR OF BLACK AND WHITE RUFFED LEMURS (*VARECIA VARIEGATA VARIEGATA*)

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Abstract

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Twin infant black and white ruffed lemurs, male and female, were fostered on a part-time basis, in conjunction with hand-rearing, with an adult pair who were highly related to them. The adult female showed allomaternal behaviour towards the twins, although she did not attempt to suckle them. The adult male ignored the twins for the first few weeks but as they became more mobile and playful he frequently initiated play with one or both. Growth rates showed a significant trend when compared with parentally raised and hand-reared infants, with the fostered twins growing at rates intermediate between those found under the two other rearing methods. Fostering of rejected infants as a captive management strategy is advocated as an alternative to traditional hand-rearing techniques because of the welfare advantages to both infants and foster parents.

Keywords: *alloparental care, animal welfare, captive management, hand-rearing, ruffed lemur*

Introduction

Although hand-rearing of many primate species is highly successful in terms of survivorship, and reintegration of individuals into social groups may frequently be feasible, hand-reared individuals may have problems socializing, and subsequently rearing young. For example, Beck and Power (1988) reported that mother-reared gorillas (*Gorilla* spp.) produced more than twice as many infants as hand-reared mothers. Furthermore, only 35 per cent of hand-reared gorilla mothers were successful in infant rearing compared with a 71 per cent success rate for mother-reared gorillas. Cotton top tamarin (*Saguinus oedipus*) infants born to hand-reared parents had a significantly lower survival rate than infants born to parents reared in family groups (Snowdon *et al* 1985).

The aim of this study was to assess whether abandoned infant black and white ruffed lemurs, *Varecia variegata variegata*, could be fostered by adults of the same species. This technique was thought to be particularly appropriate for this species as ruffed lemur mothers do not carry their infants about, but park them in nests which they visit periodically for suckling and grooming. The frequency and importance of alloparental care in this species is not known, although occurrences of male guarding and non-maternal nursing have been described in wild (Morland 1990) and semi-free-ranging groups (Pereira *et al* 1987). Allosuckling has been noted at least twice in UK zoos: once as a natural occurrence (King personal communication 1992)

and once as a management strategy (Thetford unpublished data 1992). For rejected primate infants, fostering combined with hand-rearing may improve welfare in terms of producing socially and parentally competent animals. Fostering also avoids the stressful period of reintegrating hand-reared individuals into social groups, which may take 1–4 weeks (Brockman *et al* 1987). Adults may benefit too, especially if they are inexperienced or unsuccessful in raising their own offspring or if they were removed from their natal group before another litter was born (Lancaster 1971; Hrdy 1976).

Methods

Animals

The foster parents were an adult male and female (Steak and Kidney), which had been kept together (but separate from other ruffed lemurs) for 3.5 years at Chester Zoo. At the time of the study they were kept in an 81.95m³ indoor cage linked to a 32.3 m³ outdoor enclosure. Two years previously Kidney had given birth to a male which lived for only a few hours, and 5 days prior to the fostering experiment her week-old twins had died. The infants to be fostered (male = Zig, female = Zag) were rejected by their dam (Onion) soon after birth and were placed in the nest box in Steak and Kidney's indoor enclosure when they were a few hours old. There was a high degree of relatedness between both foster parents and infants, Kidney being their maternal aunt and Steak their paternal uncle.

Feeds were administered following a standard feeding regime. This commenced with feeding 5 ml SMA Gold (John Wyeth and Brother, Maidenhead, UK) at 2h intervals. At first Zig and Zag were left in the enclosure between 1030h and 1600h each day but were removed for their feeds and at night. As both adults proved very tolerant of the infants, after 2 weeks of this regime daytime feeds were administered in the enclosure and the infants were left with the adults from about 0700h until 1600h. By 3 weeks of age the infants were fed 15ml every 3h, and the midnight feed was discontinued from 6 weeks. At 11 weeks of age the infants were sufficiently weaned to be left with the foster parents all night. Weaning was completed by 16 weeks. The infants were weighed at weekly intervals after feeding (excluding weeks 7, 15 and 16) until they were 18 weeks old.

Data collection and statistical analysis

Two to six hours of data were collected between 1030h and 1600h on 1 day per week for 20 weeks following Zig and Zag's birth (although no data were obtained for certain weeks). Adults and infants were watched simultaneously and data were recorded using check-sheets. The distance of each adult to each twin was estimated at 1-min intervals and, once they were mobile, the distance between the twins was also recorded. All instances of alloparental behaviour (grooming, visiting, resting in contact ['huddling'] and play) and all interactions between the two infants (allogrooming, play and huddling) were recorded and timed. Solitary (locomotory or exploratory) play, autogrooming, scent-marking and scratching were also recorded for both infants. Vocalizations, especially the parent-infant contact call ('mew'), were noted where possible. The behavioural definitions follow Pereira *et al* (1988), with the exception of 'visiting', which was defined as the approach of either adult to the infants accompanied by either visual or olfactory inspection.

Comparable data were obtained for a parentally raised red ruffed lemur male (Reggie; mother = Freda, father = Basil, no other group members), and for the parentally raised female twins (Pep and Liq), but with the latter for weeks 9–20 only. These twins were born to Steak and Kidney and successfully reared by them 2 years after their experience as foster parents. Zig and Zag were still in the group at this time.

Non-parametric tests (Mann-Whitney U , Wilcoxon matched pairs, Pearson's correlation coefficient [r] and Page's test for ordered alternatives) were used to analyse the data unless otherwise indicated. Data were analysed using SPSS© for Windows, version 7.5 (SPSS UK Ltd, Woking, UK).

Results

Alloparental behaviour

From the beginning of the study Kidney showed a lot of interest in the infants, making a few visits and grooming them on each observation day, and she was also aggressive to people walking past. Kidney visited ($U = 459, P < 0.00001$) and groomed ($U = 447, P < 0.0002$ [Zig], $U = 403.5, P < 0.02$ [Zag]) both infants significantly more than Steak and used the parent-infant contact call ('mew') more frequently ($U = 467, P < 0.00001$). Although Kidney groomed and huddled significantly more with her own twin infants than with her fostered ones (groom, $U = 75, P < 0.02$; huddle, $U = 176, P < 0.0001$) there were no significant differences in the frequency and duration of Kidney's visits (frequency, $U = 106.5, P = 0.8320$; duration, $U = 102, P = 0.5962$), the amount of grooming she received from the infants ($U = 100.5, P = 0.5261$), parent-infant play ($U = 133, P = 0.1131$) and agonistic behaviour ($U = 91, P = 0.1205$). Freda played significantly more with her singleton (Reggie) than Kidney with her own twins, Pep and Liq ($U = 71, P < 0.0005$; Figure 1a), but Kidney huddled with her twins significantly more than Freda huddled with Reggie ($U = 163, P < 0.02$).

Steak avoided the infants while they were confined to the nest box and once they were mobile, except for rare visits, but after a few weeks of their attempts to solicit play he responded and frequently became the initiator. He showed similar amounts of parental behaviour to his own offspring; and although he spent significantly more time huddling with Pep and Liq ($U = 82.5, P < 0.05$), he played significantly more with Zig and Zag ($U = 153, P < 0.005$).

Both adults showed a significant increase in adult-infant play during the course of the fostering study ($r = 0.695$ [Kidney with Zig] and $r = 0.665$ [Kidney with Zag]; $P < 0.01$ for both; $r = 0.661, P < 0.01$ [Steak with Zig] and $r = 0.813, P < 0.001$ [Steak with Zag]). As the infants grew, Kidney made significantly fewer visits ($r = -0.868, P < 0.001$) and mewed less ($r = -0.587, P < 0.02$) but received more grooming from the foster twins ($r = 0.770, P < 0.001$ [Zig] and $r = 0.473, P < 0.05$ [Zag]). In contrast, Steak groomed these infants more ($r = 0.554, P < 0.02$ [Zig] and $r = 0.665, P < 0.01$ [Zag]) and mewed and behaved agonistically to them more frequently ($r = 0.633, P < 0.01$ [mew]; $r = 0.574, P < 0.02$ [agonistic]) as they got older.

Freda showed the same pattern as Kidney of decreasing visits to her infant and increasing parental play and infant-to-parent grooming with time (visit, $r = -0.476, P < 0.025$; play, $r = 0.757, P < 0.0005$; receive infant groom, $r = 0.448, P < 0.05$; Figure 1). Like Steak, Basil played, mewed and behaved agonistically to Reggie significantly more as Reggie got older (play, $r = 0.780, P < 0.0005$; mew, $r = 0.473, P < 0.025$; agonistic, $r = 0.457, P < 0.025$).

Development of infant behaviour

Social play and allogrooming were seen when the fostered infants were just a few days old, but these behaviours decreased significantly between weeks 1 and 20 (social play, $r = -0.654, P < 0.01$; allogroom, $r = -0.598$ [Zag to Zig] and $r = -0.684$ [Zig to Zag]; $P < 0.01$ for both). Similar data are only available for weeks 9–20 for the parentally raised twins (see below). Solitary play was first observed at 3 weeks (Zig, Zag and Reggie) and scent-marking at 5 weeks (for Reggie) and 8 weeks (for Zig and Zag). Scent-marking was significantly positively

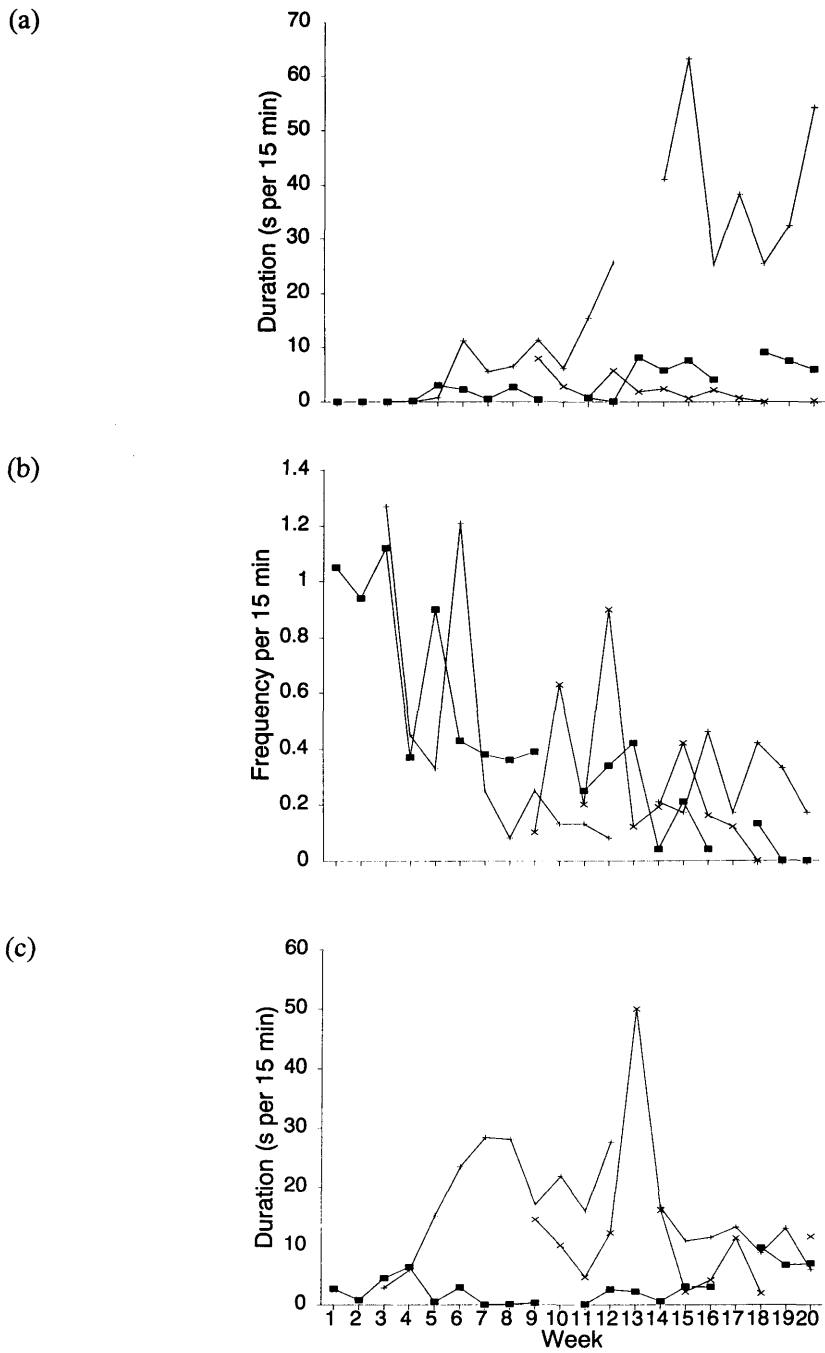


Figure 1 Changes in parental behaviour with infant age: (a) play; (b) frequency of visits; (c) groom. Durations are expressed as the mean number of seconds per 15min per individual (■ – Kidney [foster mother]; + – Freda; x – Kidney [mother]).

correlated with time (Zig, $r = 0.531$, $P < 0.05$; Zag, $r = 0.560$, $P < 0.02$; Reggie, $r = 0.811$, $P < 0.0005$). Solitary play was significantly positively correlated with age only for Reggie ($r = 0.434$, $P < 0.05$). Both males and the female infant marked horizontal branches and their projecting spurs with their anogenital regions. The singleton infant spent significantly more time marking than the twins ($U = 753.5$, $P < 0.0001$) and Zag (female) marked more than Zig (male) ($U = 265$, $P < 0.05$). The frequency of 'roar-shriek' group territorial vocalizations, first heard in week 6, significantly increased in all three infants (Zig, $r = 0.676$, $P < 0.01$; Zag, $r = 0.754$, $P < 0.001$; Reggie, $r = 0.609$, $P < 0.005$) over the study period.

During weeks 9–20 Zig and Zag displayed more affiliative behaviour than Pep and Liq, performing significantly more huddling and allogrooming (huddle, $U = 160$, $P < 0.0005$; allogroom, $U = 650$, $P < 0.0001$; Figure 2a, 2b). They also performed less agonistic behaviour, although the latter result was not significant ($U = 14$, $P = 0.1087$). In contrast, Pep and Liq engaged in significantly more solitary behaviour (solitary play, $U = 627$, $P < 0.0002$), scent-marking ($U = 232.5$, $P < 0.0001$), scratching ($U = 319.5$, $P < 0.01$) and self-grooming ($U = 567$, $P < 0.05$). The singleton infant (Reggie) performed significantly more solitary play ($U = 348$, $P < 0.0002$) and scratching ($U = 313$, $P < 0.01$) than Pep and Liq – but there was no significant difference in self-grooming ($U = 156$, $P = 0.2441$) and scent-marking ($U = 268$, $P = 0.2527$; Figure 2c).

Distance between individuals

During all observation periods ($n = 18$) Kidney was significantly nearer than Steak to both fostered infants (Wilcoxon matched pairs test: $T = 7.5$ [Zig], $T = 14$ [Zag]; $P < 0.01$ for both). In fact, towards the beginning of the study, Kidney would move between Steak and the infants if he was near them. The same trend was seen in both parental studies, with the mother being significantly nearer her offspring than the father ($T = 66$, $P < 0.005$ [Pep]; $T = 64$, $P < 0.01$ [Liq]; $T = 180$, $P < 0.001$ [Reggie]). Kidney stayed significantly nearer to her own infants than to the fostered infants ($U = 73$, $P < 0.0001$), but there was no significant difference in Steak's proximity to his own versus the fostered infants ($U = 43$, $P = 0.40$). In both the twin studies, there was no significant difference between adult distance to either infant ((Kidney foster, $T = 38$, $P = 0.222$; Kidney parent, $T = 53$, $P = 0.083$; Steak foster, $T = 55$, $P = 0.900$; Steak parent, $T = 37$, $P = 0.756$). Both adults showed a significant (Pearson's r) correlation between infant age and distance, reducing the distance to both infants over time; this difference was more marked for Steak who tended to ignore the infants when they were very young but later began to groom and play with them (Kidney, $r = -0.691$, $P < 0.01$; Steak, $r = -0.864$, $P < 0.001$). In contrast, Freda and Basil significantly increased their distance from Reggie as he grew older (Freda, $r = 0.805$, $P < 0.001$; Basil, $r = 0.578$, $P < 0.001$). For both pairs of twins, the siblings spent more time apart from each other (Zig and Zag, $r = 0.769$ and Pep and Liq, $r = 0.722$; $P < 0.01$ for both) as they grew older.

Infant weights

Zig and Zag were first weighed when 2 days old (Zig = 138g, Zag = 116g). Their weights compared favourably with published data which give a range of 80–125 g in viable lemur neonates (Benirschke & Miller 1981). Growth rates fluctuated from 0.6 to 33.3 g per day (Figure 3). Data for parentally raised twins at San Diego Zoo (Meier & Willis 1984) show no significant difference from the measurements of Zig and Zag ($T = 9$, $P = 0.201$). However, when growth rates for infants that were mother-reared, hand-reared (data from Benirschke & Miller 1981; Hick 1984) and hand-reared with fostering are compared, a significant trend is seen: fostered infants showed faster growth rates than hand-reared ones, but slower rates than mother-reared infants (Page's test, $n = 3$, $L = 41$, $P = 0.05$).

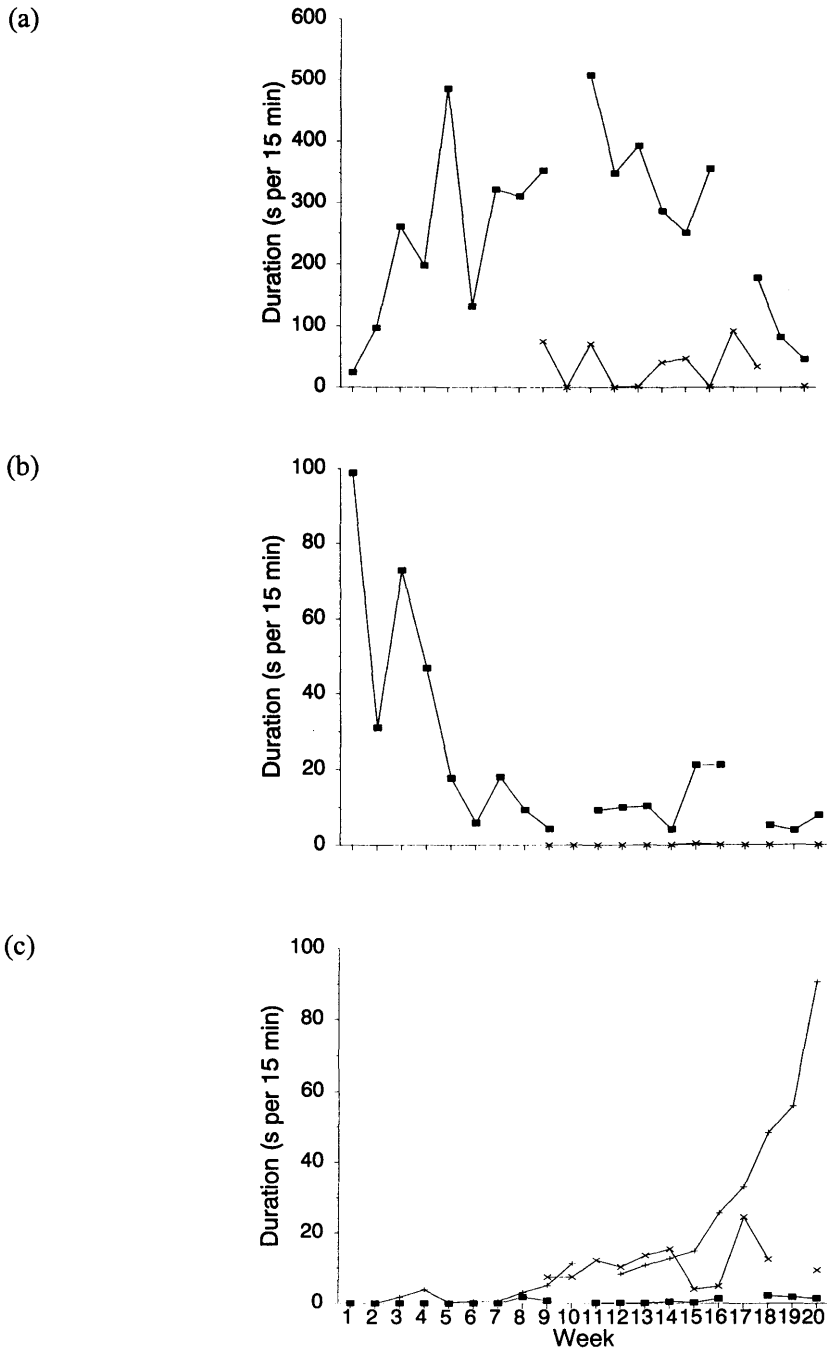


Figure 2 Development of infant behaviour: (a) huddle; (b) allogroom; (c) scent-mark. Durations are expressed as mean number of seconds per 15min per individual (■ – Zig and Zag; + – Reggie; x – Pep and Liq).

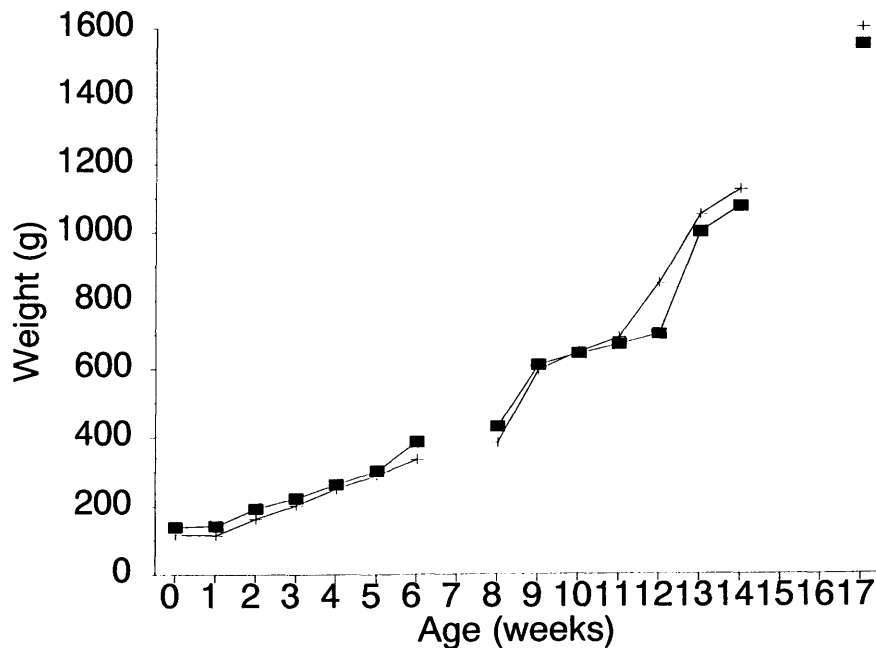


Figure 3 Growth curves for twin black and white ruffed lemurs hand-reared and fostered at Chester Zoo (■ – Zig [male], + – Zag [female]).

Discussion

Although Kidney spent significantly less time grooming and huddling the fostered infants than her own infants, she spent a similar amount of time visiting and playing with both pairs of twins. There was no significant difference in the amount of agonistic behaviour that she directed towards each pair. She did not attempt to suckle Zig and Zag – but this may have been due to the 6-day time lapse between losing her own young and being introduced to the fostered infants. Steak huddled with Zig and Zag very rarely but showed no significant difference in the level of other parental behaviours to them and his own infants. In all three studies the females were significantly nearer the infants than the males. Kidney behaved aggressively towards Steak if he got too near Zig and Zag, a protective response that has been reported in captive family groups (Downman 1993) but was not observed between mothers and fathers in the other two groups in this study.

Zig and Zag performed significantly more social behaviour with each other than Pep and Liq, although whether or not this was a consequence of maternal rejection is impossible to ascertain. The only solitary behaviour that showed a striking difference between the fostered infants and all three parentally raised infants was scent-marking. The fostered infants were first seen to scent-mark 3 weeks later than Reggie, and their amount of marking activity was far less than all three parentally raised infants. Again, it was not possible to determine if this was due to a slower rate of behavioural development caused by maternal rejection. More data are needed to examine the effects of maternal rejection on infant ruffed lemurs and to further evaluate the behavioural benefits of fostering. However, the faster growth rates of the fostered

pair compared with hand-reared individuals suggest that this technique was beneficial to the rejected twins. Fostering may also have had positive effects on Kidney and Steak's parenting skills, as following this experience they successfully reared their own offspring for the first time.

Animal welfare implications

This study fulfilled its aim by showing that fostering is a suitable technique for introducing abandoned ruffed lemur infants into a socially more complete developmental environment. It is suggested that zoos consider fostering when faced with the prospect of hand-rearing infant ruffed lemurs. Since the major reason for the study was to produce animals which are parentally competent, clearly future research should concentrate on the behaviour of fostered infants when they become parents to establish whether fostered ruffed lemurs do better at raising their own infants than traditionally hand-reared ruffed lemurs.

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