

Welfare of Ratites and Marabou Stork in Mixed Mammal/Bird Exhibits

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Abstract

Mixed or multi-species exhibits are increasingly popular and common in zoological parks. Many zoos have successfully mixed ratites and marabou stork (*Leptoptilos crumeniferus*) with various mammal species but there are also many anecdotal reports of poor welfare and excessive aggression in some exhibits. This project investigated the behaviour and space use of ratites and marabou stork housed with and without mammal species in various zoos to identify possible welfare effects of mixed-species exhibits and identify mammal/bird combinations that may be particularly suitable or unsuitable for mixing. The results show that mixed-species exhibits are very variable but not necessarily good or bad for ratite or stork welfare. Species, individuals and enclosure design impact on behaviour. In all cases, social interactions of all types are much more common between conspecifics than inter-species pairs and overall no more aggression was observed in mixed than in single-species exhibits. It appears that some of the most suitable combinations are rhea-deer and rhea-mara, as these species seem to actively form associations, whereas ostrich-giraffe was the least suitable combination, resulting in relatively high aggression and active avoidance.

Introduction

Mixed-species exhibits have a number of advantages, making them increasingly common in many zoos (Veasey and Hammer 2010). In addition to maximizing the use of available space, these include a more enriched environment for the animals, with increased interaction opportunities both directly (social interaction, active avoidance) and/or indirectly (sniffing at urine, faeces or other scents left by the other species) (Backhaus and Fradrich 1965; Baer 1998; Coe 2001; Coe 2004; Croke 1997; Richardson 1999). They can also be more stimulating and educational for visitors due to the potential to increase the amount of time at least one species is active and visible (Probst and Matschie 2008; Xanten 1992) and the opportunity to present naturally occurring sympatric species together (Baker 1992; Croke 1997; Harrison 1986) or to provide species to compare in terms of physical and behavioural adaptations (Muller 1975; Thomas and Maruska 1996). Additionally, mixed-species exhibits can be an invaluable resource for research (Freeman and Alcock 1973), allowing observation both of interactions between species and effects of inter-specific interactions on behaviour (Buchanan-Smith and Hardie 1997; Cave-brown 1986).

On the other hand, potential health and welfare problems associated with mixed exhibits include injuries as a result of interspecific aggression, transmission of disease between species, and nutritional issues if species have access to diets provided for others in the enclosure (Gupta et al. 2007; Lowenstine 1999; Mcaloose 2004; Wortman et al. 2002). Thus, it is important that the design of mixed-species exhibits and the selection of species reduce the risk of these potential health and welfare problems. One of the greatest concerns with mixed-species enclosures is negative interactions between species, but there are few quantitative studies into how frequent these are and what form they take. Ratites have been kept and bred with varying degrees of success in mixed-species enclosures (Rees 2011); ostrich (*Struthio camelus*) are often held in mixed-African savannah-style exhibits with species such as plains zebra (*Equus quagga*), giraffe (*Giraffa camelopardalis*) and various antelope,

emu (*Dromaius novaehollandiae*) are often exhibited with various types of Macropod and rhea (*Rhea sp.*) with various South American species such as capybara (*Hydrochoerus hydrochaeris*), mara (*Dolichotis sp.*) and giant anteater (*Myrmecophaga tridactyla*). Marabou stork are increasingly also housed in mixed-African savannah-style exhibits (King 1993) but seem to suffer high mortality rates possibly due to inter or intraspecific aggression, although there is little definitive evidence on the effects of hoofstock on marabou storks (Nogge and Pagel 2001).

This project investigated the behaviour and spacing of ratites and marabou stork housed with and without mammal species in various zoos to investigate possible welfare effects of mixed species and determine possible suitable and unsuitable combinations of species.

Materials and Methods

Study sites and subjects

A total of 60 ostrich (*Struthio camelus*), rhea (*Rhea americana*, *Rhea pennata*), emu (*Dromaius novaehollandiae*) and marabou stork (*Leptoptilos crumeniferus*) were observed in 17 different enclosures in five UK zoos between May and July 2012 (Table 1). All ratites were observed in at least one single-species exhibit and one exhibit mixed with mammals. Due to time, visa and financial restrictions, no marabou stork/mammal mixed enclosures were available, so storks were only observed held as single-species or mixed with other birds. Observer effects were minimized by viewing only from public areas and during normal opening hours.

Data collection

Instantaneous scan sampling was used to note the behaviour and location of each study subject every 10 minutes for five hours per day (11:00-16:00) for two days per enclosure. Behaviour was classified using an ethogram developed during preliminary observations (Table 2). For location, each enclosure was divided into zones using the modified Spread of Participation Index method (Plowman, 2003). In addition, every 30 minutes for each study subject, the distance to the nearest individual of the same and each other species in the enclosure was noted. These were recorded in four categories: < 1 metre, 1- 5 metres, 5-10 metres and >10 metres.



In this study, aggression amongst rheas was particularly high, especially at feeding time. It is suggested that additional feeding stations might help alleviate the problem.

Table 1: Study subjects and enclosures observed in a comparison of behaviour of birds in single and mixed-species exhibits in UK zoos.

Enclosure number	Zoo number	Study subjects	Mixed with	Brief Enclosure Description
1	1	1 Emu	5 Kangaroo	Large size, grass and dirt, shelter, bushes, tree,
2	1	2 Marabou	-	Small size, grass and dirt, pond, shelter, bushes, tree
3	1	2 Rhea	-	Small size, grass and dirt, shelter, bushes, tree,
4	1	1 Emu	Mixed birds	Medium size, grass and dirt, pond, shelter, bushes, tree
5	1	3 Ostrich	3 Zebra	Large size, grass and dirt, shelter, bushes, tree,
6	2	3 Ostrich	12 Lechwe 1 Waterbuck Mixed bird	Large size, grass and dirt, shelter, bushes, tree
7	2	7 Rhea	2 Tapir 10 Capybara Mixed birds	Large size, grass and dirt, pond, shelter, bushes, tree
8	3	9 Rhea	3 Tapir 35 Mara 9 Alpaca 2 Agouti 6 Capybara Mixed birds	Large size, grass and dirt, pond, shelter, bushes, tree
9	3	8 Emu	-	Large size, grass and dirt, shelter, bushes, tree,
10	3	4 Ostrich	3 Giraffes 4 Zebras	Large size, grass and dirt, shelter
11	4	2 Rhea	Mixed birds	Medium size, grass and dirt, shelter, bushes
12	4	2 Rhea	Mixed birds	Medium size, grass and dirt, shelter, bushes, tree
13	4	3 Rhea	5 Muntjac deer Mixed birds	Large size, grass and dirt, pond, shelter, bushes, tree,
14	4	2 Emu	Mixed birds 2 Wallaby	Medium size, grass and dirt, pond, shelter, bushes, tree,
15	4	2 Marabou	1 Bird	Small size, grass and dirt, logs, shelter, bushes, tree
16	5	6 Ostrich	-	Large size, grass and dirt, shelter, bushes, tree,
17	5	3 Emu	5 wallaby	Small size, grass and dirt, shelter, bushes, tree,

Table 2: Ethogram used in scan sampling for ratite and marabou stork behaviour

Welfare indicators	Definition
Activity related behaviours	
Waltzing	Twirl around, often until dizzy. Sick birds rarely twirl.
Sleep	The bird holding its neck raised or with the bird lying prone with its neck outstretched straight in front of it.
Thermoregulatory	Bird will open-mouth breath and open their wings, or bed down covering their legs with their wings.
Trembling	Resembles shivering.
Social behavior	
Threat	In a typical threatening posture, the bird will stand tall with tail erect, hissing, wings slightly open, and feathers puffed up, especially around the neck.
Vocalization	Bird makes a distress call and booming. A distress call, which is somewhat similar to that of a pigeon's prolonged throat call. Booming is a sound produced by mature males; serves to establish territorial boundaries, warn other birds
Submission	Run away from an aggressive bird or drop to the ground without defending itself.
Sexual behavior	
Clucking and fluttering	Rapidly opening and closing her beak, may flutter wings by dropping them low and forward, and vibrating in sequence.
Kanteling	The bird drops to his hocks, and fans both wings forward and backward while hitting his head on each side of his spine.
Abnormal behavior	
Feather-picking	A bird will aggressively peck feathers from the back and tail area of penmates.
Toe and face pecking	Excessive toe and face pecking
Behavioural stargazing	A bird will continually lift its head up and back to the extent that it eventually touches its spine.
Pica	The ingestion of faeces
Aggression	Bird will intensely pursue and attempt to kick another bird.

Ad libitum sampling was used during the same time period to record all occurrences of inter-specific and intra-specific interactions. For all interactions, the type of interaction (Table 3), along with the direction of the interaction (initiator and responder species) and the type of response were recorded. Moving towards and away from other individuals was included as an interaction to calculate maintenance of proximity.

Table 3: Definitions of intraspecific and interspecific interactions.

Interaction type	Definition
Actor(s)	
Threat display	Actor(s) engages in non-vocal aggressive behaviours toward member(s) of the other species.
Vocalization	Actor(s) makes a call.
Play	Actor(s) plays with member(s) of the other species or attempts to elicit play or attempts to join in intraspecific play.
Moving together	Individuals of both species travel in the same direction in close proximity (1m), include foraging or exploration behaviours.
Curious approach	Actors moves toward member(s) of other species at a slow pace and does not display any aggressive behaviour, but shows interest in other individual or initiates interaction.
Close proximately	Actor(s) moves to 1 metre of individual(s) of other species but shows no interest in interacting, and does not touch.
Unclear	An interaction occurs between two or more individuals of different species, but it is difficult to discern the type of interaction.
Recipients	
Vigilant-ignore	Recipient(s) appears aware of behaviour of the actor(s) but does not move from area.
Vocalization	Recipient(s) faces the actor(s) and makes a call.
Approach	Recipient(s) moves to 1 metre of actor(s)
Moving away	Recipient(s) retreats from actor(s) and the area they were previously occupying. Includes moving short distances away or leaving enclosure.
Segregate into species group	Members of the two species move toward their own species members to form a cluster.
Aggression	Recipient(s) behaves in an agonistic way toward the actor(s), moving into closer proximity and making threatening displays toward another individual.
No reaction	Recipient(s) does not respond to the behaviour of the actor(s), for example, does not look in direction of actor or respond in any way

Statistical analysis

Prior to analysis, some behaviour categories were pooled leaving six categories that were subjected to analysis; locomotion (walking and running), foraging, feeding (including drinking), standing, threat and vocalisation, and others (preening, body shaking, wings expanding, leg scratching). Generalized linear mixed models (GLMMs) were performed for each behaviour category and each nearest neighbour distance category using species and exhibit type (mixed or single-species) as main factors. Zoo and enclosure number were included as covariates. Following the initial model non-significant covariates and factors were removed in a stepwise method from the model to leave a final model only including those variables that significantly affected the number of times the behaviour or distance category was observed.

The total number of aggressive, neutral and friendly interactions between all possible species-species combinations were counted. The expected number of such interactions for each species pair combination was calculated based on the total number of possible dyads of that combination

observed and assuming that interactions would happen evenly across dyads. Observed frequencies were compared with expected using chi-squared tests.

Frequency of each enclosure zone was used to calculate the Spread of Participation Index (SPI) (Plowman 2003) to determine the use of available space. Maintenance of proximity describes the extent to which proximity is due to the movements of one member of the dyad rather than the other. It was calculated for all possible species dyads using the following formula:

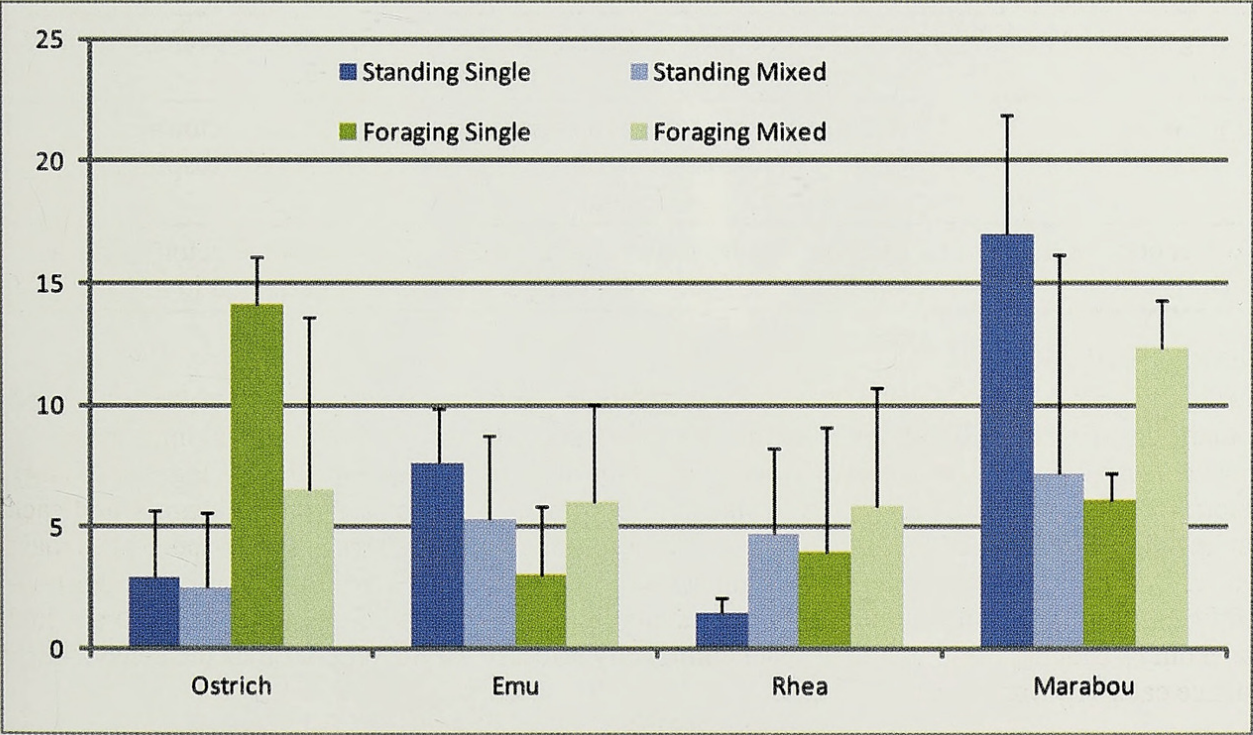
Maintenance of proximity = $U_A / (U_A + U_B) - S_A / (S_A + S_B)$

Where U_A is the number of occasions when a pair were united by species A's movements; U_B is a number of occasions when a pair were united by species B's movements; S_A is the number of occasions when a pair were separated by species A's movements; and S_B is the number of occasions when a pair were separated by species B's movements. The index ranges from -1.0 (B totally responsible for maintaining proximity) to + 1.0 (A totally responsible) (Martin and Bateson 1993).

Results

Bird species had a significant effect on the time spent performing all behaviour categories, except threat and resting. Overall, emus and rhea tend to move most and marabou stork least, whereas marabou tend to stand more than the other species and also perform more other behaviours. Emu and rhea tend to spend more time feeding and foraging. In addition, the covariates zoo and enclosure also had significant effects on most behaviour categories. However, despite the effects of these other variables it was possible to detect some overall effects of exhibit type (mixed or single-species) on behaviour. Exhibit type had a significant effect on the time spent standing ($\chi^2_{[1]} = 9.07, P = 0.003$) and foraging ($\chi^2_{[1]} = 7.23, P = 0.007$) by birds overall but no significant effect on locomotion ($P = 0.61$), threat ($P = 0.38$), feeding ($P = 0.55$), resting ($P = 0.62$) or others ($P = 0.95$). Generally birds in single species exhibits spent longer standing and more time foraging than birds in mixed exhibits (fig. 1).

Figure 1: Mean observation time spent standing and foraging by birds in single-species and mixed-species exhibits in five UK zoos.



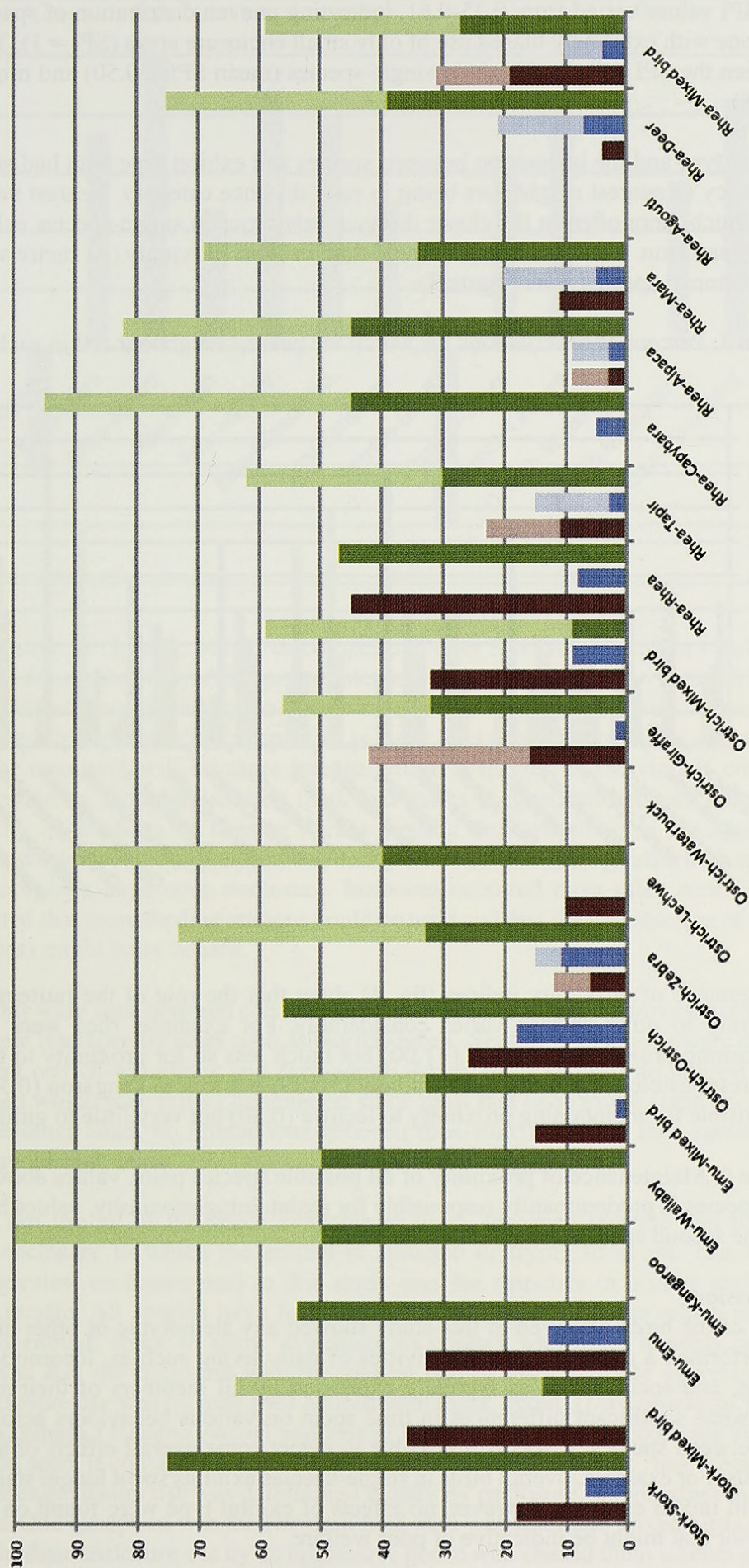
In addition, there was a significant interaction between species and exhibit type on locomotion ($\chi^2 = 16.57_{[4]}$, $P = 0.002$), standing ($\chi^2 = 26.003_{[3]}$, $P = 0.000$), foraging ($\chi^2 = 12.17_{[3]}$, $P = 0.007$) and others ($\chi^2 = 17.23_{[4]}$, $P = 0.002$). Although generally birds stand for longer in mixed exhibits, rhea do so in single-species exhibits, ostrich are the only birds that foraged more in single-species exhibits, marabou stork and rhea perform more locomotion in mixed-species exhibits, whereas emu perform less.

There were significant differences between species pairs in the frequency of aggressive ($\chi^2 = 284_{[11]}$, $P < 0.05$), friendly ($\chi^2 = 538_{[11]}$, $P < 0.05$) and neutral interactions ($\chi^2 = 966_{[11]}$, $P < 0.05$). Ostrich-zebra pairs tend to interact significantly more often than other species pairs for all three types of interaction. Emu-wallaby pairs tend to perform significantly more neutral interactions than other species pairs and rhea-deer pairs perform more than expected friendly and neutral interactions. Aggressive interactions were found mostly in rhea-rhea pairs and no aggression was seen at all between emu-kangaroo, emu-wallaby, ostrich-waterbuck, rhea-capybara and rhea-agouti pairs. Aggressive interactions were much more often initiated by the ratite/marabou than the other species (fig. 2). Most aggression towards ratites/marabou was seen in giraffe-ostrich pairs and in rhea-mixed bird and rhea-tapir pairs, with small amounts in ostrich-zebra and rhea-alpaca pairs (fig. 2). Friendly interactions were found mostly in ostrich-zebra, rhea-mara and rhea-deer pairs, but very infrequently in ostrich-giraffe pairs, and not at all between emu-kangaroo, emu-wallaby, ostrich-lechwe, ostrich-waterbuck and rhea-agouti pairs. Neutral interactions were the most common type between most pairs and were seen particularly often in emu-kangaroo, emu-wallaby, emu-mixed bird, stork-mixed bird, ostrich-lechwe, ostrich-mixed bird and rhea-capybara pairs.



In this study, emu were found to perform less locomotion in mixed-species exhibits, while other bird species performed more locomotion.

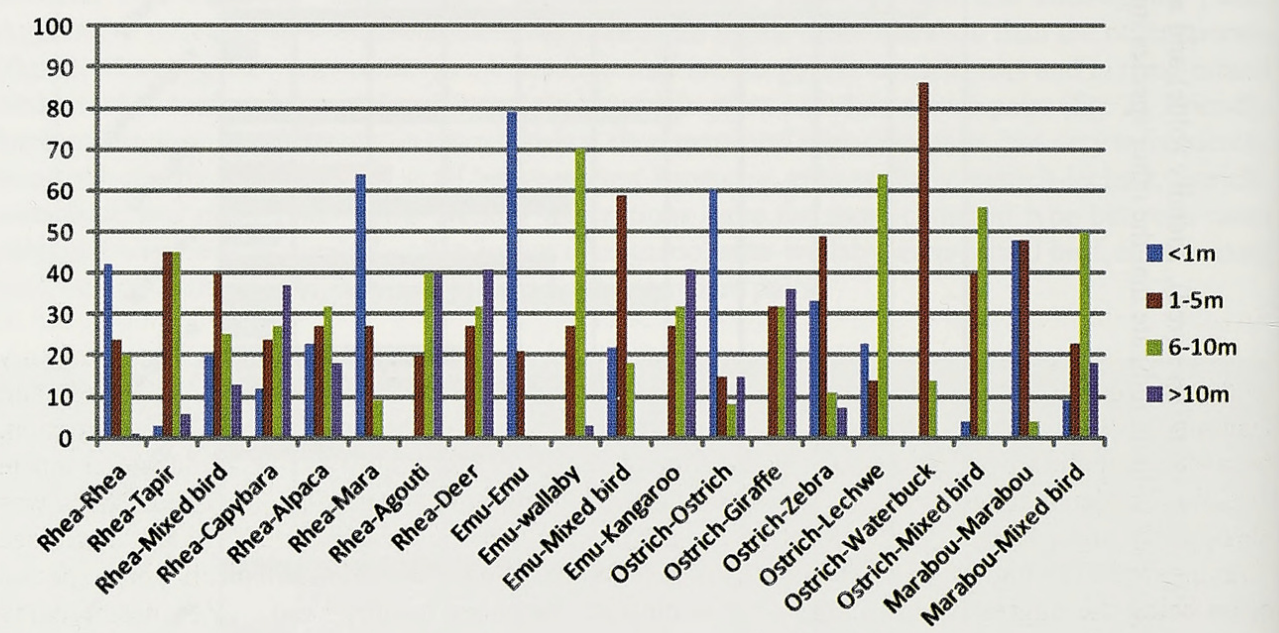
Figure 2. Percent interactions for all species pairs that were aggressive (red), friendly (blue) and neutral (green). Dark colours indicate that the ratite/marabou initiated the interaction, pale colours indicate that the other species initiated the interaction.



The SPI values varied from 0.35-0.61, indicating uneven distribution of space use in all enclosures but none with extremely biased use of only small enclosure areas (SPI = 1). There was no difference between the SPI values of birds in single-species (mean SPI = 0.50) and mixed exhibits (mean SPI = 0.48)

Exhibit type and the interaction between species and exhibit type both had significant effects on the frequency of nearest neighbours being in each distance category. Nearest neighbours of all species were much more often in the closer distance categories in single-species exhibits, especially so for ostrich and emu. Conspecifics spent more time in close proximity (<1 metre apart) compared with all bird-mammal species pairs (figure 3).

Figure 3: Percent of observations for which the nearest neighbour fell in each distance category.

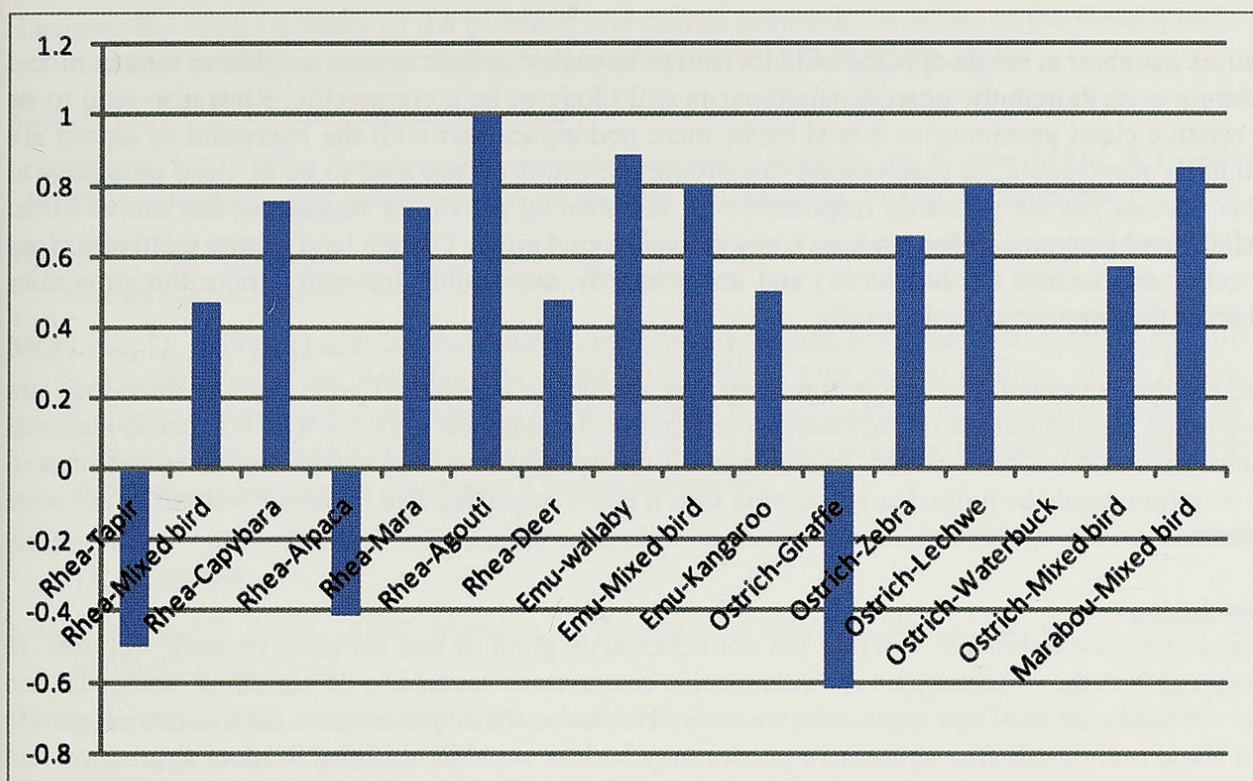


Maintenance of proximity indices (fig. 4) show that the role of the ratite/marabou in maintaining proximity to other species varies considerably. For example, rhea were totally responsible for maintaining proximity to agouti (+1.00) but much less so for proximity to tapir (-0.50). Emus, are most responsible for proximity to wallaby (+0.89) but less to kangaroo (0.50). Ostriches, are most responsible for maintaining proximity to lechwe (0.80) but very little to giraffe (-0.62).

Figure 4: Maintenance of proximity of all possible species pairs, values above zero indicate that the first species is predominantly responsible for maintaining proximity, values below zero indicate that it is the second species.

Discussion

None of the birds observed in this study showed any stereotypic or other abnormal behaviour and all performed a range of normal activities of daily living such as, locomotion, foraging, preening, resting, and socialization as typically expressed by all members of their species. Although there were some significant differences in time spent on various behaviours across zoos and enclosures and between species, it was still possible to detect some overall effects of single or mixed-species exhibits. For example, overall birds in single-species exhibits spent longer standing and foraging than birds in mixed exhibits. However, no effects of exhibit type were found on time spent performing behavior that might be indicative of poor welfare.



Aggressive interactions such as chasing, biting, or competition over food were seen but resulted in no serious consequences during the study. All types of interactions including aggressive and friendly were seen more often between conspecific pairs than between any interspecific pairs. Veasey and Hammer (2010) illustrated that intraspecific aggression is more likely than interspecific aggression, because competition for resources will be more intense within a species as individuals compete directly for identical resources, including shelter, food, and mates. Aggression between rheas was particularly high, usually in the form of chasing during feeding time, resulting in the aggressee running away. The highest interspecific aggression was seen between ostrich and giraffe, both species often being the aggressor, in a large open enclosure. Instances occurred most often near feeding stations and it is suggested that more feeding stations could be used and that the introduction of visual barriers (bushes and trees) might be of benefit.

Most friendly interactions were seen between conspecifics which tend to forage or move together but this was also true of some interspecific pairs such as ostrich-zebra. Neutral interactions were seen in almost every pair except ostrich-waterbuck and rhea-agouti. Many birds showed no interest when other species approached which may reflect habituation since most had been in the same enclosure for a long time. On the other hand, no interactions between rhea-waterbuck and rhea-agouti may reflect that these pairs avoid each other.

Many zoo animals do not use all of the space available to them, this may indicate that there is something within the enclosure to which the animal is attracted or trying to avoid. The lowest SPI score (indicating greatest enclosure use) in this study was for ostriches in a large enclosure mixed with zebra and giraffe. All species have free access to the whole enclosure which is open grassland and provided enough space to allow avoidance of contact with other animals or with people, although this was also the enclosure with the highest rate of ostrich-giraffe aggression. In contrast, the lowest enclosure use was by nine rhea housed with mara, agouti (*Dasyprocta sp.*), tapir (*Tapirus sp.*), capybara, alpaca (*Vicugna pacos*) and mixed birds. Although this enclosure is large and little aggression was seen, it contained a large pond which was not used by the rhea. Therefore, it seems that in most cases enclosure use was determined mostly by enclosure design rather than the effects of other animals. One exception was the two emu held with wallabies and mixed birds which appeared to be limited in their enclosure use by an aggressive goose who chased them whenever they approached a particular shelter.

Ratites/marabou in single-species exhibits tend to be closer to their nearest neighbour than in mixed exhibits even though the nearest neighbour is still likely to be a conspecific. Rhea also tend to be in relative close proximity to mixed birds, mara and alpaca and with the exception of alpaca are primarily responsible for maintaining this proximity. Emus do not tend to be in close proximity to other species but are primarily responsible for maintaining proximity suggesting that mixed birds, wallaby and kangaroo (*Macropus sp.*) may actively avoid emus. Ostrich tend to stay relatively close to zebra and lechwe (*Kobus leche*) and are primarily responsible for maintaining this proximity whereas they appear to avoid giraffe.

The results presented here are preliminary and should be interpreted with caution since they are based on a limited sample of enclosures, particularly for marabou stork for which a mixed-mammal enclosure could not be included. In addition, all the exhibits had been established for some time so by definition could be judged as successful, thus it is not surprising that no major welfare issues were detected.

Conclusions

Mixed-species exhibits are variable but not necessarily good or bad for ratite or stork welfare. In many exhibits the opportunities for interspecific interactions seemed to be enriching, enclosure use was not restricted and little aggression was seen. However, some species pairs such as ostrich-giraffe and some individuals (the aggressive goose) may be less suitable resulting in more aggression and active avoidance of each other. Conversely, rhea-deer and rhea-mara seem particularly suitable, actively forming associations in mixed exhibits.

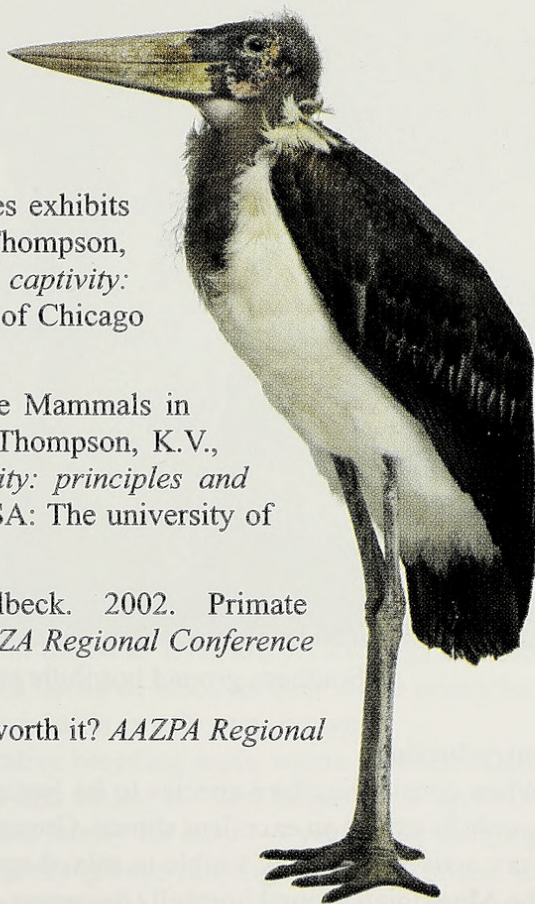
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