



Mixed Species Exhibits in German Zoological Gardens (Part 1)

Special References on Primates

Cover photos:

Left: Female elephant inspecting male baboon (Safaripark Beekse Bergen; photo: R. Deleu). Right above: Starting interaction (obviously food related) between Lion-tailed macaques and Borneo Orangutan at the "zoORANGerie" Münster (Allwetterzoo Münster). Right down: Common marmoset (right) and Spix's black-manteled tamarin (left) in outdoor enclosure, also open for visitors (Zoologischer Garten Rostock).

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Foreword

The present issue of Primate Report, presenting selected mixed species exhibits in Zoos of Germany, comprises two parts:

The first part represents a survey of **primate mixed species exhibits** in Zoos and Tierparks of Germany. It focuses on the association of primates with other primate and/or mammal species under captive conditions, in order to evaluate the feasibility of mixing specific primate species in Zoo-exhibits, as well as the potential risks and benefits for the animals involved. Individual concepts of enclosure designs based on the requirements of the mixed species are presented along with the experiences made by zoo personnel, in establishing and maintaining these polyspecific associations. Beside practical problems, technical demands for particular exhibits are also mentioned.

In the second part of this issue, some selected **mixed species exhibits without primates involved** are presented. This selection is focused on polyspecific associations of mammals which are rarely seen in captivity. By presenting these associations, some valuable information on unusual exhibits is provided to further support the development of polyspecific associations in Zoos and to promote new ideas as alternative ways of optimising keeping conditions in general.

The issue ends with final remarks on the overall experiences with mixed species exhibits made by zoo staff, including the public relation caused by such exhibits and the educational aspects for visitors.

For further information on mixed species exhibits of mammals in Zoos worldwide, the study of Dr. Gabriele Hammer, titled "Gemeinschaftshaltung von Säugetieren in Zoos", also available on CD-ROM, is highly recommended (see: HAMMER, 2001).

This issue of "Primate Report" was designed as a guide for primate mixed species exhibits in Germany, to obtain information on recommended, possible, problematic and apparently impossible combinations of species under specific conditions.

To facilitate a quick and easy access to single aspects of a special association, the information on mixed species exhibits in part one and part two of this issue is predominantly presented in tables. All mixed species exhibits are described in affiliation to the respective Zoos, which are presented in alphabetic order of location. To search for a specific primate species involved in any association, an index list can be used, which presents all primate species investigated, along with the respective Zoo, in which it is kept in a mixed species exhibit.

Beside giving a (limited) overview of primate mixed species exhibits, the additional purpose of this study is to promote such keeping concepts in captivity, not only to the benefit of the animals involved but also to strengthen the educational poten-

Foreword

tial of zoos and thus to advertise the conservation of the respective natural habitats, represented by the exhibitions.

Polyspecific associations and mixed species exhibits will also be subject of the following Primate Report (issue 65). Three scientific articles will be presented there, describing selected associations (baboons and elephants; several callitrichid species; howler monkeys and tamarins) under captive- and semi-free conditions in greater detail.

Dr. Thomas Ziegler

SELECTED MIXED SPECIES EXHIBITS OF PRIMATES AND OTHER ANIMALS
IN GERMAN ZOOLOGICAL GARDENS. ZIEGLER, T.

Background of the study

During the evolution of Zoos, from the mere presentation of animal collections, separately exhibited in single species cages, to the presentation of exhibits, set up to resemble natural habitats, the idea of mixing different species in the same enclosure became increasingly important.

Traditionally, many Zoos have considerable experience in the combination of numerous fish- reptile- and bird species in aquariums, reptile gardens or flight cages, but the concept of mixing two or more mammal species is relatively young. To a certain degree, the underlying reasons can be seen in the potential risks, technical demands and problems, that can be caused by establishing a new association of mammals in captivity.

Nevertheless, as polyspecific associations can be regularly observed in many sympatric animals including mammals in the wild, the concept of mixed species exhibits represents an important and promising measure to approximate natural conditions in captivity. Among vertebrates, stable polyspecific associations are quite common and can be observed regularly in wild fish, birds, ungulates and primates (BERTRAM, 1978; TERBORGH, 1990; BUCHANAN-SMITH, 1990). The ultimate causes of this phenomenon can be seen in behavioural strategies to avoid predators and to optimise foraging ("Safety in numbers": TERBORGH, 1990; MORSE, 1970; GADDIS, 1980; POWELL 1985; MUNN, 1986). Although not every species involved in a certain polyspecific association gains advantages equal in quantity or quality, the overall benefits of living in a mixed flock have to outweigh the potential costs for each individual, as polyspecific associations are evolutionary evolved strategies.

Many primate species are known to regularly form long term polyspecific associations in the wild (STRUHSAKER, 1981; POOK and POOK, 1982; GAUTIER-HION, 1988; HEYMANN, 1990). These associations can be formed within the taxonomic family or subfamily (e.g. Cebidae, Cercopithecidae, Callitrichinae) or between different taxonomic orders (e.g. primates and ungulates). Among Callitrichids (subfam.: Callitrichinae), the forming of polyspecific associations is already known as an integral part of their biology (HEYMANN and BUCHANAN-SMITH, 2000).

Against this background, polyspecific associations in captivity can be seen as a special enrichment, which leads to a more complex and thus more natural environment (HARDIE, 1996; HEYMANN et al., 1996), having positive effects for animals and visitors of these exhibits.

The possibility of exhibiting mammals of different species or combining mammals with bird or reptile species within the same enclosure can have several benefits on different levels. These benefits involve pure practical aspects, like alleviating

cage space problems, educational aspect for the public (as long as the association considers the zoogeographic distribution of the species involved) and last but not least, aspects of behavioural and social enrichment for the animals, due to interspecific or intensified intraspecific interactions.

The practical advantages of mixed species exhibits has become more and more important during the last decades, as Zoos have become increasingly involved in European and International breeding programs for an increasing number of species that are critically endangered in their natural habitats. While the number of these species and the demand for breeding programs in captivity increases, space for suitable exhibits in Zoos is limited. Mixed species exhibits can alleviate this problem, as already available enclosures can serve to keep two or more species at a time without disadvantages for any of the species involved. On the contrary, the association of different species in mixed exhibits can often represent an environmental enrichment for the individuals involved and this holds true especially for primates. In general polyspecific associations, as an additional stimulus in captivity, can positively influence individual behavioural patterns and time budgets in terms of interspecific and intensified intraspecific interactions. The stimulation of such interactive behavioural patterns can be an important factor for the wellbeing of the animals (e.g. to avoid stereotypic behaviours), as time budgets for foraging and predator avoidance are drastically reduced in captivity.

This study was set up to support the exchange of expertise in establishing and maintaining mixed species exhibits in Zoos and other animal keeping facilities of Germany and abroad, as well as to promote the outstanding value of this concept for future animal keeping and - exhibition facilities.

Selected Mixed Species Exhibits of Primates in German Zoological Gardens

Aschersleben

Tierpark Aschersleben, Auf der alten Burg 40, D-06449 Aschersleben

3 Associations selected here

Association 1

Associated species since 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Squirrel monkey (<i>Saimiri sciureus</i>)	3 males 3 females	unchanged	approx. 200 m ² natural ground vegetation, add. branches and ropes; visitors allowed to enter enclosure	25 m ² height: 4 m sandy ground with wooden chips, branches, ropes, resting places and sight blinds
Yellow toothed cavy (<i>Galea musteloides</i>)	3 females	unchanged		
Leopard tortoise (<i>Geochelone pardalis</i>)	3	later tortoises removed		

- **Special measures at the beginning of association:** Onset of association in indoor enclosure; monkeys almost never moved to the ground.
- **Special behavioural observations (intra- or interspecific):** Monkeys anxious about the tortoises at the beginning, later curious and finally they ignored tortoises and cavies.
- **Problems and risks (animals, technical, vet. medical):** Although no signs of threat could be observed, tortoises drastically reduced feeding for no obvious reason and were thus removed later.
- **Cause of problems and trouble shooting:** removal, see above

Association 2

Associated species since May 2002	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Golden headed lion tamarin (<i>Leontopithecus chrysomelas</i>)	1 male 1 female	loss of female (see below)	25 m ² natural ground, several small bushes, ropes and natural branches	6 m ² 3.5 m height, natural ground, brooklet, 2-3 small plants, natural branches
Pygmy marmoset (<i>Cebuella pygmaea</i>)	1 male 1 female	unchanged		

- **Special measures at the beginning of association:** Two separated feeding places and two sleeping boxes.

- **Special behavioural observations (intra- or interspecific):** At the beginning both species watched each other distrustfully from a distance. But just 2-3 days later they regularly used common resting places in close association. No behavioural problems.
- **Problems and risks (animals, technical, vet. medical):** Loss of a female tamarin due to toxoplasmosis.
- **Cause of problems and trouble shooting:** Reason for infection is still under investigation. No physical signs of infection were observed at earlier stages of the disease.

Association 3

Associated species since July 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Cotton top tamarin (<i>Saguinus oedipus</i>)	1 male, 1 female plus offspring: 2,1 juvenile	May 2002: loss of 1,0 adult and 1,1 juv. (reason see below)	association only indoor	50 m ² max. height: 4 m natural ground planted incl. a 2000 l aquarium, visitors pathway, wooden chips, small pond with sandy parts (for turtles), upper part; equipped with many branches and ropes, UV-light spots
Green iguana (<i>Iguana iguana</i>)	4	iguanas were removed after two months of association		
Turtels (divers spec.)	18			

- **Special measures at the beginning of association:** Separate feeding sites and sleeping boxes for tamarins and iguanas in the upper part (above visitors) of the exhibit.
- **Special behavioural observations (intra- or interspecific):** Initial timidity of tamarins towards visitors quickly decreased. Tamarins moved to the ground but avoided physical contact to visitors. Turtels were ignored whereas aggressive interactions with iguana were observed (see below). Aggressive behaviour of *S. oedipus* was also observed towards golden headed lion tamarins, pygmy marmosets and squirrel monkeys, housed in adjacent enclosures.
- **Problems and risks (animals, technical, vet. medical):** Tamarins behaviour towards iguana was initially cautious, then curious and finally characterised by very aggressive (territorial) interactions. Iguanas were bitten in eyes and back by tamarins and had to be removed subsequently.
- **Cause of problems and trouble shooting:** Losses of tamarins due to toxoplasmosis. No physical signs of infection were observed at earlier stages of the disease.

Beekse Bergen

Safaripark Beekse Bergen, Beekse Bergen 31, NL-5081 NJ Hilvarenbeek

1 Association selected here

Associated species since 1994	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Hamadryas baboon (<i>Papio hamadryas</i>)	24 males 33 females	25,36 many demographic changes due to breeding success and subsequent birth control measures	15000 m ² with some parts exclusively accessible for baboons; for details see DELEU et al. (2003)	separate stables for baboons and elephants; for details see DELEU et al. (2003)
African elephant (<i>Loxodonta africana</i>)	5 females	unchanged introduction of male planned; for details see DELEU et al. (2003)		

- **Special measures at the beginning of association:** Baboons were introduced first to the enclosure, then elephants were associated.
- **Special behavioural observations (intra- or interspecific):** Baboons adapted time budgets and spatial use of the enclosure to the presence of the elephants. They forage in poorly digested elephant dung, play in holes dug by elephants, and try to steal food. Since 1997 baboons (juveniles or young adults) ride on elephants backs. Sometimes elephants backs are "groomed" (i.e. seed or insect picking) and elephants even invite baboons to enter their back. For details see DELEU et al. (2003).
- **Problems and risks (animals, technical, vet. medical):** No major behavioural problems. Growth of plants is largely inhibited by elephants. A salmonella infection caused the death of several baboons and sickness of elephants. For details see DELEU et al. (2003).
- **Cause of problems and trouble shooting:** Origin of salmonella infection was not clear; successful antibiotic treatment.



Female elephant inspecting male baboon.

*Safaripark Beekse Bergen
(photo: R. Deleu)*



Hamadryas baboon riding an African elephant.

*Safaripark Beekse Bergen
(photo: R. Deleu)*

Berlin

Zoo Berlin, Hardenbergplatz 8, D-10787 Berlin

3 Associations selected

Association 1

Associated species in the 1970ies	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Japanese macaque (<i>Macaca fuscata</i>)				
Barbary sheep (<i>Ammotragus lervia</i>)				
association terminated				

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** Socio-positive interactions between species. Japanese macaques were riding and grooming the Barbary sheeps. Barbary sheeps apparently enjoyed it; calm and peaceful association.
- **Problems and risks (animals, technical, vet. medical):** no major problems

Association 2

Associated species in the 70ies	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Rhesus macaque (<i>Macaca mulatta</i>)				
Thars (<i>Hemitragus spec.</i>)				
association terminated				

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** Rhesus monkeys were biting thars. Thars subsequently tried to avoid rhesus monkeys.
- **Problems and risks (animals, technical, vet. medical):** see above
- **Cause of problems and trouble shooting:** Association was terminated – thars were removed. After thars made this negative experience with *M. mulatta* another try to associate them with *M. fuscata* was unsuccessful as the thars were now generally afraid of monkeys.

Association 3

Associated species in the 70ies	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Rhesus macaque (<i>Macaca mulatta</i>)				
Barbary sheep (<i>Ammotragus lervia</i>)				
association terminated				

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** Rhesus monkeys were biting Barbary sheeps, which were severely injured (hind limbs, scrotum ect.).
- **Problems and risks (animals, technical, vet. medical):** see above
- **Cause of problems and trouble shooting:** Problems of association caused by *M. mulatta*. Association was terminated, Barbary sheeps were removed.

Braunschweig

Arche Noah Zoo Braunschweig, Am Zoo 35, D-38124 Braunschweig

3 Associations selected here

Association 1

Associated species since April 2002	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Southern owl monkey (<i>Aotus azarae</i>)	1 male 1 female 0,1,1 offspring	unchanged	17.5 m ² natural ground, small plants as well as maple- and willow trees	14 m ² floor covered with garden mould and leaves; ornamental plants on the ground; ropes and branches in the upper parts
Common marmoset (<i>Callithrix jacchus</i>)	1 male 1 female	unchanged		
Green iguana (<i>Iguana iguana</i>)	1 male	unchanged		

- **Special behavioural observations (intra- or interspecific):** few interspecific interactions
- **Problems and risks (animals, technical, vet. medical):** no major problems



Common marmosets resting next to a green iguana.
Arche Noah Zoo Braunschweig

Association 2

Associated species since July 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Cotton top tamarin (<i>Saguinus oedipus</i>)	1 male 1 female	unchanged	15 m ² natural ground with several bushes, ropes and branches	10 m ² sealed concrete floor, covered with sawdust; ropes and natural branches
Green iguana (<i>Iguana iguana</i>)	1 male	unchanged		
Hermann's tortoise (<i>Testudo hermanni</i>)	4 males	unchanged		

- **Problems and risks (animals, technical, vet. medical):** No major problems but see also Aschersleben Tierpark for a similar association.



Cotton top tamarin inspecting a green iguana.
Arche Noah Zoo Braunschweig
(photo provided by Dr. F. Brandes)

Association 3

Associated species since July 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Common marmoset (<i>Callithrix jacchus</i>)	3 males 2 females 5 juveniles and infants (all age classes)	breed regularly	15 m ² natural ground with several bushes, ropes and branches	10 m ² sealed concrete floor, covered with sawdust; ropes and natural branches
Green iguana (<i>Iguana iguana</i>)	1 male	unchanged		
Russian (Horsfield's) tortoise (<i>Agrionemys horsfieldii</i>)	4 males 3 females	unchanged		

- **Problems and risks (animals, technical, vet. medical):** no major problems

Dortmund

Zoo Dortmund, Mergelteichstraße 80, D-44225 Dortmund

2 Associations selected here

Association 1

Associated species since 1989	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Giant anteater (<i>Myrmecophaga tridactyla</i>)	1 male 1 female 1 offspring	4 females 2 juveniles	only giant anteater have access to outdoor enclosure	five enclosures in a hall with a transparent roof construction (acryl-glass); branches, resting platforms; enclosures associated with planted areas
Owl monkey (<i>Aotus trivirgatus</i>)	several	1 male 1 female		
Two toed sloth (<i>Choloepus didactylus</i>)	2 males 1 female	2 males 1 female		

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** While lacking a female conspecific, a single male owl monkey established and maintained a close sociopositive relationship to a male sloth. This relationship was terminated when a female owl monkey was added in 2002.
- **Problems and risks (animals, technical, vet. medical):** no major problems



Owl monkey in close contact to a two toed sloth.

Zoo Dortmund

Association 2

Associated species since 1992	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Goeldi's monkey (<i>Callimico goeldii</i>)	Association initiated with emperor tamarins (<i>Saguinus imperator</i>) and green acouchis (<i>Myoprocta pratti</i>)	2 females	only indoor as part of the Amazonas-building	approx. 20 m ² floor covered with wooden chips; natural branches and twigs, rocks
Green acouchi (<i>Myoprocta pratti</i>)		1 male, 1 female 4 offspring		

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** Green acouchis like to climb onto branches to steal food items placed for *C. goeldii*.
- **Problems and risks (animals, technical, vet. medical):** Loss of one Goeldi's monkey due to callitrichid hepatitis. For further details see ASPER et al. (2001).
- **Cause of problems and trouble shooting:** Enclosure is part of the Amazonas-building, where also pygmy marmosets are housed in separate enclosures. The LCMV virus was most likely transmitted by wild mice.

Dresden

Zoo Dresden GmbH, Tiergartenstraße 1, D – 01219 Dresden

5 Associations selected here

Association 1

Associated species since Aug. 1993	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Red-bellied tamarin (<i>Saguinus labiatus</i>)	1 male 1 female	unchanged	association only indoor	12 m ² height: 3 m structural enriched
Viscachas (<i>Lagostomus maximus</i>)	1 male, 1 female plus juveniles	regularly breeding		

- **Special behavioural observations (intra- or interspecific):** Tamarins attacked and chased viscachas and dominated them. The presence of the viscachas induced excitement in the tamarins and this reaction was even more intense when female tamarin was pregnant. Infants were falling down and tamarins chased viscachas on the ground. Adults were poorly taken care for the infants. After viscachas were removed, tamarins reared their young without problems.
- **Problems and risks (animals, technical, vet. medical):** Reproduction of tamarins was connected with an increase of territorial (aggressive) behaviour.
- **Cause of problems and trouble shooting:** Distance to viscachas on the ground was too small (not sufficient); association terminated.

Association 2

Associated species from Nov. 1993 until Nov. 1994	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Red-bellied tamarin (<i>Saguinus labiatus</i>)	2 males 1 female	loss of 2 tamarins	association only indoor	10 m ² height: 2.5 m ground covered with wooden chips, upper part structural enriched, window
Golden rumped agouti (<i>Dasyprocta aguti</i>)	3 adults	reared 1 infant		

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** Frequent interspecific interactions on the ground. Tamarins actively attacked agoutis, chased and bit them. Tamarins searched for, and often monopolised agouti's food. Tamarins appeared to be the dominant species, but they also seemed to be disturbed by the agoutis.
- **Problems and risks (animals, technical, vet. medical):** interspecific aggression

- **Cause of problems and trouble shooting:** Enclosure too small; although no external intervention was necessary, under these conditions, this association cannot be recommended.

Association 3

Associated species for 4 years	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Black tufted-eared marmoset (<i>Callithrix penicillata</i>)	1 male 1 female	unchanged	association only indoor	10 m ² height: 2.5 m
Golden rumped agouti (<i>Dasyprocta aguti</i>)	1 male 1 female	reared 1 infant		

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** Interspecific interactions only on the ground, initiated by the marmosets. Compared to the tamarins (see association 2 above), marmosets felt less disturbed by the agoutis.
- **Problems and risks (animals, technical, vet. medical):** Marmosets tried to get the food placed for the agoutis on the ground. Agoutis defended their food and during these aggressive encounters one marmoset was bitten.

Association 4

Associated species from 1993 until 1994	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Geoffroy's tufted-eared marmoset (<i>Callithrix geoffroyi</i>)	1 male 1 female	reared offspring successfully	association only indoor	10 m ² height: 2.5 m enclosure structural enriched
Guinea pig (<i>Cavia apera</i>)	3-4 animals	reared offspring successfully		

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** *C. apera* obviously suffered from the marmosets curiosity (aggression?) and were displaced by the primates easily. Interspecific interactions occurred on the ground, when marmosets took the food placed for *C. apera* - before or after they chased them. Marmosets did not feel disturbed at all (but see also association 2 for red-bellied tamarins).
- **Problems and risks (animals, technical, vet. medical):** A comparable association keeping *C. apera* in combination with *Callithrix jacchus* (breeding) was maintained for 4-5 years showing very similar behavioural effects.

Association 5

Associated species from Feb. until May 1999	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Mandrill (<i>Mandrillus sphinx</i>)	1 male 1 female plus offspring	association terminated	250 m ² peninsular with natural ground, grass, bushes, rocks and roots	entrance of mongoose indoor enclosure was occupied (blocked) by mandrills
Banded mongoose (<i>Mungos mungo</i>)	6 animals			

- **Special measures at the beginning of association:** Firstly mongoose were given exclusive access to the outdoor enclosure for several days to habituate them to the environment.
- **Special behavioural observations (intra- or interspecific):** Several days after mandrills had also been given access to the outdoor enclosure, they were habituated to the new situation and chased (hunted) the mongoose whenever they could (except the alpha male). Two mongoose were lethally injured.
- **Problems and risks (animals, technical, vet. medical):** Although mongoose used their burrows, which they dug under roots, for shelter, mandrills managed to catch them; mongoose were removed.
- **Cause of problems and trouble shooting:** This association cannot be recommended.

Düsseldorf

Aquazoo + Löbbecke Museum Düsseldorf, Kaiserwerther Str. 380, D-40200 Düsseldorf

1 Association selected here

Associated species since 1998	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Common marmoset (<i>Callithrix jacchus</i>)	1 male 1 female	unchanged	association only indoor	enclosure has different horizontal levels: approx. 5 m long approx. 9 m ² , approx. 2.5 m (mean) height; wooden chips on the ground, natural plants (ficus and banana trees), willow branches of different diameter
Green acouchi (<i>Myoprocta pratti</i>)	1 male 1 female	produced 15 offspring until June 2002		

- **Special measures at the beginning of association:** intensive observation
- **Special behavioural observations (intra- or interspecific):** Male *C. jacchus* is attracted by newborn acouchis. He shows protective behaviour and tries to carry them away when keepers are present.

- **Problems and risks (animals, technical, vet. medical):** Marmosets chase female acouchi before and 1-2 days after their delivery. This phenomenon causes stress for acouchi-mothers and slight arousals in acouchi group. Nevertheless lactation of acouchis is sufficient. Additional problems can arise when deliveries of two acouchi females occur within 6 weeks and the lactation of the latest litter is disturbed by the older offspring.
- **Cause of problems and trouble shooting:** Problems might be caused by the fact that marmosets never produced offspring. Observed problematic interactions cease, when young acouchis become too big and heavy for the male marmoset to carry them around. Sufficient lactation of new born infants can be supported by the temporarily removal of older offspring. In general this association is highly recommended.



Common marmosets mixed with green acouchis (upper right side).

Aquazoo + Löbbecke Museum
Düsseldorf

Eberswalde

Zoologischer Garten Eberswalde, Am Wasserfall, D-16225 Eberswalde

1 Association selected here

Associated species since 1999	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Golden lion tamarin (<i>Leontopithecus rosalia</i>)	2 females	1 male	15 m ² wooden chips, sand, cherry-tree, small bushes, natural trunks and branches	5 x 1.8 x 2.5 m natural trunks and branches
Pygmy marmoset (<i>Cebuella pygmaea</i>)	1 male 1 female	3 males		
Guinea pig (<i>Cavia apera</i>)	1 male 6 females			

- **Special behavioural observations (intra- or interspecific):** During common resting sessions, female *L. rosalia* allowed adult *C. pygmaea* to enter their back and warm up. No other interspecific interactions were observed.

Frankfurt / Main

Zoo Frankfurt, Alfred-Brehm-Platz 16, D-60316 Frankfurt

8 Associations selected here

Association 1

Associated species since 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Southern owl monkey (<i>Aotus azarae</i>)	initially monkeys were associated with acouchis (<i>Myoprocta pratti</i>) and nine-banded armadillos (<i>Dasyus novemcinctus</i>)	<i>A. azarae</i> breeds successfully since 20 years; acouchis bred until armadillos were introduced	only indoor (Grzimek`s house for nocturnal animals)	15.4 m ² , 53 m ³ plus 1.8 m ² common sleeping box
Larger hairy armadillo (<i>Chaetophractus villosus</i>)				
Two-toed sloth (<i>Choloepus hoffmannii</i>)				

- **Special behavioural observations (intra- or interspecific):** Juvenile owl monkeys were observed to ride on the backs of young acouchis (association was systematically observed by students).
- **Problems and risks (animals, technical, vet. medical):** In former associations acouchis were frequently disturbed by nine-banded armadillos on the ground and stopped breeding.
- **Cause of problems and trouble shooting:** Nine-banded armadillos were replaced by larger hairy armadillo. Present-day association can be recommended.

Association 2

Associated species since 1997	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Golden lion tamarin (<i>Leontopithecus rosalia</i>)	3	max. group size: 5 animals	6 m ² height: 2 m	7.3 m ² height: 1.6 m
Pygmy marmoset (<i>Cebuella pygmaea</i>)	1 male 1 female	breeds but infants were lost		

- **Special measures at the beginning of association:** To habituate species to each other, they were initially separated by a wire mesh to inhibit physical contact.
- **Special behavioural observations (intra- or interspecific):** *L. rosalia* frequently displaced *C. pygmaea* (April 2000).
- **Problems and risks (animals, technical, vet. medical):** *C. pygmaea* lost infants.
- **Cause of problems and trouble shooting:** Loss of *C. pygmaea* infants due to Pseudomoniasis, possibly as a consequence of a weak immune-system. After subsequent losses of *C. pygmaea* infants, association was terminated. Species were re-associated in Mai 2002.

Association 3

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Red-bellied tamarin (<i>Saguinus labiatus</i>)		mean group size of about 10 animals	association only indoor	approx. 25 m ² height: approx. 7 m wooden chips on the ground, artificial rock walls, enclosure enriched with natural trees (<i>Ficus spec.</i>)
Green acouchi (<i>Myoprocta pratti</i>)		3 adults 1 juvenile		

- **Problems and risks (animals, technical, vet. medical):** no major problems (note the height of enclosure)

Association 4

Associated species since Feb. 1997	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Ring-tailed lemur (<i>Lemur catta</i>)		never bred when associated	480 m ² dense natural vegetation	several indoor enclosures for separate housing (14, 14, and 74 m ² , respectively with 43, 43 and 243m ³)
Ruffed lemur (<i>Varecia variegata rubra</i>)		never bred when associated		

- **Special measures at the beginning of association:** Aggression with biting attempts already occurred during phases of habituation near transparent sliding doors (species still territorially separated).
- **Special behavioural observations (intra- or interspecific):** During several attempts (from 1997 to 1998) to associate species, aggressive chasings were observed and animals were separated again after a few minutes.
- **Problems and risks (animals, technical, vet. medical):** During the first encounters *L. catta* were chasing the ruffed lemurs. Later, one *L. catta* was injured by a ruffed lemur.
- **Cause of problems and trouble shooting:** Association not successful, had to be terminated.

Association 5

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Black-handed spider monkey (<i>Ateles geoffroyi</i>)	1 male 5 females	association terminated (see below)	250 m ² island with natural vegetation	separate indoor enclosures for species: one enclosure 35 m ² for <i>A. geoffroyi</i> and two adjacent smaller ones (9.2 and 5.3 m ²) for <i>S. boliviensis</i> ; access to outdoor enclosure only possible from the larger indoor enclosure
Bolivian squirrel monkey (<i>Saimiri boliviensis</i>)	4 males 3 females			

- **Special measures at the beginning of association:** Species were habituated in their indoor enclosures while still separated by wire mesh.
- **Special behavioural observations (intra- or interspecific):** After association *A. geoffroyi* was chasing *S. boliviensis* and pressed them hard.
- **Problems and risks (animals, technical, vet. medical):** see above
- **Cause of problems and trouble shooting:** Association was terminated; association might be manageable if access to outdoor enclosure would be made possible from indoor enclosures of both species (selective access).

Association 6

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Red-bellied tamarin (<i>Saguinus labiatus</i>)	1 male 2 females	associated just for a few days	31.2 m ² approx.. 160 m ³	
Geoffroy's tufted-eared marmoset (<i>Callithrix geoffroyi</i>)	4	associated just for a few days		

- **Special measures at the beginning of association:** *S. labiatus* was habituated to the enclosure first. *C. geoffroyi* was introduced later, using a smaller cage which was put into the enclosure for a few days before the animals were released into the association.
- **Special behavioural observations (intra- or interspecific):** Physical aggression between species.
- **Problems and risks (animals, technical, vet. medical):** *S. labiatus* was aggressively displaced by *C. geoffroyi*.
- **Cause of problems and trouble shooting:** association was terminated

Association 7

Associated species since 1978	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Southern lesser bush baby (<i>Galago moholi</i>)	1 male 1 female	breed successfully (max. group size 6-7 animals)	association only indoor ("Grzimek's house" for nocturnal animals)	27.8 m ² approx. 80 m ³ approx. 50 % of the enclosure basement is equipped with a system of burrows and caves initially dug by the springhares and later stabilised artificially
Springhare (<i>Pedetes spec.</i>)	1 male 1 female	never bred		

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** no interactions observed
- **Problems and risks (animals, technical, vet. medical):** No major problems beside controlling the digging activities of the springhares; association can be recommended.



Springhare (left) associated with bush baby (center right) in "Grzimek's house" for nocturnal animals.

Zoo Frankfurt

Association 8

Associated species since 8 years	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
White-faced saki (<i>Pithecia pithecia</i>)	1 male 1 female	both species breed (max. group size for <i>P. pithecia</i> was 6)	association only indoor ("Grzimek's house" for nocturnal animals)	11.5 m ² , approx. 30 m ³ plus a 1.9 m ² box of 2 m height branches, ropes, artificial rocks; floor covered with wooden chips
Green acouchi (<i>Myoprocta pratti</i>)	1 male 1 female			

- **Special measures at the beginning of association:** Acouchis were habituated to the enclosure using the box placed inside.
- **Special behavioural observations (intra- or interspecific):** During the first days of association sakis were worried and social atmosphere was tense. Fearful behaviour and intra-specific aggression was initially observed. After four days situation relaxed, sakis were observed to copulate and from this moment they just ignored the acouchis.
- **Problems and risks (animals, technical, vet. medical):** no further problems, association recommended
- **In addition to these associations two other cases should be mentioned here:**
 1. Fat-tailed dwarf lemurs (*Cheirogaleus medius*) were successfully associated with tenrecs (*Tenrec spec.*) in an indoor enclosure (3.6 m², approx. 7 m³). One has to ensure that sleeping boxes for lemurs are not occupied by the tenrecs.
 2. A juvenile diana monkey (*Cercopithecus d. diana*) managed to escape from its group and accidentally joined a group of Hanuman langurs (*Semnopithecus entellus*) living in a neighbouring enclosure within an indoor keeping facility. The two species interact peacefully and playing behaviour was observed repeatedly. A female langur even allowed the Diana monkey to suckle.



*A male white-faced saki sitting above an green acouchi.
Zoo Frankfurt*

Gettorf

Tierpark Gettorf, Süderstraße 33, D-24214 Gettorf

7 Associations selected here

Association 1

Associated species since 1996	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Golden-handed tamarin (<i>Saguinus midas</i>)	1 male 1 female	association was terminated after a few months	association only indoor	5 x 2 x 2.7 m natural branches, ropes, ladders, pendulums, sleeping boxes
Pygmy marmoset (<i>Cebuella pygmaea</i>)	1 male 1 female			

- **Special behavioural observations (intra- or interspecific):** Both species slept together in one sleeping box. After *S. midas* was giving birth in Dec. 1996, *C. pygmaea* carried *S. midas* babies (two times observed). No problems at that time. When *S. midas* infants started to move around on their own, their parents started to attack *C. pygmaea*.
- **Problems and risks (animals, technical, vet. medical):** Adult *S. midas* attacked *C. pygmaea* when *S. midas* infants started to explore environment independently.
- **Cause of problems and trouble shooting:** Problems might be linked to the relatively small dimensions of the enclosure; association terminated.

Association 2

Associated species since 1998	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Golden-handed tamarin (<i>Saguinus midas</i>)	1 male, 1 female (breeding pair) plus 1,1 and 1,1 offspring with an interbirth interval of 8 months	association was terminated	association only indoor	5 x 2 x 2.7 m natural branches, ropes, ladders, pendulums, sleeping boxes
Black tufted-eared marmoset (<i>Callithrix penicillata</i>)	1 male, 1 female (breeding pair) plus 0,2 and 1,1 offspring with an interbirth interval of 5 months			

- **Special measures at the beginning of association:** Enclosure was equipped with new branches.
- **Special behavioural observations (intra- or interspecific):** Species did not mix up their groups and stayed spatially separated. Juveniles were not observed to play inter-specifically. Severe aggression occurred between the adult males after 2 weeks.

- **Problems and risks (animals, technical, vet. medical):** interspecific male-male aggression
- **Cause of problems and trouble shooting:** association was terminated

Association 3

Associated species since autumn 1999	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Golden-handed tamarin (<i>Saguinus midas</i>)	1 male, 1 female (breeding pair) plus 1,1 and 1,1 and 0,2 offspring)	<i>S. midas</i> continued to breed with an interbirth interval of 8 months	20 m ² tree trunks, ropes, resting platforms, concrete floor covered with wooden chips	2 x 10 m ² (2 x 5 m) height: 2.5 m trunks, branches, ropes, ladders, sleeping boxes, feeding places, concrete floor covered with wooden chips
White-faced saki (<i>Pithecia pithecia</i>)	1 male 1 female	sakis had their first offspring in July 2000; infant died after 3 months; 2 months later female saki died; in July 2001 a new female saki from Cologne Zoo was introduced; this female had a stillbirth in March 2002		

- **Special measures at the beginning of association:** Species were separated at night. Species are still temporarily separated when sakis need a more quite atmosphere esp. when giving birth.
- **Special behavioural observations (intra- or interspecific):** *S. midas* preferred to steel saki food. Species were thus separated during feeding.
- **Problems and risks (animals, technical, vet. medical):** Management of this association requires separation of species from time to time.

Association 4

Associated species since April 2002	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Golden-headed lion tamarin (<i>Leontopithecus chrysomelas</i>)	1 male 1 female	unchanged	8 m ² sandy ground, trunks and branches	16 m ² branches, trunks, sleeping boxes, floor covered with wooden chips, small caves for acouchis to hide
Acouchis (<i>Myoprocta acouchi</i> spec.)	3 males 1 female	unchanged		

- **Special behavioural observations (intra- or interspecific):** Species do not disturb each other.

Association 5

Associated species since April 1998	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Black tufted-eared marmoset (<i>Callithrix penicillata</i>)	1 male, 1 female (breeding pair) plus 0,2 and 1,1 and 2,0 offspring)	<i>C. penicillata</i> continued to breed with an interbirth interval of approx. 5 months	20 m ² tree trunks, ropes, branches, concrete floor covered with wooden chips	2 x 10 m ² (2 x 5 m) height: 2.5 m trunks, branches, ropes, sleeping boxes, feeding places, concrete floor covered with wooden chips
Southern owl monkey (<i>Aotus azarae</i>)	1 male 1 female plus 0,1 juvenile	<i>A. azarae</i> continued to breed with an interbirth interval of 12 months, but group size never exceeded 4 individuals		

- **Special measures at the beginning of association:** Species were repeatedly associated for a few hours and separated at night.
- **Special behavioural observations (intra- or interspecific):** Species did not mix up their groups and stayed spatially separated. In March 1999 the breeding *C. penicillata* male was replaced by a new male. This new male showed severe aggressive behaviour towards the owl monkeys and caused the termination of this association.
- **Problems and risks (animals, technical, vet. medical):** Problems arose with the introduction of a new *C. penicillata* male which harassed the owl monkeys until they fled to the ground.
- **Cause of problems and trouble shooting:** After several unsuccessful attempts to re-associate the groups, association was terminated.

Association 6

Associated species since June 2002	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Red-bellied tamarin (<i>Saguinus labiatus</i>)	1 male 1 female	unchanged	6 m ² sandy ground, trunks and branches	2 x 5 m ² branches, trunks, sleeping boxes
Pygmy marmoset (<i>Cebuella pygmaea</i>)	1 male 1 female	unchanged		

- **Special measures at the beginning of association:** Animals have been associated step by step (according to availability): First 0,1 *C. pygmaea*, then 1,0 *C. pygmaea*, followed by 1,0 and 0,1 *S. labiatus*.

- **Special behavioural observations (intra- or interspecific):** Conspecific pairs stay spatially together most of the time.
- **Problems and risks (animals, technical, vet. medical):** none

Association 7

Associated species since 1999	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Emperor tamarin (<i>Saguinus imperator</i>)	1 male 1 female	breed regularly and gave birth in June 2000 (0,2), June 2001 (0,1) and Jan. 2002 (1,0,1); in summer 2002 transfer of 0,2 <i>S. imperator</i> according to EEP	association only indoor	10 m ² (2 x 5m), height: 2.5 m trunks, branches, ropes, ladders, sleeping boxes, concrete floor covered with wooden chips
Pygmy marmoset (<i>Cebuella pygmaea</i>)	1 male	April 2000: introduction of female <i>C. pygmaea</i>		

- **Special behavioural observations (intra- or interspecific):** From time to time both species sit together in close contact (sleeping box) and they feed together at feeding places.

Halle

Zoologischer Garten Halle GmbH, Fasanenstraße 5a, D-06114 Halle (Saale)

4 Associations selected here

Association 1

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Common squirrel monkey (<i>Saimiri sciureus</i>)	approx. 50	group size had to be reduced to: 1 male 17 females 2 juveniles and 15 infants	approx. 250 m ² island with dense natural vegetation, ropes and branches; here monkeys are associated with wild ducks and sparrows	2000 m ³ tropical hall with natural plants, many ropes, branches and bamboo
Grey winged trumpeter (<i>Psophia crepitans</i>)	5	unchanged		

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** *P. crepitans* forages on the food remains of squirrel monkeys. Sometimes juvenile monkeys tease (pull on wings) *P. crepitans*. Squirrel monkeys prey on wild birds and their eggs, laid on the outdoor island.
- **Problems and risks (animals, technical, vet. medical):** no major problems

Association 2

Associated species since 2000	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Saddle-back tamarin (<i>Saguinus fuscicollis</i>)	9	group size was expanding up to 13 individuals	235 m ³ visitors are allowed to enter outdoor enclosure, equipped with natural trees, bushes and plants on natural ground and wooden chips	110 m ³ indoor enclosure on two levels around a giant artificial tree, surrounded by natural plants; water pool on the ground accessible for 1,1 <i>H. liberiensis</i> ; additional indoor enclosure (26 m ³) exclusively for monkeys
Red-bellied tamarin (<i>Saguinus labiatus</i>)	1 male 1 female	stillbirth of triplets female died later		
Goeldi's monkey (<i>Callimico goeldii</i>)	1 male 1 female	reared offspring		
Pygmy hippopotamus (<i>Hexaprotodon liberiensis</i>) (only indoor)	1 male 1 female	unchanged		



Mixed group of tamarins resting in the central indoor area, additionally associated with pygmy hippopotamus (only indoor).

Zoologischer Garten Halle

- **Special measures at the beginning of association:** First, 1,1 *C. goeldii* were habituated to 1,1 *S. labiatus* while they were spatially separated by a net in the middle of the smaller indoor enclosure. After the *S. fuscicollis* group was habituated to the larger indoor enclosure, *C. goeldii* was introduced. Finally, this association was completed with the introduction of *S. labiatus*.
- **Special behavioural observations (intra- or interspecific):** Initial aggressive behaviour of *S. labiatus* towards *S. fuscicollis* was observed and red-bellied tamarins occupied and defended the outdoor enclosure. After 4 weeks all species were habituated to each other and used all parts of their enclosures. Interspecific grooming was observed.
- **Problems and risks (animals, technical, vet. medical):** Initial aggressive and territorial behaviour.
- **Cause of problems and trouble shooting:** Problems disappeared after habituation. This association can be recommended.

Association 3

Associated species ≥ 2000	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Mandrill (<i>Mandrillus sphinx</i>)	2 males 2 females	females had one offspring and one stillbirth; to avoid potential risks for the infant, there were no further attempts to associate the unfamiliar mandrill pairs (see below)	220 m ² with two separated areas and pools for each hippo; mandrills have access to the whole outdoor enclosure (approx. 1000 m ³) from the upper level of adjacent building with indoor enclosures	for hippos: 3 indoor enclosures with 2 pools (approx. 40 m ²) for mandrills: 2 indoor enclosures on upper level (150 m ²)
Pygmy hippopotamus (<i>Hexaprotodon liberiensis</i>)	1 male 1 female	unchanged		

- **Special measures at the beginning of association:** The two mandrill pairs were habituated to each other having just visual contact first. One day later they were associated in the outdoor quarantine enclosure.
- **Special behavioural observations (intra- or interspecific):** Mandrill males interacted aggressively. Older male was dominated by the younger but physically stronger and aggressive male from Antwerp. Interspecific interactions are rare. Mandrills approach hippos to steal food. Mutual threats are realized. Association is not accompanied by major interspecific but by intraspecific problems. Initial association of the two mandrill pairs (coming from Antwerp and Hamburg) was not successful and pairs had to be separated again.
- **Problems and risks (animals, technical, vet. medical):** Male and female *H. liberiensis* do not tolerate each other. Initial fusion of two mandrill pairs was of limited success.
- **Cause of problems and trouble shooting:** Fusion of two mandrill pairs was accompanied by severe aggressive behaviour. Subordinate male was castrated. Pairs had to be separated again. Hippos are kept separately.



Outdoor (left) and indoor (right) enclosure for mandrills, associated with pygmy hippopotamus (only outdoor).

Zoologischer Garten Halle

Association 4

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Common marmoset (<i>Callithrix jacchus</i>)	?	13	approx. 7 x 5 x 4.5 m sandy ground partly covered with wooden chips, branches, ropes, rocky walls, wooden boxes	approx. 6 x 2.5 x 2.8 m sandy ground with straw, branches, ropes, sleeping boxes
Two-toed sloth (<i>Choloepus didactylus</i>)	?	1 male 3 females		
Channel-billed tukan (<i>Ramphastos vitellinus</i>)	?	1 male 1 female		
Hermann's tortoise (<i>Testudo hermanni</i>)	?	several		

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** *C. jacchus* breed very well.
- **Problems and risks (animals, technical, vet. medical):** no major problems
- **Further experiences made in the Zoo of Halle (Saale) can be listed as follows:**
 1. Common marmosets (*C. jacchus*) have been kept as a free ranging group in the zoo area. After the marmosets expanded their home range into neighbouring private gardens and just came back to the zoo at feeding times, this semi-free management had to be terminated.
 2. Nine cotton top tamarins (*Saguinus oedipus*) are kept in a tropical hall together with chimpanzees (*Pan troglodytes*), one green iguana (*Iguana iguana*), and one green basilisk

(*Basiliscus plumifrons*). Top areas of the chimpanzee indoor enclosure which is partly integrated into the hall for visitors are covered with a net. Only one juvenile tamarin was lost when it was caught by a chimpanzee. Tamarins interact with visitors from a distance; no major problems.

3. In general associations of callitrichids and sloths in captivity can be recommended.
4. In a mixed species exhibit of white-faced sakis and common marmosets, species tolerated each other without having close contacts.



Outdoor and indoor (background) enclosure for the association of marmosets, sloths, tukans, and tortoise.

Zoologischer Garten Halle

Hannover

Zoo Hannover GmbH, Adenauerallee 3, D-30175 Hannover

4 Associations selected here

Association 1

Associated species since 1997	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Hanuman langur (<i>Semnopithecus entellus</i>)	1 male 4 females	1 male 6 females 1,3 juveniles 2 infants	1200 m ² natural ground with grass, big stacks of trunks and branches in the centre of enclosure, resting places (niches) in stonewalls, enclosure partly surrounded by water moat	association only outdoor
Barasingha/ Swamp deer (<i>Cervus duvaucelii</i>)	1 male 6 females	2 males 5 females		
Demoiselle crane (<i>Anthropoides virgo</i>)	4	associated in 2001		
Ducks (e.g. <i>Aix galericulata</i>)		changing		

- **Special measures at the beginning of association:** First Barasingha deers were habituated to the outdoor enclosure for two months. When hanuman langurs were associated, their food was placed on tree-trunks and branches.
- **Special behavioural observations (intra- or interspecific):** Initially species formed clearly separated groups within the enclosure. Juvenile individuals of hanuman langurs and barasingha deers initiated first interspecific contacts. Since 2000 also adult individuals were observed to perform interspecific interactions. Hanuman langurs can be observed to groom and even ride barasingha deers. Contacts with associated birds do not occur.
- **Problems and risks (animals, technical, vet. medical):** Hanuman langurs sometimes jump on and off the backs of deers, which might be bothered a bit. Deers represent a strain on grass areas of the enclosure. This burden can be softened by using electric fences to protect selected areas and by additional (regular) hay feedings.
- **Cause of problems and trouble shooting:** No major problems. This association is highly recommended as it has a positive influence on the time budgets of the species involved. Furthermore the multiple (species) use of the enclosure has practical advantages, especially when all animals are well habituated. In this case all kinds of activities for maintaining or renovating the enclosure can be performed by the keepers without disturbing the animals, present at the same time.



Hanuman langurs and swamp deers tolerate the presence of keepers (background left) without showing any signs of stress.

Zoo Hannover



Hanuman langurs, swamp deers and demoiselle cranes established a relaxed and peaceful relationship.

Zoo Hannover

Association 2

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Red-fronted lemur (<i>Eulemur fulvus rufus</i>)	1 male 2 females	see below	enclosure on two levels connected by stairs upper level 14 m ² lower level 18 m ² height: approx. 4 m natural branches, wooden chips, bushes	association only indoor
Cotton top tamarin (<i>Saguinus oedipus</i>)	1 male 1 female <i>S. oedipus</i> was associated later	see below		
Black-rumped agouti (<i>Dasyprocta prymnolopha</i>)	3	see below		

- **Special measures at the beginning of association:** *S. oedipus* was associated later.
- **Special behavioural observations (intra- or interspecific):** Red-fronted lemurs (having an offspring) showed aggressive behaviour towards the cotton top tamarins.
- **Problems and risks (animals, technical, vet. medical):** see above
- **Cause of problems and trouble shooting:** Association was reduced to two species: red fronted lemurs and black-rumped agoutis; permanent observations during critical phases.

Association 3

Associated species since 1997	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Cotton top tamarin (<i>Saguinus oedipus</i>)	2 males 2 females	females produced 4 litters	approx. 22 m ² natural ground and natural vegetation, additional branches and ropes	approx. 12 m ² height 2.5-3 m
Two-toed sloth (<i>Choloepus hoffmannii</i>)	1 male 2 females			



Cotton top tamarin, associated with sloths, carrying infants in the outdoor enclosure.

Zoo Hannover

- **Special measures at the beginning of association:** Intensive observation; initially *S. oedipus* was habituated to the enclosures as single species group. Sloths were associated later.
- **Special behavioural observations (intra- or interspecific):** Male *S. oedipus* was threatening (vocalising) towards the male sloth – no physical aggression observed.
- **Problems and risks (animals, technical, vet. medical):** Multi-male multi-female group of *S. oedipus* was not stable.
- **Cause of problems and trouble shooting:** Right after delivery, female *S. oedipus* and their offspring were separated for a short period of time. No further problems, association can be recommended.

Association 4

Associated species since 1992	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Squirrel monkey (<i>Saimiri sciureus</i>)	group was composed successively 1992: 0,2 1993: 1,1	1 juvenile born in 1994 group was transferred to Darmstadt		since 1996 squirrel monkeys had access to a large tropical hall
Two-toed sloth (<i>Choloepus hoffmannii</i>)	1 male 2 females			

- **Special measures at the beginning of association:** To meet their different dietary demands, species were fed separately.
- **Problems and risks (animals, technical, vet. medical):** Squirrel monkeys used to initiate too close contacts to the visitors.
- **Cause of problems and trouble shooting:** *S. sciureus* group was transferred to Darmstadt.

Heidelberg

Tiergarten Heidelberg, Tiergartenstraße 3, D-69120 Heidelberg

4 Associations selected here

Association 1

Associated species since Jan. 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Bolivian squirrel monkey (<i>Saimiri boliviensis</i>)	1 male 3 females	no changes	approx. 32 m ² height: 2.3 m natural ground, branches and ropes	10.4 m ² height: 2.3 m sandy ground, feeding boards, branches and ropes
Northern helmeted curassow (<i>Crotophaga sulcirostris</i>)	1 male 1 female	no changes		

- **Special measures at the beginning of association:** none
- **Special behavioural observations (intra- or interspecific):** Squirrel monkeys were initially trying to inspect *C. pauxi* although they offered resistance. After one week squirrel monkeys were not interested anymore.
- **Problems and risks (animals, technical, vet. medical):** Squirrel monkeys stole and destroyed eggs of *C. pauxi*.
- **Cause of problems and trouble shooting:** Natural breeding of *C. pauxi* in association with squirrel monkeys virtually impossible. Association was terminated in July 2001.

Association 2

Associated species since Nov. 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Western lowland gorilla (<i>Gorilla gorilla gorilla</i>)	1 male 2 females	associated for just one day	association only indoor	175 m ² height 3.6 m wooden chips, trunks, rocks
Dwarf rabbit	2 males	associated for just one day		

- **Special measures at the beginning of association:** none
- **Special behavioural observations (intra- or interspecific):** One female gorilla was catching a rabbit and inspected it intensively. The other gorillas (1,1) avoided the rabbits.
- **Problems and risks (animals, technical, vet. medical):** see above
- **Cause of problems and trouble shooting:** Individual characters of gorillas are decisive for the success of such an association. This association was terminated after the first day.

Association 3

Associated species since 1999	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Geoffroy's tufted-eared marmoset (<i>Callithrix geoffroyi</i>)	1 males 1 female	3 males 1 female	18 m ² height: 2.3 m natural ground, bushes, branches and lianas	4.5 m ² height: 2.3 m feeding boards, sleeping boxes, branches
Pygmy marmoset (<i>Callithrix pygmaea</i>)	1 male 1 female	once offspring found dead after one day		

- **Special measures at the beginning of association:** Pygmy marmosets were first habituated to the enclosure for two days without *C. geoffroyi* being present.
- **Special behavioural observations (intra- or interspecific):** none
- **Problems and risks (animals, technical, vet. medical):** As pygmy marmosets already bred unsuccessfully (before) in a single species group and no behavioural problems could be observed in this association, loss of infants cannot be linked to the mixed species situation.
- **Cause of problems and trouble shooting:** *C. pygmaea* pair was handed over to another zoo.

Association 4

Associated species since June 2000	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Common marmoset (<i>Callithrix jacchus</i>)	1 male	unchanged	association only indoor (visitor area of ape house)	542 m ² height: up to 7 m tropical plantings, visitor pathways, areas for keepers
Golden rumped agouti (<i>Dasyprocta leporina aguti</i>)	1 male 1 female	breed regularly		
Pygmy marmoset (<i>Callithrix pygmaea</i>)	1 male 1 female added in Aug. 2000	1,1,1 delivery Oct. 2001		

- **Special measures at the beginning of association:** none
- **Special behavioural observations (intra- or interspecific):** Male common marmoset regularly carried the infant pygmy marmoset.
- **Problems and risks (animals, technical, vet. medical):** none
- **Cause of problems and trouble shooting:** none

Hodenhagen

Serengeti Safaripark Hodenhagen, Am Safaripark 1, D-29693 Hodenhagen

6 Associations selected here

Association 1

Associated species since 2000	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Squirrel monkey (<i>Saimiri sciureus</i>)	4 males	unchanged	4 x 3 x 2 m	2 x 2 x 2 m sleeping boxes
White-fronted brown lemur (<i>Eulemur fulvus albifrons</i>)	1 male 1 female	unchanged		

- **Special measures at the beginning of association:** Squirrel monkeys were habituated first to the enclosure. Prior to the first interspecific encounters, species were separated by a fence for half a day.
- **Special behavioural observations (intra- or interspecific):** Few interspecific interactions; few aggressive behaviours even during feeding.
- **Problems and risks (animals, technical, vet. medical):** no problems

Association 2

Associated species since 1997	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Barbary macaque (<i>Macaca sylvanus</i>)	17	well breeding	20000 m ² natural environment, water moats	for each species one room offered, between 4 and 16 m ² . <i>S. entellus</i> and <i>C. aethiops</i> prefer to use one room in common
Hanuman langur (<i>Semnopithecus entellus</i>)	8	well breeding		
Brown capuchin (<i>Cebus apella</i>)	17	well breeding		
Vervet monkey (<i>Chlorocebus aethiops</i>)	15	well breeding		

- **Special measures at the beginning of association:** no interspecific aggression
- **Special behavioural observations (intra- or interspecific):** *C. apella* group occupied and defended one indoor enclosure against other species. *M. sylvanus* was observed to behave the same way.
- **Problems and risks (animals, technical, vet. medical):** *C. aethiops* and *S. entellus* initiated aggressive physical contacts to visitors in the walkthrough enclosure.
- **Cause of problems and trouble shooting:** Association was terminated in 2000.

Association 3

Associated species since the 70ies	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Hamadryas baboon (<i>Papio hamadryas hamadryas</i>)	35-40	70 well breeding	4.8 ha drive through enclosure, natural open grassland environment with sandy areas and semi open huts for shelter	35 m ² divided in 5 rooms exclusively for baboons
Olive baboon (<i>Papio hamadryas anubis</i>)	2-3			
Black bear (<i>Ursus americanus pallas</i>)	5-6	8 well breeding		
Kulan (<i>Equus hemionus</i>)		12 since 2001 well breeding		
Bactrian camel (<i>Camelus ferus</i>)		8 well breeding		
Cape ostrich (<i>Struthio camelus australis</i>)		15-20 breeding see below		

- **Special measures at the beginning of association:** ?, more than 30 years ago
- **Special behavioural observations (intra- or interspecific):** At feeding places the following dominance hierarchy was established: 1. bears, 2. baboons, 3. other species.
- **Problems and risks (animals, technical, vet. medical):** Baboons prevent breeding success of ostriches as they steal their eggs. Female bacterian camels had to be removed during late pregnancy. Bears do hibernate. Baboons feed on afterbirth of kulans, which breed successfully. No major problems since 6 years.
- **Cause of problems and trouble shooting:** Bears had to be locked up at night. Only vegetarian food supply for all species. Dispersed feeding at several feeding places in the outdoor enclosure.



One of the large "drive through" enclosures of the "Serengeti Safaripark Hodenhagen", keeping several polyspecific associations. Shown here: bactrian camels lying in front of hamadryas baboons (on dead tree trunks).

Association 4

Associated species since spring 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
White-fronted brown lemur (<i>Eulemur fulvus albifrons</i>)	1 male 2 females 1 juveniles	1 male 2 females 1 juveniles 2 infants	3000 m ² natural environment, open grassland	three wooden huts (16, 4 and 4 m ²) height: 2 m
Ring-tailed lemur (<i>Lemur catta</i>)	4 males 4 females 4 juveniles	4 males, 4 females, 4 juveniles, 4 infants		

- **Special measures at the beginning of association:** *L. catta* group was habituated first to the enclosure. Then *E. f. albifrons* individuals were successively associated.
- **Special behavioural observations (intra- or interspecific):** With increasing group size of *E. f. albifrons* aggressive interspecific encounters occurred, including some biting especially during feeding.
- **Problems and risks (animals, technical, vet. medical):** see above
- **Cause of problems and trouble shooting:** Spatially dispersed feeding solved problems of interspecific aggression.

Association 5

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
White-fronted brown lemur (<i>Eulemur fulvus albifrons</i>)	4 males 4 females 4 juveniles	4 males 4 females 4 juveniles 2 infants	1800 m ² height: 12-17 m	three rooms 3 x 3 x 3 m each, exclusively used by <i>C. guereza</i>
Guereza colobus (<i>Colobus guereza</i>)	3 males 4 females	unchanged		

- **Special measures at the beginning of association:** *C. guereza* was habituated first to the outdoor enclosure. Then they were kept indoor for two days, when *E. f. albifrons* was habituated to the outdoor enclosure. During this habituation phase *E. f. albifrons* was already visible for *C. guereza*. Then species were associated in the outdoor enclosure.
- **Special behavioural observations (intra- or interspecific):** During a short period of time (1-2 days) *C. colobus* gang together and browbeated individual *E. f. albifrons*, but did not bite them. Thereby a species hierarchy was quickly established.
- **Problems and risks (animals, technical, vet. medical):** none
- **Cause of problems and trouble shooting:** Dispersed feeding, 4-5 times a day twigs with fresh leaves for *C. guereza*.

Association 6

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Barbary macaque (<i>Macaca sylvanus</i>)	35	well breeding	6000 m ² natural environment, water pond	association only outdoor
Barbary sheep (<i>Ammotragus lervia</i>)	10	well breeding		

- **Special measures at the beginning of association:** The group of Barbary sheeps was introduced to the outdoor enclosure when Barbary macaques were already present.
- **Special behavioural observations (intra- or interspecific):** Sociopositiv (playful) behaviour between juveniles of both species were observed. This includes riding and jumping of monkeys on sheeps.

- **Problems and risks (animals, technical, vet. medical):** Cross-contamination with endo-parasites (*Trichuris trichura*).
- **Cause of problems and trouble shooting:** medical treatment

Karlsruhe

Zoologischer Garten Karlsruhe, Ettlinger Straße 6, D-76137 Karlsruhe

3 Associations selected here

Association 1

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Black-handed spider monkey (<i>Ateles geoffroyi</i>)	4	unchanged	25-30 m ² island with natural ground, rocks, trunks and bushes	association only outdoor
Diverse species of ducks	30-40	changing group sizes of duck species		

- **Special measures at the beginning of association:** none
- **Special behavioural observations (intra- or interspecific):** Ducks enter the island without causing any conflicts with spider monkeys.
- **Problems and risks (animals, technical, vet. medical):** none

Association 2

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Ring-tailed lemur (<i>Lemur catta</i>)	6	continuously changing group size due to breeding success	25-30 m ² island with natural ground, willow tree, bushes	association only outdoor
Diverse species of ducks	30-40	changing group sizes of duck species		

- **Special measures at the beginning of association:** none
- **Special behavioural observations (intra- or interspecific):** Ducks enter the island without causing any conflicts with ring-tailed lemurs.
- **Problems and risks (animals, technical, vet. medical):** none

Association 3

Associated species since 1997	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Goeldi's monkey (<i>Callimico Goeldii</i>)	6	changing group size	30 m ² wooden chips on the ground, climbing constructions made of bamboo, trunks	indoor enclosures separated for each species; guinea pigs not able to enter the monkey room
Guinea pig (<i>Cavia apera</i>)	8	changing group size		

- **Special measures at the beginning of association:** none
- **Special behavioural observations (intra- or interspecific):** No interspecific interactions observed. Sometimes *C. goeldii* steal food items from the guinea pig indoor enclosure.
- **Problems and risks (animals, technical, vet. medical):** none

Köln

Zoologischer Garten Köln AG, Riehler Straße 173, D-50735 Köln

The Kölner Zoo (Zoo of Cologne) maintains a relatively high number of primate mixed species exhibits at different keeping facilities.

The ape house currently presents a mixed species exhibit of 1,5,1 Western lowland gorillas (*Gorilla gorilla gorilla*) and 3,2 guerezas (*Colobus guereza kikuyuensis*) in a spacious combination of an indoor and outdoor enclosure connected by gangways on different levels. Separated from the visitors area by wire mesh, a combination of 5 saddle-back tamarins (*Saguinus fuscicollis*), 1,1 red-bellied tamarins (*Saguinus labiatus*) and 2,0 golden-headed lion tamarins (*Leontopithecus chrysomelas*) is also exhibited. Both associations, maintained in adequately enriched enclosures, proved to be successful as there were no severe interspecific aggressions. In contrary, sociopositive interspecific interactions (grooming) between *S. labiatus* and *L. chrysomelas* was observed.



Guerezas (upper middle) successfully associated with Western lowland gorillas (picture shows just indoor area).

Zoologischer Garten Köln

The lemur house comprises 25 indoor and 26 outdoor enclosures almost all measuring 2 x 2.5 x 2.5 m, arranged in a U-shaped ground-plan. These facilities are completed by four sphere-shaped outdoor enclosures raised between trees and connected to the lemur house by gangways, 11 m in length. Here 3,0 ruffed lemurs (*Varecia variegata*) and 2,3 red-fronted brown lemurs (*Eulemur fulvus fulvus*) were associated successfully for approx. one year. During this time brown lemurs produced one offspring. The

future development of the lemur house will involve the reduction of the currently 11 lemur species and subspecies kept, to concentrate on further polyspecific associations of lemur species, which are known to live sympatric in the wild.

The South America house, build in 1899 and formerly used for the maintenance of birds and apes, exclusively houses neotropical primates since 1985. Nowadays eight callitrichid and four cebid species are kept here. The house comprises 15 indoor enclosures, all of which can be connected by gangways and sliding doors. This allows a flexible management of associating and separating species within this keeping facility. Animals have direct access to the outdoor enclosures from five indoor enclosures. Most of the other indoor enclosures are indirectly connected to the outdoor areas. Altogether the South America house offers a keeping area of 260 m². In addition, an outdoor gangway is connecting one of the outdoor enclosures, currently used by cotton top tamarins with a single old tree standing next to the South America house.



Connecting gangways between enclosures for polyspecific associations in the South America house.

Zoologischer Garten Köln

Several requirements have to be fulfilled to ensure a successful management of such a variety of complex associations of primates. Some of the most important ones can be listed as follows:

- There should be more than just one room for each association, so that species can be separated whenever necessary (e.g. just before and after deliveries).
- If there is a considerable difference in body size (e.g. *C. pygmea* – *P. pithecia*), there should be an area exclusively accessible for the smaller species (narrow connecting doors).

T. Ziegler: Selected Mixed Species Exhibits in Zoological Gardens

- All individuals should be habituated to all parts of the enclosure without any stress, before the groups get associated.
- Environmental enrichments for all species involved and a species specific supply of diets have to be guaranteed.

The following table gives an overview of the primate species associations kept in the South America house since 1987 (Original data published in: *Zeitschrift des Kölner Zoos*, 3/2002; 45. Jahrgang).

Polyspecific associations of primates in the South America house

No. of individuals at the beginning	Max. no. of individuals	Species	Period of time in association
1 1	1 1	Black-headed uacari (<i>Cacajao melanocephalus</i>) Red howler (<i>Alouatta seniculus</i>)	01.18.87- 07.03.87
2 5	2 5	Dusky titi monkey (<i>Callicebus moloch</i>) Pygmy marmoset (<i>Cebuella pygmea</i>)	03.06.91-01.31.94
1 2	1 2	Black-headed uacari (<i>Cacajao melanocephalus</i>) Bearded saki [Hybrid] (<i>Chiropotes</i> sp. x sp.)	03.23.92- 09.23.92
1 2 2	1 2 2	Bald (Red) uacari (<i>Cacajao calvus rubicundus</i>) Bald (White) uacari (<i>Cacajao calvus calvus</i>) Bearded saki [Hybrid] (<i>Chiropotes</i> sp. x sp.)	09.29.92- 03.17.98 09.29.92- 10.03.01 09.29.92- 05.08.98 09.29.92- 10.03.01
8 6 4 1 2	8 6 7 2 4	Pygmy marmoset (<i>Cebuella pygmea</i>) Golden lion tamarin (<i>Leontopithecus rosalia</i>) White-faced saki (<i>Pithecia pithecia</i>) Saddle-back tamarin (<i>Saguinus fuscicollis</i>) Golden-handed tamarin (<i>Saguinus midas</i>)	01.06.93- 07.03.02 01.06.93- 11.29.01 01.15.02- 07.03.02
2 11	2 17	Red howler (<i>Alouatta seniculus</i>) Geoffroy's tufted marmoset (<i>Callithrix geoffroyi</i>)	09.22.93- 11.15.98
2 14 1 3	2 14 4 3	Pygmy marmoset (<i>Cebuella pygmea</i>) Golden-headed lion tamarin (<i>Leontop. chrysomelas</i>) White-faced saki (<i>Pithecia pithecia</i>) Goeldi's monkey (<i>Callimico goeldii</i>)	06.17.94- 04.12.00
4 7	4 7	Red howler (<i>Alouatta seniculus</i>) White-faced saki (<i>Pithecia pithecia</i>)	since 07.03.02
1 1 2	1 1 4	Golden lion tamarin (<i>Leontopithecus rosalia</i>) Pygmy marmoset (<i>Cebuella pygmea</i>) Golden-handed tamarin (<i>Saguinus midas</i>)	since 07.03.02

For more detailed information on facilities, keeping, husbandry, and feeding regimes for Primates in this Zoo, please see: KAUMANN et al. (2002): Primatenhaltung im Kölner Zoo, *Zeitschrift des Kölner Zoos*, 3; 45. Jahrgang - or contact Cologne Zoo.

Krefeld

Krefelder Zoo, Uerdinger Straße 377, D-47800 Krefeld

2 Associations selected here

Association 1

Associated species since 1999	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
White-faced saki (<i>Pithecia pithecia</i>)	1 male 1 female	1 male 2 females 1 juvenile	only indoor	approx. 1000 m ² tropical hall height: approx. 12 m lava gravel and reddish soil ground, covered with wooden chips and vegeta- ble mould, diverse tropical plan- tings, visitors pathway with a raised observa- tion platform
Two-toed sloth (<i>Choloepus didactylus</i>)	1 male 1 female	unchanged		
Tamandua (<i>Tamandua tetradactyla</i>)	1 male 1 female	unchanged		
Smooth-fronted caiman (<i>Paleosuchus trigonatus</i>)	9	unchanged		
Long-tongued nectar bat (<i>Glossophaga soricina</i>)	9	decreasing group size		
Green acouchi (<i>Myoprocta pratti</i>)	2 males	unchanged		
Green iguana (<i>Iguana iguana</i>)	1 male 6 juveniles			
Green basilisk (<i>Basiliscus plumifrons</i>)	2 males 2 females			

- **Special measures at the beginning of association:** Safety measures for caimans compartment within the tropical hall had to be improved.
- **Special behavioural observations (intra- or interspecific):** Severe aggression between green iguana males. Sakis slowly explored tropical hall, avoid caiman area and feed on sloth's food. Data for several diploma theses were collected here.
- **Problems and risks (animals, technical, vet. medical):** Caimans preyed upon animals that accidentally entered their area, i.e. one grey winged trumpeter (*Psophia crepitans*), two acouchis, green basilisks and several bats. Green basilisk preyed upon a bat. Safety measures for technical installations (power lines, mechanisms of windows and doors) had to be improved to avoid accidents (esp. with tamanduas and sakis) and escapes of animals. Checking for individuals among the mixed species association proved difficult.
- **Cause of problems and trouble shooting:** Improved technical safety measures. A sufficient period of time should be given to carefully establish such a complex mixed species exhibition in a large tropical hall and to check for potential risks and problems.



Male white-faced saki sitting on the visitors pathway of the tropical hall.

Krefelder Zoo



Tamandua patrolling among the undergrowth of the tropical hall.

Krefelder Zoo



The caimans pool is part of the tropical hall.

Krefelder Zoo

Association 2

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
White-faced saki (<i>Pithecia pithecia</i>)	1 male 1 female	3 males 2 females (well breeding)	association only indoor	approx. 4 x 6 m height: 3.30 m floor covered with wooden chips, trunks on the ground, many natural branches predominantly in horizontal positions
Golden lion tamarin (<i>Leontopithecus rosalia</i>)	2 females	unchanged		
Green acouchi (<i>Myoprocta acouchi pratti</i>)	1 male	unchanged		

- **Special measures at the beginning of association:** Species were fed separately.
- **Special behavioural observations (intra- or interspecific):** No physical aggression but a golden lion tamarin was repeatedly disturbing a male saki, which subsequently avoided to enter the exhibition enclosure. Sakis were subjects of a behavioural study for a diploma thesis. In earlier days *Callithrix jacchus* were also integrated in this association and they were observed to maintain close contact to *L. rosalia*.
- **Problems and risks (animals, technical, vet. medical):** Structural enrichment of enclosure may lead to difficulties in catching individual animals, e.g. for medical treatment.

Landau

Zoo Landau, Hindenburgstraße 12-14, D-76829 Landau in der Pfalz

3 Associations selected here

Association 1

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Squirrel monkey (<i>Saimiri sciureus</i>)	2 males 5 females		19 x 9.2 m height: 4 m natural ground, bushes, dead trees, big branches, feeding spots for birds	monkeys and birds kept in the same house, but separate room for monkeys, measuring: 4.3 x 3.3 m height: 4 m
Blue-and-gold macaw (<i>Ara ararauna</i>)	2 males	changing composition of bird species		
Green-winged macaw (<i>Ara chloroptera</i>)	2 males			
Ocellated turkey (<i>Agriocharis ocellata</i>)	1 male			

- **Special measures at the beginning of association:** Monkeys are kept indoor during feeding.
- **Problems and risks (animals, technical, vet. medical):** no major problems

Association 2

Associated species since 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Brown mouse lemur (<i>Microcebus rufus</i>)	1 male 1 female	unchanged	association only indoor, but see next column and SEIBOLD et al. (2002) for technical features	26 m ² approx. height: 4.4 m partly removable glass roof, open roof areas covered with wire mesh (mesh diameter: 1 cm); two water ponds with a volume of 2.2 m ³ and 1.8 m ³ ground area of enclosure divided for male and female turtle; enclosure planted with 17 tropical species (incl. 7 species from Madagascar); separate room with cages and sleeping boxes for partridge and mouse lemurs; for more details see: SEIBOLD et al. (2002)
Madagascar big-headed side-necked turtle (<i>Erymnochelis madagascariensis</i>)	1 male 1 female	unchanged		
Madagascar day gecko (<i>Phelsuma madagascariensis grandis</i>)	1 male 3 females	two females disappeared, one juvenile was detected		
Madagascar partridge (<i>Margaroperdix madagascariensis</i>)	1 male	unchanged		
Panther chameleon (<i>Furcifer pardalis</i>)	1 male 1 female	unchanged		
Dumeril's Madagascar swift lizard (<i>Oplurus quadrimaculatus</i>)	1 male	unchanged		

- **Special measures at the beginning of association:** Reptiles were habituated to take their food (living insects) from transparent plastic cups vertically placed within the natural environment of the enclosure. Mouse lemurs are fed in separate cages (adjacent room) to ensure sufficient provision of individuals.
- **Special behavioural observations (intra- or interspecific):** Reptiles prey on all kinds of insects which enter the enclosure accidentally. It is hoped that the special measures within the enclosure (separated areas for fission and fusion of male and female) enhances the probability of future breeding success of the highly endangered Madagasy turtles.
- **Problems and risks (animals, technical, vet. medical):** no major problems
- **Cause of problems and trouble shooting:** For technical details see SEIBOLD et al. (2002).

Association 3

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Golden lion tamarin (<i>Leontopithecus rosalia</i>)	2 males		association only indoor	2.9 x 4 m height: 3.6 m soil, stones, wooden chips, planted with <i>Ficus spec.</i>
Pygmy marmoset (<i>Cebuella pygmea</i>)	1 male 1 female			
Acouchi (<i>Myoprocta acouchi</i>)	2 juveniles			
Red-footed tortoise (<i>Geochelone carbonaria</i>)	2 males 1 female			

- **Problems and risks (animals, technical, vet. medical):** no major problems

Leipzig

Zoo Leipzig, Pfaffendorfer Straße 29, D-04105 Leipzig

2 Associations selected here

Association 1

Associated species since April 2002	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Rhesus macaque (<i>Macaca mulatta</i>)	4 females 1 juvenile	1 male 4 females 1 juvenile	580 m ² surrounded by artificial cliffs and water moat, natural ground, small brook, grass, spiny bushes, bamboo areas, rocks, wooden climbing structures made of dead trees, over 5 m in height, trunks and branches connected with ropes	association only outdoor
Sloth bear (<i>Melursus ursinus</i>)	1 male 2 females	unchanged		

- **Special measures at the beginning of association:** Areas planted with bushes and bamboo were initially protected with hot (electric) wires. Monkeys were habituated first to

the new outdoor enclosure in absence of bears. Then bears were habituated to the new outdoor enclosure and the hot wires, which they never experienced before.

- **Special behavioural observations (intra- or interspecific):** During the first weeks of association, rhesus monkeys stayed in the upper levels of the central climbing structures when bears were present. Just a few weeks later monkeys could be observed to move on the ground even when bears were present. While both species move on or near the ground, monkeys show increased vigilance behaviour and keep an appropriate distance to bears.
- **Problems and risks (animals, technical, vet. medical):** When bears encountered the hot wires for the first time, they showed short, panic-like reactions and caused minor damages to wires and plantings. Later they avoided all areas protected by hot wires without any further problems.
- **Cause of problems and trouble shooting:** Animals (esp. bears) must be given an appropriate period of time to learn to avoid special areas protected by hot wires. As the indoor-outdoor connection for monkeys was also near to the ground, protective measures (hot wire, narrow door) were necessary to assure that bears do not approach this area or even try to enter the indoor area of monkeys. After both species were sufficiently habituated to the features of the new outdoor enclosure, hot wires could be removed successively. At night, bears are kept indoor, while monkeys are free to move in and out. Although this association is rarely seen in Zoos, it can be recommended here.



Left: Rhesus macaques climbing in dead tree tops, while sloth bears are being introduced to the enclosure. Right above: Sloth bear exploring the characteristics of the new enclosure. Right down: Just a few weeks later, vigilant rhesus macaques (near tree trunk) move near and on the ground while bears are present (background).

Zoo Leipzig

Association 2

Associated species since March 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Sumatran oran-gutan (<i>Pongo abelii</i>)	2 males 5 females (incl. 2 juveniles)	unchanged	approx. 1900 m ² natural environment with trees (up to 20 m), bushes, bamboo, rocks, grass. In addition: dead trees, trunks, raised platforms, ropes; enclosure partly surrounded by walls (5 m in height, outer part of indoor area), water moats (1.5 m deep and 4-5 m wide) with planted swampy areas and security zone for apes with submerged (5-40 cm) nets (2 m broad) on the inner bank zones of the moat, underwater wires and one electric wire above water surface separating shallow from deep water areas of the moat	association only outdoor
Golden-cheeked gibbon (<i>Hylobates [nomascus] gabriellae</i>)	1 male 1 female	1 female (loss of male(s) see below)		

- **Special measures at the beginning of association:** Initially species were habituated separately to the outdoor enclosure for several days. When association began, gibbons were the first to be released to the outdoor area.
- **Special behavioural observations (intra- or interspecific):** During the first days in association, juvenile orangs tried to chase and catch gibbons unsuccessfully. Gibbons soon showed a preference for the crown of an oak tree 20 m in height and accessible via adjacent trees (canopy). Initially gibbons showed very cautious behaviour towards the orangs during common outdoor feeding sessions. Nowadays female gibbons can be observed to approach and even interact with orangs (stealing food items, teasing).
- **Problems and risks (animals, technical, vet. medical):** No problems within or between species caused by association. In May 2001 the male gibbon walked on the ground (!! , no obvious reason, totally undisturbed situation) into the water moat and drowned. In June 2002 the second male (successor) gibbon was found dead in the water moat after he was introduced to the female (indoor, 4 days before) and to the outdoor enclosure (2 days before, all in the absence of orangs).

- **Cause of problems and trouble shooting:** No problems caused by association. While the first loss of a male gibbon was due to an inexplicable behaviour, the loss of the second male was probably due to an accident (sudden fall) during the night, as parts of head and body were found bloodshot. As the problems mentioned here are not caused by the association of these primate species, this mixed species exhibit is highly recommended.



Left: Orang-utan group in one of the outdoor areas of "Pongoland", which they share with golden-cheeked gibbons.

Right: Orang-utans (dead tree, left) and golden-cheeked gibbon (living tree, right) in their outdoor enclosure.

Zoo Leipzig

Magdeburg

Zoologischer Garten Magdeburg, Am Vogelsang 12, D-39124 Magdeburg

3 Associations selected here

Association 1

Associated species since Aug. 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Red-bellied tamarin (<i>Saguinus labiatus</i>)	3 males	unchanged	4 x 4.5 m height: 2.5 m natural ground, bushes, branches, resting platforms	three connected enclosures each measuring 2 x 1.5 m height: 2 m
Tamandua (<i>Tamandua tetradactyla</i>)	1 male 1 female	unchanged		

- **Special measures at the beginning of association:** *S. labiatus* were already habituated to the enclosures when tamanduas were introduced.
- **Special behavioural observations (intra- or interspecific):** Both species react adequately to occasional interspecific threats and get along very well with each other.

- **Problems and risks (animals, technical, vet. medical):** Beside the difference in activity patterns of the associated species, there are no interspecific problems.
- **Cause of problems and trouble shooting:** As tamanduas activity patterns are not restricted to the daytime, they can disturb the diurnal tamarins at night. Therefore one of the three indoor enclosures is exclusively accessible for *S. labiatus* to ensure that tamanduas cannot approach their sleeping boxes.



Tamandua watched by a red-bellied tamarin (upper background) in the outdoor enclosure

Zoo Magdeburg

Association 2

Associated species since more than 2 years	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Golden-handed tamarin (<i>Saguinus midas</i>)	1 male 1 female	2 offspring	3.5 x 4 m height: 2.5 m natural vegetation (predominantly)	2.5 x 2.5 m height 2.3 m
Common tree shrew (<i>Tupaia glis</i>)	1 male 1 female	unchanged		
Green iguana (<i>Iguana iguana</i>)	1 male	unchanged		
Red-footed tortoise (<i>Geochelone carbonaria</i>)	1 male 3 females	unchanged		

- **Special measures at the beginning of association:** A small separate enclosure (1 x 1 x 2.3 m) is exclusively accessible for tree shrews to minimize the risk of potential stress for these animals.
- **Special behavioural observations (intra- or interspecific):** Tupaia was observed to sunbathe on the back of green iguana.
- **Problems and risks (animals, technical, vet. medical):** A case of listeriosis was diagnosed – origin/transmission (tortoise or mice?) unknown.
- **Cause of problems and trouble shooting:** No further problems; association can be recommended.

Association 3

Associated species since Aug. 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
White-faced saki (<i>Pithecia pithecia</i>)	1 female	unchanged	approx. 4.4 x 5.7 m height: 2.5 m natural ground, grass, bushes, additional branches, surrounded by a stone wall and wire mesh	3 x 2 m height: 2.3 m branches, sleeping boxes
Black lion tamarin (<i>Leontopithecus chrysopygus</i>)	2 males	unchanged		

- **Special behavioural observations (intra- or interspecific):** No behavioural problems observed.
- **Problems and risks (animals, technical, vet. medical):** No problems, association can be recommended.



Male black lion tamarins successfully associated with a female white-faced saki (background, middle).

Zoologischer Garten Magdeburg



Example of a naturally enriched outdoor enclosure for single and mixed species exhibits in Magdeburg Zoo.

München

Münchner Tierpark Hellabrunn AG, Tierparkstraße 30, D-81543 München

1 Association selected here

Associated species since more than 20 years	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Hamadryas baboon (<i>Papio hamadryas hamadryas</i>)	changing size of bisexual group	well breeding	1458 m ² rocky environment surrounded by a water moat (308 m ²)	association only outdoor
Nubian ibex (<i>Capra ibex nubiana</i>)	changing size of bisexual group	well breeding		

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** Rare interspecific interactions. Sometimes juvenile baboons can be observed to ride on ibex.
- **Problems and risks (animals, technical, vet. medical):** Infant and juvenile ibex were bitten by baboons from time to time.
- **Cause of problems and trouble shooting:** New born ibex have to be isolated during the first weeks.



*Nubian ibex interacting with hamadryas baboons.
Münchner Tierpark Hellabrunn (photo provided by B. Rau)*

Münster

Allwetterzoo Münster, Sentruper Straße 315, D-48161 Münster

6 Associations selected here

Association 1

Associated species since 1998	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Goeldi's monkey (<i>Callimico goeldii</i>)	1 male 1 female	unchanged	association only indoor	30 m ² height: 5.5 m natural plantations, big freshwater pond on the ground with underwater view for visitors; exhibition on two levels
Green basilisk (<i>Basiliscus plumifrons</i>)				
Diverse bird species (<i>Thraupinae</i> , <i>Rallidae</i>)				
Tropical fish (<i>Osteoglossiformi</i> : <i>Osteoglossum bicirrhosum</i> ; <i>Rajidae</i> , ect.)				

- **Special measures at the beginning of association:** Especially thick undergrowth of plants and wooden branches was arranged at lower levels to prevent sudden falls of monkeys into the water pond, containing big fish, potentially dangerous for the relatively small callitrichids.
- **Special behavioural observations (intra- or interspecific):** Birds were aroused when Goeldi's monkeys were introduced, but they calmed down within the first week.
- **Problems and risks (animals, technical, vet. medical):** no problems; association recommended

Association 2

Associated species since 2000	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Goeldi's monkey (<i>Callimico goeldii</i>)	3 females	unchanged	2 x 2 x 1 m exclusively for Goeldi's monkeys	11 x 2 m height: 2 m natural plantings and climbing structures, wooden chips and sandy area on the ground
Red-footed tortoise (<i>Geochelone carbonaria</i>)	2 males 4 females	unchanged		

- **Special measures at the beginning of association:** none

- **Special behavioural observations (intra- or interspecific):** none
- **Problems and risks (animals, technical, vet. medical):** none

Association 3

Associated species since Nov. 1997	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Goeldi's monkey (<i>Callimico goeldii</i>)	bisexual group of 8 monkeys		approx. 2 x 10 m height: 2 m natural plantings and climbing structures	approx. 4 x 10 m, height: 3 m tropical plantings, small brook, climbing structures
Acouchi (<i>Myoprocta acouchi</i>)	1 male	died after 8 months		
Cane toad (<i>Bufo marinus</i>)	2	unchanged		
Tokay gecko (<i>Gekko gekko</i>)	several introduced in April 2002			

- **Special measures at the beginning of association:** none
- **Special behavioural observations (intra- or interspecific):** Competition over food between Goeldi's monkeys and acouchi, frequent interactions without aggression.
- **Problems and risks (animals, technical, vet. medical):** None, association can be recommended.

Association 4

Associated species since March 1997	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Geoffroy's tufted-eared marmoset (<i>Callithrix geoffroyi</i>)	2 males 1 female	2 males, 2 females (one male and one female were exchanged)	approx. 400 m ² height: approx. 8 m tropical hall with natural plantings	association only indoor
Green basilisk (<i>Basiliscus plumifrons</i>)				
Lesser malay mouse deer (<i>Tragulus javanicus</i>)				
Diverse tropical birds				
Diverse fish				

- **Special measures at the beginning of association:** Callitrichids were habituated to the tropical hall in a separate cage.

- **Special behavioural observations (intra- or interspecific):** If small, unsystematically introduced birds (visitors pets), do not show adequate behaviours of predator avoidance (insufficient flight capabilities), they get caught by the callitrichids. Monkeys do not (successfully) prey upon healthy birds, which do not show behavioural deficits.
- **Problems and risks (animals, technical, vet. medical):** none

Association 5

Associated species since 1996	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Golden-headed lion tamarin (<i>Leontopithecus chrysomelas</i>)	4 females	unchanged	approx. 100 m ² dense natural plantings	40 m ² dense tropical plantings
Diverse tropical birds		multiple changes		
Cane toad (<i>Bufo marinus</i>)	introduced in 1998			

- **Special measures at the beginning of association:** none
- **Special behavioural observations (intra- or interspecific):** During the first weeks, monkeys tend to panic when toads moved, but later fear diminished.
- **Problems and risks (animals, technical, vet. medical):** none

Association 6

Associated species since Aug. 2000	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Borneo orang-utan (<i>Pongo pygmaeus</i>)	1 male 3 females 1 juvenile (6 y)	1 male 4 females	500 m ² natural hilly ground, grass, bushes, rocks, trees, ropes, surrounded by artificial cliffs and water moat	160 m ² , approx. 330 m ³ climbing area, height: approx. 8.5 m additional indoor enclosures to keep species separately
Asian small-clawed otter (<i>Aonyx cinerea</i>)	1 male 1 female	5 males 3 females		
Lion-tailed macaque (<i>Macaca silenus</i>)	3 males introduced in Oct. 2001			

- **Special measures at the beginning of association:** Before orang-utans and otter were associated, both species were habituated to the enclosure separately. With regard to otters, introduction of lion-tailed macaques proved difficult. Thus, lion-tailed macaques were first introduced to adult female orang-utans, then to male and juvenile orang-utans and finally, all three species were associated.
- **Special behavioural observations (intra- or interspecific):** Orang-utans and otters are predominantly involved in intraspecific interactions. When interspecific (playful teasing) behaviours can be observed, species generally respect each other. During interspecific interactions otters show a behavioural mixture of impudence and caution. Otters manage

to steel vegetable food items from orang-utans, wash them in water moats and feed on it. Therefore they do not need supplemental vitamins to be added to their normal diet. This association obviously represents an enrichment for both species. Several weeks after the introduction of lion-tailed macaques, first sociopositive (physical) contacts between individuals of macaques and orang-utans could be observed. Relationships vary from friendship and playing partners to avoidance, depending on the individuals involved.

- **Problems and risks (animals, technical, vet. medical):** Hostile relationship between lion-tailed macaques and otters. On one occasion a male macaque killed an infant otter, confirming that lion-tailed macaques also prey upon small mammals and reptiles (KURUP and KUMAR, 1993). Protection of living trees had to be improved when macaques were introduced. A big group of otters can cause some difficulties in shifting the animals from one enclosure to another.
- **Cause of problems and trouble shooting:** Otters with infants do not get associated with lion-tailed macaques anymore. When young otters reach a certain body size they do not run the risk of being attacked anymore. Association can be recommended.



Asian small-clawed otter (near water moat) regularly compete for vegetarian food with Borneo orang-utans in indoor area.

Allwetterzoo Münster



Starting interaction (obviously food related) between lion-tailed macaques and Borneo orang-utan at the "zoORANGerie" Münster.

Allwetterzoo Münster

Osnabrück

Zoologische Gesellschaft Osnabrück e.V., Am Waldzoo 2-3, D-49082 Osnabrück

3 Associations selected here

Association 1

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Emperor tamarin (<i>Saguinus imperator</i>)	1 male 1 female	unchanged	association only indoor	large tropical hall with pathway for visitors; diverse tropical plantings (<i>Bromelia</i> , <i>Ficus</i> e.g.)
Diverse tropical birds (<i>Thraupinae</i> ; <i>Emberizida</i> : <i>Sicalis flaveola</i>)				

- **Special measures at the beginning of association:** medical check-up
- **Special behavioural observations (intra- or interspecific):** Tamarins seem to ignore almost all birds. They do not prey upon eggs, nestlings or small birds and they do not feel threatened by larger birds.
- **Problems and risks (animals, technical, vet. medical):** One toukan was distressed and teased by tamarins.



Naturally enriched indoor enclosure (outdoor enclosure in background) for a mixed exhibit of cotton top tamarins and two-toed sloths.

Zoologische Gesellschaft Osnabrück

Association 2

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Golden-headed lion tamarin (<i>Leontopithecus chrysomelas</i>)	3 males 1 female	3 males	association only indoor	approx. 8 x 3 m height: 2.5 m ground covered with wooden chips, planted with natural and artificial plants, small brook, artificial rocks, natural (dead) branches as climbing structures
Acouchi (<i>Myoprocta pratti</i>)	1 male 1 female	unchanged		

- **Special measures at the beginning of association:** systematic observations (probationer)
- **Special behavioural observations (intra- or interspecific):** Species feed together, association very peaceful.
- **Problems and risks (animals, technical, vet. medical):** none

Association 3

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Cotton top tamarin (<i>Saguinus oedipus</i>)	1 male 2 females	1 male 3 females	40 m ² height: 4.5 m limy forest-like soil on the ground, trees and bushes, branches, ropes, wire mesh roof construction accessible for animals	24 m ² height: 3.5 m environment similar to outdoor enclosure
Two-toed sloth (<i>Choloepus hoffmanni</i>)	1 male	1 male 1 female		

- **Special measures at the beginning of association:** Medical check for diseases and parasites. Provision of places to rest and hide for both species.
- **Special behavioural observations (intra- or interspecific):** Sloths must be given sufficient time (approx. 20 hrs) for undisturbed resting. Food provision especially for sloths must be checked regularly, as tamarins take up to 30 % of sloth's diet.
- **Problems and risks (animals, technical, vet. medical):** Elimination of all (potentially) poisonous plants; constant temperature.

Rheine

Naturzoo Rheine, Salinenstraße 150, D-48432 Rheine

1 Association selected here

Associated species since 1981	Initial group structure	Development of group structure until present	Measurements and structure of indoor enclosure	Measurements and structure of indoor enclosure
Gelada baboon (<i>Theropithecus gelada</i>)	5 males 5 females	± 20 animals	two enclosures connected by two horizontal tree trunks: one enclosure 1500 m ² (exclusively accessible for geladas) with natural hilly ground, planted with grass and bushes, central rock formation with shallow caves and shelter; encl. surrounded by water moat (4 m wide, 0.6-0.8 m deep). Second enclosure 500 m ² (for both species), concrete ground, surrounded by water moat and wire mesh, central rocky hill, dead tree trunks	association only outdoor
Barbary sheep (<i>Ammotragus lervia</i>)	5 males 5 females	about 5 offspring per year (restriction of group size to ± 10 animals)		

- **Special measures at the beginning of association:** None; geladas can move from one enclosure to the other at any given time.
- **Special behavioural observations (intra- or interspecific):** Juvenile geladas can be observed to ride on Barbary sheeps. Young Barbary sheeps initiate interspecific interactions (playful behaviour). Barbary sheeps often prove to be the dominant species.
- **Problems and risks (animals, technical, vet. medical):** No problems in general, but one cannot exclude some individual interspecific problems as interactions can become a bit rough from time to time. No severe interspecific encounters up to now.
- **Cause of problems and trouble shooting:** As faeces rarely have to be removed (it disappears in the natural soil of the outdoor area) anthelmintics are administered twice per year as a prophylactic. Up to now, there were no hygienic or parasitological problems.
- **Additional remark:** Before this association was established, the gelada baboon group, smaller at that time, was associated with 1,7 patas monkeys (*Erythrocebus patas*) without any social problems. Geladas proved to be not aggressive towards diverse species of birds and staff when entering the enclosure. For further details on this association of gelada baboons and Barbary sheeps see: SALZERT and JOHANN (1992).



Common feeding session of gelada baboons and Barbary sheeps. Parts of the additional outdoor area, exclusively for geladas, can be seen in the background.

Naturzoo Rheine

Rostock

Zoologischer Garten Rostock gGmbH, Renbahnallee 21, D-18059 Rostock

6 Associations selected here

Association 1

Associated species 1991-2001	Initial group structure	Development of group structure	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Common marmoset (<i>Callithrix jacchus</i>)	1 male 3 females	changing group size up to 3,3	4 x 4 m height: 3 m floor covered with gravel, branches; additionally <i>C. jacchus</i> had exclusive access to a bigger outdoor enclosure	5.5 x 5 m height: 3 m sleeping and nesting boxes, many branches, trunk with artificial cave, floor covered with wooden chips
Scarlet macaw (<i>Ara macao</i>)	1 male 1 female	unchanged		

- **Special measures at the beginning of association:** close observation
- **Special behavioural observations (intra- or interspecific):** Species avoided each other at feeding places. No behavioural problems for about 18 months.
- **Problems and risks (animals, technical, vet. medical):** After callitrichid group structure changed (new female introduced), they attacked the macaws: Pulling feathers, biting a macaw, which was lying on the ground e.g.
- **Cause of problems and trouble shooting:** Macaws ability to move around was drastically reduced as they were not able to fly but had to climb through the entanglement of branches and twigs. Association was terminated as macaws were distressed by marmosets (but see association 2).

Association 2

Associated species since 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Common marmoset (<i>Callithrix jacchus</i>)	1 male 3 females	see table above; one female died because of delivery problems	4 x 4 m height: 3 m floor covered with gravel, branches; additionally monkeys had exclusive access to a bigger outdoor enclosure	5.5 x 5 m height: 3 m sleeping and nesting boxes, many branches, trunk with artificial cave, floor covered with wooden chips
Severe macaw (<i>Ara severa</i>)	2 males			
Spix's black-mantled tamarin (<i>Saguinus nigricollis</i>)	1 male, 1 female (as substitute for <i>Ara macao</i> , see table above)	1 female (male died, paralysed after injury)		

- **Special measures at the beginning of association:** *C. jacchus* and *A. severa* were associated without special measures (just close observation). When *S. nigricollis* was introduced to the enclosure, *C. jacchus* was removed for several days.
- **Special behavioural observations (intra- or interspecific):** Initially no aggression had been observed. Later on, some aggressive encounters occurred and subsequently the single female *S. nigricollis* (male died) was distressed by *C. jacchus* and macaws.
- **Problems and risks (animals, technical, vet. medical):** While under pressure from associated species, female *S. nigricollis* tried to retreat or hide for several days.
- **Cause of problems and trouble shooting:** Situation relaxed after a male *C. jacchus* was removed and macaws were clipped. Further improvement of this association is expected when a male *S. nigricollis* will be associated and a new *C. jacchus* group can be established. The success of an association like this, obviously depends not only on the structure of the groups, but also on individual characters of the animals involved. Future observation of the development of this association might provide valuable information on this issue.



Common marmoset (right) and Spix's black-mantled tamarin (left) in outdoor enclosure, also open for visitors.

*Zoologischer Garten
Rostock*

Association 3

Associated species since 2001	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Common marmoset (<i>Callithrix jacchus</i>)	3 males 1 female	2 males	160 m ² natural ground with grass, several small trees and a big birch-tree, all connected by additional branches, pathway for visitors	separate indoor enclosures 12.5 and 29 m ² height: 3 m each
Cotton top tamarin (<i>Saguinus oedipus</i>)	1 male 3 females	1 male 3 females		
Spix's black-mantled tamarin (<i>Saguinus nigricollis</i>)	1 female	1 female		

- **Special measures at the beginning of association:** *C. jacchus* (one animal) entered the outdoor enclosure accidentally. As there were no severe aggressive encounters observed, the whole group was given access to the outdoor area and association with *S. oedipus* was established.
- **Special behavioural observations (intra- or interspecific):** As long as species avoid to enter the indoor area occupied by the respective other species, no severe aggression could be observed. To improve the social and interspecific rank situation of the female *S. nigricollis*, a male needs to be introduced soon.
- **Problems and risks (animals, technical, vet. medical):** The future development of this polyspecific association has to be observed systematically, to gather information on factors influencing its success.
- **Cause of problems and trouble shooting:** Changing and very different group structures and sizes of species involved. Species-specific group composition has to be improved and stabilised.

Association 4

Associated species 1998-1999	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Brown capuchin (<i>Cebus apella</i>)	2 males 8 females (adults and juveniles)	unchanged	950 m ² natural ground, diverse living trees, bushes, dead wood climbing structures, connecting branches	association only outdoor
Common marmoset (<i>Callithrix jacchus</i>)	3 males 1 female	unchanged		

- **Special measures at the beginning of association:** Species were habituated to each other using a smaller outdoor enclosure for *C. jacchus*, connecting the bigger outdoor area with an indoor area. Here species were initially separated by wire mesh and first interspecific contacts were observed.

- **Special behavioural observations (intra- or interspecific):** Occasionally *C. apella* grasped a *C. jacchus* tail, but no animal was injured. After being annoyed, the intensively vocalising *C. jacchus* group was able to displace *C. apella*
- **Problems and risks (animals, technical, vet. medical):** After six months, *C. jacchus*-group refused to enter the outdoor area.
- **Cause of problems and trouble shooting:** Association was therefore terminated.

Association 5

Associated species since 1999	Initial group structure	Development of group structure until present	Measurements and structure of indoor enclosure	Measurements and structure of indoor enclosure
Brown capuchin (<i>Cebus apella</i>)	2 males 8 females	unchanged	950 m ² natural ground with grass, diverse living trees, bushes, dead wood climbing structures, nets, connecting branches, small water pond; enclosure fenced with hot wires	two rooms: 47 m ² and 14.75 m ² height: 3 m equipped with branches and ropes; floor covered with wooden chips; boxes for <i>N. nasua</i>
Ring-tailed coati (<i>Nasua nasua</i>)	1 male (castrated)	4 males		

- **Special measures at the beginning of association:** Species were habituated to each other while separated by wire mesh. When group size of *N. nasua* was enlarged, conspecifics were habituated to each other first. Then they were associated with the brown capuchins.
- **Special behavioural observations (intra- or interspecific):** Occasionally brown capuchins pull hair of *N. nasua* but they do not seem to be disturbed by this kind of interaction and tolerate this behaviour. When *N. nasua* approaches feeding spots, they displace the monkeys. Both species respect each other.
- **Problems and risks (animals, technical, vet. medical):** No major problems. 1-2 minor injuries that might have been caused by *N. nasua*. Association can be recommended.
- **Cause of problems and trouble shooting:** When monkeys were released to the outdoor area for the first time, some individuals jumped on – and over the rather low (1.1m) fences, regardless of the hot wires. But after these first experiences and habituation of monkeys to the large outdoor enclosure, this reduced kind of fencing proved to be sufficient.



Brown capuchins and ring-tailed coatis (upper background) in outdoor area with living trees.

Zoologischer Garten Rostock

Association 6a

Associated species 1995-1997	Initial group structure	Development of group structure	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Patas monkey (<i>Erythrocebus patas</i>)	1 male (subadult) 3 females (adult)	unchanged	two adjacent enclosures: 35 m ² (<i>E. patas</i>) and 15 m ² (<i>C. petaurista</i>) height: 3.5 m	two adjacent enclosures: 3.8 m ² (<i>E. patas</i>) and 5.3 m ² (<i>C. petaurista</i>) height: 3 m
Lesser spot-nosed guenon (<i>Cercopithecus petaurista</i>)	1 male (adult) 3 females (adult)	unchanged		

- **Special measures at the beginning of association:** Long-term (1 year) habituation of species to each other, living in adjacent enclosures. Finally, enclosures were connected and both species were allowed to move freely through all four (indoor and outdoor) adjacent enclosures.
- **Special behavioural observations (intra- or interspecific):** *C. petaurista* was the dominant species.
- **Problems and risks (animals, technical, vet. medical):** *C. petaurista* group acted strategically to corner individuals of *E. patas* within the enclosure to demonstrate their dominance, however, no severe aggression or injuries were observed. Association, although successful, had to be terminated when monkey groups were moved to another facility within the zoo.

Association 6b

Associated species since summer 1997	Initial group structure	Development of group structure	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Patas monkey (<i>Erythrocebus patas</i>)	1 male 4 females	Male reached adulthood (see below)	1250 m ² including two separate enclosures 20 m ² (<i>E. patas</i>) and 62 m ² (<i>C. petaurista</i>); outdoor area with natural plantings, grass, old maple tree, raspberry-bushes, dead trees, big roots; enclosure surrounded by wire mesh and water moat	several rooms: 47 m ² (both species) 11 m ² (<i>C. petaurista</i>) and 14 m ² (as required) height: 4 m
Lesser spot-nosed guenon (<i>Cercopithecus petaurista</i>)	1 male 3 females	male died after two months		

- **Special measures at the beginning of association:** Species were already habituated to each other.
- **Special behavioural observations (intra- or interspecific):** After male *E. patas* reached adulthood and the male *C. petaurista* died two months after re-associating species, dominance relationship between species changed. Now *E. patas* distressed the remaining

C. petaurista females, which tried to hide under big roots or in raspberry-bushes and occasionally fled into the water moat.

- **Problems and risks (animals, technical, vet. medical):** No injuries or accidents occurred, but situation for *C. petaurista* was tense.
- **Cause of problems and trouble shooting:** Association was terminated again.



Lion-tailed macaques "visited" by a donkey in their outdoor enclosure (see additional remarks association 6c).

Zoologischer Garten Rostock

Association 6 c

Associated species in 2001	Initial group structure	Development of group structure	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Patas monkey (<i>Erythrocebus patas</i>)	1 male (adult, new), 4 females (adult), 5 juv.+ inf.	unchanged	see table 6b	see table 6b
Lesser spotted guenon (<i>Cercopithecus petaurista</i>)	2 males 3 females (just 2 females from former group)	unchanged		

- **Special measures at the beginning of association:** Habituation of species to each other, living in adjacent enclosures (see 6b). Finally, enclosures were connected and both species were allowed to move freely through all five (indoor and outdoor) adjacent enclosures. Then they were released to the large outdoor area.
- **Special behavioural observations (intra- or interspecific):** Initially *C. petaurista* was again acting strategically to corner the male *E. patas*. But this male was striking back (biting), resulting in diverse injuries. Subsequently patas monkeys often pursued and distressed *C. petaurista* in the outdoor area. One female patas monkey was repeatedly observed to initiate sociopositive contacts to a female guenon, but during aggressive group encounters she always rejoined her conspecifics.
- **Problems and risks (animals, technical, vet. medical):** Although no animal was injured, *C. petaurista* was permanently distressed by patas monkeys.

- **Cause of problems and trouble shooting:** Association had to be terminated.
- **Additional remarks:** To shorten the grass planted on diverse outdoor enclosures, an old donkey is regularly associated (since 1999) with diverse species of monkeys. The donkey gets access (depending on vegetation heights) to the lion-tailed macaque (*Macaca silenus*) enclosure (1220 m²), the patas monkey (*Erythrocebus patas*) enclosure (1250 m²) and the brown capuchin (*Cebus apella*) enclosure (950 m²). So far all monkeys showed great respect towards the old donkey, never tried to get physical contact, but moved on higher levels when he grazes beneath trees or climbing structures. The donkey never showed any signs of fear towards the monkeys. As this can be seen as an irregular and temporarily stimulus, this association can be recommended here.

Schwerin

Zoologischer Garten Schwerin GmbH, Waldschulenweg 1, D-19061 Schwerin

1 Association selected here

Associated species since 1998	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Common marmoset (<i>Callithrix jacchus</i>)	1 male 1 female	unchanged	18 x 11 m natural ground with grass, climbing structures made of dead wood, surrounded by a small wall (height: approx. 50 cm); monkeys regularly forage outside the enclosure	5 x 5 m, height: 3 m in addition, guinea pigs are associated here; macaws separated
Blue-and-gold macaw (<i>Ara ararauna</i>)	1 male 1 female	1-3 offspring per year		
Two-toed sloth (<i>Choloepus hoffmanni</i>)	1 male 1 female	three deliveries, but offspring died		



- **Special measures at the beginning of association:** Macaws were habituated first to the outdoor enclosure.
- **Special behavioural observations (intra- or interspecific):** Explorative and playful interactions between marmosets and macaws. Marmosets occasionally steal food items from macaws.
- **Problems and risks (animals, technical, vet. medical):** no problems

Common marmoset sitting next to blue-and-gold macaws in their outdoor enclosure.

Zoologischer Garten Schwerin

Stuttgart

Zoologischer-Botanischer Garten Wilhelma, Postfach 501227, D-70342 Stuttgart

2 Associations selected here

Association 1

Associated species since Aug. 2000	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Golden-headed lion tamarin (<i>Leontopithecus chrysomelas</i>)	1 male 1 female	8 offspring out of which 6 infants survived	97 m ² (484 m ³) surrounded by wire mesh; enclosure equipped with natural plants and branches, partly dense vegetation	37 m ² (170 m ³) part of tropical hall, natural branches, artificial rocks and cliffs with integrated rooms on the backside where species can be provisioned separately
White-faced saki (<i>Pithecia pithecia</i>)	2 males 2 females	1 male, 1 female (1 male and 1 female were removed in Aug. and Oct. 2001)		

- **Special measures at the beginning of association:** Species were habituated to each other for several weeks, being separated by a wire mesh.
- **Problems and risks (animals, technical, vet. medical):** no major problems



White-faced sakis and golden-headed lion tamarin in an indoor enclosure, integrated in a tropical hall.

Zoologischer-Botanischer Garten Wilhelma, Stuttgart

Association 2

Associated species since 1975	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Gelada baboon (<i>Theropithecus gelada</i>)		well breeding, long term association with numerous changes in group structure	550 m ² rocky enclosure with a central hill made of heavy rocks and trunks of dead trees; enclosure partly surrounded by concrete walls, glass wall and the walls of an indoor facility, equipped with resting places, inaccessible for Barbary sheeps	association only outdoor
Barbary sheep (<i>Ammotragus lervia</i>)		well breeding		
Rock hyrax (<i>Procavia capensis</i>)		well breeding		

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** Especially young geladas can regularly be observed to sit (even on the horns) and ride on the back of Barbary sheeps. Adolescent male geladas have also been observed to milk and to copulate with Barbary sheeps.
- **Problems and risks (animals, technical, vet. medical):** Sometimes juvenile Barbary sheeps get injured, as geladas tend to bite in conflict situations.
- **Cause of problems and trouble shooting:** To reduce the risk of biting and to manage group size, adolescent male geladas are being removed successively.



Gelada baboons grooming and resting on Barbary sheep.

*Zoologischer-Botanischer Garten
Wilhelma, Stuttgart*



Central rock formation in outdoor enclosure for gelada baboons, hyraxes and Barbary sheeps.

Zoologischer-Botanischer Garten Wilhelma, Stuttgart

Selected Mixed Species Exhibits of Mammals without Primates Involved

Augsburg

Zoo Augsburg GmbH, Brehmplatz 1, D-86161 Augsburg

1 Association selected here

Associated species since 1985	Initial group structure	Development of group structure until Feb. 05.2002	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Sable antelope (<i>Hippotragus niger</i>)	2 males 2 females	1 male 4 females	12650 m ² (excl. stables) natural ground with gras, old (protected) trees, several rocks; enclosure surrounded by water moats and stables plus small enclosure to separate indiv. animals	association only outdoor
Waterbuck (<i>Kobus ellipsiprymnus defassa</i>)	1 male 1 female	1 male 2 females		
Domestic sheep (<i>Ovis ammon f. aries</i>)	8 males 13 females	9 males 37 females		
Zebu - Domestic humpless cattle (<i>Bos primigenius f. taurus</i>)	2 males 5 females	2 males 6 females		

- **Special measures at the beginning of association:** Female *H. niger* were habituated to the new enclosure first; after a few days males followed. The same procedure was applied to *K. e. defassa* a few days later, as males calm down more easily when (relaxed) females are already present.
- **Special behavioural observations (intra- or interspecific):** During all the years just minor aggressive interactions between the antelopes. Especially *H. niger* like to scuffle, even with *B. p. f. taurus*.
- **Problems and risks (animals, technical, vet. medical):** During more serious aggressive encounters, keepers are not able to intervene due to safety reasons.
- **Cause of problems and trouble shooting:** Permanent observations during critical phases.

Braunschweig

Arche Noah Zoo Braunschweig, Am Zoo 35, D-38124 Braunschweig

1 Association selected here

Associated species since several years	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Bactrian camel (<i>Camelus terus</i>)	1 male 1 female	unchanged	550 m ² sand/natural ground, tree trunks and branches for gnawing; protected lime tree	separate stable boxes with straw layer
Indian crested pocupine (<i>Hystrix indica</i>)	8 animals	breeds regularly		

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** Occasional playful scuffling
- **Problems and risks (animals, technical, vet. medical):** One *H. indica* was lost at the beginning of the association due an injury caused by camel kick. After this experience, unpleasant for both species, no further problems occurred.



Bactrian camels sharing their enclosure with Indian crested pocupines.

Arche Noah Zoo Braunschweig

Dortmund

Zoo Dortmund, Mergelteichstraße 80, D-44225 Dortmund

3 Associations selected here

Association 1

Associated species since 1975	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Lowland tapir (<i>Tapirus terrestris</i>)	1 male 2 females	changed several times during the last 27 years anteaters and tapirs bred regularly; capybaras, pudus and peccaries also bred successfully; for details see BARTMANN (1980, 1990)	3000 m ² paddock with natural ground planted with grass of different heights (for cover), surrounded by a 1.3 m high fence; it includes a pool, a sandy area, trees, tree trunk, scrubs and rocks; for details see BARTMANN (1980, 1990)	2 x 25 m ² separated indoor sleeping quarters
Giant anteater (<i>Myrmecophaga tridactyla</i>)	changing			
Capybara (<i>Hydrochoerus hydrochaeris</i>)	1 male 2 females			
Collared peccary (<i>Tajassu tajacu</i>)	1 male 4 females			
Crested screamer (<i>Chauna torquata</i>)	1 male 1 female			
Pudu deer (<i>Pudu mephistophiles</i>)	1 male 1 female			

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** Occasional agonistic interactions between giant anteaters and crested screamers. In general: Occasional interspecific social behaviour (esp. anteaters use to sniff and lick other species), common use of preferred resting places, interference of a disturbing nature is rare. Successful long-term polyspecific association that positively influences behavioural patterns of the species involved. For details see BARTMANN (1990).
- **Problems and risks (animals, technical, vet. medical):** A female tapir had to be removed as it was intolerant of conspecifics. Peccaries have to be separated when capybaras or pudus rear their young.
- **Cause of problems and trouble shooting:** Facilities to separate animals (species) at times.



The spacious outdoor enclosure called "Estância do Lobo" for the mixed exhibit of South-American animals.

Zoo Dortmund

Association 2

Associated species since 1992 (in changing composition)	Initial group structure	Development of group structure	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Two-toed sloth (<i>Choloepus didactylus</i>)				association housed in the Amazonas-building (three levels) of the zoo; ambient temperature maintained at approx. 26° C, humidity at about 80 %; floor covered with wooden chips, diverse tropical vegetation; integrated aquariums and terrariums
Green acouchi (<i>Myoprocta pratti</i>)				
Green iguana (<i>Iguana iguana</i>)				
Green basilisk (<i>Basiliscus plumifrons</i>)				
Grey-winged trumpeter (<i>Psophia crepitans</i>)				
diverse species of geckos and birds				

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** Grey-winged trumpeters preyed upon young green acouchis.
- **Problems and risks (animals, technical, vet. medical):** no other major problems

Association 3

Associated species	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Common eland (<i>Taurotragus oryx</i>)			3650 m ² incl. a central island of trees to move around	stables separated for species
Sable antelope (<i>Hippotragus niger</i>)				
Grant's zebra (<i>Equus burchelli</i>)				

- **Special measures at the beginning of association:** unknown
- **Problems and risks (animals, technical, vet. medical):** Male zebra killed formerly associated marabus.
- **Cause of problems and trouble shooting:** Zebras not permanently associated anymore.

Hamburg

Tierpark Hagenbeck gGmbH, Hagenbeckallee 31, D-22527 Hamburg-Stellingen

1 Association selected here

Associated species since 1998	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Chapman zebra (<i>Equus burchelli antiquorum</i>)	1 male 4 females		2200 m ² recycled concrete ground covered with sand, partly natural ground, several stones and rocks, robinia (<i>Robinia spec.</i>) plantations under trees, stacks of branches, two small stone caves	ostriches and zebras share the same stable (separate boxes)
Cape ostrich (<i>Struthio camelus australis</i>)	1 male 4 females			
Defassa waterbuck (<i>Kobus ellipsiprymnus defassa</i>)	1 male 8 females	defassa waterbucks were removed in 2001		
Warthog (<i>Phacochoerus aethiopicus</i>)		introduction of 1.1 warthog in June 2000		

- **Special measures at the beginning of association:** At the beginning species were associated separately for hours, under permanent observation: First contacts of warthogs with ostriches in absence of zebras and first contacts with zebras in absence of ostriches.
- **Special behavioural observations (intra- or interspecific):** Established dominance hierarchy within this mixed exhibit is: 1. zebras, 2. warthogs, 3. ostriches.
- **Problems and risks (animals, technical, vet. medical):** The integration of waterbucks failed as zebras attacked new born waterbucks and inhibited the development of the neces-

sary mother-infant bond. Burrows and holes dug by the warthogs are a permanent risk of injuries for other species (esp. zebras) as they represent stumble traps.

- **Cause of problems and trouble shooting:** Association of waterbucks and zebras was terminated and cannot be recommended. To minimize the risk of injuries, esp. for zebras, keepers have to check for- and if necessary refill ground holes dug by the warthogs within their daily routine works.

Halle

Zoologischer Garten Halle GmbH, Fasanenstraße 5a, D-06114 Halle (Saale)

In addition to the mixed species exhibits of Zoo Halle presented in part one, pygmy hippos (*Hexaprotodon liberiensis*), capybaras (*Hydrochoerus hydrochaeris*) and Egyptian goose (*Alopochen aegyptiacus*) were associated successfully here in an outdoor enclosure.

Heidelberg

Tiergarten Heidelberg, Tiergartenstraße 3, D-69120 Heidelberg

3 Associations selected here

Association1

Associated species since 1981	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Syrian bear (<i>Ursus arctos syriacus</i>)	1 male 1 female	2 males 5 females	472 m ² brook, pond, water moat, concrete, natural ground, several stones and rocks, dead wood, roots	association only outdoor
Corsac fox (<i>Vulpes corsac</i>)	1 male 2 females	8 males 6 females regularly breeding		

- **Special measures at the beginning of association:** Initially foxes were habituated to the enclosure without bears being present.
- **Special behavioural observations (intra- or interspecific):** Male juvenile foxes often steal food items from bears at close range. Bears subsequently chase foxes over short distances. This challenging behaviour was rarely observed in female foxes.
- **Problems and risks (animals, technical, vet. medical):** Loss of some infant/juvenile foxes caused by the bears was reported from the early years of this association.
- **Cause of problems and trouble shooting:** Nowadays newborn foxes and parents are kept in the indoor enclosure for approx. eight weeks. Then they get access to the outdoor enclosure during the nights. Finally they have exclusive access to the outdoor enclosure for one day before the group is (re)associated with the bears. This procedure prevented further losses of young foxes until now.

Association 2

Associated species since the 70ies	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Asian elephant (<i>Elephas maximus</i>)	3 females	1 female	3244 m ² sandy and natural ground; elephant area restricted to 480 m ²	association only outdoor
Axis deer (<i>Axis axis axis</i>)	?	3 males 3 females		
Black buck (<i>Antilope cervicapra</i>)	?	2 males 10 females		

- **Special measures at the beginning of association:** unknown
- **Special behavioural observations (intra- or interspecific):** Black bucks rarely approach elephants whereas axis deers even walk among elephant legs to participate in feeding. Since she lacks conspecifics, the female elephant frequently approaches the axis deers with her trunk to initiate contacts. Deers move away in a very relaxed manner.
- **Problems and risks (animals, technical, vet. medical):** No problems due to association ever reported.

Association 3

Associated species since March 1999	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Red panda (<i>Ailurus fulgens</i>)	1 male 1 female	unchanged	565 m ² big central walnut-tree on natural ground with grass, bamboo and bushes, dead wood and rocks	20 m ² height 2.5 m branches and sleeping boxes for pandas, feeding boards, saw-dust floor cover
Barking deer (or Indian Muntjak) (<i>Muntiacus muntjak</i>)	1 male	1 male 1 female		

- **Special measures at the beginning of association:** Barking deers were initially kept in the indoor enclosure for several days, while red pandas had access to both enclosures through sliding doors in the upper level.
- **Special behavioural observations (intra- or interspecific):** Barking deers are regularly waiting for food items, dropped by the pandas, to feed on.
- **Problems and risks (animals, technical, vet. medical):** none

Leipzig

Zoo Leipzig, Pfaffendorfer Straße 29, D-04105 Leipzig

1 Association selected here

Associated species since Dec. 2000	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
African lion (<i>Panthera leo</i>)	2 males 1 female (genders kept separately)	2 males	1100 m ² natural ground with grass, kopje-like rocks, heated cave, bushes, bamboo, trees, surrounded by artificial cliffs (walls of indoor area), dry ditch and water moat; enclosure partly (e.g. planted areas) equipped with hot wires	association only outdoor
Black-backed jackal (<i>Canis mesomelas</i>)	1 juv. male 1 juv. female			

- **Special measures at the beginning of association:** Jackals were given sufficient time to explore the outdoor enclosure; habituation in absence of lions. Planted areas between the dry ditch and jackals indoor area exclusively accessible for the jackals (protected against lions through hot wires).
- **Special behavioural observations (intra- or interspecific):** During the first weeks jackals preferred to use the outdoor enclosure during the night. They did not try to dig burrows and accepted sleeping boxes indoor. Since Jan. 2001 jackals showed more diurnal activities in the outdoor enclosure, together with lions.
- **Problems and risks (animals, technical, vet. medical):** In February 2001, the female jackal incautiously ignored the distance to the next shelter and was cornered by the male lions. During this encounter the jackal was lethally injured and subsequently euthanised. To reduce the risk of further jackal – lion encounters, artificial tubes were integrated into the ground of the outdoor enclosure, but they were not used by the remaining male jackal. About six weeks after the loss of the female, the male jackal was found with multiple bone fractures on the ground of the dry ditch (5 m deep). This lethal accident occurred in the absence of lions during the night.
- **Cause of problems and trouble shooting:** The curiosity and playful behaviours of the relatively young (approx. 2.5 years of age) male lions towards new stimuli might be one reason for the failure of this association. Another reason can be seen in the wet and loamy soil of the outdoor enclosure, preventing the jackals to dig a system of protective burrows. No further tries to associate these species will be undertaken, before an improved enclosure concept for this association can be established.

München

Münchner Tierpark Hellabrunn AG, Tierparkstraße 30, D-81543 München

3 Associations selected here

Association 1

Associated species since 4 years	Initial group structure	Development of group structure until present	Measurements and structure of indoor enclosure	Measurements and structure of indoor enclosure
Alaska muskox (<i>Ovibos moschatus wardi</i>)	2 males 2 females	well breeding	1440 m ² natural ground 470 m ² water pond	association only outdoor
American beaver (<i>Castor canadensis</i>)	1 male 1 female 4 juveniles	well breeding		

- **Special measures at the beginning of association:** When beaver were introduced, muskoxen were already habituated to the enclosure. Beavers are provided with a little hut for shelter situated on a small island but their burrows extend to the dry areas for muskoxen.
- **Special behavioural observations (intra- or interspecific):** Beavers almost always stay in the pond area during the day. At night, when muskoxen are kept indoor, beavers use the entire enclosure.
- **Problems and risks (animals, technical, vet. medical):** none

Association 2

Associated species since more than 5 years	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Wood bison (<i>Bison bison athabascae</i>)	1 male 3 females	well breeding	4534 m ² natural ground, feeding area with solid ground	association only outdoor
Black-tailed prairie dog (<i>Cynomys ludovicianus</i>)	30	well breeding		

- **Special measures at the beginning of association:** When prairie dogs were introduced, bison were already habituated to the enclosure.
- **Special behavioural observations (intra- or interspecific):** Prairie dogs prefer open (no trees) areas to stay alert for birds of prey. Prairie dogs initiate physical contacts to the bison to pull out pieces of old fur, which they use to stuff their underground nests. Bison willingly tolerate this special behavior.
- **Problems and risks (animals, technical, vet. medical):** Burrows and holes dug by the prairie dogs causes a risk of injuries for bison as they represent stumble traps for these heavy animals.
- **Cause of problems and trouble shooting:** Refills of new or potentially unstable holes in the ground.

Association 3

Associated species since	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Malayan tapir (<i>Tapirus indicus</i>)	1 male 1 female		962 m ² for both species plus adjacent enclosures for separation	association only outdoor
Babirussa (<i>Babirussa babirussa</i>)	1 male 1 female			

- **Special measures at the beginning of association:** Initially species were habituated to each other while being separated by a fence. When babirussas were introduced, tapirs were already habituated to the enclosure and babirussas were given the option to retreat.
- **Special behavioural observations (intra- or interspecific):** Tapirs were bitten by babirussas.
- **Problems and risks (animals, technical, vet. medical):** see above

Nürnberg

Tiergarten der Stadt Nürnberg, Am Tiergarten 30, D-90480 Nürnberg

2 Associations selected here

Association 1

Associated species since 1991	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Californian sea-lion (<i>Zalophus californianus</i>)	1 juvenile male	1 male 3 adult females 1 infant female	1500 m ³ pool area and more than 100 m ² dry and roofed area (used by sea lions)	enclosure equipped with several toys; animals take part in a training program several times a day
Bottle-nosed dolphin (<i>Tursiops truncatus</i>)	1 juvenile male 2 adult females	1 male 3 females 1 juvenile female		

- **Special measures at the beginning of association:** Animals were offered sufficient space to avoid each other.
- **Special behavioural observations (intra- or interspecific):** Frequent interspecific interactions including physical contacts and simple interspecific communication between certain individuals of both species. Close sociopositive relationships were observed between the adult sea-lion bull and a certain female dolphin (partly resembling mating behaviour) as well as between a female sea-lion and another female dolphin (playful behaviours). The other individuals sporadically join these "interspecific couples" but they are predominantly involved in intraspecific interactions (see also: EEP Research Committee Newsletter 7th Issue, August 2000).
- **Problems and risks (animals, technical, vet. medical):** Newborn sea-lions have to be separated from dolphins to prevent them from being maltreated as playmates.
- **Cause of problems and trouble shooting:** Sea-lions and dolphins are trained and fed separately.



Bottle-nosed dolphin and Californian sea-lion engaged in interactions with body contact.

Tiergarten der Stadt Nürnberg

Both photos provided by Dr. K. Baumgartner



A red panda preyed upon an infant reeves muntjak.

Tiergarten der Stadt Nürnberg

Association 2

Associated species since Nov. 1998	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
Red panda (<i>Ailurus fulgens</i>)	2 males	2 males	585 m ² three living and one dead tree, several bushes and grass on natural ground	20 m ² , height: 2.7 m two compartments permanently accessible for both species, but only one equipped with climbing structures
Reeves (or Chinese) muntjak (<i>Muntiacus reevesi</i>)	1 male 1 female	2 males (one female died of infectious disease)		

- **Special measures at the beginning of association:** Muntjak were habituated first to the enclosure.
- **Special behavioural observations (intra- or interspecific):** Adult muntjaks seem to be dominant over red pandas and use to displace them.
- **Problems and risks (animals, technical, vet. medical):** After muntjaks successfully reared their offspring several times in presence of red pandas, the fourth (2000) and the sixth infant (2001) was killed and partly devoured by a red panda in the outdoor enclosure. A third victim was lightly wounded (2002).
- **Cause of problems and trouble shooting:** Pregnant deers will be separated before delivery. 1-2 weeks after birth, infant deers are out of danger. Additional provision with non-vegetable proteins did not affect red pandas behaviour.

Schwerin

Zoologischer Garten Schwerin GmbH, Waldschulenweg 1, D-19061 Schwerin

2 Associations selected here

Association 1

Associated species since several years	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
European brown bear (<i>Ursus arctos</i>)	3 females (8 years of age, two siblings)	unchanged	3000 m ² of which 800 m ² are exclusively accessible for wolfs; entire enclosure integrated in a natural forest area with grass, rocks, many trees and bushes, brook and water moat	separate rooms for bears, which they also use to rest from Nov. to March
European wolf (<i>Canis lupus</i>)	2 males	unchanged		

- **Special measures at the beginning of association:** Species were habituated to each other for one week, separated by wire mesh. Subsequent association caused no problems.
- **Special behavioural observations (intra- or interspecific):** Interspecific interactions occur during feeding sessions. When female Brown bear climbs down a tree trunk, a wolf can be observed to pinch her fur.
- **Problems and risks (animals, technical, vet. medical):** No problems; given the conditions presented here, this association of large bodied predators can be recommended.



Wolves (upper middle) patrolling in the "bear area" of their natural outdoor enclosure.

Zoologischer Garten Schwerin

Association 2

Associated species since 1998	Initial group structure	Development of group structure until present	Measurements and structure of outdoor enclosure	Measurements and structure of indoor enclosure
African lion (<i>Panthera leo</i>)	1 male 2 females	unchanged	700 m ² hilly area with grass and rocks, including an extensive system of underground caves and tubes (6 x 14 m), comprising 28 exits	12 m ² exclusively for viverrids; sandy ground including burrows; enclosure equipped with heaters
Yellow mongoose (<i>Cynictis penicillata</i>)	1 male 2 females	currently 5, well breeding		
Meerkat (<i>Suricata tetradactyla</i>)	1 male 1 female	well breeding		

- **Special measures at the beginning of association:** The tube system was extended and the viverrids were habituated to the enclosure for 14 days in absence of lions. During this habituation phase, animals were regularly frightened by several stimuli to improve their anti predator behaviours (i.e. to run into underground tubes for cover).
- **Special behavioural observations (intra- or interspecific):** Two *C. penicillata* were preyed upon by lions. With rising numbers of lions present in the outdoor enclosure, mongoose become more cryptic.
- **Problems and risks (animals, technical, vet. medical):** Risk for inexperienced mongoose to get preyed upon by lions. *C. penicillata* might prey upon young *S. tetradactyla*.
- **Cause of problems and trouble shooting:** System of underground tubes had to be extended and stabilised.



Outdoor area for African lions, yellow mongoose and meerkat.

Zoologischer Garten Schwerin

Final remarks

According to the experiences made in this study, the advantages and disadvantages of mixed species exhibits in zoos are as different as the enclosure qualities and the species involved. As a general rule, it can be stated that problems in associating different species are inversely proportional to the size and structural enrichment of the enclosure: the larger and the more naturally enriched the enclosure, the fewer the problems. To prevent competitive situations within the enclosure, one should avoid combining animals that occupy the same ecological niche. Therefore combinations of aquatic, semi-aquatic, terrestrial and arboreal species can be recommended, as they would occupy different sections of the enclosure. As long as associated species have exclusive access to certain sections of the enclosure (resting rooms or boxes), combinations of diurnal, nocturnal and cathemeral animals can also be helpful in creating non-competitive situations.

For behavioural, practical and educational reasons, the species for a mixed exhibit, should generally be selected according to the models found in the respective natural habitats. Although such a selection is often helpful in preventing major problems, it can not exclude some unexpected difficulties, as the success of a mixed exhibit does not only depend on the selected species, but also on their group structure and individual characters of the animals involved. That's why even among Callitrichids e.g., which are well known for forming a variety of stable polyspecific associations in the wild (HEYMANN and BUCHANAN-SMITH, 2000), a successful combination in captivity can not always be taken for granted. On the other hand, sloths seem to be compatible with a vast variety of other species and even a combination between primates and potential predators (e.g. rhesus monkeys and sloth bears: see Zoo Leipzig) can prove workable. Thus, the establishment of polyspecific associations in captivity will always be a matter of trial and error to a certain amount and the initial phases as well as periods of demographic changes have to be intensively monitored.

Once an association is successfully established, it will not only be an enrichment for the animals involved, but also for the zoo visitors and thus for the zoo itself. The attraction of mixed species exhibits for visitors is not only documented by their positive comments, anecdotally cited by keepers, but it can also be measured quantitatively. The mixed species exhibits e.g. in the zoos of Landau (SEIBOLD et al., 2002) and Beekse Bergen (DELEU, pers. com.) are reported to motivate visitors to linger for longer periods of time and to observe the animals and their interactions more closely. In some cases, newly established mixed species exhibits are even the main reason for visitors to come, as they have heard about this attraction from other people or from reports in the media. This way, mixed species exhibits, zoologically and environmentally adapted to natural habitats, can have a considerable educational value for the public and they can be helpful in gaining support for *in situ* conservation measures for the species presented.

As the numerous advantages of successfully established mixed species exhibits by far outweigh their potential problems and risks, this concept of keeping and presenting (often endangered) animals should be followed up in a cooperative manner between zoos, by exchanging their experiences and expertise.

Acknowledgement

The author would like to thank all the Zoo Directors, Curators and Keepers, which contributed data to this study and invested time and effort to transmit all the information needed, to make this publication possible.

Appendix: Index of Primates in Mixed Species Exhibits

Species	Zoo
<i>Alouatta seniculus</i>	Köln
<i>Aotus azarae</i>	Braunschweig, Frankfurt, Gettorf
<i>Aotus trivirgatus</i>	Dortmund
<i>Ateles geoffroyi</i>	Frankfurt, Karlsruhe
<i>Cacajao calvus calvus</i>	Köln
<i>Cacajao calvus rubicundus</i>	Köln
<i>Cacajao melanocephalus</i>	Köln
<i>Callicebus moloch</i>	Köln
<i>Callimico goeldii</i>	Dortmund, Halle, Karlsruhe, Köln, Münster
<i>Callithrix geoffroyi</i>	Dresden, Frankfurt, Heidelberg, Köln, Münster
<i>Callithrix jacchus</i>	Braunschweig, Düsseldorf, Halle, Heidelberg, Rostock, Schwerin
<i>Callithrix penicillata</i>	Dresden, Gettorf
<i>Callithrix pygmaea</i>	Aschersleben, Eberswalde, Frankfurt, Gettorf, Heidelberg, Köln
<i>Cebuella</i>	see <i>Callithrix</i>
<i>Cebus apella</i>	Hodenhagen, Rostock
<i>Cercocebus patas</i>	see <i>Erythrocebus</i>
<i>Cercopithecus petaurista</i>	Rostock
<i>Chiropotes</i> sp. x sp.	Köln
<i>Chlorocebus aethiops</i>	Hodenhagen
<i>Colobus guereza</i>	Hodenhagen
<i>Erythrocebus patas</i>	Rostock
<i>Eulemur fulvus albifrons</i>	Hodenhagen
<i>Eulemur fulvus rufus</i>	Hannover
<i>Galago moholi</i>	Frankfurt
<i>Gorilla gorilla gorilla</i>	Heidelberg
<i>Hylobates [nomascus] gabriellae</i>	Leipzig
<i>Lemur catta</i>	Frankfurt, Hodenhagen, Karlsruhe
<i>Leontopithecus chrysomelas</i>	Aschersleben, Gettorf, Köln, Münster, Osnabrück, Stuttgart
<i>Leontopithecus chrysopygus</i>	Magdeburg
<i>Leontopithecus rosalia</i>	Eberswalde, Frankfurt, Köln, Krefeld, Landau
<i>Macaca fuscata</i>	Berlin
<i>Macaca mulatta</i>	Berlin, Leipzig

Species

Macaca silenus
Macaca sylvanus
Mandrillus sphinx
Microcebus rufus
Papio hamadryas anubis
Papio hamadryas hamadryas
Pithecia pithecia

Pongo abelii
Pongo pygmaeus
Presbytis entellus
Semnopithecus entellus
Saguinus fuscicollis
Saguinus imperator
Saguinus labiatus

Saguinus midas
Saguinus nigricollis
Saguinus oedipus

Saimiri boliviensis
Saimiri sciureus

Theropithecus gelada
Varecia variegata rubra

Zoo

Münster, Rostock
Hodenhagen
Dresden, Halle
Landau
Hodenhagen
Beekse Bergen, Hodenhagen, München
Frankfurt, Gettorf, Köln, Krefeld,
Magdeburg, Stuttgart
Leipzig
Münster
see *Semnopithecus*
Hannover, Hodenhagen
Halle, Hannover, Köln
Gettorf, Osnabrück
Dresden, Frankfurt, Gettorf, Halle,
Magdeburg
Gettorf, Köln, Magdeburg
Rostock
Aschersleben, Braunschweig,
Hannover, Osnabrück, Rostock
Frankfurt, Heidelberg
Aschersleben, Halle, Hannover,
Hodenhagen, Landau
Rheine, Stuttgart
Frankfurt

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