HABITAT DESIGN

Minimum Standards for Housing Asian Lorisines
(Adapted from AZA guidelines for the Family Lorisidae)

Contributed by Lisa Bottcher-Law

When developing spaces for lorises, every consideration should be made to enhance and maximize their use of that space. If space available is of a lesser quality—possibly because it is temporary housing or there are other extenuating circumstances—here are some minimum guidelines.

Temperature: 65½ F (18½ C) min. - 85½ F (30½ C) max.
In warmer climates where outdoor access is possible, heated nest boxes and/or indoor access (which are kept within the above range) should be provided. Providing a temperature gradient is always optimal. It allows a variety of options for this taxa, whose thermoregulatory capabilities are primitive.

Lighting
The lighting requirement is approximately 12 hrs/day. Unless they are outdoors in natural lighting, full spectrum illumination is suggested (a minimum of 75fc is required, (Keeling, 1974)). A dimming feature to simulate dawn/dusk is preferable. Moonlighting should be done with neutral density acetate filters. It has been suggested that a blue filter may be perceived just as white light is to the prosimian eye (Frederick and Fernandes, 1994). It follows, that if neutral density is not available, red light would be a better choice.

Ventilation
In indoor situations with non-recirculated air, 15 changes per hour are recommended (Keeling, 1974). Where possible, keeper/public areas should be ventilated separate to the animal areas.

Humidity
Relative humidity should be maintained between 40% and 60%. Substrate on floor (i.e. leaves and chipped wood) help maintain humidity if cage is misted daily.

Exhibit/Cage Size
This space should allow the loris to be able to meet its need to have solitary foraging and to locomote easily from branch to branch, as they will not leap. Maximizing surface area by providing many pathways of varying sizes (1/2"-4" diameter) and making visual barriers will make the most of any space. At least one nest box should be provided (no smaller than 12"1 x 4"w x6"h). They do like to vary sleep sites, so leafy cover in branches and boxes on the floor can also provide other options. Exhibit dimensions for this group should be no smaller than 2.5x2.5x2.5m. This is the minimum and not the optimum, so when new spaces are being designed more space should be considered.

Social Grouping
In the wild, male home ranges overlap with several females. Optimally, separate cages that individuals can rotate into when they cannot be housed together (e.g. situation where breeding should be avoided) is preferable. Lorises are usually best housed as a breeding pair or mother with

immature offspring. If an individual has to be separated for any length of time (for medical or breeding reasons), visual and olfactory access should be allowed. Lorises have been shown to do well in same sex and extended family groups, but individual situations (aggression) may not allow this. Lorises are solitary by nature, but they are NOT asocial. Maximizing space by housing multiple individuals together allows individuals more stimulation. Shared space is usually larger than individual space, and the animals are able to interact with their cohorts. Social housing also allows zoos to free up much-needed nocturnal prosimian space.

General Habitat Design

The cage design needs to fulfill a variety of animal and keeper needs. Because lorises will not jump from one branch to another, climbing structures need to be close enough to each other to provide a continuous pathway. The animals should be able to reach one branch while situated on another. Vertical trunks and branches with large diameters do not provide adequate climbing structures for lorises (Schulze, 1998). Dangerous falls can result when the animals are unable to maintain their grip on such surfaces. Thus horizontal branches, wire mesh, and lianas provide much more suitable climbing and clinging surfaces.

It is important to also consider keeper access when designing the perching network. When handling is necessary, dense vegetation requires tactics such as baiting or timing captures when the lorises are asleep in their nest boxes. Chasing them in dense vegetation is destructive to the enclosure and very stressful to the lorises.

Plant foliage and nest boxes will provide cover and sleeping sites. Some lorises change sleeping sites frequently, so several nests should be available. A removable nest box that is situated in an easily accessed area is advantageous for handling or capture. The whole box can be removed while the loris is contained inside. The nest box should have a smooth surface so that the animal can easily be removed without obtaining a grip on the box.

The least stressful method of separating lorises is to provide a passage or tunnel between two adjacent cages. An animal can be coaxed through the tunnel into the other cage while a gate is closed behind the loris. The keeper should be able to view both cages and the tunnel simultaneously while operating the gate from the outside.

Horizontal branches are especially important for breeding purposes, because copulation usually takes place in a suspended position from a horizontal branch. Additionally, most behavioral postures are exhibited preferentially on the horizontal branches (Glassman and Wells, 1984). When given a choice, lorises prefer to occupy the higher elevations of the enclosure. They usually flee upwards when threatened by other than conspecifics. Cover at low levels in the cage provides animals with escape from aggressive cage mates and may facilitate avoidance of agonistic encounters.

If the lorises are in public view, it is additionally important to provide adequate cover. The animals should have enough foliage to feel secure and comfortable moving around, without becoming invisible to zoo visitors. Open areas can be provided toward the middle of the enclosure so that the public can look through a foreground of vegetation to open areas with water or food sources. Food bowls should not be situated too close to the ground, since some lorises may be reluctant to

climb to lower levels if they are shy or stressed. It is also a good idea to offer food in several areas of the enclosure to provide an enriched environment *(see Enrichment section).* A shelf above the food dishes will prevent urine and feces from falling into the food from above.

In exhibit areas, a small waterfall or pool of water may be added to make the enclosure more attractive and humidify the air. However, lorises will not voluntarily go into the water, and there may be a drowning risk. A slender loris juvenile in Germany was found dead with its head in a pool created by a waterfall, although the exact cause of death was not determined.

Slender lorises are easily upset during transfers, and this may result in mortality. Environmental enrichment and special attention to housing conditions the first days after transfer can minimize stress. This can be accomplished by covering the cage fronts with blankets, minimizing disturbances, and offering live insects to encourage food intake.

Daschbach, Schein, and Haines (1982/1983) conducted an experiment at West Virginia University to investigate the behavioral effects of cage size on slow lorises. Two male-female pairs were switched between a 0.42 cubic meter and a 8.75 cubic meter cage, and social behaviors did not differ significantly between the two cage sizes. Animals kept in the larger cage locomoted significantly more, and residue accumulation was much heavier in the smaller cage. This resulted in poorer conditions of the lorises' coats, which were tacky to the touch. The lorises in the larger cage were observed to roll in sawdust on the floor. When the animals in the smaller cage were allowed access to sawdust their coat conditions improved. (However, it should be noted that sawdust may cause respiratory problems in lorises.) The study concluded that lorises can be kept together in relatively small cages but a decrease in activity will result. Psychological effects of small cage size are more difficult to determine. An optimum environment provides enough space and enrichment for an active, healthy lifestyle.

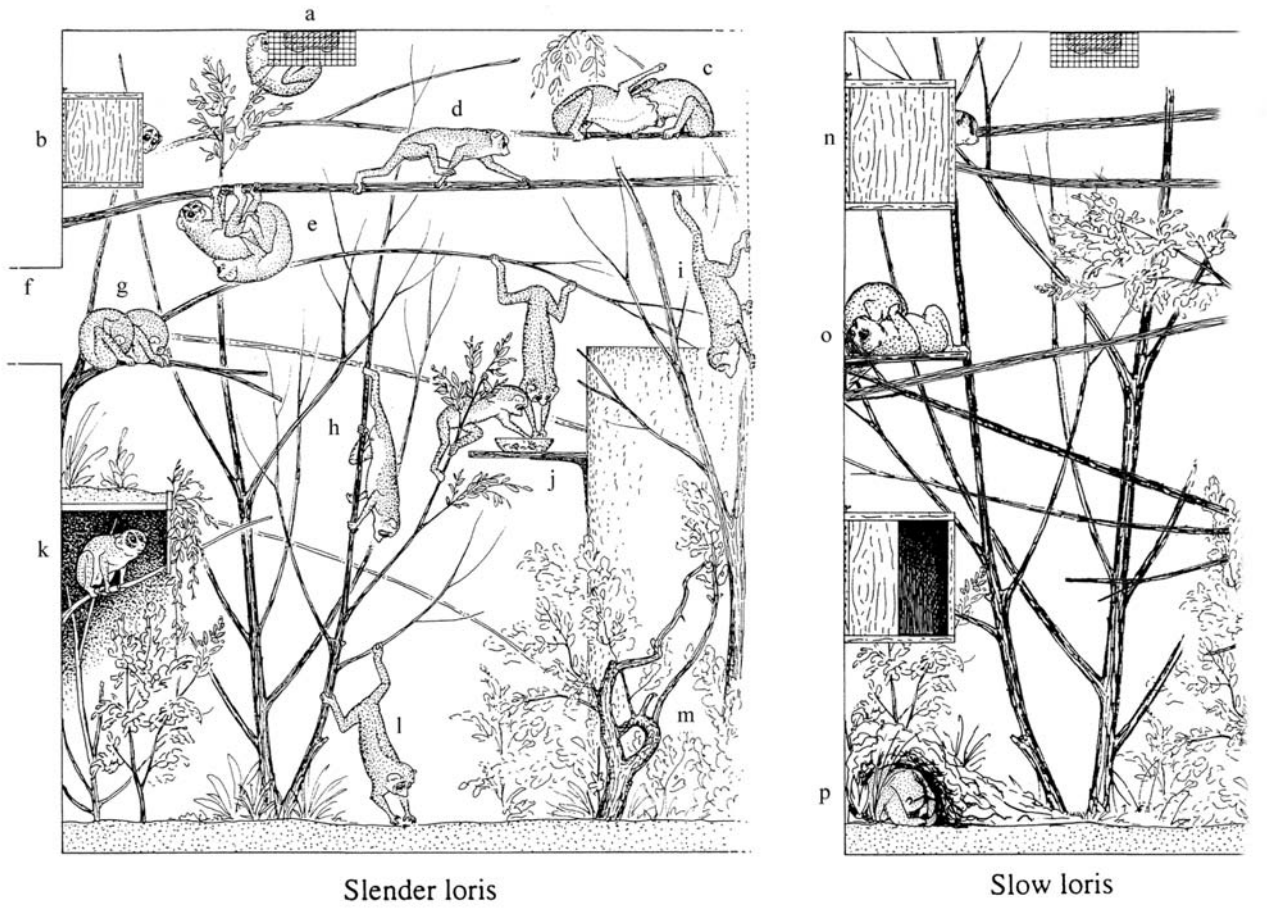

Figure 29: Examples for the use of adequately furnished cages (see page 74). The figure does not show normal population density of the species. (Figure from: Schulze 1998).
Left: *Loris tardigradus*. If lorises are disturbed or frightened, they usually go up as high as possible, for instance clinging to a wiremesh ceiling in hanging posture behind some cover (**a**). Some animals prefer to hide in boxes (**b**) when disturbed, some like to sleep in boxes or hidden between leaves, but often *Loris* sleep in the open. Energy-saving stay on top of horizontal branches is characteristic for most Loridae behavior, particularly for resting and comfort behavior (**c:** allogrooming). **d:** Longer horizontal branches in *Loris* encourage a fast, trot-like locomotion which is seldom seen on irregular substrate. **e:** Substrates in the upper part of the cage allowing hanging postures (thin horizontal branches, wiremesh) are important for sexual behavior. **f:** Passages to neighbouring cages have several advantages: they allow easy separation of animals, cleaning of cages without animals inside, they are frequently used by the animals for having a look at the environment and considerably promote locomotor activity. **g:** For sleeping, places with a lateral support are appreciated. **h:** Vertical substrate is used for climbing up and down. **i:** Wiremesh, both horizontal and vertical, is a valuable substrate for climbing. Wiremesh walls can help to assure continuous locomotor opportunities without "dead end" branches. **j:** Food ought to be offered in an elevated place; for shy animals, some cover close to the feeding places is helpful. **k:** In cases of quarreling, frightened animals go down and try to hide; shelters protecting the refugee against sight from above can diminish social stress. Such hideaways ought to have a second exit allowing escape from aggressive conspecifics. **l:** live insects on the floor promote climbing and hunting. **m:** The use of the lower parts of cages can be improved by undergrowth.
Right: Additional recommendations for *Nycticebus* cages. In both slow loris species, sleeping boxes (**n**), tubes, or other hollow hideaways or dense plant cover around comfortable sleeping branches are apparently more important than in *Loris*. Boxes must be large enough for the group; additional boxes in lower parts of the cage or even on the ground have been readily used by some groups under normal conditions, with no

evidence of social stress (Fitch-Snyder; Schweigert, pers. comm.; Lippe, pers. comm.). If the temperature is very warm, *N. coucang* at the San Diego Zoo like to sleep flat on their backs on a shelf (**o**); in *N. pygmaeus*, lying on the back while sleeping has not been observed (Fitch-Snyder). *N. coucang* in the wild have been found walking on the ground or sleeping hidden under leaves on the ground (Wiens, pers. comm.); in captivity, sleeping on the cage floor, hidden under newspaper, straw, towels, or other available substrate (**p**) also occurs in *N. coucang*. *N. pygmaeus* at the San Diego Zoo prefer sleeping on top of straw and in higher parts of the cage, but in other facilities they also regularly sleep on the floor, in boxes, or hidden under substrates (Fitch-Snyder; Schweigert, pers. comm.). In *N. pygmaeus*, post-sleeping period cases of hypothermia (cold body, abnormal movements and equilibrium problems or animal even lying on the ground, showing little reaction) have occurred. A sufficiently high temperature for all potential sleeping places (including the floor) seems necessary (Schweigert, Lippe, pers. comm.). Left figure: with permission by *International Zoo Yearbook*.

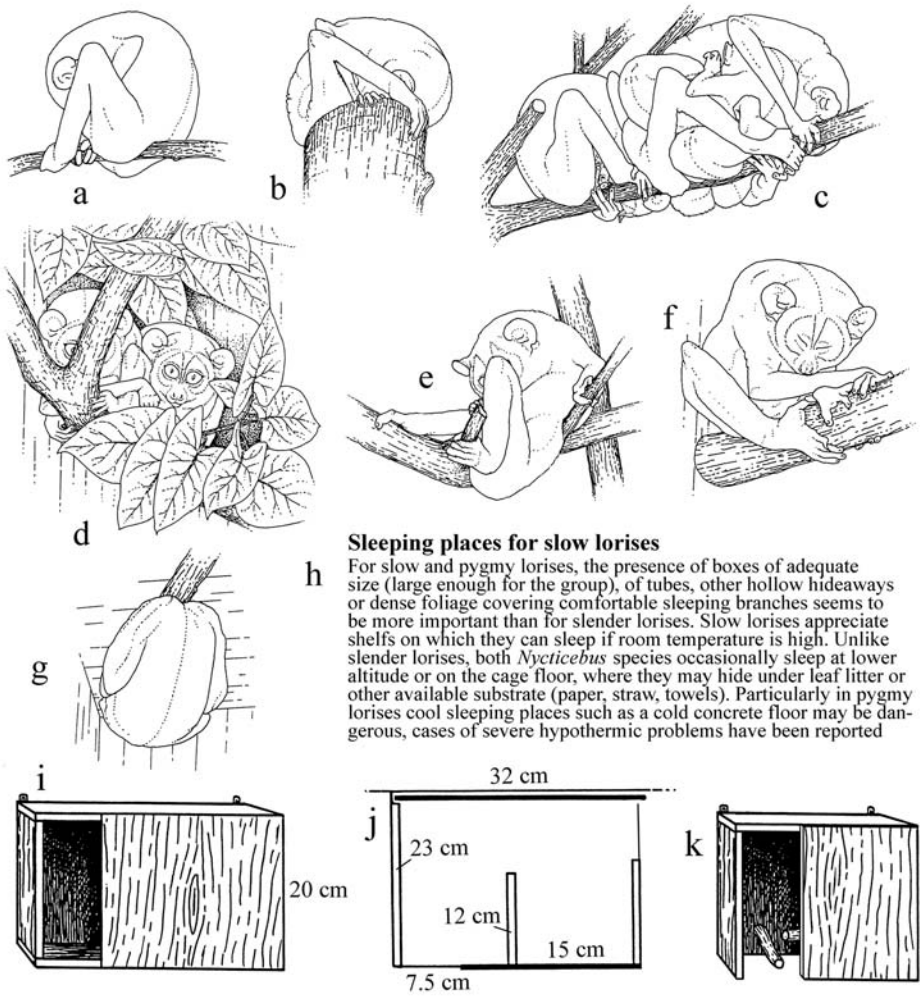

Figure 30: Choice of sleeping places and meaning of different sleeping postures (behavioral examples: *L. t. nordicus*).

Slender lorises usually sleep in the upper parts of their cage, sitting on branches (**a**, **c**) or on horizontal surfaces (**b**; for slow lorises, see also Figure 29 **o**). Sleeping in the open is common in animals that feel safe. Sleeping places providing some cover and lateral support (**d**), however, are appreciated. Cover as shown in (**d**) or sleeping boxes are particularly preferred by shy animals or in periods of environmental distrubance. Sleeping huddled together (**c**) is common. If animals formerly sleeping together suddenly choose distant sleeping places, social stress after quarreling may be a reason. Sleeping on branch forks in the lying posture is sometimes shown by youngsters still used to sleeping cradled on their mother's legs (**e**), as an individual habit or in sick and old animals as a sign of weakness. When ambient temperatures are high, the animals often do not roll up tightly as usual, but in relaxed postures more adequate for emitting heat (**f**). Hanging under the ceiling of the cage during sleeping periods (**g**) is usually a sign of environmental distress; it shows flight tendency upwards where the animal feels safest. The text under (**h**) mentions different needs in the Nycticebus species. Warm sleeping places for *N. pygmaeus* may prevent hypothermic problems in cool rooms. Slender lorises, particularly old and sick animals, may need a warm place for sleeping. (**i**) and (**j**) show a sleeping box as used at Ruhr-University, size adequate for slender lorises, with a second lateral exit added for escape in cases of quarreling. (**j**): interior seen from above, with a small median wall providing additional opportunity to hide; the back wall can be removed for cleaning. The box might be further improved by branches inside as in the second proposed type of sleeping box (**k**); no preference test for different boxes has been made so far at Ruhr-University. Slow lorises would of course need larger boxes, sufficient for several animals.

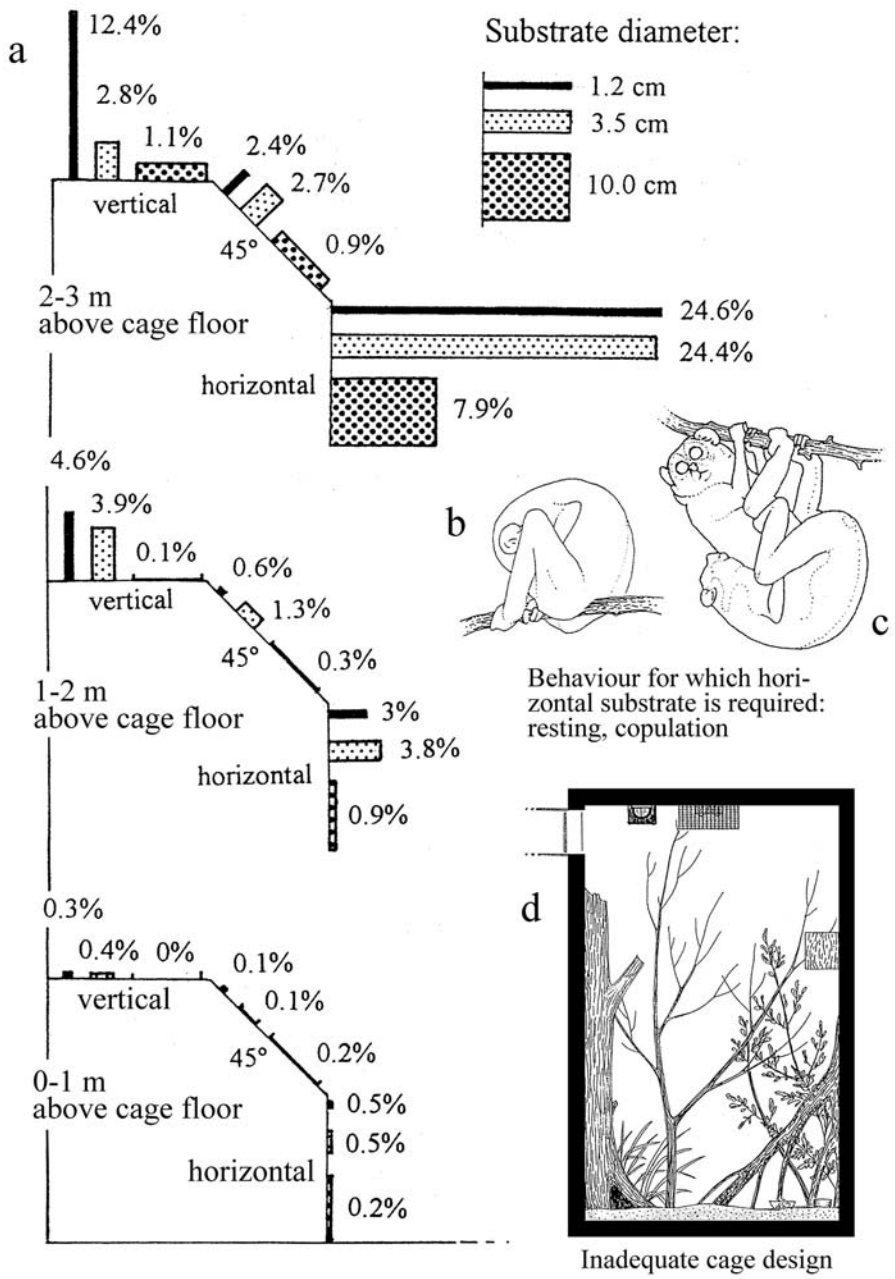

Figure 31: Substrate use during activity period by captive slender loris.

In captive breeding of lorises, substrate qualities play an important role. **a:** substrate utilization in a cage furnished with equal amounts of smooth round timber perches of the following types: diameters 1.2 cm, 3.5 cm and 10 cm, each offered in three altitudes and three inclinations. (Data by G. Hoeschen; 10 animals; n = 5527 observations = 100%). Under normal conditions, animals show a clear preference for the upper part of the cage (under conditions of social stress, inferior animals would tend to stay at lower altitudes). Small diameters allow a safe grip with the rather small hands and are therefore preferred, especially in vertical substrate. Horizontal perches allow energy-saving locomotion and postures (on top of the substrate or in hanging posture). The highly preferred thin horizontal perches in the upper part of the cage are particularly important for resting and copulatory behavior; low breeding success in some zoos might be due to a lack of such substrates.

Temperature Levels

Lorises kept in outside enclosures may require additional heating during cooler months. Slow lorises at San Diego Zoo have heat lamps and large heated nest boxes. Although outdoor temperatures can drop below 5°C (40°F) during the coldest season, slow lorises remain fairly active as long as these heat sources are available.

Slender and pygmy lorises are less tolerant of low temperatures than slow lorises. Lowland slender lorises, with their slender limbs and large ears, are more adapted to high temperatures than to cold exposure. Healthy *L. t. nordicus* withstood a temperature of 16-17½C(60-61½F) for some time. During cold exposure, in *Loris* only a rather small body core is kept warm, whereas large parts of the body are allowed to cool (Müller et al., 1985). Two old *L. t. nordicus* showed equilibrium problems immediately after sleeping in a cooler room. The mountain form *L. t. nycticeboides* with its thick fur is adapted to rain and mist forests where temperatures may fall below 0½C. Loris infants have very thin fur and can easily become hypothermic. Slender lorises suffer less from heat than the other lorises because they can increase heat emission over their slender limbs and large ears. They show reduced activity and energy-saving behavior that, under normal circumstances, would be regarded as signs of weakness or disease. They do not roll up as usual and sometimes sleep laying down. They sleep with their faces visible, often hanging with their limbs down. They apparently emit heat from enlarged veins in the ears and, in males, over-enlarged testes.

Pygmy lorises are more tolerant of cold environments than slender lorises, but they do not adjust as well as slow lorises. For example, in cold weather, pygmy lorises may not venture out of a warm nest box to feed if food items are not within their reach. Conversely, they may sleep in the coldest areas of their enclosure instead of seeking the warmth of their heat lamp or nest box. In pygmy lorises, a hypothermic condition with locomotor problems to unconsciousness has been reported after sleeping in cool places (Schweigert, pers. comm.; Lippe, pers. comm.).

In general, lorises appear to be most comfortable in temperatures around the mid 20s C (mid 70s F) during the day and low 20s C at night (high 60s F).

Lighting Conditions

Animals modify their activity rhythms according to the light and dark phases of the day, and environmental factors modify their "internal clocks." Loris activity usually begins at dusk, which changes seasonally. Dim light cues influencing emergence can be overridden by meteorological and physical factors such as rain, heat, or hunger (Kavanau and Peters, 1976).

A study of slow lorises under an experimentally varied light regime showed that their locomotor activity became synchronized to the period of darkness. When the conditions were continuously dark, an endogenous cycle of less than 24 hours emerged. The slow lorises drifted out of phase with the outside world. Animals housed together synchronized their schedules (Redman, 1979).

Kavanau and Peters (1979) found that arboreal, nocturnal primates are not well adapted for activity in complete darkness. Illuminance preference was assessed by allowing subjects to control the ambient light level and by assessing activities in imposed light conditions. Slow lorises were found

to be adapted for a relatively broad range of night illuminance (0.007 to 0.19 lux). They appear to prefer a mid-dim range of 0.07 to 0.19 lux. Complete darkness and very bright light could severely inhibit activity. Another study suggested that the activity level is a function of illumination. Moonlight illumination resulted in low activity behaviors while twilight intensities resulted in high activity behaviors (Trent, et al., 1977).

In captivity, reversed light cycles are often used, especially when the animals are exhibited to the public. The reversion is also preferred when caretakers work regular hours because it is difficult to observe the animals' condition and recognize unusual behavior as they sleep. Night lighting is simulated with dim red lights while bright white lights are used for the simulated day. Incandescent lights with acetate filters are a natural-looking alternative.

Frederick and Fernandes (1994) studied a nocturnal exhibit at the Franklin Park Zoo that housed *Perodicticus*. The potto is the African "equivalent" of the slow loris. The animals were inactive and usually out of sight of the viewing public. After the lighting scheme was modified, the result was a dramatic increase of the activity level and exhibit use.

The lighting directly outside the exhibit was reduced, which decreased glare and level of contrast between the light inside and outside the exhibit. The "day" lighting was increased, which caused activity to be displaced to "night." The "night" lighting was changed from blue fluorescent lights to track lights with white incandescent bulbs. The bulbs were covered by a .6 neutral density acetate filter that removes 75% of the light. By covering the light source with an acetate filter, the visible portion of the spectrum was filtered evenly and the ultra-violet light was significantly reduced.

Cleaning Cages

Frequent cage cleaning is not usually recommended. Lorises (especially the slender lorises) can become stressed by cleaning procedures. Keeping the animals in two cages that allow separation may minimize the stress. The animals can be moved to one cage while the other is being cleaned.

Loris feces are small, dry, and do not require prompt removal because they do not have a strong scent. Washed off urine will promptly be replaced because it serves as territory marker. However, too much urine build-up can irritate skin, and branches should be replaced or washed every few weeks. Some zoos clean the cages relatively often and their lorises have become habituated to the procedure. Slender loris cages stay cleaner longer than slow and pygmy loris cages because the build up of body secretions occurs at a faster rate among the larger species (Weisenseel, 1986).

When using leaf litter (refer to Environmental Enrichment section) it should be loosened or "fluffed" to provide a fresh area for the loris to traverse. This should be on a daily basis. The leaves and branches above should be misted with a hose to rinse away food residue, dilute scent-marking trails, and increase humidity in the enclosure. A super-fine misting system that intermittently sprays tepid water from above can be used to recreate the rain forest experience. A mist fine enough to dissipate before reaching the floor is best. The floor substrate should be allowed to dry out on a daily basis; if kept wet, the fallen food/feces can become moldy overnight. Earwigs and earthworms may exist in the leaf litter but seem to cause no problems; earwigs will consume feces and fallen food items. Intermittently, the substrate should be completely removed and the enclosure disinfected. The timing

of this is dependent on the size of the enclosure and the number of animals. At Woodland Park Zoo, this is done every three to four weeks. Between cleanings, fresh mulch is added to give the lorises new olfactory stimulation.

Washable enclosures should be cleaned with water and a disinfectant. Hot water should be used cautiously because it aerosolizes microorganisms. It is important to rinse well because detergent residues can otherwise cause skin lesions. The branches and vines should be replaced as they are chewed by the lorises. Floors that are not covered with bedding should be hosed off daily.

Food dishes should be removable and mounted on washable surfaces. Surrounding branches may become caked with formula and sticky food residues. A solid wire mesh hanging over the food can instead give access to the food. The wire mesh should be constructed so it can effortlessly be removed for cleaning. Another solution is to provide smaller twigs that can easily be replaced.

An Enriched Environment
Contributed by Lisa Bottcher-Law

Environmental enrichment for lorises, as for any captive species, consists of providing conditions that are as similar as possible to their natural habitat. Exhibit design and enrichment are paramount in providing a loris with a stimulating environment that results in an active lifestyle.

Lorises are found in dense tropical forests that are characterized by high humidity and fairly stable temperatures. These conditions allow for a high diversity of densely growing vegetation. For this reason, lorises feel most comfortable with lots of cover. A variety of branch widths (1”-4” diameter) both vertically and horizontally placed is best for the basic framework. Branches should be placed so as to maximize the use of the whole exhibit. No zoo exhibit comes close to the size of their natural home ranges, so it is important to make the most of the space that is available.

Branches

At Woodland Park Zoo, plastic cable ties are threaded through pre-drilled holes at the ends of branches for easy installation. Lorises will use a variety of widths of horizontally placed branches, but the limited enclosure dimensions allotted for most lorises will preclude use of anything larger than 3”-4” diameter. Once the larger branches have been installed, interconnecting all the major areas of the enclosure, smaller branches with lots of leaves can be placed vertically. These smaller branches can be attached to the horizontal branches, again with the use of plastic cable ties. (See Table 29 for list of plants.) Any type of leafy branch that is non-toxic will do, but some with good leaf retention (when dry) include birch, bamboo, and camellia. As always, if the climate is warm enough to keep them outside, using live plants that can be rotated when they become “worn” is best. Few locales meet these climate requirements, and most zoos will be dealing with indoor nocturnal enclosures. One big advantage of this is that dried leaves look good under artificial moonlight.

Attaching branches so that there is some movement is always more naturalistic than runs of rigid ones. This allows the loris to become more adept at negotiating its surroundings. Hanging smaller width branches (1”-2”) vertically, with only one attachment at the top and an open space around to allow rotation, makes for an interesting pathway for these prosimians. Lorises may be insecure about

climbing on branches that swing freely, so it may be necessary to bait the branches with food to encourage exploration. Once they became familiar with the swinging branches, the lorises at Woodland Park Zoo used them exclusively.

The use of leafy vegetation provides the loris with visual barriers to the public. Visual barriers (any item natural or unnatural that blocks a view) can also provide the animal with more interest and the sense that their enclosure is larger than it appears. Without the ability to see from one end of its enclosure to the other, the loris is encouraged to explore its environment. Surreptitiously hiding items all around the enclosure will increase the loris' foraging/exploration time. They will check areas that have previously had food even if no food has been present for some time.

Floor substrate

Lorises are arboreal primates but are known to come to the ground and even to sleep in leaf litter. With the small home range that lorises are allocated in captivity, optimal use of floor space can increase useable surface area. A natural way to achieve this is to cover the floor with a bottom layer of chipped wood. At Woodland Park Zoo, Horticultural staff supplies trees/shrubs that have been through the chipper. Some tree services will drop off their mulch for free, but it is important to be sure that no pesticides or toxic plants have been used. With a good 2" layer of wood mulch on the bottom, a layer of leaf litter (1-2") on top can be added using fallen deciduous leaves. Even leaves, such as oak, that are toxic when green lose this toxicity once they have fallen. Leaves can be collected year round. Even if collected when wet, they can be stored in plastic bags for many weeks, as long as the bags are left wide open to air out. The natural decomposition that takes place in this natural floor strata does an amazing job of cutting down the loris odor. Fresh mulch/leaf litter can be added to give them new olfactory stimulation. Lorises will scent mark all over the fresh leaves.

Hide areas

In addition to the conventional nest boxes that are hung in the upper portions of the enclosure, lorises will choose boxes provided on the floor. Thick, four-inch diameter cardboard tubes can also be used. Boxes as large as an inverted apple box can provide a good hide area. Cylindrical oatmeal containers make for great entry portals. Cutting flaps into various areas in the box easily provide various entries/exits. This is important to allow an animal an easy exit if being pursued by another, most commonly in a mating situation.

Boxes are usually only acceptable when a naturalistic look is not as important, such as in holding areas. However, even a plain brown cardboard box, carefully concealed with mulch, tall grass, or leaves, can disappear into the surroundings. The same can be done with larger (6") PVC tubes that are painted a natural color. By using floor space to create new spaces (rooms), the usable surface area is increased, giving extra sleeping sites and a place to hide food items. Lorises appear to spend more time on the ground if there are:

* Several perching pathways that lead to the ground.
* Substrate on the floor (encourages them to scent mark and hunt for food).
* Grass clumps, boxes, tubes, any structure to allow hiding places as they travel on the floor.

By providing lorises with a varied dense and leafy enclosure, many behavioral needs can be met. Besides having a variety of pathways to locomote through, the visual barriers created by dense foliage or other structural barriers give the appearance of a larger space. The novelty of discovering food items found on a branch in a unseen area has many benefits. As David Shepherdson, Ph.D pointed out in his seminar at Woodland Park Zoo (January 1993), " The ability to provide an animal with the control over his environment is very important for captive species." Lorises are provided a level of this control by being able to hide deep in the leafy branches when threatened, and being able to explore new, unseen areas in their environment. Ideally, lorises would be foraging independently and intermittently cross paths with other lorises where ranges overlap. This natural model is not possible to duplicate when individuals must share the same small space. But with the presence of visual barriers, several sleeping areas, food distributed throughout the branches, and leaf litter, captive lorises can have a semblance of their natural routine to potentially allow them to retain their unique adaptations through generations of captive life.

Environmental Enrichment: A Holistic View

Environmental enrichment is a term that has become very popular in the zoo world in the past few years. It is a very necessary progression in the welfare of captive species, but it suggests, through the word enrichment, that we are providing an abundance or at least an ample amount of stimulation relative to the wild situation. Captive life, in the best of circumstances, only scrapes the surface at providing even the basic number of variables necessary to keep a species phenotypically correct over an individual's lifetime or any number of generations. Some of these variables include climatic adaptability, foraging technique, competition, predation, and mate selection. The importance of these interactions has become abundantly clear as more field information is gained about species in their natural ecosystems, and as the interrelatedness and interdependence of multiple organism is better understood. The challenge for zoos, therefore, is to gain as much natural history information as possible on a species held in captivity and then try to mimic that scenario as closely as possible. In general, the goals for enrichment should be to provide as many variables as possible so that species/ individuals can develop and maintain natural behavioral repertoires. In return, the needs of the zoo can be more easily met. Increased natural activity will serve to entertain and educate the public, while increased reproduction will be more likely. Therefore, environmental enrichment goes far beyond providing toys for animals to play with in an enclosure. A holistic viewpoint should be taken, one that includes factors such as naturalized exhibit design, social structure, climatic variability, and foraging strategy.

The Natural Model

Conditions in the native habitat provide the basic model upon which species-specific enrichment should be based. Enrichment should be an integral part of lorisine husbandry - not an "if time allows" situation. In fact enrichment should be looked upon as improved husbandry. It can be done with some ingenuity and not much extra effort. The benefits to the animals and the viewing public will be readily apparent.

Lorisines have special requirements that are most easily discovered by looking to life history; although due to the difficult nature of field study (dense forest, nocturnal activity, government, and access to *in situ* sites), information is presently sparse. As field methodology improves and findings

become available, that knowledge can be applied to captive loris environs. The more closely we can mimic the natural situation, the more likely we are to be able to retain the specific characteristics unique to each lorisine species. For example, there are specific reasons why *N. coucang* and *N. pygmaeus* are able to occupy the same geographic locations. Knowing in detail the different niche requirements for each species and trying to mimic those in captivity can only benefit the goal of maintaining diversity in a captive group.

Keeping a log

Enrichment must be dynamic in order to try to mimic the barrage of stimuli the wild loris would encounter on a daily basis. For this reason, enrichment must occur at many different levels, such as, physical environment, social environment, food, and sensory (Shepherdson, 1993). Variety is the basis for captive enrichment, and maintaining a log can simplify the process (see Table 28). The simpler the log is to use, the more likely it is that keepers will keep it up to date. Over time, it is important to have good records in order to remember all the enrichment items that have been tried, which animals were involved, and, in brief, their responses. If the behaviors surrounding an enrichment are more involved, detailed information can be written on the animal's individual record. An enrichment log should be your quick reference catalog of activities.

Table 28: Enrichment Log

Species	Animal	Date	Activity	Reaction Summary
N. pygmaeus	930331	35034	goldfish in water	grabbed at fish, picked romaine leaves looking for them; bit them but would not eat
N. coucang	890716	35036	willow treat log	Licked gum acacia, did not chew wood (due to gingivitis?)

By promoting natural activities with stimulating additions to the loris habitat, the conservation of these animals is improved. Reproduction, parent-rearing, normal social interactions, and speciesspecific behaviors are all enhanced by enrichment. These improvements are partly due to the increased physical well-being of individuals. More exercise and stimulation lead to proper physical and mental development.

Stimulating all the senses

There are many ways to simulate the "wilds" in captivity. As mentioned in the Housing chapter, climbing structures, visual barriers, substrate, and appropriate humidity are the basic framework. Auditory stimulation through the use of native nocturnal sounds adds another layer to filling in the complete environmental picture. A repeating CD or tape provides constant stimulation, which can help to submerge the public in the naturalistic experience and may drown out some of the unnatural human vocalizations for the lorises.

Olfaction is very important to this intermittently solitary species. Every loris begins its evening with a round of scent-marking, slowly dragging its hind end on the appropriate pathways. Several things can be done to encourage this important territorial behavior. Misting the cage allows some of the

previous night's scent-marking to be slightly diluted as it may be in the wild during rain showers. Maintaining naturally high levels of humidity also helps to carry the important scents to the nose (Agosta, 1992). Additionally, enclosures should be reperched every 4-6 months. This gives the loris a whole new environment to make its own. In between reperching, the addition of fresh floor substrate (see Housing chapter), individual tree/shrub branches, and grass clumps intermittently will encourage scent-marking.

Socially, lorises are thought to maintain individual home ranges, with males' ranges overlapping the females' on the periphery (Fitch-Snyder, 1995). As with most solitary animals this makes scentmarking the cornerstone of communication. In order to mimic this situation in captivity, it would be ideal to have several enclosures that have access (i.e. through transfer doors) to one common area. In order to prevent unwanted copulations or fighting, individuals could have access to these common areas singly or with cagemates. For periods of time, they could be allowed access alternating with other individuals in adjoining cages. These enclosures would allow a natural level of communication between a captive population of individuals that, without this set-up, would most likely not "interact." This alone could provide hours of activity. If this is not possible, scent-markings of other species that would occur in that region or any animal scents including lanolin, African civet musk, or coendu porcupine rubbings, just to name a few, would be stimulating. This can mimic other species passing through their territory. Feces of other species put on the substrate could definitely peak a loris' interest, especially if it could be a potential predator. The introduction of feces and scent marks has potential disease risks, so the zoo veterinarian should first approve these items. General scents of herbs and spices can also add interest. Some favored ones have been fennel, catnip, and freshly picked mint stalks.

The bulk of loris activity periods in the wild are allocated to the procurement of food. Unfortunately, the limit of enclosure size in captivity greatly reduces the time spent on this activity. One of the most basic and straightforward strategies for enrichment is to come up with as many ways as possible to make lorises "work for their supper." Presentation of food items tests the creativity of any keeper. Lorises collect most of their food as they move in and amongst the branches. Placing food items on branches, stabbing them on twigs, smearing softer food items on vertical surfaces, and stuffing food into pre-drilled holes in perching can greatly increase foraging time. This also gets the loris to use all areas of its enclosure in the pursuit of food. In this scenario, the smaller the portions of the diet, and the more places it is hidden, the more time it takes to find it. An alternative to this that can be done intermittently, is to provide a large chunk of fruit or vegetable either stabbed onto perching or suspended using a screw with a paperclip to attach to mesh or perching. This has a great side benefit for lorises that are prone to gingivitis, as they are unable to pop the whole item into their mouths and are forced to rub their gums along the surface of a firm food item. (Apple and yam are great for those dentally challenged that no longer have the ability to bore into wood). Note: of course with any large amount of food presented, adjustments must be made to their diet accordingly.

Other forms of food presentation include scattering items on the leaf litter substrate and hiding food in boxes or sacks. Lorises have tight-gripping prehensile hands with pseudo-opposable thumbs, but dexterity is not their forte. For this reason, hiding food inside of objects has to be much more straightforward than it would be for a simian. Paper sacks filled with hay provide a novel space that they have to pick through in order to find insects or other food items. This same paper sack with live crickets inside, with the top folded over, offers great auditory stimulation. Lorises will circle the bag

for quite some time; after a while a small hole can be added at one end that allows crickets to slowly exit and gives the loris a place to possibly work the bag open. There appears to be quite a bit of individual variation in their ability to do this. One loris was intrigued that something was there, but he walked away after some time. Another loris immediately began to rip up a bag or box with her mouth, using her tight gripping hands to brace the box/bag. She began doing this after only a few introductions to the set-up. It has been suggested that an enriched environment may increase an animal's general ability to learn (Rosenzweig et. al., 1972). It may be possible that even if an animal is doing a task that is not identical to one that it would perform in the wild, the fact that it is doing a task and learning allows it to maintain a greater capacity for learning.

Vegetation for stimulation

Plants are an excellent enrichment item. Edible browse provides a loris with bark to strip or bore holes into, leaves to eat or give cover, fruits, buds, and flowers to sniff and eat, or a new climbing structure to scent-mark, and all this can be provided with the addition of one branch (see Table 29, Browse list). The offerings will of course vary seasonally and regionally, but variety is best. Grass clumps are another easy addition; adding one with dirt intact around the roots brings in invertebrates to be consumed or just observed. Lorises will drag their bottoms across it to scent-mark. Mealworms or other insects can be put on top of the grass and will move down into the grass for cover, making it more difficult for the loris to retrieve them. This is another item that is easily changed and provides fresh scents.

Conclusion

The benefits of enrichment are many. The most important and beneficial reason for maintaining animals in captivity is to educate the public. An enriched animal with a natural set of activities will highlight that species' intrinsic value, and its role in the larger ecosystem. Instilling people with the intrinsic value of each species teaches respect for animals and their role in the world. By stimulating lorises through enrichment, their activity level increases, which piques the public interest in these slow-moving primates.

Realistically, zoos will never be able to recreate all the variables of a complex, dynamic ecosystem and the selective pressures so important to species adaptability and eventual radiation throughout a region. The goal then should be to incorporate as many variables as possible in the captive habitats and apply new information as it becomes available. Most importantly, our knowledge of how ecosystems maintain species vigor compared to zoos should be kept in the foremost of all our minds. Finally, zoos can be an important educational means to an end. However, the conservation of species lies only in the preservation of habitat and most importantly, complete ecosystems.

Following are instructions for specific enrichment programs used at Woodland Park Zoo.

PVC Insect feeder

- PVC tube (any small diameter; a three inch one works well)
- caps to fit each end of tube
- drill with 3/8" drill bit
- insects

Drill holes all around the tube. 3/8" seems to be a good size; adult crickets can exit but not quickly.

This feeder dispenses the insects slowly and randomly, whether the loris moves this tube or the insects come out on their own. Most lorises will watch and/or listen for insect movement and capture once they exit.

Go Fish
- shallow pan (e.g., 9"X13" baking pan. Pyrex is good; it allows lorises to watch from the side)
- goldfish (1-2/loris) monitor the amount; some lorises will readily consume; others don't seem to like the taste but will capture and kill.
- lettuce

Place water and goldfish first. Once the loris comprehends fishing, small pieces of romaine can be added for the fish to hide under, thereby increasing the challenge for the loris. This setup can be placed on the floor of the enclosure. Insects can be substituted for goldfish (e.g., giant mealworms and crickets).

Table 29: Browse list.

Plants	Flowers	Fruits	Exhibit plants
Acer (maple)* *Alnus* (alder)* Bamboo (Poadeae) *Betula* (birch)* *Buddleia* (butterfly bush) *Camelia* *Cornus* (dogwood) *Corylus* (hazelnut) *Cotoneaster* *Cratageus* (hawthorne)# *Eleagnus*# *Escallonia* *Fagus* (beech) *Ficus* *Foeniculum vulgare* (fennel) *Hibiscus* *Loricera* (honeysuckle) *Mentha* (mint) *Nepeta* (catnip) *Philadelphus coronarious* *Populus* (poplar)** *Rubus* (berries)# *Gaultheria shallon* (salal) *Salix* (willow) *Spirea* *Ulnus* (elm)* *Viburnum* *Vitis* (grapes)	*Hibiscus* (summer) *Rosa rugosa* (summer) *Viburnum* (specifically high bush cranberry, late spring) *Camelia* (spring) *Loricera* (spring/summer) *Philadelphus coronarious* (summer)	*Rubus* (wild berries, late summer) Rosa rugosa (hips, late summer) Vitis (summer) Viburnum (specifically high bush cranberry, late summer / fall)	Good leaf retention: *Bamboo* *Betula* *Camelia* *Eleagnu*s

** most favored * favored # thorns could cause slight injury, use cautiously

Hanging Pine Cones
- pine cones (preferably wide open ones)
- syringe
- gum arabic or honey
- nylon string (approximately 12" hang per pine cone)
- paper clip

Wind the string around the cone several times, and attach the string to a paper clip for easy attachment in the enclosure. Thick gum arabic, honey or honeycomb can be injected deep into the cone. Make the honey hard to reach. Cones can also be used as hiding places for bits of regular diet.

Treat Log
- log (2"-3" diameter, approx. 12" long, soft woods, such as willow and poplar, are best)
- drill with 3/8" drill bit
- plastic tie (use dark colored ties in exhibits)
- food item of choice

Cut a section of wood. Drill a hole at one end, so that a plastic tie can be threaded through it to attach to existing perching. Drill holes randomly all around the log; do not drill all the way through. Retain food items and leave spaces for the loris to bore into the wood. This encourages a natural woodboring behavior that supposedly is a way to obtain carbohydrates and mark their territory. A variety of food items can be injected/stuffed into the holes; e.g., honey, gum acacia, and bananas. Most lorises will chew into the wood well beyond the original hole's diameter. Any type of edible wood can be used.

Table 30: Specialty foods - Items beyond the scope of most regular diets. Given randomly throughout the year (fruits as they come into season).

Vegetables	**Fruits**	**Live Food**	**Misc. Foods**
Squash, pumpkin (cooked or raw) Asparagus Water chestnuts Beets Green pepper Jicama* Corn on the cob Zucchini Cucumber Green beans* Celery Snow and snap peas **Herbs:** Fennel stalks Chives Catnip Oregano Mint Dill Basil Tarragon	*Kiwi* Pineapple* Coconut (whole or pieces)* Mango* (offer the pit so loris will work to get off remaining fruit) Pears Cherries Durian fruit* (SE Asia, wild-caughts love, some captive-born refuse) Papaya All berries (let lorises pick off branch if possible) Dried fruits (use sparingly, esp. with animals that have existing tooth problems)	Feeder goldfish Crickets* (various life stages, 2-week olds are good for lorises in need of calorie reduction) Waxworms* Mealworms* (larvae, pupae, and beetle) Grasshoppers	Gum arabic Chew-eez rawhide (esp. with barbeque flavoring, some *will* chew and get gum work) Honeycomb Sugarcane

* Favored in the Woodland Park population

Bamboo, the handheld treat log
- bamboo (1" diameter and 8"-12" sections)
- stuffable food item

Cut bamboo into sections (using loppers works well). Make it long enough that the loris can't easily pry out the food item from the ends. Ideally, the loris will be encouraged to try to bore through the bamboo to get to the hollow center for the food. Using choice foods (e.g., dried fruits) is sometimes necessary to keep them motivated to do this hard task. The shorter length will allow lorises to carry the bamboo log.

Snake Shed/Rubber Snake
- snake shed (must be gassed with anprolene to kill salmonella and other bacteria)
- rubber snake
- exhibit with lots of places to hide

The snake skin can be frightening to lorises; ensure the skin does not remain too long in the exhibit, particularly if the animal is overly frightened. Having appropriate covered areas to retreat into is very important to allow the loris some control over this introduced predator. The rubber snake could be wrapped around a branch or placed on the floor. The same can be done with the shed. Response to this varies.

Hammock
- cloth (old mealworm bag or burlap)
- four plastic ties
- hay or leaves
- insects or other food items

Make four holes slightly inset, one at each corner. Thread the plastic ties through these holes. Suspend it within the enclosure to make a quasi-hammock. Initially, the hammock was to have been a possible sleep site, but lorises appear to like sleeping on non-moving surfaces only. The hammock works well as an area in the branches in which to hide food and insects. Moss (*Sphagnum*-type) also works well as an insect hiding spot when placed randomly in the forks of branches.

Bag O'Bugs
- paper lunch sack
- hay or leaves
- live insects (crickets and giant mealworms make the most noise)

Fill bag half-full with chosen substrate, add insects, roll down the top of the bag and place on enclosure floor. If the loris listens but does not attempt to break in, make a small hole in the bag (large enough for insects to randomly crawl through). With repeated exposure to this item, most lorises will get inside.

Mixed Species Housing
Contributed by Barbara Lester

The three main reasons for housing more than one species together are conservation/utilization of space, public education, and animal enrichment. Each of these issues stand alone in their importance, but combined, make a more compelling reason to advance efforts in mixing species. Although this is not a new concept, the documentation of these efforts is new. Knowing which

species were housed together and the processes that were involved is vital information for animal managers. Information concerning the three species of loris housed in polyspecific groups came partly from the Prosimian Regional Collection Plan published in 1994 (Porton, 1994) and by a survey done in December 1996 of 23 U.S. facilities either holding lorises (19 zoos/1 university) or having held them historically (3 zoos).

In 23 North American institutions, the survey found that 43 % had mixed species with one or more loris species. The only polyspecific primates that were housed with lorises were nocturnal prosimians (8 species). The other polyspecifics, (12 species), involved in mixed species exhibits were nocturnal mammals, with two exceptions: tree shrews, a diurnal mammal, were housed with slender lorises. The other exception was the only overtly unsuccessful mixed species situation reported. A Tokay gecko (reptile) was mixed with a loris species and was unfortunately eaten by the loris. All other institutions reported overall success with housing lorises with polyspecifics.

The only problems found were obesity in some of the lorises or the other prosimians. The husbandry issue of how to feed each species independently of the other became problematic in some situations. The lack of control over the food consumption and the type of food required for each species were pointed out as factors to be considered when mixing lorises with polyspecifics. As an example, slow lorises housed with giant fruit bats, Egyptian fruit bats and aardvarks presented a feeding problem in one facility. The soft produce fed to the bats was eaten by the lorises and more feeding stations were needed for the bats where the lorises could not avail themselves of the food. In addition, a potential dental problem was reported in this situation because of too much soft produce being eaten by the lorises with no way to limit their access in this particular exhibit. Although these as well as many other potential problems are faced when mixing any species, animal managers found these as the only major problems to be considered when planning a mixed species exhibit which includes lorises.

Editor's Note: After the section on Mixed Species Housing was written, we received a report of three slow loris deaths at Cleveland Zoo due to Pasteurella. The lorises apparently contracted this bacteria from a Prevost's squirrel (*Callosciurus prevostii*) that was housed in the same enclosure and showed no signs of illness. Although highly desirable from a management point of view, mixed species housing can also carry potential disease risks that should be considered.

Table 31: Species and the number of individuals that have been successfully kept in same exhibits as pygmy lorises. Regarding number of individuals, the first number refers to males, the second number females, and if a third number is given the gender was unknown. The data is based on survey in December 1996.

Pygmy Loris *Nycticebus pygmaeus*			
Institution	**# of Individuals**	**Other Species**	**Enclosure Size**
Duke University Primate Center	1.1	1.1 Slender Loris 1.0 Bushbaby 1.1 Coquerel's Mouse Lemur	4.5m x 2.7m x 2.7m
	1.1	1.0 Bushbaby 1.1 Coquerel's Mouse Lemur	4.5m x 4.5m x 2.7m
	1.1 NOTE: 0.1 became pregnant, removed for birth, reintroduced with juvenile Reconfigured group 3.1	1.2 Slender Loris (0.1 juvenile) 1.1 Potto 2.0 Bushbaby 1.1 Slender Loris 1.1 Potto 1.1 Bushbaby	4.5m x 2.7m x 2.7m
Brookfield Zoo	1.3 (0.1 juvenile, 0.1 infant) NOTE: Reconfigured group; 0.1 (older juvenile) + 0.1 (juvenile) introduced to group later	0.1 Slender Loris 1.1 Slender Loris (1.0 introduced after the females were together)	1.8m x 1.2m x 2m (Initial introduction done in two cages of this size.)

Table 32: Species and the number of individuals that have been sucessfully kept in same exhibits as slow lorises.

Slow Loris *Nycticebus coucang*			
Institution	**# of Individuals**	**Other Species**	**Enclosure Size**
Duke University Primate Center	0.2	1.0 Aye Aye (slept side-by-side with loris) 1.1 Bushbaby	4.5m x 6m x 2.7m
	0.2	1.0 Aye Aye 1.1 Potto 1.1 Bushbaby	4.5m x 6m x 2.7m
	1.1	1.0 Aye Aye 1.0 Slender Loris 1.2 Bushbaby 0.2 Coquerel's Mouse Lemur	$82m^3$ hexagonal room
	1.1	1.0 Aye Aye 1.1 Slender Loris 0.2 Coquerel's Mouse Lemur 1.1 Potto	4.5m x 6m x 2.7m
	1.1	2.0 Bushbaby 0.2 Coquerel's Mouse Lemur 1.1 Potto 1.1 Lesser Mouse Lemur (removed due to obesity)	4.5m x 6m x 2.7 m
Cincinnati Zoo	1.1 (bred and reared young)	1.2 Malayan Mouse Deer	1.8m x 1.2m x 1.8m
	1.1	0.0.1 Echidna	unknown
	1.1	0.0.1 Aardvark Giant Fruit Bat Colony Egyptian Fruit Bat Colony	3.6m x 3m x 2.4m
	1.1	1.0 Betton	unknown
Bronx Zoo/Wildlife Conservation Park	1.1	1.1 Malayan Mouse Deer	1m x 2m x 1.5m
Audubon Park and Zoo	1.1 geriatric	2.0 Bushbaby	3m x 3m x 2.4m indoors, glass fronted
Minnesota Zoo	l. l	0.1 Asian Crested Porcupine	6m x 4.5m x 6m
	0.1	0.2 Tree Shrews	1.8m x 1.8m x 3.6m glass fronted
Santa Barbara Zoo	1.1	1.0 Sugarglider	2.1m x 2.4m x 1.5m

Table 33: Species and the number of individuals that have been sucessfully kept in same exhibits as slender lorises.

Slender Loris *Loris tardigradus*			
Institution	**# of Individuals**	**Other Species**	**Enclosure Size**
Duke University Primate Center	1.2 (0.1 juvenile)	1.1 Potto 3.1 Pygmy Slow Loris (removed due to obesity and pregnancy) 1.1 Bushbaby 0.3 Fat-Tailed Dwarf Lemur	4.5m x 2.7m x 2.7m indoor enclosure
	1.1	2.0 Tarsier 1.1 Pygmy Slow Loris	4.5m x 2.7m x 2.7m indoor enclosure
	1.1 (removed after one year due to obesity)	1.1 Tarsier	unknown
	1.1	1.0 Bushbaby 1.1 Coquerel's Mouse Lemur 1.1 Pygmy Slow Loris 0.2 Fat-Tailed Dwarf Lemur (removed due to obesity)	4.5m x 2.7m x 2.7m indoor enclosure
	1.1	1.0 Aye Aye 1.1 Pygmy Slow Loris 0.2 Coquerel's Mouse Lemur 1.2 Galago 1.1 Potto	4.5m x 6m x 2.7 indoor enclosure
	1.1	0.2 Fat-Tailed Dwarf Lemur 0.2 Bushbaby 0.2 Coquerel's Mouse Lemur	4.5m x 2.7m x 2.7m indoor enclosure
Cincinnati Zoo	1.1 (bred and reared young)	1.2 Malayan Mouse Deer	1.8m x 1.2m x 1.8m
Philadelphia Zoo	0.1 -	1.3 Tree Shrews	2.7m x 0.76m x 1.6m
	1	1.3 Tree Shrews	same as above
	0.1	Longeared Hedgehogs	same as above
	1	Longeared Hedgehogs	same as above
	1	0.0.1 Greater Hedgehog Tenrec	same as above
	0.1	0.0.1 Greater Hedgehog Tenrec	same as above