Zoo Animal Husbandry and Care of Small Mammals

Donald E. Moore* and Michelle R. Farmerie

(extracted from ZOOKEEPING)

ZOOKEEPING is a book everything about zoo and veterinary, having been written in pieces by some of the best wild animal veterinarians and the best zoo persons in the world. Drs. Mark C. Irwin, John B. Stoner and Aaron M. Cobaugh authored and edited the book. Many, many zoophiles were happy to produce excellent articles about all manner of things a zookeeper need to know. Every issue of ZOOS' PRINT (almost) carries extracts from Chapters and Parts of ZOOKEEPING that may be useful to our readers.

This issue features rest of Part 5, Zoo Animal Husbandry and Care (Small Mammals), including Observational Skills, Zoo Environment Abiotic Environmental Factors, Humidity and temperature, Barriers, gates, and their maintenance, Substrates and their maintenance, Bedding and its maintenance, etc. Next issue will be devoted to Husbandry and care of Hoofstock.

OBSERVATIONAL SKILLS

Small mammal keepers need excellent observational skills to identify individual animals and determine changes in their condition and daily behavior, because these parameters are scaled down to the sizes of the small mammal species under their care. Animals might be identified through passive integrated transponder (PIT) tags, individual characteristics, tattoos, or body part clipping. Even the least visible identification method (PIT tags) requires the keeper to have the time and expertise to get close to the animal with a digital reader.

Condition changes are relatively easy to observe in large animals like deer and antelope, but difficult to observe in small mammals, unless the keeper takes the time to observe each animal as it moves toward food and around in the environment; these observations need to take place at the appropriate time every day. It is difficult, for example, to determine the condition of a sloth or mouse housed in a diurnal environment if that nocturnal animal is asleep in a nest box every time the keeper tries to observe it. So it might be better if occasionally the keeper were scheduled on an evening shift (e.g., during an evening event at the zoo) to observe the animal while it is active.

THE ZOO ENVIRONMENT ABIOTIC ENVIRONMENTAL FACTORS

Light

Effects of light and public activity on the behavior of small mammals need to be considered. In small mammal exhibits in a diurnal house, it may be best practice to have glass that allows full-spectrum light penetration, and for keepers to keep this glass clean. Small mammal exhibits may be reverse- lighted to be dark in the daytime. In "nocturnal small mammal houses" with light- dark cycles reversed from the outdoors, keepers will need to ensure that full-spectrum light bulbs are used and make sure they are cleaned and replaced as necessary.

Shelter

Naturalistic shelters and other environmental necessities must be carefully researched and provided to small mammals in captivity. Most small mammals, diurnal or nocturnal, have evolved to use shelter of some kind during different life stages, seasons of the year, or times of day. Squirrels (sciurids) make tree nests or use branch hollows, carnivores like raccoon relatives (procyonids), members of the mongoose family (viverrids) and weasel family (mustelids) use natural caves or tree hollows, and some rodents and insectivores use tunnel systems. The unifying qualities of all of these refuge areas may be darkness and quiet. While a keeper might turn on a radio to create comforting ambient sound for hooved animals, the unique sensory abilities of small mammals suggests that keepers in these areas should provide quiet surroundings, as well as species-appropriate types and amounts of nest boxes. For example, sloths may need one or two open- faced nest boxes per animal, because in nature they sleep in branch forks high in trees. Tree shrews are known to need at least two nest boxes per reproductive female.

Humidity and temperature

Small mammals are found in hot dry areas, cold, dry areas, and hot humid areas. In winter they can even be active in swampy areas: American star-nosed moles *(Condylura cristata)* can be observed swimming and foraging under ice during winter and early spring in their native wetlands habitat. The point is that provision of supplemental heat or cooling and humidity or low humidity needs to be carefully planned on the basis of the species' natural history, and with consideration of its life stages. Supplemental humidifying or dehumidifying may also be needed for small mammals in captivity. Adult sloths, for instance, may remain in excellent condition in a normal building humidity of 65 per cent, but reproductive females and their infants may need more than 80 per cent humidity for adequate milk production and weight gain (author's pers.obs.).

Barriers, gates, and their maintenance.

Barriers and gates should be constructed of stainless steel or some other non-chewable, impervious material, and can be installed to slide vertically or from side to side. In some cases (e.g., for sloths or

***Smithsonian's National Zoo Smithsonian Conservation Biology Institute Washington, DC 20008, USA**

prehensile-tailed porcupines that move relatively slowly), swing gates should be used. Small mammals will be very active when keepers are not present, and latching mechanisms should be routinely checked for security.

Substrates and their maintenance
Wood shavings, bark chips, sand, and other materials are often used as substrates; cleaning practices vary by species. Keepers need to be observant with meerkats and other species that maintain "latrine" areas in nature, because the amount of urine in the latrine area in captivity may compact sand or other substrate to a significant depth (almost one meter, in the author's experience) while being subject to "cave-in" on top of an exhibit specimen that makes a burrow underneath it. (The senior author's case resulted in an animal surviving for two days buried in a pocket under the compacted sand and being found only when keepers carefully dug up the entire exhibit one shovelful at a time). Some small mammals, mostly from montane or arctic regions where they have not evolved with our temperate parasite and bacterial biota, may need to be kept on stainless steel mesh of appropriate size; this is true for snowshoe hares (*Lepus americanus*) and some other delicate animals that need to be continuously monitored and treated for parasites. Stainless steel mesh is strong enough to be scratched and chewed without damage, and resists rust and corrosion better than other mesh types. Animals like the delicate arctic species can urinate and defecate through the mesh, so that their urine and feces are removed from contact with them; this reduces infestation or re-infestation of the animals by parasites and other harmful biota that might build up or arrive in more organic bedding.

Bedding and its maintenance. Bedding is different from substrate. However, preferred bedding can be made to mimic bedding and substrates that animals prefer in nature. Gerbils and other small rodents from small desert areas, for instance, can be kept on sand, but their burrow bedding may be wood shavings or some other organic compound they can use to make "nests". Generally, small mammals should not be kept on cedar or pine bedding, which can release volatile compounds and cause contact dermatitis, respiratory disease, and even death. However, fir and aspen shavings have been found to be safe for a variety of small mammals. Fir shavings also have good absorbency (a urine consideration) and low dust levels (a respiratory consideration). Oak leaves have been used for giant elephant shrews (Family Macroscelidae) to create nests for their offspring, and seem to be one key to good reproduction of natural habitat for these relatively difficult-to-care-for small mammals from African forest areas (personal observation). Keepers need to watch their animals' hair coat condition closely, because each species and each individual may react differently to different types of bedding. Cleaning practices for bedding must be based on species' natural history needs; some species have evolved to have deep litter in their bedding sites, others have evolved to keep their bedding areas immaculately clean.

Pools, furniture, and other enclosure amenities
All enclosure furniture, pools, and other amenities should be species-appropriate. If the mammal is an otter, platypus, or water-dwelling shrews, its enclosure should have a pool with adequate poolside drying areas for absorbent bedding or substrate, appropriate denning areas that are monitored (or even on public view), and a life support system that keeps the water clean and at the appropriate temperature and pH for the mammal and for the live prey for which it naturally forages.

Note that the term "life support systems" often means aquarium systems, but keepers can use it in a more general way for delicate small mammals. The term can and should be expanded to include all temperature, humidity, lighting, and water quality systems that help to keep delicate small mammals within their minimum and maximum critical values, and therefore physically and behaviorally healthy. Keepers should be adequately trained in the maintenance of these systems, or should at least be able to work with facilities staff to understand when a life support system is challenging environmental quality (e.g., water quality) and beginning to affect an animal's well-being.

Burrowing animals need noncollapsible substrates in which to create burrow systems, or clear species-sized burrows that are built into the exhibit so that visitors can see their fascinating tunneling behavior. They also need solid bottoms on these enclosures; the anecdotes about prairie dogs digging out of their exhibits are legion! A concrete or metal bottom under the diggers' substrate is a good idea.

NUTRITION
It is important to consider natural diet versus captive diets and their supplements, with a focus on small mammal diversity. Calltrichids in captivity seem especially prone to vitamin D deficiencies (calcium deficiency, brittle bones, etc.). Most zoos give them a canned marmoset diet that is very similar to the canned primate diet—with some exceptions. The canned marmoset diet is much higher in vitamin D3 than is the regular primate diet (this can cause a problem in mixed species exhibits, where another animal might be exposed to the marmoset diets; there have been cases of vitamin D toxicity in those other animals that ate from the same pan). Marmosets and tamarins also need to be provided higher amounts of vitamin C than exists in most commercially prepared diets. The companies that manufacture prepared diets for zoo animals generally warn us of known potential nutrition issues like these; we need to understand and heed their warnings.

CONSIDERATIONS FOR FEEDING CAPTIVE DIETS

Keepers need to understand the impact of sociality on food consumption, solo and group feeding, and pest control. Dominant individuals may selectively eat favored foods, or more food, than do their con-specifics. It is important that keepers observe this carefully and manage it if necessary. Small mammals are often messy feeders. They sometimes spill small mammal diet out of dishes and into the substrate where it can become a highly nutritious food for cockroaches, rodents, and other pests. Integrated pest management (IPM) is important to reduce shelter and access to loose food and water for pests in a zoo's small mammal house; keepers should collaborate with pest control professionals to design the best- possible IPM plan for a zoo environment.

Husbandry staff must be concerned about standard diets and "diet drift". Scientifically based diets are created through careful research and trials for acceptance by diverse species. It is important that keepers achieve consistency of presentation so that the animals in their care achieve consistency of consumption. "Drift" away from the standard diet, even though it might be well meant (e.g., the provision of "treats" to an animal during training, or the provision of the animal's favorite foods), should be minimized, and any changes to the diet should be approved by nutritionists, veterinarians, and/ or the area's curator.

FEEDING BEHAVIOUR AND ENRICHMENT FEEDING FOR SMALL MAMMALS

Different species feed in different ways. Ground-dwelling mammals may feed easily out of ground-based bowls or platforms. Tunneling mammals like mole rats may eat and behave normally only in tight burrows. Arboreal mammals like ruffed lemurs (*Varecia sp*.) and sloths may prefer to eat while hanging down in some way. Many herbivorous mammals forage during a large proportion of their daily activity budget in nature, and a keeper may help stimulate long foraging activity in such an animal by hiding its food or placing it in some kind of artificial or naturalistic feeder that requires manipulation by the animal, like a puzzle feeder. Note that these manipulable feeders will need to be placed in accordance with an individual's preferred feeding heights and locations. Some animals are so sensitive to novel objects that keepers will need to take great care in presenting their diet items in food containers known to (and perhaps marked by) them.

WATER PROVISION

Mammals are very diverse, so they may drink in different ways. Though some arid land mammals may not drink much at all, note that water should still be offered to them all the time (*ad lib*). Some small mammals may only lick water off leaves and may not drink out of bowls. One study of arboreal lorises and "enrichment waterers" showed that some arboreal mammals may prefer to drink from elevated drinking bowls and may not drink from bowls on the ground (Chepko-Sade and Miller, pers. comm).

SEASONAL CHANGES IN NUTRITIONAL REQUIREMENTS AND DIETS

Many species from temperate areas, or from ranges where food availability changes seasonally, have evolved metabolic rates that lower during winter or other times of seasonal change. Keepers, curators, and nutritionists may determine that these animals can receive reduced amounts of food at these times. In some cases it is best practice to at least offer minimal dry food to ensure that the animal has the option of eating if it feels hungry (e.g., in the case of a hibernating bear, *Ursus sp*.). It is also best practice to offer water *ad li*b even if it is apparent that the animal is hibernating.

CAPTIVE BEHAVIOURAL MANAGEMENT PRACTICES

SEPARATION VERSUS GROUP HOUSING, AND DOMINANT ANIMAL MANAGEMENT

Keepers may witness social group breakdown within an animal group, and may not always understand the underlying reasons for the social behavior change. The animals may be experiencing a change in dominance hierarchy, or the keepers may be causing a problem by feeding or training a subordinate animal before feeding the group's dominant individual. An animal's motivation to avoid a terrible altercation with a dominant animal is often stronger than its motivation to obtain favored food through training. Keepers may find little or nothing in the scientific literature about social interactions in "nonsocial" or "solitary" species, but keepers' observational skills may reveal that individual animals are being social behavior does not lie! Keepers should carefully observe and report changes in animal behavior, because such changes often suggest an underlying issue. For example, when subordinate animals take food from a dominant animal, hindsight through review of thorough animal records may show that the dominant animal was sick at the time.

TECHNIQUES FOR SHIFTING AND SEPARATING ANIMALS

The easiest way to shift a mammal is to prepare a shift cage that contains a portable nest box already known to the animal, and to use this box as a shift area by regularly securing the animal in it while cleaning and checking its home enclosure. Modern care methods often suggest that animals should be transferred to new enclosures or zoos inside their own nest boxes; this means that some nest boxes should be designed to double as transport boxes. Cotton top tamarin induction boxes have been

designed by staff members of the Pittsburgh zoo (Farmerie, pers. comm.) and other zoos; the animals can then be trained to enter these boxes and remain calm in them. These husbandry training techniques for mammals and other animals with good learning capabilities have led to a major improvement in humane care of captive mammals during routine and non-routine care, and keepers should learn them thoroughly.

MIXED-SPECIES EXHIBITS

Benefits and complicating factors. Mixed- species exhibits of small mammals have benefits for the animals, because there may be social relationships between species and individuals that include olfactory, tactile, auditory, and other behavioral interactions. This is then more engaging and interesting for the staff and visitors, as well as for the animals, than single-species exhibits, because the animals are often more active at all times of day and night than are animals in more traditional exhibits. This kind of management may allow keepers to maintain more conservation-managed species and individuals in a given area. The complications inherent in this kind of management may include agonistic behaviors between species or between individuals. Individual candidates for multi-species enclosures need to be evaluated carefully by keepers who know the different species very well and who can interpret individual behavioral characteristics (e.g., whether the animals are individually aggressive, shy, extroverted, or introverted). At worst, seemingly benign individuals of a given species may be aggressive at night when keepers are not around; or adults of one species (e.g., neotropical rodents) may be aggressive toward infants of another species (e.g., sloths).

Guidelines for intra- and interspecific animal introductions. One-on-one introductions via "howdy" cages within enclosures are important to make after considering which species is least dominant, which species should be introduced into the area first to establish "territory," and which individual might be most likely to be calm and not aggressive with the other. Note that introductions should take as long as the animals' responses dictate, and should not be rushed. It is good practice to communicate about needs and intentions with as many experienced keepers from other institutions as possible, in order to most effectively introduce species and individuals. It is also important to be able to recognize stress in individuals of each species prior to an attempted introduction, and to be observant for these signs during the introduction itself.

REPRODUCTIVE MANAGEMENT

For best possible reproductive management, keepers should be familiar with small mammal behaviors related to reproductive seasonality, breeding, pregnancy, birth, rearing, and the introduction of infants to a group or exhibit. Small mammals, like all mammals, are diverse in their reproductive strategies and may be born naked and helpless (altricial) or fully furred with their eyes open and the ability to move like adults (precocial). Keepers must take these strategies into account, and to minimize stress on the animals they should schedule their neonatal exams only when altricial young are fully bonded with their mother (dam) or when precocial young are calm before being handled. Keepers should take great care to avoid being injured by protective mothers; even the smallest mammalian mother is willing to attack with tooth and claw to protect her off spring, and due to maternal hormonal and behavioral changes she may even attack familiar keepers at this time.

VETERINARY CARE

DISEASES OF IMPORTANCE IN MANAGEMENT

It is known that some diseases (zoonoses) can be transferred between small mammals and humans. Small mammal keepers should consider using rubber gloves and dust/surgical masks as best practice to prevent disease transfer between themselves and their small mammal charges. This is especially true for keepers who are prone to cold sores (viral herpes simplex lesions); this particular human disease can cause death in New World tamarins and marmosets, just as macaque herpes transmitted in fresh body fluids can cause death in human caretakers.

CHALLENGES IN VETERINARY TREATMENT AND HANDLING

Small animals, especially the "delicate" small mammals that have thin legs for leaping and long-distance running, may be prone to long-bone fractures. Inferior handling of domestic rabbits may cause broken backs or other physical problems. The message for keepers is that knowledge of the species' anatomy and potential stressors is always necessary, and that one must always take care to handle each individual appropriately for its species, age class, muscular power, and individual health condition.

PREVENTIVE CARE FOR CLAWS, HOOVES & TEETH

Small mammals with good nutrition in zoos may grow long claws and even long teeth, so any overgrowth should be managed by keepers and veterinary staff . Preventative care is easiest: hard items, such as nontoxic hardwood branches or blocks for chewing, allow the ever-growing teeth of rodents and rabbits to wear down naturally; appropriate substrate and digging areas allow their toenails to wear down naturally. If there is overgrowth of teeth or claws, it can be trimmed by appropriately experienced and careful personnel using professional nail trimmers, or even a small electric filing tool.

ENRICHMENT AND TRAINING
Each institution needs to have a formal enrichment approval process. Small mammal enrichment items should be species-appropriate and naturalistic, and all must be evaluated as safe. There should be no latex rubber for small carnivores, and no cotton rope toys, which may cause gut torsion or blockage in dogs and small cats.

OPERANT CONDITIONING WITH SMALL MAMMALS
Prey animals have a lower fear threshold, and therefore need more time to build trust in keepers. Animals that have not been husbandry-trained and for which keepers do not have accurate individual histories, may be difficult to train due to lack of trust-based relationships. Keepers need to move slowly, deliberately, and quietly in order to build these relationships. When offering treats to a prey mammal, a keeper should have enough of them so that if the animal drops one while taking it, the keepers does not need to bend over and risk looking like a predator to the animal. The keeper should watch where the animal is looking and be aware of its potential next movement; the keeper may be standing at some boundary where the animal may be ready to either target forward or flee backwards. Keepers should also note that many small mammals have cheek pouches in which they may store training treats without swallowing them. Such an animal may suddenly end an operant conditioning session, especially if it is in a social group. Smaller treats or more time between treats may need to become part of the keeper's training plan.

Good Practice Tip:
Care should be taken to assess risk and safely of entertainment items. Raisins used for "preferred enrichment food," for instance, may get caught in mammal molars and cause tooth decay. Size of vines, ropes, and other habitat enrichment items may cause entanglement of hands, hooves, toes, or toenails. This caveat is meant not to discourage enrichment, but to encourage keepers to use their institutional risk management assessment through the enrichment approval process to create the best possible conditions for their animals.

CRATE AND INDUCTION BOX TRAINING
Mammals are different from other wild animals due to their level of intelligence. While other animals often are driven by innate behavior, the duration of maternal care and sociality in many mammals creates a solid basis for learning as a behavioural adaptation. Even the brief duration of mother-offspring relations in asocial mammals is enough to result in learning. Consequently, training and learning should not be ruled out for most mammals, including those normally considered "flighty". Mara and cotton- topped tamarins are recent, well- known examples of animals that have been trained to calmly enter transport or induction boxes.

PROGRAM ANIMALS
Small mammals are a particularly popular group of mammals frequently and appropriately used as "program animals." Program animals deserve enclosure conditions as good as those of similar animals kept in "traditional" zoo exhibits, and it is appropriate that keepers caring for them should have extra training in nature interpretation, safe handling of animals, and public speaking.

SUMMARY
Small mammals are challenging to work with. Many are rare in the wild due to threats to their diverse environments, and many are rare in zoos and aquariums because they are difficult to care for appropriately. Keepers who choose to work with these animals will have rewarding experiences, but will need to constantly be attentive to safety, and to all the diverse factors that affect the animals' physical and behavioral health. These factors include the challenge of keeping animals from deserts, dry forests, tropical rain forests, wetlands and other areas, often in the same "small mammal house." They also include the provision of nutritious and palatable diets for animals whose diet has not yet been thoroughly evaluated in nature. But the reward of keeping these animals physically and mentally healthy, in breeding condition, and in species survival programs for their benefit and for that of future human generations is huge and incredibly satisfying.

Case Study 26.1. Small Mammals at Smithsonian's National Zoo

Despite the nocturnal nature of most small mammals, National Zoo's Small Mammal House is operated on a "local" (not reversed) light cycle because of the presence of numerous diurnal small mammals in the collection.

In consideration of the known Vitamin D needs of diurnal tamarins (Callitrichids) and an iguana (mixed with diurnal agoutis, nocturnal sloths [*Choloepus sp*.], and other animals) in the exhibits, staff members requested the installation of roof window glass that would allow the "fullest" spectrum of light into the animal enclosures.

Other diurnal small mammals in the house included a variety of diurnal rodents from around the world, as well as meerkats and other small carnivores. The rationale for the request for UV-transmissible glass

roofing was from the Callitrichid Husbandry Manual (AZA 1999): "In captivity, callitrichids should be provided with 12 to 14 hours of daylight. The distribution of callitrichids in the neotropics where little variation in day length occurs has led several authors to recommend a 12 light /12 dark photo-period (Snowdon *et al*. 1985; Stevenson 1975; Savage 1995; DuMond 1972). Beck *et al.* (1982) preferred a photoperiod of 14 light / 10 dark for Callimico; at least five hours of light were provided after the afternoon feed. Rettberg- Beck (1990) recommends 12 to 14 hours of daylight for *Leontopithecus rosalia*, as well as 30 to 60 minutes of exposure to ultraviolet light to provide Vitamin D3."

Some curators have noticed dramatic changes in the coat color of golden lion tamarins (*Leontopithecus rosalia*) when they are exposed to direct outside light v/s fuller-spectrum interior light versus filtered light.

The mechanics behind the change is not entirely understood; the most plausible explanation is that some part of the UV spectrum is affecting the melanin in the tamarins' skin, creating a much deeper and richer golden color in those receiving a fuller spectrum of light.

The question is: "What do we not know about the positive effect of this lighting on other diurnal small mammals, or even on nocturnal animals that sleep exposed to these light rays?"

We have long known that it is part of the B-range of UV light that is most important for reptiles, but there are still debates among reptile professionals about which part of UV is important and why. Less is known about the small mammal species kept in zoos. We do know from glass company technical representatives that the UVB- levels are often the first levels to drop off, over time, in both glass skylights and the UV- emitting bulbs.

The product called Starfire glass seemed to be among the best on the market for roof windows that would allow the fullest spectrum of light into animal enclosures, and last the longest.

National Zoo curatorial experience was that all glass tended to lose UV transmitting properties over time, and that some became opaque after a few years. Thus, that zoo's engineers chose glass that would retain its clarity and ability to transmit UV in the Small Mammal House.

There was some concern that the brighter light might increase the heat in the building, but since the installation of new glass, the building has not experienced any thermal problems. Given the still-debated discussion of specific parts of the light spectrum and the known drop-off in transmission levels, staff opted for the broadest spectrum of lighting possible. It is best practice to measure indoor exhibits' light levels and wavelengths with good-quality light meters on a regular basis to ensure that glass and lightbulbs are transmitting wavelengths for the appropriate distances and for the species within the space.

REFERENCE

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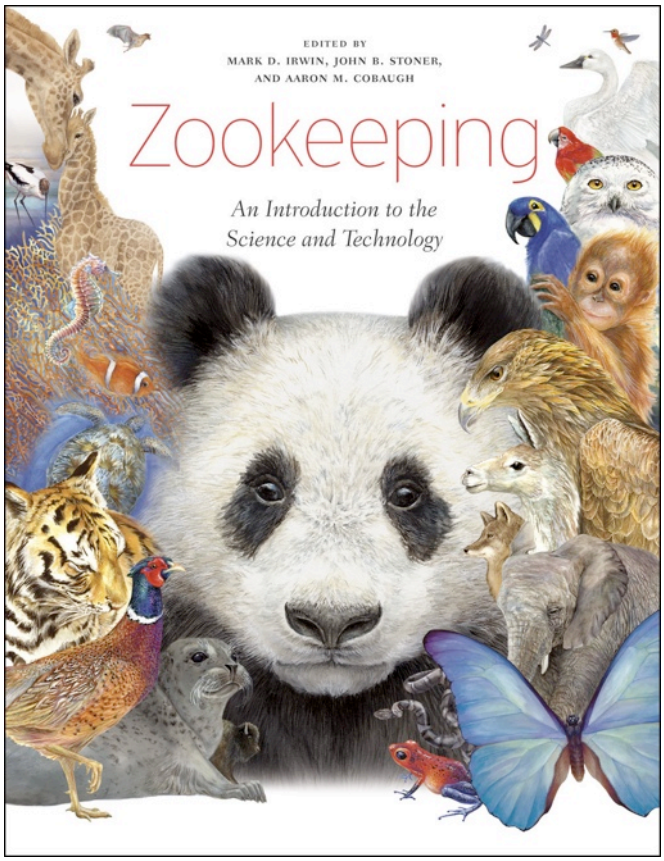

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