

GUEST EDITORIAL (International Zoo News, Jan./Feb. 2004)

Last October, our paper in the leading scientific journal *Nature* showed that in Carnivora, captive infant mortality and individual stereotypy performance is predicted by a species' natural ranging behaviour. Our finding showed objectively, for the first time, that specific aspects of wild behaviour make species resistant – or vulnerable – to captive welfare problems. It also showed that hunting does not underlie the pacing of carnivores, despite what is usually assumed. This has two practical implications for zoos. First, mimicking aspects of a wide-ranging lifestyle should be the key to effective environmental enrichment; providing larger enclosures, with more dens, and perhaps most importantly, more day-to-day variety, is likely to be most effective. Second, if improving an enclosure proves too hard or expensive, wide-ranging carnivores could instead be replaced by naturally more stay-at-home species, e.g. polar bears by grizzly bears, brown hyaenas by spotted hyaenas, fishers by pine martens, and so on. Such recommendations should not be controversial; after all, the World Zoo Conservation Strategy itself calls for zoos to focus on those species for which they can provide the best husbandry.

In his editorial in the November issue of *IZN*, Nicholas Gould attempted to critique what he perceived our methods and conclusions to be. It is a pleasure to use this Guest Editorial to correct his errors of fact and interpretation. Here, we explain in more detail how and why we did this research (as the word limit of the *Nature* Brief Communication – half that of this editorial! – did not permit this); identify and deal with Gould's various errors; and discuss how zoos should react to animal welfare research.

Our work first arose from a desire to understand carnivore stereotypy. Many had suggested that carnivores pace because they are motivated to hunt, yet this idea had never been scientifically tested. Furthermore, other hypotheses also existed – again, all untested; for example, that omnivorous, or territorial, or wide-ranging, animals are most stereotypic. Properly testing these ideas seemed important, and several UK zoos, along with UFAW and the International Zoo Veterinary Group, helped fund our project. Our approach was to use species differences to identify the correct hypothesis. If the hunting hypothesis was correct, species that naturally hunt for 100% of their prey, or pursue them over great distances, should be more stereotypic than species that are naturally omnivorous, carrion-eating, or have 'sit and wait' hunting strategies. But if the ranging hypothesis was correct, then in contrast, species with naturally large home ranges should be most stereotypic.

The research involved well over two years' intense data acquisition, sorting and analysis. First, we compiled all the good-quality reports of carnivore stereotypy that we could. This totalled *c.* 100 studies, representing over 300 stereotyping individuals and 35 species, across 40 sites. The studies were largely recent (85% from 1990 onwards), and all from the developed world. From this, we calculated the mean proportion of time spent stereotyping by the pacing individuals at each site (the only variable we could calculate accurately; non-stereotyping animals are generally not studied, and so prevalence or mean levels across all animals cannot be assessed reliably); and calculated the median value across sites for each species. Next, we quantified typical activities in the wild. An exhaustive trawl through specialist books, and the last four decades' field research journals, generated over 500 good-quality data sources for our 35 target species. From this, we could calculate each species' typical (i.e. median) natural home range size, time spent hunting, time spent active, distances covered while hunting and per day, and several other variables. Because home range size and daily distance travelled vary enormously with food availability, we also calculated the typical minimal values for these variables, to represent behaviour when conditions are good. Finally, we collated further data relevant to welfare. Stereotypies generally signify poor environments, but indications also exist that they help animals to cope. We therefore needed extra information to assess whether species differences in stereotypy have real welfare significance. Many aspects of functioning can be affected by stress, but the one variable we could assess similarly for all our target species was infant

mortality. We collated figures from the *International Zoo Yearbook*; from 1988 onwards, these volumes provided data from over 500 zoos worldwide, 80% in the developed world, on over 26,000 births and c. 9,000 deaths in our target carnivores. We calculated period mortality figures for each zoo, and then a median value for each species. Regressing wild data against captive variables gave two main results: (1) to our surprise, no aspect of hunting or foraging behaviour predicted captive stereotypy or infant mortality; and instead (2), daily distance travelled in the wild, and both median and minimum home range sizes, predicted median stereotypy and infant mortality levels. The infant mortality effect was particularly striking: highly statistically significant, and a true home range effect quite independent of body size.

With these details in mind, let us turn to Gould's attempted criticisms of our work. His first gripe, a 'suspicion that the authors had decided beforehand what it was they wanted to prove', is as ridiculous as it is insulting. Our aim was to objectively test competing hypotheses, and that is what we did. If we had had any prior expectations, they were that hunting would be the key – an idea that proved to be wrong! Next, he raises issues about just one of our 35 species: lions. First, in captivity, aren't they largely inactive, and breed well? Who knows for sure, without good data on stereotypy prevalence and birth rates, but our data show that when lions develop pacing, they spend a lot of time in the behaviour (a median of 48%); and that when they breed, 40% of cubs die before one month of age. Second, isn't cub mortality very high in the wild? Gould cites Schaller's account of 66% of wild cubs dying in their first year, but omits to note that only 30% die before the age of six months, at least a third of which succumb for reasons that are absent in zoos (e.g. predation). Thus from Schaller's work, we would actually expect lion cub mortality in the safe zoo environment to be under 20% in the first month. Next, Gould compares information he has looked up on animal density for lions and snow leopards. These data are, however, irrelevant as they are not about home range size (which is the area an animal ranges over – if there are 55 lions in an 100-km² area, but they each use all of that area, their range size is 100 km², *not* 100/55 km²!). Our thorough literature survey shows that, in fact, the median home range for lions is over twice that for snow leopards. Gould next tries to say that we have ignored the effects of food availability, apparently not noticing that we looked at minimum range sizes for this very reason. (And it is perhaps worth pointing out here that Craighead and colleagues have shown that well-fed grizzly bears exploiting rubbish dumps still range over areas of 20 km² or more!) Gould ends by giving an idealistic view of zoos and animal welfare, and it is this that we would like to end with.

We agree with Gould that the best zoos care about welfare, and strive to optimise it. We also agree that some enclosures are very successful; and that measures like infant mortality have generally improved over time (our own data, for example, show this in Carnivora over the last 10–15 years). But his implication that zoo welfare problems are all things of the past, and that zoos do not need any outside input thank you very much, is absurd. Everyone knows that stereotypies, infanticide, self-mutilation (e.g. fur-chewing), failures to mate, failures to conceive or bear young to term, and even short lifespans are not unusual in zoos. Everyone in their right mind also wants to solve these problems – but zoos often do not have the resources or expertise to do this themselves; their research budgets are small (or non-existent), and their staff usually unfamiliar with the huge recent literatures on assessing and reducing animal stress. So if animal welfare researchers like ourselves – and there are a lot of us, and we are not going to go away! – become interested in zoo issues, how should zoos react? Some have responded with the knee-jerk hostility and denial typified by Gould's editorial, but others, especially some of the large, wealthy North American zoos, have simply welcomed the work, and found it helpful and unthreatening. Surely this is a more appropriate response (and far more effective in PR terms, too)?

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