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Animals Longs and Shorts

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A complete listing of his writings at <http://psychologywritings.synthasite.com/>. See also material at <https://archive.org/details/orsett-psych>.

1. EXTINCTION RESEARCH AND INFECTIOUS DISEASES

- 1.1. Introduction
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1.1. INTRODUCTION

The extinction of species only became known in the 19th century with the discovery and understanding of fossils as extinct creatures. "Today, there is little disagreement that most species of life to have ever lived on Earth are now extinct... and that extinction is currently occurring at a greatly elevated rapid pace... Conservation of Earth's biodiversity is therefore of acute interest to all of humanity" (Alroy and Brook 2024 p1).

One consequence is the interdisciplinary science of extinction. But extinction research is not straightforward to define as "the field encompasses a range of studies from the purely biological to the cultural, necessitating a flexible definition. Furthermore, almost anything having to do with extinct or threatened species, ecosystems or cultural change could imaginably fall within this broad area. Indeed, one perspective is that all of palaeontology qualifies as extinction research because nearly all fossil organisms are extinct...; and that all of conservation biology also qualifies because organisms are presumably worth conserving exactly when threatened with extinction... At the other extreme, one might argue that to qualify as such, extinction research must be concerned explicitly with documenting and explaining extinctions that have actually occurred" (Alroy and Brook 2024 p1).

Alroy and Brook (2024) tried a definition of extinction research to capture its "spirit" that included that "(1) the system under consideration - biological or otherwise - must include a reproducing community of individuals that may collectively cease to exist; (2) the system is either extinct or at risk of extinction; (3) the research is concerned primarily with documenting or explaining this fact, not just with documenting general features of the system" (p2).

1.2. INFECTIOUS DISEASES

"Extinction is a natural and inevitable process... However, the current rate of extinction is several orders of magnitude greater than what has occurred through evolutionary time, and there is little doubt that extinction rates will increase still further in the near future" (McCallum et al 2024 p1). Diamond (1984) explained extinctions with the "evil quartet" of habitat destruction, overkilling, introduction of exotic species, and secondary extinctions (other species go extinction as a result of the extinction of a key species first). Climate change can be added to this list, and so can infectious disease, argued McCallum et al (2024) (though it is often seen as a sub-category of the introduction of exotic species).

Infectious diseases are "caused by a biological agent transmitted from one individual to another, either directly, or possibly via other species or via infective stages in the abiotic environment ¹. In addition to viruses and bacteria, infectious biological agents may include fungi, protozoa, metazoan parasites, transmissible cell lines and prions" (McCallum et al 2024 p1).

The extinction threats posed by infectious diseases are "probably under-recognised" (McCallum et al 2024 p7). For example, one study (Smith et al 2006) found that only thirty-one of 833 extinctions (animals and plants) could be attributed to infectious diseases. At the same time, "[U]nequivocally attributing extinction or decline to infectious disease (or indeed any cause) is not straightforward" (McCallum et al 2024 p2) (table 1.1).

McCallum et al (2024) listed a number of variables that will influence whether an infectious disease leads to extinction:

- i) Properties of pathogens - eg: mutation rate; ability to survive outside of (primary) host.
- ii) Host characteristics - eg: genetic diversity of the population; immunocompetence.
- iii) Environmental and community characteristics - eg: temperature and moisture; island/isolated population.
- iv) Anthropogenic factors - eg: habitat loss; climate change; travel and tourism; globalisation. These factors impact species directly, and indirectly via

¹ Abiotic environment is non-living (eg: soil; air) while biotic is living.

DISEASE	DETAILS
Chytridiomycosis (caused by fungus)	Fatal skin disease in amphibians; particularly frog species in the Americas and Australia
Sarcoptic mange (caused by a mite)	Skin disease of many mammals; particularly wombat species in Tasmania, and San Joaquin kit foxes in California
White-nose syndrome (fungal disease)	Local extinctions of bats in North America
Bacterium (Pasteurella multocida)	Occasional mass mortalities of saiga antelope in central Asia

Table 1.1 - Four examples of infectious diseases threatening different animals (McCallum et al 2024).

infectious diseases, for example.

1.3. REFERENCES

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2. PREY RESPONSE TO EXTINCT PREDATORS

How and why do prey respond to extinct predators? One possibility is the retention of specific anti-predator strategies (eg: going to ground when an avian predator appears), particularly if there was a long evolutionary history between the prey and that predator. This is the "ghosts of predators past" hypothesis (Peckarsky and Penton 1988). The strategies may persist if there are similar predators still around currently (the "multi-predator hypothesis"; Blumstein 2006). Alternatively, the "relaxed selection" hypothesis (Lathi et al 2009) proposed that certain anti-predator strategies will disappear with the extinct predator, particularly if the strategies are costly, and/or they are not applicable to current predation threats (Sanchez-Vidal et al 2024).

Innate predispositions and learning appear to be involved in primate response to predator calls. For example, individuals born in captivity, without predation experience, do not respond to such calls, whereas playback of predator calls can teach a response (Sanchez-Vidal et al 2024).

Sanchez-Vidal et al (2024) used the example of the mantled howler monkey (*Alouatta palliata*) in their research. The key predators are the jaguar and the harpy eagle, but in some forest areas impacted by humans, these animals are no longer present. In other words, they are extinct to the monkeys still in these areas. Sanchez-Vidal et al (2024) tested the response to the calls of these predators among howler monkeys who had lived several generations without them.

The study took place in a deforested area of southern Mexico (Los Tuxtlas) (with no jaguars or harpy eagles for approximately fifty years, based on human observations), and a forested area nearby with the predators (Uxpanapa Valley). Six groups of monkeys were tested in each area (a total of 126 individuals). Playback recordings of jaguar growls, harpy eagle shrieks, and a non-predator bird call were used in the study between July 2022 and April 2023. Each playback session was 15 seconds of the call, twenty seconds of silence, and another fifteen seconds of the call. Playback was begun when "(i) most adults (>50%) were resting or feeding without moving in the canopy, (ii) at least two adult individuals could be clearly observed, and (iii) no vocalisations had been emitted by the focal group or other neighbouring groups during the previous 15 min" (Sanchez-Vidal et al 2024 p4). All three types of

recordings were played in random order, and the behaviour of the monkeys was observed (eg: vigilance; vocalisations) (table 2.1). Overall, there were 72 trials with naive monkeys (Los Tuxtlas) and 55 with experienced ones (Uxpanapa Valley).

- Vigilance - "frequency of head movements associated with visual exploration of environment toward area where the speaker was placed".
- Vocalisation - duration of loud calling bouts (defined as "the emission of vocalisations, mainly roars and barks, in different combinations by one or several individuals that can range from a few seconds to 60 min with short (<1 min) silence pauses").
- Approach - "locomotion towards the speaker".
- Avoidance - "locomotion away from the speaker".
- Latency of behaviours - time between beginning of playback and first display of behaviour.
- No response after 10 minutes = No Response trial (27% of total trials).

(Source: Sanchez-Vidal et al 2024 p4)

Table 2.1 - Behavioural responses of howler monkeys to calls.

Both sets of monkeys responded similarly to the jaguar calls, but there was a difference for the harpy eagle calls, with naive monkeys not responding. The findings were thus mixed, and supported both ideas about the loss or retention of anti-predator strategies no longer needed.

The apparent loss of a response to the eagle call fitted with the "relaxed selection" hypothesis. This had also been previously found by Gil-da-Costa et al (2003). "Compared with similar-sized primates, howler monkeys have high-energy expenditure... and follow an ecological strategy of energy expenditure minimisation... Under a relaxed selection scenario, these energetic constraints could favour the loss of costly behavioural responses to stimuli without ecological relevance" (Sanchez-Vidal et al 2024 p2).

The retention of a response to the jaguar calls fitted with the "ghost of predators past" hypothesis, and the "multi-predator hypothesis". It could be that terrestrial predators are a greater risk generally than

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aerial predators (Sanchez-Vidal et al 2024).

Table 2.2 lists the main strengths and weaknesses of this study.

STRENGTHS	WEAKNESSES
<p>1. Calls of two different key predators, and a control playback of the plain chachalacas (non-predator bird).</p> <p>2. Two different areas in the same part of Mexico - one deforested and the other forested.</p> <p>3. Recordings of the calls from a specialist sound archive.</p> <p>4. Randomisation of call order between the different groups.</p> <p>5. Speaker height adjusted to fit caller (ie: jaguar on the ground and eagle six metres above).</p> <p>6. Natural experiment method.</p>	<p>1. Sanchez-Vidal et al (2024) admitted: "We sampled the first individuals who displayed behavioural responses to playbacks. As we did not know who they were (we did not identify study subjects systematically), we could not assess inter- and intra-individual behavioural variation and this could potentially lead to pseudo-replication issues in our statistical models. Therefore, our results should be interpreted with caution" (p5).</p> <p>2. Not equal numbers of trials between naive and experimental groups due to "difficulties in reaching groups in mountainous areas" (Sanchez-Vidal et al 2024 p4).</p> <p>3. Response behaviour was observed from a short distance away. Video recording appears not to have been used.</p> <p>4. Less control than a laboratory experiment, particularly in terms of the observation of responses.</p> <p>5. The extinction of predators was based on last recorded human observations.</p> <p>6. The impact of the presence of the researchers, particularly in setting up the physical equipment.</p>

Table 2.2 - Main strengths and weaknesses of Sanchez-Vidal et al (2024).

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3. FISH SWIMMING TOGETHER

Energy conservation can be achieved by individual animals moving in a co-ordinated group. This is especially important for movement in water. "In water, a fluid that is 50 times more viscous than air and contains much less O₂ [oxygen] per Kg than air, the need for aquatic animals to reduce fluid dynamic drag for energy conservation is even greater than for aerial or terrestrial locomotion" (Zhang and Lauder 2023 p1).

When an individual swims at high speed, as in escaping a predator, it is fuelled by aerobic metabolism, particularly anaerobic glycolysis [transformation of glucose to lactate]. "The direct consequences of unsustainably engaging anaerobic glycolysis include both fatigue and metabolic perturbation (such as changing blood acidity) that need time to recover after bouts of intense locomotion. Animals become vulnerable during recovery because of their hindered ability to repeat peak locomotor performance in the presence of predators" (Zhang and Lauder 2023 p2).

Using the example of a small tropical fish, giant danio (*Devario aequipinnatus*), Zhang and Lauder (2023) calculated that fish schools reduced total energy expenditure (TEE) per tail beat by up to 56% compared to solitary swimming fish. "When reaching their maximum sustained swimming speed, fish swimming in schools had a 44% higher maximum aerobic performance and used 65% less non-aerobic energy compared to solitary individuals, which lowered the TEE and total cost of transport by up to 53%, near the lowest recorded for any aquatic organism. Fish in schools also recovered from exercise 43% faster than solitary fish" (Zhang and Lauder 2023 p1).

More energy was used when swimming fast, but also when hovering slowly, than at a moderate swimming speed (eg: one body length per second). This moderate speed was used for long distance (migratory) swimming (Zhang and Lauder 2023).

The energy used in swimming was measured by a swim-tunnel respirometer, or an "aquatic treadmill" (ie: adjustment of the flow of the water in a tank - between 0.3 and 8.0 body lengths per second)². The swimmers were inside a tunnel that limited their movement and they had to swim against the flow of water. The aerobic costs of swimming were measured through the regulation of water

² Technically, an "Integrated Biomechanics and Bioenergetics Assessment System" (IBAS).
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velocity (Zhang and Lauder 2023).

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4. SPATIAL-SOCIAL INTERACTIONS

- 4.1. Overview
- 4.2. Predator-prey interactions
- 4.3. Environmental pathogens
- 4.4. Individual differences
- 4.5. Information sharing
- 4.6. References

4.1. OVERVIEW

Albery et al (2024) observed: "Animal space use and sociality are tightly interlinked and reciprocal, and it is therefore integral to study how and why individuals move, meet and interact in concert to understand the ecological and evolutionary consequences of many types of behavioural variation" (p1). The "spatial-social integration" framework (Webber et al 2023) has been proposed as a means by which to understand this situation. It has four components - spatial phenotypes, social phenotypes, spatial environments, and social environments (Albery et al 2024) (table 4.1).

Social and spatial behaviours can be intertwined in different ways, including (Webber et al 2023):

a) Both influenced by similar "drivers" (eg: predation; parasitism).

b) Influence each other - "The spatial distribution of resources drives the spatial proximity patterns that are prerequisite for many forms of social interaction, for example, information about food sources affects space-use decisions" (Webber et al 2023 pp869-870).

c) Shared consequences - eg: both impact resource depletion.

Gahm et al (2024) pointed out: "Animal movement patterns are influenced by both the physical and the social environment. Animals may seek the presence of others because of the benefits they gain from sociality (eg: removal of parasites, avoidance of predators), or they may avoid each other (eg: owing to competition). These social interactions are affected by the physical environment because most animals need to be in proximity to one another to interact. The physical environment might facilitate or constrain social interactions - for example, by attracting individuals to a shared resource

- Phenotype = “a suite of measurable characteristics that reflects underlying interactions between an individual’s genotype and its environment. Social and spatial phenotypes are individually quantifiable traits, including mate preferences, social network centrality, home range size, and dispersal distance. For a phenotype to evolve, it must differ between individuals, be heritable (and repeatable for behavioural phenotypes), and ultimately drive variation in fitness” (Webber et al 2023 p870).
- Environment = “a set of spatial or social elements that an animal faces and can be characterised by risks, resources, and conditions... The fitness outcomes associated with an environment can differ among individuals: for example, lifetime reproductive success (ie: fitness) is the result of certain individual (predetermined) genotypes and their plastic phenotypes may be more or less optimal for a certain environment - for example, different habitat or social group configurations” (Webber et al 2023 p870).
- Spatial phenotype - eg: resident movement tactic or nomadic; home range size; habitat preference.
- Social phenotype - eg: individual differences in sociability/social preference; dominance rank; number of mates; position in social structure (social centrality).
- Spatial environment - eg: habitat configuration; “landscape of fear”.
- Social environment - eg: group size and composition; population density; competition; type of interactions (eg: grooming).

Table 4.1 - Four components of the spatial-social integration.

or preventing them from moving across barriers” (p1). Animals may come together through social attraction (social phenotype and social environment) or through spatial constraints (spatial phenotype and spatial environment). Habitat fragmentation can be an example of the latter.

Using data from 75 GPS-tracked Eurasian griffon vultures in the Negev Desert in 2022, Gahm et al (2024) showed that social attraction (or avoidance) was more important than spatial constraints (eg: food availability; thermal uplift to aid flying) on bringing the birds together.

Introducing a special issue of the “Philosophical Transactions of the Royal Society B” on this topic, Albery et al (2024) distinguished four broad topic areas:

i) The cognitive mechanisms underlying the connections between spatial and social behaviour.

"When describing social information, people often use spatial language – describing others as 'close friends' and 'distant strangers', for example. Accordingly, it has been prominently argued that the pervasive use of spatial metaphors to describe social relationships (and other abstract information) is not merely an example of using metaphors for linguistic flourish, but rather, a reflection of how the mind represents such information" (Thompson and Parkinson 2024 p1). These researchers noted the growing evidence of underlying neural mechanisms common to both social and spatial information (eg: Park et al 2021). For example, the encoding of some types of social knowledge in the brain in "cognitive maps and/or graphs akin to those used to represent space" (Thompson and Parkinson 2024 p2). The exact brain areas have not been established at this point.

ii) How spatial and social phenotypes produce the socio-spatial environment.

Understanding the evolution of socio-spatial integration in humans is based on studies of primate relatives, and modern-day human groups that live in a similar way to early humans. Wood et al (2024) used olive baboons at Mpala, Kenya as the former, and the Hadza hunter-gatherers of Tanzania as the latter in a comparative study. Previously collected GPS data on both groups living in the Rift Valley were analysed (baboons in 2012, Strandburg-Peshkin et al 2015; Hadza between 2005 and 2018, Wood et al 2021).

Both groups showed a "central place foraging strategy". This is where individuals move away from a home base during the day and return there at night. The Hadza travelled further afield than the baboons on average. The Hadza, thus, accumulated more knowledge about "things over the horizon" than the baboons. "The larger and more complex socio-spatial world illustrated by the Hadza is one where heightened cognitive abilities for spatial and episodic memory, navigation, perspective taking and communication about things beyond the here and now all have clear value" (Wood et al 2024 p1). This fits with the idea of the evolution of the larger brain, and of complex language in humans. For example, one of the features of human language is displacement (the ability to communicate about things not in physical sight, including the past and future), and communication about things over the horizon requires this ability.

Wood et al (2024) commented: "The Hadza's diverse travel patterns create opportunities for frequent interactions where individuals can share ecological information that others are unaware of. By contrast, among Mpala baboons, the 'ecological news' gathered by one group member is largely equivalent to others'. The evolution of more Hadza-like patterns, we suggest, would generate conditions more conducive to communication about places and events beyond the here and now, a key adaptive feature of language" (p6).

Social animals make decisions based on their own familiarity with the environment, and on the behaviour of group members. In a study of 66 bison in Yellowstone National Park, USA, of their grazing behaviour (Merkle et al 2024), it was found that "high spatial familiarity allowed individual bison to determine their own movements, in its absence, high social familiarity allowed them to use others' movements to pursue and obtain resources" (Albery et al 2024 p3).

iii) A bottom-up approach to the topic - ie: from the level of the individual to the population.

In a study of GPS-tagged caribou in Newfoundland and fidelity during reproduction, for instance, Hendrix et al (2024) had findings that "site fidelity - proximity to familiar sites - and social fidelity - proximity to familiar conspecifics - are correlated strategies at the individual level, suggesting synergy between spatial and social traits in determining calving site locations" (Albery et al 2024 p4). Site fidelity did not appear to relate to reproductive success (Hendrix et al 2024).

iv) A top-down approach - ie: the broader population level.

In a study of the "resource landscape" of a wild population of bighorn sheep in Nevada, USA, Ricci et al (2024) found that movement decisions were influenced by social resources (eg: mate availability) and spatial factors (eg: droughts and food availability). Long-distance travel for mates varied for males between inside and outside the breeding season.

The impact of humans via weather anomalies was seen in herring (Gaynor et al 2024), "by altering the distribution of resources (spatial environment), which fed into their space use (spatial phenotype), thereby altering the age composition of the population (social environment), which influenced social learning of migration knowledge (social phenotype), with possible

consequences for migration routes (spatial phenotype)" (Albery et al 2024 p5).

"Spreading dynamics" is defined as "how information, behaviours or pathogens spread through a population" (Chimento and Farine 2024 p1). The social-spatial interface impacts this process. "In general, the more contact between individuals, the more opportunity there is for the transmission of information or disease to take place. Yet, contact between individuals, and any resulting transmission events, are determined by a combination of spatial (where individuals choose to move) and social rules (who they choose to interact with or learn from)" (Chimento and Farine 2024 p1).

Movement can follow different rules, including localised, semi-localised, nomadic, or resource-based (towards and away from resources), while social transmission rules included conformity (majority acquire behaviour) and anti-conformity (minority acquire behaviour) (Chimento and Farine 2024).

Using simulation modelling, Chimento and Farine (2024) found that combinations of different movement and social transmission rules led to different spreading dynamics.

4.2. PREDATOR-PREY INTERACTIONS

Movement by prey to avoid predators and collective aggregations as predator defence are examples of spatial and social dynamics in the predator-prey relationship. The concept of a "habitat domain", defined as "the spatial extent of habitat space that predator and prey use during foraging behaviour" (Schmitz et al 2017 quoted in Prokopenko et al 2024), can be used here.

For instance, the predator's domain is linked to the hunting mode -ie: the strategies used to search for and capture prey. This includes ambush predators who use stealth, surprise, and waiting, while cursorial predators actually chase prey. "Typically, we expect active cursorial predators to have a broader domain and for prey to respond accordingly" (Prokopenko et al 2024 pp1-2). While for prey, for example, grasshoppers at risk from sit-and-wait predators moved less and had a smaller domain than those when the risk was active-hunting spiders (Miller et al 2014). "Similarly, ungulate prey varied their behavioural response with predator hunting mode. Ungulates were more vigilant when exposed to cursorial predators but not ambush predators and also

decreased time in risky areas with ambush predator cues but not cursorial predators [Wikenros et al 2015]" (Prokopenko et al 2024 p2).

Prey vulnerability is another relevant variable. "Prey can assess and counteract their own vulnerability to predators through many tactics including detection, evasion and injury. For example, more vulnerable penguin chicks fled sooner and farther distances when approached. Variation in anti-predator responses can be driven by vulnerability in offspring as illustrated by adult mule and white-tailed deer exhibiting different anti-predator responses when with vulnerable young" (Prokopenko et al 2024 p2).

Prokopenko et al (2024) concentrated on two study areas in Canada and predator-prey interactions - elk and wolves in Riding Mountain National Park (RMNP) in Manitoba between 2008 and 2018, and caribou, coyotes and black bears in Middle Ridge Wildlife Reserve (MRWR) in Newfoundland between 2005 and 2014. GPS data were used to establish the habitat domains of prey and cursorial predators (table 4.2). Movement synchrony of prey was calculated by distance to the nearest neighbour when moving based on 15-minute intervals of data.

STUDY AREA	PREDATORS	PREY
RMNP, Manitoba	23 adult wolves	38 adult female elk
MRWR, Newfoundland	10 adult coyotes 42 adult black bears	41 adult female caribou

Table 4.2 - Data of tagged individuals used by Prokopenko et al (2024).

Both sets of prey moved in groups (synchronous) when predator pressure was greatest - elks in the winter, and caribou in the spring. This behaviour can be described as "risk-driven sociality", where prey "balance the costs and benefits of using conspecifics to mediate risk" (Prokopenko et al 2024 p1). Put simply, the benefits of synchronous group movement outweigh costs when the predation risk is higher, but in low-risk predation seasons, the costs may outweigh benefits (and prey prefer to be alone). "Ungulates trade-off forage for safety from predators: the resource-risk trade-off is pervasive across scales of responses from the decision to migrate, to within-range selection and patch use, to raising their

head to be vigilant" (Prokopenko et al 2024 p7).

Prokopenko et al (2024) concluded: "We emphasise the importance of considering not only how spatial variation in predation risk can impact the use of social behaviour as an anti-predator strategy by prey but also the role of other factors such as prey vulnerability and predator hunting mode" (p9).

4.3. ENVIRONMENTAL PATHOGENS

Environmental pathogens (as opposed to directly transmitted or vector-borne pathogens) are "transmitted through shared locations in space, making their dynamics particularly sensitive to not only the social configuration but also the spatial distribution and movement patterns of host populations. Different hosts must visit the same site at time-delays shorter than the pathogen's environmental persistence time in order for transmission to occur, introducing a layer of complexity that is crucial to understanding the disease spread" (Pandey et al 2024 pp1-2).

The key variables include (Pandey et al 2024):

i) Host space use and movement patterns - Host mobility can spread disease in different ways. "Highly mobile hosts can escape infected patches thereby reducing infection via the environment. With short environmental persistence and shorter infectious period, infected patches can become pathogen free before a susceptible group encounters the patch thereby limiting intergroup transmission" (Pandey et al 2024 p7). On the other hand, high mobility can increase disease dissemination (eg: bovine tuberculosis in African buffalo) (Pandey et al 2024).

ii) Social structure of host populations - eg: wild male chimpanzees who are more socially integrated have a higher risk of respiratory disease, while African swine fever in wild pigs depends on distance between groups (Pandey et al 2024).

iii) Pathogen life history - "Many pathogens can be transmitted from environmental 'reservoirs', with transmission rates influenced by time since environmental deposition. How long a pathogen remains viable in the environment directly affects the probabilities and dosages of host exposure. For example, the longer persistence of spores from the protozoan parasite

Ophryocystis elektroscirrha leads to a higher infection prevalence in monarch butterflies; and factors like substrate, desiccation, temperature and sunlight that influence the environmental persistence of Mycobacterium bovis also alter the risk of M. bovis infection in cattle, badgers and deer" (Pandey et al 2024 p2).

Using computational modelling Pandey et al (2024) varied host mobility (spatial), host gregariousness (social), and pathogen decay (environmental persistence) in order to see the impact on epidemic peak, time to epidemic peak, and final epidemic size. Overall, "longer infectious periods, higher group mobility, larger group size and longer pathogen persistence lead to larger, faster growing outbreaks..." (Pandey et al 2024 p1). More specifically, shorter infectious period led to lower epidemic peak (ie: maximum number of individuals infected), faster time to epidemic peak, and lower final epidemic size (ie: total number of infected individuals).

So, in terms of disease control, different strategies are required. "Larger group sizes, particularly with long infectious periods, require strategies that address both the high rate of intra-group transmission and the potential for inter-group spread. Vaccination strategies might be more effective in these settings, as they can reduce transmission within large groups and prevent spillover to other groups. Vaccination of wildlife has been successfully used in small populations of conservation concern (eg: rabies in Ethiopian wolves) or in systems with established methods of mass deployment (eg: raccoon rabies oral baits by hand-baiting, bait stations or aircraft). For diseases with short infectious periods in smaller groups, early detection via environmental surveillance and quarantine might be more appropriate, given the limited spread of these infections" (Pandey et al 2024 p7).

4.4. INDIVIDUAL DIFFERENCES

"How animals move throughout their environment is rarely random, with these non-random patterns in space forming the population's underlying spatial structure. To reduce the costs of social conflict, the associations between conspecifics are also typically non-random, with individuals displaying distinct preferences or aversions towards conspecifics within their environment" (Baker et al 2024 p1).

As a general rule, species that are more active (ie:

move around and so meet more conspecifics) tend to be more sociable. But within a species there are individual differences (or among-individual variation) in sociability, and activity. Baker et al (2024) studied these differences in 118 wild estuarine crocodiles in the Wenlock River in Queensland, Australia over a ten-year period. The crocodiles had acoustic transmitters attached which provided movement data.

Sociability was scored as the number of tagged individuals nearby at each sampling point, and activity was the mean river distance travelled per day. It was found that individuals rated as more active were less sociable.

This research showed that individual difference is an aspect of the spatial-social interface.

4.5. INFORMATION SHARING

Animals that eat foods that come and go need to know when the food is available. "Generally, individuals have two sources of information at their disposal: self-acquired experience or memory, and information acquired socially by interacting with, and monitoring the behaviour of, conspecifics. The degree of investment in acquiring social information is contingent upon the species' social structure and resource distribution dynamics" (Lourie et al 2024 p1).

There is a general rule where "less-predictable resources usually select for greater reliance on social information to facilitate finding them, whereas exploitation of more predictable ones favours memory use" (Lourie et al 2024 p1).

Fruits, for example, are predictable spatially (ie: the trees do not move position), but unpredictable in time (ie: when the fruit appears). Individual memory aids the former, while social information helps in the latter. The "information centre hypothesis" (Ward and Zahavi 1973) proposes that successful foragers return to the group and share their information with naive members. It is suggested that information sharing is a key driver in the evolution of communal living, according to this theory. The information may be shared indirectly (eg: visible food items; scent cues; fatness), and by naive individuals following those with knowledge. This latter behaviour has been recorded in Eurasian griffon vultures (Harel et al 2017). Some species directly communicate their information, like honeybees and their "dance language" (Lourie et al 2024).

Lourie et al (2024) performed an experiment to show the role of indirect cues by smearing fruit pulp on Egyptian fruit bats from the sycamore fig tree that had no fruits at that time. Over 200 bats at sites in northern Israel had GPS systems attached. The likelihood of naive colony members visiting sycamore fig trees was significantly greater in the following 1-6 nights after smeared bats returned than when non-smeared bats returned to the colony. There were six "manipulation nights" when a total of sixteen foraging bats were captured and smeared (and fed) with fruit pulp.

This research showed the role of social information combined with individual spatial memory for the tree sites. The findings suggested that "inadvertent social information, in the form of odour-cues carried by incoming roost mates, drove bats to visit the corresponding new resources using spatial memory, obviating the need to follow informed individuals" (Lourie et al 2024 pp6-7). Though the researchers accepted that they could not rule out following behaviour entirely.

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5. SONGBIRDS FOR SALE

Many bird species' existence is threatened by the trade in captive and pet birds, especially in South-east Asia, "where keeping birds is deeply entrenched in local culture" (Grimwood et al 2024 p1592). Songbirds in particular are threatened, and the phrase "Asian Songbird Crisis" (Marshall et al 2020) has been used.

Concentrating on Indonesia, it has been estimated that seventy million birds are kept by the population, and many are sought for songbird competitions. Although many species are legally protected, the (illegal) wildlife trade continues, added by the Internet in recent years (Grimwood et al 2024).

Grimwood et al (2024) investigated bird sales on Facebook. Twelve Facebook groups in Indonesia with bird-selling posts were sampled between 5th April and 5th October 2022. In total, there were 2371 posts selling 1884 individual birds from 176 species. The most popular bird was the White-rumped Shama (figure 5.1). Thirty of the species were listed as protected by the Indonesian Government (eg: Greater Green Leafbird; Javan Green Magpie), and around 10% of species were categorised as threatened by the "IUCN Red List"³.

Similar proportions of species were sold online as compared to data from four studies (eg: Chng et al 2018) of the physical markets in Indonesia between 2014 and 2018 (eg: both sources around thirty protected species). The physical markets had a wider number of species (n = 222), but this was not statistically significantly more. Grimwood et al (2024) summed up: "While there was a large proportion of threatened, protected, and conservation priority species for sale online, this was no more than that in physical markets, although the latter did have a higher relative abundance of protected species. It may be that some online trading groups are hotbeds of particularly rare, valuable and endangered taxa, as found elsewhere... but our Facebook groups acted similarly to physical markets" (p1598).

The study focused on the twelve most popular Facebook groups based on keyword searches of Indonesian bird species for sale. Sales may occur on other social media sites, and on the "dark web".

³ See <https://www.iucnredlist.org/>.



(Source: Ltshears - Trisha M Shears; public domain)

Figure 5.1 - White-rumped Shama.

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6. GOBI BEAR NUMBERS

One of the most endangered brown bears is the Gobi bear (*Ursus arctos gobiensis*) sub-species/population, estimated at around thirty individuals or less between 2009 and 2017 by one study (Tumendemberel et al 2021). It lives in the mountain ranges of the Gobi Desert in Mongolia, eating mostly plants (Anile et al 2024) (appendix 6A).

Estimates of the numbers of bears usually comes from "rub sites". "Bears rub against trees to leave chemical messages for other individuals, resulting in hair samples being inadvertently trapped on tree bark" (Anile et al 2024 p346). But trees are scarce in the Gobi Desert, so enclosed feeders have been left around, enclosed with barbed wire that captures hair samples ("hair traps"). Camera traps close to water holes, for instance, is another method used (table 6.1).

STRENGTHS	WEAKNESSES
1. Use for long periods of time (beyond what is feasible for human observers).	1. Depends upon the decisions of where to site the cameras.
2. Activated when an animal passes rather than continuous recording.	2. Only detects animals that appear within the camera's range. No way of knowing how many individuals did not pass near the camera.
3. Involves no human presence, which is particularly important for shy species.	3. The quality of images can vary.
4. Makes use of camera technology.	4. Technology can break down or be damaged.
5. Possible to assess the physical condition of individuals, for instance, from the images.	5. Requires the researchers to return to the site of the camera to check for images, which can vary in frequency.
6. Over long periods of time can show changes in population density and activity.	6. Can be expensive.

Table 6.1 - Main strengths and weaknesses of using camera traps.

This is the method reported by Anile et al (2024). Thirty-six camera traps were placed within the Shar Khulst mountain range in the "Great Gobi A Strictly

Protected Area" (GGA) in Mongolia in 2020. Overall, 68 bear detections were made from 2032 camera-days. Most detections came from one site near a water hole (n = 53), and in total 51 detections produced high quality images that allowed the identification of five bears.

Using statistical modelling the researchers estimated a population abundance of seventeen individuals, and a population density of 1.92 individuals per 1000 km². Tumendemberel et al (2021) had calculated a population density of 0.93 from hair traps, and detected fifty-one unique individuals in surveys in 2009, 2013, and 2017.

APPENDIX - 6A DIFFERENT HABITATS

Weldon Owen Group (2008) listed nineteen types of habitats used by animals: "Habitats are the locations or surroundings in which living organisms survive. They are the providers of food, shelter, and other fundamental requirements necessary for plants and animals" (p40).

Classification is based on climate and geography as well as the communities of species that dominant them (eg: coral reefs).

- Rain forests
- Tropical monsoonal forests
- Coniferous forests
- Temperate forests

- Moorlands and heaths
- Open habitats
- Deserts and semi-deserts

- Mountains and highlands
- Tundra

- Polar regions

- Lakes and ponds
- Seas and oceans
- Mangrove swamps
- Coral reefs
- Coastal areas
- Rivers and streams
- Wetlands

- Urban areas
- Parasitic lifestyles

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7. NEW SPECIES OF FOREST HEDGEHOG

New species are being distinguished regularly, and modern genetic techniques have aided this process. Take the example of the forest hedgehog.

The hedgehog genus *Mesechinus*⁴ has four species - *M.dauricus* (Daurian hedgehog), *M.hughi* (Hugh's hedgehog), *M.miodon* (small-toothed forest hedgehog), and *M.wangi* (Gaoligong forest hedgehog) - found predominantly in northern China and adjacent areas in Mongolia and Russia. "Mesechinus dauricus and *M.hughi* mainly inhabit semi-desert habitats, including cold-temperate deciduous and temperate deserts, warm-temperate deserts, grasslands and deciduous broad-leaf forests, *M. miodon* mainly inhabits semi-arid and dry steppe habitats and sub-alpine and low-elevation coniferous forests, and only *M.wangi* inhabits tropical or sub-tropical rainforest" (Shi et al 2023 p144).

Shi et al (2023) proposed a fifth species - *Mesechinus orientalis* (eastern forest hedgehog as proposed common name) (figure 7.1)⁵. This was based on analysis of seven hedgehogs collected in eastern China (Anhui and Zhejiang provinces) between 2018 and 2023.

The key distinctions for a new species in this include:

i) Morphology - eg: external body measurements (eg: tail length; head-body length); cranio-dental variables (eg: length of skull; length of upper tooth row). The new species was similar to *M.hughi*, but smaller size, shorter spines, and cranial differences.

The researchers listed the morphological characteristics that led to a classification as the *Mesechinus* genus: "the absence of pure white spines; relatively small ears, almost similar in length to the surrounding spines; no bare part on the forehead nor at the top of the forehead which divides the spines on the head into two halves; and a U-shaped suprarnarial fossa [part of skull]" (Shi et al 2023 p154).

ii) Genetic - eg: mitochondrial genome.

iii) Phylogenetic analysis - where the new species fits in the "evolutionary tree". The new species fitted

⁴ See <https://www.mammaldiversity.org/tree.html#genus=Mesechinus>.

⁵ Open data on specimens used to establish new species available at <https://zookeys.pensoft.net/article/111615/list/5/>. Official registration at <https://zoobank.org/NomenclaturalActs/BB3A29EC-F0A8-4DFD-A954-D5AC8E03B4B2>.

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(Source: Shi et al 2023; Creative Commons licence CC BY 4.0)

Figure 7.1 - A living eastern forest hedgehog.

in with the lineage of *M.hughi* and *M.wangi*, but diverged around 1.1 million years ago.

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8. PIGS HELPING OTHER PIGS

"Helping behaviour, in which an individual assists another to reach an otherwise unachievable goal, is of special interest for the study of pro-sociality. Helping can be costly and often does not provide immediate benefits to the helper, but rather appears to be motivated by an understanding of the needs of others, also referred to as targeted helping" (Moscovice et al 2023 p1).

This behaviour can be tested experimentally with different animals. For example, Ben-Ami Bartal et al (2011) created a device where one rat could open a door to a small compartment to release another rat trapped inside. Moscovice et al (2023) developed this idea with pigs.

A version of the criteria for targeted helping of Perez-Manrique and Gomila (2018) were used: "(i) helpers should show an other-oriented reaction, including cognitive appraisal of the situation and a moderate level of arousal, consistent with emotional regulation; (ii) helpers should show a flexible helping response that is appropriate to the situation; and (iii) helping should lead to an improvement in the situation for the individual in need" (Moscovice et al 2023 p2).

It was predicted that pigs would open doors to release trapped group members. Three extra variables were tested - the proficiency in the novel door-opening behaviour, attentiveness to the trapped individual, and the distress signals of the trapped individual.

In total, 78 "German Landrace" breed of pigs at an experimental pig facility in Germany were involved. They were housed in groups of 9-10 individuals from soon after birth. The pigs were familiarised with the novel door-opening behaviour over a number of days. "Opening the door required the use of 1.3 kg of force to lift the handle with the snout high enough to release an inner latch, causing the door of the compartment to swing open into the home pen. This design is suitable for pigs, who can exert strong force with their snout to dig or lift" (Moscovice et al 2023 p3).

During testing a "victim" pig was placed in the test compartment (separate from the home pen) (which could not be opened from the inside), and whether a pig outside opened the door within 20 minutes was measured. There was also an empty compartment as the control. The whole procedure was video-recorded. There were 74 trials.

In 85% of trials, a pig released the trapped group member (within an average of around two minutes), while

in 68% of trials the empty compartment was opened (average time around four minutes).

In terms of the variables, pigs who spent more time looking at the trapped pig (attentiveness) were more likely to help, and greater distress signals by the trapped animal increased the probability of being helped. Concerning proficiency, the researchers explained: "Pigs who opened doors at greater rates during familiarisation were more likely to help others, suggesting that their ability or willingness to solve this novel task played a role in their helping behaviour" (Moscovice et al 2023 p9).

An interesting observation was that in a majority of cases the helper pig entered the test compartment immediately after helping and when the trapped pig had left. Similar behaviour was observed with rats (Moscovice et al 2023). Moscovice et al (2023) suggested that in their experiment "helpers entered the test compartment to gather relevant information for themselves after witnessing the trapped pig, which is consistent with selfish motivations" (p10).

Applying the criteria of targeted helping, Moscovice et al (2023) stated that the "results provide partial support for targeted helping in that: (i) helpers exhibited visual assessment of the situation, (ii) trapped pigs who signalled more distress were more likely and quicker to be helped and (iii) helping improved the situation for trapped pigs by reuniting them with their social group. However, the lack of evidence for physiological arousal in helpers argues against an other-oriented response. We also point out alternative explanations based on local enhancement and selfish motivations to enter the test compartment that can more readily explain why the majority of helpers entered the compartment after helping, and why a small percentage of trapped pigs were helped without showing obvious signs of distress" (p11).

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9. AFRICAN MANATEES

Manatees are found, surprisingly, 4000 km up the Niger river in Guinea, and this group may be a sub-species of the West African manatee (*Trichechus senegalensis*) (Wendle 2024).

Two other species exist in the West Indies/Antillean (*Trichechus manatus*) (figure 9.1) and the Amazon (*Trichechus inunguis*). Genetic analysis suggests that West African manatees diverged from a South American population between 5-3 million years ago (Wendle 2024). "How the creatures, which are reliant on fresh water, swarm across the Atlantic is a mystery" (Wendle 2024 p39).

The Niger sub-species may be one of four sub-species of African manatee (Wendle 2024).



(Source: Ramos Keith, US Fish and Wildlife Service; public domain)

Figure 9.1 - West Indian manatee.

Satellite tracking has been used with manatees over the years in different parts of the world, and they show a variety of distances travelled (table 9.1).

In the first tagging of African manatees, in January 2009, Keith-Diagne et al (2021) tagged three adults in the Senegal River. One male was found to travel 45 km per

STUDY	DETAILS
Bengtson (1981) (unpublished; quoted in Keith-Diagne et al 2021)	15 wild Florida manatees in St John's and Hontoon Dead rivers and adjacent lakes followed over two years; mean distance travelled 80-95 km per month
Deutsch et al (2003)	78 manatees on Florida's Atlantic Coast followed over 12 years; average 87 km per day
Castelblanco-Martinez et al (2013)	5 wild Antillean manatees in Cheternal Bay, Mexico followed for 4-301 days; up to 240 km travelled over 89 days

Table 9.1 - Three studies of satellite tracking of manatees.

day, while another male moved 33 km per day on average. The female travelled over 900 km in 160 days of tracking. All three manatees travelled further than found in previous studies, especially the female. This may be a product of the Senegal River with "very limited aquatic and shoreline vegetation" (p27), suggested Keith-Diagne et al (2021).

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10. CHINSTRAP PENGUINS AND MICRO-SLEEP

Though sleep is crucial, it leaves animals vulnerable to predators. "Although animals can dilute this risk by sleeping in groups, the benefit is greatest for those in the centre, farthest from approaching predators. Indeed, mallards (*Anas platyrhynchos*) switch from sleeping with both eyes closed and both cerebral hemispheres [bihemispheric slow-wave sleep (BSWS)] when safely flanked by other birds to sleeping unihemispherically, with one eye open and the contralateral hemisphere awake [unihemispheric slow-wave sleep (USWS)], when exposed at the edge of a group [Rattenborg et al 1999]" (Libourel et al 2023 p1026). But groups can be noisy.

Libourel et al (2023) investigated sleep in chinstrap penguins (*Pygoscelis antarcticus*) (figure 10.1) on King George Island, Antarctica. These birds nest in colonies, where there is aggression between neighbours and noise from birds walking around, and there is the threat from a predatory bird, the brown skua, on the eggs and small chicks. One parent guards the nest, while the other is away foraging. Do the guarding parents sleep?



(Source: Eamonn Maguire; public domain)

Figure 10.1 - Chinstrap penguin.

The researchers attached dataloggers to fourteen penguins incubating eggs in December 2019. Electroencephalogram (EEG) activity was recorded from both cerebral hemispheres, in order to score BSWs and USWS. The penguins were also video recorded.

An incubation bout lasted about 22 hours before swapping with the other parent to forage. From the EEG readings it was found that the penguins "nodded off" >10,000 times per day, engaging in bouts of bihemispheric and unihemispheric slow-wave sleep lasting on average only 4 seconds, but resulting in the accumulation of >11 hours of sleep for each hemisphere. The investment in micro-sleeps by successfully breeding penguins suggests that the benefits of sleep can accrue incrementally" (Libourel et al 2023 p1026).

Contrary to Rattenborg et al (1999), birds nesting at the edge of the colony slept better (ie: less fragmented) than those in the centre. "This is likely driven by intraspecific aggression and associated stress, as well as noise in the centre of the colony" (Libourel et al 2023 p1029).

Generally birds are known to have shorter bouts of slow wave sleep than mammals, but the researchers admitted that "the acquisition of SWS primarily through thousands of micro-sleeps lasting only 4 secs is unprecedented, even among penguins" (Liboural et al 2023 p1029). Captive emperor penguins have been observed to alternate between waking and SWS in what Buchet et al (1986) "drowsiness", however.

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11. ABNORMAL BEHAVIOUR BY CAPTIVE ANIMALS

Captive animals can show “abnormal behaviour” - ie: “behaviours that deviate from behaviours seen in wild-living animals... These behaviours are observed in many taxonomic groups and have many different expressions such as stereotypic pacing in carnivores..., licking/biting of non-food objects in ungulates... and in horses..., self- and other-directed aggression in birds... and circular swimming in marine mammals...” (Vinken et al 2023 p1).

Three main groups of explanations have been proposed (Vinken et al 2023):

i) A mismatch between the captive environment and the natural one (which the animal is adapted to) that produces stress and frustration, and this manifests as the abnormal behaviour.

ii) Neurophysiological changes in the animals due to captivity, which produces the abnormal behaviour.

iii) Associative learning through reinforcement (conditioned reinforcement) - “It is proposed that the arrival of primary reinforcers (eg: food, social interaction or foraging opportunities) can inadvertently reinforce abnormal behaviours. For example, the arrival of food can reinforce the behaviours exhibited just before the feeding takes place... In domestic animals, inadvertent reinforcement through gaining caregiver attention can cause unwanted behaviour... Additionally, stereotypic behaviour ⁶ itself could have a reinforcing effect if it allows the animal to better ‘cope’ with stressors in the environment” (Vinken et al 2023 p2).

Vinken et al (2023) tested these explanations using computational models, and found that “the combination of conditioned reinforcement and genetic predispositions that mismatch the captive environment may be important in the development of abnormal behaviour” (p8).

DISCUSSION POINTS

1. The usefulness of computational modelling for understanding animal behaviours.

⁶ Stereotypic behaviours are “repetitive, unvarying sequences of movements without any obvious goal or function” (Odberg 1987 quoted in Vinken et al 2023).

2. The application of knowledge to the caring for captive animals.

3. Whether there are differences between animals born in captivity and those brought from the wild.

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12. URBAN LEOPARDS IN INDIA

With increasing human urbanisation more animals are living near or in such settlements, like leopards (*Panthera pardus fusca*) in India (appendix 12A).

"The biomass of domestic animals in human-use landscapes can be higher than that of wild prey... Anthropogenic food sources such as garbage and pet food can also contribute to the diet of wild carnivores... These food resources can be abundant, leading to densities of wild carnivores comparable to, or even greater than, their densities in the wild" (Athreya et al 2016 p156).

GPS data are showing the movement patterns of such animals. Athreya (2023) described the case of "Ajoba" (an ageing male leopard) from 2009: "Ajoba walked right out of the forest and travelled over farmland, through another wildlife preserve, across an industrial estate full of smoke-belching factories and a four-lane highway, and past a busy train station. After walking 125 kilometres in about a month, he reached Mumbai and settled down near the edge of the Sanjay Gandhi National Park (SGNP), where jungle borders a city of more than 20 million people" (p48). Two years later Athreya (2023) heard that Ajoba had died when hit by a car.

The simple conclusion is that felines refuse to be confined to the "natural areas" that humans leave them (eg: 5% of India's land area; Athreya 2023). Thus, two species (leopards and humans) come into contact in a way that can be risky for both (eg: poaching, and retaliation by farmers vs attacks on humans (table 12.1) and their domesticated wildlife).

- Half of the States in India report human injuries and deaths from leopards. In particular, Himachal Pradesh State (in western Himalayas) reported thirty lethal and 287 non-lethal such attacks between 2004 and 2015.
- Around 14% of the attacks were classed as "unprovoked", defined as "when the leopard was described to exhibit one or more stages of a non-human prey hunt: (1) a bite on the neck/nape (2) dragging of the body away from the attack site, and (3) ultimately feeding on the body in a secure place" (Shivakumar et al 2023 p3).
- The data came from the Himachal Pradesh Forest Department records of attacks, and interviews with survivors.

Table 12.1 - Shivakumar et al (2023).

Stressed animals are more likely to be aggressive. For example, tigers in Russia who did attack humans did so in response to provocation or injury, while Asiatic lions in response to forced relocation (Athreya 2023).

Camera traps can help in establishing the population density of leopards. For example, Athreya (2023) reported that motion-triggered cameras in a 179-square-kilometre area around the town of Akole (population 20 000) in Maharashtra state in the 2000s produced an estimate of five leopards per 100 km² (compared to 1-4 per 100 km² in Namibia). The average human density was 357 per km² in Akole compared to three per square kilometre in Namibia. The same camera traps around Akole saw hyenas also. The study also found that leopards were eating mostly domesticated animals, particularly dogs.

Tracking data showed that leopards "spent their entire day hiding in small bushes or inside the dense, six-foot-tall sugarcane fields - within pouncing distance of people going about their business, unaware of the leopards lurking nearby. At night, when the rural landscape was devoid of people, it was, from the cat's perspective, just another wild space. The tracking data showed us that this was the leopards' time when they stalked houses, looking for goats and pets, and prowled garbage dumps hunting for foraging dogs and domestic pigs" (Athreya 2023 pp53-54).

Athreya et al (2016) walked the nearby trails of Akole between December 2007 and April 2009 collecting scat. Eighty-five scats were confirmed by DNA analysis as from a leopard, and could be used for dietary analysis. Around 87% of the identified diet was domesticated animals (pig, sheep, cat, dog, goat, cow), while the remainder included birds and small mammals like rats. Dogs constituted the single largest species group (39% of biomass consumed).

The scat samples were opportunist in terms of those found on the days when researchers walked around, noticed the scat, and in a state to be analysed.

Athreya et al (2020) found that 242 compensation claims for livestock loss to leopards were made to the Maharashtra Forest Department between 2006 and February 2009 in the Akole study area. An interesting finding was that the presence of dogs guarding farms increased predation of livestock rather than decreased as found elsewhere. The researchers offered the explanation that the dogs were generally smaller than guard dogs and were

like pet and companion dogs. Also leopards preyed on these dogs.

Surve et al (2022) compared the leopards in an urban national park (Sanjay Gandhi National Park; SGNP) and a rural one (Tungareashwar Wildlife Sanctuary; TWLS) in the Mumbai area of India. Camera traps were used to estimate the density of leopards in 2015 and 2016 - 26 per 100 km² in the SGNP and 5 in the TWS. The prey density explained the large number of leopards in the urban area.

Wild prey density was estimated by the researchers walking around the parks, and domestic dogs from observations on a motorcycle. Leopard scats were also sampled to understand the diet. Domestic dogs were the highest content of the leopard's diet, and the average density of dogs was 17 per km² in areas around the SGNP compared to 3 around the TWLS. Wild prey eaten by leopards was also more plentiful in the SGNP. For example, five times as many wild pigs based on camera traps over 100 nights.

The researchers summed up: "Leopard density reported from SGNP is amongst the highest ever reported. This interesting result is probably due to much higher biomass of potential food resources in and around SGNP" (Surve et al 2022 p1). Any negative aspects of living close to urban areas are amply compensated in terms of prey available for the leopards.

APPENDIX 12A - PREDATORS IN THE URBAN WORLD GENERALLY

Katju et al (2023) commented that "urbanisation has not been uniformly deleterious for all carnivores. Some species (eg: leopards, black bears) have established themselves and are thriving in both urban and suburban landscapes" (p1).

These researchers introduced six articles that explored the carnivores in urban centres and the human-carnivore relationship ⁷.

1. Jaguars in the US-Mexico borderlands was the topic of the research by Connolly and Nelson (2023).

Human-wildlife interactions vary from negative (conflict) to neutral (passive tolerance) to positive (co-existence) (Connolly and Nelson 2023). "Carter and Linnell (2016) describe co-existence as a 'dynamic but sustainable state in which humans and [wildlife] co-adapt

⁷ There were seven articles in the special issue, but Surve et al (2022) is included in the previous section as it covers leopards in India.

to living in shared landscapes' (p575). Co-existence is complex and context-laden, with varied meanings across landscapes, but this definition highlights three key aspects: co-existence is dynamic, active, and integrated. Dynamic, because co-existence is not a fixed endpoint, with the human-wildlife relationship constantly evolving and negotiated daily... Active, because co-existence is facilitated by mutual adaptations. Conscious and unconscious behaviour changes by humans and wildlife minimise their interactions, allowing them to share time and space... Integrated, because under co-existence, humans and wildlife interact as parts of a broader whole" (Connolly and Nelson 2023 p2).

"Multi-naturalism" is a version of co-existence which "posits that natures are multiple and can be known in many ways, and that many natures can co-exist in the same geographical space" (Connolly and Nelson 2023 p1) (table 12.2). Applying this idea to the stakeholders in the US-Mexico borderlands ⁸, and jaguar conservation, the researchers defined a "nature" as "an individual's or group's perceptions, knowledge, values, attitudes, and actions towards jaguars" (Connolly and Nelson 2023 p1).

- "Fortress conservation": protecting nature from people, and conservation without or despite people.
- "Conservation for benefits": conserving nature for benefits of people.
- "Anthropocene conservation" ⁹: "considering natures with peoples" (Connolly and Nelson 2023 p3), including multi-naturalism.

(After figure 1 Connolly and Nelson 2023)

Table 12.2 - Different models of conservation.

Analysing semi-structured interviews, a number of themes emerged from different groups. For example, "many conservationists and activists value the jaguar as an apex predator because its presence signifies ecosystem health and balance, while some ranchers hold existence value for the jaguar's power and beauty, but resent its

⁸ US and Mexican conservationists, volunteers with relevant NGOs (non-governmental organisations), US ranchers, and Indigenous community members.

⁹ The Anthropocene describes the current era, and the beginning can be dated as AD 1610 (Lewis and Maslin 2015), or involve two distinct stages, according to Steffen et al (2011), the nineteenth century "Industrial Revolution", and the "Great Acceleration" (mid-20th century) (Powell et al 2021).

role as a predator, due to potential for conflict with livestock" (Connolly and Nelson 2023 p1). The multi-natural standpoint showed the different perspectives on jaguars and their conservation (and even reintroduction in other areas).

2. Livestock depredation is a cause of much human-predator conflict. For example, one estimate suggested that over half of snow leopard poaching was retaliatory killing (Pahuja and Sharma 2021). This is important as snow leopards are classed as highly endangered.

Pahuja and Sharma (2021) studied livestock loss by this predator and others in Ladakh, India (north-western trans-Himalayan region). A sample of households in sixteen villages were surveyed about their livestock mortality, and attitudes towards predators (table 12.3).

Livestock loss from weather-related events was most common, followed by predation by snow leopards, then free-ranging dogs, and wolves. However, the interviewees had a "counter-intuitive" positive attitude towards wild predators, particularly snow leopards (but a neutral attitude towards free-ranging dogs). This finding was contrary to previous research in the area (eg: Bagchi and Mishra 2006).

One explanation offered by Pahuja and Sharma (2021) for the difference was the villages in this study had access to a variety of source of income (eg: tourism), and so reliance on livestock keeping was relatively low.

- "What comes to your mind when you think of snow leopards/wolves/ free-ranging dogs?" Like (+1), Indifferent (0), Dislike (-1)
- "I would like to see snow leopards/wolves/free-ranging dogs in the pastures and mountains around my village". Yes (+1), Don't Know (0), No (-1)
- "Should children be taught about these animals in their school?" Yes (+1), Don't Know (0), No (-1)

(Source: table 1 Pahuja and Sharma 2021)

Table 12.3 - Examples of survey questions.

However, there were contradictions in the attitudes expressed. "For instance, while an overwhelming majority of the respondents expressed support toward protection and conservation of wild predators and agreed that their

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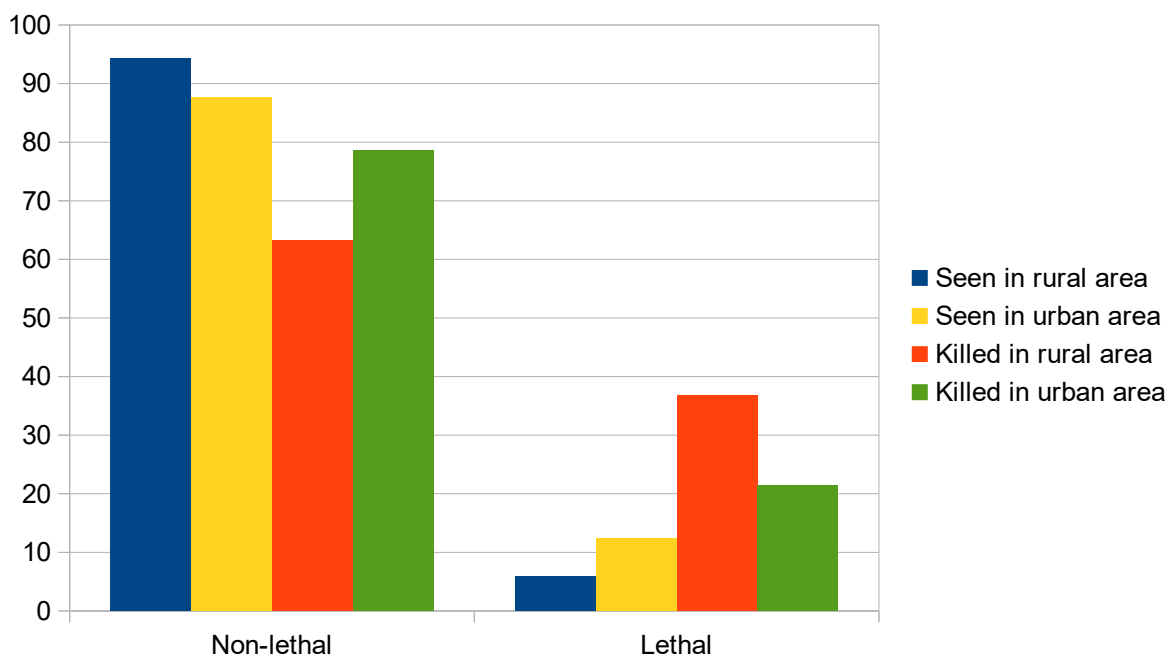
presence was a sign of a healthy environment, the willingness to share space with them was less discernible as half of the respondents remarked that predators should be conserved only inside formally protected areas such as national parks" (Pahuja and Sharma 2021 p10).

3. Pumas in the urban areas of Latin America were investigated by Guerisoli and Schiaffini (2022) using media reports. All news reports between 2011 and mid-2021 in Spanish and Portuguese including the terms "puma" and "urban" (or "city" or "town") were collected via Google searches (n = 162 events). Nearly half of the events came from Brazil, and there was a high concentration overall in 2020 (during the covid-19 pandemic restrictions). "Of the total, 41% were only sightings, 58% were captures, and a minor percentage were considered as mascotism. Almost the same number of records came from highly populated areas (cities) than from low populated areas (rural) but with important differences between countries. The countries with more records in urban areas (Brazil and Mexico) showed a larger surface occupied by cities. The countries with most records in rural areas (Argentina and Chile) present the opposite pattern of occupied surface. This might indicate that different percentages of areas dedicated to cities or urban spaces might explain the differences among countries" (Guerisoli and Schiaffini 2022 p1). Artificial night lighting was a key variable (ie: pumas were attracted by a certain amount).

4. Stanger et al (2022) considered predator control in urban areas, particularly the public's preferences. An online survey was undertaken in 2016 of 645 Ohio residents about bobcats, and 651 general US residents about coyotes. Four scenarios involving these animals were presented with three types of control option - leave alone and monitor (non-lethal), attempt to frighten away (non-lethal), or trap and kill (lethal). The scenarios were seen in an agricultural or urban area, and killed a domestic animal (sheep or pet dog). Respondents only viewed two of the four scenarios. General attitudes towards wildlife were also measured - eg: "wildlife is for human use" (domination values) or "animals have rights of their own" (mutualism values) - with nineteen statement and a seven-point response scale.

Usable data were available for 406 Ohio residents and 397 general US residents. Non-lethal responses were most favoured in the two "seen" scenarios (eg: 41% of

respondents chose the “leave alone and monitor” option for a coyote or bobcat seen in an urban area) (figure 12.1). The lethal option was more popular for killing a sheep (36.8% of respondents) than a pet day (21.4%). Around 10% of respondents preferred a lethal response to both “seen” and “killed” scenarios, while 72% wanted non-lethal control in both cases, and the remainder gave mixed answers (ie: sensitive to the predator’s behaviour). There was little difference in response between a coyote (common species in the USA) and a bobcat (uncommon), nor related to general attitudes about wildlife.



(Data from Stanger et al 2022 table 1)

Figure 12.1 - Lethal and non-lethal control (%).

The urban residents in the study preferred non-lethal control, and previous research has shown translocation of problem carnivores as popular (eg: Lute and Carter 2020). “Ironically, translocated carnivores sometimes suffer from an increased mortality rate, which defeats the purpose of those who wished to avoid lethal control... Furthermore, translocated carnivores that do survive, often travel long distances to return to the original location or continue conflict-causing behaviour in a new location” (Stanger et al 2022 p9).

5. Powell et al (2021) investigated the presence of leopards in Seoul, Korea, in a historical context with published books, field notes, correspondence, and private journals of Westerners in the late 19th century. Twelve cases of urban leopards were found between 1870 and 1900. Stray dogs and domestic pigs roamed the city at this time, and these would have been attractive to leopards. Also there were patches of dense vegetation within the city (eg: royal gardens).

6. The high availability of food (despite its low quality compared to the wild) at a city waste dump in Mekelle, Ethiopia, has attracted spotted hyenas. Struller et al (2022) observed the foraging groups on nine consecutive nights in May 2019 (10-11 hours per night) including video recording. The researchers divided the dump into three relevant areas - "chicken excavation" (a shallow pit of poultry products), "fresh pile" (unloaded meat waste from the local slaughterhouse), and "plain area" (household meat waste). Subsequent analysis of the video recordings identified 144 individuals.

The foraging group size was eleven individuals on average. "Hyenas shared the abundance of food at the waste dump without overt aggression" (Struller et al 2022 p1). The large number of individuals suggested that the hyenas commuted from different dens and daytime resting sites around the city. No information was collected in relation to this idea. There was no territorial behaviour observed at the dump, and so these hyenas appeared to behave in ways different to in the wild.

The young hyenas took part in a "fission-fusion dynamic", which has been seen in non-urban environments. Eighteen cubs were seen on more than one night, and the adults around them varied each night in the main. But "those that were seen multiple times with a cub seemed to play important roles. Only those adults were observed providing food, cleaning, disciplining or grooming cubs" (Struller et al 2022 p6). These adults were called "reference adults".

Struller et al (2022) explained: "The lack of exclusive association of a cub with one adult may reflect that cubs learn their urban lifestyle by local enhancement... With local enhancement, an individual learns not by observing a model individual performing an action but develops knowledge or skills when its attention is drawn to a certain aspect of the environment by other individuals in a specific location. However, it is possible that cubs are more strongly associated with

particular adults at younger ages not represented in our data set" (p6).

The researchers continued, that at the dump, "where satiation and absence of conflict seems guaranteed, it may become rather irrelevant which foraging group any individual decides to join. We propose that this social closeness or lack of aggression among foraging groups fosters a more loose and flexible foraging group membership than would be possible for hyenas in non-urban areas that are members of one specific clan" (Struller et al 2022 pp6-7).

Animals that show territorial behaviour in the wild, but not in urban environments has been reported in red foxes, badgers, and raccoons, for example (Struller et al 2022). The high abundance of food, as at the Mekelle waste dump, means that no individual or group can defend it and there is no logic in risking injury in doing so.

Yirga et al (2012) had observed previously that the hyenas around Mekelle returned to hunting and livestock depredation when offal at the waste dump was scarce (as during Christian fasting periods). "The present offal in food waste enables a larger population of hyenas to live around Mekelle than what would be expected in a more natural ecosystem. A sudden reduction in accessible food waste would leave a large population of predators without sufficient food sources, potentially leading to devastating consequences for both livestock and humans in the region" (Struller et al 2022 p7).

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13. LOSS OF OLD ANIMALS

Old individual animals have an important place in ecosystems, but old age-classes are being particularly hit by human behaviour. "Certain functions of old individuals (eg: reproductive, trophic, knowledge, wisdom, and leadership) cannot be replaced by younger adults" (Kopf 2024 p1).

Long-lived animals tend to have stable populations with plenty of middle and old age individuals providing what has been called the "old animal storage effect" (Kopf et al 2024). "Storage effects can take several forms, including egg banks or adults of long-lived species that buffer populations during recruitment failure and persist despite adverse or fluctuating environmental conditions" (Kopf et al 2024 p2).

Kopf et al (2024) focused on four important functions of old individuals:

i) Reproduction and recruitment (survival to sexual maturity) - "Declines in reproductive output at advanced ages ultimately occurs in most wild animals, but examples where older, often larger individuals make disproportionately large contributions to offspring production, quality, and survival have been documented in most vertebrate classes and some invertebrates. Even post-reproductive individuals have been shown to enhance offspring survival in some cases" (Kopf et al 2024 p3). The "grandmother hypothesis" (Hawkes 2004) is an example of this. By caring for grandchildren, daughters can produce viable offspring.

ii) Behaviour, knowledge, sociality and culture - Older individuals within a group can maintain stability (eg: loss of old wolf pack leaders through human behaviour creates pack instability), transfer their acquired knowledge to younger group members (eg: post-reproductive female killer whales and movement to feeding grounds), and potentially have the experience to adapt to environmental change.

iii) Ecosystem structure and function - The loss of older animals impacts the whole ecosystem, not only their group, population or species. "Overexploitation of old fish and wildlife can reduce stability and resilience while altering food web structure" (Kopf et al 2024 p5). Long-lived animals are often larger, and the removal of such individuals leaves an ecosystem populated with small-bodied, younger individuals.

iv) Resistance and resilience to global change - "Long-lived species and large old individuals within species have different responses and vulnerabilities to anthropogenic and ecological disturbances (eg: heat waves, cold spells, fire, floods, disease, hypoxia, food scarcity, altered timing of seasonal events) when compared to short-lived species and younger, smaller individuals" (Kopf et al 2024 p6).

The researchers argued not just for conservation strategies, but "longevity conservation" - ie: a special emphasis on older individuals. "Longevity conservation should prioritise old individuals from populations of long-lived life-history strategists, including less well-known forms, such as sponges, corals and animals of deep-sea environments generally, many turtles, freshwater and marine fishes, and cold-water sharks - all with long lifespans and ecological functions threatened by anthropogenic pressures. Management and restoration strategies need to focus on within species age and size-based approaches and will require timeframes that extend across years and decades to achieve the overall goal of reducing mortality of old individuals" (Kopf et al 2024 p7).

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14. DREAMING ANIMALS?

Sleep appears to be universal among animals, so does everyone dream also? Humans dream, in the main, during rapid eye movement (REM) sleep, where the eyes move though the eyelids are closed, and muscles twitch slightly (Marshall 2023). So, if animals show REM sleep, it can be assumed that they are dreaming. But it is not straightforward to discover this in certain species. Here are four examples of studies.

1. Octopus (Pophale et al 2023)

Octopuses have been found to sleep, and every sixty minutes within that is a roughly one-minute period of "rapid transitions through a series of skin patterns, accompanied by pronounced eye and body movements and increased breathing rate and arrhythmicity" (Pophale et al 2023 p129). This has been called "active sleep" (AS) as opposed to "quiet sleep" (QS) in the remainder of the sleep time.

The interval between bouts of AS depends on water temperature, with an increase reducing the interval, while the bouts of AS persisting in octopuses kept in constant darkness or light. Preventing sleep for two days led to more AS in the subsequent two nights. Weak stimulation of the sleeping octopus did not produce a response during AS, suggesting that "active bouts are rapidly reversible states of decreased arousal" (Pophale et al 2023 p130).

Electrophysiological recordings (via implanted electrodes) were made on nine octopuses (*Octopus laqueus*), and during AS there were large increases in local field potential activity in the brain resembling that of waking.

2. Pigeon (Ungurean et al 2023)

Ungurean et al (2023) made functional magnetic resonance imaging (fMRI) and pupillometry measures of awake and sleeping pigeons. Fifteen adult domestic pigeons (*Columba livia*) (Budapest highflyer variety) were trained for eighteen days to sit in a specially designed imaging machine.

There was evidence of REM sleep, "a paradoxical state with wake-like brain activity, is accompanied by the activation of brain regions involved in processing

visual information, including optic flow during flight" (Ungurean et al 2023 p1). Cerebral spinal fluid flow in the brain increased during non-REM (NREM) sleep relative to waking, but dropped sharply during REM sleep. Similar characteristics have been found in human studies, but differences were evident in brain area activity compared to mammalian studies (Ungurean et al 2023).

The researchers commented that "the bilateral activation of primary and higher order visual regions in pigeons might support visual imagery during REM sleep. Such imagery might be linked to rapid eye movements, which are thought to track visual scenes in dreams. Activation of the amygdala suggests that such experiences involve emotions. The potential emotional content might be linked to the rapid constrictions of the pupils occurring during REM sleep, which also occur during courtship and aggression in awake birds. However, even in humans, it remains controversial whether behaviours occurring during REM sleep are directly linked to dream content" (Ungurean et al 2023 p6). Though not being able to say that pigeons dream, the researchers speculated that the dream content may be flying.

3. Jumping spider (Roessler et al 2022)

Roessler et al (2022) studied a jumping spider (*Evarcha arcuata*) which suspends upside down on a silk line to rest during the night. This is assumed to be sleeping.

Thirty-four spiderlings and three adults were filmed during the night with an infra-red camera, and four behaviours were scored - retinal movement bouts, leg curling, stretching, and cleaning behaviour.

Bouts of retinal movements were observed, lasting approximately one-minute, every 20 minutes, and the duration of and the intervals between the bouts increased as the night progressed. Body movements were observed during the retinal movement bouts. The observations were taken as "direct evidence for an REM sleep-like state in a terrestrial invertebrate - an arthropod - with clear parallels to REM sleep in terrestrial vertebrates. The combination of periodic limb twitches and eye movements during this sleep-like state as well as the increase of duration of REM sleep-like bouts meets core behavioural criteria of REM sleep observed in vertebrates, including humans" (Roessler et al 2022 p2).

4. Mouse (Senzai and Scanziani 2022)

One issue tested in humans is whether rapid eye movements during REM sleep may be related to content of dreams. The results are contradictory. "Most of these studies, however, were based on the potentially inaccurate reporting of dreams by human subjects rather than on an objective measure of the cognitive processes that occur in the brain during REM sleep" (Senzai and Scanziani 2022 p999).

Senzai and Scanziani (2022) used the objective measure of cells in the "head direction" (HD) system in the thalamus of the mouse. The cell activity "reports the direction of the head of the animal along the azimuth as it explores or navigates through its environment. During REM sleep, the population activity of HD cells is similar to that which occurs during actual navigation, thus potentially representing an internal 'virtual heading' of the sleeping animal" (Senzai and Scanziani 2022 p999). The HD cell activity was mapped onto saccade-like eye movements in awake animals as they explored their environment. Then the researchers measured HD cell activity and rapid eye movements during sleep. It was discovered that "the direction and amplitude of rapid eye movements during REM sleep reveal the direction and amplitude of the ongoing changes in virtual HD. Thus, rapid eye movements disclose gaze shifts in the virtual world of REM sleep, thereby providing a window into the cognitive processes of the sleeping brain" (Senzai and Scanziani 2022 p999).

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15. LLAMAS LEARN FROM HUMANS

Learning new behaviour from others (social learning) is more effective than individual trial-and-error learning, particularly in unpredictable and rapidly changing environments, and where there are high costs to mistakes. Social learning can occur with conspecifics (eg: older group members) or heterospecifics (eg: species with shared environments or predators). Pahl et al (2023) investigated experimentally both types of social learning by adult llamas (*Lama glama*) (figure 16.1).



(Source: Petey21; public domain)

Figure 16.1 - Two captive adult llamas in Sweden.

Forty-three adult llamas were tested at three farms in Germany. A food bowl was placed inside a V-shaped fence turned away from the participant. This was a "spatial detour task".

There were three conditions - conspecific demonstrator (trained adult llama), heterospecific demonstrator (adult human), and no demonstrator (control group). In the demonstrator conditions, a participant observed the demonstrator go around the fence and get the food. All trials were video recorded and scored for success (reach food or not), and time taken (maximum 60 seconds).

Overall, half of the llamas tested achieved success, but significantly more in the demonstrator conditions (70% with human and 60% with llama) than the control

condition (20%). "Individual differences in behaviour (ie: food motivation and distraction) further affected the success rate. Animals did not necessarily use the same route as the demonstrators, thus, indicating that they adopted a more general detour behaviour. These results suggest that llamas can extract information from conspecific and heterospecific demonstrations; hence, broadening our knowledge of domesticated species that are sensitive to human social behaviour" (Pahl et al 2023 p1623).

The test animals were domesticated, and it has been argued that domestication leads to greater sensitivity to humans.

METHODOLOGICAL QUESTIONS

1. What was the independent variable(s)?
2. What was the dependent variable?
3. What is type of participant design was used and why?

Answer

1. Two independent variables - (i) a demonstrator or not, and (ii) the demonstrator as human or llama.
2. Reaching the food bowl.
3. Independent (or unrelated or between-participant/subject) design. The participant's performance on later conditions would have been impacted by doing more than one condition.

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