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ANIMAL WELFARE SCIENCE UPDATE

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The aim of the animal welfare science update is to keep you informed of developments in animal welfare science relating to the work of the RSPCA. The update provides summaries of the most relevant scientific papers and reports received by the RSPCA Australia office in the past quarter. **Click here to subscribe.**

Free and low-cost community veterinary services can help struggling pet owners

Many pet owners struggle to afford the costs of animal care including veterinary bills. These struggles have been compounded in many places as more people face unemployment and hardship associated with the ongoing COVID-19 pandemic. Free and low-cost community veterinary services aim to assist struggling pet owners. These community veterinary services can have animal welfare benefits including improved care for individual animals and a reduction in animal over-population, if pet desexing services are provided.

This study investigated client satisfaction with two community veterinary services in North Carolina in the United States. Clients at the Asheville Humane Society (AHS) Affordable Pet Care Clinic (APCC) (n = 64) and Mobile Vet Clinic (MVC) (n= 33) were surveyed 2017 to 2020. The majority of clients were unemployed and had an annual household income of <$US 20, 000. The clinics were staffed by small veterinary teams led by one veterinarian. Services for dogs and cats included free and low-cost preventative care (e.g. vaccinations), wellness exams and care for injuries and illness.

Over half (54.5%) of respondents reported that their pet had never received veterinary care before. Barriers to accessing veterinary care included personal finances and accessibility/transport issues. The majority of clients rated the AHS community veterinary services positively. For example, over 80% of respondents rated 'discussion about treatment options and costs' as 'good', over 85% trusted the veterinary team and over 90% felt that the veterinarian respected their culture/beliefs and the role their pet played in their lives. These findings highlight the value of accessibility, communication, cultural competence and empathy in the provision of free and low-cost community veterinary services.

Kogan LR, Accornero VH, Gleb E et al (2021) Community veterinary medicine programs: pet owners' perceptions and experiences. Frontiers in Veterinary Science 8, 678595.

Human social deprivation factors influence the risk of animal surrender to shelters

Companion animals may be surrendered to an animal shelter for reasons associated with the owner(s), animal(s) and/or their shared circumstances. Despite acknowledgement that social factors such as financial hardship and housing insecurity can influence animal surrender, few studies assess the social determinants of animal surrender on a broadscale.

This study assessed the social determinants of animal surrender across British Columbia in Canada. A total of 29,236 owner surrender records from 2016 to 2020 were collected from shelters of the British Columbia Society for the Prevention of Cruelty to Animals. Shelter records included the reason for surrender (e.g. personal issues, housing issues, inability to afford to keep the animal). Using postcodes listed in the shelter records, the data was overlain with the four factors of social vulnerability from the Canadian Index of Multiple Deprivation (CIMD): (1) Ethnocultural composition, (2) Economic dependency, (3) Residential instability and (4) Situational Vulnerability.

Ethnocultural composition increased the risk of surrendering due to personal issues (e.g. relationship breakdown), housing issues, owner health and inability to afford to keep the animal. This is consistent with research indicating that ethnic minorities in Canada are at higher risk of poor health and housing instability. Situational vulnerability (e.g. lack of formal education) increased the risk of surrendering litters of puppies or kittens. Economic Dependency (e.g. unemployment rate) increased the risk of surrendering animals with poor health status. These findings highlight the need for free or low-cost veterinary and desexing services in low-socioeconomic areas. Overall, the authors recommend further services be provided to people and animals to reduce the risk of surrender due to deprivation factors.

Ly LH, Gordon E, Protopopova A (2021) Exploring the relationship between human social deprivation and animal surrender to shelters in British Columbia, Canada. Frontiers in Veterinary Science 8, 656597.

Transitioning animal shelters to social enterprises can have human and animal welfare benefits

Not-for-profit social enterprises are hybrid operations that use revenue generating activities to conduct charitable activities. Not-for-profit organisations can transition to social enterprises by incorporating commercial revenue streams and implementing a more professional corporate-style management approach. However, concerns have been raised about how corporatisation, commercialisation and commodification may affect the operation of animal shelters.

This qualitative study profiled two social-enterprise not-for-profit animal shelters. A total of 51 interviews were conducted with staff and volunteers at the two social-enterprise not-for-profit animal shelters in the US and Australia. To ensure more stable income, the shelters had rebranded and incorporated revenue streams such as selling pet food and supplies, developing shelter tracking software, operating thrift shops, leasing event space, holding puppy parties and running animal crematoriums. These shelters implemented a more professional corporate style management approach including hiring more experienced and qualified staff, enforcing professional standards, employing volunteer coordinators, improving training and rewarding results. In addition, the consumer (potential adopter) experience was improved via direct communication, streamlined paperwork and upgraded shelter facilities.

The authors of this study conclude that transitioning to a social enterprise model helped these two animal shelters to improve the welfare of animals in their care. More stable income, improved organisational culture, more efficient operations and higher staff and volunteer morale were seen to contribute to better animal welfare outcomes. For example, dogs in the shelters received more daily care and enrichment due to effective volunteer coordination. Hiring animal behaviour experts allowed more dogs to be rehabilitated and rehomed. While these two shelters successfully transitioned to a social-enterprise model, further research is required to better understand how the social enterprise model could be applied more widely across different animal shelters.

Thomsen J, Thomsen B, Copeland K et al (2021) Social enterprise as a model to improve live release and euthanasia rates in animal shelters. Frontiers in Veterinary Science 8, 654572.

FARM ANIMALS

Routine separation from their mothers has long-term effects on gosling behaviour

In the commercial poultry industry, goslings are routinely hatched artificially and deprived of maternal care. Deprivation of maternal care is known to affect behavioural development. However, little is known about the effects of deprivation of maternal care on goslings in different production systems.

This study, conducted in Turkey, investigated the effects of deprivation of maternal care on goslings housed in intensive and free-range production systems. Native Turkish goslings in intensive and free-range systems were randomly allocated to be either incubated artificially (n= 120) or naturally (n= 120). Immediately after hatching, artificially incubated goslings were taken to the production house whereas naturally incubated goslings were allowed to remain with their mothers for three days. At 7 and 18 weeks of age, the mean percentage of geese performing certain behaviours (e.g. fearfulness, foraging, feather pecking, preening and resting) was recorded.

In both intensive and free-range production systems, naturally hatched goslings showed less fearfulness than artificially incubated goslings. Based on the behavioural observations of geese huddling in the outdoor free-range area, the authors also concluded that a higher percentage of intensively housed geese, both naturally and artificially hatched, behaved less fearfully in comparison to geese in free-range systems. When given outdoor access in the free-range production system, a greater percentage of geese were foraging than in intensive systems without outdoor access. In these free-range systems, naturally hatched geese were observed to forage more than artificially hatched geese. These behavioural differences across both production systems suggest that maternal deprivation in combination with environmental stressors may play an important role in gosling behavioural development.

Akif Boz M, Sarica M, Yamak US et al (2021) Behavioural traits of artificially and naturally hatched geese in intensive and free-range production systems. Applied Animal Behaviour Science 236, 105273.

Stress and negative affective states in commercially reared chicks

Worldwide, billions of chicks are hatched in highly stressful conditions in commercial hatcheries. Hormonal indicators of stress (e.g. corticosterone) can be measured in the egg from the chick's down feathers, which develop around day 14-15 of incubation. At hatching and later in life, behavioural indicators of stress can also be assessed (e.g. cognitive judgement bias test).

This study from Sweden hypothesised that commercially hatched chicks would be more stressed (i.e. higher corticosterone concentration) and have more 'pessimistic' responses on cognitive judgement bias (CJB) tests compared to control chicks raised at the university facility. Following hatching, commercial hatched chicks underwent standard commercial procedures (which included manual sex sorting, vaccination, transportation on conveyer belts, packing in boxes, transportation in a vehicle for 3.5 hours, and on-farm placement for rearing), while control chicks underwent much less invasive handling, only being sex sorted and then placed directly into rearing pens. More 'pessimistic' responses in CJB tests are correlated with stress. For the CJB tests, chicks were put in an arena with four stimuli: a mirror, picture of a chick, picture of an owl and morphed picture of a chicken and owl (to act as ambiguous stimuli for chicks). Taking longer to approach the ambiguous stimuli was interpreted as a 'pessimistic' response.

There were no significant differences in down feather corticosterone between commercially hatched chicks (mean ~750 pg/mg, n=20) and control chicks (mean ~700 pg/mg, n= 18). The authors suggest this could be because the chicks left the commercial hatchery shortly after hatch, before exposure to the stress of the perinatal period. In the CJB tests, at ≤1 week and 10 weeks of age (total n = 120), commercially hatched chicks were significantly slower to approach all ambiguous stimuli. The authors conclude that commercially hatched chicks overall showed more pessimistic responses which is indicative of poorer welfare, than control chicks.

Hedlund L, Palazon T, Jensen P (2021) Stress during commercial hatchery processing induces long-time negative cognitive judgement bias in chickens. Animals 11(4), 1083.

More space during lactation improves pig welfare and production

Traditionally, pregnant sows are subject to extreme confinement during farrowing (birthing) and lactation. Conventional farrowing crates do not even allow sows enough space to turn around. This level of extreme confinement severely compromises animal welfare. The rationale behind conventional farrowing crates was to reduce the risk of sows crushing their piglets. However, the use of conventional farrowing crates is increasingly being challenged.

This study, conducted in Ireland, randomly assigned pregnant sows (n= 46) to conventional farrowing crates (184 x 250 cm, 4.6 m^2) or 'free' farrowing crates. On average, the sows farrowed over 14 piglets per litter. From day five post-partum, 'free' farrowing crates were opened during the day to allow the sow enough space to turn around (212 x 261 cm, 5.5 m^2) and interact with piglets. The behaviour of all piglets (e.g. play, social interactions, response to enrichment, ear biting, tail biting, fighting) was recorded for the ~26 days that they remained with their mothers. Other tests conducted included a pooled faecal analysis for cortisol (stress hormone) and body weights were recorded soon after birth and weekly as pigs were moved from weaner to finisher pens, until they reached the target slaughter weight (105 kg).

Pigs reared in 'free' farrowing crates had better feed conversion efficiency, higher overall average daily weight gain, reached target slaughter weight faster and finished at a heavier weight than pigs reared in conventional farrowing crates. These differences may be attributable to the greater milk let-down by sows in 'free' farrowing crates and their piglets being able to suckle more. Overall, there was no significant difference in mortality rate between piglets in conventional versus 'free' farrowing crates. The authors concluded that 'free' farrowing crates offer both animal welfare and production advantages in comparison to conventional farrowing crates without a difference in overall piglet mortality rate.

Kinane O, Butler F, O'Driscoll K (2021) Freedom to grow: Improving sow welfare also benefits piglets. Animals 11(4), 1181.

Present and future pain relief options for sheep

Numerous painful procedures are routinely performed on sheep (e.g. tail docking, castration, mulesing). Common injuries and illnesses in sheep can also be painful (e.g. lameness, shearing cuts, mastitis). Providing sheep in commercial production systems with adequate pain relief is an increasing societal and customer expectation.

This systematic review synthesises over 960 articles on pain and pain relief in sheep published from 2000 to 2019. Pain indicators in sheep include inflammatory markers and measures of blood pressure, heart rate, oxidative stress and physiological stress. Other methods to assess pain in sheep have included thermal imaging, pressure mat readers, telemetry, geolocation, electroencephalography (EEG), postures and facial expressions, behavioural analyses (e.g. Qualitative Behavioural Assessment) and judgement bias tests.

Pain relief options for sheep discussed in the literature include local anaesthetics (e.g. lidocaine), non-steroidal anti-inflammatories (NSAIDs), enolic acid derivatives (e.g. Meloxicam), propionic acid derivatives (e.g. Carprofen), pyridinemonocarboxylic acids (e.g. Flunixin) and combinations of the above. The potential use of sedatives (e.g. xylazine, clonidine), dissociative agents (e.g. ketamine, benzodiazepines) and opioids (e.g. fentanyl) has been discussed in the literature. However, these agents are unlikely to be suitable for widespread

use in the commercial sheep industry due to regulations and the potential for substance abuse. There are several agents and techniques which may have future pain relief potential but there is currently little available information about their use in sheep. Many knowledge gaps remain about the pharmacokinetics and efficacy of pain relief agents and their possible production benefits. That being said, there is sufficient evidence that use of local anaesthetics in combination with NSAIDs is best practice.

Small A, Fisher AD, Lee C et al (2021) Analgesia for sheep in commercial production: Where to next? Animals 11(4), 1127.

Why are Australian dairy farmers culling cows?

Dairy cows can have a lifespan of around twenty years but few live to that age because they are killed (culled). Dairy farmers may cull cows involuntarily (e.g. due to illness, injury) or voluntarily (e.g. economic decisions related to low milk yield).

In this study, over 2.4 million records from DataGene (previously the Australian Dairy Herd Improvement Scheme) from 1995 through to 2016, were analysed to examine the main reasons for culling Holstein and Jersey cows as cited by Australian dairy farmers.

Excluding unspecified 'other reasons' (37.5%), the top three reasons cited for culling Holstein and Jersey cows in Australia were infertility (17%), mastitis (12.87%) and low production (9.31%). The average age of the cows at culling was 6.75 years for Holsteins and 6.73 years for Jerseys. Younger cows (early to middle lactation) were more likely to be culled for infertility and low production. Older cows were more likely to be culled for mastitis. There were some breed differences in culling trends. For example, from 1995 to 2016, culling for mastitis declined slightly for Holsteins (0.1% per year) but increased slightly for Jerseys (0.2% per year). Over the 21-year timeframe, culling for low production decreased slightly (0.5-0.6% per year) possibly due to selective breeding for production traits. However, the probability of culling for infertility has increased by 6 to 8% possibly due to reproductive disease, negative energy balance or other physiological issues.

These analyses, together with further genetic and phenotypic (observable characteristics) information, can be used to examine factors that affect productive herd life (length of time a dairy cow stays in the herd).

Workie ZW, Gibson JP, van der Wel HJ (2021) Analysis of culling reasons and age at culling in Australian dairy cattle. Animal Production Science 61:680-689.

ANIMALS IN SPORT, ENTERTAINMENT, PERFORMANCE RECREATION AND WORK

The horse-rider relationship and perceptions of animal welfare

Over the past few decades, the model most commonly used to study the relationship between coaches and athletes has been the 4Cs model: Closeness, Commitment, Complementarity and Co-orientation. Closeness represents feelings such as respect and trust. Commitment represents thoughts such as focus and motivation. Complementarity represents behaviours such as cooperation and support. Co-orientation represents mutual understanding.

This study uses the 4C model to characterise the horse-rider relationship as a unique coach athlete relationship. Elite female riders (average age ~40 years) with decades of competitive experience in eventing (n= 5) and dressage (n= 5) were filmed working with their horses (average age ~12 years). Each rider was asked to watch the footage and provide a commentary describing their and their horse's perceptions of their interactions.

Based on the riders' commentaries, the authors concluded that the riders had Closeness, Commitment, Complementarity and Co-orientation with their horses as per the 4C model. One way that the 4C model manifested was in the riders' perception of their horse's welfare. The riders' commentary suggested that they understood the need to constantly assess the horses' wellbeing and willingness to work. For example, one rider said *"there is a limit, there's a moment where you have to know when you have to back off because you're doing something wrong"*. While prioritising elite performance, the riders acknowledged that their horses needed to rest, relax and recover from competition. For example, one rider said, *"I don't necessarily push him as much as I probably should, I just don't want him to ever feel too negative with it."* The authors recommend further work to identify the development of these horse-rider relationships with a view to fostering healthy human animal relationships.

Tufton LR, Jowett S (2021) The elusive "feel": Exploring the quality of the rider–horse relationship. Anthrozoös 34(2):233-250.

Declining interest in the Melbourne Cup due to animal cruelty concerns

The Melbourne Cup Thoroughbred horse race is one of the most controversial public events held in Australia. Animal welfare concerns include injuries, wastage, use of painful tack (e.g. whips, tongue-ties) and death of horses on track.

This study investigated how Australians' views of the Melbourne Cup varied with demographic factors (e.g. gender, age, income, education level). Data was collected during a 2018 online poll which asked respondents (n=1028) to rank their level of agreement with six statements: (1) I regularly bet on horse races, (2) I rarely bet on horse races but will be watching the Melbourne Cup and placing a bet, (3) I will watch the Melbourne Cup but will not place a bet, (4) I have never been interested in the Melbourne Cup, (5) I have become less interested in the Melbourne Cup over recent years because of my concerns with gambling and (6) I have become less interested in the Melbourne Cup because of my concerns about animal cruelty.

A total of 294 (29%) respondents 'Agreed' or 'Strongly Agreed' with the statement "I have become less interested in the Melbourne Cup because of my concerns about animal cruelty". Women were more likely than men to agree with this statement. This may reflect previous findings about gender differences in concern for animal welfare. Six distinct clusters were identified: Devotees to the cup (31%), Flaneurs (low cup interest) (22%), Disapprovers (16%), Casuals (14%), Gamblers (12%) and Paradoxical-voters (5%). Most respondents (52%) were Flaneurs, Disapprovers or Casuals who were unlikely to bet on the Melbourne Cup. The authors recommend follow up polling to compare Australian attitudes to the Melbourne Cup after a 2019 media exposé about the slaughter of healthy Thoroughbred racehorses leaving the industry (wastage).

Wilson BJ, Thompson KR, McGreevy PD (2021) The race that segments a nation: Findings from a convenience poll of attitudes toward the Melbourne Cup Thoroughbred horse race, gambling and animal cruelty. PLoS ONE 6(3), e0248945.

ANIMALS IN RESEARCH AND TEACHING

The benefits and risks of Brexit for the welfare of animals used in experiments

European Union (EU) laws have directed animal welfare legislation in many Member States. For example, over 80% of animal welfare law in the United Kingdom (UK) is from the EU including 8 legislative clauses relating to animals used in experiments. The UK reports the highest number of animals used in animal experiments of any EU Member State. This raises concerns about how British laws pertaining to animals used in experiments may change post-Brexit (the departure of Britain from the EU).

This article discusses the possible benefits and risks of Brexit in the context of animals used in experiments in the UK. Although some funding security has been negotiated, one of the main risks of Brexit is loss of EU funding for the development of non-animal alternatives to animal experimentation. In addition, Brexit means that Britain will not be able to access the centralised EU database that facilitates information sharing and reduces the need for repeat animal testing of chemicals. There are concerns that loss of access to this database may lead to more animals being used in chemical testing in the UK.

Post-Brexit, the UK will retain the majority of EU law. Beyond this, the author sees that the main benefit of Brexit is the opportunity to strengthen laws protecting animals used in experiments. Post-Brexit, the UK will no longer be constrained by Article 2 of Directive 2010/63/EU that prohibits Member States from increasing protection for animals used in experiments beyond the Directive. Consequently, Brexit provides Britain the opportunity to review severity limits and stop animal experimentation that falls into the 'severe' suffering category. The author concludes that post-Brexit, the UK can be a leader in animal welfare provided it realises and builds upon opportunities to strengthen current policy and legislation.

Dunn R (2021) Brexit: A boon or a curse for animals used in scientific procedures? Animals 11(6), 1547.

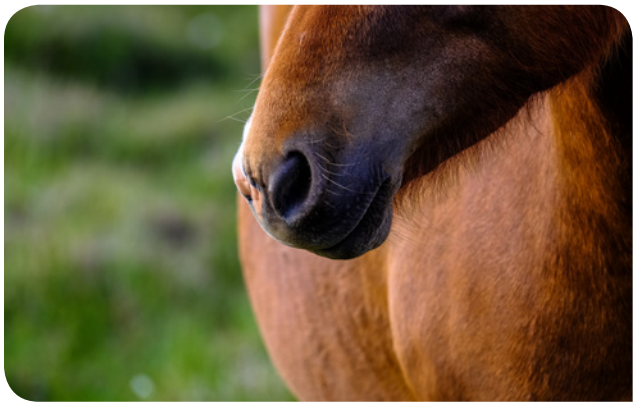
Better care required for horses used to produce biomedical substances

Thousands of horses are used to produce hormones, antibodies and other biomedical substances such as anti-venom. Welfare concerns include the risk of fear, stress, pain, infection and other illnesses. For example, to produce antibodies, horses undergo procedures that may cause fear and they may suffer pain from injection site reactions, abscesses and fever. To increase the yield of pregnant mare urine (PMU) which is used in the pharmaceutical industry, mares may be forced to undergo painful abortions. Use of horses to produce biomedical substances often occurs with little veterinary oversight and few animal welfare regulations, standards or guidelines.

This paper proposes minimum levels of care for horses used to produce biomedical substances. The authors recommend that horses are individually identified preferably by microchipping and examined by a veterinarian to assess fitness for the proposed use. Transport should be minimised. Horses should be fed sufficient roughage and given at least 4 to 8 hours of access to pasture daily. They should be afforded good quality bedding and at least enough space to lie down, turn and stand. As social animals, horses should be able to spend time with other horses. Appropriate preventative health and veterinary care should be provided and records kept. Euthanasia should only be performed by a veterinarian or trained and skilled professional.

Recommendations are also made about procedures commonly performed on horses used to produce biomedical substances. No more than 10% of the horse's circulating blood volume should be drawn and a sufficient recovery period should elapse before repeat blood collection. Abortions should only be conducted for clinical reasons on the advice of a veterinarian, not to increase the yield of PMU. Ideally, non-animal alternatives should be found to replace use of horses to produce biomedical substances.

Vilanova XM, Beaver B, Uldahl M et al (2021) Recommendations for ensuring good welfare of horses used for industrial blood, serum or urine production. Animals 11(5), 1466.



WILD ANIMALS

Snakes prefer enclosures that include environmental enrichment

Opportunities to engage in natural behaviours are essential for good animal welfare. Environmental enrichment, the provision of complexity in an animal's surrounds, is one way to provide behavioural opportunities. However, little information is available about the benefits of environmental enrichment for snakes held in captivity.

This study, conducted at the University of Lincoln in the United Kingdom, investigated the response of captive corn snakes (*Panthereophis guttatus*) (n = 14) to environmental enrichment. Snakes were individually assigned to a Standard or Enriched enclosure. Standard enclosures (83 x 35 x 39 cm) included a small water bowl, rock/cave hide and newspaper on the floor. Enriched enclosures were the same size but included: a hanging hide, wooden branch and peg board to allow climbing; a large water bowl to allow bathing; and wood shavings and a hide containing moss and compost to allow for burrowing. The behaviour of all snakes was monitored for approximately a month. Snakes underwent behavioural tests (exposure to a novel area and a novel object). Snakes were then swapped to the other enclosure type. After experiencing both the Standard and Enriched enclosures, the snakes were placed in the centre of the two enclosure types and allowed to choose (preference test).

Results indicated that environmental enrichment offers animal welfare benefits to captive snakes. All snakes used the enrichment elements, climbing and burrowing and displaying a clear preference for the enriched enclosure when given the choice. Behavioural test results were not significantly different between snakes in Standard versus Enriched enclosures, but the authors questioned how appropriate the tests may be for snakes. While further research is needed to establish which environmental enrichment elements are most effective, it is clear that environmental enrichment should be provided to captive snakes.

Hoehfurtner T, Wilkinson A, Nagabaskaran G et al (2021) Does the provision of environmental enrichment affect the behaviour and welfare of captive snakes? Applied Animal Behaviour Science 239, 105324.

How to save flying-foxes during heatwaves

Thousands of Australian flying-foxes have died in recent heatwaves. For example, during summer 2019/2020 over 66,000 flying foxes are estimated to have died across 40 camps (bat roosting sites). Different methods have been used to attempt to save flying foxes during heatwaves.

This review synthesises published and unpublished literature on methods used to save flying foxes (*Pteropus* species) during heatwaves. One peer-reviewed paper, one thesis and seven reports were found that describe camp and individual-scale intervention methods. Most available information was anecdotal. Camp-scale cooling methods included manual misting, spraying vegetation, spraying flying foxes, ground based sprinklers and canopy-mounted misting systems. There are anecdotal accounts that some of these wetting interventions reduced the mortality rate in treated versus untreated camps but in the absence of experimental frameworks, differences in mortality rates may be due to factors other than or in addition to the interventions. Intervention methods may inadvertently expose flying foxes to risks including stress associated with human disturbance and decreased capacity to regulate their body temperature by evaporative cooling due to increased humidity. Individual-scale methods included hand spraying or cooling and rehydrating *ex situ*. *Ex situ* cooling methods included water spraying, immersion and covering with wet cloths. *Ex situ* rehydration methods included fluids administered orally, under the skin, intravenously or intraperitoneally. Trigger points and thresholds for interventions are also discussed.

As heatwaves are increasing in intensity and frequency due to climate change, effective methods are required to save flying-foxes. The authors recommend that the efficacy of these methods be evaluated using an experimental framework during heatwave events.

Mo M, Roache M (2021) A review of intervention methods used to reduce flying-fox mortalities in heat stress events. Australian Mammalogy 43(2):137-150.

Enclosures should be big enough to allow snakes to fully stretch out

Providing animals with enough space to move around and adopt normal postures are basic requirements for animal housing. There is increasing recognition of the sentience and cognitive capacity of reptiles and that they should be afforded similar considerations given to mammals kept in captivity or as companion animals. However, snakes kept in confinement (e.g. at zoos or as companion animals) are commonly held in enclosures where they cannot fully stretch out.

This paper synthesises 65 resources about snake enclosure size. The aim was to assess the evidence-base for snake space recommendations. Sources, including 25 peer-reviewed publications, recommended that enclosures must be ≥1 snake length (SL). These sources involved research and discussed evidence about snake biology, behaviour, life history and home ranges. Based on this evidence, professionals and organisations concerned with animal health and welfare largely recommended enclosures ≥1 SL. On the other hand, sources that recommended or condoned enclosures of <1 SL were often based on erroneous beliefs and opinions and/or vested interests in the reptile trade.

Fully stretching out (rectilinear behaviour) is a normal and common posture for snakes. Enclosures that restrict a snake's ability to fully stretch out represent a risk to their health and welfare. For example, confinement of snakes in smaller enclosures is associated with health issues (e.g. abrasions, dermatitis, degenerative joint disease) and behavioural problems (e.g. hyper-alertness, head hiding). The authors adopt the precautionary principle and make a clear, evidence-based recommendation for snake space requirements. All housed snakes should be afforded enough space to fully straighten out in any direction.

Warwick C, Grant R, Steedman C et al (2021) Getting it straight: Accommodating rectilinear behaviour in captive snakes – A review of recommendations and their evidence base. Animals 11(5), 1459.

TRANSPORTATION OF ANIMALS

Transportation represents an animal welfare risk to wild animals

Transport poses a risk to all Five Domains of animal welfare: nutrition, environment, health, behaviour and mental state. Wild animals often suffer during transport (e.g. when translocated) yet there is little research on the effects of transport on the welfare of wild animals.

This review synthesised 60 articles published 1990 to 2020 that describe the responses of wild mammals to transport. Measures included morbidity and mortality rates, behavioural responses, fluid shifts, metabolic changes, and changes in muscle enzymes, white blood cell counts, glucocorticoids (stress hormones), heart rate and body temperature.

There is overwhelming evidence that transport is stressful for wild animals. The majority (n = 40/44, 91%) of studies investigating the mental state domain identified challenges to animal welfare. Muscle cell damage, possibly indicative of exposure to environmental stressors, was identified in 93% (14/15) of the studies investigating the environmental domain.

In terms of the nutrition domain, wild animals are often given no water or feed during transport putting them at risk of dehydration, fluid shifts and metabolic changes. Transport-induced changes in immune system function were reported in 85% (17/20) of the studies considering the health domain. These immune system changes have potential consequences for the health of transported wild animals. Transport is understood to cause stress, anxiety and fear but few studies (n = 4) provide empirical data on the behaviour of wild animals during transport. Further research is required to characterise how transport duration, ambient temperature and other factors may influence the response of wild animals to transport. Evidence-based, species-specific recommendations are needed for different transport types.

Pohlin F, Hooijberg EH, Meyer LCH (2021) Challenges to animal welfare during transportation of wild mammals: a review (1990-2020). Journal of Zoo and Wildlife Medicine 52(1):1-13.

HUMANE KILLING

More information needed to ensure humane killing of stranded cetaceans

Humane killing is where an animal is rendered immediately unconscious followed by loss of brain function. Humane killing of cetaceans (e.g. whales) is often required when strandings occur. Challenges include cetaceans' unique anatomy and physiology, logistics, regulations and human and environmental safety. Methods used to kill stranded cetaceans include barbiturate overdose and shooting. However, little information is available to assess whether these methods are humane.

This review synthesises 66 articles that stated the method of killing applied to marine mammal(s). Overall, chemical agents (e.g. barbiturates) were the most common method (n = 60 articles, 91%). Intravenous injection (n = 35 articles) was the most common route of administration. Some articles described the use of sedatives (e.g. xylazine and diazepam) prior to killing. In New Zealand, due to concerns about chemical residues, only firearms have been used to kill cetaceans with .30 being the most common calibre ammunition. Non-expanding (solid) projectiles fired from a dorso-ventral or lateral aspect and aimed at the occipital condyles of the skull are recommended. Inappropriate or incorrectly applied firearms are likely to cause pain, distress and suffering. Time to death (TTD) was rarely recorded but ranged from 1 to 3 minutes for chemical agents and instantaneous to 12 hours for firearms. Signs of insensibility (e.g. absence of eye reflexes, lack of response to stimuli around the blowhole) and verification of death (e.g. fixed and dilated pupils, no capillary refill) were rarely reported (n = 10 articles).

The authors identify significant knowledge gaps that place the welfare of stranded cetaceans at risk. They recommend more consistent reporting and further work to evaluate the relative humaneness of different killing methods for different cetacean species.

Boys RM, Beausoleil NJ, Betty EL et al (2021) Deathly silent: Exploring the global lack of data relating to stranded cetacean euthanasia. Animals 11(5), 1460.

Electrical stunning can render crustaceans insensible in less than one second

Humane slaughter centres around the principle that if an animal is to be killed, they should be rendered immediately insensible with death ensuing with minimal fear, pain or suffering. With the exception of a handful of countries (e.g. New Zealand, Norway and Switzerland), there are few humane slaughter guidelines, standards or regulations protecting crustaceans from stress and pain at slaughter.

Numerous studies demonstrate that decapod crustaceans (e.g. prawns, crabs, lobsters) demonstrate responses consistent with stress and pain. This review synthesises those studies and available information about the relative humaneness of different slaughter methods used to kill crustaceans for human consumption.

People use a range of methods in an attempt to stun crustaceans. The authors conclude that electrical stunning (e.g. using Crustastun™), is the most humane method as it renders crustaceans insensible in less than one second and dead in 5 (e.g. lobsters) to 10 seconds (e.g. crabs). They propose that splitting or spiking may be humane if performed by skilled operators who rapidly sever the relevant nerve centres. Crustaceans are documented to remain sensible and/or exhibit responses consistent with stress, distress and pain when exposed to dismemberment, drowning in

freshwater, salt baths, CO_2, boiling, and chilling in cold water, air or ice. Hence these cannot be considered humane stunning methods. Several knowledge gaps remain such as a lack of data on high pressure killing and decapods' aversion to low temperatures. Nevertheless, the authors adopt the precautionary principle and recommend that animal welfare legislation specifies the use of methods likely to cause the least suffering.

Conte F, Voslarova E, Vecerek V et al (2021) Humane slaughter of edible decapod crustaceans. Animals 11(4), 1089.

The discomfort of pigs routinely stunned with carbon dioxide in a commercial abattoir

In commercial abattoirs, pigs are routinely stunned using high concentrations of carbon dioxide (CO_2) gas before slaughter. The use of CO_2 is an animal welfare concern because of its aversive nature causing severe respiratory distress, breathlessness and acidic irritation of the mucus membranes (e.g. nose, eyes, mouth, throat, lungs).

This study, conducted at a commercial slaughterhouse during routine operations, assessed the discomfort period of fattening pigs and sows in a CO_2 stunning system. The discomfort period was defined as 'the time between the first pigs' reaction to the environment or to the gas and the observation of complete relaxation of the head of the last pig. Mostly in groups of three, fattening pigs were loaded onto gondolas and exposed to 160 seconds of >88% CO_2 before being shackled and bled. The gondola (n = 259) was the unit of analysis for fattening pigs and individual animals (n = 89) were the units of analysis for sows. Video recordings were collected of the pigs as they were exposed to CO_2. Measurements of ambient temperature, humidity and noise levels were also taken.

Behaviours in pigs exposed to CO_2 during the routine stunning procedure included gagging, gasping, escape behaviours (e.g. sudden jumping, turning, running), and loud vocalisations which is considered a sign of intense distress. The mean discomfort period in fattening pigs was 46±7 seconds (30 to 88 seconds). The mean discomfort period in sows was significantly longer at 57±11 seconds (35 to 82 seconds). It is unknown why sows' discomfort period was significantly longer compared to fattening pigs. The authors suggest that contributory factors may include differences in lung volume, pre-existing damage of lung tissue or buffering capacity. The results confirmed the aversive nature of higher concentrations of CO_2 in pigs. They also showed that higher humidity and temperature levels were associated with an increased discomfort period but the effects of these parameters on CO_2 stunning are still not well understood.

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MISCELLANEOUS

Evidence that fish and crustaceans feel pain

Numerous studies demonstrate that fish and decapod crustaceans (e.g. prawns, lobsters, crabs) demonstrate responses consistent with pain. However, detractors criticise study design, claim that observed pain responses are merely reflex movements or believe that animals who have different neural structures to humans cannot feel pain.

Elwood has published 13 experiments (mean sample size 91.7) relating to the welfare of four species of decapod crustaceans. In this review, he synthesises these and other studies to show that similar experimental approaches have been used to demonstrate pain responses in fish and decapod crustaceans.

Crustaceans have been shown to be willing to pay a cost to avoid painful stimuli (e.g. leaving the safety of shelter when electric shocked). Fish and decapod crustaceans display behaviour changes (e.g. rubbing or grooming the affected body part) consistent with pain when exposed to stimuli such as crushing force or chemicals. These behavioural responses can be mitigated by treating with pain relief drugs. For example, glass prawns (*Palaemon elegans*) exposed to noxious stimuli (crushing force, acetic acid, sodium hydroxide) groom and rub the affected antenna against the tank but do so less frequently with prior application of local anaesthetic. The evidence indicates that responses are sustained and require significant integration of information to be dismissed as simply reflex movements. For example, experiments in crayfish (*Procambarus clarki*) showed long-term, serotonin mediated anxiety in response to electric shocks, and that anxiety was alleviated by administration of anti-anxiety drugs. Elwood adopts the precautionary principle and concludes that fish and crustaceans demonstrate responses consistent with pain.

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