Review Report

Guidelines for the use and reuse of animals for teaching within veterinary medical education programs

John Cavalieri,[a] Brad Dowling,[a] Leo Foyle,[a] Craig Godfrey,[b] Janice Lloyd,[a] Josephine Penny,[a] William Tranter,[a] Sally Watts,[a] Jamie Wearn,[c] Graham Willis[d]
[a]College of Public Health, Medical and Veterinary Sciences, James Cook University, Townsville, QLD, Australia, [b]Research and Innovation Services, James Cook University, Townsville, QLD, Australia, [c]U-Vet Werribee Equine Hospital, The University of Melbourne, Werribee, VIC, Australia, [d]PowerMation, Brisbane, QLD, Australia

Abstract

Use and reuse of animals for educational purposes could adversely affect animal welfare. Guidelines for quantifying, monitoring, and planning the use and reuse of animals have been developed. Within this framework, animals are assigned points for usage, with more points being allocated to procedures that may have a greater adverse effect on animal welfare. Usage of individual animals is limited to a maximum of 8 points in a calendar week, 24 points in a month, or 60 points within a 16-week study period and any associated examination period. Advantages and disadvantages of the system are discussed, while modifications are expected as knowledge emerges on the impacts of procedures on animal welfare.

Keywords: Animal welfare, ethics, education, veterinary science, domestic animals, fish

Introduction

Education in veterinary science is reliant on the use of animals for students to develop a sufficient level of competence in a range of clinical and diagnostic procedures and an ability to maintain a safe work environment for them and others who may be in proximity. In the last 10 years, there has been a worldwide increase in the number of students enrolling in veterinary degrees to meet a combination of workforce demands and high demand for student enrolments. The United States (US) Bureau of Labour and Statistics in 2021 projected that the number of people employed as veterinarians between 2020 and 2030 will increase by 16.8%.[1] The number of students enrolled in US and Australian colleges of veterinary medicine has more than doubled since 1980 with a steady average increase in enrolment per year in the US between 2000 and 2020 by about 3%.[2] In Australia, between 2007 and 2013, there was a 61% increase in the number of students who commenced veterinary degrees.[3] This increase in student enrolments could increase the usage of individual animals for educational purposes that could reduce welfare outcomes for animals, particularly where there are budgetary constraints or limitations on animal numbers resulting in individual animals being used more often. Given the need to maintain animal welfare and to satisfy increasing community concerns for the usage and quality of care of animals, it is imperative that educational institutions operate within frameworks that maintain appropriate standards of animal welfare.[4]

Increasing use of alternatives to animal use through the use of models, mannequins, simulators, multimedia software, virtual reality, and cadavers has reduced the reliance on live animals.[5,6] A systematic review of humane alternatives to the use of animals for education within life and health sciences identified that humane methods of teaching resulted in learning outcomes superior (30%), equivalent (60%), or inferior (10%) to those produced by traditional, more harmful methods of animal use.[6] Simulations can better prepare students for carrying out procedures on animals in some situations but not in every circumstance, which, therefore, requires educators to continue to use animals for educational purposes.[6,7] When the use of animals is necessary for educational purposes, a tiered approach to training is advocated where students progress from using non-animal simulators to cadavers and finally live animals if necessary.[7,8] Simulations of varying fidelity have been used, for example, to train students in venipuncture, animal handling, intubation, bandaging, surgical and reproductive procedures,

CONTACT John Cavalieri **john.cavalieri@jcu.edu.au**

Citation line: Clinical Theriogenology 2023, 15, 9593, http://dx.doi.org/10.58292/CT.v15.9593

obstetrics, and imaging. The use of animals for teaching purposes, however, provides several educational advantages that cannot always be achieved through simulation.[4,9–12] Use of animals provides authentic learning opportunities directly mimicking procedures and scenarios that students will encounter in clinical practices. In some instances, the use of animals compared to alternatives for educational purposes was more appropriate for teaching complex, multifaceted skills, and it may increase the depth of understanding and retention of knowledge.[4] Use of animals offers kinesthetic learning experiences and provides valuable opportunities for learners to rapidly assess and respond to scenarios that involve multiple body systems. While working with animals, students may learn to develop empathy and improved moral awareness.[13] This may assist students to better understand the impact of procedures on animals and the importance of how to ameliorate any adverse changes in behavior or animal welfare that might arise when undertaking procedures with animals. Using animals in veterinary education, however, causes students to become desensitized and/or develop a utilitarian ethical standpoint on the use of animals and reduces empathy.[14,15] This highlights the need for students to appreciate any potential implications for animal welfare when using animals and to be able to recognize and ameliorate activities that may have a detrimental effect on animal welfare. Development of proficiency also requires some repetition to develop required standards of proficiency. Use of animals is also necessary for students to develop competencies required for certification.[16] Any increased usage and reusage of animals for educational purposes could, however, present adverse outcomes for animal welfare unless animal usage is managed appropriately.

There is relatively limited information available providing guidelines on how animals should be used for educational purposes, particularly, with regard to the welfare burden of repetitive use, although a number of reports describe physiological and behavioral responses to routine procedures conducted during veterinary education.[17–20] Upholding the principles of reduction, refinement, and replacement, the so-called 'Three R's' are embedded within the ethical framework that governs the conduct of the use of animals for research and education.[21] Principles are also provided through legislation, codes of practice, and guidelines and policies.[22–29] A guide to optimize animal welfare, entitled the 'Five provisions and aligned animal welfare aims' (Table 1), has overarching aims to help animals not only to survive but also to thrive within the environment in which they are maintained.[30]

Specific guidelines are lacking that would govern a range of procedures and learning activities that are commonly undertaken within veterinary training facilities and in a context where animals may be reused during an academic year for education and/or research. In response to the potential for increased animal usage and adverse effects on the health and welfare of animals during the education of veterinary students, guidelines and procedures were developed to monitor, quantify, and plan animal usage at James Cook University. The guidelines inform how and when animals can be used for educational purposes and when periods of rest are required and provide a framework for quantitatively monitoring animal usage. These guidelines, although far from a definitive or perfect guide, give assertion to comments by Dr Bernard Rolling that, "animals [are] were more than just resources, that they [are] were complex creatures that humans should treat with care and dignity."[31]

Animal usage guidelines

These guidelines are used to assess the usage of large animals, fish, and laboratory animals owned by James Cook University for practical classes for teaching veterinary students and, where necessary, to limit their usage in each duration. The guidelines represent an attempt to quantify the welfare burden on an animal from involvement in teaching activities and to set limits to animal usage for educational purposes. It should be noted that although usage scores have been assigned, the results of research studies that directly validate the scores or limits that have been assigned were not always available. While impacts of various procedures and usage are not fully known, there is also a risk that misdiagnoses of the effects of various procedures on animal welfare that could occur. As such, usage scores will be subject to review, and modifications are expected. This document is also not meant to provide a detailed description of the procedures undertaken or provide an ethical judgement on whether a procedure should be undertaken or not. Rather, for procedures that are approved by an Animal Ethics Committee, it aims to provide a reference guide to animal usage allowing for usage

Table 1. Five provisions and aligned animal welfare aims[26]

Provisions	Animal welfare aims
1. **Good nutrition**: Provide ready access to fresh water and a diet to maintain full health and vigor	Minimize thirst and hunger and enable eating to be a pleasurable experience
2. **Good environment**: Provide shade/shelter or suitable housing, good air quality and comfortable resting areas	Minimize discomfort and exposure and promote thermal, physical, and other comforts
3. **Good health:** Prevent or rapidly diagnose and treat disease and injury, and foster good muscle tone, posture and cardiorespiratory function	Minimize breathlessness, nausea, pain, and other aversive experiences and promote the pleasures of robustness, vigor, strength, and well-coordinated physical activity
4. **Appropriate behavior:** Provide sufficient space, proper facilities, congenial company, and appropriately varied conditions	Minimize threats and unpleasant restrictions on behavior and promote engagement in rewarding activities
5. **Positive mental experiences:** Provide safe, congenial, and species-appropriate opportunities to have pleasurable experiences	Promote various forms of comfort, pleasure, interest, confidence, and a sense of control

Citation line: Clinical Theriogenology 2023, 15, 9221, http://dx.doi.org/10.58292/CT.v15.9593

to be monitored and documented with the purpose of avoiding over-usage of animals to an extent that will adversely affect their health and welfare.

Recommendations on usage limits

In developing the guidelines, points were initially applied on a scale from 1 to 8, with more points being applied with an increasing magnitude of the stress load expected to be imposed on animals (Table 2). It is recommended that each individual animal not exceed a total score of 8 points in each calendar week, 24 points in a month, or 60 points within a 16-week study period and any associated examination period where animals are used for assessment of student competencies. Points have been assigned to species that are frequently used within veterinary education programs and for procedures that are taught within the veterinary program at James Cook University. Consideration was given when assessing the magnitude of points assigned for various procedures that in an educational setting may take longer to apply and cause more stress (e.g. a procedure by an experienced clinician during a routine clinical procedure may impose less stress [Table 3]).

Records should be kept for each individual animal use and the total cumulative score for each animal. Where scores are likely to exceed recommended usage within the time frames suggested, these animals should not be used in further classes or used within this time frame. Timetables and resources should be continually revised to determine ways of avoiding any potential overuse. When extenuating circumstances prevail, individual requirements should be discussed with a veterinarian or other appropriate expert and those who oversee or are managing the practical class to determine what other options are available, or whether further use can be considered. For example, illness of some animals may require them to be removed from a class. If replacements are not available, activities will need to be curtailed or modified, or consideration may need to be given if planned activities can be accommodated by the remaining animals.

Animals suffering from any illness that renders the animal with ongoing pain, lethargy, incoordination, or elevation of vital signs above normal limits will render the animal unsuitable for any practical class. Minor illnesses that do not involve elevation of vital signs above normal values, where any pain or distress is minor or where the bodily region affected is remote from the region being used in a practical class and where involvement of the animal is unlikely to adversely affect the health and welfare of the animal use may be permitted following the approval of a veterinarian. Where relevant, the opinion of others who have expertise in the care and use of the animal in question can also be sought.

Common sense should prevail regarding inclusion or exclusion of animals from practical teaching activities. The observations of the person in charge of the practical session should be taken into consideration, and the well-being of the animal is to be considered irrespective of the number of points it has accumulated. For example, if an animal has accumulated a total of 4 points for a given week (with 8 points being the maximum) but is expressing aversion to reuse, then it should be considered that an adequate rest period is recommended before considering further use or that further training of the animal and/or the user or adjustments to facilities may be needed before reuse is contemplated. There are examples of behaviors (Table 4) that, when expressed, would be associated with a recommendation for immediate withdrawal from a learning activity.

Medication of animals is often required as part of a practical teaching activity (e.g. reproductive hormones, sedatives, and local anesthetic and analgesic medications). The use of these medications will be included in any ethics application and description of the practical teaching activity. If treatments are required that are directly associated with a teaching activity,

Table 2. Description of categories related to levels of intervention that may impact upon animal welfare

Category	Description
1. Minimal interference/ observation	No or virtually no potential for stress. There is no pain or suffering involved. Activities requiring only passive cooperation from the animal, not be expected to compromise the animal's welfare any more than normal handling or feeding, and any restraint is well tolerated and of relatively short duration (< 2 hours).
2. Minor conscious intervention	Little potential for stress. Animal is subjected to procedures that would normally not require anesthesia or analgesia. Any pain is minor, and analgesia is usually unnecessary. Procedures do not normally require chemical restraint or are associated with significant aversion.
3. Mild intervention	Moderate potential for stress. Animal is subjected to procedures that would normally not require anesthesia or analgesia, but procedures are generally more invasive or longer in duration than a minor conscious intervention. Any pain is mild, and analgesia is likely to be unnecessary, although some distress may occur. Minor procedure with light sedation or local or topical anesthesia.
4. Moderate intervention	Significant potential for stress. Animal is subjected to a procedure that requires deep sedation and/or the short-term administration of analgesics. Invasive surgery with the animal conscious. General anesthesia of short duration where any surgical procedure is minor. The number or duration of procedures is more than an animal usually experiences with a routine clinical procedure.
5. Major intervention	Major potential for stress. Animal may be rendered unconscious with as little pain or distress as possible. Depending on the procedure, pain may be minor or moderate, and post-operative analgesia is likely to be appropriate.

Table 3. Animal use point score allocation

Score	Category description	General	Equine	Bovine	Ovine/caprine	Porcine	Fish	Laboratory animals/ rodents	Chickens
1	Minimal interference observation	Single acts, not requiring confinement Observation General animal handling External palpation Non-invasive physical examination Rectal temperature Body condition scoring Oral administration of a substance Confinement in stocks (< 60 minutes) Semen collection with artificial vagina (AV)	Lunging (< 1 hour) Teasing (< 1 hour) Application of halter Cardiac, pulmonary, or abdominal auscultation Limb bandaging Semen collection (AV, 1 collection) Confined in stocks for physical examination, external palpation (< 60 minutes)	Application of estrus detection aids. Partial clinical examination Blood sample (1 collection) Semen collection (AV, 1 collection)	Handling, restraint, and examination session which mainly involve body condition scoring, oral drenching, hoof trimming, non-invasive physical examination, including rectal temperature Semen collection (AV, 1 collection)	Catch with minor restraint (juvenile) Semen collection (1 collection)		Manual restraint for short duration (< 30 seconds)	Manual restraint for short duration (< 2 minutes)
2	Minor conscious intervention	Confinement in stocks/crush (60-120 minutes) Confinement out of stocks (< 240 minutes) with feed, water, and shade continually available Intravenous, subcutaneous, or intramuscular injection of a low volume of non-irritating substance Venipuncture Complete clinical examination Fecal sample collection from rectum	Flexion testing, hoof testing (< 1 hour) Application of a nose twitch (unexperienced operator) Single nasogastric intubation by experienced operator including application of nose twitch Confined in stocks for physical examination, external palpation (60–120 minutes). Confined outside stocks (tied to fence) for bandage application, limb lifted, cardiorespiratory auscultation, and hoof tester application. Artificial insemination Nasolacrimal duct irrigation	Administration of an intravaginal insert. Breeding soundness examination (BSE; 1 collection; electroejaculation or manual). Pregnancy diagnosis up to 3 transrectal examinations Orogastric intubation. Epidural anesthesia. Abdominoparacentesis. Rumenocentesis Lifting of limbs, lameness examination, and claw trimming. Artificial insemination Clinical examination	Handling, restraint, and examination session which may involve body condition scoring, oral drenching, hoof trimming, non-invasive physical examination, including rectal temperature, venipuncture, BSE, urine collection, and rectal fecal collection. Clinical examination BSE with semen collection by artificial vagina	Physical examination with confinement for restraint. Apply nose snare <2 minutes. Ear notching (neonate) Tail/teeth trimming (neonate)	Light restraint for a short duration (<1 minute) and tank transfer.		

(*Conttinued*)

Citation line: Clinical Theriogenology 2023, 15, 9221, http://dx.doi.org/10.58292/CTv15.9593

Table 3. Animal use point score allocation

Score	Category description	General	Equine	Bovine	Ovine/caprine	Porcine	Fish	Laboratory animals/ rodents	Chickens
4	Mild intervention	Confinement in stocks (2–4 hours) Detailed examination of a body system requiring diagnostic tests that involve mild intervention and subcutaneous or intramuscular injection of a low volume of non-irritating substance Procedures may involve venipuncture for the administration of sedatives and/or anxiolytics	Neurological examination (< 2 hours) Detailed lameness evaluation (< 3 hours) Detailed ophthalmic examination Detailed oral examination Nasogastric intubation demonstration by veterinarian (1 attempt) with student palpation/assistance Upper respiratory endoscopy Gastroscopy Reproductive examinations (< 2 hours) palpation per rectum, up to 8 examinations, with a maximum of 5 minutes recommended after evacuation of the rectum, transrectal ultrasonography of the reproductive tract and vaginal cavity examination including uterine lavage and endometrial/uterine swab	Limb restraint with light sedation. Casting. Confinement 4 hours. Reproductive examinations (4 to 8 transrectal examinations, up to 5 minutes in duration) Nasogastric intubation Local anesthesia: Head (3 points) Regional intravenous anesthesia Paravertebral nerve blocks Line block/inverted L-block Subconjunctival injection Liver biopsy Casting with sedation Insertion of an intravenous catheter	BSE with semen collection by electroejaculation				Handling, restraint, and examination session, which may involve body condition scoring, non-invasive physical examination, venipuncture (one procedure), wing clipping, and cloacal swab.
6	Moderate intervention	Examination of a body cavity and sample collection by student Minor surgery not involving general anesthesia (< 2 hours) Heavy sedation and/or general anesthesia without surgery Procedures may involve venipuncture for the administration of sedatives and/or anxiolytics	Dental procedures requiring heavy sedation Abdominocentesis. (Mandatory 6-month exclusion before repeated) Minor surgery performed by student undertaking sedation and analgesia – laceration repair, mass removal	Castration (< 3 months) – non-surgical	Vasectomy	General anesthesia with venipuncture	General anesthesia with venipuncture and/or parenteral injection		

(*Conttinued*)

Table 3. Animal use point score allocation

Score	Category description	General	Equine	Bovine	Ovine/caprine	Porcine	Fish	Laboratory animals/ rodents	Chickens
8	Major intervention	General anesthesia requiring pre- and/or postoperative analgesia	Castration Nasogastric intubation by students (3 students, 1 repeat per student) under heavy sedation (including opioid analgesia). Mandatory 6-month exclusion until procedure repeated.	Castration – surgical Calf processing (castration, dehorning, branding) Cesarean section (minimum 4-week recovery).				General anesthesia with tail venipuncture and oral gavage	

Table 4. Examples of signs seen in animals from different species necessitating withdrawal from teaching activities

Animal reaction to activity	Equine	Bovine	Ovine/caprine	Porcine	Fish	Laboratory animals/rodents	Chickens
Animal strongly resists activity, shows significant signs of stress and/ or aggression, and behaves in a way that puts itself or people in danger	Trembling, abnormal sweating, persistent pawing of ground, abnormal elevation in heart or respiratory rate, attempts to jump out of stocks, refusal to go into stocks	Difficulty ambulating, rising, open mouth panting, unexpected aggression, repeated recumbency	Open mouth breathing, charging (rams), repeated vocalization, trembling	Open mouth breathing, skin discoloration, muscle tremors, out of control movement, willing to run under, over, or through handlers and obstacles	Disorientation, inability to submerge or maintain orientation. Change in skin pigmentation	Ruffled hair coat, separation, crouched position, disorientation, persistent agitation, tremors	Isolation, inappetence, mouth breathing, inability to maintain posture or balance, persistent ruffled feathers. Abnormal discharges

Citation line: Clinical Theriogenology 2023, 15, 9221, http://dx.doi.org/10.58292/CTv15.9593

this does not incur additional usage points, as this has already been factored in the categorization of teaching activities.

Potential advantages and disadvantages of the guidelines

These guidelines help provide clear limits of animal usage that can be followed by animal managers and users, providing an auditable trail for external assessment of animal usage. When planning learning activities, the number of animals required within a given period can be determined. When animal numbers are inadequate to service the educational needs, the guidelines provide objective data for justifying the sourcing of additional animals. In these circumstances, where educational needs cannot be met by existing animal resources, simulations to ease animal use should be considered, even if this is perceived as a lower quality learning experience.

Software has been developed to record animal usage, enabling rapid assessment of an animal's eligibility to be enrolled within a learning activity and electronic capture of animal usage.[32] This software was developed in response to the need to record, quantify, and monitor animal usage. It includes an exportable electronic database that tabulates data such as the date, animal identification, species, practical class group, procedure being conducted, weight, and body condition score. The database also stores information about treatments that have been applied, comments can be recorded, and the identification of the person who entered the data is recorded. Data are entered as a report form that is viewable in a web browser, which includes a drop-down menu to select the procedures being conducted, with the points value being automatically assigned (although this can be manually overridden). Data can be entered via an electronic mobile device facilitating data capture at the point and the time of usage with data being uploaded to a server when reception of a wireless fidelity service is available. Reports for individual animals and their accumulated points over several set intervals, and reports for all activities and treatments can be produced. As with all data recording tasks, compliance remains a challenge. Developing an interface between the software and a full clinical recording database would broaden the utility of the application in a clinical teaching facility, although provisions are available within the existing software to manually describe treatments and provide comments. This, however, currently remains beyond the budgetary priorities of our institution. Other modifications include maintaining animals in groups with technical staff recording and monitoring the points accumulated for each group of animals, and the group being assigned to teaching activities that are permissible within their accumulated number of points.

The guidelines are limited in that they do not consider that repetitive exposure may induce a degree of habituation and reduce stress responses over time.[33] This is difficult to incorporate for individual animals as their responses may differ and the time taken to habituate may vary. Nevertheless, with future iterations, it may well be that the level of points assigned for a particular procedure could be greater for an initial exposure or when student experience is low, whereas lesser points may be assigned to animals when habituation has occurred, and stress has lessened or student experience improves. In addition, real-time adjustment in point allocations could occur for individual animals that appear to be less tolerant of procedures. The guidelines also do not consider stressors that may exist in an animal's environment and outside of specific learning sessions. Examples include the quality of housing and husbandry, provision and quality of environmental enrichment, recent adverse weather events or illnesses, stage of pregnancy or interval postpartum, the quality of animal care, the training of individuals involved in the care and movement of animals, and the state of facilities that are used to house and handle animals. There is also a possibility that resources or the ability to express certain behaviors "might provide 'relief' by reducing the intensity of some negative effects or 'benefit' by increasing opportunities to experience positive affects," thereby influencing an animal's stress load or ability to manage stress.[34] This acknowledges that stress may be imposed from the procedures conducted within a learning activity and imposed or ameliorated in association with the quality of the animals' life and surrounding experience within its environment. This should be considered when assessing an animal's short-term and cumulative stress load and suitability to be included within a learning activity.[35] However, it is acknowledged that it is difficult to capture this 'history' within the current animal usage system as described. In time, it may be possible to assign points attempting to quantify stress loading that may occur outside of a learning activity or perhaps to reduce points where animals are suitably habituated, students are more experienced, or if activities or the environment outside of learning activities enhances or adversely affects an animal's ability to manage stress.

Usage within research studies

Research studies may be undertaken in a context where it may be more difficult to manage animal usage within the recommended guidelines presented in this paper. For example, investigation into the development of a new vaccine may induce elevations in vital signs that, according to the guidelines, would render an animal unsuitable for usage but such a study would be necessary to document responses to treatment. Some studies may require the intensive use of animals for short periods that would mean that the number of points could exceed limits that have been set in the guidelines. For example, animals may be intensively blood sampled and subjected to several examinations relevant to the context of a study. Animals could also be given a general anesthetic and have surgery performed, and follow-up sampling could exceed the points system as outlined, but this may be necessary in the context of where the aims and methods for a research project have been approved by an animal ethics committee and meet any regulatory requirements. Some studies might also have outcomes that are unexpected and require additional monitoring to fully evaluate responses. Therefore, the use of these guidelines may be inappropriate for some research studies in the context of showing that the points have been exceeded, and that all work should immediately cease. Preconsideration of the justification, purpose, and planned interventions and possible outcomes as part of the normal process for managing the ethical use of animals in scientific studies will help manage welfare outcomes in this context. Mandatory reporting of adverse and unexpected events is also part of the normal process for managing research studies involving the use of animals.[25] Nevertheless, these guidelines could provide additional reference to ethics committees and researchers and serve as a guide as to when animal usage is exceeding limits that could adversely impact on animal welfare.

Application to fish

There appear to be no specific guidelines on how to regulate and assess use and repeated use of fish from a welfare perspective, although fish have been included in these guidelines. There is little doubt that fish exhibit behaviors in response to

noxious stimuli that cause pain in other animals, and that they possess nociceptors and opiate receptors involved in pain information processing analogous to those in mammals.[36] There are a number of publications that describe the welfare of recreational fishing and welfare indicators in fish.[37–39] However, most of the published work on assessing the welfare of fish relates to research and farming rather than teaching. Unlike terrestrial animals, the endpoint of most teaching exercises involving fish often results in euthanasia, precluding the need for methods to assess welfare based on repetitive use. International and national differences in legislation result in differing approaches to welfare. In Australia, for example, South Australia and Western Australia do not include fish in their animal welfare legislation, whereas the Northern Territories only cover the welfare of fish when they are held in captivity or dependent on a person for food, a position that would appear to cover teaching activities. The Australian Veterinary Association's position statement on Fish Welfare covers captivity, handling, illness, and euthanasia, but there is no reference to repeated use.[40] Fish are included in the Australian Code for the Care and Use of Animals for Scientific Purposes, which includes teaching activities and provides guidance to Animal Ethics Committees to consider the ratio of students to animals (fish).[25] It also considers the number of times that each animal will be used in each class and/or handled per day and/or per week, and whether an animal (fish) is appropriate for reuse. At James Cook University, fish are currently not reused for activities involving anesthesia, handling, examination, venipuncture, and parenteral medications including vaccinations.

Conclusion

Guidelines for quantifying, monitoring, and planning the use and reuse of animals have been developed and are being applied at James Cook University to regulate animal usage. Procedures associated with animal usage in each species are assigned points from 1 to 8, where 1 is assigned for minimal intervention and/or observation and 8 is where a procedure is regarded as a major intervention and is expected to be associated with relatively minor to moderate pain, normally requiring analgesia and may render the animal unconscious with subsequent recovery. Points are assigned following known impacts on animal welfare from scientific literature or, when not available, by veterinarians and other suitable experts, experienced with the application of procedures to animals and expected outcomes. Usage of individual animals is limited to a maximum of 8 points in a calendar week, 24 points in a month, or 60 points within a 16-week study period and any associated examination interval. Limitations of the system are acknowledged, given that the impact of procedures on animal welfare may not have been subjected to controlled studies, and that the system may not be applicable in every scenario in which animals are used or take into consideration stressors that may exist in an animal's environment or experience outside of a learning activity. The points system can be modified according to changes in knowledge or by consensual agreement based on knowledge of and potential adverse effects on animal welfare. The system as outlined provides guidelines for planning, monitoring, and limiting animal usage in veterinary education.

Conflict of interest

Authors, except Graham Willis, do not have any conflict of interest to declare. Graham Willis is a director of PowerMation that designed and sells the software Zumon for recording animal usage.

Authors' contributions

John Cavalieri: Conceptualization, original draft writing, and manuscript review.

Brad Dowling, Leo Foyle, Craig Godfrey, Janice Lloyd, Josephine Penny, William Tranter, and Sally Watts: Writing – review and editing

Jamie Wearn: conceptualization, review, and editing.

Graham Willis: Software and manuscript review.

All authors gave their final approval of the manuscript.

References

1. U.S. Bureau of Labor Statistics: Employment projections program. 2021. Available from: https://www.bls.gov/emp/tables/emp-by-detailed-occupation.htm [cited 11 March 2022].
2. American Association of Veterinary Medical Colleges: Annual data report 2020–2021. Available from: https://www.aavmc.org/wp-content/uploads/2021/05/2021-AAVMC-Annual-Data-Report.pdf [cited 11 March 2022].
3. ThinkPlus: The Australian Veterinary Association report on projection modelling for the veterinarian workforce. Australian Veterinary Association: 2014. Available from: https://www.ava.com.au/siteassets/advocacy/veterinary-workforce/australian-veterinary-workforce-technical-paper.pdf [cited 11 March 2022].
4. Vemulapalli TH, Donkin SS, Lescun TB, et al: Considerations when writing and reviewing a higher education teaching protocol involving animals. J Am Assoc Lab Anim Sci 2017;56:500–508.
5. Noyes JA, Carbonneau KJ, Matthew SM: Comparative effectiveness of training with simulators versus traditional instruction in veterinary education: meta-analysis and systematic review. J Vet Med Educ 2021;49:25–38. doi: 10.3138/jvme-2020-0026
6. Zemanova MA, Knight A: The educational efficacy of humane teaching methods: a systematic review of the evidence. Animals 2021;11:114. doi: 10.3390/ani11010114
7. Pereira GD, Dieguez J, Demirbas YS, et al: Alternatives to animal use in veterinary education: a growing debate. Ank Univ Vet Fak Derg 2017;64:235–239. doi: 10.1501/Vetfak_0000002804
8. Valliyate M, Robinson NG, Goodman JR: Current concepts in simulation and other alternatives for veterinary education: A review. Vet Med (Praha) 2012;57:325–337.
9. Annandale A, Annandale CH, Fosgate GT, et al: Training method and other factors affecting student accuracy in bovine pregnancy diagnosis. J Vet Med Educ 2018;45:224–231. doi: 10.3138/jvme.1016-166r1
10. Baillie S, Crossan A, Brewster SA, et al: Evaluating an automated haptic simulator designed for veterinary students to learn bovine rectal palpation. Simul Healthc 2010;5:261–266. doi: 10.1097/SIH.0b013e3181e369bf
11. Bossaert P, Leterme L, Caluwaerts T, et al: Teaching transrectal palpation of the internal genital organs in cattle. J Vet Med Educ 2009;36:451–460. doi: 10.3138/jvme.36.4.451
12. Rousseau M, Beauchamp G, Nichols S: Evaluation of a jugular venipuncture alpaca model to teach the technique of blood sampling in adult alpacas. J Vet Med Educ 2017;44:603–611. doi: 10.3138/jvme.1115-188R

13. Daly B, Suggs S: Teachers' experiences with humane education and animals in the elementary classroom: implications for empathy development. J Moral Educ 2010;39:101–112. doi: 10.1080/03057240903528733
14. Capaldo T: The psychological effects on students of using animals in ways that they see as ethically, morally or religiously wrong. Altern Lab Anim 2004;32(1_suppl):525–531. doi: 10.1177/026119290403201s85
15. Paul ES, Podberscek AL: Veterinary education and students' attitudes towards animal welfare. Vet Rec 2000;146:269–272. doi: 10.1136/vr.146.10.269
16. RCVS: Day one competencies. London; RCVS, Belgravia House: 2020. Available from: https://animalowners.rcvs.org.uk/document-library/day-one-competences/ [cited 11 March 2022].
17. Guinnefollau L, Bolwell CF, Gee EK, et al: Horses' physiological and behavioural responses during undergraduate veterinary practical teaching classes. Appl Anim Behav Sci 2021;241:105371. doi: 10.1016/j.applanim.2021.105371
18. Schonbom H, Kassens A, Hopster-Iversen C, et al: Influence of transrectal and transabdominal ultrasound examination on salivary cortisol, heart rate, and heart rate variability in mares. Theriogenology 2015;83:749–756. doi: 10.1016/j.theriogenology.2014.11.010
19. Ille N, Aurich C, Aurich J: Physiological stress responses of mares to gynecologic examination in veterinary medicine. J Equine Vet Sci 2016;43:6–11. doi: 10.1016/j.jevs.2016.04.010
20. van Vollenhoven E, Fletcher L, Page PC, et al: Heart rate variability in healthy, adult pony mares during transrectal palpation of the reproductive tract by veterinary students. J Equine Vet Sci 2017;58:68–77. doi: 10.1016/j.jevs.2017.08.013
21. Russell WMS, Burch RL: The principles of humane experimental technique. Methuen: 1959. Available from: https://caat.jhsph.edu/principles/the-principles-of-humane-experimental-technique [cited 11 March 2022].
22. European Union: Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01998L0058-20191214 [cited 10 May 2023].
23. Qld Government: Animal Care and Protection Act 2001. Queensland Government: 2001. Available from: https://www.legislation.qld.gov.au/view/pdf/2016-07-01/act-2001-064 [cited 11 March 2022].
24. United States Department of Agriculture: Animal welfare act and animal welfare regulations. Animal Plant Health Inspection Service. Washington, DC; United States Department of Agriculture: 2022. Available from: https://www.aphis.usda.gov/animal_welfare/downloads/AC_BlueBook_AWA_508_comp_version.pdf [cited 10 May 2023].
25. National Health and Medical Research Council: Australian Code of Practice for the Care and Use of Animals for Scientific Purposes. 8th edition, Canberra, NSW; Australian Government: 2013. Available from: https://www.nhmrc.gov.au/about-us/publications/australian-code-care-and-use-animals-scientific-purposes [cited 11 March 2022].
26. Australian Veterinary Association: use of female cattle for pregnancy testing and artificial insemination schools. Australian Veterinary Association: 2008. Available from: https://www.ava.com.au/policy-advocacy/policies/cattle-health-and-welfare/use-of-female-cattle-for-pregnancy-testing-and-artificial-insemination-schools/ [cited 11 March 2022].
27. Godfrey C: Animal monitoring and humane intervention points. James Cook University: 2018. Available from: https://www.jcu.edu.au/__data/assets/pdf_file/0005/632948/Animal-Monitoring-and-Humane-Intervention-Points-Guideline.pdf [cited 11 March 2022].
28. Australian and New Zealand Council for the Care of Animals in Research and Teaching (ANZCCART): Ethical guidelines for students in laboratory classes using animals or animal tissues. 2013. Available from: https://anzccart.adelaide.edu.au/ua/media/9/aust-ethical-guide2013.pdf [cited 10 May 2023].
29. Animal Research Review Panel: A policies and guidelines – use of animals for teaching. NSW Department of Primary Industries: 2019. Available from: https://www.animalethics.org.au/policies-and-guidelines/animals-in-teaching [cited 11 March 2022].
30. Mellor DJ: Moving beyond the 'Five Freedoms' by updating the 'Five Provisions' and introducing aligned 'Animal Welfare Aims'. Animals 2016;6:59. doi: 10.3390/ani6100059
31. Nolen RS: Obituary: Bernie Rollin, ethicist who wanted a better world for animals, dies at 78. JAVMAnews. January 01, 2022. Available from: https://www.avma.org/javma-news/2022-01-01/obituary-bernie-rollin-ethicist-who-wanted-better-world-animals-dies-78 [cited 11 March 2022].
32. Willis G: Zumon. Powermation: 2021. Available from: http://www.zumon.net/ [cited 11 March 2022].
33. McLean AN, Christensen JW: The application of learning theory in horse training. Appl Anim Behav Sci 2017;190:18–27. doi: 10.1016/j.applanim.2017.02.020
34. Hemsworth PH, Mellor DJ, Cronin GM, et al: Scientific assessment of animal welfare. N Z Vet J 2015;63:24–30. doi: 10.1080/00480169.2014.966167
35. Webster J: Ethical and animal welfare considerations in relation to species selection for animal experimentation. Animals 2014;4:729–741. doi: 10.3390/ani4040729
36. Sneddon LU: Pain perception in fish: indicators and endpoints. ILAR J 2009;50:338–342. doi: 10.1093/ilar.50.4.338
37. Ferter K, Cooke SJ, Humborstad O-B, et al: Fish welfare in recreational fishing. In: Kristiansen TS: editor. The Welfare of fish. Springer: 2020: 463–485.
38. Segner H, Reiser S, Ruane N, et al: Welfare of fishes in aquaculture. FAO Fisheries and Aquaculture Circular No. 1189. Budapest: FAO. Available from: https://jukuri.luke.fi/bitstream/handle/10024/544503/welfare_published.pdf?sequence=1 [cited 11 March 2022].
39. Toni M, Manciocco A, Angiulli E, et al: Review: assessing fish welfare in research and aquaculture, with a focus on European directives. Animal 2019;13:161–170. doi: 10.1017/S1751731118000940
40. Australian Veterinary Association: Fish welfare. Australian Veterinary Association: 2009. Available from: https://www.ava.com.au/policy-advocacy/policies/hunting-and-fishing/fish-welfare/ [cited 11 March 2022].