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Applied cognition research to improve sheep welfare
Commentary on **Marino & Merskin** on *Sheep Complexity*

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Abstract: If a change is going to occur in the care and management of domestic sheep, there needs to be a collaborative effort across many disciplines. This review by Marino & Merskin of the literature on cognitive processing in domestic sheep is limited by the inherent bias of the authors, including the impracticable goal of eliminating sheep production. Animal welfare concerns about the management of commercial sheep are valid; however, in order to make a difference, we need to develop an application for this knowledge about cognitive abilities in sheep.

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1. "Intelligent" animals. I would echo Vonk's (2019) commentary suggesting that Marino & Merskin's (2019) (M&M) argument needs to be more objective. M&M criticize the anthropocentric ranking of sheep in the animal kingdom, but then directly compare the cognitive abilities of sheep to those of humans and other "higher" mammals (e.g., primates, dolphins, and dogs). As Phillips (2019) states in his commentary, "sheep are as intelligent as they need to be," given both the natural and the artificial selection pressures on the domesticated species. Sheep have evolved subtle behavior patterns to avoid communicating disease, injury or physical impairment to predators. Given that sheep associate in social flocks, it makes evolutionary sense to be able to identify individuals and communicate emotion using visual cues (e.g., body/ear postures). The cognitive "complexity" of sheep as reviewed by M&M does not, in fact, reflect unique "complex" abilities. There is a wealth of research on cognitive abilities in traditionally "unintelligent" species, for example, memory of painful experiences in fish (Braithwaite & Boulcott, 2007), judgment bias in insects (Bateson et al., 2011; d'Ettorre et al., 2017), and personality assessment in invertebrates (Kralj-Fišer & Schuett, 2014). As noted in Adolph's (2019) commentary, M&M should not have tried to match information processing in sheep to that of humans; they could instead have provided a more applied approach in highlighting the cognitive abilities of this ruminant species.

2. Applied sheep cognition research. Animal cognition research can help inform animal welfare standards and assessments. M&M miss the opportunity to highlight this. How can we, as animal

caretakers of this domestic species, improve the quality of life for sheep given the results of the studies reviewed? The common welfare issues for sheep include housing and transportation (e.g., stocking rate, temperature, and ventilation), painful procedures (e.g., tail-docking, castration), abnormal behaviors in intensive systems (e.g., wool-pulling), and high levels of perinatal lamb mortality (i.e., "mis-mothering" by ewes) (Dwyer & Lawrence, 2008). By encouraging a collaboration among animal scientists, comparative psychologists, veterinarians, and others, the academic community could develop answers to important questions in applied sheep cognition research. For example, can we modify the design of transportation housing (trucks, ships, etc.) based on our knowledge of the sensory perception and social preferences of sheep? Or can we use operant conditioning to train sheep to stand still during shearing (which could prevent the need for restraint)? Or, given these "advanced" cognitive abilities of sheep, should we incorporate cognitive enrichment for sheep in feedlots or research facilities? Given that the quality of sheep handling by shepherds can be influenced by the stockperson's attitude toward the sheep (e.g., pigs: Coleman et al., 2000; poultry: Cransberg et al., 2000; dairy cattle: Bertenshaw & Rollinson, 2009), there is even value in using the information reviewed by M&M (e.g., subtle expressions of pain in sheep, importance of low-stress handling) to educate shepherds, stockpersons, and animal caretakers in research facilities. This education, coupled with hands-on training, may help improve the way sheep are treated by the humans interacting with them most frequently.

3. Importance of human-sheep interaction. Commercial sheep production consists of two main types of operations: extensive (large flocks grazing on rangelands or pastures) and intensive (small flocks on pastures or in feedlots). Although sheep used in commerce are more often managed extensively than other livestock species, this increase in "behavioral freedom" still comes with welfare issues (such as predation risk and parasite load) (Dwyer, 2009). M&M (2019) state that the goal of their review is to provide evidence for the argument against the use of sheep "as commodities in modern agricultural production." However, as Vonk (2019) noted, "domestic sheep do not occur naturally; they exist because of their utility to humans." To remove sheep from a production setting and place them in a sanctuary with limited human contact could actually decrease the welfare of these animals if not managed diligently. It is important that the sheep experience recurring, positive human contact (i.e., Waiblinger et al., 2006) in order to habituate the animal to handling during veterinary checks and husbandry procedures. For example, while the process of shearing is associated with physiological indicators of stress (Jephcott et al., 1987; Hargreaves & Hutson, 1990), it is essential for the health and welfare of the animal. If the animal is not sheared in a timely manner, the excess wool can obstruct thermoregulation (which can cause heat stress and death), and infections can develop if flies and maggots collect on the urine and feces trapped in the wool (Piccione et al., 2002).

A recent news article out of Australia provides an excellent example of the necessity for human-animal interaction to ensure good welfare in sheep. A hiker came across a merino ram that had wandered from its farm and lived for nearly 6 years alone in the woods. This ram was in a poor health state, as his excess wool had immobilized the animal from feeding (blocking eyesight and joint movement), skin burns developed from urine trapped in his fleece, and the weight of

his wool had caused severe hoof cracks and infections (McCaffery, 2015). After contacting the Royal Society for the Prevention of Cruelty to Animals for help, the ram was sheared of the world-record breaking weight of 89 lbs. Thus, human interaction is necessary for maintaining good welfare in woolly sheep, as we have selectively bred them to be dependent on humans (e.g., they no longer shed thicker winter coats as the mouflon ancestors did, but now require a human to remove the excess wool) (Dohner, 2001).

4. Conclusion. There are three general schools of thought when it comes to animal welfare: emphasizing the animal's (1) biological functioning, (2) opportunities for expressing natural behavior expression, or (3) subjective feelings (Fraser, 2008). M&M have provided a review of the scientific literature on sheep cognition to support their argument that sheep are more complex than they are stereotyped to be. M&M appears to take the subjective-feeling perspective (3) on animal welfare to make their point. This is understandable, as this is what the public emphasize as well (Watanabe, 2007). The research that M&M review is valid, but their inherent bias is disappointing. Much of the research that M&M have weaponized as a way to achieve their agenda — which does not seem to be to improve the welfare of sheep but to abolish their use by human beings (Francione & Garner 2010) — is actually funded by agricultural and biomedical stakeholders. Rather than using a laundry list of reports on cognitive processing in sheep as evidence that sheep should no longer be used (as a source of wool, meat, milk, or an animal model for human health), M&M could have offered solutions for extending knowledge of sheep cognition to relevant audiences in order to improve management standards and regulations.

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