

## Opinion paper: Smell: an affordable way to improve livestock welfare

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The current model of livestock management is questioned in many ways because of consumers' concern about animal welfare, safety of products and the environmental impact of meat production, which entails increasing regulations, more manpower and higher costs. Concerning the first two matters, it is widely accepted that stress of any origin (handling, transport, overcrowding, confinement, disease, unfamiliar environment) is detrimental not only to welfare, but also to yield and meat quality. These effects can be mitigated by treating animals well and by early detection of physio-pathological issues. However, it is often at the price of time-consuming acclimation of young animals to human handling and frequent, attentive observation (Des Roches *et al.*, 2016). Olfaction may be an affordable way to make up for human manpower scarcity, on the one hand, by detecting biologically significant odors (either negative like stress but also those requiring intervention like estrus), and on the other, by timely dispensing soothing or positive mood-inducing scents. Indeed, positive emotions are deemed beneficial for animal welfare and olfaction is the one sensory system to have shortcut access to the limbic system in the brain (Boissy *et al.*, 2007).

Odorants carry a wealth of information. Many of them are body odors, with high biological significance: mother–pup communication, foraging, hierarchy and kin signals, prey–predator interplay, sexual and reproduction cues, disease and death scents. As they carry information, these odorants are called semiochemicals (from the Greek *semeion* meaning 'signal'). I shall not dispute here whether they are pheromones (i.e. evoking innate, stereotyped responses) or if their meaning is learned (and odor memory is strong and long-lasting), or whether they are perceived through the main or the accessory (vomeronasal) olfactory system. It only matters that, according to species, age and physio-pathological state, they induce specific behaviors and/or moods, or give clues regarding these issues.

In some cases, the chemical composition of these products has been deciphered. However, as a rule, more research and development, as well as more education, are needed before widespread use.

Yet, as listed by Archunan *et al.* (2014), some applications have already been proposed in farm animals, mainly with the aim of enhancing productivity:

- Male scents accelerate puberty (sheep, goats, pigs, cows), induce and synchronize estrus during the non-breeding season (sheep, goats) or during *postpartum* anestrus (cattle), or elicit the standing posture characteristic of sow readiness to mate.
- Conversely, female estrus is revealed by the emission of potent semiochemicals that are detected not only by kin males (cattle, horses), but also by dogs and rats (male rats, for instance, are capable of detecting estrus-signing ketones in females; Nielsen *et al.*, 2015); female estrus scent also enhances penis erection and sperm quantity (buffalo, horses).
- 'Appeasing pheromones' – according to their commercial name – are used to reduce aggressiveness both in farm animals (pigs, horses) and pets. In pigs, this product is derived from the sow body odor. Even simpler products like grass 'green' odor improve steer behavior.
- Additional instances when odorants play a key role are feeding and foraging (perception of food olfactory clues begins *in utero* or *in ovo*), stress and fear, reproduction and maternal care, disease and environmental enrichment. These have been largely documented in rodents, but much less in livestock (Nielsen *et al.*, 2015). Last (again much more studied in rodents), body odors guide social investigation at a distance, and provide information regarding the health status of the emitter. Detection of sickness odor minimizes social interactions, thus preventing disease transmission between individuals and promoting healthy group living (Arakawa *et al.*, 2011).

As airborne chemicals are inherently difficult to control, measure and work with, progress should be made in three directions in order to improve livestock management: (i) prevention of negative odorous cues, (ii) early detection of significant ones and (iii) dispensing adequate semiochemicals.

We first need to master negative scent sources. Except in insects, fish and rodents, fear- or stress-signaling volatiles have not been identified. In mice, it happens that the alarm pheromone, produced by males and females in stressful

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conditions, contains 2-sec-butyl-4,5-dihydrothiazole, which resembles chemicals present in predator scents. Thus, as fear and anxiety could be communicative, their emission should be prevented by gentle animal handling, or isolation of potentially releasing individuals, or by spraying appeasing mixtures. If negative sources are still present, isolation from farm buildings and/or appropriate ventilation could prevent this risk.

The second need would be to automatically detect the significant odorous cues: behaviors correlated with estrus, pregnancy, stress and diseases may be inconspicuous, at least at the beginning. I suggest using electronic noses, which have come of age since their invention in the 1980s (Bernabei *et al.*, 2013). Different from many current methods which require collecting samples (i.e. needing manpower) for further analysis, these devices can give real-time (or nearly real-time) results without any sample handling. Consequently, they are valued for such purposes as raw material control or food assessment in industries. We can imagine detection portals, equipped with electronic noses, through which animals must pass when entering pens or going to the milking parlor. Besides their industrial applications, electronic nose portals are envisaged for detecting drugs or explosives in human passengers in airports or stations. Although olfactory diagnostics is currently overlooked compared with other methods, breeding should benefit from the current developments published in clinical research.

When it comes to spreading odorants, the problem is two-faced. On the one hand, except in a few, already mentioned, species, the appropriate products are unknown. On the other hand, semiochemicals need to be dispensed in a timely manner, which first requires the detection of significant cues (see above) and second, an effective diffusion system. According to the circumstance, diffusion may be performed with simple disposable scent tablets (e.g. in trucks during transport) or with stationary sprayer equipment (e.g. in stables). One of the interests of this kind of 'aromatherapy' is that, different from pharmaceuticals, semiochemical concentrations are too low to enter the organism, but rather act through stimulation of neuroendocrine pathways (Herz, 2009). This is a change of paradigm as compared with the current pharmaceutical intervention into physio-pathological processes. In addition, it would meet consumers' concern about chemical and hormonal residues in meat.

Concerning parasitism, livestock are severely affected by insects, which cause stress, anemia and even death, as many bloodsucking insects are vectors for pathogens. Because of the global climate change and increasing resistance to insecticides, insect parasitism is a growing health concern worldwide. Catching pests with pheromone traps is a common practice, but parasites could also be repelled by spreading deterrent products. A popular protection (in particular for humans) against mosquitoes is provided by *N,N*-diethyl-meta-toluamide, because it interferes with the insect olfactory receptors, yet animals do not easily put up with its irritant smell. Alternatively, some vertebrates

(mustelids, e.g. badgers) secrete semiochemicals which protect themselves against insects. Mimicking these products may open promising ways of preventing vector-borne diseases as exemplified by horse protection against the Diptera Simulid (Creton *et al.*, 2016).

Last, but not to be forgotten, breeder – and veterinarian – education must accompany the introduction of these new techniques, which potentially could alleviate their tasks, while maintaining animal welfare. Detection and diffusion devices may seem expensive, at least at the beginning, but probably less so than operating loss due to mortality and reduced performance. Moreover, they would be versatile enough to adapt to animal species, age, season, latitude, etc.

The benefit of these techniques would be to improve animal (and breeder) welfare without additional handling or extensive use of drugs. They also address an important societal demand. As consumers have become wary of intensive agricultural practices and care about animal welfare, olfactory interventions, practiced at key breeding steps, may offer new alternative methods for farmers. Chemical ecology, applied to livestock, calls for the mustering of forces from various fields, from olfaction to veterinary science, through reproduction, entomology, ethology, neurosciences, molecular biology and chemistry, and engineering. Either in research or on farm practice, the invisible influence of odors is liable to bring unexpected results, at a moderate cost but with positive consequences.

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