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THE USE OF AEROSOL REPELLENTS AS AN AVIAN DETERRENT STRATEGY

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ABSTRACT: Traditional protective measures to keep wildlife away from areas include exclusion by use of netting, hazing, and chemical repellents. The primary problem with most hazing systems is that wildlife quickly habituate to the devices if their use falls into a predictable pattern. Repellent substances cause wildlife species to avoid otherwise attractive or palatable resources by creating a disincentive to visit a specific area or consume a particular resource. Chemical repellents, both lethal and non-lethal, are typically used for agricultural and horticultural purposes, but in addition may provide a strategy to deter wildlife in other contexts. Aerosol delivery of chemical repellents might work to effectively target birds in the air prior to landing in a hazardous area (i.e., a toxic waste water impoundment). In theory, aerosol delivery of a known avian irritant could be used as an ancillary tool in bird hazing systems, to complement more traditional auditory and visual scare tactics.

KEY WORDS: aerosol, repellents, hazing, trigeminal irritants, methyl anthranilate

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Traditional protective measures to keep wildlife away from areas include exclusion by use of netting, hazing, and chemical repellents (Jackson 1990; Hyngstrom et al. 1994). However, exclusionary netting or fencing may not be economically or logistically feasible when large areas need to be protected. Additionally, fencing tends to restrict access for most terrestrial vertebrate species, but does little to prevent birds from utilizing the resource. Common hazing techniques rely on auditory and visual devices to repel birds from an area, e.g., bird distress calls, pyrotechnics, propane cannons, flashing lights, effigies of humans or predators, and flagging (Allen 1990; Jackson 1990; Denver Knight Piesold 1992). These techniques are usually presented on a static (i.e., continuous) or timed interval schedule. The primary problem with most hazing systems is that wildlife quickly habituate to the devices if their use falls into a predictable pattern (Allen 1990). In terms of an operant conditioning paradigm, habituation is defined as the extinction of a behavioral response (i.e., an avoidance response) due to the lack of a salient reinforcing stimulus (Lehner 1996). For example, numerous techniques were employed at the Paradise Peak Gold Mine to prevent bird use of the cyanide leachate ponds, but within a few days birds were observed perching on, or swimming around, the 6,000 watt loudspeakers and propane cannons (Allen 1990). Thus, habituation can account in large part for the failure of most traditional hazing systems.

Repellent substances cause wildlife species to avoid otherwise attractive or palatable resources by creating a disincentive to visit a specific area or consume a particular resource (Rogers 1980; Harborne 1982). Chemical repellents, both lethal and non-lethal, are typically used for agricultural and horticultural purposes, but in addition may provide a strategy to deter wildlife in other contexts. Primary chemical repellents tend to promote avoidance upon first exposure, whereas secondary repellents require learning to associate post-ingestional sickness with consumption of the repellent

(Rogers 1980). Secondary repellents are less desirable in situations where ingestion of a resource carries a high risk of mortality, i.e., in agricultural contexts where toxic granular pesticides may be mistaken by birds for food or grit. Most chemical compounds used in wildlife management are derived from natural plant products. Plants have responded to animal depredation by incorporating repellent or toxic chemicals into their tissues that target animal chemosensory systems, thereby eliciting chemosensory irritation as a defense mechanism (Harborne 1982). Chemosensory irritation is mediated via stimulation of the trigeminal nerve, the principle somatosensory nerve of the head that codes for mechanical, thermal, and chemically noxious stimuli. A familiar example is the transient burning sensation experienced when ingesting capsaicin, the active ingredient in chili peppers. Interestingly, this compound only affects mammals, while avian seed dispersers are insensitive to capsaicin's effect (Szolcsanyi 1986; Clark 1998). Birds are sensitive to other naturally-derived compounds, however (Mason et al. 1992; Shah et al. 1992). Methyl anthranilate (MA), the principle ingredient of grape flavoring, has been shown to be a potent avian irritant (Kare 1961). MA has been successfully used as a non-lethal repellent in laboratory feeding (Glahn et al. 1989; Mason et al. 1989; Cummings et al. 1992; Avery et al. 1995) and drinking trials (Dolbeer et al. 1992; Clark and Shah 1993; Belant et al. 1995; Clark 1996), and as a topical application to turf grass (Cummings et al. 1995), landfills, and standing water at airports (Dolbeer et al. 1993) to minimize the extent of bird-associated damage.

Waste water impoundments resulting from industrial operations can be a significant contributory risk factor for morbidity and mortality of migratory birds (Kay 1990; Denver Knight Piesold 1992). The risk is increased when these sites occur in arid areas where potable water is generally less available. For example, impoundments located in deserts can attract migrating waterfowl to areas

not previously documented to be migratory flyways (Allen 1990). Artificial waste containment ponds such as those affiliated with gold mining activities can be acutely lethal to birds upon contact or ingestion, or may generally reduce health due to bioaccumulation of toxic substances (Clark and Shah 1991). In these situations, incorporating topical applications of chemical repellents (i.e., to the pond surface) would still allow waterfowl contact with hazardous materials, and would most likely not achieve the goal of zero mortality established by regulatory requirements. For this reason, chemical repellents have not previously been used as a protective tactic in industrial waste water settings.

Aerosol delivery of chemical repellents, however, might address this shortcoming, and work to effectively target birds in the air prior to landing. The nociceptive system that mediates the detection of orally presented irritants also innervates the mucosae of the nose and eyes. The principle behind the use of avian aerosol repellents, therefore, is the same as that exploited in the use of CS and CN tear gases for human crowd control (Yih 1995; Anderson et al. 1996). Aerosol delivery strategies have also been used in agricultural contexts to effectively disseminate insect pheromones in communication-disruption programs. It was found that "puffer cans" (aerosol-releasing devices) provided an efficient means to target insect pheromone receptors under field conditions (Shorey et al. 1996). In order to determine the efficacy of such a deterrent strategy for birds and the nature of the behavioral response to aerosols, laboratory trials were conducted in which European starlings (*Sturnus vulgaris*) were exposed to short (30 second) aerosol bursts of methyl anthranilate (Stevens and Clark in prep., a). Results illustrate that birds demonstrate a clear irritation response to MA aerosols, with no evidence of habituation (i.e., reduced responsiveness) under repeated exposures.

In theory, aerosol delivery of a known avian irritant could be used as an ancillary tool in bird hazing systems to complement more traditional auditory and visual scare tactics. Sensory irritation caused by contact with MA aerosols would be the aversive reinforcing stimulus that attaches a tangible consequence—a punishment—to the visual and auditory stimuli (Lehner 1996). The integration of such a chemical irritant could thus boost the efficacy of the system as a whole by increasing the salience of these other stimuli and minimizing habituation.

In the field, aerosol delivery strategies must take into account factors affecting aerosol plume behavior. Standard plume monitoring involves measurements of windspeed and direction, the amount of effluent released, the source height, and initial velocity of the plume (Neiburger 1973). For large-scale plume releases, e.g., industrial smokestacks, knowledge of weather conditions and local topography also contributes to monitoring efforts (Briggs 1969). For the relatively small scale on which aerosol hazing devices would operate, the most important factor to measure is aerosol droplet density as a function of source height, downwind distance, and windspeed. If birds' threshold sensitivity to the repellent is also known (i.e., from laboratory studies on concentration-response relationships), droplet density measurements in the field can significantly aid in predicting whether or not incoming birds will respond to aerosol plume exposure.

Software packages that model aerosol plume behavior have been developed for use in the industrial sector to aid in site selection of hazardous materials or to predict downwind effluent concentrations. Clark and Shah (1992) have applied this technology to predict olfactory-mediated foraging behavior in Leach's storm petrels (*Oceanodroma leucophrys*). Application of aerosol plume models to the planning of bird hazing operations will allow system managers to optimize placement of aerosol sprayers in order to maximize the likelihood of targeting birds in flight with an effective dose. Computer simulations of plume behavior must incorporate data on prevailing wind conditions, bird flight patterns over the protected area, estimates of aerosol sprayer coverage, and avian detection thresholds (Stevens and Clark in prep., b). Initially this necessitates intensive field observations, but avoids inefficiencies and errors in the siting of hazing devices within the protected area.

In conclusion, results of recent laboratory and field studies indicate that incorporating aerosol delivery of a chemosensory irritant such as methyl anthranilate into a bird hazing system can minimize habituation and increase the efficacy of the system as a whole. Aerosols provide a practical and efficient solution to traditional bird hazing problems, and merit further investigation and refinement as an avian deterrent strategy.

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