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PHEROMONES: THEIR POTENTIAL FOR GROUND SQUIRREL CONTROL

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ABSTRACT: Olfactory communication appears to be an important aspect of the biology of most ground squirrels. Several scent-producing glands have been described as having scent-marking behavior. Although the adaptive significance of these glands has not been determined, possible functions are discussed. The potential of using pheromones in an integrated ground squirrel management program is discussed.

INTRODUCTION

There is overwhelming evidence that chemical signals of an olfactory nature modify many social activities of mammals. While these chemicals can be from many sources (e.g., various types of food), those known as pheromones probably have the greatest potential for modifying key behavior of rodents. A pheromone is a chemical secreted by one organism that influences the behavior of another organism of the same species.

Communication via pheromones has several advantages for the squirrel over visual or auditory signals. For example, pheromones could have value in total darkness, as in a burrow or dense vegetation, where transmission of visual messages would be severely limited. Highly volatile pheromones can be carried some distance by air currents, potentially much farther than a visual or auditory display. Once a pheromone is deposited it can remain at that site and transmit the message for a period after the sender animal has left the area. That can be a distinct advantage over visual or auditory displays in situations such as marking territorial boundaries.

It has been suggested that pheromones can function for recognition of individuals or groups of animals to determine the age, sex, and reproductive status of a conspecific; to mark home ranges, territories, trails, or other specific locations; as a warning defense or alarm, distress, and/or other signal; or to indicate social status, such as dominance or submissiveness. If it can be shown that ground squirrels utilize pheromones in such ways, it might be possible to develop methods of using pheromones to manipulate ground squirrel behavior so as to minimize ground squirrel/human conflicts.

While practical application of rodent pheromones has received little attention, extensive research on insect pheromones has resulted in their use in integrated insect management of some species (Tette, 1974). Even though knowledge of rodent pheromones is very limited, especially those of ground squirrels, their potential use in rodent control programs should not be overlooked. Christiansen (1976) gives a general overview of the potential of pheromones in rodent control.

SCENT GLANDS AND SCENT-MARKING BEHAVIOR

Olfactory communication appears to be an important aspect of the biology of most ground squirrels (Steiner, 1975; Kivett *et al*., 1976). Integumentary glands of many species of ground squirrels have been described, as have various behaviors believed to be associated with scent marking by those glands (Kivett *et al*., 1976). Three glandular areas on the squirrel's body are particularly obvious and have been described by several workers, although their function remains unknown.

The oral or cheek glands, in the skin at the corners of the mouth, produce a secretion which is deposited at the base of the hair (Kivett, 1975). A characteristic behavior pattern of wiping the cheek on prominent objects has been described by several investigators (Owings *et al*., 1977; Kivett *et al*., 1976; Steiner, 1975). These glands may be involved also in individual or group recognition Steiner, 1973, 1975) as well as food-seeking, investigation, or sharing (Steiner, 1975).

Apparently all ground squirrels of the genus *Spermophilus* have a series of scent glands located in the skin over the scapular region of the back. This dorsal gland consists of many individual small glands positioned in a particular pattern although with some variation between individuals and species. As with the oral gland, the dorsal gland produces a secretion which is deposited on hairs. The secretions are transferred from hairs to the substrate by a characteristic twist-marking behavior. The animal first makes contact between the oral gland area and the object to be marked, then rolls on its shoulder and finally applies the dorsal gland region to the object to be marked (Kivett, 1975; Quanstrom, 1971; Steiner, 1973). The secretion can be deposited also by rubbing the dorsal area on particular objects without association with the cheek gland (Kivett *et al*., 1976).

The anal gland, in the posterior area, as the name suggests, is often mentioned in studies of olfactory communication of *Spermophilus*. The anal gland, consisting of three papillae (one median and two lateral to the anal openings), produces a small amount of secretion which, because of the gland's location, is likely to be transferred to the feces as it passes out the anus. The secretion can also be deposited on the ground by dragging or otherwise touching the gland region on the substrate.

FUNCTION OF THE PHEROMONES

Because the actual messages transmitted by the scents, or pheromones, of ground squirrels have not yet been positively determined, the following comments offer some clues to possible roles of pheromones to ground squirrels and how these might be exploited in squirrel population control methods.

The relationship between amount of pheromone secretions and the breeding season has been demonstrated in many rodent species (Stoddard, 1974). It is for this reason that some pheromones are believed to be associated with reproduction. In the Columbian ground squirrel (Spermophilus columbianus) both the oral gland and the dorsal glands enlarge during the reproductive season (Kivett, 1975). Steiner (1974) observed anal-dragging behavior in Columbian ground squirrels during the reproductive period, and he suggests that that has a role in reproduction.

Pheromones of ground squirrels may be important also in aggressive interactions between conspecifics. A meeting of two male California ground squirrels (Spermophilus beecheyi) often leads to extensive investigation of the anal, dorsal, and cheek gland areas. Each male may be using pheromones to assess the potential aggressiveness of the other male. Specific greeting behaviors which are believed to be associated with pheromones are common with many ground squirrels. This behavior, generally involving sniffing of the oral gland region, may be for identification of individuals or members of the squirrel's social group (Steiner, 1975).

Many scent-marking behaviors of ground squirrels are directed toward objects the animal may encounter, such as burrow openings or mounds (Quanstrom, 1971), rocks (Armitage, 1975), logs, sticks, and other prominent objects. The squirrel may mark objects to identify them as a possession, to warn others that the marked area is occupied, or as orientation or familiarization cues. Whatever the intent of the scent mark, it may elicit particular behaviors from conspecifics: attraction to a particular area, initiation of food-searching behavior, repellency, aggressiveness, etc.

Ground squirrel pheromones might serve as alarm or warning signals. They are not likely to be used to repel predators by producing a noxious taste or smell, but they may warn nearby squirrels of impending danger.

Undoubtedly there are other messages communicated by ground squirrel pheromones that have not been observed. Continued research is needed to study ground squirrel pheromones as well as to define their adaptive significance.

PHEROMONES AND GROUND SQUIRREL CONTROL

Speculation on possible methods of application of pheromones to ground squirrel control leads to some interesting ideas. It is obvious that present information is insufficient for pheromones to be applied today in a program of ground squirrel control. The following are pure speculations.

Once the actual messages of the specific pheromones are known, application to ground squirrel control may be feasible. Pheromones with attractant properties could be used to improve trapping efficacy by attracting animals into traps or to bait stations, reducing the period of neophobia to the station. With an attractive pheromone the amount of bait needed to obtain control might be drastically reduced by improving the animal's ability to locate widely dispersed baits. Pheromones that are used as territorial markers or location markers might be useful as area repellents. While it is generally accepted that these types of scents do not prevent other animals from entering the marked area, the intruding animals may still have reluctance about entering, especially if a negative stimulus such as a sound or mechanical scaring device were also used. Alarm pheromones, if they exist, might also help repel animals from specific areas.

Pheromones involved in reproduction are logical candidates for use in controlling pest populations. While pheromones that influence estrus and pregnancy have not been demonstrated in ground squirrels, they have been found in other rodent species. It may be possible to manipulate these pheromones so as to reduce the reproductive rate, an obvious advantage in rodent control. A delay of reproduction could have considerable impact on the total squirrel population by lowering survival probabilities for the young because optimal food resources would not be available.

Application of pheromones to ground squirrel control will depend on full understanding of the pheromones in relation to the complete sociobiology of the animal. I seriously doubt whether pheromones alone can effectively control ground squirrel populations, but their use as part of an integrated management program might prove to be highly effective.

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