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Notes and Discussion

Wolf Population Survival in an Area of High Road Density

Abstract.—Wolf mortality in a high-road-density area of Minnesota exceeds that in an adjacent wilderness, and is primarily human-caused. The wolf population there is maintained primarily by ingress from the adjacent wilderness areas. A road density of 0.58 km/km^2 can be exceeded and the area still support wolves if it is adjacent to extensive roadless areas.

Introduction

A primary source of wolf (*Canis lupus*) mortality is interactions with human beings. Wolves are hit by cars (DeVos, 1949; Mech, 1977; Berg and Kuehn, 1982) and shot and trapped illegally (Weise *et al.,* 1975; Robinson and Smith, 1977). Therefore they tend to survive where human density is low (Hendrickson *et al.,* 1975), and the density of roads passable by 2-wheel-drive vehicles is <0.58 km/km^2 (Thiel, 1985; Jensen *et al.,* 1986; Mech *et al.,* 1988). The present study examines wolf mortality in an area where road density exceeds 0.58 km/km^2 but that is adjacent to an extensive area having fewer roads.

Study Area

The study area was a 975-km^2 region in the Superior National Forest just N of Isabella, Minnesota, with a road density averaging 0.73 km/km^2, including U.S. Forest Service Road types A, B and C (U.S. Forest Service, 1986). About 80% of the roads are impassable by vehicles during winter but all can be traveled by snowmobile. Immediately N is the Boundary Waters Canoe Area Wilderness, a roadless region contiguous with the entire Canadian wolf population. In the other directions, the mean road density is lower than that of the study area.

The study area encompassed the territories of the Jackpine and Sawbill wolf packs as well as parts of three or four others (Mech, 1973, 1986). After October 1970, wolves on federal property, which comprised ≥90% of the land within the study area, were legally protected, and after August 1974 all wolves were protected. In winter the study area supported the only white-tailed deer (*Odocoileus virginianus*) for at least 20 km to the W, E and N. Deer are the major wolf prey in this area (Nelson and Mech, 1986).

Methods

Wolves were radio-tagged from 1969 through 1986 and located at least weekly by aerial radio-tracking (Mech, 1974). Dead animals were examined for cause of death. I assumed that radio collars removed from wolves by humans represented animals killed by humans.

Results

Seventy-one wolves were radio-tagged in the study area. Of those, eight are currently being monitored, 15 (21%) died of human causes, another 17 (24%) probably were killed by humans, and 17 died natural deaths. (The signals from 14 others were lost prematurely, which could have indicated radio failure, dispersal or additional human-caused mortality.) Thus, total known or probable mortality was 69%, most of which was known or probable human-caused. Some 60% of the human-caused mortality occurred after wolves were protected by the Endangered Species Act of 1973. In addition, nine radio-collared wolves from outside the study area immigrated there, and two of them were killed by humans, and four others probably were. At least one other member of an immigrating radio-collared pack was shot.

Dispersers caught elsewhere also used the area as part of their larger ranges (Mech and Frenzel, 1971; Mech, 1986), so they were exposed to the same mortality as resident wolves. They also could colonize the area (Rothman and Mech, 1979; Fritts and Mech, 1981). Of three breeders whose origins were known, two immigrated into the area.

Of 53 wolves radio-tagged just N of the study area during the same period, 22 emigrated from the roadless area, eight of which immigrated into the study area, at least one being shot there; four that immigrated to other accessible areas were also killed by humans. Causes of death are known for 10 wolves that remained in the roadless area, and all were natural. No human-caused mortality was discovered in the roadless area despite accessibility by hiking trail and canoe.

Discussion

My study area had 26% more roads than other areas of similar habitat where wolves did not survive (Thiel, 1985; Jensen *et al.,* 1986; Mech *et al.,* 1988); yet it supported wolves throughout the study. These wolves sustained unusually high human-caused mortality, with survival below the threshold required to maintain a wolf population (Mech, 1970:63–64; Peterson *et al.,* 1984; Ballard *et al.,* 1987). Thus it appears that the main reason this area continued to support wolves was that it lay adjacent to regions of low road density.

I conclude (1) that the road-density threshold described by other studies applies most directly to areas not adjacent to large reservoirs of occupied wolf range, and (2) that relatively small areas of high road densities can sustain wolves so long as suitable roadless reservoirs are nearby.

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Selective Fruit Abscission by Juniperus monosperma as an Induced Defense against Predators

ABSTRACT.—Abscised fruits of *Juniperus monosperma* were more likely to contain predator larvae than were undamaged fruits. Larvae in abscised fruits were more likely to die than larvae in fruits still attached to the tree. Selective abscission of damaged fruits is viewed as an adaptive plant defense for two reasons: (1) abscission reduces the plant's losses by terminating any further investment into a doomed propagule; (2) abscission may reduce the number of fruit predators that mature to attack future fruit crops.

INTRODUCTION

Although environmental variables are usually considered the most common factors leading to the abscission of plant parts (*e.g.*, late frosts: Addicott and Lynch, 1955; Hutchinson and Bramlett, 1964; high temperatures: Addicott and Lyon, 1973), here we consider the importance of abscission as a way of reducing the impact of fruit and seed predators. Although it is well-documented that seed predation by insects results in the selective abscission of young fruits (*e.g.*, Lloyd, 1920; Phillips, 1940; Janzen, 1969, 1971a, b; Mattson, 1978; Boucher and Sork, 1979; Queller, 1985), we are aware of no studies that demonstrate the impact of fruit abscission on insect pests.

Several benefits of selective abscission for the plant have been proposed. (1) Selective abscission of damaged fruits is a mechanism whereby plants terminate investment in fruits that contain offspring that would be unlikely to contribute to future generations (*e.g.*, Stephenson, 1981). (2) The energy saved by terminating damaged fruits can be reallocated to other healthy fruits to increase their attractiveness and/or survival (Stewart and Sterling, 1988). (3) Janzen (1971a) suggested that fruit abscission dumps larvae into a hostile environment where they must make do with fewer nutrients. If true, selective fruit abscission may increase pest mortality and reduce the herbivore population. To the extent that selective abscission saves valuable nutrients and energy which can be reinvested and/or reduces the pest population, then abscission should be considered a plant defense (Williams and Whitham, 1986). We do not argue that abscission has evolved solely in response to herbivory, but rather represents a generalized plant trait that may serve several adaptive functions.

This paper addresses the pattern of fruit predation by unidentified larvae of Anobiidae (Coleoptera) (W. E. Clark and H. R. Burke, pers. comm.) and fruit abscission by *Juniperus monosperma* (Engelm.) Sarg. (Cupressaceae), the one-seed juniper. Two questions are addressed: (1) Is abscission selective in singling out predator damaged fruits for removal? If abscission represents an adaptive host response to insect attack, damaged fruits containing larvae should be selectively abscised and we would expect abscised fruits to contain more predators than fruits remaining on the tree. (2) Does fruit abscission reduce predator survival? For selective abscission to represent a meaningful defense against fruit