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Potential Effects of Insecticides on the Survival of Dabbling Duck Broods

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Potential Effects of Insecticides on the Survival of Dabbling Duck Broods

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ABSTRACT — The effect of insecticides on the survival of dabbling duck broods was investigated by reviewing studies of natural brood survival and depression of growth rates for ducklings raised on wetlands treated with insecticides. Ducklings raised on an insecticide-treated wetland took 5 days longer to reach the normal 14-day body weight. Normal brood mortality for three species of dabbling ducks was highest in the first two weeks of life and ranged from 25% to 51%. High mortality of young ducklings is probably related to their small size. Thus, mortality rates could be increased to 35% to 70% because of the delay in growth. Other potential effects of invertebrate reductions on breeding dabbling ducks are discussed and suggestions for future research are provided.

Introduction

Most persistent insecticides are no longer used in the United States because they can produce harmful physiological and behavioral effects in wildlife (1, 2, 3, 4). Insecticides that are currently used are usually short-lived and relatively nontoxic to vertebrates at normal application rates, but many are very toxic to aquatic invertebrates.

Invertebrate food availability is an important factor influencing the attractiveness of wetlands to breeding dabbling ducks and ducklings (5, 6). Breeding female dabbling ducks (7, 8) and ducklings (9) rely heavily on invertebrates to meet their nutritional needs. Insecticide applications that reduce invertebrate abundance and increase energy or time costs for breeding females or ducklings to acquire their essential needs will probably reduce reproductive success. However, only one study has documented this effect. In a study of the growth of captive ducklings reared on control and experimentally sprayed ponds in Maine, Hunter et al. (10) found depressed growth rates resulting from insecticide application.

The effect of mosquito control programs on the survival of dabbling duck broods is unknown. In this paper we review known information about 1) the influence of insecticide application on duckling growth rates and invertebrate abundance, and 2) the normal patterns of duckling mortality. Through integration of this information, we estimate the increase in mortality that might be expected from a broad spectrum invertebrate reduction.

Methods

Studies of the effects of insecticide application on growth rates of ducklings have been previously reported (10). A brief summary is presented here. Captive mallard (*Anas platyrhynchos*) and black duck (*Anas rubripes*) ducklings were raised on an untreated (control) pond and a pond sprayed from an airplane with carbaryl at a 840 g active ingredient/ha dosage (experimental). Ducklings were weighed each day for 7 days before spraying and for 8 days after spraying. Duckling behavior and invertebrate abundance were also recorded during the experiment.

Studies of the normal mortality patterns of ducklings have also been reported (11, 12), but we provide the following brief summary. Brood females were radiotracked so that they and their broods could be repeatedly sighted. Reductions in the number of ducklings in individual broods could then be accurately estimated over known time intervals and would include mortality of entire broods.

From the above two types of study, we have first estimated how much longer it takes ducklings raised on ponds treated with insecticides to reach a particular stage of development than ducklings raised on control ponds. This information was combined with a daily mortality estimate derived from the natural mortality that might result from a broad spectrum invertebrate reduction.

Results

Effects of insecticide application on duckling growth

Ducklings raised on ponds sprayed with carbaryl grew significantly more slowly than ducklings raised on control ponds (Figure 1) (10). Control ducklings gained more weight each day than the experimental ducklings.

Application of the insecticide also influenced duckling behavior (10). After spraying, ducklings on the experimental pond increased the time they spent searching and moving about from 37% to 46%, whereas ducklings on the control pond actually reduced the time spent moving and searching (43% to 34%). Ducklings on the experimental pond reduced

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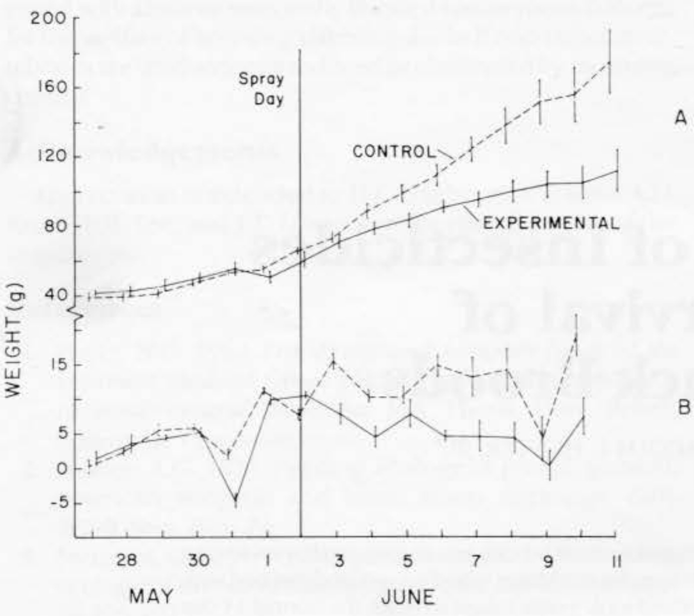

Figure 1. Morning weight (A) and net weight change from morning to morning (B) ($X \pm SE$) for ducklings on the control (---) and experimental (—) ponds (10).

the amount of time they spent resting or in comfort movements from 33.0% to 23.2%, but ducklings on the control pond increased time spent in these activities from 29.0% to 37.1%.

The reduction in growth rate and change in behavior seemed related to differences in invertebrate numbers and biomass (10). Before spraying, there were no differences evident between the numbers and biomass of invertebrates in control and experimental ponds (Figure 2). But after spraying, invertebrate numbers and biomass were consistently higher on the control pond.

Mortality patterns of wild duck broods

Mortality was greatest during the first two weeks of life in wood duck (*Aix sponsa*) and mallard broods in Minnesota (11), and black duck broods in Maine (12) (Figure 3). During the first two weeks, 51% of all wood duck ducklings, 39% of all mallard ducklings, and 25% of all black duck ducklings died. Total mortality for the entire brood rearing period was 59% for wood ducks, 56% for mallards, and 57% for black ducks. High duckling mortality rates during the early stages of rearing have been reported by others for wood ducks (13), black ducks (14), and mallards (15, 16).

Predicted effects on brood survival

The mechanisms of brood mortality (i.e., predation, starvation, intolerance of inclement weather) probably have greater effect on ducklings less than two weeks old because of their small size. Any depression in growth rate would probably increase the amount of time ducklings are most vulnerable and thus increase brood mortality. An estimate of the increase in brood mortality rates can be determined using results from previous studies, although this estimate should be used with caution because it is not based upon observed effects.

Based upon research in Maine (10), ducklings raised on a treated wetland would be expected to reach the same body

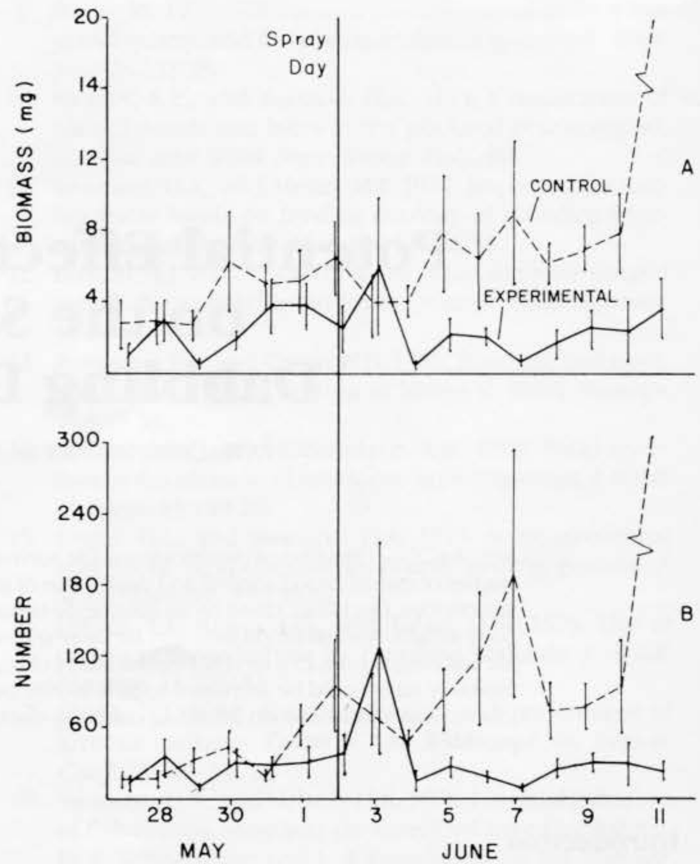

Figure 2. The mean daily biomass (A) and numbers (B) ($X \pm SE$) of invertebrates in sweep net samples on the experimental (—) and control (---) ponds (10).

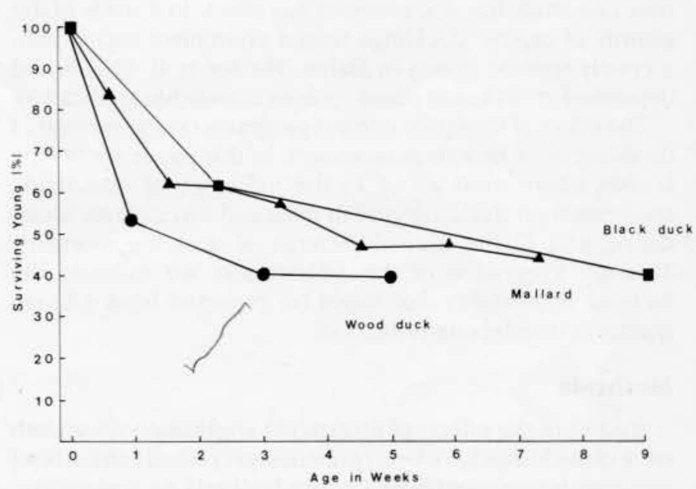

Figure 3. Survival of wood duck and mallard broods in Minnesota (11), and black duck broods in Maine (12).

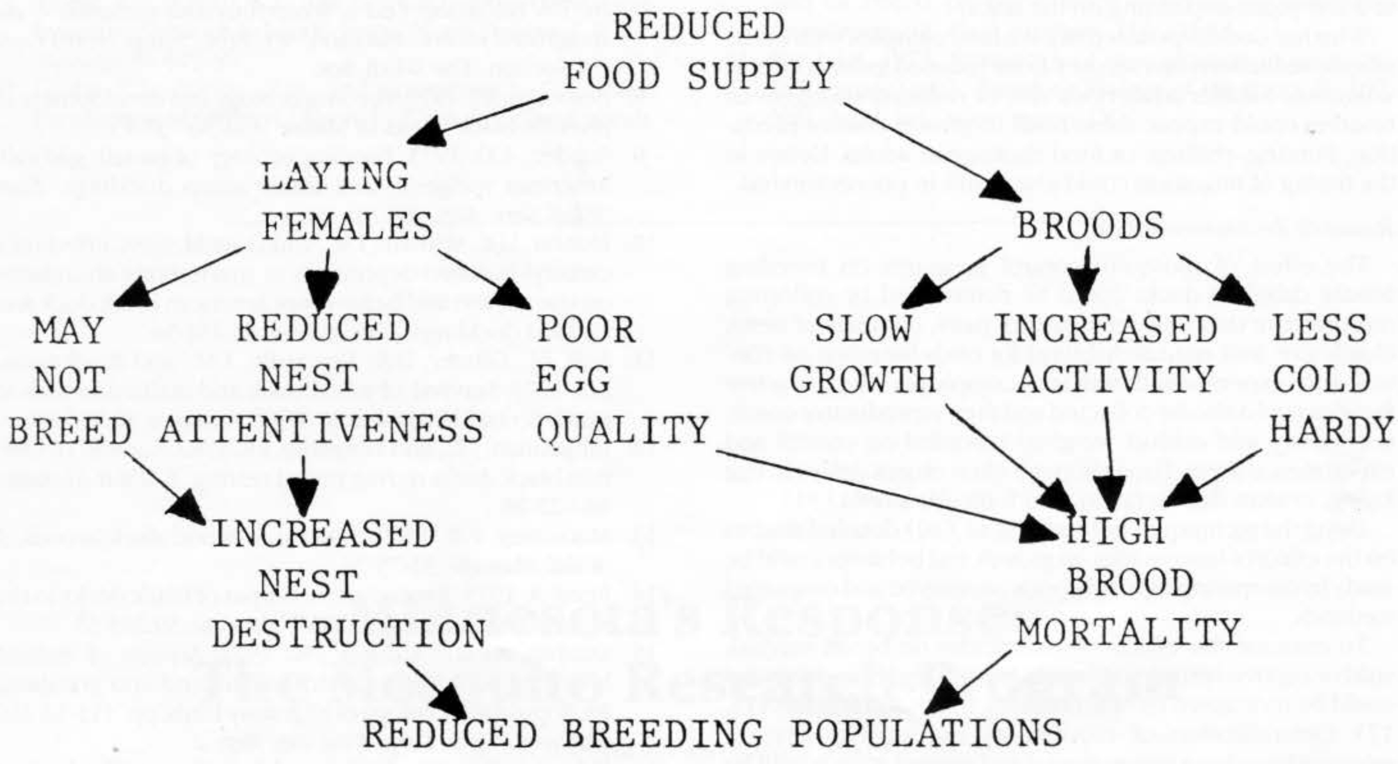

Figure 4. Potential effects of invertebrate reductions on the breeding biology of dabbling ducks.

weight at 19 days of age as ducklings raised on an untreated wetland at 14 days. The period of maximum vulnerability (up to two weeks) would thus be increased by 37%. Using the mortality rates observed by Ball et al. (11) and Ringelman and Longcore (12), the increase in time of maximum vulnerability could increase mortality rates for wood ducks to 70%, mallards to 54%, and black ducks to 35% for the first 14 days of life. If mortality accrued as in normal broods through the 6-8 week remainder of the growth period for these species (17), total mortality would be 78% for wood ducks, 71% for mallards, and 67% for black ducks.

Discussion

Any event that significantly reduces the food supply of breeding female dabbling ducks or growing ducklings may produce dramatic effects (Figure 4). Reductions in food quantity or quality would first affect egg laying females and could result in termination of egg laying, laying of fewer eggs than normal, reduced egg weight, nest abandonment, and/or reduced egg hatchability (18).

The reduced egg weight resulting from a poor maternal diet could impair survival of ducklings. Female mallards fed a balanced control diet laid larger eggs than females fed a poorer quality diet (18). Ducklings hatched from larger eggs (>47g) survived food deprivation longer than did ducklings hatched from smaller eggs (<45g). A similar influence of maternal diet on egg "quality" has been reported in red grouse (*Lagopus lagopus scoticus*) populations (19).

Reduced invertebrate abundance could impair growth and survival of ducklings because dabbling ducks rely heavily on invertebrates through the first 3-6 weeks of life (9, 6, 8). Only two studies have focused on the effect of insecticides on broods. Increased mallard duckling mortality resulting from application of an insecticide (Dursban) has been demonstrated in a freshwater environment (20). The total mortality of mallard ducklings was 42% on treated ponds and 0% on control ponds. Whether the mortality was caused by toxic effects of the insecticide or reduced food availability was unclear. Hunter et al. (10) reported a decline in growth rate and changes in the behavior of ducklings that seemed related to dramatic declines in invertebrate foods.

Decreased invertebrate abundance would probably increase duckling mortality because: 1) small ducklings would be more vulnerable to predators (21, 22, 23, 24, 25) and the increase in time spent searching for food (and reduction in time resting) would make them more conspicuous to predators; 2) chilling and/or exhaustion (26, 14) would be more likely in small ducklings; the ability to survive short-term food shortages is related to body size with larger animals better able to withstand food shortages (27); 3) dabbling duck broods often move their broods overland between wetlands (11, 28, 29) and would probably undertake similar movements if faced with a food shortage, an action generally associated with high duckling mortality (11), and 4) black duck females often leave their broods and fly to other wetlands to feed. Females may make more frequent flights and/or spend more time away from the brood if they are faced with a food shortage. Considering these mortality factors, a 35% increase in mortality predicted in this report seems a conservative estimate for the increase in brood mortality occurring in the first 14 days of life.

How long would the effects of an invertebrate reduction linger? A reduction in invertebrate biomass will likely continue after spraying until ovipositing adults recolonize the pond (30). For most invertebrates, this will take a few weeks to a few years, depending on the taxon.

Whether ducklings raised in a wetland complex with invertebrate reductions can recover from reduced growth rates is unknown. Smaller adult body size or reduced endogenous reserves could expose these birds to greater risks or predation, hunting, chilling, or food shortage as adults. Delays in the timing of migration could also result in poorer survival.

Research Recommendations

The effect of mosquito control programs on breeding female dabbling ducks could be determined by collecting reproductive data (e.g., censuses of pairs, numbers of nests, clutch size, and egg hatchability) for birds breeding on control and experimental wetland complexes. Reproductive females could also be collected and their reproductive condition (ovary and oviduct weights) recorded on control and experimental areas. Food shortage often causes delays in egg laying, ovarian degeneration, and follicular atresia (31).

Using the techniques of Hunter et al. (10) detailed studies on the effect of insecticides on growth and behavior could be made by comparing captive broods on sprayed and unsprayed wetlands.

To examine the effects of insecticides on brood survival, wild or captive-reared, wild-strain broods and brood females could be monitored by radio-tracking the brood females (11, 12). Determination of movements and survival rates of released broods on experimental and control areas would be an effective measure of the insecticide's effect on brood survival and habitat use.

In areas where the food habits of wetland birds are unknown, feeding birds should be collected to determine their food preferences before insect control is initiated. By comparing the known foods to the invertebrate taxa that will be killed, probable conflicts could be discerned. For example, dabbling duck broods are often found on ponds that have high Chironomid populations (29). *Bacillus thuringiensis israelensis* is an effective agent against mosquito larvae and some species of midge (Chironomidae) larvae. But it is unknown if the midge larvae killed by *B.t.i.* are the same species that are important foods of breeding female and duckling dabbling ducks.

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