The Role of the Red-Winged Blackbird, *Agelaius phoeniceus*, as a Predator of Insects

by

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ABSTRACT

M.Sc. Barry E. Bendell Entomology

The role of the Red-winged Blackbird,
Agelaius phoeniceus, as a predator of insects

The impact of predation by the Red-winged Blackbird, *Agelaius phoeniceus*, on populations of the European corn borer, *Ostrinia nubilalis* (Hübner), and the picnic beetle, *Glischrochilus quadrisignatus* (Say), has been studied in the vicinity of a major blackbird roost at Beauharnois, Quebec. Both insects were recovered from blackbird gut contents. A significant relationship was found between estimates of corn borer populations and their distances from the roost. Activity of the picnic beetle, as monitored with baited pitfall traps, fell to low levels before blackbirds became active in corn fields. During the breeding season, neck-collar food samples were obtained from nestlings. These indicated a high risk of predation for some insect species feeding on grasses, alfalfa and clover. No evidence was found that blackbirds were attracted by moderate insect populations in either corn fields or other habitats.

RESUME

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L'importance du carouge à épaulettes,
Agelaius phoeniceus, en tant que prédateur d'insectes

Les effets de la prédation par le carouge à épaulettes, *Agelaius phoeniceus*, sur les populations de la pyrale du maïs, *Ostrinia nubilalis* (Hübner), et du nitidule à quatre points, *Glischrochilus quadrisignatus* (Say), ont été étudiés à proximité d'un important dortoir à Beauharnois, Québec. Ces deux espèces d'insectes ont été retrouvées dans les contenus stomacaux des carouges. Une relation significative a été trouvée entre les estimations des populations de la pyrale du maïs et la distance de ces populations au dortoir. Des échantillonnages au moyen de pièges à fosse avec appât ont démontré que l'activité du nitidule à quatre points a diminué avant que les carouges aient envahi les champs de maïs. Durant la couvaison, des échantillons de bol alimentaire pris sur des oisillons au nid, ont indiqué un risque élevé de prédation pour certaines espèces d'insectes trouvées sur de la luzerne, du trèfle et des graminées. Il semble que le carouge à épaulettes ne soit attiré ni par les populations modérées d'insectes des champs de maïs, ni par celles des biotopes avoisinants.

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GENERAL INTRODUCTION

The present study was undertaken as part of a larger research program, under Agriculture Canada Contract #1SU77-00424, on the ecology and behavioural patterns of the Red-winged Blackbird, *Agelaius phoeniceus*. A principal aim of that research was to determine the feasibility of using surfactants to reduce the population of blackbirds, and thereby reduce the damage they caused to agricultural crops, especially corn, *Zea mays*. As Red-winged Blackbirds have a potential role as consumers of noxious insects, it was proposed that the present study be undertaken to investigate that role in order to understand the broader ecological implications of the control of blackbird numbers.

The present study has been divided into three parts. First, samples have been obtained of food brought to nestling Red-winged Blackbirds on agricultural land; for the purpose of identifying those insects being consumed, and to assess the potential impact of blackbird predation on their populations. Second, populations of two corn insects, the European corn borer, *Ostrinia nubilalis* (Hübner), and the picnic beetle, *Glischrochilus quadrisignatus* (Say), have been assessed with respect to blackbird activity, in order to evaluate the potential impact of Red-winged Blackbird predation. Third, the role of insects as a factor affecting the attractiveness of agricultural crops as a foraging area for Red-winged Blackbirds has been examined.

LITERATURE REVIEW

Birds are amongst the most conspicuous of insect predators, and so it might be believed that they could play a major role in controlling pest insects. However, scientific evidence for such a belief is limited, and most general discussions of the biological control of insects give only brief mention of avian predation. As a result, many may have a pessimistic view of the potential effectiveness of birds as insect predators. Such a view may not be justified. The evidence supporting bird predation as an effective insect control agent is weak because of the few cases where it has been proven to be effective, but this may partly reflect the fact that avian predation is more difficult to quantify than other causes of insect mortality.

The first step in any study of the impact of bird predators on insect populations is to ascertain that birds do indeed eat the insects concerned. Reports of birds eating pest insects are commonplace, but the most reliable source of information is stomach contents. Detailed reports of the stomach contents of Red-winged Blackbirds, *Agelaius phoeniceus*, are available (Bird and Smith 1964, Hintz and Dyer 1970, Mott *et al*. 1972, Potvin *et al*. 1976, McNicol 1980), and many of these show that important pest species are consumed by blackbirds. It is now possible to compile, from the literature, an impressive list.

of pest insect species eaten by Red-winged Blackbirds. These include pests of agriculture and forestry, and even household pests. That Red-winged Blackbirds consume some abundant insect pests should not be surprising, as they are a generalist species and feed in a diversity of habitats.

Unfortunately, stomach contents do not provide a quantitative basis for the assessment of the economic importance of birds (Hartley 1948). Where the rate of a bird's digestion of an insect has been determined, it is possible to adjust counts of insects in stomach contents to determine the number of insects eaten per unit time. This has been done by Mook and Marshall (1965) to determine the number of spruce budworms, *Choristoneura fumiferana* (Clemens), consumed by Olive-backed Thrushes, *Hylocichla ustulata*. The problem of the differential digestion of insect and vegetable matter and the assessment of their relative importance in the diet of Red-winged Blackbirds has been considered by Gartshore *et al.* (1979).

Information on the diet is sometimes more easily obtained from nestling birds than from adults. Betts (1955) and Tinbergen (1960) used glass-backed nest boxes placed against a blind to directly observe the type and number of food items brought to nestling titmice (Paridae). Royama (1970) recorded this activity with an automatic camera. Samples of nestling food may be obtained by the pipe-cleaner neck-collar technique

(Orians 1966), which has been used on nestling Red-winged Blackbirds by Snelling (1968), Orians and Horn (1969), Orians (1973) and Voigts (1973).

In order to determine the proportion of the insect population consumed by birds, an estimate of the insect population is needed. For many free-living insects, this can be a formidable task. The many techniques available for sampling insect populations are almost as varied as the insects eaten by birds. For a discussion of these techniques see Southwood (1978).

In order to circumvent some of the problems involved in insect sampling and gut content analysis, it is sometimes possible to use exclosures in order to compare the survival of populations exposed to birds with those protected from them. This technique has been very effectively used to study predation by woodpeckers (Picidae) on bark beetles (Scolytidae) (Knight 1958, Shook and Baldwin 1970, Koplin and Baldwin 1970). Exclosures have also been used in some studies on lepidopteran larvae (Sloan and Coppel 1968, Thurston and Prachuabmoh 1971, Frye 1972, Morris 1972, Pollard 1979). Campbell and Sloan (1977a) discouraged birds from feeding on gypsy moth larvae, *Lymantria dispar* (L.), by placing "burlap-poultry netting strips" around trees.

In some cases birds leave identifiable clues of their predation. This is especially true of woodpeckers. Several authors have calculated the number of larvae taken by woodpeckers from corn stalks (Wall and Whitcomb 1964, Black *et al.* 1970, Frye 1972), corn ears (Barber 1942), goldenrod galls (Cane and Kurczewski 1976, Schlichter 1978) and hardwood trees (Solomon 1969, Hay 1972). The empty pupae and cocoons left by woodpeckers and titmice have been used to measure their predation (MacLellan 1958, Waldbauer *et al.* 1970, Solomon *et al.* 1976). Wearing (1974) labelled 5th instar larvae of the codling moth, *Cydia pomonella* (L.), with ^{58}Co and was able to locate their overwintering cocoons and follow their individual fates. The predation by titmice on overwintering insects in goldenrod galls (Schlichter 1978), leaf-mines (Itämies and Ojanen 1977) and pine cones (Gibb 1958) has been measured. Also, the proportion of vespid wasp nests destroyed by birds has been calculated (Windsor 1976, Gibo and Metcalf 1978).

The results of the above mentioned studies have been varied. However, several generalizations about bird predation can be drawn from them. Firstly, predation by woodpeckers, titmice and other birds on overwintering insects is often high. MacLellan (1958) found that woodpeckers destroyed 52% of cocooned larvae of the codling moth in a 6 year study on Nova Scotia apple orchards. Similarly, Wearing (1974) found that birds, especially the Silvereye, *Zosterops lateralis*, destroyed 53% of codling moth cocoons in New Zealand orchards.

Titmice destroyed 95% of codling moth cocoons on logs placed in apple orchards in England by Solomon *et al.* (1976). Titmice also destroyed 45% of the larvae of *Ernarmonia conicolana* (Heyl.) in pine cones (Gibb 1958). The Downy Woodpecker, *Dendrocopus pubescens*, and the Black-capped Chickadee, *Parus atricapillus*, attacked 60 to 80% of goldenrod galls in a study in Ontario (Schlichter 1978). Woodpeckers consumed large numbers of European corn borer larvae, *Ostrinia nubilalis* (Hübner), overwintering in corn stalks in North Dakota (Frye 1972) and Arkansas (Wall and Whitcomb 1964). Flickers, *Colaptes auratus*, destroyed 64.0 and 81.8% of the larvae of the southwestern corn borer, *Diatraea grandiosella* (Dyar), in Mississippi (Black *et al.* 1970), and 1.7 to 54.6% in different areas of Arkansas (Wall and Whitcomb 1964). In Colorado, during an epidemic of the spruce beetle, *Dendroctonus obesus* (Mann.), woodpeckers were found to reduce the beetle population in trees by 45 to 98% (Knight 1958), while at endemic levels, they reduced beetle survival 13 to 25% (Koplin and Baldwin 1970).

The results of studies on the effects of predation by woodpeckers and titmice on overwintering insect populations are markedly different from those obtained from studies on the impact of breeding birds. Betts (1955) and Tinbergen (1960) found that breeding titmice in England and Holland generally took less than 5% of available lepidopteran larvae.

However, they may have taken higher proportions (20 to 25%) of larger species (Tinbergen 1960). Morris *et al.* (1958) estimated that birds took less than 1% of an epidemic population of spruce budworm, but they believed that birds could take a higher proportion of endemic populations. Mook and Marshall (1965) estimated that the Olive-backed Thrush ate 2.1% of available spruce budworm larvae and pupae. Mook (1963) estimated that the Bay-breasted Warbler, *Dendroica castanea*, ate less than 2% of available 6th instar larvae of the spruce budworm. Gage *et al.* (1970) found that breeding birds ate 1.8 to 4.8% of large larvae and pupae of the black-headed budworm, *Acleris gloverana* (Walsingham). Several authors have stressed the potential of flocks of non-breeding birds in controlling forest insects (Redshaw 1964, Buckner and Turnock 1965, Mattson *et al.* 1968). However, Buckner and Turnock (1965) found that even when all 43 species of avian predators of the larch sawfly, *Pristiphora erichsonii* (Htg.), were considered, they had the "potential" to consume only 0.5% and 5.6% of larvae in two different years. Unfortunately, sawfly larvae may have low palatability for birds (Prop 1960), which may explain why the potential consumption of adult sawflies was much higher (5.6 and 64.9%). Mattson *et al.* estimated that flocks of non-resident birds, and especially blackbirds (Icteridae), could have consumed from 40 to 45% and 60 to 65% of the late instar larvae of the jack-pine budworm, *Choristoneura pinus* Freeman, during the 2 years of their study.

An important aspect of bird predation, mentioned by many authors, but almost never investigated, is the influence of alternate foods. Its importance can be seen when comparing the extent of predation by titmice during the breeding season (Betts 1955, Tinbergen 1960), when there is a variety and abundance of food, with predation during the winter (Gibb 1958). Betts (1955) found that tits took a negligible proportion of the population of winter moth larvae, *Operophtera brumata* (L.), during the spring, but may have taken as much as 20% of the adult females during the winter. In the tropics, Windsor (1976) found that bird predation on the nests of *Polybia* wasps rose progressively through the months of the dry season, to a high of 50%. As well, breeding territorial birds can have only a limited numerical response to changes in insect populations; an important factor, given the limited potential functional response of most birds. On the whole, reports on the effects of avian predation on overwintering insects are more common, simply because these insect populations are relatively easy to estimate and only a few predator species are involved. Studies on free-living insects have been few, and unfortunately, many of these have been incomplete and inconclusive. Most have been on forest defoliators. Studies on pests of agricultural crops have been even fewer. In addition to the studies of woodpecker predation on corn borers, studies have found high levels of predation by Red-winged Blackbirds on corn earworm larvae, *Heliothis zea* (Boddie) (Mott and Stone 1973); by Common Grackles, *Quiscalus quiscula*, on tobacco hornworm larvae, *Manduca sexta* (Johanssen) (Thurston and Prachuabmoh 1971); and by the Silvereye, *Zosterops gouldi*, on potato moth larvae, *Phthorimoea operculella* (Zeller), in Australia (Matthiessen and Springett 1973).

Work on forest defoliating insects have generally shown that birds could not possibly consume large enough numbers of these insects to affect epidemic populations. However, it has been proposed that birds could have an important impact on the low populations that occur between epidemics. It is postulated that epidemics may result when insect populations 'escape' the regulatory effects of bird predation (Morris 1958, Readshaw 1964, McNamee 1979). It is usually thought that changes in weather conditions, favourable for the development of the insect, could result in the insect population rising above a critical value at which regulation no longer occurs. The upper limit of the population is then set by the food supply. Other mechanisms for the escape of insect populations are suggested by the literature. Pollard (1979) found that bird predation was a key factor in the regulation of a population of the white admiral butterfly, *Ladoga camilla* L., and that low survival occurred during cool summers, when the period of susceptibility to predation was prolonged. In this way, he accounted for the spread of the butterfly in southern England during a period of warm summers in the 1930s and '40s. Mattson *et al.* (1968) found that jack-pine budworms in small tree stands were more susceptible to predation from flocks of non-resident birds than were budworms in large expanses of jack pine. For this reason large expanses were more likely to develop as the focus of an infestation. Campbell and Sloan (1977b) believed that outbreaks of gypsy moth could occur where there was an abundance of natural or man-made shelters protecting larvae and pupae from mammalian and avian predation.

Determining the proportion of an insect population consumed by birds cannot, in itself, demonstrate that birds are important factors in controlling an insect population. Many studies have collected data to show that bird predation is positively density-dependent over some range of the prey's population density. Density-dependence is a necessary condition for the regulation of a population, but a key mortality factor need not be density-dependent (Varley 1963); nor is showing that a mortality factor is density-dependent sufficient to demonstrate that it is a key factor. To identify a key factor, it is necessary to quantify other contemporaneous and successive mortality factors operating during the life-stages of the insect. This provides the information for a life-table which can be analyzed, using the methods of Morris (1959) or Varley and Gradwell (1960), to determine the factor(s) responsible for changes in the insect's population. Only 2 recent studies (Wearing 1979, Pollard 1979) have collected data on avian predation for inclusion in life-tables. Wearing (1979) found that bird predation made a major contribution to variation in generation mortality of the codling moth, and Pollard (1979) showed that larval and pupal mortality, thought to be due to birds, was the key factor in determining population changes in the white admiral butterfly.

In summary, it can be shown that bird predation is an important factor in the regulation of some insect populations. However, these cases are few, and it is not clear if regulation of insect populations by avian predators occurs more widely. As a rule, higher levels of predation have been shown by non-breeding birds, preying on overwintering insect populations, than by breeding birds, preying on free-living insects.

CHAPTER I

The food of nestling Red-winged Blackbirds, *Agelaius phoeniceus*, in an agricultural upland.

INTRODUCTION

Many reports have identified pest insects in the stomach contents of Red-winged Blackbirds, and this has prompted several authors (Hintz and Dyer 1970, Robertson *et al.* 1978, McNicol 1980) to suggest that Red-winged Blackbirds may be of some economic benefit. However, assessing the net economic impact of a bird from stomach contents has proven extremely difficult (Hartley 1948). The partial digestion of stomach contents makes insect species identification difficult, while the differential digestion of hard and soft bodied insects makes impossible the assessment of the relative importance of various food types. Predation on insects by Red-winged Blackbirds is particularly important during the breeding season when, for the only time during the year, insects are the most important element in the diet (Hintz and Dyer 1970, Mott *et al.* 1972, McNicol 1980). During this period, nestling food may be sampled using the pipe-cleaner neck-collar technique (Orians 1966). This technique can provide good representative samples of identifiable insect foods. Detailed reports have been published on samples from nestling Red-winged Blackbirds in marshlands (Orians and Horn 1969, Orians 1973, Snelling 1968, Voigts 1973). However, no neck-collar sampling has been done in upland areas. This is where the greatest benefit from insect predation is likely to occur, and it is also the area where the majority of Red-winged Blackbirds now breed (Graber and Graber 1963).

This study reports on neck-collar samples taken in an agricultural area near Beauharnois, Quebec. These neck-collar samples made possible the identification of insect pests being eaten and provide the basis for an evaluation of the impact that bird predation has on prey populations.

METHODS

Neck-collar samples were taken from nests located at two sites: one in Beauharnois Co. (Site 1) and another 3.1 km away in Chateauguay Co. (Site 2). Land at Site 1 was sown to grain, corn, alfalfa and clover, or was used for pasture and hay. There were few trees or shrubs in the area. Site 2 was along a railway embankment bordered by corn and fallow fields.

Neck-collars were made from flesh-coloured pipe cleaners. They were applied only when nestlings were judged to be at least three days old. All nestlings in the same nest were collared at the same time and for a period of one hour. At least two days separated successive applications of collars to the same nestlings. Food taken from the mouths and gullets of collared nestlings were preserved in alcohol for later identification. Specimens of several of the important larval forms recovered in the neck-collars were collected from the field and reared to adults in order to facilitate species identification.

Quadrat sampling was begun when it was realized that many of the larval prey which were the bulk of the nestling diet came from grasses, or alfalfa and clover. This kind of sampling allows one to evaluate the number of potential prey items available with respect to the numbers actually taken. Samples consisted of 10 0.1 m^2 quadrats of vegetation, each taken 10 paces apart, starting from a randomly selected point. Four such samples were taken in a hay field, a pasture, along a roadside ditch and a drainage ditch. Two samples were taken across the width of a mixed alfalfa and clover field. Each quadrat of vegetation was carefully examined for larvae, which were preserved in alcohol for later identification. During a second minor nesting period at site 1 in late July and early August, grasshoppers were the main component of the diet. These were sampled by taking three samples, each consisting of 50 sweeps of a sweep net, taken at randomly selected points in a hay field, in a mixed alfalfa and clover field, along a roadside ditch and a drainage ditch.

RESULTS

The contents of the neck-collar samples are presented in Tables 1, 2 and 3. A single sample represents the total amount of food taken from all nestlings in the same nest over 1 hour. All insects were identified to the family level wherever possible. Data for site 1 are presented for two periods: the principal nesting period in June and a second minor nesting

Table 1. Contents of 36 neck-collar samples - Site 1, June 2 - 21.

	No. of items	Proportion of items	Frequency of occurrence	% of total volume
Arachnida				
Phalangida	16	.072	.25	.01
Araneida	12	.054	.22	.01
Insecta				
Ephemeroptera				
Ephemeridae-A	17	.076	.17	.09
Odonata				
Libellulidae-I	1	.005	.03	.02
Orthoptera				
Acrididae - I	1	.005	.03	.01
Tettigoniidae				
Conocephalinae-I	8	.036	.11	.03
Total Orthoptera	9	.041	.14	.04
Hemiptera				
Miridae-A	1	.005	.03	<.01
Nabidae-I	1	.005	.03	<.01
Homoptera				
Cercopidae-I	7	.032	.03	<.01
Cicadellidae-I&A	29	.131	.17	.02
Coleoptera				
Carabidae-A	4	.018	.08	.01
Dytiscidae-I	1	.005	.03	.01
Scarabaeidae-A	7	.032	.11	.04
Byrrhidae-A	1	.004	.03	<.01
Elateridae-A	2	.009	.06	<.01
Cantharidae-A	1	.005	.03	<.01
Curculionidae				
Hypera punctata-I	18	.081	.14	.05
Total Coleoptera	34	.153	.47	.12
Lepidoptera				
Pyralidae-A	1	.005	.03	<.01
Tortricidae-P	5	.023	.08	.02
-I	5	.023	.06	.02
Geometridae-I	3	.014	.08	.02
Noctuidae	2	.009	.06	.02
Amphipoea velata-I	40	.180	.39	.31
Euxoa messoria-I	3	.014	.06	.02
others-I	14	.063	.22	.22
Hesperiidae-P	1	.005	.03	.01
Thymelicus lineola-I	2	.009	.06	.01
Unidentified - I	1	.005	.03	<.01
Total Lepidoptera	77	.346	.75	.65

Table 1. Cont'd..

	No.of items	Proportion of items	Frequency of occurrence	% of total volume
Diptera				
Chironomidae-A	1	.005	.03	<.01
Tipulidae-A	1	.005	.03	<.01
Hymenoptera				
Formicidae-A	7	.032	.03	<.01
Gastropoda	4	.018	.08	<.01
Shell fragments			.11	<.01
Grain	5	.023	.08	.01
Total No. of items	222			

Note: A - Adult
I - Immature
P - Pupa

Table 2. Contents of 10 neck-collar samples - Site 2, June 6 - 14.

	No. of items	Proportion of items	Frequency of occurrence	% of total volume
Arachnida				
Phalangida	17	.27	.10	.03
Araneida	2	.03	.20	<.01
Insecta				
Ephemeroptera				
Ephemeridae-A	16	.25	.70	.36
Hemiptera				
Miridae-A	2	.03	.10	<.01
Nabidae-I	1	.02	.10	<.01
Homoptera				
Cercopidae-I	1	.02	.10	<.01
Cicadellidae-I	1	.02	.10	<.01
Coleoptera				
Carabidae-A	2	.03	.20	.03
Lepidoptera				
Tortricidae-P	1	.02	.10	.01
-I	2	.03	.20	.04
Noctuidae				
Amphipoea velata-I	4	.06	.30	.09
Others-I	5	.08	.30	.26
Hesperiidae				
Thymelicus lineola-I	6	.09	.50	.12
Unidentified-I	1	.02	.10	.01
Total Lepidoptera	19	.30	.90	.53
Diptera				
Unidentified-A	1	.02	.10	<.01
Gastropoda	1	.02	.10	<.01
Shell fragments			.20	.04
Total No. of items	63			

Note: A - Adult
I - Immature
P - Pupa

Table 3. Contents of 6 neck-collar samples - Site 1, July 23 - August 2

	No.of items	Proportion of items	Frequency of occurrence	% of total volume
Arachnida				
Phalangida	2	.03	.17	.04
Araneida	13	.18	.67	.14
Insecta				
Orthoptera				
Acrididae-A	2	.03	.50	.16
Tettigoniidae				
Conecephalinae-A&I	6	.09	.17	.38
Total Orthoptera	8	.12	.67	.54
Hemiptera				
Phymatidae-A	6	.09	.17	.08
Homoptera				
Cicadellidae-A	9	.13	.50	.03
Aphidae-A&I	17	.25	.67	<.01
Lepidoptera				
Hesperiidae-P	1	.02	.17	.01
Diptera				
Syrphidae-A	1	.02	.17	.03
Dolichopodidae-A	1	.02	.17	<.01
Unidentified-I	1	.02	.17	<.01
Hymenoptera				
Formicidae-A	3	.04	.33	<.01
Crustacea				
Isopoda	1	.02	.17	.01
Grain	6	.09	.17	.08
Total No. of items	69			

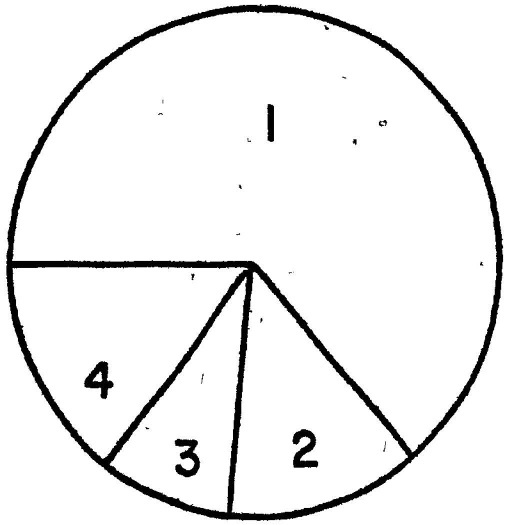
Note: A - Adult
I - Immature
P - Pupa

Figure 1. Composition by volume of neck-collar samples.

Site 1

June 2 - 21

n=36

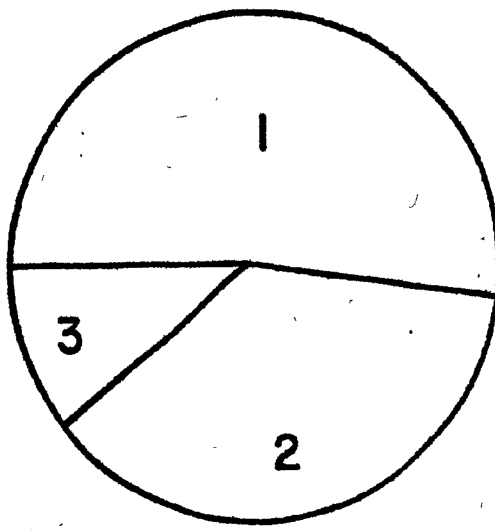


1. LEPIDOPTERA - 65%
2. COLEOPTERA - 12%
3. EPHEMEROPTERA - 9%
4. OTHERS - 14%

Site 2

June 6 - 14

n=10

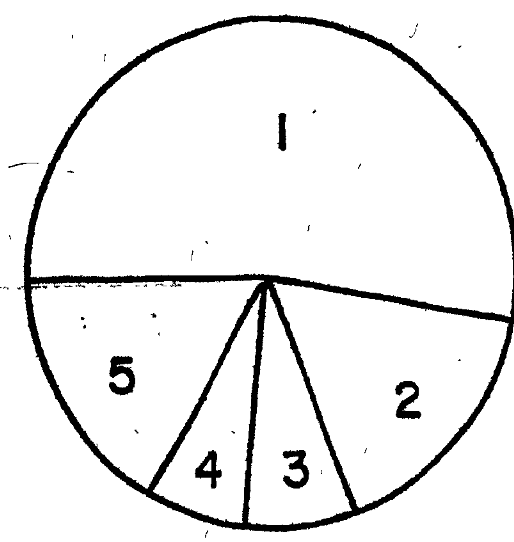


1. LEPIDOPTERA - 53%
2. EPHEMEROPTERA - 36%
3. OTHERS - 11%

Site 1

July 23 - August 2

n=6



1. ORTHOPTERA - 54%
2. ARANEIDA - 14%
3. HEMIPTERA - 8%
4. GRAIN - 8%
5. OTHERS - 16%

period in late July and early August. Most nestling activity occurred during the first two weeks of June. Eighty-six percent of all samples from site 1 during June were taken in the single week of June 5 to 12.

Nestling Red-winged Blackbirds were fed a variety of insects from 27 families in 9 orders, as well as spiders, isopods, snails and grain. However, in every collection of samples, one insect order composed greater than 50% of the volume (Figure 1). Most striking was the fact that the largest collection of samples (Site 1, June 2-21) was dominated by the family Noctuidae (54% by volume), of which a single species, *Amphipoae velata* (Walker), composed 31% of the volume of the samples. Samples taken from Sites 1 and 2 during June were both dominated by lepidopteran larvae, though Site 2 had a high proportion of mayflies (Ephemeroptera) because of its location near the Chateauguay River. Samples taken at Site 1 from July 23 to August 2 differed markedly from previous samples, in that lepidopteran larvae, mayflies and beetles were totally absent and were replaced in the diet by orthopterans and orb-weaver spiders (Araneidae). This seasonal change in the diet was also noted by Snelling (1968), and likely reflects a change from predominantly lepidopterans to orthopterans in the fauna of large herbivorous insects. As a result, greater similarities exist between samples taken in June from the two different sites than exist between samples from the two breeding periods at site 1. A significant rank order correlation exists between the numbers of items of each major classification (11 arthropod orders, snails and grain) at site 1 during June and those at site 2 (Spearman rank correlation, $r_s = 0.60$). However, no correlation exists between the major classifications (12 arthropod orders, snails and grain) at site 1 for the 2 sampling periods.

The productivity of the neck-collar samples has been calculated (Table 4) to allow comparison with other studies. In calculating these figures for the period July 23 to August 2 at Site 1, all aphids in a single sample were counted as one, because aphids, being colonial, were probably taken in aggregate. The values calculated for the number of items/nest/hour of sampling are similar to those obtained for Red-winged Blackbirds in a tropical marsh (3.4 and 4.1 items/nest/hour), but are much lower than those obtained in a highly productive temperate marsh (22 items/nest/hour) by Orians (1973). The high number of items/nest/hour recorded at site 1 from July 23 to August 2 was not significantly different from the earlier period. At site 1 in June, the number of items per hour sampling decreased from 7.1/hour in the morning period (5:00-9:00 hr) to 2.9/hour during the evening period (17:00-21:00 hr). However, these differences were not significant (Median test).

Several pest species were identified from among the larvae in the nestling diet. These were the clover leaf weevil,

Table 4. Summary of neck-collar sampling and nest success.

	No. of active nests	No. successfully fledged	No. neck-collars applied	No. of food samples	Vol./ sample (ml)	Items/ nest/ hour
Site 1 June 2-21	26	17	50	36	.38	4.4
Site 2 June 6-14	8	6	15	10	.39	4.2
Site 1 July 23 - August 2	4	3	6	6	.61	8.7

Hypera punctata (Fab.), the European skipper, *Thymelicus lineola* (Ochsenheimer), and the dark-sided cutworm, *Euxoa messoria* (Harris). The family Noctuidae, which contains many important pest species, was the most important insect family in the diet. However, the most important noctuid taken by the birds was *Amphipoea velata* (Walker), a species of no economic significance. The majority of the remaining unidentified noctuids were probably *Apamea* spp. This genus feeds largely on grasses and has 10 representatives in Quebec (Rockburne and Lafontaine 1976), of which 2 are of potential significance to cultivated Gramineae. Other groups of insects, not identified to species, which contained possible pests, were the short-horned grasshoppers (Acrididae), leafhoppers (Cicadellidae), aphids (Aphidae) and click beetles (Elateridae).

Quadrat sampling produced few specimens of the species eaten by the birds. In 160 0.1 m^2 quadrats taken in grass, only one specimen of *A. velata* and none of the European skipper or *Apamea* spp. were recovered. The majority of the larvae recovered were sawfly larvae (Tenthredinoidea). In 20 0.1 m^2 quadrats taken in a mixed alfalfa and clover field, 5 clover leaf weevil larvae, 5 dark-sided cutworms and 2 sawfly larvae were recovered.

DISCUSSION

The most important diet elements of nestling Red-winged

Blackbirds were herbivorous insects taken from grasses or alfalfa and clover. Particularly striking was the absence of insects associated with the soil and surface litter, in contrast to items taken from foliage. Dark-sided cutworms were found to be as common as larvae of the clover leaf weevil in quadrat samples from an alfalfa and clover field, but no dark-sided cutworms and 10 clover leaf weevils were recovered in neck-collar samples taken from nests in the same field. The larva of the clover leaf weevil passes the day in the crown of alfalfa and clover, whereas the dark-sided cutworm was found on the soil surface, and may in fact pass the day beneath the surface (Cheng 1973). The quadrat sampling done here underrepresents the relative number of dark-sided cutworms, as the cutworm has a wide range of plant foods, other than alfalfa and clover, and no subsurface samples were taken. Therefore, the dark-sided cutworm appears to have a low susceptibility to Red-winged Blackbird predation because of its diurnal subterranean habits. This would apply equally to most of the other cutworm pests.

Noctuid larvae were the most important element in the nestling diet, yet no pupae of the family were recovered in neck-collar samples. Most noctuids pupate on or beneath the soil surface, whereas those pupae which were recovered belonged to families (Hesperiidae and Tortricidae) which often pupate in vegetation.

It has been suggested that Red-winged Blackbirds use a gaping type of foraging (Orians 1973). Evidence for this is suggested by the manner in which kernels of milk stage corn are evacuated, and by the use of larvae with a leaf rolling habit (Tortricidae). However, most insects fed to nestlings are normally exposed, and the failure to take items from the soil or litter, as do species with a well developed gaping behaviour, suggests that gaping is little developed.

Because the Red-winged Blackbird was originally exclusively marsh-dwelling, it is adapted for foraging for emergent aquatic insects on the vertical vegetation of marshes. Its short legs make it a better forager in vegetation than other more terrestrial and long-legged blackbirds. In highly productive western marshes, where it competes with the Yellow-head Blackbird (*Xanthocephalus xanthocephalus*), it is better able to exploit the denser vegetation of the marsh edge than the open areas of the marsh (Orians and Horn 1969). The same attributes are evident in the Red-winged Blackbird's exploitation of foliage feeding larvae in upland habitats.

Sweep-netting between July 23 and August 2 at Site 1 recovered many more short-horned grasshoppers (Acrididae) than long-horned grasshoppers (Conocephalinae) in all habitats swept. Sweep-netting is more likely to underrepresent the short-horned grasshoppers as they are better jumpers and fliers. Many of the short-horned grasshoppers were very small, but even in the larger size classes, which were taken as food by birds, the short-horned greatly outnumbered the long-horned grasshoppers. Despite this, neck-collar samples contained more long-horned than short-horned grasshoppers. Significantly fewer Conocephalinae than Acrididae were taken in neck-collar sampling than by sweep-netting in each habitat (Fisher exact probability test, $P<.05$). This apparent preference for long-horned grasshoppers may be related to the fact that short-horned grasshoppers are more agile and require more energy to pursue. Females probably foraged for grasshoppers in the long grass along ditches, where long-horned grasshoppers and other prey items, such as ambush bugs (Phymatidae) and orb-weaver spiders (Araneidae) were most abundant.

Most insects in the nestling diet were passive, slow-moving prey items with no escape reaction, which required a high degree of searching but little active pursuit. Therefore, many of the important prey items in the nestling diet were cryptically coloured. The larvae of *Amphipoea velata*, the majority of undetermined noctuids, the European skipper and clover leaf weevil were all green with one or more longitudinal white stripes, a typical disruptive colour pattern. However, the majority of larvae taken in quadrat sampling were brownish in colour. These were mainly cutworms in alfalfa and clover, and sawflies in grasses. Tinbergen (1960) found that sawfly larvae in a European pine wood generally ran a low risk of being consumed by tits. Prop (1960) showed that this was due to the low palatability of sawfly larvae, and that species with a typical green and white disruptive colour pattern were more palatable than those with an aposematic colour pattern. It seems possible, therefore, that the failure by Red-winged Blackbirds to feed on sawfly larvae is related to palatability.

Several factors limit the quantitative interpretation of neck-collar data. Small food items may slip through the neck-collars and females may respond negatively to them; as well, only nestlings over 3 days old may be collared (Orians 1966). In the neck-collars done in the present study, many small items were recovered (e.g. Aphids). This would suggest that little loss due to slippage occurred, and what slippage did occur would not affect the relative volumes of major items in the diet. The food intake recovered in neck-collar samples may be compared with published reports on the dietary needs of nestling Red-winged Blackbirds. Wilson (1978) has estimated that 2,940 "average" prey items are needed in a normal 9-day nestling period, an average prey item being a 13 mm orthopteran. A 13 mm grasshopper has a volume of approximately .09 ml. The total volume of food recovered in 50 hours of neck-collar sampling at Site 1 during June was equivalent to 150 13 mm grasshoppers. With an average of approximately three nestlings per nest, there was an average of one "average" sized food item recovered per nestling per hour of neck-collar sampling. However, to receive 2,940 items in 9 16-hour days, a nestling would have to receive approximately 20.4 items per hour.

Therefore, the neck-collar retrieved only 1/20th of the expected volume of food. An adverse reaction by the female seems the best explanation for this low rate of return from neck-collar sampling.

Assuming that neck-collar sampling retrieved 1/20th of the food normally consumed, and that each successful nest was active for 9 16-hour days, then it is possible to extrapolate the numbers of insects actually eaten. In the case of *A. velata*, 40,000 larvae are estimated to have been consumed at Site 1 based on the 17 nests which fledged during June. For 4 nests in a mixed alfalfa and clover field which consumed 10 larvae of the clover leaf weevil, 9,600 larvae are estimated to have been consumed. In this same field, following fledging, five larvae of the weevil were taken in 20 0.1 m^2 quadrat samples, which represents 25,000 larvae/ha. If the four females foraged over the same hectare, then the total clover leaf weevil population would have been 34,600 larvae/ha, of which 28% were consumed by the birds. Of course, these figures are of low accuracy, but they do illustrate the point that the levels of predation were potentially of a magnitude to influence prey populations.

A few larvae of the European skipper were taken in neck-collar samples at both Sites 1 and 2. Some circumstantial evidence that Red-winged Blackbirds may be having an impact on skipper populations is found in the fact that the European skipper becomes a pest of major importance in areas of marginal agricultural land along the edge of the Laurentians (McNeil *et al.* 1975), a region where Red-winged Blackbird populations are very low.

Neck-collar sampling, when combined with information from quadrat and sweep net sampling, provided important information on which prey species were most susceptible to predation. Clearly, cutworms, acridid grasshoppers and sawflies did not suffer a high risk of predation. Those species that were susceptible were cryptically coloured larvae found in foliage during the day. In order to assess the impact of predation on these species, an estimate of the numbers consumed by birds and the size of the prey population is needed. Quadrat sampling may provide this kind of information, but it must be planned with an understanding of the biology and life history of the individual prey species being sampled. This point can be illustrated with *A. velata*. Quadrat sampling produced only one specimen of this species, which was the most common item in the nestling diet. This insect completes its larval growth in one month (Dethier 1944), and the final instars, which are most attractive as food would only be available for a brief period. Quadrat sampling followed the main period of nestling activity, and therefore may have missed completely the population of *A. velata*. Information on prey species identification and their relative importance in the diet is provided by neck-collar sampling, and this information coupled with a knowledge of the prey species provides the basis on which a comprehensive sampling program could be undertaken. Such a sampling program would provide a precise estimate of the size of the prey population and the number consumed. Sampling should take account of all mortality factors acting on the prey population and be done before and after the period of nestling feeding.

CONCLUSIONS

Although nestling Red-winged Blackbirds were fed a wide variety of insects, herbivorous insects from grasses, alfalfa and clover were the most important elements in the diet. These included several pest species. Of these, the dark-sided cutworm and short-horned grasshoppers were found to be at a low risk of predation. However, the larvae of the clover leaf weevil and European skipper appear to be at a high risk, and blackbird predation may have an impact on their populations.

CHAPTER II

The role of the Red-winged Blackbird, *Agelaius phoeniceus*, as a predator of the European corn borer, *Ostrinia nubilalis*, and the picnic beetle, *Glischrochilus quadrisignatus*.

INTRODUCTION

Corn is the most important item in the diet of Red-winged Blackbirds (*Agelaius phoeniceus*) in agricultural areas. It is taken either from standing corn when the crop is in the milk and soft dough stages or as waste from the ground in the fall and early spring. A small portion of the diet at these times is also composed of insect material (McNicol 1980), and some of the insects consumed may be important pests of corn. This study reports on the possible impact of blackbird predation on two common species of corn insects; the European corn borer, *Ostrinia nubilalis* (Hübner), and the picnic beetle, *Glischrochilus quadrisignatus* (Say).

The European corn borer is a serious pest of corn in many of the world's major corn growing regions. In North America, blackbirds have been mentioned as predators of corn borers in several early reports (Barber 1925, 1926, Baker *et al.* 1949), but these reports have not been substantiated by more detailed studies. Fankhauser (1962) found that caged Red-winged Blackbirds did not feed on corn borers in upright stalks. Wall and Whitcomb (1964) found no evidence that vertebrates, other than woodpeckers, took corn borers from stalks in Arkansas. Stomach contents showed that other species seen feeding in corn fields were taking only the grain. Barber (1925), Frye (1972) and Wall and Whitcomb (1964) all found that woodpeckers, especially the Downy Woodpecker, *Dendrocopus pubescens*, were important predators of the European corn borer. Hudon and LeRoux (1961) observed Common Grackles and Red-winged Blackbirds in experimental corn plots in Quebec, but found no evidence of corn borer mortality due to bird predation.

The picnic beetle is one of the most abundant insects in corn growing areas. It reproduces in corn fields on waste grain (Foott and Timmins 1970). This insect does not cause damage to field corn, but in some areas the adults have become important pests of other fruit and vegetable crops. Picnic beetles have been reported from Red-winged Blackbird stomach contents by Hintz and Dyer (1970).

METHODS

The study was conducted in 1979 in the vicinity of a major blackbird roost in Beauharnois Co., Quebec. The roost was situated in a large expanse of *Phragmites communis* south of the St. Lawrence Seaway and adjacent to a major farming area. The Red-winged Blackbird was the most important species in the roost, which was also used by Starlings (*Sturnus vulgaris*), Common Grackles (*Quiscalus quiscula*), and Brown-headed Cowbirds (*Molothrus ater*).

Ten corn fields, at varying distances south of the roost, were chosen for use in this study. In each of these fields, a plot 75 m long by 50 rows wide was selected. In all 10 of these plots picnic beetles were trapped, and in 8 of them an estimate was made of corn borer numbers and blackbird damage, as described below.

Red-winged Blackbird activity in corn fields was assessed in two ways; by direct estimates of the number of birds observed in fields, and by using damage caused by birds as an index of activity. In the former case, an estimate of the number of birds was made after ten minutes observation of each field. Ten fields were observed twice weekly throughout July and August. These estimates do not provide a highly accurate basis on which to compare levels of bird activity between fields, but they did provide an accurate indicator of when the peak period of activity occurred. Using damage estimates provides a more accurate basis by which to compare different levels of activity. However, approximately 90% of damage by birds has been found to occur in a two week period following the milk date (Bridgeland 1979). Therefore, damage can be used as an index for only that period.

Damage by blackbirds was estimated in 8 plots using the methods of DeGrazio *et al.* (1969). They developed a table relating the weight of kernels on each ½ inch section of a cob to the total length of the cob. Such a table allows one to estimate the weight of kernels lost to birds by measuring the length of a cob and the length of the damaged portion. Martin (1977) developed such a table for the Beauharnois area in 1976.

DeGrazio *et al.* (1969) found that the weight to length relationships remained constant between years, but that the tables needed to be adjusted for changes in the average weights of cobs from year to year. In order to adjust the table of Martin (1977), 50 7-inch cobs were dried and the kernels weighed. The average weight of the kernels was found to be 10% less than in 1976. Therefore, all damage estimates calculated from Martin's (1977) table have been adjusted by 10%. Damage was estimated in each plot from 5 samples of 50 cobs taken across the rows at randomly selected points. The average weight loss of 50 cobs was converted to weight loss per hectare using an estimate of the number of cobs per hectare. This was calculated using the average number of cobs in 5 randomly selected 10 m rows and the distance between rows (a standard 76 cm).

Populations of the European corn borer were sampled in September in 8 plots. At 5 randomly selected sample sites, each plant down a row was examined for corn borers, the presence of which is indicated by cavity openings in the stalk and accumulations of frass. Sampling continued until 20 plants with corn borer damage had been found. These were cut down and the stalks opened. The number of corn borers located in the stalk below the ear, above the ear, and in the shank and ear was recorded. This provided an estimate of the number of corn borers per stalk damaged by corn borers. It was thought that this figure would provide an indicator of blackbird predation, as fewer corn borers per borer-damaged stalk would be expected if predation occurred. However, an estimate of corn borers per stalk (damaged or undamaged by corn borers) was found to be more useful. This was calculated for each sample site by dividing the number of corn borers found by the total number of plants examined. The figures for the 5 sample sites were averaged to arrive at an average number of corn borers per plant examined in each plot.

One plot was sampled for corn borers again in November, after the corn had been harvested and the stalks left lying in the field. Samples, consisting of 20 stalks from below the ear, were taken at 5 randomly selected points. These samples were taken for comparison with the number of corn borers in the first 20 stalks examined during previous sampling. However, stalks had been heavily damaged by the time of the second sampling and only complete stalk segments from below the ear could be used for comparison. This clearly results in a bias towards a high estimate of the number of corn borers, as borers from fragmented stalks are more likely to be exposed to bird predation and other causes of mortality.

In the spring of 1979, a corn field which had been left standing over the winter was examined at St. Jean, Quebec. Fifteen randomly selected samples of 10 stalks were taken in the 0.25 ha field. The field was sampled twice, once on March 26 and again on May 7. Eleven hours of observation of bird activity in the field were made during the intervening period.

Populations of picnic beetle were monitored in 10 plots with baited pitfall traps (Newton and Peck 1975). A plastic container, 23 cm deep, was sunk into the ground up to its rim and approximately 4 cm of water, with a few drops of detergent, placed in the bottom. The bait consisted of 100 gm of ripe mashed banana, which was wrapped in cloth (tergal) and suspended from a stick placed across the rim. All baits were prepared from the same batch of mashed banana, so that the baits at all traps were of equal ripeness. Baits that were not immediately used were refrigerated. Traps were placed in the centre of each plot once a week for 24 hours, after which all beetles trapped in the water or on the baits were removed and preserved in alcohol.

The gizzard contents of 219 birds, and the gullet (combined proventriculus and oesophagus) contents of 99 birds were examined for the presence of corn pest insect species. Birds were taken in roosts at Beauharnois and Farnham, Quebec, using mist nets or a 12-gauge shotgun. Other birds were shot on breeding territories or in corn fields in the Beauharnois area.

RESULTS

The picnic beetle and European corn borer were recorded in gizzard and gullet contents. The numbers found are presented in Table 5. Remains of the picnic beetle were readily identified in both gizzards and gullets, and figures for both are presented. Corn borer larvae, being very soft bodied, were not easily identified from the gizzard, and only figures for the gullet are given.

The total estimated number of Red-winged Blackbirds in 10 fields on each date is plotted (Figure 2). The number of birds observed increased dramatically from August 14 to August 16. This was the period coinciding with the milk date, when damage to corn was first detected.

The number of picnic beetles caught in baited pitfall traps was highest in late July and fell to low levels two weeks before high levels of bird activity were observed in the same fields (Figure 2). A similar rapid rise and fall in numbers of beetles were recorded by counts on corn plants by McCoy and Brindley (1961).

The total number of picnic beetles trapped in eight plots is shown in Table 6. Also shown are the estimates of bird damage for these plots and the total number of beetles taken during three trap dates between August 16 and 30. A linear regression (Figure 3) of bird damage against numbers of picnic beetles trapped between August 16 and 30 shows a significant negative correlation ($r = -0.66$). There was also a significant negative correlation between damage by birds and distance from

Table 5. European corn borer presence in gullet samples and picnic beetle presence in gullet and gizzard samples of Red-winged Blackbirds

Season	Source	Sex	Gullet					Gizzard	
			# of samples	# with borers	# of borers	# with beetles	# of beetles	# of samples	# with beetles
Pre-breeding April 1-31	Beauharnois roost	M	-	-	-	-	-	12	0
		F	-	-	-	-	-	8	0
Breeding May 1 - June 30	Territories	M	-	-	-	-	-	25	1
		F	-	-	-	-	-	19	0
Early post-breeding July 1 - August 14	Beauharnois roost	M	-	-	-	-	-	8	0
		F	-	-	-	-	-	2	0
	Corn fields	M	6	1	2	0	0	8	0
		F	3	0	0	0	0	6	0
Milk and Dough stage corn August 14-31	Beauharnois roost	M	23	1	1	1	1	44	2
	Farnham roost	M	19	0	0	1	1	30	4
Late fall Sept. 1 - Nov. 7	Beauharnois roost	M	31	9	14	7	21	47	3
		F	5	0	0	0	0	9	0
Totals			107	11	17	9	23	218	10

Figure 2. Red-winged Blackbirds observed and picnic beetles trapped in 10 corn fields.

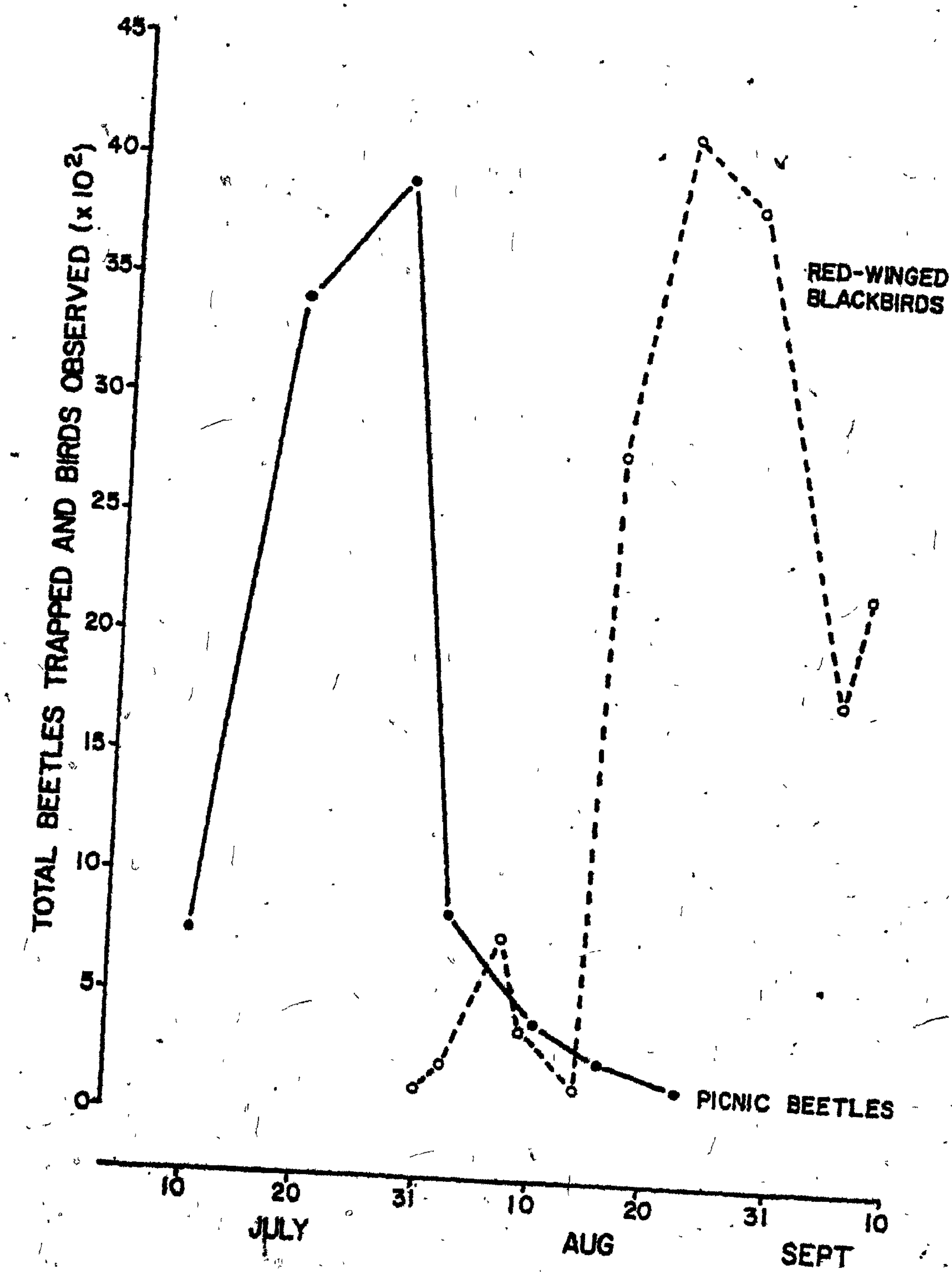

TOTAL BEETLES TRAPPED AND BIRDS OBSERVED (x 10²)
45
40
35
30
25
20
15
10
5
0
RED-WINGED BLACKBIRDS
PICNIC BEETLES
10
20
31
10
20
31
10
JULY
AUG
SEPT

Table 6. Bird damage, corn borer density and picnic beetle catch in corn fields at various distances from the Beauharnois roost

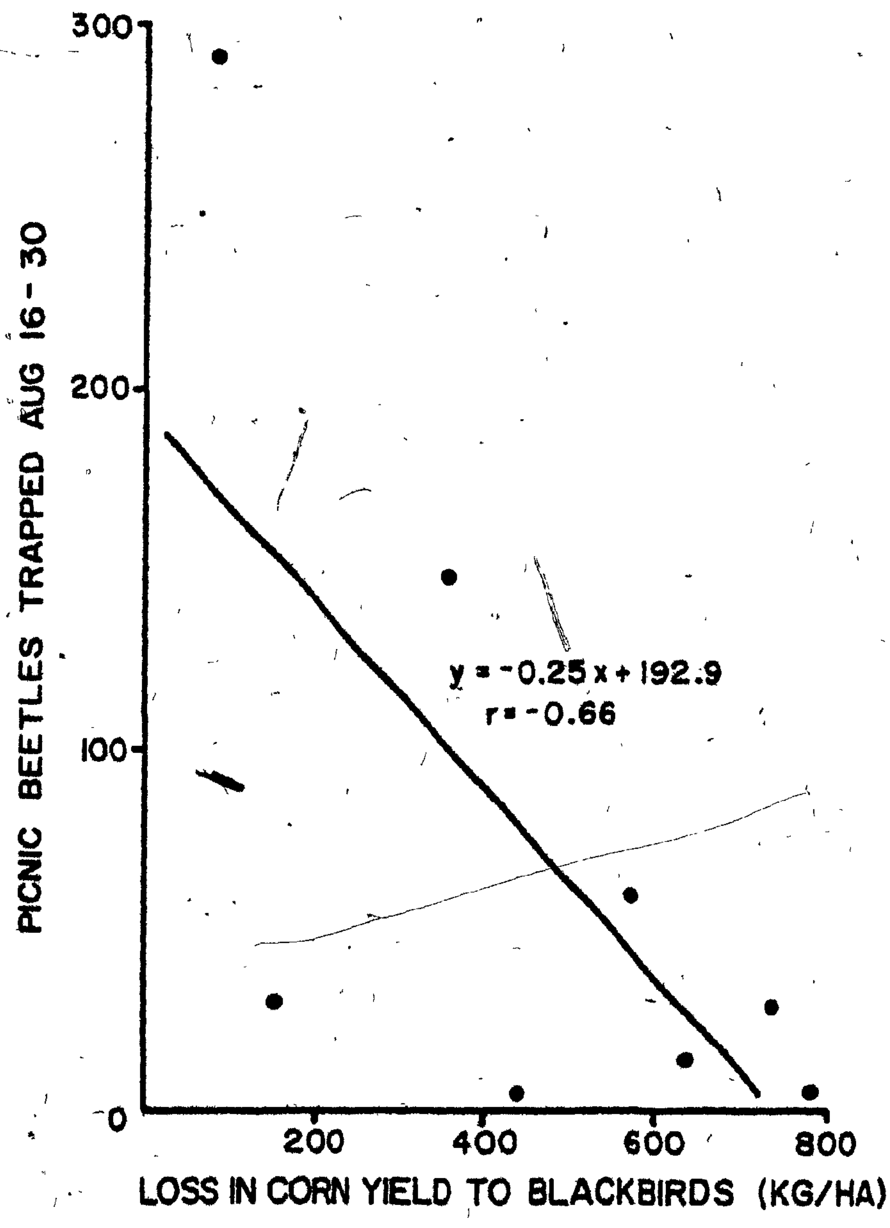
Distance from the roost (km)	Bird damage (kg/ha)	Corn borers per stalk	Picnic beetles trapped	
			July 10 - Aug. 30	Aug. 16-30
1.2	781	0.30	184	7
1.5	366	0.29	1197	149
1.6	741	0.40	533	30
2.4	639	0.88	542	14
2.7	156	0.30	463	32
3.1	574	0.55	1979	60
4.3	418	0.53	715	5
7.5	86	1.06	1408	292

the roost (r = -0.69) (Figure 4). In spite of the significant correlation between picnic beetles and damage, and between damage and distance, a trend toward higher catches of picnic beetles away from the roost was not significant.

The estimated number of corn borers per stalk in each plot is presented in Table 6. Estimates varied from .30 borers per stalk in fields near the roost to 1.06 borers per stalk in the field furthest removed. When the number of corn borers per stalk is plotted against the distance of each plot from the approximate centre of the roost (Figure 5), a significant linear correlation is seen to exist (r = 0.77).

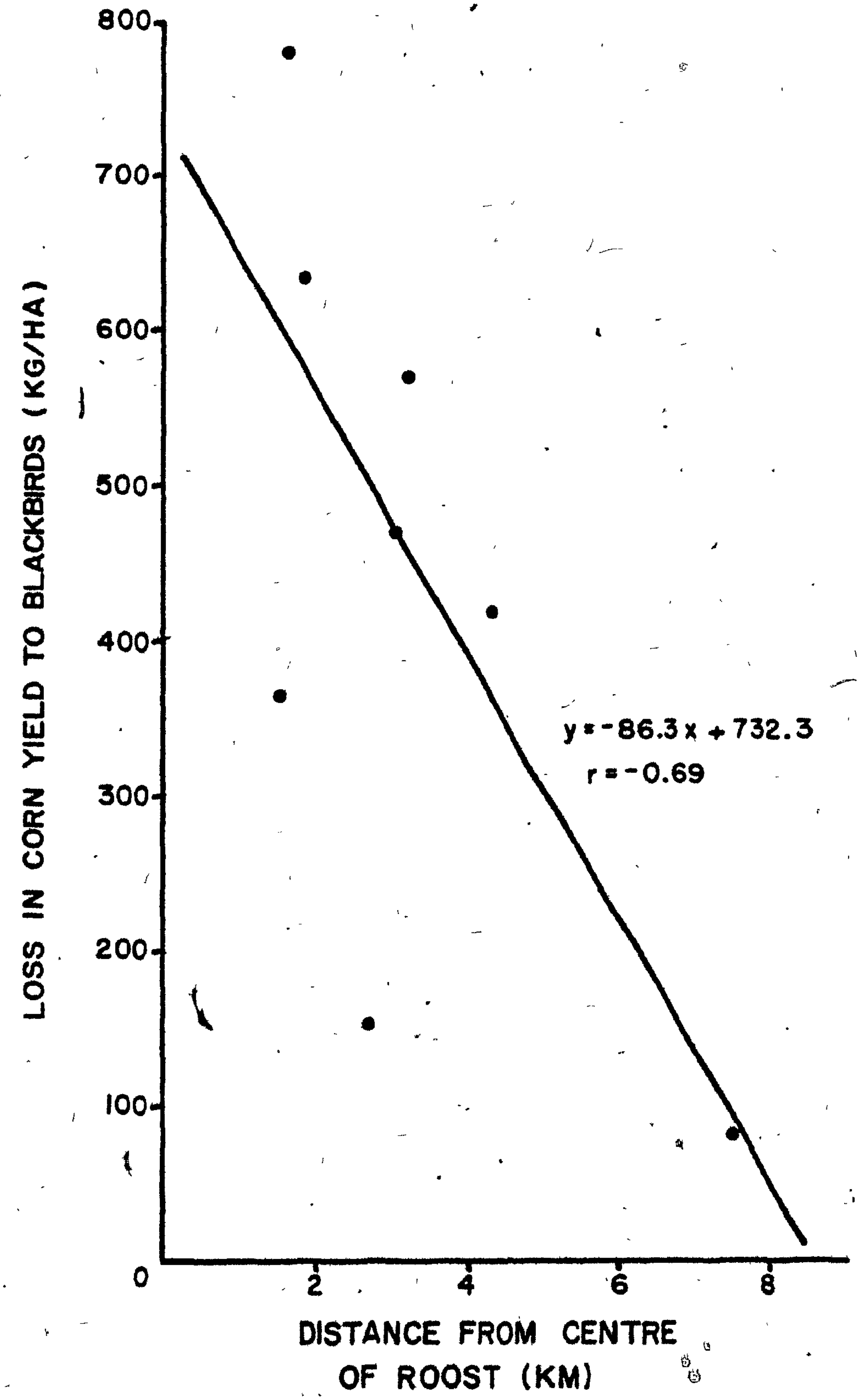
Sampling of corn borers in the plot that was re-examined after harvesting showed a significant drop in the number of borers per 20 stalks below the ear between September 20 and November 5 (Mann-Whitney U test, U = 4, P = .048). This indicates high levels of corn borer mortality following harvest, which may be due in part to the bird predation observed from gullet samples taken during the same period. Samples of corn stalks from the plot at St. Jean, Quebec, showed no significant difference in the number of corn borers between March 26 and May 7. In 11 hours of observation, only a single male Red-winged Blackbird was observed in the plot.

Figure 3. Relationship of picnic beetles trapped from August 16 to 30 and damage by blackbirds in 8 corn fields.



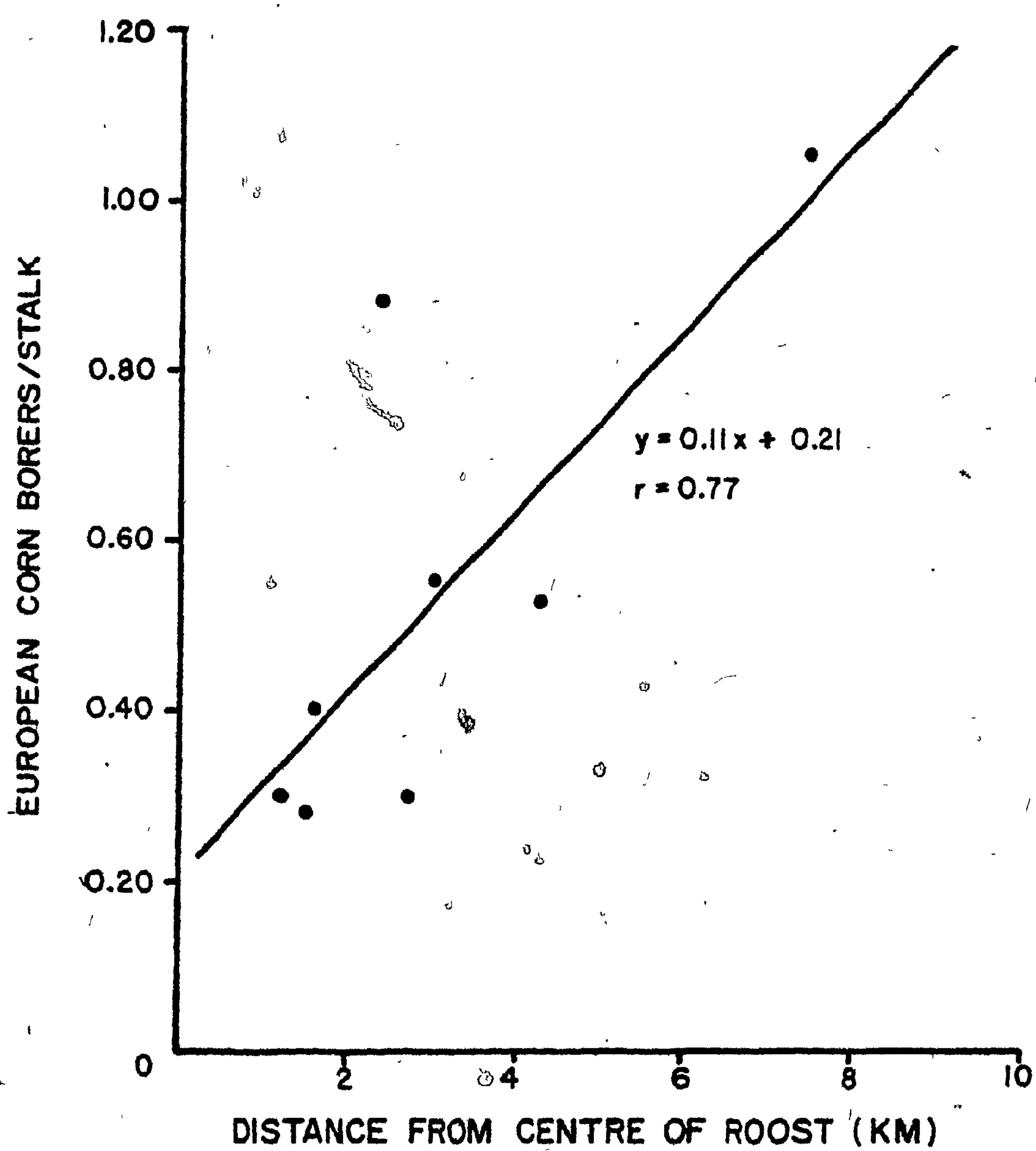
PICNIC BEETLES TRAPPED AUG 16 - 30
300
200
100
0
200
400
600
800
LOSS IN CORN YIELD TO BLACKBIRDS (KG/HA)
y = -0.25 x + 192.9
r = -0.66

Figure 4. Relationship of damage by blackbirds and distance from roost.



800
700
600
500
400
300
200
100
0
2
4
6
8
LOSS IN CORN YIELD TO BLACKBIRDS (KG/HA)
y = -86.3 x + 732.3
r = -0.69
DISTANCE FROM CENTRE OF ROOST (KM)

Figure 5. Relationship of European corn borer populations and distance from roost.



EUROPEAN CORN BORERS/STALK
1.20
1.00
0.80
0.60
0.40
0.20
0
2
4
6
8
10
DISTANCE FROM CENTRE OF ROOST (KM)
y = 0.11x + 0.21
r = 0.77

DISCUSSION

The European corn borer

Red-winged Blackbirds composed approximately 80% of the roosting population at Beauharnois in the autumn of 1979. The presence of European corn borers in their gullets clearly suggests that predation by these birds was responsible for the observed depression of the borer population in the vicinity of the roost. Gullet contents also indicated that most predation occurred following the harvest of grain corn. No gizzard or gullet contents were examined from other bird species in the roost.

There was little evidence of significant predation on European corn borers when Red-winged Blackbirds were feeding on standing corn. Only one corn borer was found in gullet contents in late August, and observations during this period showed that most borers were well inside the stalks and not susceptible to predation. No evidence was found of damage to stalks by birds attempting to remove borers, and there was no correlation between bird damage to corn and the number of borers in stalks showing corn borer damage.

Observations on August 6, when bird activity in corn was low, showed that many borers could be found partially exposed in the leaf axils of corn plants. Birds shot in corn fields during this period were found to be feeding on weed seeds and oats from neighbouring fields or on Chironomidae (Diptera) which had emerged in large numbers from the marsh which was the roosting site of the birds. Of 8 gullets containing chironomids, 1 also contained 2 larvae of the European corn borer. Chironomids were seen in larger numbers in corn fields than in other fields, possibly because of the windbreaking effect of the corn plants, which also provided suitable perches for the large numbers of swallows and blackbirds attracted to the area. However, chironomids were available in large numbers for only a brief period, and it seems unlikely that this unique coincidence of events could be responsible for the low corn borer populations in the vicinity of the roost.

European corn borers were more susceptible to predation by Blackbirds following harvesting of grain corn. This may be because the borers were exposed by mechanical damage to the stalks, or because stalks lying on the ground surface were more easily opened by birds. Many of the stalks sampled for corn borers on November 5 were heavily damaged. This damage resembled the "shredding" of stalks described by Barber (1925), and which he attributed to Grackles, Starlings and "blackbirds". The evidence would suggest that, while Red-winged Blackbirds do not feed upon corn borers in standing stalks, they may be able to apply enough force to stalks on the ground to expose corn borers. The same may also be true of dent stage corn which is not damaged on standing stalks (Bridgeland 1979), but is taken as waste from the ground.

It seems likely that blackbird predation is responsible for lower corn borer populations in the vicinity of the roost; however, an alternative explanation presents itself in the form of the tachinid parasite, *Lydella thompsoni* Herting. This fly is the most widespread introduced parasite of the European corn borer in North America, but its effectiveness has been limited by the fact that its life cycle is poorly synchronized with that of its host. Adult flies emerge in the spring before corn borer larvae are available. However, the existence of an alternative host may maintain high populations of the parasite until the corn borer population develops (Hsiao and Holdaway 1966). In southern France, Galichet and Radisson (1976) found that a lepidopteran larva, which was common on *Phragmites communis*, was important for maintaining populations of *L. thompsoni*. In southern Ontario, Wishart (1942) found greater parasitism by *L. thompsoni* in the vicinity of marshes along Lake Erie and the Detroit River. It seems possible, therefore, that high corn borer mortality due to *L. thompsoni* parasitism may be associated with the large stand of *Phragmites communis* which is the roosting site of Red-winged Blackbirds at Beauharnois. This possibility warrants further investigation.

If *L. thompsoni* is shown to be an important cause of corn borer mortality in the roost area, then it may be acting with bird predation to bring about regulation of the host population. Tinbergen and Klomp (1960) used the parasite-host interaction theory of Nicholson (1933) to show that bird predation, acting in a density-dependent fashion, could bring about a regulation of a host population that neither the predator nor the parasite could achieve alone.

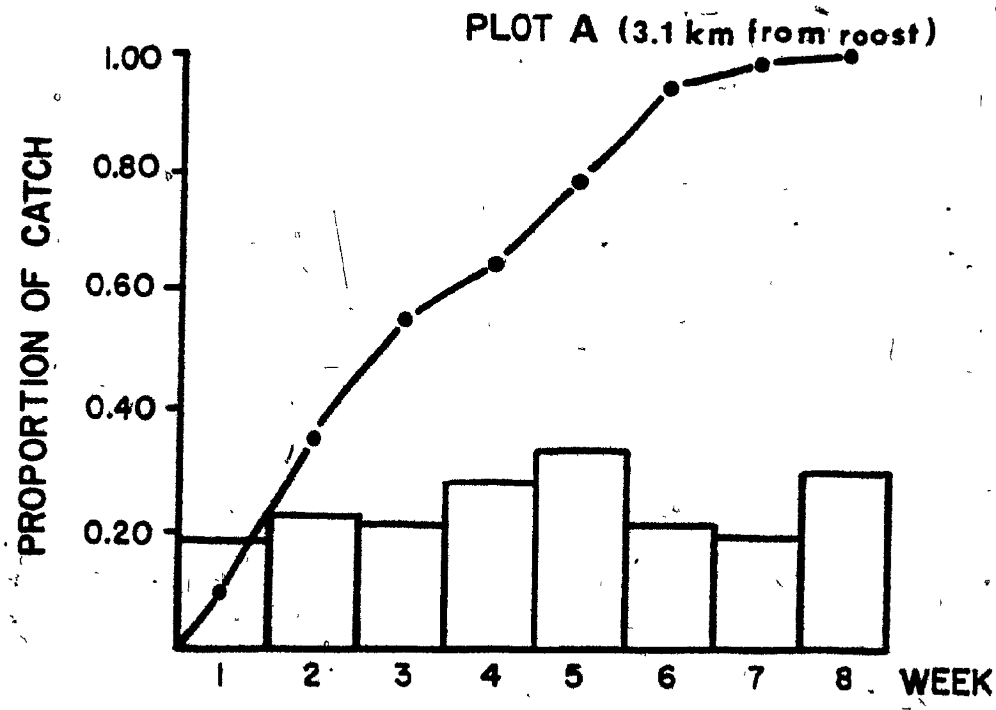
The picnic beetle

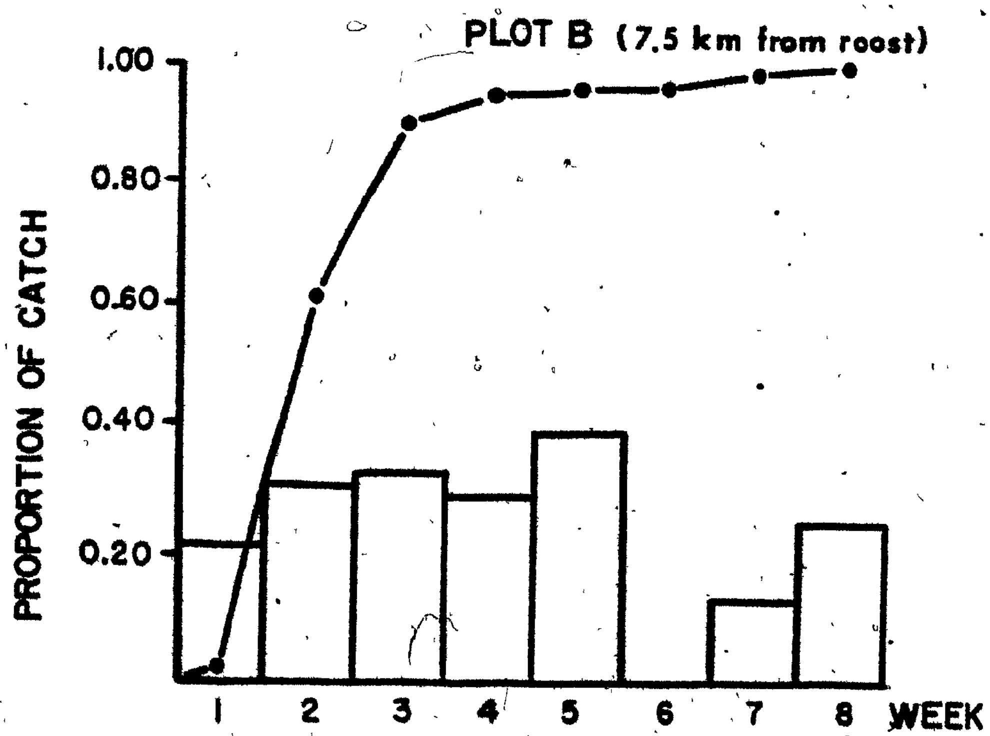
The numbers of picnic beetles trapped in baited pitfall traps fell to low levels in early August. The fall in catch appears to represent a lower level of activity of the adults and reduced attractiveness to them of the bait. Newly emerged adults, distinguishable by their tan coloration (Luckman 1963, Foott and Timmins 1979), appeared to be more attracted to baits than older adults, as they made up a high proportion of all catches, even after the peak trap period had passed (Figure 6).

The low levels of activity of mature beetles when birds became active in corn fields suggests that the major part of the picnic beetle population is at a low risk of blackbird predation. However, the significant relationship between bird damage to corn and the number of beetles trapped during the period when the damage was done suggests that those beetles active in corn fields at that time were at a high risk of predation. Beetles may also be at a high risk in the spring

Figure 6. Curves representing cumulative catch of picnic beetles.

Histograms representing proportion of catch with tan or brown coloration.


PLOT A (3.1 km from roost)
1.00
0.80
0.60
0.40
0.20
PROPORTION OF CATCH
1
2
3
4
5
6
7
8
WEEK

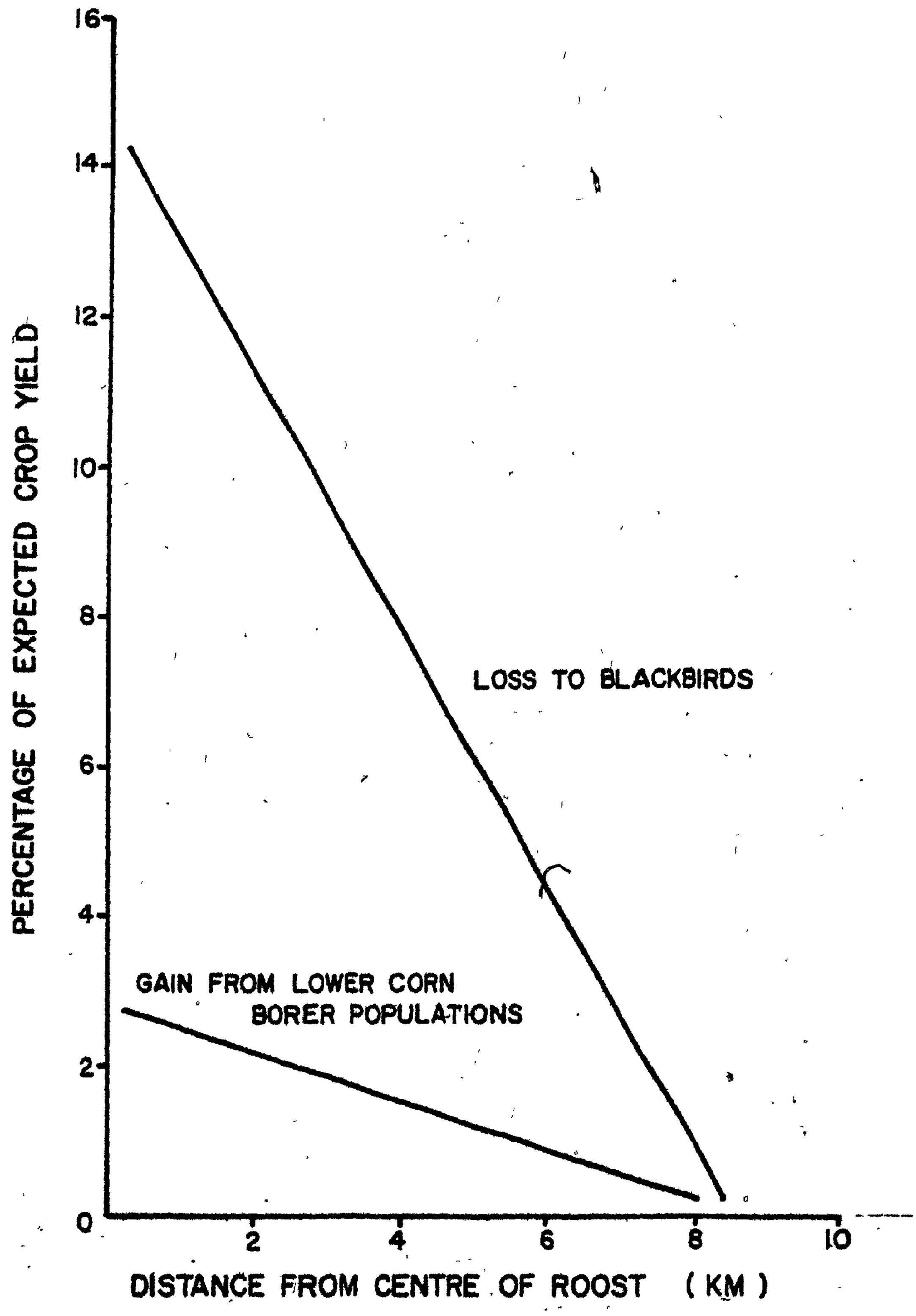

PLOT B (7.5 km from roost)
1.00
0.80
0.60
0.40
0.20
PROPORTION OF CATCH
1
2
3
4
5
6
7
8
WEEK

when birds are feeding on the waste corn on which the beetles breed. The general trend towards higher catches of beetles farther from the roost may reflect, in part, the effects of predation; but it may also be due to the fact that blackbirds compete with beetles for waste corn, and that picnic beetles are attracted to the frass and plant damage of corn borers, which are also more abundant away from the roost. When 2 samples of 100 corn plants from 2 fields were examined for corn borers and picnic beetles, significantly more plants damaged by corn borers had picnic beetles than did undamaged plants (X^2, $P < .05$ and $P < .02$). Picnic beetles may enter the tunnels of the corn borer and mechanically injure and subsequently attrack the larva. McCoy and Brindley (1961) attributed a 17% reduction in the number of corn borer larvae reaching third instar to picnic beetles, and Carlson and Chiang (1973) found a highly significant negative correlation between the number of picnic beetles and the ratio of corn borer larvae per tunnel. In the Beauharnois region, picnic beetles were most active in corn fields before corn borers entered the stalk. As larvae are most susceptible to crowding and injury by beetles when they are in the stalk, the timing of the entry of the stalk has considerable adaptive significance. Corn borers which are outside the stalk in late July, when picnic beetle populations were high, would be less susceptible to injury than those inside the stalk; but those that had not entered the stalk by the time the plant reached the milk stage in mid-August would be prone to predation by blackbirds.

Cost-benefits of the Beauharnois roost

Patch (1942) estimated an average yield loss of 3% per mature corn borer per plant. This figure is still the best available for estimating losses to corn borers, and it provides a basis by which to compare losses to blackbirds with benefits resulting from lower corn borer populations. The linear regression between corn losses to birds and distance from the roost (Figure 4) has been converted to per cent loss for a farmer with an expected yield of 5,000 kg/ha (Figure 7). Losses fall from 14% of yield at the roost to 0%, 8.5 km from the roost. If the outer limit of damage by birds is also the outer limit of benefit from lower corn borer populations, then there would be 1.14 corn borers per stalk at 8.5 km, as estimated from the linear regression (Figure 5). Corn borer populations fall to an estimated 0.21 corn borers per stalk at the roost, which would result in a 2.8% increase in yield. The linear relationship between the gain in yield due to lower corn borer populations and distance from the roost is presented in Figure 7. By calculating the areas under the loss and benefit lines it can be seen that the loss in corn yield due to birds was approximately 5 times greater than the benefit resulting from lower corn borer populations.

Figure 7. Cost-benefits of the Beauharnois roost. Gain from lower corn borer populations derived from Figure 5 and loss to blackbirds from Figure 4.



PERCENTAGE OF EXPECTED CROP YIELD
16
14
12
10
8
6
4
2
0
2
4
6
8
10
LOSS TO BLACKBIRDS
GAIN FROM LOWER CORN BORER POPULATIONS
DISTANCE FROM CENTRE OF ROOST (KM)

These results have considerable implications for the management of the Beauharnois blackbird roost. In a program to control losses to blackbirds, maximum benefits would be obtained by keeping the birds from corn when it is most susceptible to damage, while maintaining the blackbird population for the benefits accrued from predation on insects. Generally, more noxious corn insects were consumed when birds were feeding on waste corn than when they were actually damaging the crop. If such a control program is not feasible, then elimination of the roost altogether would improve the present situation, but benefits would be offset, to some extent, by increased corn borer populations. If the tachinid parasite *L. thompsoni* proves important in maintaining lower populations of corn borers near the roost, then maintaining the vegetation of the roost would be desirable.

CONCLUSIONS

European corn borers were eaten by Red-winged Blackbirds, particularly in the late fall. Significantly lower corn borer populations were associated with the blackbird roost. Red-winged Blackbird predation may be lowering corn borer populations, but the role of the tachinid parasite *L. thompsoni* must be considered. The picnic beetle was also eaten by blackbirds, but because of a temporal displacement of the activity of the 2 species, it is unlikely that there is much interaction. However, picnic beetle populations may be influenced by blackbirds through their impact on corn borer populations and by competition for waste grain.

The blackbird population in the Beauharnois area appears to be having an impact on populations of corn pest species, and while benefits from blackbird predation on insects does not outweigh losses suffered to crops, a management program which retains blackbirds as insect predators while reducing damage to crops, would maximize benefits.

CHAPTER III

Insectivory of Red-winged Blackbirds, *Agelaius phoeniceus*, in a patchy environment.

INTRODUCTION

The availability of alternate foods for granivorous birds may affect their depredation of grain crops. In Africa, the preferred food of *Quelea quelea* is wild grass seed, the absence of which leads to severe damage to cultivated cereals (Ward, 1965). In North America, Wiens and Dyer (1975) have suggested that insects may play a role as an alternative to agricultural crops for the Red-winged Blackbird. Another possibility is that insect populations may enhance the quality of cropland as a foraging area for birds, attract them and subsequently increase crop damage. These possibilities are examined in the present study by considering insect populations in relation to Red-winged Blackbird activity.

METHODS

In 1979, the available insect biomass in several habitats near Beauharnois, Quebec was monitored using sweep net sampling. Samples, consisting of fifty consecutive sweeps of a net, were taken at three randomly selected points along a roadside ditch, a drainage ditch, a railway embankment and a hay field. Samples were taken at intervals between June 15 and September 4. Birds were breeding in these habitats, and they remained active in them as long as breeding continued. In five corn plots (0.28 ha), chosen at varying distances from a blackbird roost at Beauharnois, five sweep net samples were taken once a week between July 9 and September 7. Each sample consisted of 50 sweeps along a randomly selected row of corn. The insect catch from all sweep net samples was dried to a constant weight and weighed on an analytical balance.

Populations of other insects which occur in corn fields, but which are not readily sampled with a sweep net, were sampled using other techniques. Populations of the European corn borer (*Ostrinia nubilalis*) and the picnic beetle (*Glischrochilus quadrisignatus*) were sampled as described in Chapter II. Aphid populations were assessed using the aphid infestation categories of Foott and Timmins (1973).

Bird activity was monitored in 10 fields each of corn and oats. Activity was observed in a field for a 10 minute period, and then an estimate made of the number of birds in the field. Oat fields were monitored between July 12 and August 15, and corn between July 31 and September 7.

In 1978, bird activity in three early successional old fields at Baie d'Urfé, Québec was monitored between July 18 and August 16. Birds were counted by walking into the fields and flushing them from the vegetation. At the same time, populations of grasshoppers were monitored by taking a sample of fifty sweeps from each field. The catch of grasshoppers in

Figure 8. Invertebrate biomass availability in habitats at Beauharnois, 1979.

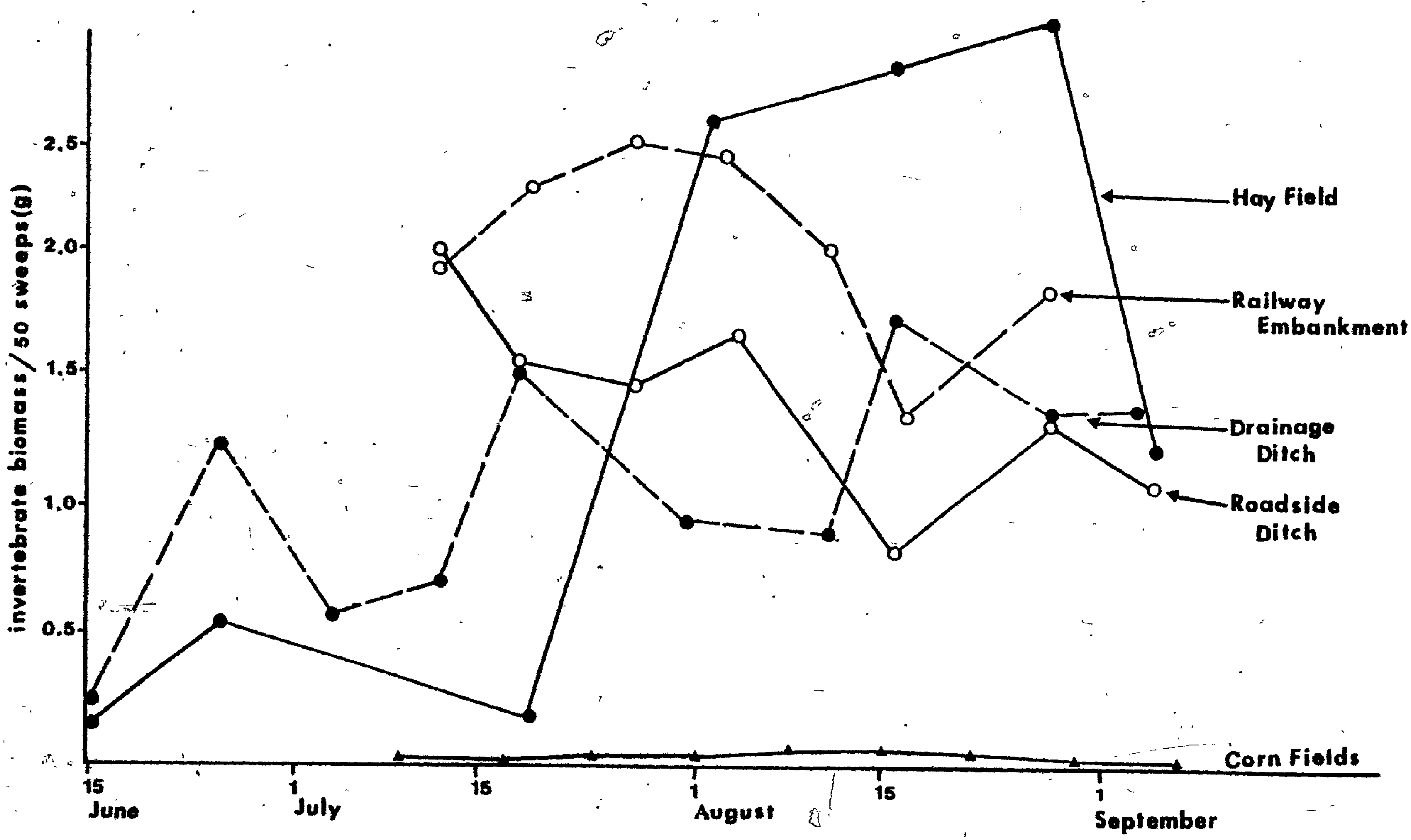

invertebrate biomass/50 sweeps(g)
2.5
2.0
1.5
1.0
0.5
15
June
1
July
15
1
August
15
1
September
Hay Field
Railway Embankment
Drainage Ditch
Roadside Ditch
Corn Fields

Figure 9. Red-winged Blackbird activity in corn fields, oat fields and breeding sites at Beauharnois, 1979.

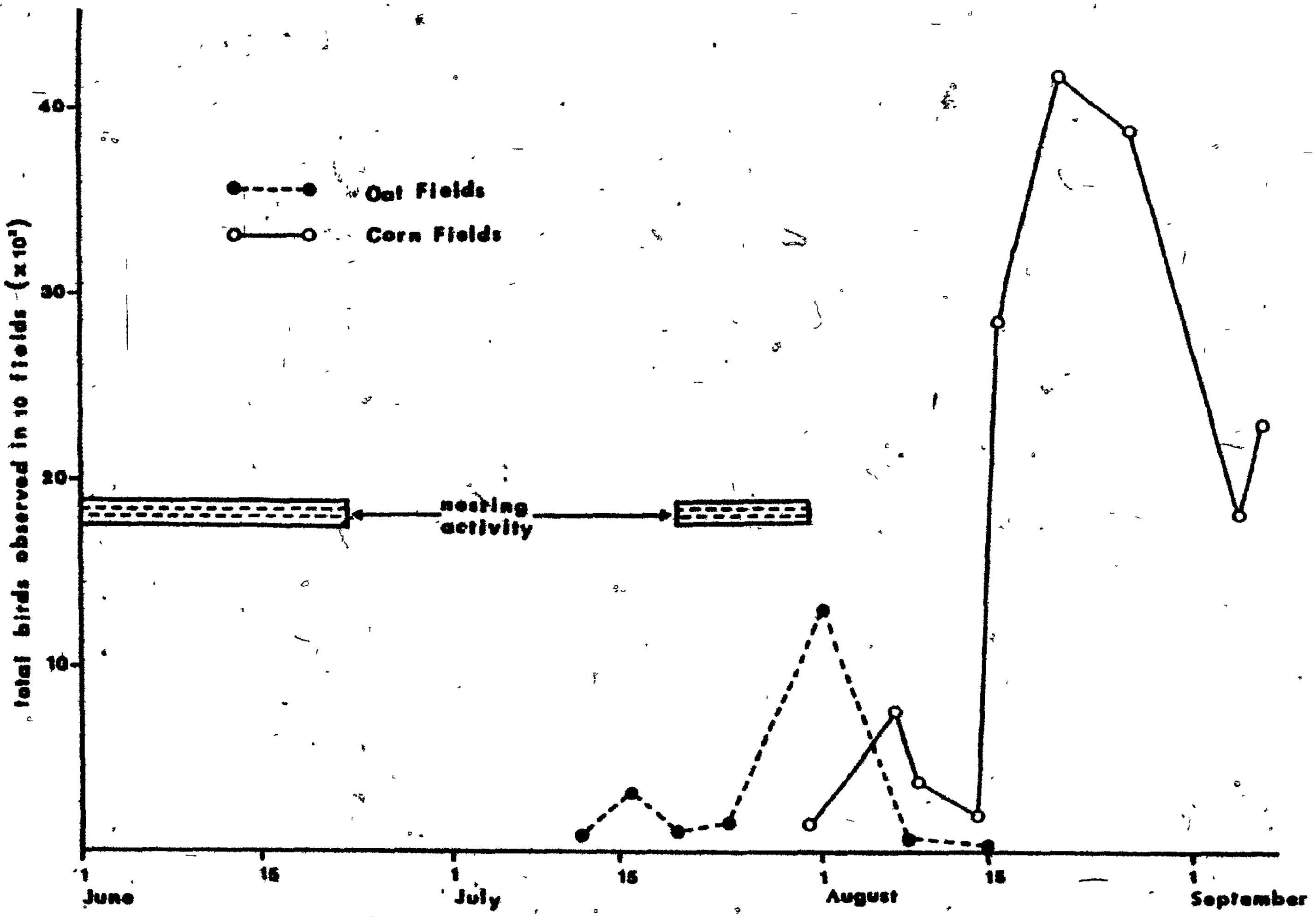
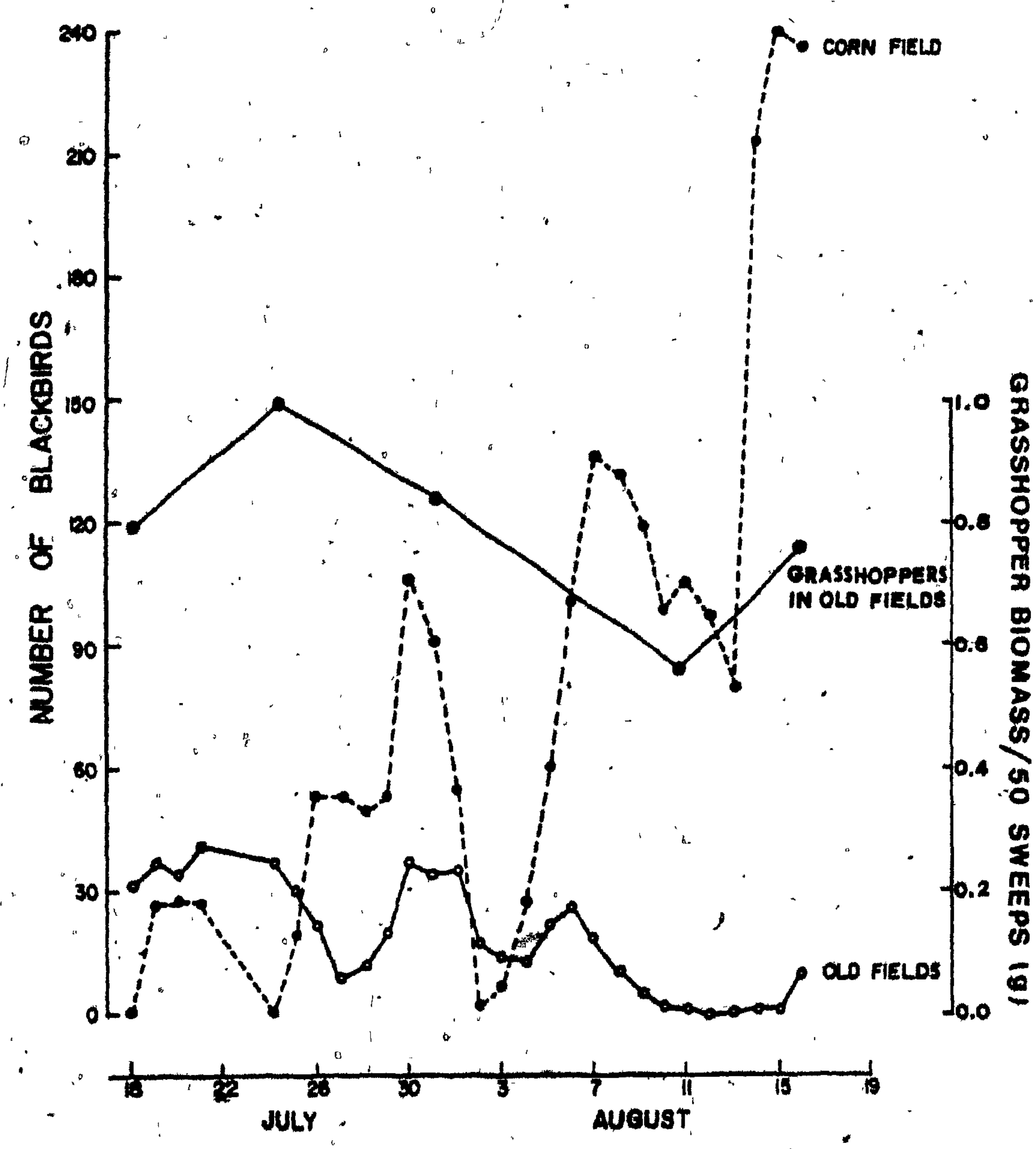

Oat Fields
Corn Fields
total birds observed in 10 fields (x 10²)
40
30
20
10
nesting activity
1
June
15
1
July
15
1
August
15
1
September

Figure 10. Red-winged Blackbird activity at Baie d'Urfé, 1978.



NUMBER OF BLACKBIRDS
240
210
180
150
120
90
60
30
0
CORN FIELD
GRASSHOPPERS
IN OLD FIELDS
OLD FIELDS
GRASSHOPPER BIOMASS/50 SWEEPS (g)
1.0
0.8
0.6
0.4
0.2
0.0
18
22
26
30
3
7
11
15
19
JULY
AUGUST

each sample was dried and weighed. During the same period, bird activity in a nearby corn field on the Macdonald College farm was monitored by estimating the number of birds in the field after viewing it from a convenient vantage point.

RESULTS

Sweep net sampling showed that the total insect biomass at four sites near Beauharnois did not decline late in the summer (Figure 8) when birds moved into oats and corn (Figure 9). Therefore, the movement into cultivated cereals cannot be attributed to a decline in insect foods in the habitats examined here. Grasshoppers were the most important item in sweep net samples at both Beauharnois and Baie d'Urfé. The decline in bird activity in old fields at Baie d'Urfé, at the same time that bird activity increased in corn fields on the Macdonald College farm, was not associated with a decline in the average mass of grasshoppers in sweep net samples (Figure 10).

The insect biomass taken by sweeping in corn fields was only a small fraction of the biomass available in other habitats (Figure 8), and unlikely to positively attract birds. Populations of the picnic beetle were low during the period of bird activity in corn and catches of beetles during this time were negatively correlated with bird damage (Figure 3, Chapter II). Populations of the European corn borer were significantly lower closer to the blackbird roost (Figure 5, Chapter II) where greater damage occurred. Aphid populations were very light (0 to 50 aphids on the tassel at pollination) in all corn fields.

DISCUSSION

During the course of studies at Beauharnois, no evidence was seen of a positive response by flocking Red-winged Blackbirds to insect populations on agricultural land. However, in early August, large flocks of Red-winged Blackbirds were seen feeding on chironomidae (Diptera) which emerged in very large numbers from the *Phragmites* marsh which was the roosting site of the birds. McNicol (1980) found that during the moult period, the consumption of oats was lower in the Kingston, Ontario area, where caddisflies (Trichoptera) were an important item in the diet, than in an area where caddisflies were not available. These insects, like chironomids, have aquatic larvae and are often extremely abundant locally. It appears, therefore, that Red-winged Blackbirds may respond to insect populations, but only where they are extremely abundant. The failure of blackbirds to respond positively to normal insect populations would seem to severely restrict their potential as an agent of control of agricultural pests.

A density-dependent response is normally considered of prime importance in determining the ability of a predator to regulate a prey population. However, density-independant factors are of importance in determining the mean level around which regulation occurs, and these factors, such as weather conditions, agricultural practices and plant resistance, are of particular importance in controlling insect pests in agricultural systems. The apparent lowering of European corn borer populations by Red-winged Blackbirds in the Beauharnois roost area does not occur as a result of a response to corn borer populations, but as a result of the association of the corn borer with the red-wing's primary food item - corn. That is, the predation pressure suffered by the insect is not a function of its density, but a function of the total amount of food resources available in the corn fields in which it occurs, and the distance of these fields from communal roosts. Such foraging behaviour is consistent with models of the optimal use of a patchy environment (MacArthur and Pianka 1966, Royama 1970). One conclusion of optimal diet theories is that if an item is considered good to eat, it ought to be eaten whenever it is encountered, irrespective of its absolute abundance. However, in making decisions about which patch to forage in, a predator should choose the one with the greatest abundance of food. Tinbergen *et al.* (1967) proposed that in cryptic species, crowding would "blow their cover". However, as optimal foraging theory suggests, crowded prey species, cryptic or otherwise, are more easily exploited by predators. This effect of crowding should also exist between prey items of different species as well as prey items of the same species (Smith and Sweatman 1974). This may result in a species becoming a food item as a result of "guilt by association".

Though vegetable matter dominates the Red-winged Blackbird's diet through most of the year, some small portion of animal matter always seems to be present. Birds feeding in corn fields took insects typical of these fields. During the milk stage of corn, grasshoppers and orb-weaver spiders, which had been earlier fed to nestlings, were still abundant around the margins of corn fields, but were never taken as food by birds feeding on corn. Clearly, the presence of corn and not insects was important in determining the foraging site of these birds. Dolbeer (personal communications) had some evidence that red-wing activity was lower in corn fields sprayed with insecticides. This is understandable if animal matter provides some basic nutrient requirement. Although insect populations in corn fields are generally low, they normally seem to provide a basic minimum of insect material for the diet.

The Red-winged Blackbird is an apparent generalist, in that it has an unspecialized foraging behaviour and bill structure, and includes a wide variety of animal and vegetable matter in its diet. However, when the spatial distribution of the red-wing is considered, it is distributed as a specialist

(Rotenberry and Wiens, 1976). This anomaly is not surprising if it is considered that red-wings specialize on certain patches of the environment at a given time, but use a wide variety of patches through the course of the year. The red-wing can be considered a "patch specialist" (MacArthur and Pianka 1966). In order to optimize patch exploitation in a "coarse-grained" environment, flocking and roosting behaviour is advantageous (Ward and Zahavi 1973). Therefore, the highly localized feeding patterns associated with blackbird roosts can be considered in terms of the parameters that determine the "graininess" of the environment. These parameters include the number, size and temporal displacement of the patches.

The utilization of several of these patches was examined during the course of this study. These patches included milk stage corn, milk stage oats and upland breeding sites (Figure 9). The insects fed to nestlings came mainly from gleaning in grasses, alfalfa and clover (Chapter I). This remained true during a second minor nesting period in late July, but suitable foraging areas were mainly restricted to the margins of fields and ditches because of the cutting of timothy, alfalfa and clover, and the grazing of pastures. The old fields at Baie d'Urfé provided a unique expanse of undisturbed grasses and weeds. However, the area was not attractive to birds when corn entered the milk stage, despite the continued abundance of insects. The evidence would suggest that corn is a much preferred food. Oats was also damaged at the same time that insects were available. However, some birds were seen feeding on insects at the same time that others were feeding on oats. In the Baie d'Urfé area, birds at this time appeared to be feeding on grasshoppers, which were the main food fed to nestlings at Beauharnois during this period. It may be, that as McNicol's (1980) evidence would suggest, that when insects are available in abundance they could provide an attractive alternative to oats.

CONCLUSIONS

Red-winged Blackbirds do not appear to respond positively to moderate insect densities on agricultural land, and there is no evidence that insects provide an alternative to corn, though they may be an alternative to oats. Nor is there any evidence that birds are attracted to corn fields by insect populations.

The idea of the Red-winged Blackbird as a patch specialist provides a useful conceptualization of its exploitation of agricultural crops and their associated insect fauna. These concepts would place an emphasis on the distribution of an insect with respect to other food resources rather than treating these predator-prey relations in terms of simple density-related functions.

GENERAL CONCLUSIONS

Sampling for the European corn borer, *Ostrinia nubilalis* (Hübner), near the Beauharnois blackbird roost, showed that there was a significant relationship between the number of corn borers per stalk and the distance from the roost. European corn borers were recovered in the gullet contents of the Red-winged Blackbird, *Agelaius phoeniceus*. Though alternate explanations can be proposed, the existing evidence strongly suggests that blackbird predation is having an important local impact on European corn borer populations. This situation provides a rather unique opportunity to demonstrate the capacity of birds to influence the population of a prey species.

Catches from baited pitfall traps showed that the activity of the picnic beetle, *Glischrochilus quadrisignatus* (Say), was lowest when blackbird activity was greatest in corn fields. There seems little likelihood that bird predation in the late summer could influence the beetle population. However, more predation may occur in the spring when birds are feeding on the waste corn on which the beetles breed. Birds may also indirectly influence populations of the picnic beetle through their impact on corn borer populations and by competition for waste corn.

Neck-collar samples taken from nestling Red-winged Blackbirds on agricultural land showed that herbivorous insects from grasses, alfalfa and clover were the most important items in the nestling diet. Several of these species appeared to have a high risk of predation, and included the larvae of 2 pests; the clover leaf weevil, *Hypera punctata* (Fab.), and the European skipper, *Thymelicus lineola* (Ochsenheimer).

The activity of Red-winged Blackbirds in corn fields does not appear to be influenced by insect populations, either in corn fields or in alternate foraging areas.

The results of the present study suggest that roosting populations of blackbirds can have an important impact on populations of noxious insects. Consequently, control programs for blackbird populations would obtain the greatest benefits if damage to crops was reduced while retaining the benefits from Red-winged Blackbird predation on insects.

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APPENDIX

List of insect pests recovered from Red-winged Blackbirds in gizzard, gullet and neck-collar samples near Beauharnois, Quebec.

Coleoptera

Nitidulidae

Glischrochilus quadrisignatus (Say), the picnic beetle

Curculionidae

Hypera postica (Gyllenhal), the alfalfa weevil
Hypera punctata (Fab.), the clover leaf weevil
Sitona hispidula (Fab.), the clover root curculio
Tychius picirostris (Fab.), the clover seed weevil
Tychius stephansi Schoenherr, the clover head weevil

Lepidoptera

Pyralidae

Ostrinia nubilalis (Hübner), the European corn borer

Noctuidae

Euxoa messoria (Harris), the dark-sided cutworm

Hesperiidae

Thymelicus lineola (Ochsenheimer), the European skipper

Other families which were recovered and may have contained pest species were:

Acrididae, short-horned grasshoppers
Aphidae, aphids
Cicadellidae, leafhoppers
Elateridae, click beetles

Stomach samples taken at Ste-Anne-de-Bellevue, Quebec in 1978 produced the following specimens:

Glischrochilus quadrisignatus (Say), the picnic beetle
Forficula auricularia L., the European earwig