

by R. G. B. Brown

# Bird damage to fruit crops in the Niagara Peninsula



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by R. G. B. Brown

Canadian Wildlife Service  
Report Series Number 27



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### The author

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### Perspective

The Niagara Peninsula of southern Ontario is a major fruit-growing region. The climate is such that this is one of the two areas in Canada (the Okanagan Valley of British Columbia is the other) which can support a wine industry. Cherries, peaches, apples and other tree-fruits are also economically important crops.

One of the built-in complications of fruit-growing is that the very qualities which make the fruit attractive to man, also make it attractive to birds. The monoculture represented by an orchard or a vineyard serves to intensify the birds' depredations. As a result the Robin, so highly regarded elsewhere, has become a major pest in the

Niagara Peninsula. The damage caused by this and other species can have serious economic consequences, especially in the relatively small holdings owned by the majority of Niagara growers.

It is not at all easy to prevent this damage. Fruit-eating by birds is a very basic behaviour, and difficult to deter. To be effective a protective system must be complex, and therefore often expensive. The ideal system is one which costs less than the fruit it saves, but we are a long way from achieving this ideal.

This study looks at the problem from several angles. Which birds do the damage? How strongly motivated are they to eat fruit? How much damage do they do? What is the best system for stopping them, and is this economically feasible? Unfortunately there are at present more questions than answers.

### Abstract

Cherries and grapes are the fruits suffering the most bird damage in the Niagara Peninsula. The amount of damage varies among years, areas and cultivars, but a 25 per cent loss of the sweet cherry crop is not uncommon; grape damage is usually less than 10 per cent of the crop.

Early sweet cherries are taken mainly by Robins (*Turdus migratorius*) and Grackles (*Quiscalus quiscula*); later cherries are taken mainly by Starlings (*Sturnus vulgaris*). Grapes are mainly taken by Robins, though Baltimore Orioles (*Icterus galbula*) damage some of the early cultivars.

Much of the Robin damage is caused by young birds, probably reared in the Niagara Peninsula. The Starlings also appear to be mainly local juveniles; the timing of their influx into the orchards varies from year to year, which in turn leads to wide fluctuations in the amount of damage done.

Both Robins and Starlings prefer the reddest cherry cultivar available to them, and the blackest grape. However, this preference is a relative one, and it is unlikely that one could develop a cherry or grape cultivar whose colour would not attract

birds. Robins begin to eat cherries in late June, long before they are fully ripe, and appear to prefer fruit to animal food. There is no decline in the availability of animal food at this time, as measured by the Robins' hunting success; in fact adult birds appear to feed their young mainly on animal food, while themselves feeding more on fruit. The physiological basis for this preference for fruit in June is not clear; later on in the season, however, migrant birds may be using the sugar concentrations in fruit as a quick way of building up their fat reserves.

The amount of damage can be affected by the Robins' foraging behaviour, which is often surprisingly localised. Individual Robins may return again and again to individual cherry trees, ignoring equally ripe trees nearby.

In theory, the ideal protective system would be a long-term one, in which the orchard/vineyard habitat is altered in such a way as to minimize bird damage. The possibility of using "spoil" crops to distract the birds from the commercial crop was investigated, but seems unlikely to be effective. Physically excluding the birds from the fruit by nets was quite effective, but may not be economically feasible. Intensive shotgun patrols were also effective, but must be done on a scale which is prohibitively expensive. Large-scale trapping of Starlings appears to be both technically and economically feasible, and is probably the best way of dealing with these birds.

All other systems work on the "scarecrow" principle. Because of the positive preference for fruit shown, for example, by Robins, these must be particularly meaningful to the birds if the birds are not to become habituated to them. Suspended silhouettes of flying hawks, and trees decked with aluminum foil had little or no effect. Acetylene and gas-powered exploders, the protective devices most commonly used in the Niagara Peninsula, were quite effective in deterring Starlings, but had little or no effect on Robins. Experiments elsewhere have shown that broadcast distress calls

will disperse Robins, but field trials in the Niagara area were unsuccessful. The "Av-Alarm" system of broadcast electronic pulses is at present the only protective device which works against Robins, but it is probably economic only for large-scale growers.

### Résumé

Les cerises et les raisins sont les fruits auxquels les oiseaux font subir le plus de dommages dans la péninsule du Niagara. L'importance des dégâts varie selon les années, les régions et les variétés cultivées, mais il n'est pas rare de voir se perdre 25% de la récolte de cerises de France; les dommages causés aux raisins touchent habituellement moins de 10% de la récolte.

Ce sont principalement les merles (*Turdus migratorius*) et les mainates (*Quiscalus quiscula*) qui s'emparent des premières cerises de France, tandis que les tardives sont surtout la proie des Étourneaux sansonnets (*Sturnus vulgaris*). Ce sont également les merles qui sont les plus grands mangeurs de raisins, bien que les Orioles de Baltimore (*Icterus galbula*) causent aussi quelque dommage aux cultures hâtives.

Les dégâts attribuables aux merles sont en grande partie le fait de jeunes oiseaux, qui ont probablement grandi dans la péninsule du Niagara. Les étourneaux dévastateurs semblent aussi être, pour une bonne part, des juvénats de la région; le moment de leur arrivée dans les vergers varie cependant d'année en année, ce qui engendre d'importantes fluctuations dans la quantité de dégâts causés.

Les merles ainsi que les étourneaux préfèrent les cerises les plus rouges et les raisins les plus foncés qu'ils peuvent trouver. Toutefois, comme cette préférence est relative, il semble peu probable qu'on puisse mettre au point une variété de cerises ou de raisins dont la couleur n'attirerait pas les oiseaux. Les merles commencent à manger des cerises vers la fin de juin, longtemps avant que les fruits ne soient complètement mûrs, et paraissent préférer ce

type d'aliments à la nourriture animale. Comme on peut le voir d'après les tentatives faites par cette espèce d'oiseaux pour chercher de la nourriture animale, cette dernière se trouve en abondance à cette époque de l'année; en fait, il semble que les adultes procurent surtout à leurs petits de la nourriture animale, alors qu'eux-mêmes mangent principalement des fruits. La raison physiologique de cette préférence des adultes au mois de juin n'est pas claire; par contre, plus tard dans la saison, il se peut que les oiseaux migrants se servent des concentrations de sucre dans les fruits comme d'un moyen rapide d'accumuler des réserves de graisse.

Les tendances naturelles des merles peuvent influencer sur l'importance des dommages. En effet, certains individus de cette espèce retournent maintes et maintes fois aux mêmes cerisiers en négligeant les fruits tout aussi mûrs d'arbres voisins.

En théorie, le système protecteur idéal en serait un qui donnerait des résultats à long terme, un qui modifierait l'environnement des vergers et des vignobles de façon à minimiser les dégâts dus aux oiseaux. La possibilité d'utiliser des récoltes de diversion a fait l'objet d'une étude, mais s'est révélée peu prometteuse. Interdire l'accès des oiseaux au moyen de filets est un moyen très efficace, mais risque de ne pas être économique. L'utilisation intensive de fusils à détonation donne aussi de bons résultats; cependant, elle doit se faire à une échelle qui rend son coût inabordable. Un piégeage d'envergure des Étourneaux sansonnets paraît être faisable, tant sur le plan économique que sur le plan technique: c'est donc probablement le meilleur moyen de protéger les récoltes contre ces oiseaux.

Tous les autres systèmes s'inspirent du principe de l'épouvantail. Par exemple, à cause de la préférence certaine des merles pour les fruits, les systèmes protecteurs doivent marquer les oiseaux d'une façon particulière pour que ceux-ci ne s'y habituent pas à la longue. Ni les silhouettes d'oiseaux de proie suspendues ni les arbres garnis de papier aluminium ne semblent

# Introduction

avoir eu beaucoup d'effet. Les détonateurs à acétylène et à gaz, dispositifs protecteurs le plus souvent employés dans la péninsule, ont très bien réussi à détourner les Étourneaux sansonnets, mais leur succès dans le cas des merles a été faible ou nul. Bien que des expériences réalisées ailleurs aient déjà démontré que l'émission de cris de détresse disperse les merles, les essais faits dans la région du Niagara ont échoué. Le système *Av-Alarm* qui diffuse des vibrations électroniques est pour l'instant le seul mécanisme efficace contre les merles, mais il n'est probablement d'un emploi économique que pour les gros exploitants.

The Niagara Peninsula is the principal fruit-growing region in eastern Canada for everything except apples. The key area is the narrow plain between Hamilton and the Niagara River, bounded by Lake Ontario to the north and the Niagara Escarpment to the south (Fig. 1); it is about 35 miles long, and between 1 and 8 miles wide.

During the last fifteen years there has been increasing concern over the amount of damage birds do in this small but economically important area. The fruits which suffer the greatest damage are sweet and sour cherries and grapes; although strawberries, raspberries, apples, apricots, peaches, plums, pears and currants are all affected to some extent. Taking the industry as a whole, the impact of this loss is probably not very important. Virgo (1971) estimates that in the 1965 season birds took sweet cherries valued at \$44,500, or about 2.8 per cent of the value of the whole crop. Stevenson and Virgo (1971) estimate that in the same year, grapes worth \$24,000 were lost, only 0.5 per cent of the whole. (The value of the grapes lost to birds has almost certainly increased since 1965. Growers are changing over from table grapes to the more valuable French hybrid wine cultivars, and the birds have an unfortunate preference for wine grapes.) Unfortunately, the damage is not spread evenly, and growers with small orchards and vineyards can suffer serious losses.

It was therefore necessary to investigate the problem, and search for ways to prevent bird damage. The work was begun in 1962 by A. B. Stevenson, of the Canada Department of Agriculture, Vineland Station. The Canadian Wildlife Service took over the study in 1965, first with B. B. Virgo and then, from 1967 onwards, myself. Virgo and Stevenson's work has already been published (Virgo, 1971; Stevenson and Virgo, 1971). This report describes my own investigations.

I thought it important to take as broad a view of the problem as possible. Newton (1966), describing his work on bud damage by Bullfinches (*Pyrrhula pyrrhula*), has

stressed the need for an overall, biological approach:

In the past, many attempts to deal with pest-species have begun with expensive research on chemical deterrents and poisons. Most of these "blood and thunder" methods achieved little or no lasting success but have resulted in considerable wastage of public money and unnecessary destruction of other wildlife. Recent studies have adequately demonstrated that any attempt at pest control must be preceded by a thorough study of the pest's biology (work that many would consider of academic interest only). But only with such a basic knowledge, are we likely to be able to formulate a sound control policy that is economically and morally justifiable — a simple principle, but all too often forgotten in the past.

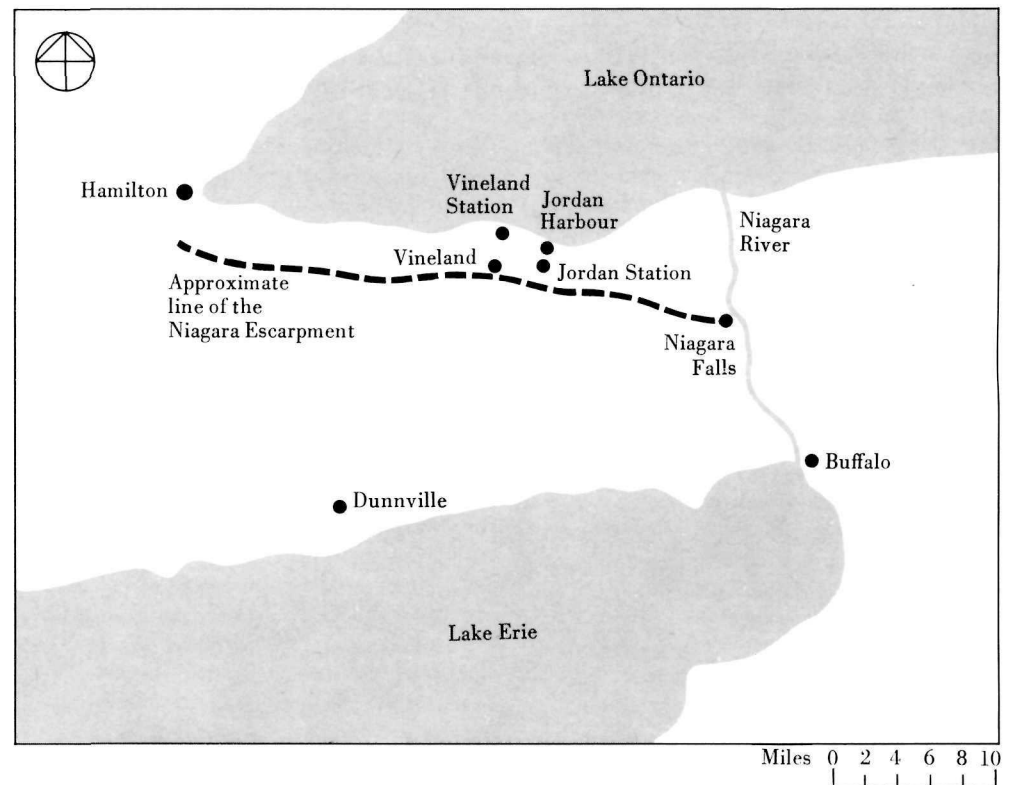
This does not, I believe, mean that "blood and thunder" methods are redundant. Newton's point is that, by taking a broad approach to the pest species' biology, we are in a better position to see which "blood and thunder" methods to apply, and how to do so most efficiently.

This is what I have tried to do here. The first chapter describes the extent of the damage to different fruits. The second section identifies the birds which are mainly responsible for this, and the breeding populations to which they belong. The next discusses the importance of colour and other factors in stimulating birds to eat fruit. The fourth section deals with the relative importance of fruit and animal food in the diet, and shows how foraging behaviour can influence the amount of damage. From a strictly academic point of view the investigation of many of these points has not been as complete as I would have liked, since their object has been not research as such, but to bring out background information relevant to the problem of preventing bird damage. In the last chapter I have tried to combine the results of these investigations with field trials on the effectiveness of various protective systems, in order to suggest the most suitable way to deal with each species.

# The bird damage problem in southern Ontario

Figure 1. Map of the Niagara Peninsula.

Figure 1



## Damage to cherries

### Methods

The method I used for assessing the damage to cherries was the one developed by Virgo (1971). I marked off two branches, at about head height and one on each side of the tree, and counted the cherries on each. I then checked them at regular intervals, counting and removing any damaged fruit. I used the accumulated total of damaged fruit at picking time to estimate the percentage of damage. In some cases, the tree was not actually picked. For these, I took the picking date to be that on which other trees of the cultivar in question were picked in that year; failing this, I used the average picking dates given by Eaton *et al.* (no date).

I worked in the following orchards (Fig. 1):

- Victoria Farm: medium and large trees in plots V1, V4, V13, V15 and V17 of the Ontario Department of Agriculture's Victoria Farm orchard, at Vineland Station;
- Jordan Farm: young and large sour cherry trees in the Canada Department of Agriculture's Jordan Farm, at Jordan Harbour;
- Pond Farm: young sweet cherry trees on the Canada Department of Agriculture's Pond Farm, at Jordan Harbour.

I used information given me by the owners of two commercial orchards: Honsberger's, near Jordan Station; and Stempski's, west of Vineland at the foot of the Niagara escarpment.

### Damage to different cherry cultivars

Table 1 shows the percentage damage at picking time to different cherry cultivars in different years. In almost every case, the



**Table 1**  
Percentage damage to cherry cultivars on various plots at picking time in 1967, 1968 and 1969.

Cultivar	Plot										
	Victoria Farm					Pond Farm				Commercial	
	V1	V4		V13	V15		V17			Stempski's	Honsberger's
	1967	1968	1969	1968	1968	1969	1968	1969	1968	1969	1969
Vista	47.1	44.0	34.5				57.0	41.8	98.8	11.3	none†
Venus	15.1	<5.0	0		54.8	45.2	46.3		70.9	14.5	light
Sam	22.6						17.0				none†
NY 1512	13.1						48.6				
Black Tartarian				heavy*						heavy†	light†
Hedelfingen		> 5.9		5.4	41.2				45.3	54.7	none†
Vic		<42.6		2.3	53.0	46.5					
Bing		57.5	57.7		15.4	52.8	13.3		42.3	85.0	none†
Van		7.1					> 9.2				
Windsor		50.8	28.4	light*					100.0	100.0	light†
Schmidt				heavy*					1.9		light†
48021		32.0	10.7								none†
Vernon		2.0									
Velvet		48.5									
Victor		8.4									
NY 1486							66.7				
NY 1495							48.6	50.5			
51061							62.6	13.3			
Black Russian						c. 90.0	39.2				
Sue	1.8										
27021	20.0										
Hudson	62.8										
Noble	35.8										
Merton Bounty	40.6										
Sour cherries		heavy	45.6	1.1	42.7	19.7					none†

\*Cultivars grown in a commercial orchard adjacent to V13. The grower estimated damage.

†Damage estimated by grower.

damage is considerably greater than that which Virgo (1971) recorded from other orchards in the Vineland area in 1965; his highest figure was 21.9 per cent. It is always possible that damage in the 1965 season was unusually low, but I suspect that my figures were inflated by the unusually large bird population around Victoria Farm.

This was particularly obvious with Robins (*Turdus migratorius*). These birds do not normally nest very close together (Young, 1956; Bent, 1949), but on Victoria Farm they were so concentrated as almost to form a colony. In 1967, for example, I found a total of 21 nests and suspected the presence

of six more in the 105 acres of this orchard; of these, 13 known and one suspected nests were in the 38.1 acres of plot V4 and an adjacent cedar hedge. The European Fieldfare (*Turdus pilaris*) regularly forms such "colonies" (Bent, 1949; personal observations), but as far as I know they have not been reported for the Robin, or indeed any other *Turdus* species. The same cedar hedge also held several Grackle (*Quiscalus quiscula*) nests. As Robins and Grackles are responsible for most of the damage to early sweet cherries, their high densities no doubt explain why these cultivars were so heavily damaged on Victoria Farm.

**Table 2**  
Percentage damage to Jordan Farm sour cherries by year, location and age of trees.

Size	Location	1967	1968	1969	1970
Large trees	North end	27.0	11.4	6.5	18.1
Large trees	South end	—	4.9	5.9	17.2
Young trees	North end	100.0	54.7	6.1	1100.0

On the other hand, most of the damage to sour and late sweet cherries is done by the large flocks of Starlings (*Sturnus vulgaris*) which build up in the Niagara fruit belt from mid July onwards (see p. 22ff). Most of the commercial orchards have been picked by this time, and so it is likely that the Starlings pay exaggerated attention to the few unpicked trees left to them on Victoria and Jordan Farms.

For these reasons, Table 1 gives an inflated picture of the amount of damage which birds may do to cherries. But this is not necessarily a disadvantage in a study of this kind: the increased predation pressure makes it easier to detect differences in the birds' preferences for different cultivars, the effectiveness of control measures, and so on.

Even so, the variability of damage seems to be rather wide. Table 1 shows that it varied from year to year and from plot to plot, even for a given cultivar on Victoria Farm. Table 2 shows the same variability for the Jordan Farm sour cherries. Evidently Vistas, for example, were rather heavily damaged in all years and on all the Victoria Farm plots, while Venus and Bing were much more variable; the Jordan Farm sour cherries also varied from year to year; Windsors on Pond Farm were affected much more than Windsors on Victoria Farm.

Part of this variation may be due to differences in picking dates in different years; these depend, not just on when the trees are ripe, but on the weather, availability of labour, and other uncontrolled factors. Part, too, may be due to differences in ripening times. For some reason, Windsors ripened at the end of June on Pond Farm (the first cultivar to do so in that orchard), but not until mid July on Victoria Farm. Again, 48021 started to ripen ahead of Vista in

Figure 2a. Cumulative damage rates to cherries in Victoria Farm plot V4, 1965.

Figure 2b. Cumulative damage rates to cherries in the Jordan Farm sour cherry orchard, 1967–1970.

1968, but behind it in 1969; as Robins tend to take the reddest available early cultivar (p. 30), this undoubtedly affected the extent of the damage. Variations in the birds' behaviour can also be important. Later chapters show that Robins' foraging behaviour influences the amount of damage they may do, and that the Starlings' very late arrival in 1969 lessened the damage to the late Jordan Farm sour cherries.

In short, bird damage to cherries (and to other fruits as well) is highly variable. Because this variability is the compounded product of several largely independent factors, it is unfortunately not yet possible to predict whether the damage to a particular cultivar or orchard, or during a particular season, will be heavy or light.

#### The timing of damage

The damage estimates in Table 1 are static: they show only the total loss at an arbitrary picking date. But it is just as important to see whether this damage built up gradually over the preceding weeks, or whether there was a period during which the cherries were particularly vulnerable. Control measures are usually expensive, and so it would be useful to know when they can most economically be applied.

Figure 2 shows some typical examples of how damage accumulates during the cherry season. Figure 2a shows this for four cultivars in Victoria Farm plot V4 in 1968. Here, the damage to Vistas and 48021, the two early cultivars, started in mid June and accumulated gradually: that to 48021 remained more or less linear, but that to Vista increased in mid July. Bing, which ripens later, accumulated damage rapidly in mid and late July. Windsor, ripening later still, accumulated damage even faster: it rose from 28.9 per cent to 99.6 per cent between July 25 and August 1. The late Jordan Farm sour cherries show the same pattern as the Windsors, though the timing of the rapid accumulation phase varies from year to year (Fig. 2b). Both figures, when related to the annual build-up of flocks, indicate the importance of the Starling in damaging the

Figure 2a

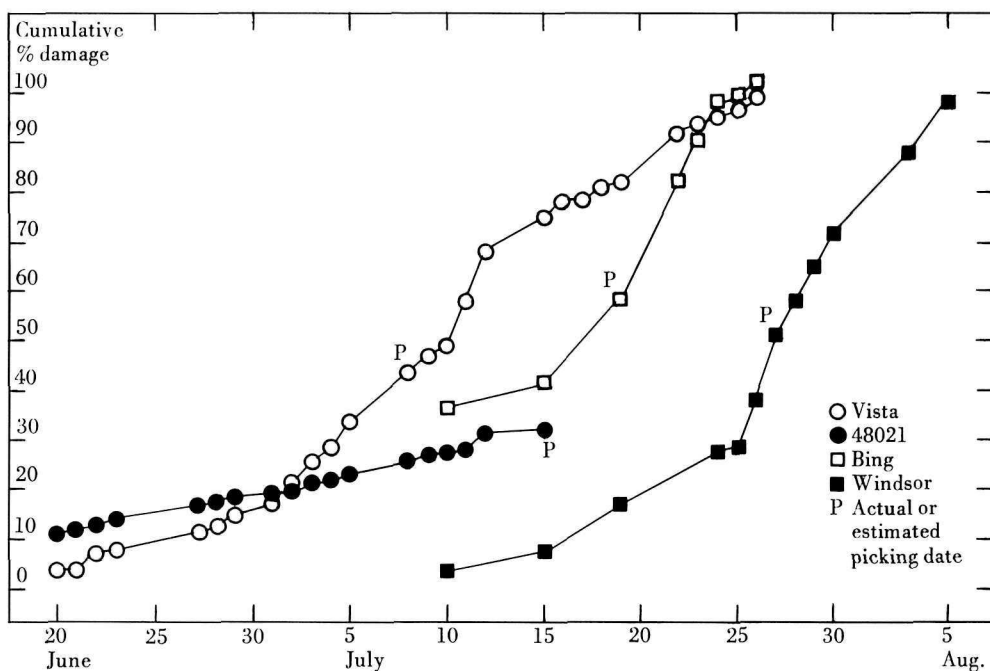


Figure 2b

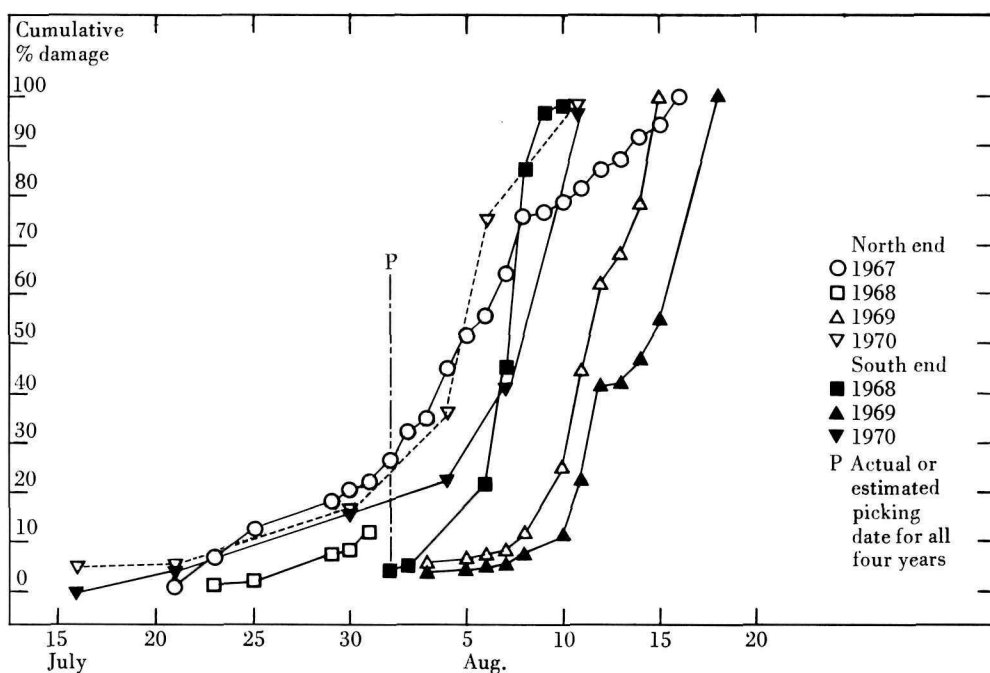
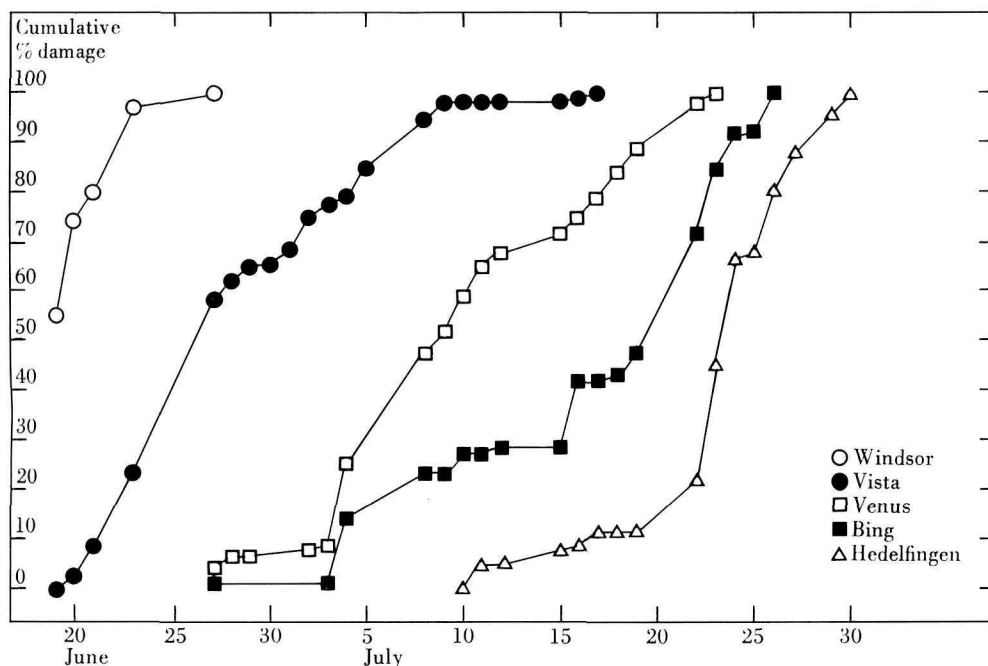


Figure 2c. Cumulative damage rates to cherries at Pond Farm, 1968.

Figure 2c



later cherry cultivars, as will be discussed in the next chapter. However, Starlings are not essential for the rapid accumulation of damage: Figure 2c shows that the Windsors and Vistas on Pond Farm were already accumulating damage at a rapid rate by early July 1968, before the Starling flocks appeared; this was apparently caused by Robins and Grackles.

Figure 2 offers two immediate conclusions with practical applications. Granted the inflated nature of bird damage on Victoria and Jordan Farms, it suggests that the vulnerable period for cherries is during the two weeks or so before picking. It also shows that, especially among the later cultivars, even a few days' delay in picking can have disastrous effects on the crop.

## Damage to grapes

### Methods

Stevenson and Virgo (1971) describe a visual technique for estimating the amount of damage done to bunches of grapes. Their system gives results which are very close to

those obtained through detailed counts and it is, of course, much easier to operate. But I felt that their technique would not be sensitive enough to detect small, day-to-day changes in damage. I therefore used an adaptation of the system I have described for assessing damage to cherries. On each vine to be assessed I marked off one branch on the upper and one on the lower supporting wires, preferably on either side of the trunk. I then counted the numbers of grapes on each. This requires patience and a hand tally-counter. (The alternative would be to postpone the counts till the end of the season, then cut the bunches, weigh them, subtract 5 per cent for the weight of the stems, and then divide by the weight of the average berry.) On subsequent visits, I counted and removed all damaged berries; for French hybrid cultivars where the birds remove the whole berry, I removed the empty stem with a pair of nail clippers.

I worked in the following vineyards (Fig. 1):

- **Jordan Farm:** the Canada Department of Agriculture's experimental vineyard at Jordan Harbour; this was laid out in a checkerboardlike arrangement of Seibel 10878, Delaware, Fredonia and Agawam cultivars;
  - **Ontario Farm:** the Ontario Department of Agriculture's experimental vineyard southwest of Vineland Station;
  - **Honsberger's Vineyard:** a commercial vineyard south of Jordan Station;
  - **Stempski's Vineyard:** a commercial vineyard west of Vineland, half way up the Niagara escarpment.
- I also used information given me at Stevens' Vineyard, a commercial vineyard at the top of the escarpment, southwest of Vineland.

#### Damage to different cultivars

Table 3 shows the proportion of damage to a number of grape cultivars at harvest time, in different vineyards and years. Because of our differing assessment techniques it is difficult to compare my figures with those of Stevenson and Virgo (1971), but the two sets of data seem to be similar. There certainly did not seem to be any unusually large concentrations of birds in the vineyards where I worked, and in any case I doubt if these could have inflated my grape damage estimates in the way they seem to have done with the cherries.

Nonetheless, damage varied greatly among vineyards and among years for several cultivars. In some cases, one can explain the variations. For example, migrating Robins arrived later in 1969 than in 1968, and this probably explains the differences in damage to Seibel 13053, the first cultivar to ripen in Ontario Vineyard. Robins in that vineyard were controlled by an effective shotgun patrol, which probably explains why the later-ripening Seibel 10878 was untouched there, even though it was quite heavily damaged on the unprotected Jordan Farm. New York Muscats and Fredonias were probably damaged by Baltimore Orioles (*Icterus galbula*) (see next chapter); the year-to-year variations in damage might

**Table 3**

Percentage damage to grape cultivars at various locations at harvest time in 1967, 1968 and 1969 (lf indicates a French hybrid cultivar; "0" indicates no damage; "0.0" indicates minimal damage).

Fig. 7.

Cultivar	Vineyard										
	Honsberger's			Jordan Farm			Ontario		Stempski's		Stevens'
	1967	1968	1969	1967	1968	1969	1968	1969	1968	1969	1968
Foch (f)	12.0*	24.6	0.9				12.7	7.1			
Niagara	0.0						0				
Catawba	0.0										
Concord	0.0						0				
NY Muscat	10.2	5.9	5.0				0				
Duchess							0.4				
Seibel 10878 (f)				9.0	13.9	11.2	0.0			15.7	none†
Delaware				0	0.0		5-10				
Agawam				0.0	c. 5.0						
Fredonia				8.8	1.2	0.9	0.3		6.4	2.2	
Seibel 13053 (f)							59.1	11.6			
Seibel 9249 (f)							1.1				
Van Buren							0				
Seibel 5279 (f)							1.6				
Seibel 9110 (f)							0				
Seibel 7093 (f)							0.0				
Seneca							9.6	0			
Seibel 1000 (f)							<0.1				
Elvira							0.1				none†
Ontario							9.0				none†
Seibel 9549 (f)									0.5	c. 1.0	

\*Only a central strip of vines was sampled in 1967. The entire vineyard of Foch cultivars was done in 1968 and 1969. (In 1968 damage on the central strip was 12.0%.)

†Damage estimated by grower.

reflect differences in the timing of the fall migration. Honsberger's Foch failed to ripen properly in 1969, and therefore escaped damage. There is, in general, the same degree of variation as there is with cherries, and it is equally difficult to predict whether, and to what extent, a cultivar or a vineyard will be damaged by birds.

The daily changes in damage rates were much slower for grapes than for cherries. As Stevenson and Virgo (1971) point out, the damage rates, when applied to graphs, demonstrate two kinds of change:

- French hybrid cultivars show steady linear changes (Fig. 3a). The Foch and the 1967 Seibel 10878 graphs show that damage

started two weeks or so before harvest and increased more or less in a straight line. Stevenson and Virgo (1971) show very similar patterns for Foch and Seibel 10878 during the 1965 season. The 1968 Seibel 10878 showed the same pattern at first; but in early October, about a week after the estimated picking date, the vineyard was extensively damaged by a large flock of Starlings, and this converted the accumulated damage rate into something like the accelerating curve typical of late cherry cultivars. The damage to Seibel 13053 starts off in the same way as the others, though increasing even faster; this was the only ripe cultivar in the vineyard in late



Figure 3a. Cumulative damage rates to grapes for French hybrid cultivars.

Figure 3b. Cumulative damage rates to grapes for New York Muscats and Fredonia cultivars.

Figure 3a

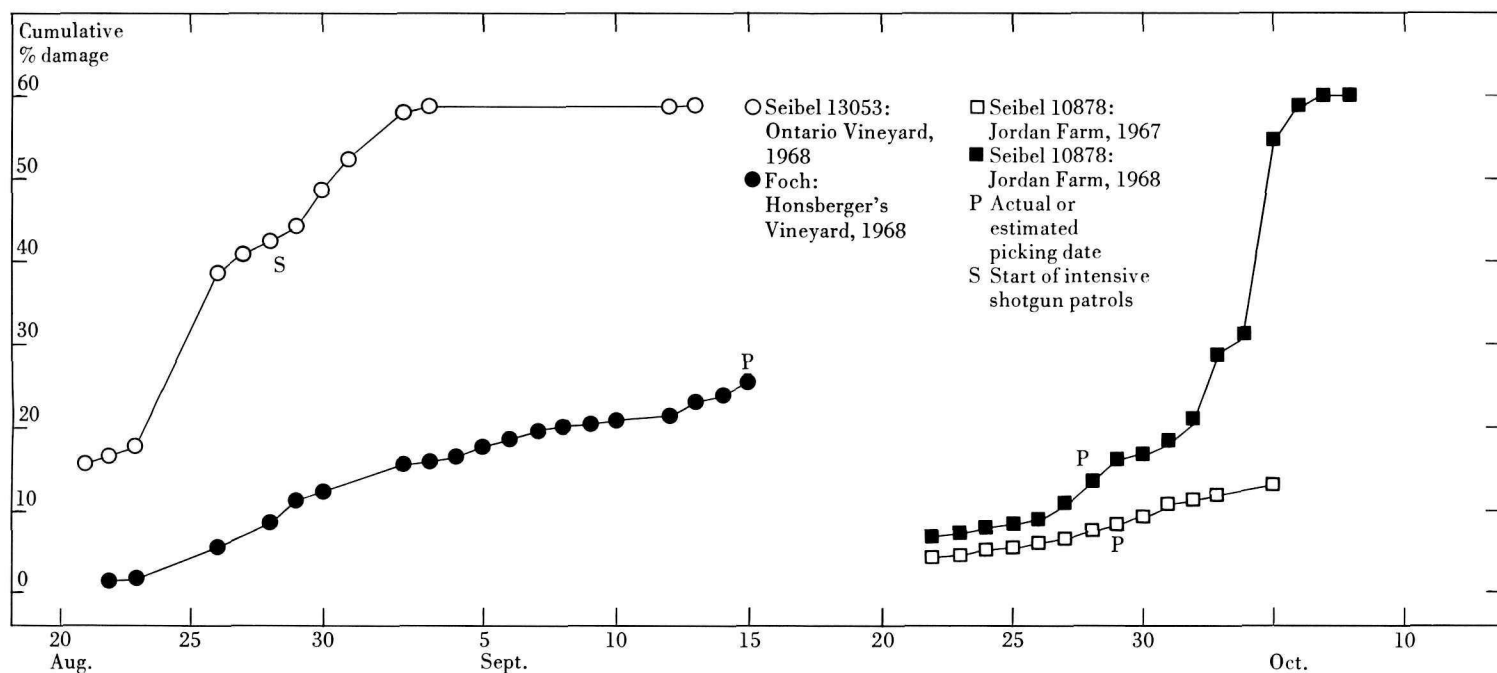
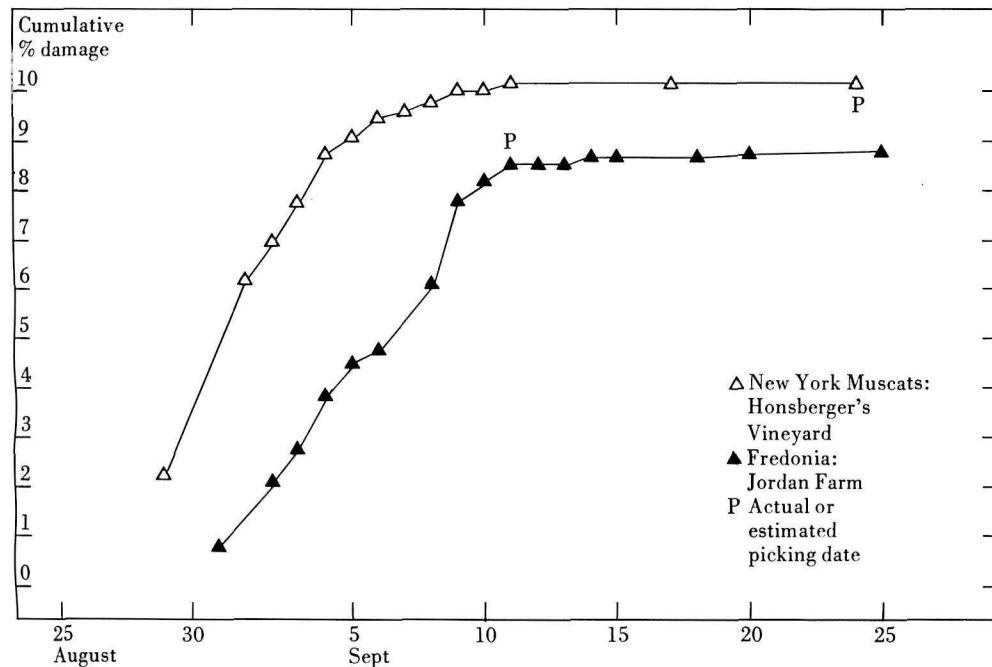


Figure 3b



August, and the Robins apparently concentrated their attention on it. But by the end of August the shotgun patrols began to take effect, and there was negligible damage after the first few days of September, because the birds had all been either killed or frightened off.

- While New York Muscats and Fredonias were moderately damaged in late August and early September 1967, they were left alone after that (Fig. 3b). Stevenson and Virgo (1971) found exactly the same for New York Muscats in 1964 and 1965 as I did at Honsberger's in 1968 and 1969. There was too little damage to the Jordan Farm Fredonias in the other two years to show any pattern; however, all the damage to this cultivar at Stempski's in 1968 took place by early September. In none of these vineyards were the birds being driven away by any protective system. It seems probable that the damage was caused by a migrating species which left southern Ontario by early September: the Baltimore Oriole is the likeliest possibility.

Two practical points seem to come out of these figures. First, damage to grapes does not escalate in the way that it does for cherries, and so the grower should have more leeway in selecting his harvest dates. However, some kind of protection is desirable for French hybrid cultivars during the two weeks or so before harvest; with the others, the key period seems to be the end of August.

Secondly, it seems fairly clear that at least two species are important in causing grape damage in southern Ontario: Robins and Baltimore Orioles. This means that it will be difficult to separate the two, and specify why certain cultivars or vineyards are vulnerable to damage; it probably also means that we have to think in terms of more than one protective system. I shall discuss both points further later on.

### Damage to other fruits

My observations on the damage to other fruits are less systematic, but it seems worthwhile to include them for the sake of completeness.

### Apples

Birds sometimes peck at windfall apples, especially those that have been partly eaten away by insects. But I found only one case where they damaged apples on the tree. The plot next to the Jordan Farm sour cherries was planted with young apple trees of several cultivars, and some of these were damaged quite severely by Starlings after all the cherries had been picked or eaten.

The affected cultivars were Melba and Cortland, located in the rows closest to the cherry plot; McIntosh, Delicious and Spy were not touched, either because their fruit was less ripe or because they were farther away from the cherries. Table 4 shows how apple damage changed during the season.

Three points come out of Table 4. First, Melba, the redder of the two varieties, was damaged more; this fits in with the importance of redness in stimulating birds to eat fruit. Secondly, this damage increased sharply during the second week of August

**Table 4**  
Cumulative percentage damage to apple cultivars on Jordan Farm in August, 1967, 1968 and 1969.

Date	1967		1968	1969
	Melba	Cortland	Melba	Melba
August 8			2.4	
August 11	8.2			
August 12			4.2*	
August 13				2.2
August 14	55.2	2.5		
August 16	74.3	7.7		
August 18	79.0	10.5		8.3
August 20				6.8†
August 21	69.0†	9.8†		
August 25	58.1†	5.4†		

\*The apples were too rotten for later assessments in 1968.

†This decline in cumulative damage is of course statistically impossible, and is due to damaged apples falling and therefore not being counted.

1967 — just after the last of the sour cherries had either been picked, or eaten by the birds; it looks as though the Starlings simply turned to the nearest available red fruit in the area. Thirdly, apple damage was much lighter in 1969, the year in which the build-up of Starling flocks was unusually late — an indication of the advantage to be gained from an effective protection system.

### Other orchard fruits

I took some counts on Bartlett pears and on apricots growing on Victoria Farm in 1967, but the damage was negligible. However, Starlings were eating peaches in mid August of that year on both Victoria and Pond Farms.

On August 19, 1968 I checked some branches of apricots and nectarines growing on Victoria Farm. The apricots averaged 23 per cent and the nectarines 11.3 per cent pecked fruit. Starlings appeared to be responsible.

### Wild and garden fruits

It cannot be more than a century since grapes and orchard fruits were first grown commercially in the Niagara Peninsula, so all the birds which now eat them (except the Starling, which did not reach Ontario until

1914 [Godfrey, 1967]) must previously have relied on wild fruits in the summer and autumn, if they took fruit at all. It would be interesting to know the extent to which non-commercial fruits are still damaged.

On the grounds of the Research Station at Vineland there was a medium-sized mountain ash tree (*Sorbus decora*) which was visited by Robins every fall. It was damaged particularly heavily in 1967. I first noticed the birds in it during the first week of October; by October 10 I estimated that they had taken 15 per cent of the berries; by October 23 this had risen to 27 per cent.

At the same time, Robins and Hermit Thrushes (*Hylocichla guttata*) were feeding on yew (*Taxus baccata*) berries nearby. From June onwards, Robins and Starlings were feeding extensively on mulberries (*Morus rubra*) both at the Research Station and at Jordan Harbour. Faecal analyses (see p. 33ff) show that these fruits formed an important part of the Robins' diet.

Finally, I have some notes on the damage caused, mainly by Starlings, to a wild cherry tree (probably a self-sown cultivated variety) in the Jordan Farm woodlot. Damage accumulated even faster than on the sour cherry plot: in 1968 it increased from 30.3 per cent on July 11 to 98.4 per cent on July 18; in 1969 it went up from 2.2 per cent on July 11 to 82.2 per cent on July 18 and 100 per cent on July 21. In late September 1968, both Robins and Starlings were feeding on wild grapes (*Vitis* sp.) and in a wild black cherry tree (*Prunus serotina*) in the same woodlot; they had done 35 per cent damage to the latter by September 27. But neither seemed to be bearing fruit in 1969.

It is, of course, slightly absurd to speak of "damage" to a non-commercial fruit. I have done so deliberately, to emphasize the anthropocentric attitude we have towards this whole problem. From an agricultural point of view, 27 per cent seems a very high proportion of mountain ash berries to be lost, and 35 per cent an even higher one for wild black cherries. But actually, in evolutionary terms, it is probably rather too low.

# Bird populations and migrations

The point is that the fruit of both species, and of the ancestors of our cultivated grapes and cherries, functioned mainly as a dispersal mechanism. Such plants spread their ranges by being transported in the stomachs of birds and other animals. To do so, their fruits had to be specifically adapted in colour and content to attract the attention of these animals. The ways in which they do this are varied and elaborate (Snow, 1971). The point is that if we, as one of the dispersal agents, choose to improve on some of these attractive characteristics for our own purposes, we ought not to be too surprised if by doing so we attract the birds as well. We subconsciously assume that it is "wrong" or "unnatural" for animals to eat fruit, when actually the problem is as old as Genesis.

## The species causing the damage

Virgo's (1966) questionnaire survey on bird damage asked growers to list the species which they thought were responsible. Starlings were named by 61 per cent of them, followed closely by 51 per cent who named Robins. These were far ahead of the other species named: Grackles (17 per cent) came next, followed by Red-winged Blackbirds (*Agelaius phoeniceus*) (9 per cent). The order was the same among growers of both sweet and sour cherries, grapes and, indeed, all the common fruits except strawberries and raspberries, where Robins replaced Starlings as the most accused species.

Virgo (1971; Stevenson and Virgo, 1971) followed this up with regular counts of birds in cherry orchards and vineyards, combined with stomach content analyses of the commoner species. His counts confirmed and amplified the growers' impressions: Starlings, followed closely by Robins, were the commonest birds in sweet cherry orchards, though Grackles and Red-winged Blackbirds were also fairly common. Starlings, followed by Robins, were the commonest birds in vineyards, while very few birds of other species were seen there. However, on the basis of the stomach content analyses, Virgo concluded that Robins were actually more important than Starlings in causing damage to grapes. On the other hand, few of the Robins he shot in sweet cherry orchards contained the remains of cherries: he concluded that Robins were visiting the orchards mainly to feed on the ground on animal food, not to take fruit.

My own observations on Robin, Starling and Grackle numbers and my analyses of their diets will be given in detail below; I will consider only a few points here. The only disagreement between my conclusions and Virgo's is over the Robin's importance in damaging sweet cherries. In contrast to his experience, I found that not only did Robins visit sweet cherry plots to feed on cherries, but at least up to mid July they probably did more damage than any other bird.

**Table 5**

Numbers of feeding entries by Robins, Starlings and Grackles into sweet cherry trees in plots on Victoria Farm, over certain periods of observation.

Plot	Period	Entries		
		Robin	Starling	Grackle
V1	to July 9, 1967	539	201	102
V1	July 10 and after, 1967	94	269	10
V4	June 18-July 15, 1968	201	111	15
V17	June 13-27, 1968	247	185	50

For example, I counted the birds visiting cherry trees in Victoria Farm's V1 plot in 1967, and in the V4 and V17 plots in 1968. As an index of the relative importance of the three main species, Table 5 shows the total number of Robin, Starling and Grackle entries into cherry trees in each plot, omitting entries where the bird did not feed on cherries. There can be no doubt that Robins caused significant damage to sweet cherries in this orchard. This is confirmed by the frequency with which I found cherry pits in nests from which the young were fledging, as well as cherry remains in the fledglings' faeces. It is true that the Robin "colony" on Victoria Farm may have inflated the number of birds visiting the cherry trees. However, this still does not explain the discrepancy between Virgo's observations and my own over whether the Robins were actually feeding on cherries. Both Smith (1963) in Massachusetts, and P. J. Austin-Smith (pers. comm.) in up-state New York, regarded the Robin as one of the principal species damaging cherry orchards.

There is also a minor difference in our assessments of the importance of the Baltimore Oriole. Both Virgo and I found that it did minor damage to sweet cherries, and we both found it scarce in vineyards. However, I feel that it is commoner in vineyards than the counts of this inconspicuous bird would suggest, and that it is in fact responsible for a significant amount of damage at the end of August.

I have described how New York Muscat and Fredonia grapes were damaged only in late August and early September. This

damage takes the form of a triangular peck, perhaps a quarter of an inch deep, suggesting a bird with a fairly stout but also fairly long bill. This would rule out a sparrow or a warbler. One rarely sees birds in the vineyards at this time: this in itself would appear to eliminate Robins and Starlings, which are always fairly conspicuous; besides, as Robins and Starlings are present all through the grape season, it is hard to see why they should suddenly start, then stop, eating these cultivars, long before harvest. It is much more likely that whatever does the damage leaves southern Ontario by early September. This timing fits the fall migration of the Baltimore Oriole very well; the bill shape of this bird seems right; and its habit of skulking in the foliage would explain why it is rarely seen in the vineyards. As confirmation, both Smith (1963) in Massachusetts and P. J. Austin-Smith (pers. comm.) in upstate New York have found that Baltimore Orioles cause substantial damage to grapes. (Both also regard the species as a serious predator of cherries. It is curious that this should not be true in southern Ontario, yet I practically never saw Orioles during my watches at Victoria Farm or in any other cherry orchard.)

#### **Damage done by the individual bird**

So far, I have described damage en masse — the amounts eaten by birds in an orchard or vineyard over the whole season. It is useful to translate these figures into the amounts eaten by individual birds.

The basic problem is to estimate the frequency with which individuals eat cherries (I made no studies with grapes). During cultivar choice trials in 1968 (p. 31), I found that four caged Robins ate an average of 1.18, 1.19, 1.17 and 1.42 cherries per hour when given nothing else to eat. This is slightly faster than one would expect from digestion rates: a fledgling fed with a sweet cherry showed the first trace of colour in its faeces 85 minutes later on one test, and 120 minutes later on another. But the stomach and oesophagus are probably

clear by the time the first traces of fruit reach the rectum. The rates for caged birds agree with my observations of Robins feeding in the Victoria Farm V1 plot (Table 7); these took an average of 1.41 cherries per visit to this plot, and the one colour-marked bird made about one visit an hour.

The cherry season lasts for about six weeks. So, if a Robin ate nothing but cherries it would take something of the order of 20 in a 15-hour day, or 850 (about 1.8 pounds) over the season as a whole. In one way this must be an overestimate, since Robins eat cherries mainly at the start and end of the season, and even then they take animal food as well (p. 40ff). But it is probably an underestimate of the amount of damage they do: their technique is to peck at, and even swing on, fruit after fruit until one breaks loose, then fly down to the ground and break it up with sideways jerks of the head, much as a European Song Thrush (*Turdus ericetorum*) shakes a snail out of a broken shell. In this process, they must damage more than they eat, though it is hard to say how much more. P. J. Austin-Smith (pers. comm.), working in upstate New York, thinks that they damage three times as many cherries as they actually eat.

On top of this, they feed cherries to their young. At the Robin nests I watched, the parents made about seven visits per hour. (Hamilton [1935] reports 10 visits per hour.) This would add up to 100 to 150 cherries a day, assuming that the birds brought one cherry per visit (they very occasionally carry two, by the joined stems) and, again, that they brought nothing else. So a pair of Robins, eating only cherries themselves and feeding them to their young, might take 150 to 200 fruits a day. But, as faecal analyses show (p. 33ff), they in fact bring animal food as well. But this is almost certainly an exaggeration of how much they eat, though not, perhaps, of how much they damage.

Observations on caged Starlings in 1968 suggested that they might be taking cherries at a faster rate than Robins. Flocks 1 and 2

(p. 32) averaged 2.32 and 1.24 cherries per bird per hour and two sub-groups, tested before they were combined into Flock 2, averaged 2.15 and 0.81 respectively. This may be a question of larger stomach size combined, perhaps, with a faster handling time. (Starlings tend to swallow cherries whole in the tree, instead of breaking them up on the ground.) The digestion rates, to judge from birds autopsied at intervals after they had been fed cherries, seemed to be of the same order as the Robins'. (Kuroda [1962] found similar rates for the Grey Starling [*Sturnus cineraceus*].) However Starlings, like Robins, take animal food as well as fruit during the cherry season, so any rates based on these caged birds are almost certainly too high. Probably the individual Starling does about the same amount of damage in a season as does the individual Robin. But their greater overall influence on the damage situation comes, of course, from the size of their flocks in the orchards.

#### **Robin population fluctuations**

##### **Seasonal changes in numbers**

In order to census Robins (and also Starlings and Grackles) in the Vineland area, I drove around a regular route on Victoria Farm and the adjacent grounds of the Vineland Research Station, counting all the birds I could see, excluding newly fledged juveniles still dependent on their parents. Figure 4 shows the changes in numbers during the 1968, 1969 and 1970<sup>1</sup> seasons; my impression is that 1967 was very similar, with an absence of Robins in September, followed by an influx in early October.

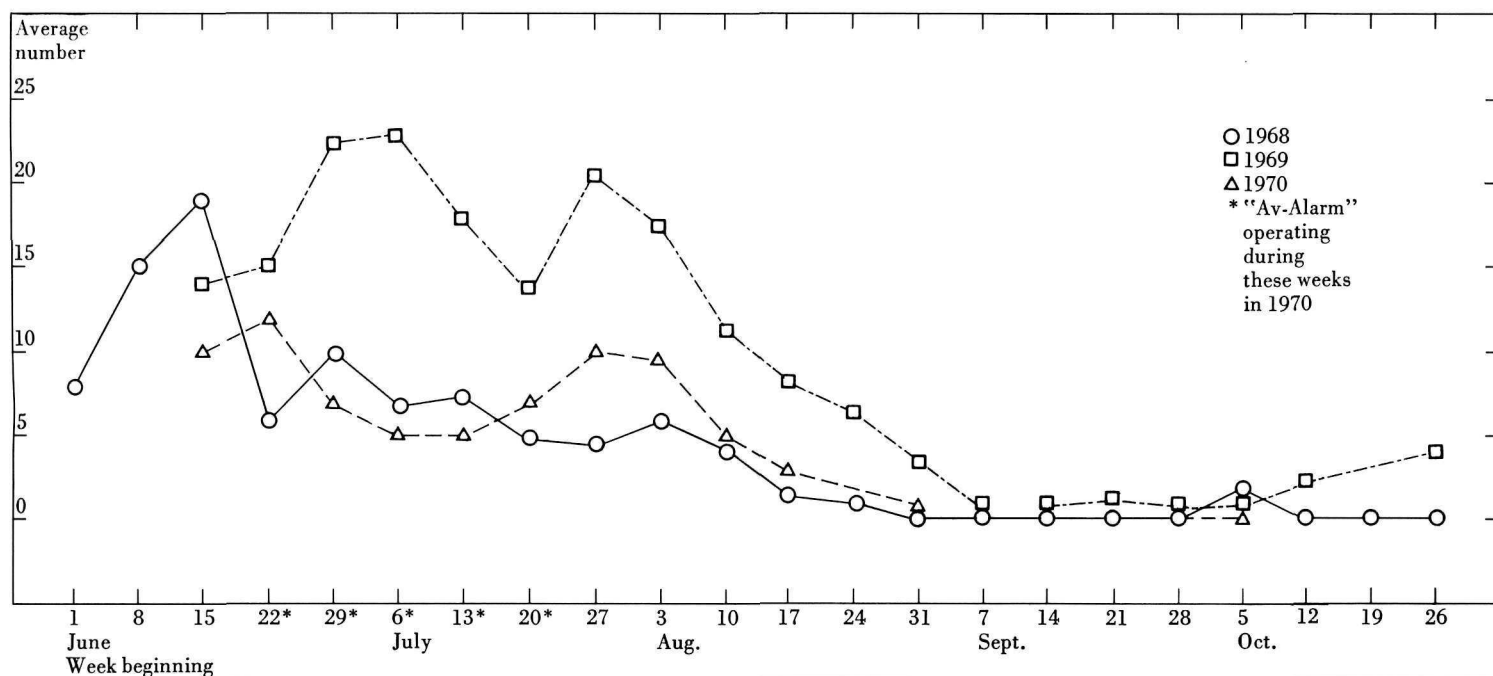
The disappearance of birds from the census area in August and September is at least partly due to a change in feeding habits. The birds at first move into the cherry orchards. Within the Vineland census area there was a relative increase in Robin numbers on Victoria Farm, with its cherry or-

<sup>1</sup> In 1970 the Victoria Farm orchard was rather effectively protected by the Av-Alarm system. Robin, Starling and Grackle numbers were artificially low for late June and early July of that year.



Figure 4. Average number of Robins seen per day in the Vineland census area, 1968–1970.

Figure 4



chards, in July, followed by a decline after the fruit was picked. In 1968, for example, the ratio of Robins on Victoria Farm compared to the Research Station, where there are no cherries, was 1.73 for the June counts; it increased to 3.12 in July, but declined to 0.59 in August. (Picking took place in mid and late July.) Similarly, flocks of Robins visited the Jordan Farm sour cherry orchard during the first two weeks in August during all four years, leaving only when all the fruit had been eaten or picked.

The birds also move into the vineyards from late August onwards, as the grapes ripen. Unfortunately, the layout of a vineyard is such that it is extremely difficult to count the birds in it, and my attempts to do so can be little more than quantified impressions. Nonetheless, they show a general pattern of movement. Figures 5a and b give some week-to-week estimates in various years in the Jordan Farm, Ontario<sup>2</sup>, Honsberger and Stempski vineyards, as well as in the small woodlot near the vineyard on

Jordan Farm. Birds were present in the vineyards from the time observations began in late August, with a big influx in late October — presumably of migrants from the north.

However, there was some variation from year to year; for example, Robins seemed commoner in both the Honsberger and Jordan Farm vineyards in 1967 than in later years. In some cases, these differences can be linked to the food supply. Robins were common in the Jordan Farm woodlot in 1968, when they fed on a wild black cherry tree, but almost absent in 1969, when this tree did not bear fruit. But this does not explain all the variations. It may be that the late summer Robin flocks choose a food source (which may vary from year to year) and stay close to it, without exploring elsewhere. This certainly happens a little earlier on. Hirth *et al.* (1969) found in Massachusetts that flocks of juveniles stayed in the

<sup>2</sup> The September counts in Ontario vineyard are artificially low, the result of intensive shotgun patrols.

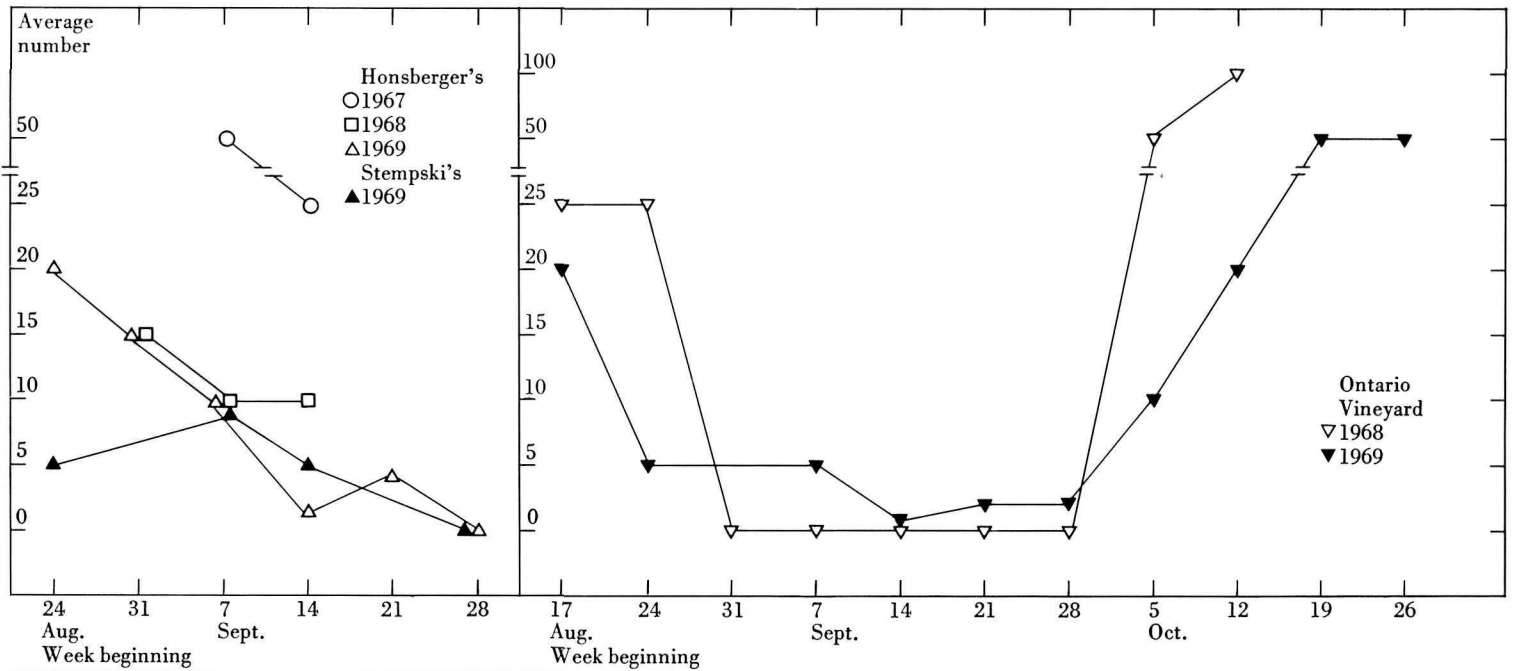
area of their former nests for at least two months after fledging, repeatedly visiting individual cherry orchards and raspberry and blueberry patches for as long as the fruit was available. In a later chapter I shall give similar examples in breeding adult Robins.

I should emphasize, also, that Robins are not found exclusively in orchards and vineyards after the breeding season ends. For example, there was always a small flock of birds in a plot of old apple trees on Victoria Farm in July, even though there were ripe cherries in plots nearby. In mid August 1969, I saw a small flock feeding at the edge of a woodlot for several days in succession, although only a quarter of a mile away other Robins were taking Jordan Farm sour cherries. Even the birds caught in cherry orchards had been taking at least some animal food. So the disappearance of Robins in the later part of the summer is in fact at least partly due to a change in habits rather than habitat. They also seemed to keep much more under cover, and while I

Figure 5a. Average number of Robins seen per day in the Honsberger, Stempski and Ontario vineyards.

Figure 5b. Average number of Robins seen per day in the Jordan Farm vineyard and woodlot.

Figure 5a



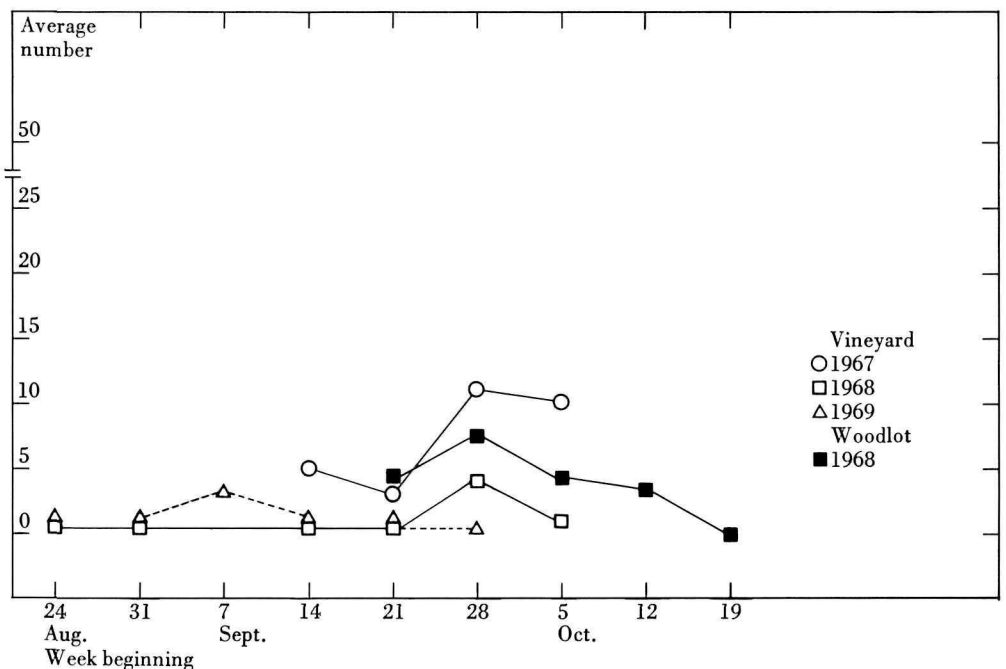
could see few from the car during my standard census, I could usually find birds at Vineland by searching for them on foot. It may be that the birds were staying in cover while moulting.

#### Seasonal changes in the ratio of adults to juveniles

The damage to the early sweet cherry cultivars was done mainly by adult birds, which both ate the fruit themselves, and took it off to feed their young. I have no exact counts, but I estimated that over 90 per cent of the Robins visiting Victoria Farm plots V1, V4 and V17 in late June and early July in 1967 and 1968 were adults.

This ratio was reversed by late July. During the last week of July and the first two weeks of August in 1967, 1968 and 1969 I mist-netted a total of 20 Robins on Victoria Farm: 15 (75 per cent) were juveniles. The proportion was even higher in the Jordan Farm sour cherries, where 39 of the 44 birds caught (88.6 per cent) were juveniles. Virgo (pers. comm.) mist-netted

Figure 5b



329 Robins in the same orchard in August 1966, of which 325 (98.8 per cent) were juveniles; by contrast there were only 27 (34.6 per cent) juveniles among the 78 birds he caught in July on Victoria Farm and the Research Station. The trend continues in the later part of the season. All 25 Robins collected at Ontario Vineyard between August 10 and 23, 1969 were juveniles. On September 14, 1967 I counted four adults and seventeen juveniles in a flock on Victoria Farm, and one adult and 28 juveniles in another in Honsberger's Vineyard. Smith (1963) reported a similar shift in fruit-growing areas in Massachusetts. The change of course reflects the entry of increasing numbers of newly independent young birds into the population, though there is probably also some sampling bias: I would expect that juvenile birds are easier to net and shoot.

But the observed change in adult/juvenile proportions also reflects the fact that the young birds form flocks from the time they become independent in July, while the adults stay on their own territories at least until mid August. For example, an adult male Robin with a distinctive song pattern stayed on its territory at Jordan Harbour at least until Robin song stopped, in late August 1969. Some counts of adults and juveniles show this in more detail. Table 6 shows that the proportion of adult birds in the Victoria Farm and Research Station census area remained high right up until the end of August 1969, although other counts and mist-netting showed a high ratio of juveniles in the orchards at the time. It would therefore appear that the adults are still in the area, but that they play a relatively less important role in damaging late cherries than they do with the early cultivars.

#### Banding returns

The next problem is to determine where these large flocks of juvenile Robins come from: were they bred in the Niagara area, or did they migrate in? The evidence at first suggests an immigration. Virgo (pers.

**Table 6**

Counts of adult and juvenile Robins in certain areas of Vineland over several weeks in 1969, with the proportion of adults to the total.

Week starting	Research Station and Victoria Farm			Jordan Farm area		
	Adult	Juv.	Proportion of adults (%)	Adult	Juv.	Proportion of adults (%)
June 29	72	11	86.7			
July 6	57	14	80.3			
July 13	No data					
July 20	55	11	83.3			
July 27	38	15	71.7			
August 3	22	14	61.1			
August 10	35	13	72.9	10	34	22.7
August 17	22	25	46.8	13	18	41.9
August 24	20	18	52.6			

**Table 7**

Recoveries between April and September of Robins banded in Ontario and Quebec, using all recoveries reported up to the end of 1969.

Banding area *	When banded	Number of recoveries		Recoveries outside the banding area	
		In banding area	Elsewhere	Time	Location *
Niagara (43°–43°20'N, 79°–80°W)	to June	4	0		
	July and after	11	2	April May	41°30'N, 83°40'W 43°40'N, 79°20'W (Toronto area)
Toronto (43°30'–44°10'N, 78°–81°W)	to June	69	5	April May	45°00'N, 79°20'W 43°10'N, 79°40'W (Niagara area)
				May	43°40'N, 87°40'W
				May	39°20'N, 75°00'W
				August	45°20'N, 80°00'W
	July and after	35	4	May June July Sept.	43°00'N, 87°50'W 48°10'N, 71°10'W 44°20'N, 79°30'W 44°40'N, 79°20'W
Ottawa (45°–45°30'N, 75°30'–76°W)	to June	41	0		
	July and after	7	0		
Montreal (45°–46°N, 73°–74°W)	to June	43	1	April	45°50'N, 74°20'W
	July and after	54	4	April April May July	46°30'N, 72°10'W 36°00'N, 79°20'W 45°50'N, 64°20'W 46°10'N, 73°30'W

\*Latitudes and longitudes to the nearest 10'.

comm.) caught and banded a total of 649 Robins before and during the cherry season at Vineland in 1966, without making a single retrap (though I recovered some of his birds in later years). In contrast, Smith (1963) reports one per cent and 9 per cent

retrap rates in Massachusetts, and P. J. Austin-Smith (pers. comm.) had about 10 per cent in upstate New York. So the absence of retraps at Vineland suggests a large, nomadic Robin population. On the other hand, it is possible that the birds be-

Figure 6. Recovery locations of Robins banded in the Niagara, Toronto, Ottawa and Montreal regions, and recovered elsewhere. See text for further details.

came net-shy. R. C. Long (pers. comm.) tells me that he very rarely retraps Robins in the Pickering Beach area east of Toronto, even though he knows from colour bands that the birds are still in the area.

Besides, this lack of retraps is only negative evidence. Banding data in general seem to point the other way. There are four areas where most Ontario and Quebec Robins are banded: almost all breeding season recoveries occur in the area where the birds were originally banded (Table 7). The only Robin in Table 7 which could conceivably have been an immigrant into the orchards was banded in the Niagara in July 1956 and recovered in the Toronto area almost 13 years later, in May 1969. The Niagara sample is admittedly small, but it suggests that the early damage to fruit — in particular, to cherries — is done, not by immigrants, but by birds which are breeding, or have been bred in the fruit growing areas.

This may also be true of the Robins which damage the early grape cultivars. However, the increase in Robin numbers by the end of September (Fig. 5) suggests that migrants are coming into the area. Figure 6 shows the recovery points, outside their respective banding areas, of Robins banded in the Niagara, Toronto, Ottawa and Montreal. (The Toronto and Montreal groups include birds banded in the winter in the southern United States, and recovered in the Toronto and Montreal areas during the breeding season.) It appears from this that the general trend of seasonal movement of Robins from Canada lies between north/south and northeast/southwest. The westward shift is greater in the Montreal birds (as well as those banded by Middleton [1960] in southeast Pennsylvania) — presumably they are diverted by the coastline. The direction of this trend suggests that any Robins which migrate into the Niagara Peninsula later in the fall are from the Toronto area and farther north in Ontario, and are probably not coming in from New York State or farther east.

Figure 6

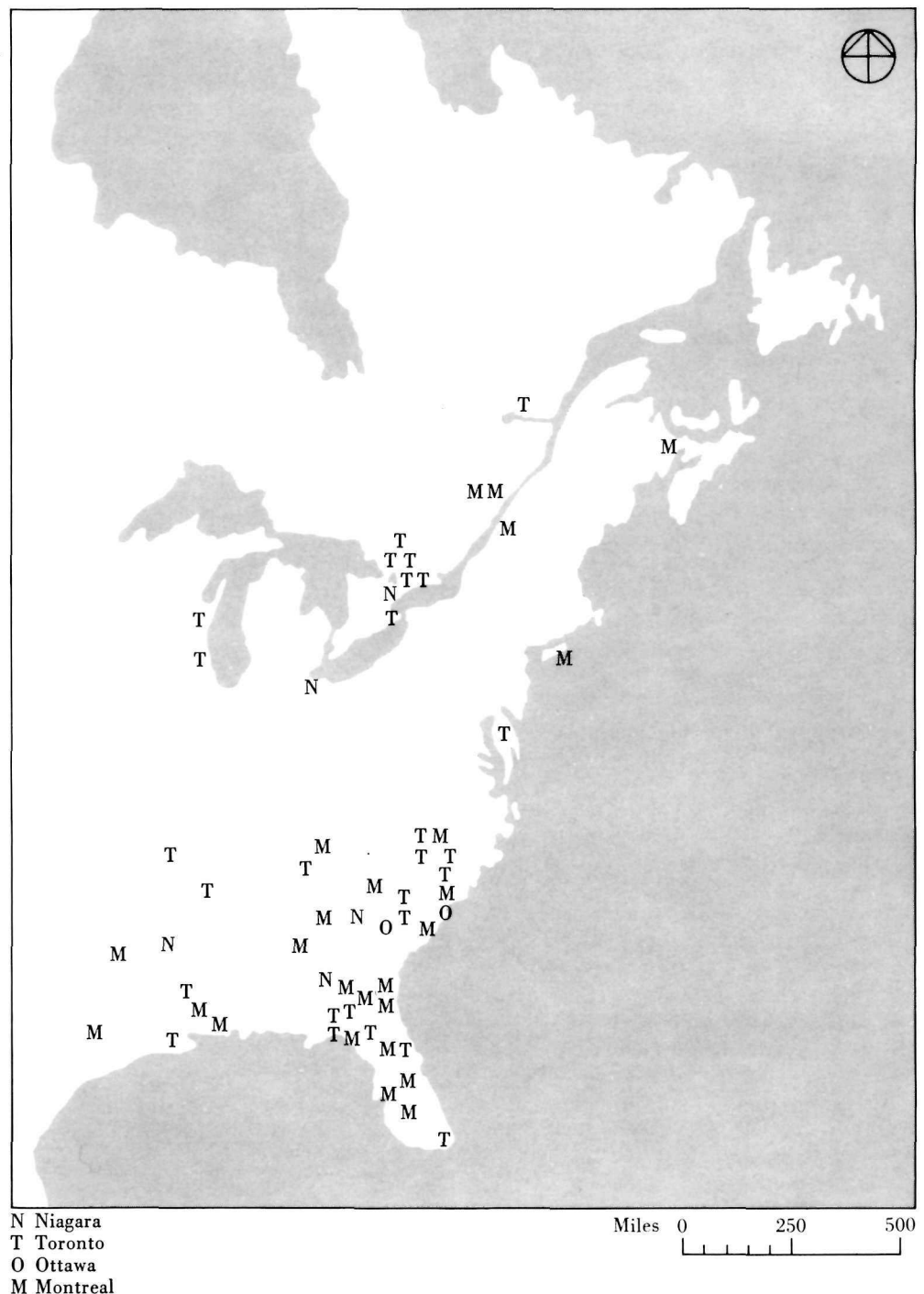




Figure 7. Map of southern Ontario showing the principal places mentioned in the text.



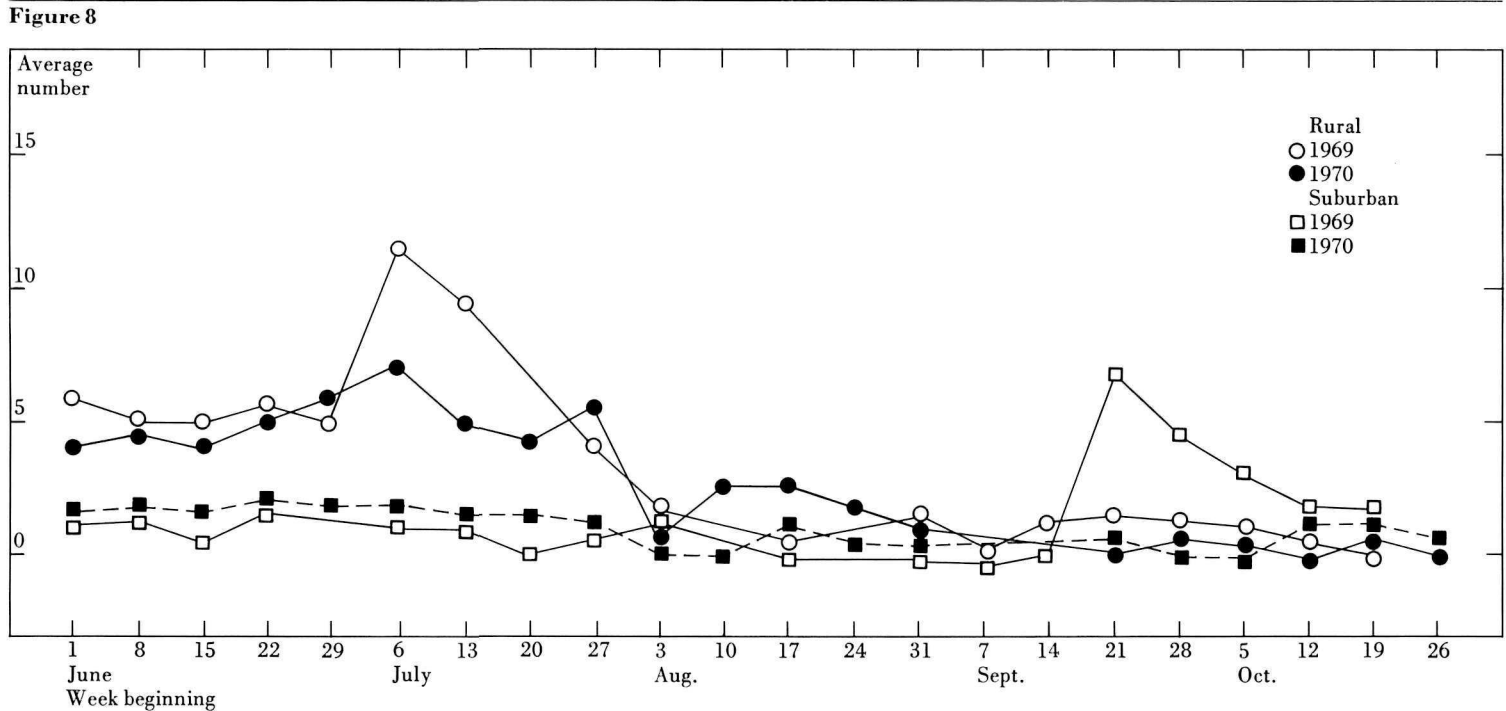
**Robin movements elsewhere in southern Ontario**

This hypothesis was checked by direct observations elsewhere in southern Ontario. In 1969 and 1970 I made regular counts of Robins along three miles of concession road east of Newmarket (Fig. 7), and outside my apartment in the suburban part of Newmarket. During the 1969 season I had members of the Ontario Bird Banding Association and CWS make similar counts

elsewhere, covering Ottawa, Bowmanville, Peterborough and Toronto (where I combined the counts of three observers). Each observer was asked to do his counts in a standard way, but I made no attempt to use a standard system for all observers. The important point here is not the absolute numbers of Robins, but their relative fluctuations in each area during the summer and fall.

There was an increase in Robin numbers in the rural Newmarket area in early July

Figure 8. Average number of Robins seen per day in the Newmarket census areas, 1969 and 1970.



1969, though not in 1970 (Fig. 8). Robins became scarce in both Newmarket habitats in both years after the end of July, and did not appear again in any numbers until the last few days of September and the beginning of October, when large migrant flocks arrived in the area. (Observations outside the census areas showed that the counts underestimated the size of this movement in 1970.)

Robin numbers at Toronto and Bowmanville stayed fairly constant all through the summer of 1969 (Fig. 9); unlike Newmarket, there seems to have been no decline in July and August. This may perhaps be due to local differences in food supply: the Toronto birds, at least, had access to garden fruits. Robins increased in both areas at the beginning of September and remained abundant into early October; they had mostly gone by mid October. The observer at Peterborough noted that Robins were scarce until the last weeks of September when, as at Newmarket, they built up for a short time. By contrast, the Ottawa

birds showed rather a different pattern. Numbers were fairly constant all through June, but increased at the end of July, apparently due to an influx of juveniles. The birds stayed all through August and September, their numbers fluctuating rather erratically, apparently due to local movements: their September peak, for example, was apparently due to the attractions of a ripening fruit tree in the census area.

The fluctuations of the Ottawa birds seem quite different from those in other areas; however, given the general north/south trend shown by the banding data, it is unlikely that birds from so far east would contribute much to the other populations. But the other areas fit together rather well: there were peaks of movement in September at Newmarket, Peterborough, Toronto and Bowmanville, but the birds had left these areas by mid October. At the same time, Robin numbers increased both at Victoria Farm and in the Ontario Vineyard in the last half of October (Fig. 5). It may be that the birds moved into the Niagara

area from north of Lake Ontario. The whole migratory wave may, perhaps, have been triggered by frost or snow further north in Ontario. Fortunately, most of the Niagara grape harvest has been completed by the beginning of October, so these immigrants can cause little damage.

On the other hand, there were no obvious earlier fluctuations in numbers north of Lake Ontario, which could be correlated with the changes in numbers at Vineland from mid July onwards. It still seems likely that the birds which damage fruit come from the Niagara area itself.

### Starlings

Figure 10 shows the changes in Starling numbers in and around Victoria Farm. There is a marked increase in the later part of the cherry season — from mid July onwards in 1968 and 1970 (and, to judge from entry rates into the V1 plot, in 1967 as well), but not until early August in 1969. These increases are almost all of juvenile birds; for example, the Starlings I caught

Figure 9. Average number of Robins seen per day in census areas in Ontario, other than Newmarket, 1969.

Figure 10. Average number of Starlings seen per day in the Vineland census area, 1968-1970.

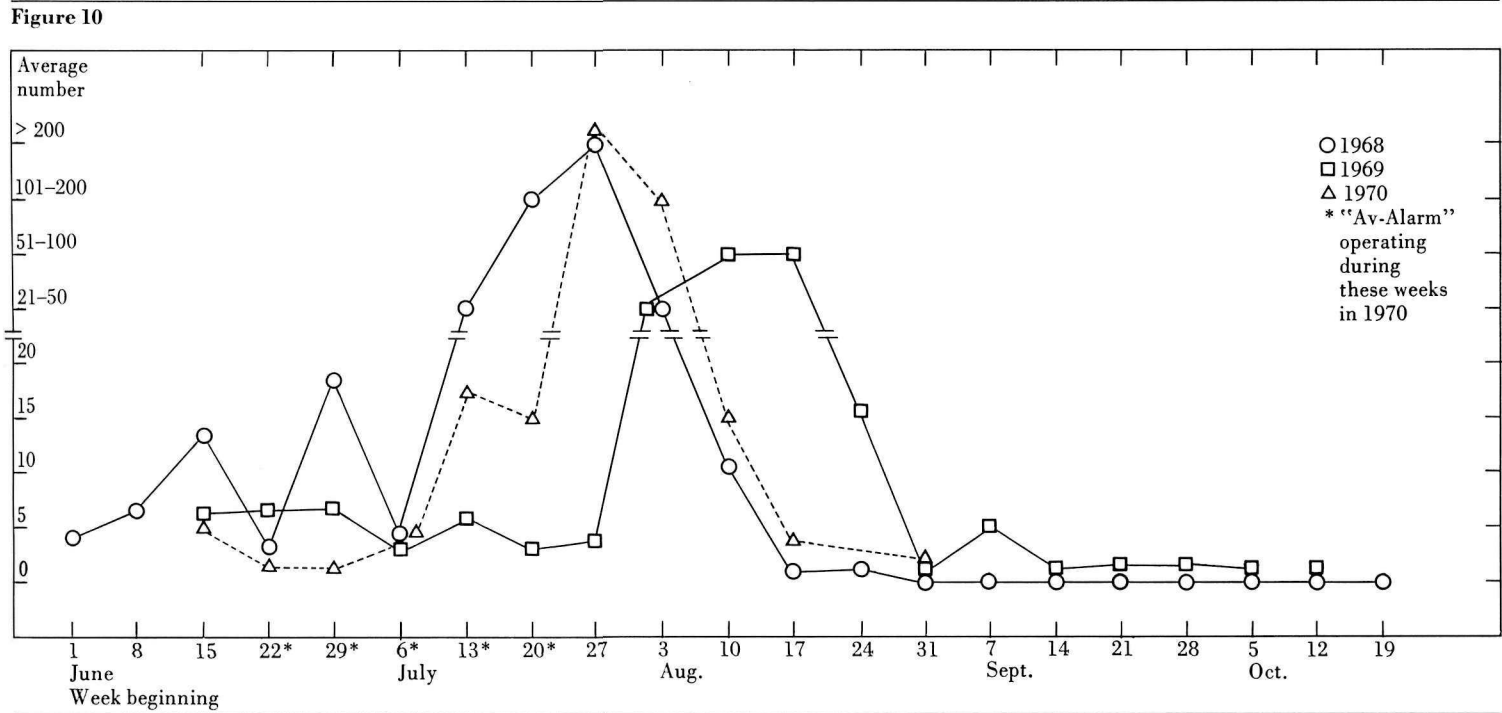
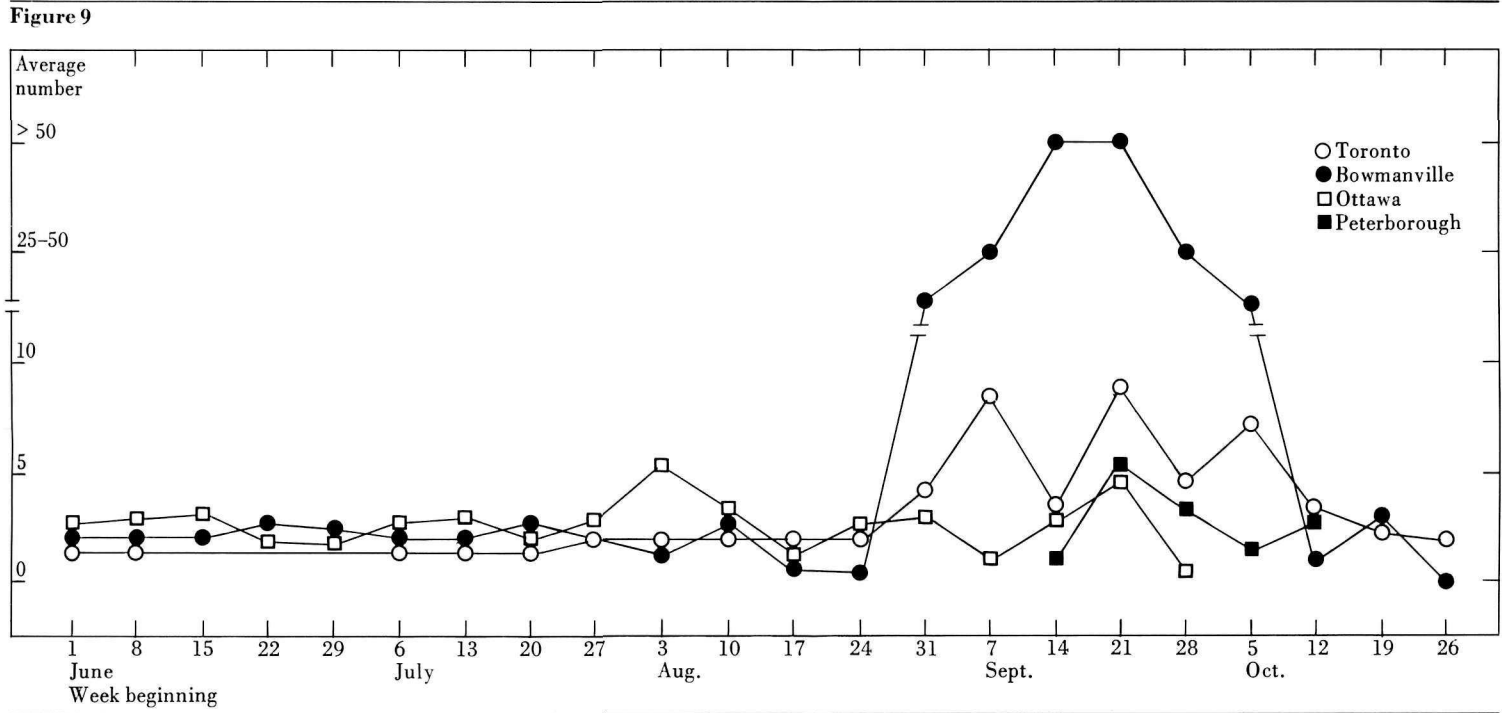
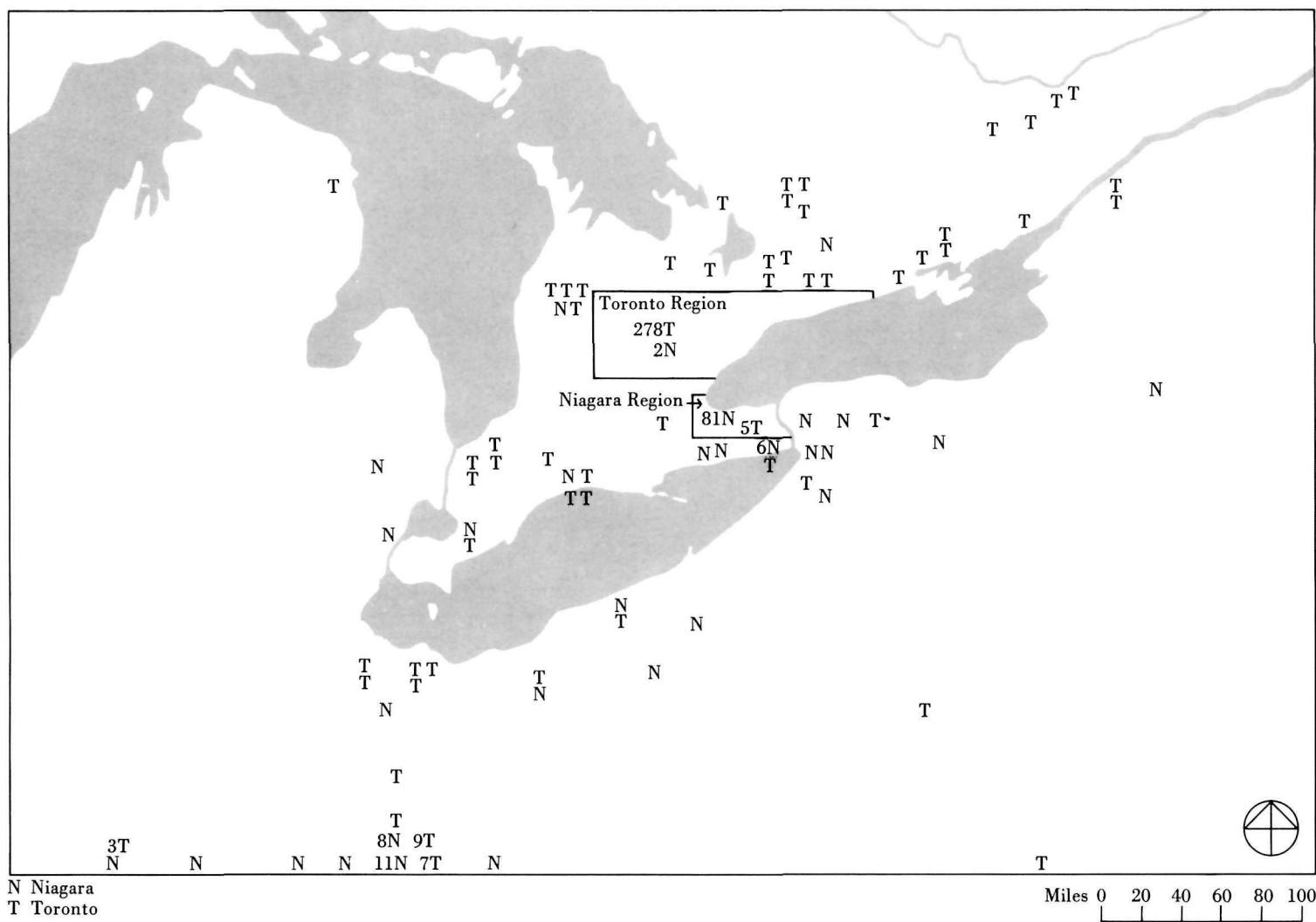


Figure 11. Recovery locations in the lower Great Lakes area of Starlings banded in Niagara and Toronto.

Figure 11



in the cherry orchards at those times in 1968 and 1969 for food choice trials comprised three adults and 29 juveniles. The increase in numbers is responsible for the sharp increase in the damage rate to the sour and later sweet cherry cultivars (p. 10). The numbers decline in mid August, after all the cherries are gone, and the birds are virtually absent after the end of that month.

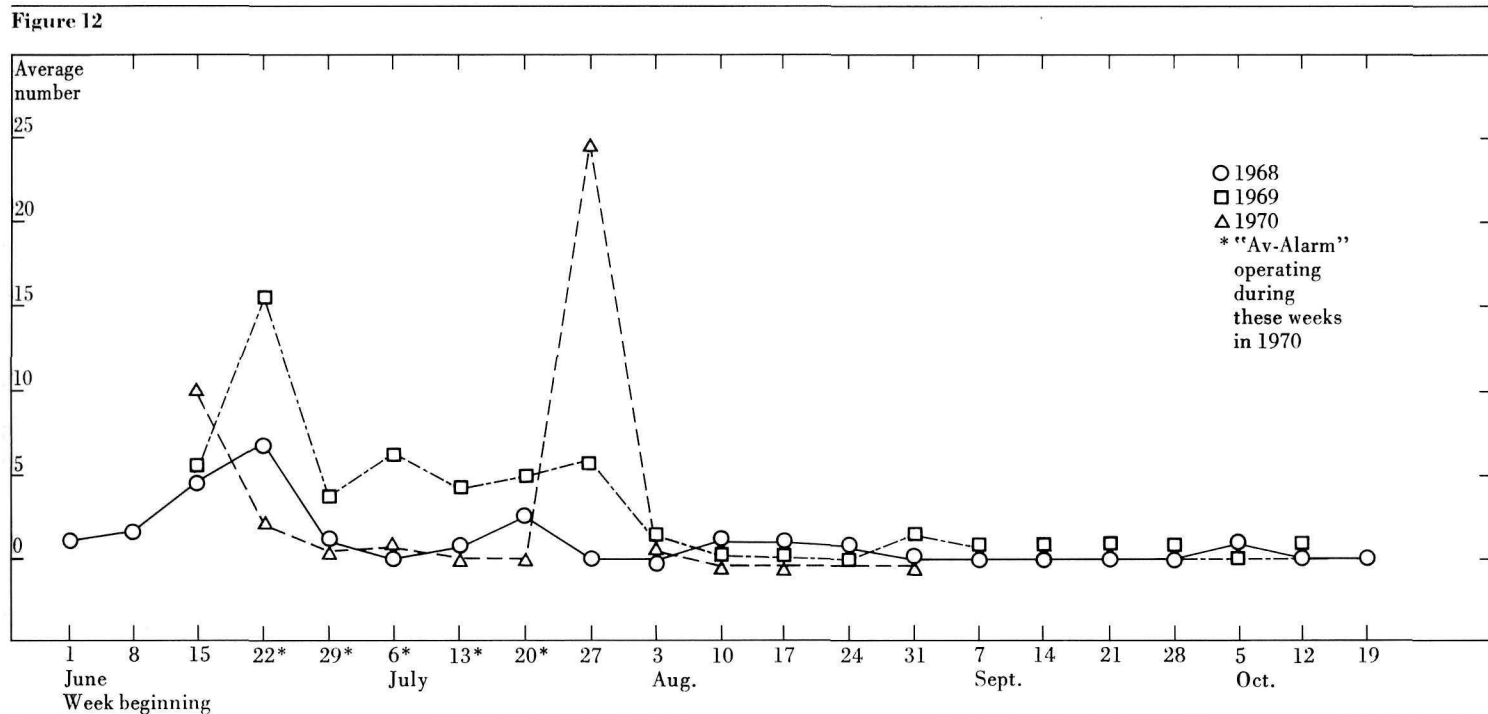
Starlings probably do not roam nomadically during this period, but stay within a

fairly small area. Collins (1960:135), observing colour-marked birds and retrapping banded ones in the Vineland area, concluded that "flocks of Starlings may feed in more or less specific areas day after day, until the supply of cherries diminishes." Such behaviour means that any control measures will be dealing with a relatively small Starling population.

At first sight, Figure 10 suggests that large numbers of Starlings are immigrants,

stopping off in the Niagara fruit growing areas to feed on cherries. But banding returns do not confirm this. Kessel (1953) shows that migrating Starlings have a pronounced northeast/southwest directional trend in eastern North America. This is at least partly determined by the topography: the birds fly along river valleys and avoid large stretches of water. Thus, she suggests that the Starlings which migrate into southern Canada in the spring have come up the

Figure 12. Average number of Grackles seen per day in the Vineland census area, 1968–1970.



Mississippi and Ohio valleys, pass to the north and south of Lake Erie and Lake Ontario, and from there up into the St. Lawrence valley. Figure 11 shows the situation around the lower Great Lakes, plotting the recoveries of birds banded in the Niagara and Toronto areas. (The boundaries of the Niagara area are the same as for Robins, but the northern Toronto boundary for Starlings [and Grackles] extends only to 44°00'N.) It seems from Figure 11 that, while some Starlings enter and leave the Niagara fruit belt west along the north shore of Lake Erie, most of them stay south of that lake. Presumably they enter the Niagara from New York State. Toronto birds, on the other hand, usually keep to the north of the two lakes, and there seems to be little contact between Starlings from the two areas, either during or after the breeding season. Thus, out of 159 recoveries of Niagara birds, 81 are from the Niagara itself and only five from the Toronto area, while 278 of 402 Toronto recoveries are from the Toronto area, against only two

from the Niagara. Furthermore, the two Toronto birds were not recovered in the Niagara during the fruit season, and the five Niagara birds later recovered in the Toronto area had not been banded during the fruit season.

In other words, the large Starling flocks found in the Niagara area in July and August are not immigrants from north of Lake Ontario. If there is any immigration, it would have to be from upper New York State. But there have not, in fact, been any recoveries of New York birds in the Niagara during the fruit season; so it seems more likely that most of the birds are juveniles bred in the Niagara.

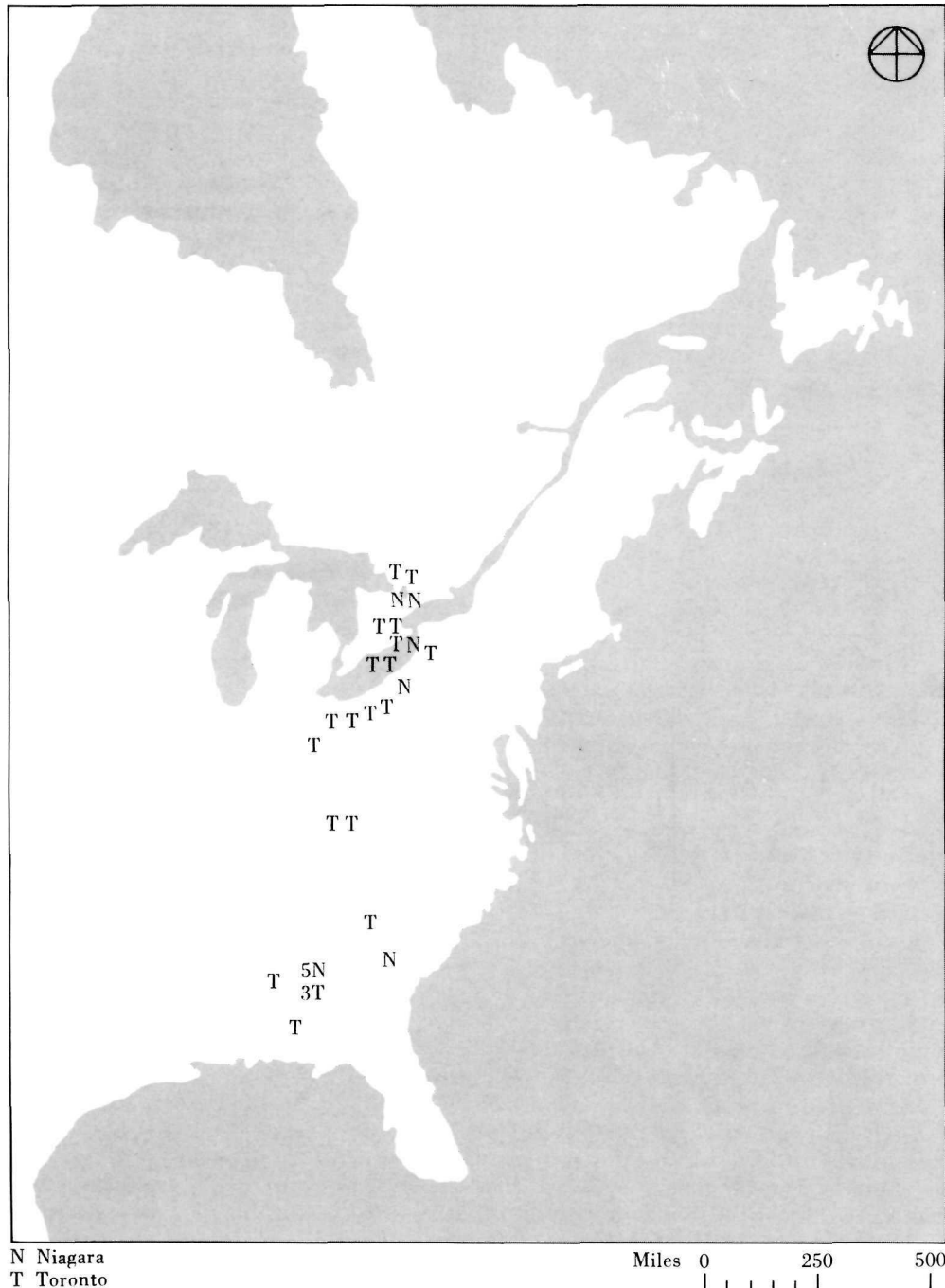
In fact, it is erroneous to suppose that Starlings are concentrated in fruit-growing areas at this time. Part of the reason for the apparent concentration around Vineland in July and August is that Victoria and Jordan Farms are perhaps the only ones left with unpicked cherries, and thus attract whatever Starlings are in the area. But even this population is not very large. In 1969

and 1970 I regularly drove around the whole Niagara Peninsula, counting Starlings. I found that the largest numbers were in areas where there was no fruit; specifically, there were always large flocks feeding in the parklands along the Niagara River south of Niagara Falls, and in the pasturelands along the Grand River west of Dunnville (Fig. 1). This suggests that Starlings are not exceptionally attracted to fruit at this season, and that a large proportion of the Niagara birds must be feeding almost entirely on animal food. In fact, as I shall show later, even the Starlings feeding in the Vineland orchards were taking animal food as well as fruit.

The counts show that the build-up in Starling numbers at Vineland was smaller, and came later, in 1969 than in the other years. (As another index, note the later start of damage to the Jordan Farm sour cherries, caused mainly by these birds, in that year [Fig. 2]). Similarly Collins (1960), banding Starlings at Jordan Farm, noted that they were scarcer in 1957 than



Figure 13



in 1956. For some reason, there must have been unusually low breeding success for Niagara Starlings in 1957 and 1969, linked perhaps with a later start to the breeding season.

## Grackles

Grackles bred in small numbers on Victoria Farm. In 1968 they had mainly left the area by the end of June (Fig. 12); observations at plot VI suggest a similar timetable for 1967. However, they were present all through July in 1969. It may be that whatever delayed the Starling breeding season in the Niagara that year had the same kind of effect on the Grackles, delaying their breeding season and therefore their departure.

Where they go after they leave is not at all clear: they can still be seen regularly in other parts of the Niagara Peninsula, as well as north of Lake Ontario. There are too few Grackles banded in the Niagara area and recovered elsewhere to draw any conclusions, although the general trend of movement of Ontario birds is north/south or northeast/southwest (Fig. 13). This should also bring birds from north of Lake Ontario down through the Niagara area later on in the fruit season; but if they do come, they stay away from the fruit-growing belt.

# The stimuli influencing cultivar preferences

## Field observations

Turcek (1963) has investigated the importance of colour in the choice of seeds and fruit by various European birds. He notes that red and black are the commonest colours among fruits which depend on birds for their dissemination. As one would expect, this agrees with the preferences, shown by stomach content analyses, of the birds themselves. Many birds eat red, black and to a lesser extent, blue seeds and fruits; very few take white, orange or green. The range of colours shown by ripe grapes and cherries is more limited; even so, the degrees of damage suffered by the different cultivars suggest that here, too, the birds prefer red, black and blue fruits.

It is worth looking at this in more detail. A mixed vineyard or cherry orchard is, in a sense, a large-scale choice experiment: the birds are presented with a selection of very similar fruits which differ most obviously in colour, but also in size, pH and sugar content. One must allow for differences in ripening time; and idiosyncratic variations in foraging behaviour may also complicate matters (see p. 42*ff*). But the amount of damage done to different cultivars in mixed arrangements of this kind would seem to be a good guide to the birds' preferences.

The Jordan Farm vineyard consisted of Seibel 10878, Delaware, Fredonia and Agawam, arranged in an almost chess-board-like system of small blocks which made it ideal for a large-scale choice experiment. Eaton *et al.* (no date) note that the average picking date at Vineland for Fredonia is September 11; for Delaware, September 27; for Seibel 10878, September 28; and for Agawam, October 7. But, as the Fredonia were not in fact picked, the Robins which were damaging this vineyard during the last days of September 1967 had the choice of Fredonia (large, blue berries), Seibel 10878 (small, black berries) and Delaware (small, red berries). Table 3 shows that they took only Seibel 10878 — the damage to Fredonia took place in early September, long before the Robins arrived.

**Table 8**

Average invert sugar percentages and pH values for some of the cherry and grape cultivars discussed in the text (from Zubeckis, 1962).

Cultivar	Sugar (%)	pH
<b>Cherries</b>		
Bing	13.70	3.61
Black Tartarian	12.95	3.61
Hedelfingen	14.18	3.71
Montmorency (sour)	9.50	3.30
Van	13.54	3.76
Venus	12.69	3.77
Vic	12.16	3.81
Vista	11.95	3.56
Windsor	12.79	3.68
<b>Grapes</b>		
Concord	12.39	3.17
Delaware	17.41	3.38
Fredonia	11.66	3.02
Niagara	13.74	3.31
Ontario	14.65	3.40
Seibel 10878	16.42	3.27
Seibel 9110	15.87	3.23
Seibel 9549	14.03	3.27

Fredonia and Delaware bunches do tend to be concealed more by the foliage than are Seibel 10878 — but there was no damage to bunches which were exposed. It may be that the differences in sugar content and pH directly or indirectly influence the Robins' choice (Table 8). But on the face of it, the preference seems to be for small, black grapes.

Some observations in the Ontario Vineyard confirm this. By October 9, 1968, a row of experimental cultivars was almost the only unharvested part of the vineyard. This row was visited by both Robins and Starlings; the birds flew in from a parallel line of trees about 25 yards away, and presumably had equal access to each of the cultivars in the row. Table 9a shows the cultivars, the size and colour of their berries, and an estimate of their damage based on an arbitrary scale. To summarize the results, I then took the average score for each cultivar, and classified it according to the cultivar's size and colour (Table 9b). Once again, the birds seem to prefer the

**Table 9a**

Damage assessments for grapes of different cultivars in Ontario Vineyard Row #8, October 9, 1968. The cultivars are listed in their order in the row, from south to north, with the size and colour of the berry indicated. Row #1, between Row #8 and the cover in which the birds were based, consisted of rather conspicuous, large red Ruby grapes. These had suffered little or no damage.

Cultivar	Colour	Size	Damage scores for each vine	Average
NY 21270	Blue	Medium	3, 3	3.0
NY 25542	White	Medium	$\frac{1}{2}$ , $\frac{1}{2}$ , $\frac{1}{2}$	0.5
NY 31987	Blue	Small	2, 2, 2	2.0
NY 32037	Blue	Small	3, 3	3.0
NY 32042	White	Small	2, 2, 1	1.7
NY 33873	Red	Medium	1	1.0†
NY 33957	Blue	Small	2, 2, 1	1.7
NY 34791	Blue	Small/Medium	2, $\frac{1}{2}$	1.7
NY 36037	White	Medium	1, 1, $\frac{1}{2}$	0.8
NY 36268	Blue	Medium	3, 2, 2	2.2
?	White	Medium	1, 1, 1	1.0
NY 36661	White	Small	1, 1, 0	0.7
NY 36806	White	Small	0, $\frac{1}{2}$ , 0	0.1
NY 37376	Blue	Medium	0, 1, $\frac{1}{2}$	0.5
NY 38167	Blue	Medium	$\frac{1}{2}$ , 0, $\frac{1}{2}$	0.3
NY 42439	Blue	Small	0	0*
NY 42603	Blue	Medium	0, $\frac{1}{2}$ , $\frac{1}{2}$	0.3
Dunkirk	Blue-Red	Medium	$\frac{1}{2}$ , $\frac{1}{2}$ , 0, 0, 0, 0, 0, 0, 0	0.1

\*Based on a single vine only.

**Table 9b**

Average damage scores\* for each cultivar, classified by size and colour grouping of the berry.

Size	Colour		
	White	Blue	Red
Medium	1.0, 0.8, 0.5	3.0, 2.2, 1.7 0.5, 0.3, 0.3	1.0†, 0.1
Small	1.7, 0.7, 0.1	3.0, 2.0, 1.7, 0†	No data

\*Damage rated on an arbitrary scale of 0–3. The highest score, 3, indicates 50% damage or more. †Based on a single vine only.

**Table 10**

Percentages of red fruit and of damage on three adjacent NY 1495 cherry trees in plot V17 in June, 1968, estimated from colour photographs.

Date	Tree #1		Tree #2		Tree #3	
	% Red	% Damage	% Red	% Damage	% Red	% Damage
June 14	8.9	0	5.3	2.5	36.2	11.5
June 17	18.7	1.6	37.4	5.0	74.2	26.1
June 20	55.4	28.1	52.7	25.8	93.7	66.9

darkest cultivars, though in this case berry size does not seem to be important.

The size of a sweet cherry does not differ very much from cultivar to cultivar, but the colour often does. For present purposes, these colours can be divided into three classes: "black" — actually a very dark red; "pink" — a pale red (technically, these are known as "white" cherries, but the term is confusing); and "yellow" — a few cultivars of Maraschino cherry are yellow when they are fully ripe.

As with the grapes, the damage figures indicate that the birds prefer the darker cultivars. For example, among later cultivars on Victoria Farm plot V4 in 1969, the "black" Bing and Windsor had suffered 67.8 per cent and 31.7 per cent damage respectively up to August 6, against 22.3 per cent for the "pink" NY 1503, and 15.1 per cent for the "yellow" Maraschino Gold. The fruit of the two paler cultivars was left to rot uneaten on the trees, even though the large flocks of Starlings in the orchard had completely finished off the Bing and Windsor by about August 11. There was the same kind of preference among earlier cultivars in the V1 plot in 1967. Here, adjacent "black" Venus, Sam, NY 1512 and NY 27021, and "pink" Sue trees ripened together, and were all picked on July 18 to 20. The Robins, Starlings and Grackles visiting the plot ate only 1.8 per cent of the Sue crop, against 10.7 per cent of the 27021, 13.6 per cent of the NY 1512, 15.1 per cent of the Venus and 22.6 per cent of the Sam.

It is sometimes even possible to find differences of this kind between adjacent trees of the same cultivar which have ripened at different rates. For example, I used colour photographs to estimate the percentage of red fruits on three adjacent NY 1495 trees in plot V17 in 1968 (Table 10). Evidently, the Robins, Starlings and Grackles were feeding in the tree with the reddest fruit. However, not all differences between adjacent trees of the same cultivar can be explained in this way. I have records of similar differences between trees

**Table 11a**

The average number of feeding entries per  $\frac{1}{4}$  hour by Robins, Starlings and Grackles into 12 trees of four different cultivars, in Victoria Farm plot V1, over two time periods in 1967.

Tree*	Period†	Species			Tree*	Period†	Species		
		Robins	Starlings	Grackles			Robins	Starlings	Grackles
Venus‡ #3	A	0.13	0.18	0.29	Sam ‡ #3	A	0.25	0.05	0.07
	B	0.31	3.14	0.07		B	0.27	1.17	0
Venus #2	A	0.30	0.20	0.08	Sam ‡ #2	A	0.30	0.33	0.13
	B	0.76	1.52	0.07		B	0.17	0.90	0.07
Venus #1	A	0.30	0.46	0.08	Sam ‡ #1	A	0.25	0.12	0.09
	B	0.69	1.41	0.10		B	0.48	0.55	0
Vista #3	A	1.27	0.71	0.08	Sue‡ #3	A	0.05	0.03	0.01
	B§	0.24	0.03	0.03		B	0.03	0.21	0
Vista #2	A	1.12	0.88	0.18	Sue #2	A	0.11	0.07	0.03
	B§	0.03	0.07	0.03		B	0	0.07	0
Vista #1	A	3.19	1.03	0.33	Sue #1	A	0.07	0.01	0.04
	B§	0.17	0	0		B	0	0	0

\*The trees are shown in their relative positions in the plot. North is towards the top. There were other trees to the north, adjacent to Venus #3 and Sam #3, but none to the east, south or west of the group shown here.

†Period A: June 25–July 9. Total observation time was  $18\frac{1}{4}$  hours. Vista was picked on July 9.

Period B: July 10–20. Total observation time was  $7\frac{1}{4}$  hours. Remaining trees picked July 18–20.

‡The angle of observation gave poor views of these trees; therefore, the entry rates may be underestimates.

§These trees had been picked by this period.

**Table 11b**

The total number of entries, by cultivar, of Robins, Starlings and Grackles, for Period A only.

Species	Vista	Venus	Sam	Sue	$\chi^2$ *	P
Robin	409	57	59	16	747.48	<0.001
Starling	192	64	40	7	259.83	<0.001
Grackle	43	33	22	6	26.50	<0.001

\*Based on the Null Hypothesis that each cultivar is entered equally frequently.

with equally red fruit; these are probably the result of idiosyncracies in the birds' foraging behaviour (see p. 42ff).

Damage estimates are the simplest ways to measure cultivar preferences in the field, but they have disadvantages. In particular, as three species of bird are involved, it would be useful to separate the preferences of each. In any case, it is better to use direct observations in work of this kind on choice behaviour. I found that birds pay little attention when one sits in a car, 25 yards or so from the study plot. So I was able to observe their cultivar

preferences directly. In 1967 I watched Victoria Farm plot V1; the arrangement of trees at the southern end of this plot is shown in Table 11. Vista, Venus and Sam are "black" cultivars, and Sue is "pink". Vista was the first to carry 100 per cent red fruit (June 27), followed by Sam (June 30), Venus (July 6) and Sue (c. July 12); Vista was picked on July 9, and the rest on July 18 to 20. I watched the birds in the early morning and late evening, after the orchard was closed, to avoid human interference; there was no difference between morning and evening watches, so these have been combined. During each quarter-hour within a watch, I counted the numbers of Robins, Starlings and Grackles entering each of these twelve trees, excluding occasions when the bird did not feed after it entered.

Table 11 shows that all the birds preferred Vista, the first cultivar to become red. In fact, the Robins were already feeding in it

when observation began on June 25, although only 80 per cent of the cherries were red and these were very far from being ripe. After the Vistas were picked, the birds switched to Venus. The “pink” Sue were almost totally ignored; the table refers only to feeding entries, but in fact there were very few non-feeding entries either.

Two points come out of this. First, Robins, Starlings and Grackles are all reacting to the same stimulus; they prefer the reddest fruit available to them at any given time. Secondly, the stimuli provided by redness are relative, not absolute: the birds take what is available. The Robins were taking Vista when the reddest fruit on the trees was only as red as Sue at its ripest. In fact, I have often watched them pecking at, and even swinging on, cherries early in the season when the fruits showed the first flush of redness. There is no evidence of an “absolute” stimulus, with the birds feeding on any fruit whose redness reaches a certain point in the colour spectrum.

The relative nature of redness as a stimulus is confirmed by similar direct observations in the southeast corner of Victoria Farm plot V4 in 1968. Table 12 shows that Robins, Starlings and Grackles all started off by choosing 48021 trees, in preference to the adjacent Vistas. But after June 20 they switched to Vistas, and almost entirely ignored the 48021. Table 12 shows that 48021 started off by being the redder of the two cultivars in 1968, but from about June 22 onward there was a change, and Vista became the redder. By contrast, Vista started off the redder in 1969 and stayed ahead all through the season; it was fairly heavily damaged, while 48021 was little touched.

**Experiments with caged birds**  
**Robins**

The next step was to compare these field observations with experiments on the birds’ preferences in captivity. I mist-netted Robins in the orchards and kept and tested them individually in 3x2x2-foot cages.

**Table 12a**  
Average number of Robin (R), Starling (S) and Grackle (G) entries per ¼ hour into 4 Vista and 2 48021 trees in Victoria Farm plot V4 in 1968.

	Vista			48021			Total hours observation
	R	S	G	R	S	G	
to June 20	0.67	0	0	11.33	0	1.33	0.75
June 21–25	2.00	0.83	0.67	1.83	0.33	0	1.50
June 26–30	1.10	0.80	0	0.30	0	0	2.50
July 1–5	1.50	2.30	0	0.20	0	0	2.50

**Table 12b**  
Total number of cherries eaten on the sample branches of 4 Vista and 3 48021 trees in Victoria Farm plot V4 in 1968 and 1969 (the same trees in both years). The percentages of red fruit on the trees are given in brackets.

	1968		1969	
	Vista	48021	Vista	48021
to June 20	17 (17.2)*	67 (28.5)*	27 ( 7.4)	3 ( 2.1)
June 21–25	33	30	97 (75.4)	20 ( 9.2)
June 26–30	76	27	124 (78.1)	17 (10.9)
July 1–5	118	29†	95 (90.0)	18 (55.0)

\*I have no further quantitative information on redness in 1968. However, the fact that the Vista were eventually picked on July 8, but the 48021 not until July 15, shows that there must have been a reversal in relative ripeness. In fact, the Vista seemed to redden suddenly around June 22.

†This total is an underestimate; the sample branches on one of the trees blew down on July 1.

I tested one adult and three juveniles in 1968, banding and releasing them at the end of the experiments. I retrapped and re-tested the adult (the “repeat” bird) in 1969, as well as testing two other adults and five juveniles. All the tests were done in late July and early August.

My procedure was to give the birds 10 of each cultivar to be tested, in a shallow tray filled with water. I would present this at about 0930 hours, come back to replace it with the next test combination at 1700 hours, check again at 0930 hours next morning, and so on. I sometimes also checked the progress of the test between these times.

My standard combination of cherry cultivars was 10 “yellow” Maraschino Gold, 10 “red” sour cherries and 10 of a “black” sweet cherry cultivar (either Vista or Venus; but I did not mix the “black”

cultivars in a given test). The idea behind this was to examine the relative importance of colour and taste, comparing sweet “black” and “yellow” cultivars with a cherry which is bright red but sour when ripe. Table 13 shows that, in both years, “black” cherries were taken all through the tests. In 1968, though not in 1969, there was a decline in the number of “reds” taken during the series. In 1969, “yellows” were at first ignored, but the Robins suddenly started to eat them at the third test. This was not apparent in 1968, when birds #2, #3, and #4 had to be taught to take Maraschino Golds, by being given this cultivar alone.

Table 13 shows that individual Robins appear to vary in their preferences for “black” versus “red” cherries, though the figures are too small for any meaningful analysis. It also appears that these prefer-



**Table 13**  
The preferences of caged Robins for “black”, “red” and “yellow” cherries, as indicated by the number taken out of 10 of each in trials. B–“black” cherries, either Vista or Venus sweet cherries. R–“red” sour cherries. Y–“yellow” sweet cherries; Maraschino Gold.

Bird	Trial																	
	1			2			3			4			5			6		
	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y
1968																		
1*	3	7	0	2	8	0												
2	6	5	0	6	0	0	5	0	0†	8	0	1	5	0	5‡			
3	4	6	0	4	2	0	2	0	0†	7	2	0	5	5	3‡			
4	5	6	0	10	1	0	10	0	0	10	2	0†	10	0	1	5	3	5‡
1969																		
5*	4	0	0	10	10	0	9	3	9	5	4	10						
6*	7	5	0	9	3	0	10	10	10	10	10	10						
7*	4	3	0	6	9	0	6	1	5	8	0	4						
8*	2	3	0	6	7	0	10	10	1	8	8	3						
9	9	9	0	10	3	0	10	10	0									
10	7	4	0	9	7	0	3	1	7									
4	9	5	3	10	5	10	5	5	10									

\*These birds were trapped in sweet cherry orchards; all others came from sour cherry orchards.  
†Birds #2 and #3 ate “yellow” cherries during an intermediate trial between Trials 3 and 4, and Bird #4 did so between Trials 4 and 5.  
‡Trials in which only 5 of each type of cherry were given.

ences could change during the course of the trials. This change may be at least partly influenced by the birds’ previous experience. The birds caught in sour cherry orchards showed a statistically significant relative decline in the proportions of “red”, sour cherries; when trials 1, 2 and 3 are compared for these birds,  $\chi^2=8.872$ ,  $P<0.02$ . (For details of this and other statistical procedures followed in this study, see Seigel [1956].) There is no comparable significant change in the birds from sweet cherry orchards. It may be that, given the opportunity to choose, Robins prefer a “black” to a “red” cherry — the stimulus could be colour or taste. However, it is also possible that some more immediate effect of experience could be acting here: the birds might be reacting against a “monotonous” diet, and taking what they had not been feeding on previously.

Table 13 shows that the individual Robins also varied in their preferences for “yellow” cherries. In every case (except for the repeat bird in 1969) “yellows” were rejected for at least the first two trials. However, several of the birds eventually accepted them once they had sampled them, and birds #5 and #4 (in 1969) seem to have come to prefer them over either of the red cultivars. Evidently, there is nothing intrinsically distasteful about this cultivar; but it would appear that the birds have to learn that despite its colour, it is ripe.

An alternative possibility is that the birds’ preferences depend on the interaction of colour and some other stimulus — taste, for example. The cultivars tested here differ not only in colour, but also in sugar content and pH. Maraschino Gold is the sweetest; a sample of those used in the

1969 tests had an average soluble sugar percentage of 18.2, and a pH of 4.3; the Vista had a sugar percentage of 14.2 and pH of 4.4; the sour cherries had a sugar percentage of 14.2 but a pH of 3.9. (I did not analyse the Venus used in these tests; this cultivar has an average sugar percentage and pH slightly above that of Vista [Table 10]). The cultivars therefore differ enough for taste to be a factor in the birds’ preferences. If so, then the birds may be associating a particular colour with their own preferred taste, which may in turn vary between individuals along the lines of a “sweet tooth”.

The preference for “black” and “red” over “yellow” cultivars is at first probably innate, as opposed to being acquired by experience. The closely related European Blackbird (*Turdus merula*) feeds extensively on cherries, and Snow (1958) notes of it:

A captive young blackbird, which almost certainly could not have eaten cherries before, since the cherry season had not started when it was caught, pecked at them once they were offered. It preferred red ones to yellow, as do blackbirds in the wild.... (p. 30)

The results quoted here show that this innate preference can be overridden, at least over short periods, by learned experience of “yellow” cherries. But the case of the repeat bird, #4, shows that this learning may persist for at least a year. This bird took no “yellows” at all until its fifth trial in 1968, and then only after it had learned to take them during an intermediate trial in which it had no choice. But in 1969 it was the only bird which took any “yellows” at all during the first two trials. The difference between its performances in 1968 and 1969 on the first three trials is significant ( $\chi^2=13.77$ ,  $P<0.001$ ), as is the difference in its performance on these trials in 1969 compared with the other 1969 birds ( $\chi^2=20.14$ ,  $P<0.001$ ). It is of course impossible to show that only the prior exposure to “yellows” was responsible for the change, since this bird may have received reinforcement from eating Maras-

**Table 14**

The preferences of caged Robins among various cherry cultivars and mulberries.

Total number of fruits eaten *		No. of birds tested
6 Vista	18 Venus	4
10 Windsor	18 Venus	3
33 Vista	34 48021	5
25 Vista	31 48021	5
46 Vista	42 Mulberries	5†

\*Each bird was given 10 of each fruit.

†Mulberries were the first choice of four of these birds.

**Table 15**

The preference of caged Robins between "black" and "green" grapes.

Year	Test	No. of grapes eaten		No. of birds tested
		"Black"	"Green"	
1968	1	25	0	3
1969*	1	70	41	7
	2	70	49	7
"Repeat" bird (not included in the 1969 totals above):				
1968	1	9	0	
1969	1	8	0	
	2	10	9	

\*Only one bird in 1969 took no "green" at all. Direct observations showed that all birds took "black" as their first choice.

chino cherries or some similarly coloured fruit in the interval. However, it seems clear enough that Robins' preferences for cherry cultivars are not fixed, but may be modified by experience.

It seemed worthwhile to check my field observations on the preferences of Robins for certain cherry cultivars, on the caged birds. Table 14 shows that, despite their observed choice in the field, Robins took Vistas and 48021 in almost equal quantities. Nor are there any significant differences from Null Hypothesis in their choices of Venus against Vista, or Venus against Windsor. Evidently, there is nothing inherently distasteful about, for example, Venus which would explain why the Robins in the Victoria Farm plot V1 ignored it in favour of Vista. I also checked their preferences for Vistas compared with mulberries, hoping to see whether these wild fruits

**Table 16**

The preferences of caged Starling flocks among cherry cultivars of various colours, as indicated by choice tests.

		No. of fruits eaten *					
		After 30 minutes			After 90 minutes		
Flock #	Test	"black"	"red"	"yellow"	"black"	"red"	"yellow"
1968							
1	1	20	3	0	20	20	19
	2	18	4	4	20	5	16
	3	16	1	3	20	6	20
	4	15	2	5	20	4	18
	5	9	1	7	20	1	20
	6	12	3	1	15	4	7
	7	18	2	0	20	2	17
2	1	16	1	2	20	3	4
	2	1	1	5	9	1	13
	3	6	0	8	6	0	12
		After 60 minutes			After 120 minutes		
		"black"	"red"	"yellow"	"black"	"red"	"yellow"
1969							
3	1	3	1	0	8	3	0
	2	6	5	0	9	6	0
	3	3	1	4	6	1	6
	4	3	0	3	5	1	7
4	1	8	6	0	10	8	0
	2	10	1	3	10	2	8

\*In 1968 20 of each test fruit were used; in 1969 10 of each fruit.

**Table 17**

The preference of caged Starlings between "black" and "green" grape cultivars, in choice tests.

Flock	Number of fruits eaten* after 120 minutes		
	Test	"Black"	"Green"
<b>1968</b>			
1	1	4	4
2	1	9	2
<b>1969</b>			
3	1	10	0
	2	10	0

\*In 1968, 20 of each fruit were given; in 1969, 10 of each fruit.

could be used to lure Robins away from the orchards, but there was no difference.

I was unable to keep my caged birds through to the Ontario grape season. However, I tested them with two Californian cultivars — a round, black grape ("black")

and an oblong green one ("green"). Table 15 shows that the birds ate only "black" in 1968; in 1969 they learnt to eat "green", but their first choice remained "black".

### Starlings

In testing Starling preferences, I used a slightly different technique. I tested the birds in small flocks, kept in a 10x6x6-foot aviary. The birds' regular food was moistened dog kibble; they were given only cherries during the tests. I usually ran two tests each day, in the morning and afternoon, each lasting for two hours. I checked the cage every quarter-hour during the tests. The experiments were done in early August of 1968 and 1969, using the following birds:

- Flock #1: one adult and nine juveniles, mist-netted in a sweet cherry orchard on July 30, 1968;

# Diet and foraging behaviour

- Flock #2: one adult and 12 juveniles, mist-netted in a sour cherry orchard, August 7–9, 1968;
- Flock #3: five juveniles caught in a sweet cherry orchard, August 7–8, 1969;
- Flock #4: one adult and three juveniles caught in a sour cherry orchard, August 13, 1969. (The adult died after the first test with this flock.)

The 1968 birds were given 20, and the 1969 birds 10, cherries or grapes of each cultivar to be tested.

As with the Robins, my basic test involved the choice between “yellow” (Maraschino Gold), “red” (sour) and “black” (Venus, Vista or 48021). Table 16 shows the numbers of each cultivar eaten by the 1968 flocks after 30 and 90 minutes of each test, and for the 1969 flocks after 60 and 120 minutes. All the flocks initially preferred “blacks”, and this was maintained through the tests by all except Flock #2. All the flocks showed a progressive decline in the numbers of “reds” eaten, and an increase in “yellows”; in Flock #2 (and perhaps also Flock #3), “yellows” came to be the preferred variety by the end of the series. The Starlings’ preferences are therefore very like the Robins’. They too initially choose the reddest fruit they can find, and are using redness as the indicator of some taste factor, perhaps sweetness.

The Starlings also resemble the Robins in their preference for “black” grapes. I tested them with the same Californian cultivars. Table 17 shows that Flock #1 took very few grapes, and showed no preference; on the other hand, Flocks #2 and #3 had a clear preference for “black”.

To see how the birds would compare “black” cherries and grapes, I gave 10 of each to the combined Flocks #3 and #4. On the first test, they took 10 cherries and two grapes after 60 minutes; on the second, they took nine cherries and two grapes.

The Starlings, like the Robins, showed no preferences between sweet cherry cultivars. Flock #1, given the choice between Vista and Venus, took 16 Vistas and 15 Venus after 60 minutes.

## Fruit and animal food

Newton (1964) has shown the value of taking a broad view of the diet of a pest species, instead of considering only the immediate damage. He found that the damage done by Bullfinches to fruit tree buds in spring was inversely related to the abundance of other foods. These buds are actually of very low nutritive value; the birds eat them only in winters when the ash seed crop has failed, and then only after all other food seeds have been exhausted. I thought it important to take an equally broad view of the diets of the birds damaging fruit crops. I used three techniques: analysis of faeces, analysis of stomach contents, and direct observations of birds taking animal food. Almost all my data refer to Robins.

## Analysis of faeces

Hamilton (1940, 1943) has described the spring and summer food of the Robin in upstate New York through the analysis of a collection of faeces. The great advantage of this technique is that it allows one to observe seasonal changes in the diet of a population; this is rather difficult if one has to shoot the birds for stomach analysis. The disadvantage of the technique is that, by the time they reach the faecal stage, the remains of the prey are usually too fragmented for detailed identification. There is also, of course, the problem of being absolutely certain which bird left the faeces.

I collected faeces from several sources:

- Fence posts and tree stumps in a small area at Jordan Harbour (Fig. 1). This consisted of lawns, a vegetable plot, tall shade trees, some mulberries and a lone sweet cherry tree, with a sour cherry orchard nearby. Robins and Song Sparrows (*Melospiza melodia*) were the only birds which regularly used these perches; I tried to eliminate Song Sparrow faeces by rejecting any very small pellets. I also rejected six characteristically long, very large pellets consisting almost entirely of ant remains; I judged that these had been left by Yellow-shafted Flickers (*Colaptes auratus*).

- Faeces collected on Victoria and Jordan Farms from empty Robin nests, and from the branches and ground immediately underneath, after the young had left; I also collected cherry pits from these nests. The parents stop carrying faeces away two or three days before the young leave, so these pellets reflect the diet during that period.
- Faeces on the leaves around heavily damaged cherry branches. I sampled both sweet and sour cherry orchards; the faeces from the former were almost certainly from Starlings, and those from the latter either from Starlings or Robins.
- Faeces left by the Robins and Starlings used in my food-choice experiments, during the first hour or so of captivity, before they had been given anything to eat.

To analyse these pellets, I moistened them and teased them apart under a microscope. I did not try to identify the prey species, but simply noted the presence or absence of three food types: insects, identified by chitinous fragments; worms, identified by the presence of setae and/or substantial quantities of earth; and fruit, identified by the presence of a pink stain in the faeces, or fruit skins, or seeds or pits.

Figure 14 shows the frequency with which faeces were found to contain fruit, worm and insect remains, and how this changed during the season; as another index of fruit-eating, I have added the average number of cherry pits found at nests.

It appears from Figure 14a that the Robins at Jordan Harbour began to eat fruit (in their case, mostly mulberries) in the last week of June, as soon as it became ripe. The birds in the orchards started to bring fruit to their young in early July; this reached a peak in late July and declined again by early August, when all the berries had been picked. (Less detailed notes on faeces and cherry pits in nests in 1967 and 1968 show the same picture.) Mulberry feeding declined in August 1968, but it stayed at a high level in August 1969. It is difficult to explain this: there may have been differences in the size of the mulberry crop. Figure 14c shows that insects were eaten

Figure 14a. Seasonal changes in the proportion of fruit in the Robins' diet at Vineland.

Figure 14b. Seasonal changes in the proportion of worms in the Robins' diet at Vineland.

Figure 14a

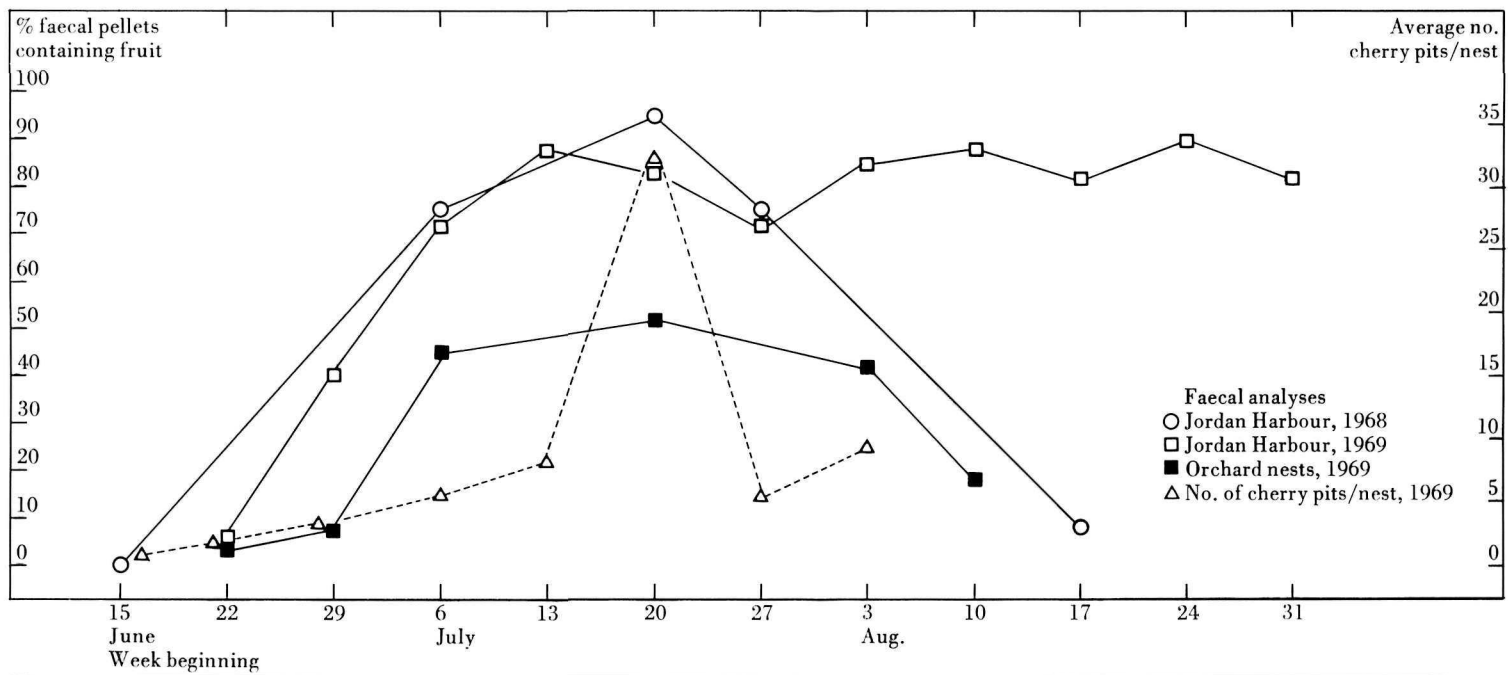


Figure 14b

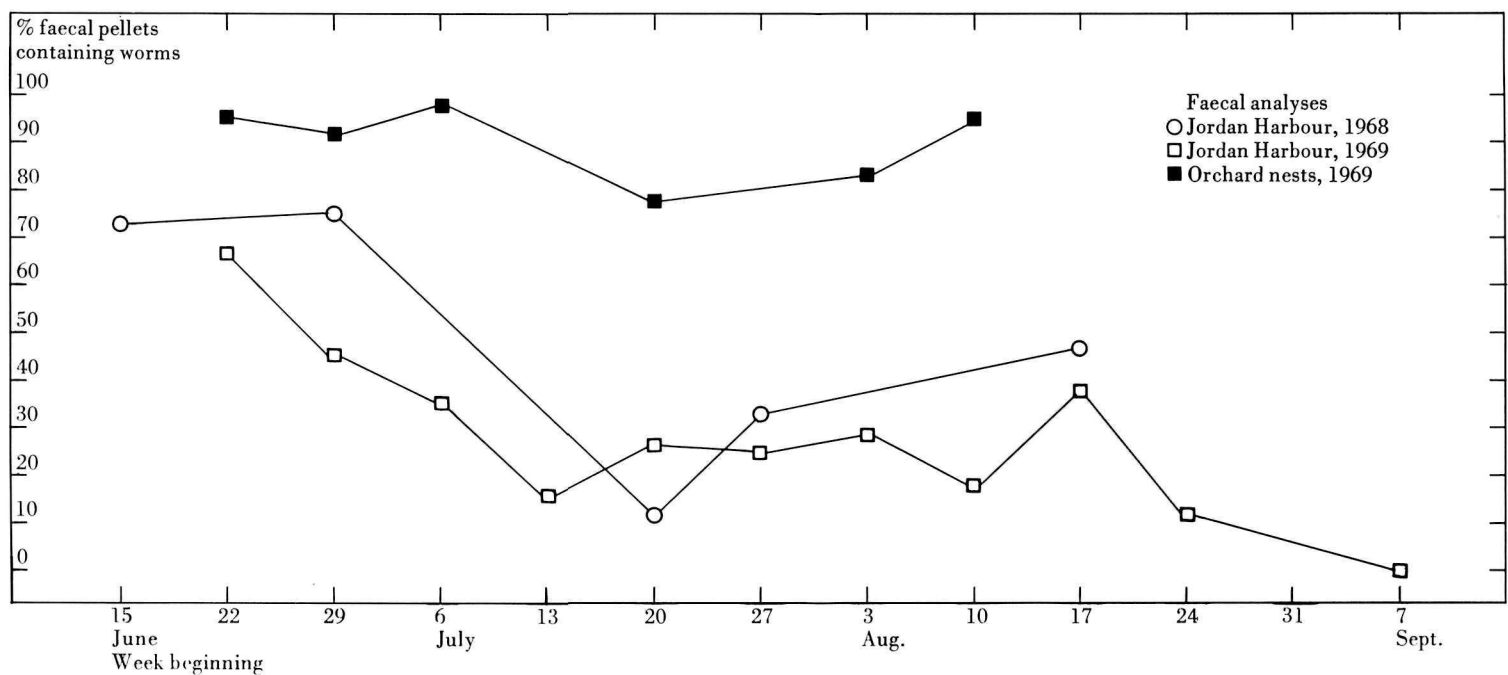
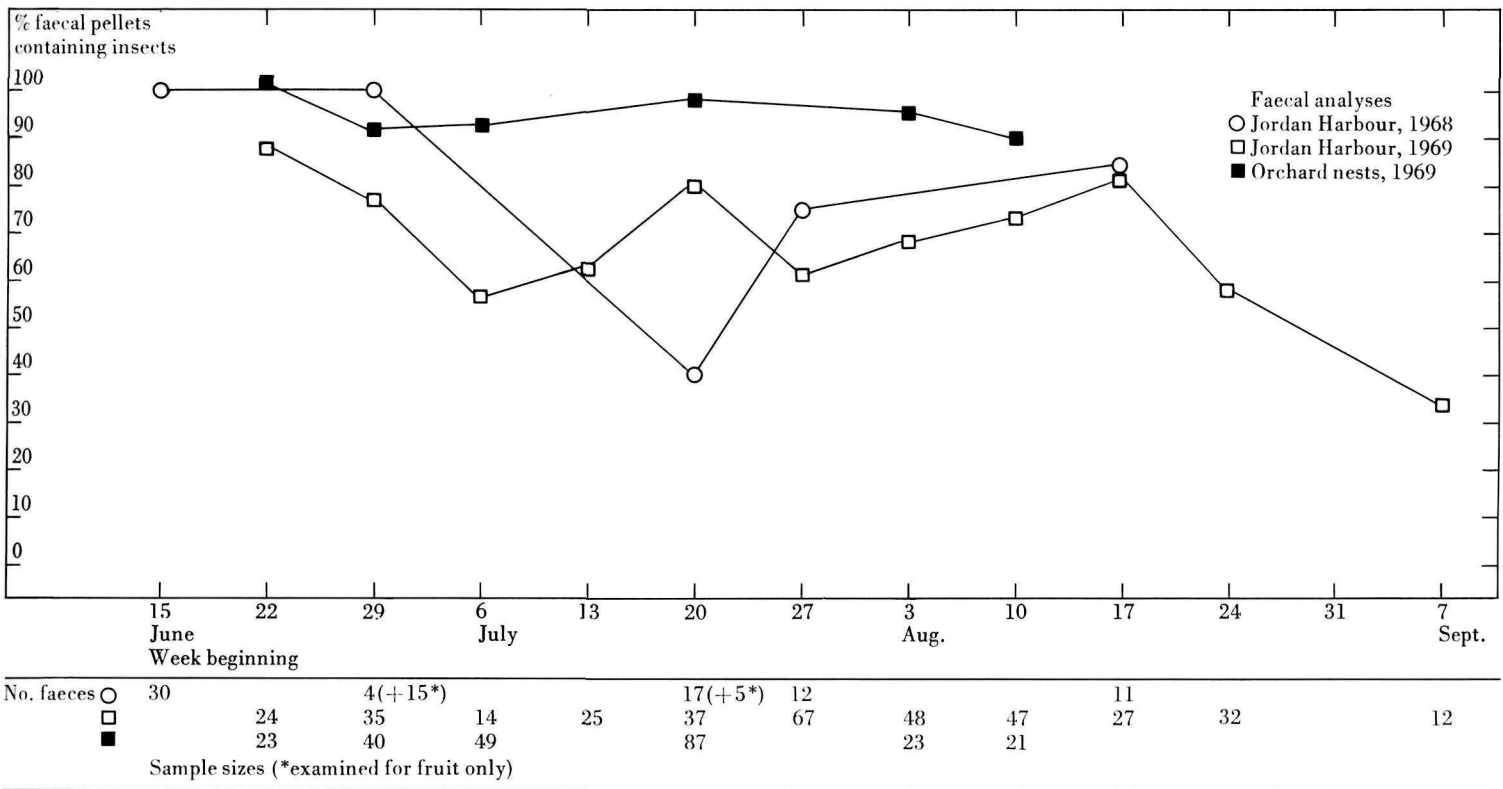


Figure 14c. Seasonal changes in the proportion of insects in the Robins' diet at Vineland.

Figure 14c



by the adults and fed to the young at a fairly constant level all through the season; the apparent decline in early September is not statistically significant. On the other hand, there was in both years a steady decline in the frequency with which worms were eaten by the Jordan Harbour birds (Fig. 14b). This is probably not, as it might appear, because the worms are aestivating in the summer drought: direct observations on feeding Robins in the Vineland area (Fig. 15) show that in both years the birds were catching large prey, mainly worms, at a fairly constant rate all through the season. It seems rather that the decline is due to choice by the birds.

In support of this, Figure 14b shows that there was no corresponding decline in the frequency with which worms were brought to the nest. In fact, the overall frequency with which both worms and insects were

found in nest faeces was significantly higher than in the Jordan Harbour birds. (Over the period July 6 to August 16: Insects  $\chi^2 = 50.51, P < 0.001$ ; Worms  $\chi^2 = 126.40, P < 0.001$ .) The frequency with which fruit occurs was, on the other hand, lower in the nest faeces, though the difference is barely significant ( $\chi^2 = 4.48, P < 0.05$ ). One cannot make much of this last point, since different fruits are involved. But the differences in animal food are extremely interesting. Ideally it would have been better to have samples from adult birds as well as nestlings in the orchards. But the rates at which Robins found animal food were similar at Jordan Harbour and in the orchards (Fig. 15), and there were no obvious differences in habitat which would explain the difference between the two sets of data. So it looks very much as though the adult birds are giving their young more animal food

(and, perhaps, less fruit) than they are eating themselves.

Royama (1970) points out that, in time-and-motion terms, it may be more efficient for adult birds to feed large prey to their nestlings, while eating small prey themselves. This may be one reason for the relative increase of worm remains in the nest faeces. There is no way of telling whether they were also bringing larger insects. But nutritional factors must also apply. Young birds need a high-protein animal diet for growth (Kuroda, 1962; also discussion below). This would explain the relative increase of animal remains in the nest faeces. If these possibilities are correct, there is then the further implication that Robins are eating fruit by choice, and not through the absence of suitable animal food.

Figure 14 suggests that, even when fruit-eating is frequent, the Robins are still tak-



ing a good deal of animal food. This is also true of Starlings; in late July, for example, the flocks move through the orchards feeding in the grass, and fly up to take cherries whenever they come to an unpicked tree. The faeces of birds caught in the orchards confirm this point. Three out of four Robins caught in a sour cherry orchard on August 12 and 13, 1969 had been feeding on both fruit and insects; the other had fed on fruit alone. Similarly, I collected faeces from the Flock #4 Starlings, caught in the same orchard at about this time; 29 of the faeces contained insect remains, but only 22 contained fruit. Faeces collected from the leaves of damaged trees show the same thing (Table 18). As I have already pointed out, the bulk of the Niagara population of Starlings is at this period not in the orchards at all, but feeding on animal prey in parts of the Peninsula where fruit is not grown.

#### Analysis of stomach contents

In analysing Robin stomach contents, I used the same three food categories as for the faecal analyses. The results are shown in Table 19. These figures show several points. First, it is clear that animal food is important in the Robin's diet in late August and early September, even when the birds are feeding in a vineyard. The birds were still taking insects in mid October. The Newmarket sample is interesting for another reason: it shows that fruit is an important part of the Robin's diet in the fall, even outside the Niagara fruit belt. Finally, the reason for checking the rectum as well as the stomach of some of the birds was to see how accurately the analysis of material found in faeces reflects what was in the birds' stomachs — within these simple categories, the two measures agree well.

I should add that my analyses of stomach contents and faeces from Vineland Robins do not agree with the stomach analyses by Virgo (1971; also Stevenson and Virgo, 1971) of Robins shot in the same area in 1965. He examined 52 birds collected in sweet cherry orchards: 43 (82.7 per cent) contained animal food — which agrees well

**Table 18**

Insect and fruit remains in Starling and Robin faeces collected from the leaves of damaged cherry trees in 1970.

Date (1970)	Cherry	Probable bird species	No. faeces	No. containing	
				Insects	Fruit
July 30	Sour	Starling or Robin	1	1	0
July 30	Sweet	Starling	28	26	20
Aug. 4	Sweet	Starling	5	5	1
Aug. 7	Sweet	Starling	18	16	12
Aug. 10	Sour	Starling or Robin	53	49	38

**Table 19**

Analysis of Robin stomach contents at various times and locations.

		No. samples containing		
	No. samples	Fruit*	Insects	Worms
<b>Victoria Farm</b>				
June 26 and July 7, 1967				
Stomach	2	1 (50.0%)	2 (100.0%)	?
<b>Ontario Vineyard</b>				
August 22–Sept. 8, 1969				
Stomach	23	23 (100.0%)	19 (82.6%)	3 (13.0%)
Rectum	19	17 (82.6%)	16 (84.2%)	0
<b>Newmarket</b>				
October 15, 1969				
Stomach	15	15 (100.0%)	9 (60.0%)	3 (20.0%)
Rectum	11	11 (100.0%)	6 (54.6%)	3 (27.2%)

\*The fruit eaten on Victoria Farm was sweet cherries, and in Ontario Vineyard grapes (mainly Seibel 13053). The Newmarket birds had been eating some wild or garden fruit—possibly a Nightshade *Solanum* sp.

enough with my data; but, by contrast, only six (11.5 per cent) had been eating fruit. Again, he collected 85 stomachs from birds shot in vineyards: all 85 contained fruit, as did all of mine, yet only one (1.2 per cent) contained any animal food. I am quite unable to explain these discrepancies.

Finally, it is worth putting these data into the context of the Robins' food through the year. Table 20 summarizes the faecal analyses of Hamilton (1940, 1943) in upstate New York, and the stomach analyses of Forbes (1879) in Illinois. Both show the increase in fruit-eating during the summer, though they also show that the birds fed freely on insects. (Forbes and Hamilton make no mention of worms; I take it that this reflects the difficulty of identification.)

Table 20 also summarizes the stomach content analyses for fruit of Martin *et al.* (1951), for Robins collected from all over the United States. These too show that fruit-eating increases in July, and stays at a high frequency at least through January. In fact, Martin *et al.* show that fruit is the food most commonly found in Robin stomachs for nine months of the year. Bent (1949) quotes a number of observations which also indicate that the birds eat fruit for much of the time. Ontario Bird Banding Association members tell me that the Robins which winter in the Toronto area feed extensively on fruit; unpicked apples which have been split by frost are apparently much favoured. Similarly, Hartley (1954) shows that the European Song Thrush and

**Table 20**  
The occurrence or proportion of various foods in the Robin's diet at different times of the year, in percentages.

Month	Forbes* Illinois (1879)		Hamilton New York (1940, 1943)		Brown Niagara (this report)			Martin <i>et al.</i> USA (1951)
	Fruit	Insects	Fruit	Insects	Fruit	Insects	Worms	
November								75
December								69
January								62
February								56
March	0	100.0						51
April								31
May	55.5	89.9	81.5	93.5				25
June					6.5	100.0	80.0	44
July	78.9	52.6	73.1	78.9	87.3	67.6	40.5	62
August					16.7	81.8	54.5	75
September								81
October								88

\*Forbes' and Hamilton's percentages are based on the frequency with which fruit and insects occurred in the stomachs and faeces. Martin *et al.* show the proportion of fruit in the diet as a whole.

Blackbird feed mainly on fruit for much of the year.

This extensive fruit-eating is at first sight surprising, as we are used to the idea of a commercial fruit season which lasts only from about June to October. But of course wild fruits are available for much longer than that. In fact, the fruit does not even have to be fresh to be eaten. In May 1968 I watched Robins feeding on the dried-up berries of an unidentified garden shrub at Newmarket. Both Gabrielson and Lincoln (1959) and Bent (1949) report that the first spring migrants regularly feed on dried berries left over from the previous year. All this shows that Robins are fruit-eaters at least as much as animal-feeders and it is hardly surprising that they are attracted to orchards and vineyards.

**Observations on animal-feeding**

The analyses of faeces and stomach contents have suggested some interesting relationships between feeding on fruit and

feeding on animal prey; in particular, the possibility that Robins start to take fruit each season out of a positive preference for it, rather than through the absence of anything else to eat. Points such as this are worth examining in more detail, since the timing of the switch to fruit-eating each season has obvious economic implications. I therefore tried to develop quantitative measures of animal-feeding which could be compared with the quantitative estimates of damage to fruit.

To do this, I used a tape-recorder to make running commentaries on Robins as they hunted on the ground for animal food. When I transcribed the tapes, I timed the feeding movements with a stop-watch, and from this calculated the rates at which the birds were finding animal food. Any changes in these rates should be an indication of changes in the availability of animal food.

There are two complicating factors here. First, I am assuming that the efficiency with which the Robins find and catch their

**Table 21**  
Adult Robin handling times for different types of animal prey.

Handling time, secs.	Number of prey items		
	Identified large prey		Unidentified prey
	not worms	worms	
1	—	—	2930
2	3	21	13
3	1	0	24
4	0	2	23
5	4	10	34
6	2	5	17
7	3	4	20
8	2	9	12
9	3	6	9
10	2	11	12
11	0	6	7
12	1	5	8
13	0	7	7
14	0	4	10
15	6	5	4
16	1	4	6
17	2	6	4
18	1	4	5
19	3	3	4
20	3	0	3
21	1	2	3
22	0	7	1
23	0	1	3
24	0	4	3
25	0	6	1
>25	3	98	16
Average handling time	13.1	42.5	1.9

prey remains constant throughout the season. One would expect that young birds would at first be less efficient than adults, so I watched adult birds only. Secondly, the size of the prey may have an effect: a bird takes very little time to catch and eat a small insect, but it often needs a minute or more to catch and kill a large worm. This is what Royama (1970) has called the "handling time"; I shall discuss it in more detail later, but for present purposes I have eliminated its complicating effects by calculating all rates with reference to the "search time" — that is, the total time the feeding bird was under observation, minus the "handling time".

Figure 15a. Average success rate for finding large prey per 100 seconds search time for Robins at Newmarket.

Figure 15b. Average success rate for finding small prey per 100 seconds search time for Robins at Newmarket.

Figure 15a

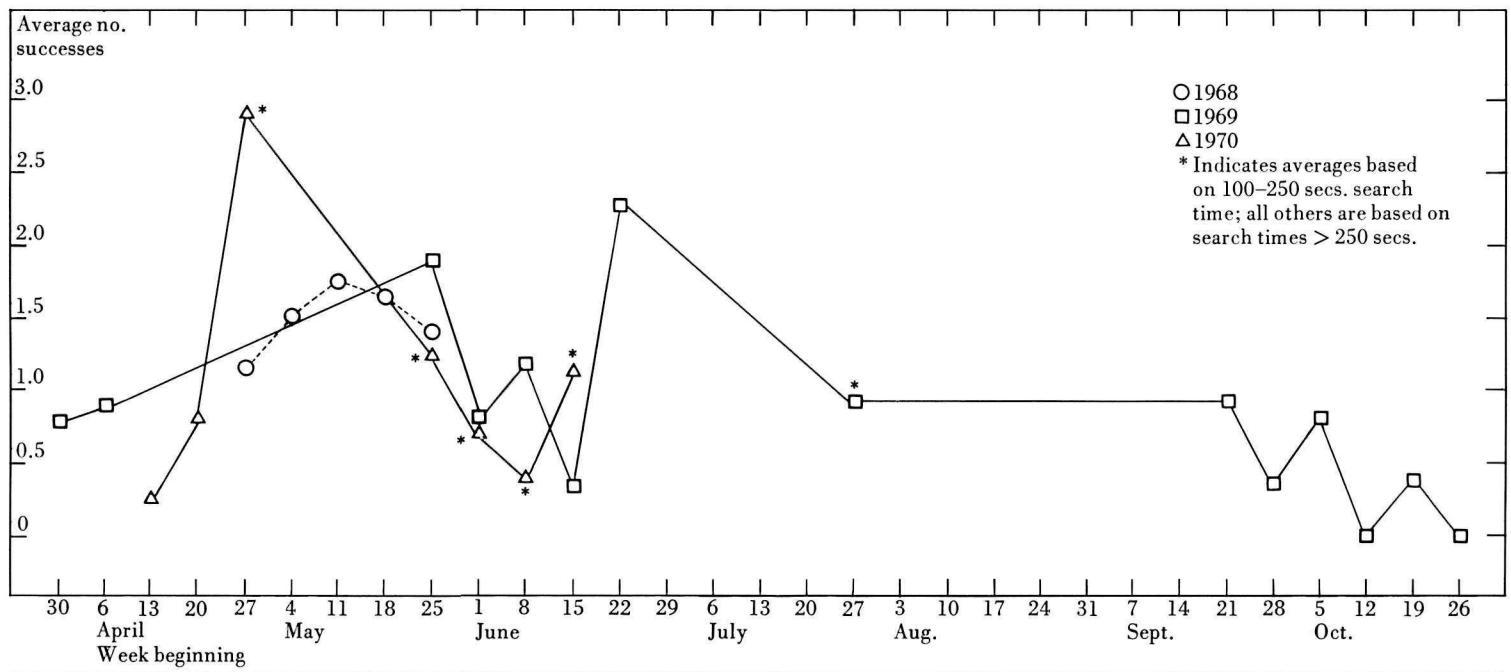


Figure 15b

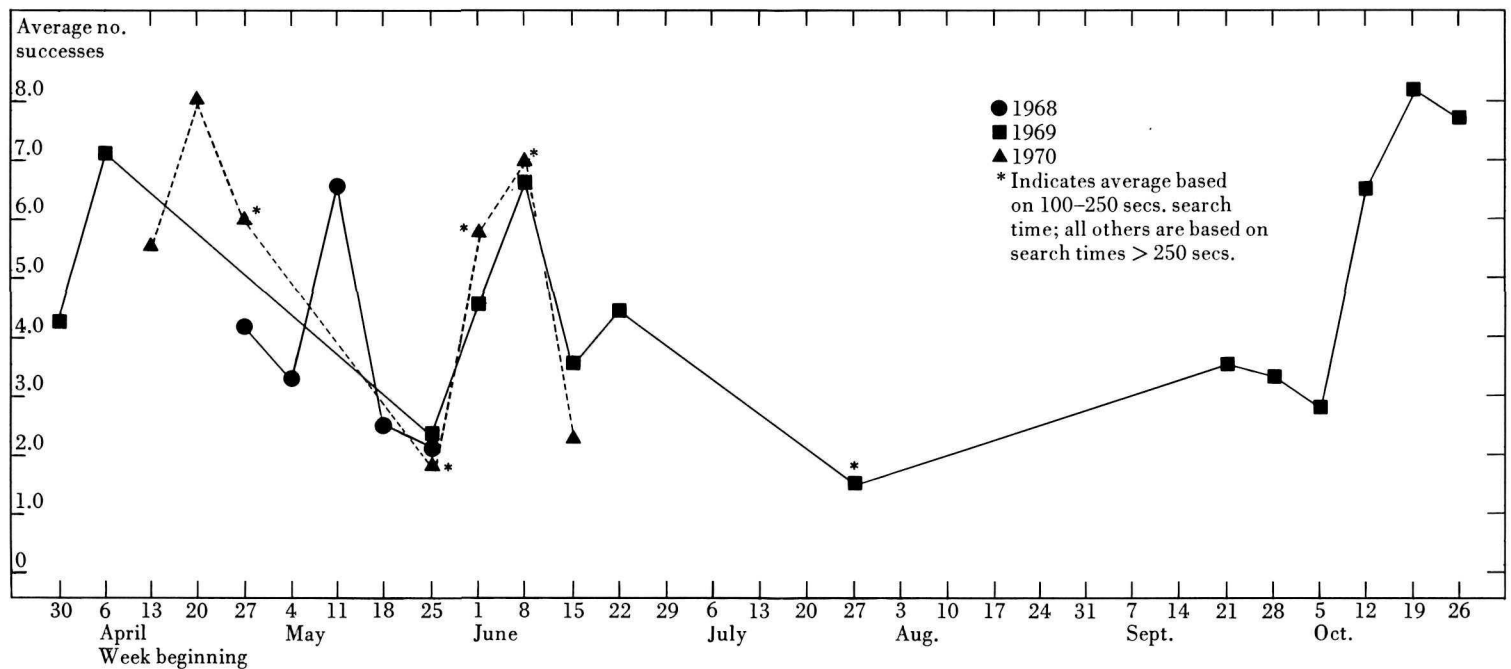


Figure 15c. Average success rate for finding large prey per 100 seconds search time for Robins at Vineland.

Figure 15d. Average success rate for finding small prey per 100 seconds search time for Robins at Vineland.

Figure 15c

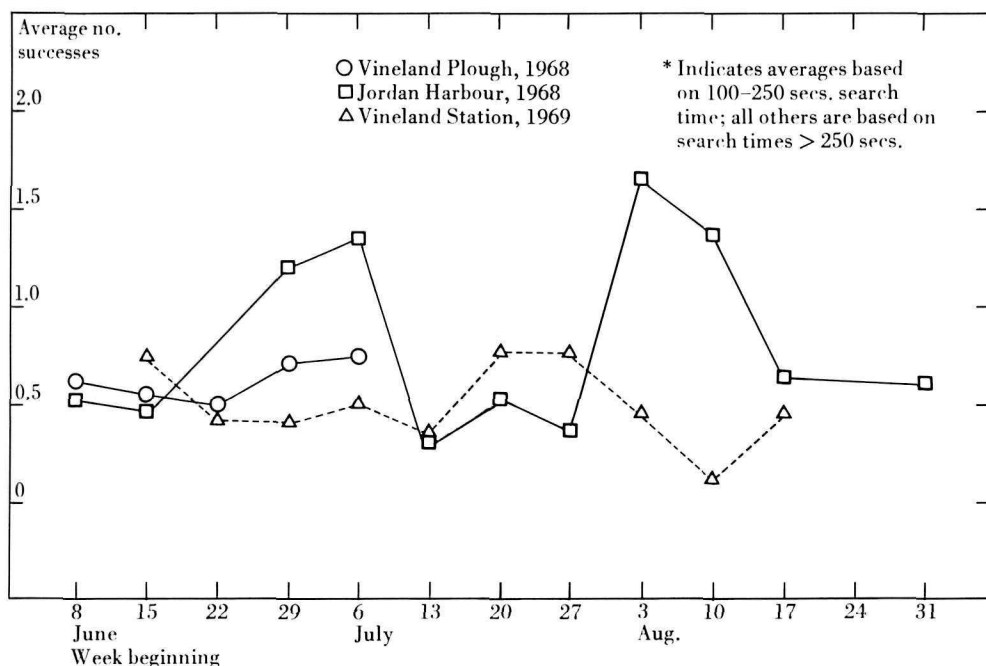
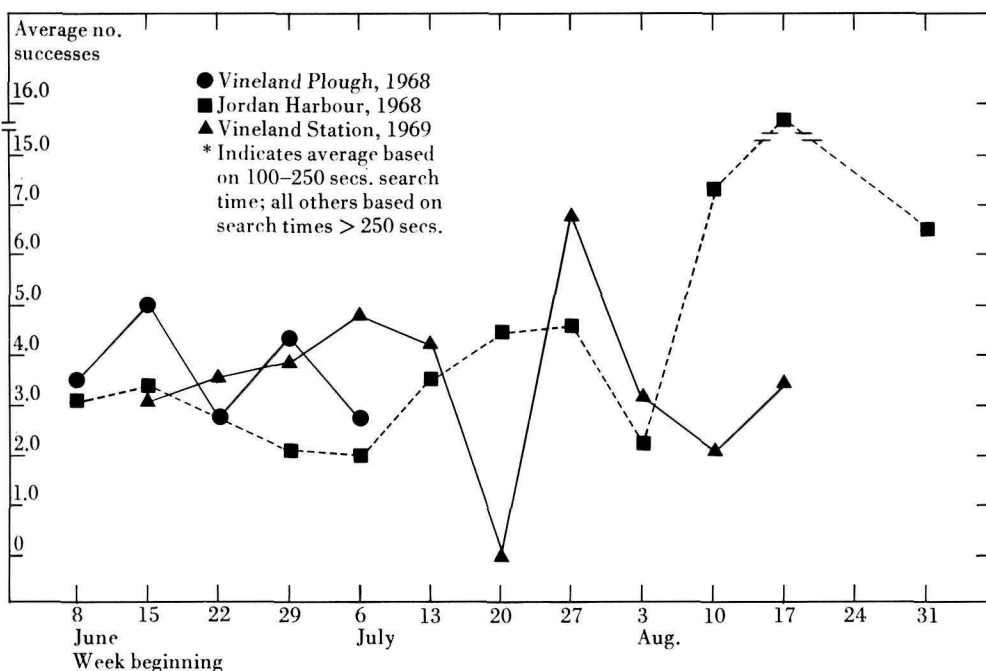


Figure 15d



The main disadvantage of this system is that it is seldom possible to make more than a very rough identification of the prey, and even that is usually out of the question. I was able to classify the prey only as "large" or "small", based on the handling time: "large" prey took more than one second to handle, and "small" less. Small prey must have consisted of small insects, spiders and other arthropods; large prey, when it could be identified, usually consisted of earthworms, though caterpillars and beetle larvae were also sometimes seen. Table 21 shows the handling times for large prey positively identified as worms, for large prey definitely not worms, and for all other unidentified prey. Evidently, any prey which took over 20 seconds to handle was almost certainly a worm.

I watched Robins in several areas, mostly in Vineland:

- Vineland Plough: in 1968 I watched Robins feeding on a ploughed section of the Victoria Farm orchard. This was next to the V17 cherry plot, and so I was able to watch simultaneously birds eating fruit and animal prey.
- Jordan Harbour: in 1968, I also watched the lawns at Jordan Harbour, in the area where I collected faecal samples (see above).
- Vineland Station: in 1969 I watched Robins feeding on the lawns of the Horticultural Research Institute at Vineland Station. (A few records from these lawns in 1968 have been included with the Jordan Harbour data for that year.)
- Newmarket: I was interested to compare the feeding behaviour of birds inside the Niagara fruit-growing area with those from outside it. In 1968, 1969 and 1970 I watched Robins feeding on the lawn outside my basement apartment at Newmarket.

The average rates per 100 seconds of search time, at which Robins were finding large and small prey in each of these areas during each seven-day period, are shown in Figure 15. (Unless otherwise stated, each rate is based on a total of at least 250 seconds of search time.)

**Table 22**  
Rates of fruit and animal feeding by Robins on  
Victoria Farm in 1968.

Date*	Fruit Av. no. entries per ¼ hour		Animal feeding rates per 100 secs. search time; Vineland Plough	
	V17	V4	"Large" prey	"Small" prey
June 13	3.25		0	1.48
June 14	2.10		0.48	3.87
June 15	0.50		0.32	1.77
June 17	1.25		0.38	9.99
June 18	3.50	5.25	0.92	5.85
June 19	5.25	5.50	0.58	6.67
June 20	8.00	4.25	0.40	3.51
June 21	12.50	8.00	0.77	2.30
June 22	8.00		0.43	1.56
June 24	12.50		0.56	4.57
June 27	4.25	2.00	1.01	3.40
June 30		1.50	0.39	4.70
July 4		3.67	1.74	6.39
July 8		2.50	0.51	2.62
July 9		6.50	0.43	2.59

\*Days on which there was less than  
250 seconds of search time for animal food  
have been omitted.

There was no correlation between the rates at which Robins were taking animal food, and the rates at which they visited cherry orchards. I started by supposing that Robins might turn to fruit when animal prey was not available, but it was soon clear that this was not so. For example, I once watched a female Robin catch a large worm on Vineland Plough, feed it to her fledged chick, then fly across to V17, come back two minutes later with a cherry, and feed that to the chick too. In May 1968, Robins were eating dried-up berries at Newmarket, even though animal prey was readily available (Figs. 15a and 15b). Again, in July 1971, I watched Robins taking half-ripe sour cherries from a tree in a garden at Guelph, as well as hunting successfully for animal food on the ground.

Table 22 quantifies these impressions. It takes the rates at which Robins were finding large and small prey on Vineland Plough, and compares them with entry rates at the same time into plot V17, and the entry rates later in the same day into V4. Spearman

rank-order correlations show no correlation of any kind.

Figure 15 shows that, both at Vineland and Newmarket, the rates at which Robins found both kinds of prey remained fairly constant all through the season (and, for that matter, from year to year as well). There are some fluctuations from week to week, and in a few cases the changes are significant. To analyse them, I took individual watches in which the bird spent at least 50 seconds in search time, and used these to compare the seven-day periods. Table 23 shows the averages for these birds, and lists the cases where significant changes are found. Such changes as do exist are probably due to climatic variations — the presence or absence of rainfall, for example. But the point is that there is no sustained increase or decrease over the season as a whole which could trigger off fruit-eating.

Figure 15 also shows that the ratio of large to small prey usually stays fairly constant during the season. Table 23b shows this in more detail. There were no signifi-



cant changes on Vineland Plough, Vineland Station or at Newmarket in 1970. But at Jordan Harbour in 1968 large prey was commoner than expectation in the weeks beginning June 15 and August 3, and less common after August 31. But this did not seem to have any obvious bearing on the start of fruit-eating. There were also some variations at Newmarket: in 1968 large prey became relatively commoner at the end of May; in 1969 there were increases in late May and late June, and a decrease in late October. It is perhaps a little surprising that large prey does not decline in relative importance during July, since this is the time when earthworms aestivate. However, the faecal analyses (see above) show that Robins are indeed able to find worms at this time. Besides, these may be supplemented by other large prey, such as caterpillars and beetle larvae.

It appears from these observations that Robins feeding on lawns are able to find animal food at a fairly constant rate all summer. One can still argue that lawns are not a typical habitat, and could bias the findings in several ways. They are, for example, kept cut all summer, whereas most grassy areas are not — and Robins need short grass to hunt on the ground. They are also often watered (this was true of Vineland Station, but not of Jordan Harbour or Newmarket), and so might have a larger earthworm population than drier ground. However, while only a relatively small proportion of Robins have territories which include lawns, there are plenty of lawns in the Vineland area for the birds to visit. In any case, as Young (1956) shows, the birds regularly feed outside their own territories. (To judge from observations on Robins feeding in orchards, they often fly at least a quarter of a mile to feed.) All things considered, I conclude that Robins start to take fruit out of a positive preference, not through lack of other foods.

#### Nutritional influences

So far, I have discussed fruit and animal food as though they were interchangeable;

**Table 23a**

Changes in the frequency with which Robins were able to find large and small animal prey, expressed as the average rates per 100 seconds search time. Birds with less than 50 seconds search time have been omitted.

been omitted.

Week starting	Vineland								
	Vineland Plough, 1968			Jordan Harbour, 1968			Vineland Station, 1969		
	Large	Small	Birds	Large	Small	Birds	Large	Small	Birds
June 8	0.57	2.82	33	{ 0.52	3.24	17	{ 0.46	3.35	11
June 15	0.69	3.64	32						
June 22	0.51	2.69	16						
June 29	0.79	4.36*	14	{ 0.94*	1.89	8	{ 0.43	4.12*	13
July 6	1.00	1.83*	12						
July 13									
July 20				{ 0.34*	3.95	10	{ 0.46	2.23	7
July 27									
Aug. 3									
Aug. 10				{ 1.49	4.06	11	{ 0.77	3.79	12
Aug. 17									
Aug. 24									
Aug. 31				{ 0.59	7.77	8	{ 0.58	4.19	6
	Newmarket								
	1968			1969			1970		
	Large	Small	Birds	Large	Small	Birds	Large	Small	Birds
March 30				0.89	6.17	15			
April 13							0.19	5.70	7
April 20							{ 1.20	6.86	8
April 27	1.17	4.61	18						
May 4	1.26	3.88	21						
May 11	1.51	7.08	12						
May 18	0.67	5.14	5						
May 26	1.19	2.17	28	{ 1.47	3.58	10	{ 0.49	4.82	7
June 1									
June 8									
June 15				{ 0.78	3.71	11	{ 1.68	4.08	11
June 22									
June 29									
July 6				{ 1.68	4.08	11			
July 27									
Sept. 21									
Sept. 28 and after				1.00*	3.34	13			
				0.19*	5.71	12			

\*See Table 23b

\*See Table 23b

**Table 23b**

Significant differences in the frequency with which Robins were taking animal prey. Mann-Whitney U-tests were applied to all the data in Table 23a; the only significant differences are those set out below.

<b>Vineland</b>		
Vineland Plough, 1968	June 29 Small > July 6 Small	$P < 0.02$
Jordan Harbour, 1968	June 29 + July 6 Large > July 13 + July 20 Large	$P < 0.05$
Vineland Station, 1969	June 29 Small > July 13 + July 20 Small	$P < 0.05$
<b>Newmarket</b>		
1969	Sept. 21 Large > Sept. 28 Large	$P < 0.01$

but, of course, they differ widely in their nutritional content. Table 24 gives the percentages of protein, fat and carbohydrate in a number of wild and cultivated fruits and, for comparison, three species of earthworms. It is clear that fruits are strong on carbohydrate and weak on protein, while the opposite is true of worms. Presumably the birds reach some kind of balance in their diet, by direct selection of different kinds of food. Kear (1962) and Pulliainen (1965) have shown that finches and partridges (*Perdix perdix*) are capable of selecting a mixed, apparently nutritionally balanced diet; I have suggested that individual Pigeons (*Columba livia*) may show preferences for different seeds because of this (Brown, 1969). Bent (1949) quotes the case of two captive Gray-cheeked Thrushes (*Hylocichla minima*) which were given fruit and animal food, and always chose a mixture. It seems likely enough that Robins and Starlings are also able to adjust their diet to suit their nutritional requirements.

However, this must be a fairly complex process, since these requirements change during the season: young birds need a high protein diet for optimum growth. Kuroda (1962) has shown that Grey Starling chicks in urban nests, fed mainly on cherries, grew more slowly than those from rural nests, fed mainly on insects; he confirmed the importance of the type of food by raising birds on all-fruit and all-insect diets. It is particularly interesting that faecal analyses indicate that the Vineland Robins are feeding their young a relatively higher proportion of animal food in July than they are taking for themselves (Fig. 14).

On the other hand, fruit must become particularly important in the fall, at around the time of migration. The birds have to build up a fat reserve, and they apparently use the fruit to do so. Evans (1966), discussing the migration of sylviid warblers in northeast England, points out that in August and September these normally insectivorous birds switch to eating fruit. He says:

Insects have a high protein content, but are low in carbohydrates. Thus they are an excellent food for promoting growth of nestlings, or supplying protein for new feathers during moult. However, the energy reserve for migration consists, in those species so far examined, chiefly of dry fat....which cannot be metabolised efficiently from protein. Nor can fat itself be digested and stored readily, as it is transported across the gut wall only slowly....For rapid assimilation and efficient conversion into fat, the best material is a concentrated sugar solution and this is precisely what ripe soft fruits provide. (p. 331)

It seems very likely that nutritional requirements of this kind are one of the reasons for fruit-eating, and especially for the damage to grapes in the Niagara area. The two vulnerable periods for these are at the end of August, and in late September and early October, when the fruit is taken by migrating Baltimore Orioles and Robins respectively. I cannot, of course, say whether this gives the birds the necessary reserves of fat, as it apparently does with Evans' warblers. But a note by Audubon, quoted in Bent (1949:38) is suggestive: he describes the former practice of shooting

Robins in fall and winter in fruit-bearing trees and notes that "they are then fat and juicy, and afford excellent eating."

But such results do not provide an explanation for the damage done to early sweet cherries by breeding adult Robins, or for the damage to sour cherries and early French hybrid grapes by what appear to be non-migratory flocks of juveniles. Nor can they explain Starling damage, since these birds do not leave southern Ontario before October. If the physical or chemical constitution of the fruit is a reason for this early damage, then the key factor might be water. Cherries, for example, are about 80 per cent water (Zubeckis, 1962), and feeding on them would be one way of obtaining water during the summer drought. However, there was no obvious correlation between the availability of water in the orchards, measured in terms of rainfall, and either the damage to sweet cherries or the frequency of Robin visits to orchards, in late June and early July.

### Foraging behaviour and search images

It would be easy to understand and control bird damage to crops if the birds' feeding behaviour was as stereotyped as, say, their courtship. But feeding behaviour must of necessity be highly flexible: the birds must learn which of the many objects in their environment are edible, and they must also learn where these objects are most easily found. The ways in which birds forage have been investigated by such workers as Tinbergen (1960), Gibb (1962), Royama (1970), Croze (1970), and Smith and Dawkins (1971), and although all these studies deal with birds feeding on animal prey, their conclusions are relevant to the problem of fruit-eating.

The studies have centered on the relationship between the birds' foraging behaviour and the density of their prey. Tinbergen described this in detail for the Great Tit (*Parus major*): he showed that, when a prey species was at medium density, it was eaten statistically more often than expecta-

**Table 24**  
The nutritional content of various plant and animal foods.

Food	Nutritional content*		
	Protein	Fat	Carbohydrate
<b>Fruits†</b>			
Wild cherry	2	2	23
Sweet cherry	1	tr	15
Hackberry	6	3	42
Raisins	2.6	3.3	76.1
Grapes Concord	1.3	1.6	14.9
Malaga	0.8	1.4	20.0
<b>Worms‡</b>			
<i>Lumbricus terrestris</i>	9.3	1.0	3.0
<i>Lumbricus rubellus</i>	10.4	0.8	2.7
<i>Eisenia rosea</i>	10.5	0.7	3.0

\*In percentages of total, corrected to undried weights.

†From Martin *et al.* (1951); except for raisin and grape data, from Hodgman (1950).

‡From French *et al.* (1957).

tion, while it was taken less often than expected at very high or very low densities. He suggested that the tits learned to develop "specific searching images" (or "search images") for each type of prey. In the course of random foraging in the foliage, the birds would encounter the prey species more and more as it increased in density, and would eventually be sufficiently rewarded so as to learn to search specifically for it. (De Ruiter [1954] gives an example for a different predator: a European Jay [*Garrulus glandarius*] failed to find cryptic caterpillars in its cage until it accidentally trod on one; it then searched out and ate all the rest.) Once the search image is established, the prey species forms a relatively high proportion of the tits' diet. Why this proportion should decline again at very high densities is not clear. Tinbergen suggested that at these levels the birds revert to a more mixed diet, as opposed to the full but monotonous one which they could have by staying with the one prey species.

As Tinbergen outlines it, the search image is established gradually, through repeated chance encounters with the prey. But this need not be so. First, the case of de Ruiter's jay, quoted above, shows that a search image can be established after a

single experience, and Croze's detailed work with Carrion Crows (*Corvus corone*) demonstrates that prey recognition is always very rapid. Secondly, Gibb found that Blue and Coal Tits (*Parus caeruleus* and *Parus ater*) may actively search for an unfamiliar prey species, even when this is at low density. His birds were feeding on the larvae of the moth *Ernarmonia conicolana*, which winter inside the cuticles of pine cones. These cannot be found accidentally; the birds must first tap on the outside of the cones and then, when they find a hollow area, dig out the larva. The birds apparently search all the time for this prey, even when its density is so low that they are seldom rewarded. Gibb suggests that they reject it at extremely low densities "as an uneconomical food on which to concentrate" (p. 108) — presumably measured in terms of the energy it provides against that expended in the effort of search. But at higher densities it becomes an "economical" food, and is taken more commonly than expectation. Gibb does not explain the subsequent decline below expectation which occurs, as with Tinbergen's birds, at the highest densities of all.

The concepts of economy and efficiency, in the time-and-motion sense, have been

applied to foraging behaviour in great detail by Holling (1965) in studies of mammals. More recently Royama (1970) has used them in the analysis of his work on Great Tits. He assumes that the tits are constantly trying to maximize their hunting efficiency, and it is this which determines their choice of prey. The switch from one prey species to another will be determined by relative "profitability": the amount of food the predator can collect for a given hunting effort. Profitability is related to the prey's density and also to its size — which in turn is an index both of the energy it will provide, and of the time needed to "handle" it (that is, to kill and digest it).

According to Royama's mathematical model, it is unprofitable to hunt a prey species at very low densities because the birds spend too much time searching, for too little result. By contrast, at very high densities the birds must spend relatively too much time in handling the prey and too little in searching for it, so this too becomes unprofitable; this seems, in every sense, a more economical explanation than Tinbergen's.

Tinbergen assumed that his birds were foraging over the whole of the area available to them, but this is probably not so. Royama found that, though his tits would bring several prey species to the nest on a given day, they were not collecting them at random. There were long sequences in which only one species was brought in, then long sequences with another, and so on. Since the different prey species were found in different tree species, or in different parts of the same tree species, Royama suggests that the birds were temporarily restricting their foraging to a very limited microhabitat — presumably returning again and again to a place where the prey species was abundant. Similarly, Davies and Snow (1965) noted that the European Song Thrush repeatedly visits "good" areas when food is plentiful but forages at random when it is scarce; Morris (1954) found the same when these birds were hunting for snails. Croze investigated

**Table 25**

The numbers of Robins visiting different sub-areas at Newmarket, on most days during May and early June 1968, to hunt for animal prey, based on varying spot checks during each day.

Date	Sub-area			
	A	B	C	D
May 12	12	No data		
May 13	2	No data		
May 14	2	0	1	0
May 15	0	6	2	2
May 17	1	1	0	2
May 18	0	1	2	0
May 20	0	3	0	0
May 21	0	0	1	0
May 23	0	2	0	0
May 25	0	0	3	4
May 26	0	1	6	6
May 27	0	0	3	3
May 28	0	0	2	2
May 29	0	6	1	0
May 30	0	7	14	4
May 31	4	5	6	11
June 1	1	0	1	0
June 4	3	2	2	3
June 5	6	0	0	1

the point experimentally. He trained Carrion Crows to turn over camouflaged mussel shells to find food; they turned over all the shells within the area where they were normally fed, but ignored many other shells immediately outside it. In another experiment, using Great Tits, Smith and Dawkins (1971) found that most of their birds' foraging was done in areas where prey was at maximum density.

Three basic points come out of these studies. Learning is an important part of the birds' foraging behaviour: they must learn the identifying characteristics of a suitable food. They also learn where it is most abundant, and tend to confine their searches to such areas. Beyond this, the choice of a food depends, not just on its availability, but on how efficiently it can be collected.

There is no obvious reason why these points should not apply to fruit-eating — indeed, it is clear that they do. The birds'

**Table 26**

Sub-area preferences of individual Robins at Newmarket, 1968.

Date	Time (EDT)	Sub-area	Sex
<b>Bird #1</b>			
May 12	0634	A	
	0645*	A	
	0718*	A	
	0737	A	
	0805	A	
May 15	0835	A	
	0555	B	
	0754*	B	
	0825	B	
	0837*	B	
	0850	B	
<b>Nesting pair</b>			
May 7	1921	C	?
May 12	1510	C	?
May 18	2045	C	?
May 26	2011	C	?
	2045	C	?
	2055	C	?
May 28	0820	C	♂
	0820	C	♀

\*Indicates cases where the identification was not completely certain.

reactions to Maraschino Gold cherries (see previous section) show that they must learn to identify food, while their tendency to keep to the earliest cherry cultivar to ripen in an orchard shows that they regularly revisit profitable areas. Similarly, cumulative damage curves (e.g. Fig. 2b) are often S-shaped, suggesting a relationship between damage and density: presumably it is unprofitable to search trees with little fruit on them, whether this is because few are ripe or most have been eaten.

My most detailed observations are on how Robins restrict their area of search, both for fruit and for animal food. For example, it was clear that the birds feeding on my lawn at Newmarket had definite preferences for certain areas on it, and that these changed from day to day. This was obvious in all the summers that I watched them; I shall give only the 1968 figures as an example. The Newmarket

**Table 27a**

Differences in the frequency of feeding entries into three Vista cherry trees in plot V1\*, by Robins, Starlings and Grackles, over 18¼ hours† of observation from June 25 to July 9, 1967.

Bird	Number of entries			$\chi^2$ ‡	P
	Vista #1	#2	#3		
Robins	239	83	94	24.97	<0.001
Starlings	75	64	53	3.78	n.s.
Grackles	24	13	6	11.37	<0.001

\*See Table 11.

†The Robin data includes an additional 1½ hours of observation.

‡Compared to the Null Hypothesis that all trees are entered with equal frequency.

lawn covered an area of roughly 100 by 50 yards, divided among several gardens; while watching Robins, I divided it into four roughly equal sub-areas. Table 25 shows the number of birds visiting each on a given day; these counts are based on varying numbers of spot-checks of the lawn during the day. It appears that sub-area A was frequently visited in mid May and early June but not in between; sub-areas C and D were the ones most visited in late May; and so on.

These preferences at least partly reflect the preferences of individual birds. (This is not necessarily the same as saying that they feed in their own territories, since Young [1956] shows that in fact they usually feed outside them.) None of the Newmarket birds was colour-marked, but I could identify one by plumage characteristics, and another two as owning a nest on the edge of the lawn area. Table 26 shows that the pair regularly fed on sub-area C, close to their nest. Bird #1 fed consistently on A on May 12, and B on May 15; moreover, it did not range through the sub-area on either day, but fed only in a plot of about 5 by 3 yards. These preferences were presumably related to the abundance of food, though I have no evidence on this. However, the preference for sub-area B on May 18 and 20 was clearly related to the presence of some newly planted bushes: the Robins first flew into these, fed on dried berries, and then flew down into B to search for animal food.



**Table 27b**

Robin preferences among the three Vista trees in plot V1, showing the sequence of trees entered, when the birds entered more than one tree during a visit to the plot, over 19¾ hours of observation from June 25 to July 9, 1967.

First tree	Next tree		#3
	Vista #1	#2	
Vista #1	29	1	1
Vista #2	10	4	6
Vista #3	3	2	7

Comparing re-entry into the same tree with shift to a new tree:

#1 vs. #2:  $\chi^2 = 25.60$ ,  $P < 0.001$

#3 vs. #2:  $P = 0.035$ , using Fisher's exact test.

I have even more striking evidence to show that fruit-eating Robins restrict their area of search. I have already described the arrangement of Victoria Farm plot V1 in 1967, with three trees each of Venus, Vista, Sam and Sue (Table 12). Robins, like Starlings and Grackles, preferred Vista, the first sweet cherry cultivar on V1 to ripen, and largely ignored the adjacent "black" Venus and Sam even when these trees were ripe too. Tests with caged birds show that there is no such preference for Vista under controlled conditions (see previous section), and so it would seem that the birds had become conditioned to visit only these trees, ignoring the others.

But the area of search was more restricted than that: the Robins clearly preferred Vista tree #1 to #3 to #2, in that order (in contrast to the Grackles, which preferred #1 to #2 to #3, and to the Starlings, which showed no significant preference [Table 27a]). Even a Robin which had fed in #2 tended to move on to one of the other trees: Table 27b deals with birds which made more than one feeding entry into a Vista during a visit to the plot: birds which had been feeding in #1 almost always went back to #1, whereas birds from #2 usually switched to #1 or #3.

The reason for this was not at all obvious. One might expect birds to become conditioned to visit the first Vista they reached on arriving at the orchard, and up to a point this may be true. Table 27c shows the directions which Robins took on leaving

**Table 27c**

Robin preferences among the three Vista trees in plot V1, in relation to their flight direction after leaving the plot, as observed over the period as above.

Tree from which bird left	Relative location	Direction of flight		Total
		NE*, N*, NW, W	SW, S, SE*, E*	
Vista #1	South	7	29	36
Vista #2	Middle	10	10	20
Vista #3	North	17	12	29
Total		34	51	85

$\chi^2 = 11.36$ ,  $P < 0.01$

\*Probably underestimated, due to angle of observation.

the plot (these are easier to record than directions from which they arrived); birds leaving #1, the southernmost of the three, tended to fly south, while those leaving #3 tended to go north. However, my only colour-marked bird invariably approached from the south or southeast, yet it almost always fed in #3. (During the observation period I recorded 12 feeding entries by this bird into #3, against one into #2, two into #1, and none at all into any other tree in the plot. Assuming a Null Hypothesis of equal entry into each Vista, the difference is significant [ $\chi^2 = 14.80$ ,  $P < 0.001$ ]). Since no Robins bred in the plot, there were no territorial interactions which might account for the differences. Tree #2 was the largest, and #3 the smallest of the three, but otherwise there were no obvious differences in the density, size, conspicuousness or (to judge from a very small sample) sugar content of the fruits of these trees. The only other possible difference seems to be in the order of ripening: in colour photographs taken on June 25, 75 per cent of the fruit on #1, 50 to 60 per cent of that on #3 and 50 per cent of that on #2 were red. I have already suggested that Robins prefer the reddest available cultivar. It may be that they even come to prefer the reddest tree of a given cultivar, and subsequently restrict their search to it.

This exclusiveness seems, in every sense, short-sighted. But one must remember that the artificial arrangement of cherry trees into large orchards is barely a century old

in southern Ontario. Fruit trees are few and far between in the forest (a scattering which comes, incidentally, from the birds' carrying off the fruit in the first place, which is in turn the cherry fruit's *raison d'être*.) It may well be that, until recently, it was more efficient for a Robin to continue to visit a fruit tree for as long as the fruit lasted, instead of searching for other ripe trees, however close they might be. The result, unfortunately, is devastating. Even allowing for the lesser depredations of Starlings and Grackles, I estimated that trees #1 and #3 had lost about 70 per cent of their fruit, against only 20 per cent from #2.

In a preliminary reference to these observations (Brown, 1969), I suggested that this restricted foraging was evidence that the birds had developed a search image. But, as Dawkins (1971) has pointed out, this is a very loose use of the term. "Search image" has never been rigorously defined, but the term seems to imply the existence of some kind of perceptual filter; the feeding bird "recognizes" only a few of the stimuli reaching it through its sense organs. In most of the cases where the term has been used, the existence of such a filter has been deduced only from direct or indirect observations of feeding behaviour; in these, the hunting bird, apparently as the result of learning, has restricted its search to certain food-types and/or areas (Tinbergen, 1960; Gibb, 1962; Croze, 1970; Murton, 1971). But, as Royama (1970)



and Smith and Dawkins (1971) point out, observations of this kind are only evidence of regular association learning, and to apply the term "search image" to them is to make that term so broad as to be practically meaningless. It seems better to confine "search image" to cases such as Dawkins (1971) describes, where a perceptual filter has been experimentally demonstrated. For the rest, it seems better to use a neutral term such as "foraging behaviour", in which one can allow learning to play an important and often highly selective part, without implying too much about the actual selection mechanism.

It would be interesting to take Royama's "profitability" model further, to see whether one can use it to explain the switch from animal food to fruit. Unfortunately, I have no absolute data on the densities of the animal prey species. But it is conceivable that such densities could be a factor influencing the changeover. At Vineland in 1968 I found that Robins feeding on lawns took an average of 2.18 small and 0.33 large prey per minute of search and handling time; in the V1 plot in 1967 they took 0.37 cherries per minute. Therefore, if one considers only the size of the food item, it is far more efficient to feed on a cherry than on small prey. (Since small prey, by definition, take less than one second to handle, this means that they have to be very small indeed; 2.18 ants or spiders come nowhere near the size of a cherry or even a third of one.) The rates for cherries and large prey, on the other hand, are very similar (a good deal would depend on the size of the worms or grubs taken under this heading). But of course, this takes no account of the nutritional differences between animal food and fruit (see above).

Basically, there are two ways of protecting a crop against bird damage. The first is to stop them coming in. This approach can vary from simply covering the crop with an impenetrable net, to attempts to alter the habitat so that the birds are not attracted to the area where the crop is grown. The second approach is more active, and more traditional. It assumes that the birds will get into the crop, and must be either killed before they can eat it, or else driven out by some kind of scarecrow.

Man has probably been trying to invent the perfect scarecrow ever since he invented agriculture, and there are many reasons for his failures. One of the most important is his anthropomorphic approach. We think of some more or less elaborate device which will scare us, and then assume that it will scare the birds too. But there is no reason why the birds should react in the same way as we do, and in fact it is clear that in many cases they do not. For example, Niagara Peninsula crops are most commonly protected by exploders, yet these loud noises have no effect whatever on the Robins which do most of the damage. I once saw a bird eating cherries in a tree immediately above an exploder; the bird's feathers swayed at every blast, yet it never missed its stroke on the cherry it was pecking. In fact, there is a sour local joke that exploders actually attract Robins, by showing them where the fruit is ripe. This could well be true.

So it is important that we design our scarecrows from the point of view of the birds, not of ourselves. All scarecrows are attempts to exploit the birds' fear of predators. The grower can hardly mount a sentry beside each tree or vine; instead, he installs some sight or sound which he hopes will have the same effect. The difficulty is that anti-predator behaviour follows the "never cry wolf" principle: if the scarecrow is not constantly reinforced by an actual attack of some kind, the birds quickly learn to ignore it.

This waning of the response occurs even in the wild, where one would have supposed

the birds to be adapted to avoid the predator for as long as possible. For example, Hinde (1954) shows that the mobbing responses of Chaffinches (*Fringilla coelebs*) to an owl model quickly wane, and in two separate ways. There is a short-term waning during each exposure to the owl, but after a little time away from it the birds quickly revert. And there is also a long-term waning which ensures that the intensity of the mobbing response, despite these short-term recoveries, gradually declines after repeated exposures to the model.

Therefore, any efficient scarecrow must allow for this habituation, either by being so frightening that the birds' initial reaction is slow to wane, or by being so complex and unpredictable that the birds never learn that the threat is never carried out. Either way, this means that the scarecrow has to be based on something which is tailored to stimulate the birds' anti-predator behaviour to the maximum extent; something like the broadcasting of the birds' own alarm calls, or the presence of an actual if not very efficient predator, such as a man with a shotgun.

### Long-term approaches

One of the most promising approaches to the problem of preventing bird strikes on aircraft has been to make airports as unattractive to birds as possible (Kuhring, 1969). One can hardly transfer this approach directly to fruit damage problems, because birds like trees, and without trees it is difficult to grow cherries. But the object-lesson still holds good: if we understand why birds visit orchards, it may be possible to develop a bird-proof orchard layout, or perhaps even develop a bird-proof cherry, which might in the long run be cheaper and more efficient than short-term scarecrow devices. At the very least, this biological approach should help us to decide which protective system is most likely to work, and how it can most effectively be applied.

For example, Newton (1966) was able to go quite far in translating his biological

approach to a bird damage problem into practical terms. He was concerned with the damage which Bullfinches cause to fruit-tree buds. He found that the birds ate buds only in alternate winters, when the ash (*Fraxinus excelsior*) seed crop failed. On this basis, he suggested that:

- protective measures are unnecessary in many years.
- Bullfinch shooting and trapping in "non-ash" years should be done in the fall, and not in the following spring when the damage actually occurs. This would reduce the number of birds competing for wild seeds, and so delay the damage to buds later on.
- growers should prune their trees in "ash-crop" years wherever possible; thus the greater numbers of buds in "non-ash" years would be proportionately less damaged.
- there is no point in providing an alternative food supply in "non-ash" years: the Bullfinch population would simply expand to the limit of this new supply, and then once again start to damage the buds.

In the two previous sections I have tried to examine some of the factors which influence fruit-eating, and I am not able to produce a solution as neat as Newton's. Not only do the birds I have to deal with belong to at least four different species, but they are omnivorous at the time that they are eating fruit, and it is hard to find the weak links in so many food chains. But I hope that these chapters at least have the value of showing what it is *not* worth wasting further time and money over.

There is, for example, no question of preventing damage to fruit by giving the birds an ample supply of animal food, because Robins, at least, have a positive preference for fruit over animal food. (This in turn implies that any scarecrow system for Robins has to be particularly "meaningful" to them, in order to counteract this positive attraction.)

Nor is there much point in trying to develop a bird-proof cherry cultivar. It is true that cherry cultivars which are pink

or yellow when ripe, and grape cultivars which are white or green, are little damaged. But the experiments with caged birds show that the birds' preferences are relative, not absolute: they readily take non-preferred cultivars for lack of anything else. To develop a bird-proof cultivar, one would presumably have to change not just its colour but its taste as well — and that would probably make it human-proof too.

Given the positive attraction for fruit, the likeliest long-term approach may be to see whether one could provide some other fruit which would distract the birds from commercial cultivars. I have shown that Starlings prefer cherries to grapes, which suggests that birds might be distracted from feeding in vineyards if reddish, firm-fleshed wild fruits were growing nearby. I also found that Robins ate mulberries first in a mulberry vs. cherry test — even though they went on to eat the cherries as well by the end of the test (Table 16).

Both points suggest that it might be worth using wild fruits as a "spoil" crop. However, I am not very optimistic about this. In the first place, I imagine that one would have to plant an uneconomically large proportion of the cultivated area with spoil trees if the birds were to be given enough spoil fruit for a real alternative to the commercial crop. Secondly, my limited observations suggest that the presence of wild fruit does not, in fact, protect cultivated ones. For example, there was a sweet cherry tree in my Jordan Harbour observation area which was stripped by birds, even though there were several ripe mulberry trees nearby. Also, most of the damage to the Jordan Farm Seibel 10878 was done by Robins based on the woodlot nearby: Table 4 shows little difference in damage between 1968, when the wild black cherry tree in that woodlot bore fruit during the grape season, and 1969 when it did not.

The only other possibility is to compare the relative attractions of the commercial cultivars themselves. Some cultivars of fruit are clearly damaged more than others

**Table 28**  
Damage scores for different cultivars of sweet cherry (from Virgo, 1966).

Cultivar	Score*	No. records
Seneca	132	123
Black Tartarian	111	467
Schmidt	110	71
Venus	100	135
Bing	99	454
Vista	98	222
Windsor	96	491
Hedelfingen	92	461
Vernon	86	94
Victor	79	214

\*The damage score for the "average" variety = 100.

(Tables 1 and 4); what effect does the presence of such a cultivar have? Does it act as a spoil crop, distracting birds from whatever other cultivars are present? Or does it act as a "loss leader", so that the birds are first attracted to the orchard and then, when they have eaten all of the vulnerable cultivar, go on to eat whatever else there is? The observations on Robins feeding in Victoria Farm suggest that, up to a point, Vista acted as a spoil crop for Venus and Sam in plot V1 in 1967, and for 48021 in V4 in 1968. But, as I have explained, Robin damage was probably atypically high in this orchard; in any case, orchards are so variable that one needs a much larger sample before drawing any conclusions. Since such a sample must inevitably be based on cruder assessments, it is necessary to eliminate additional biases which may be caused by variations in the timing of migration and the numbers of migrant birds. So, in the discussion which follows, I shall deal only with the early sweet cherry cultivars, which are damaged mainly by the presumably fairly stable population of breeding Robins.

The data which form the basis of this discussion come from a survey of growers made by Virgo (1966) during the 1965 season. The growers were asked to list the cherry cultivars they grew, and to judge whether the damage to each cultivar was "heavy", "moderate", "light" or "none".

**Table 29**  
Damage scores to Black Tartarian cultivars in the absence and presence of Seneca cultivars, expressed as total numbers and percentages\*.

	Black Tartarian damage		
	"Heavy"	"Moderate"	"Light/None"
Seneca absent	136 (74.3%)	21 (11.5%)	26 (14.2%)
Seneca present	60 (61.2%)	27 (27.5%)	11 (11.2%)

\*From Virgo (1966). See also Table 28.

**Table 30**  
The influence of exploders on Robin and Starling entry rates (both feeding and not) into the sweet cherries on Victoria Farm plot V4, in 1968, shown through average entry rates per ¼ hour on days when the exploder was and was not firing.

Species	Dates	Exploder firing	Not firing
Robins	before June 24	6.0, 4.75, 9.75, 5.0	6.0
	average	6.00	6.0
	after June 24	2.75, 3.0, 2.0, 5.0, 2.5, 9.5, 7.0, 3.5	9.0, 8.67, 6.0, 2.5
	average	4.41	6.54
Starlings	before June 24	0, 0, 2.75, 1.5	0.25
	average	1.06	0.25
	after June 24	0, 2.0, 4.0, 2.33, 3.5, 1.5, 1.0, 0.5	4.25, 6.33, 14.5, 4.5
	average	1.85	7.39

Virgo used these assessments to create a damage index for each cultivar, and this is summarized in Table 28. (I have omitted cultivars for which Virgo had less than 50 reports.) I used the reports to assess the damage to a given cultivar in the presence and absence of other cultivars. For example, take the Seneca/Black Tartarian pair: I noted the numbers of "heavy", "moderate" and "light/none" assessments of damage to Black Tartarian when the earlier-ripening Seneca was present in the same orchard, and also when there was no Seneca (so Black Tartarian was the earliest cultivar to ripen) (Table 29).

The damage to Black Tartarian is significantly higher when it is the earliest cultivar to ripen, than when Seneca ripens ahead of it ( $\chi^2 = 11.74$ ,  $P < 0.01$ ). There is no such difference if one compares the damage to Seneca in the presence and absence of Black Tartarian ( $\chi^2 = 2.00$ , n.s.), which is not surprising, since a later-ripening cultivar is unlikely to affect an earlier one.

Similarly, the presence of the earlier-ripening Black Tartarian is linked to significantly less damage to Vista than when Vista is the first cultivar to ripen ( $\chi^2 = 7.06$ ,  $P < 0.05$ ). Again, the damage to Black Tartarian is unaffected by the presence or absence of Vista ( $\chi^2 = 2.50$ , n.s.).

These results suggest that an early-ripening, vulnerable cultivar can, to a certain extent, act as a spoil crop, and distract birds from later cultivars in the orchard. At any rate, the presence of the vulnerable cultivar seems to cause no positive harm to the others. At the same time, the birds are by no means completely distracted, and I doubt if it would be worth planting a vulnerable cultivar specifically as a spoil crop.

### Protective devices

#### Exploders

Acetylene or butane-powered exploders are the bird-scaring devices most commonly used in the Niagara Peninsula. They

are small, cannon-like machines in which gas is sparked off, at pre-set intervals, to produce a fairly loud explosion. They have the advantage of being cheap to operate, and the disadvantage of creating considerable nuisance if used near houses. But the most serious disadvantage, from the point of view of the present discussion, is that they are not very effective as bird-scarers. Victoria Farm, for example, was protected by exploders up to mid July in all three years; the damage figures shown in Table 1 do not suggest that the protection was very effective.

I have some direct observations which show the point in more detail. When I was watching Victoria Farm plot V4 in 1968, the exploders there were sometimes working, and sometimes not. Table 30 shows the average number of Robin and Starling entries in each case. Since Robin entries tended to decline and Starling entries to increase in late June and early July, I have treated separately the data for before and after June 24. There was in fact only one day before June 24 when the exploder was not firing, but there was no obvious increase in Robin entries. After June 24, the average frequency of Robin entries seemed slightly higher on days with no exploder, but the difference is not significant if the Mann-Whitney U-test is applied. On the other hand, the exploder seems to have been rather effective in keeping Starlings away after June 24; applying the U-test, the difference is significant at the 0.002 probability level. The Starling entry rate on the days with no exploder is in fact very similar to the entry rate after June 24 into plot V17, which was not protected by exploders at all; they averaged 7.39 and 7.12 entries per quarter hour respectively.

It is harder to assess the effect of exploders in preventing damage to grapes in this way, because the Robins which are responsible for most of it stay well under cover. But it was a common experience to flush Robins out of vineyards which had exploders in them. Honsberger's Foch, for example, was protected by exploders in

both 1967 and 1968, yet the Robins still did extensive damage (Table 4). In 1967, one group of my sample vines in this vineyard was beside an exploder, another had an exploder two rows away, and the third had no exploder near it at all. The damage to the three groups at harvest time was 19.0 per cent, 4.5 per cent and 14.0 per cent respectively, so it appears that the devices had no effect on the Robins. It is hard to say whether, as in the cherry orchards, they help scare away Starlings; it may be significant that these birds were scarce in Honsberger's Foch, but quite common a little later on in the unprotected Jordan Farm vineyard.

#### **Aluminum foil**

Some growers claim that birds avoid trees and vines which are hung with scraps of cloth, old newspapers or, especially, shiny aluminum foil. I tested this in 1968, when several Vista cherry trees in Victoria Farm plot V4 were decked in aluminum foil, in rectangles of about 5 inches by 3 inches, red on one side and silver on the other. At picking time, one of these trees had suffered 28.9 per cent damage, compared with 33.6, 30.4, 29.5, 23.3 and 20.9 per cent for trees which were not so protected. This method does not seem to be very effective.

However, it is possible that a more sophisticated approach might do better. Zwicky (1965), working in Europe, strung lines across a vineyard with various lengths of foil dangling down almost to the level of the vines. The lines were attached to a pulley system and moved to and fro across the vineyard by a small motor. Zwicky found that this gave almost complete protection. I suspect, however, that the greater size of North American vineyards would make such an arrangement impracticable over here.

#### **Model hawks**

It has been claimed that birds can be kept out of fruit trees if the silhouette of a model hawk is suspended overhead. For example, workers in France (Busnel and Giban,

1958) hung a model of a flying European Sparrow Hawk (*Accipiter nisus*) over a cherry tree which had until then been visited frequently by Starlings and various thrushes. The average number of Starling visits per half hour dropped from 6.4 to 0.1 after the hawk was installed, and stayed there over the 19 days of the experiment. The thrush average fell from 16.3 to between 1.3 and 4.8, though after day 13 it rose to about 6.8. This has an obvious practical application, and model hawks are used by commercial growers both in Europe and in the United States. I understand that in the United States, at least, these models have been only erratically successful.

Two such models were installed over Honsberger's New York Muscats on August 29, 1967, at a time when these grapes were being damaged extensively, probably by Baltimore Orioles. The models were grey, life-size, semi-three-dimensional silhouettes of Cooper's Hawk (*Accipiter cooperi*), and were slung about 15 feet above the ground between two poles, one at each end of the vineyard. I compared the damage on the vines immediately under the hawks with that on control vines nearby. The results are at first sight impressive: the grapes under the hawks received only 2.2 per cent damage, against 8.3 per cent for the controls. But this is rather misleading, since the controls were barely 20 yards from the hawks. One would presumably need a large number of models to provide anything like complete cover. I can only conclude that this is not a very effective control system, at least for birds like Baltimore Orioles which stay well in cover. It is conceivable that it might be more effective with birds, such as Starlings, which stay in the open — as indeed the French data suggest.

#### **Protective netting**

I used Honsberger's New York Muscats to test the effects of protective netting in 1967. This netting was made of blue, vinyl-coated nylon, of 0.4 by 0.4-inch mesh,



manufactured and supplied by Bay Mills Ltd., Midland, Ontario. I used it to cover a number of vines in blocks scattered through the vineyard, and compared the damage with that done to adjacent control vines.

The nets were not completely effective. They were held under the vines with clothes pins, and this left gaps through which birds could enter. Nonetheless, there was a significant reduction in damage: on average, 8.9 per cent of the grapes were damaged on the control vines, but only 3.2 per cent inside the nets. (The latter figure includes a small amount of damage done before the nets were installed; the minimum percentage known to have been taken inside the nets was 2.25 per cent.) In every case, damage done to a netted area was significantly lower than that to its adjacent control at the 0.001 probability level, using the  $\chi^2$  test.

Damage in this vineyard was highest in the corner next to the woodlot in which the Baltimore Orioles seemed to be based. It was interesting that the damage to the netted portion of this area, though less than that to its control, was higher than that to any other netted area in the vineyard. It would appear that the orioles, faced with a netted vine, do not go elsewhere to feed, but merely try harder to get in. The point here is that netting is not a scarecrow device; to the birds it presumably represents nothing more than some exceptionally dense foliage.

Wider meshed netting, about  $1\frac{1}{2}$  by  $1\frac{1}{2}$  inches, was used to protect some experimental cherry varieties on Victoria Farm in 1969. The nets were attached to a wooden frame built around each tree. I made no damage estimates; however, G. Tehrani (pers. comm.) tells me that they bore a good crop in 1969, whereas in previous years they had been completely stripped by birds.

Netting therefore seems quite an effective way to protect both cherries and grapes. In practical terms, I doubt if it would be economical to cover cherry trees in a commercial orchard. But it might be pos-

sible with grapes, since it is a simple operation to cover vines with netting. A good deal depends on the durability of the netting (the manufacturers claim that the material I used will last five years), as well as the initial cost. It should be possible to reduce the latter by increasing the size of the mesh: I judge that a 1 by 1 inch square mesh would be just as effective.

#### **Broadcast distress and alarm calls**

Recently a good deal of attention has been paid to the possibility of clearing birds from crops and airfields by the broadcasting either of their alarm calls (the call of a free bird on seeing a predator) or of their distress calls (the scream of a bird actually caught by a predator). The results of experiments in Europe and the United States have been given, for example, by Busnel and Giban (1958, 1962), Murton and Wright (1968), and Boudreau (1968). The birds' response to these calls varies; sometimes they fly away at once, and sometimes they approach and circle the loudspeaker before eventually dispersing. But the fact that they eventually leave the area is certain enough for protective systems broadcasting these calls to be commercially available to growers both in Europe and in the United States.

It is claimed that the advantage in using this natural and presumably "meaningful" system is that the birds do not habituate to it. I am not completely convinced on this point, since I have found habituation to distress calls in corvids and shorebirds on airfields in Britain (Brown, Sugg and Brough, 1962). But if habituation occurs, it is obviously not very great. G. Boudreau (pers. comm.) tells me that he prevents it in his commercial system by the use of a sophisticated and unpredictable automatic switching system. The difficulty is that this inevitably increases the price. The average Niagara grower has only a small plot of grapes or cherries, and this kind of apparatus is likely to be beyond his reach.

My only experience with broadcasting distress and alarm calls in the Niagara

Peninsula was not very encouraging. In the fall of 1969 I did some pilot tests in vineyards, using a 12-watt amplifier and a small horn speaker. I recorded alarm calls from caged Robins used in the food-test experiments and distress calls from a juvenile Robin caught in a mist-net. For the acoustic trials I broadcast for about 30 seconds, using either the distress calls, or distress plus alarm. I held the speaker above the level of the vines, to prevent any muffling by the foliage; the sound was clearly audible at 50 yards and could be heard faintly 80 yards away.

The Robins usually ignored the broadcast alarm call. When they reacted to the distress call, they would fly towards the speaker and perch 10 yards or so away. Then, while the call was still playing, they would move off. After the end of the broadcast they usually flew down again into the vines. In most cases, no birds left the vineyard. On one occasion I searched through the vineyard after the end of the broadcast; it was clear from the number of Robins I saw that, although some had reacted to the call in the way I have described, most of the birds in the vineyard had not reacted to it at all.

Boudreau (pers. comm.) has had good results in dispersing Robins from orchards in California by the use of broadcast calls. I am unable to explain why this system did not seem to work with my birds.

#### **Av-Alarm**

The Av-Alarm Company of Santa Clara, California, has recently marketed an acoustic bird-scaring device of another kind. Instead of broadcasting bird calls, this device sends out an electronic warble. This must be adjusted depending on the species which is causing most of the damage; it apparently jams the reception of sounds by the birds' auditory nerves, temporarily deafening them. This deafening is apparently repellent. The sound is played automatically in short bursts, at intervals which can be adjusted by the operator. The manufacturers claim that the birds move



away from the area in which the device is operating after they have been exposed to it for a day or two.

The Ontario Department of Agriculture obtained one of these devices during the 1970 fruit season and operated it on Victoria Farm, near the junction of plots V4 and V17. The range of the device is such that it is difficult to make direct comparisons between experimental and control areas; instead, I took the damage done on V4 and V17 in 1970, and compared it with the damage in preceding years. I also compared bird numbers in the plots in 1970 with those in 1969.

On both criteria, the Av-Alarm seems to have been rather effective. Table 31 shows the damage at picking time (or up to July 28, when the device was removed) for Vista, 48021, NY 1495 and the sour cherry cultivar Richmond. There were substantial reductions in damage to all except NY 1495. This cultivar had already suffered 56.9 per cent damage by June 22, when the Av-Alarm was first installed; this rose to 74.7 per cent by June 26, and all the fruit was gone by July 8. It may be that it is harder to drive birds away from a well-established food source. However, the device seems to be initially slow-acting, and nearly half the additional damage took place in the first few days after installation, when it might not yet have taken effect.

There was also a decline in bird numbers, compared with previous years. The average daily count on Victoria Farm in 1970, during the period from June 22, when the Av-Alarm was installed, to July 8, when the Vistas were picked, was 5.0 Robins, 2.4 Starlings and 0.7 Grackles; for the comparable period in 1969 the average was 15.3 Robins, 3.5 Starlings and 7.8 Grackles.

The device was installed in the Ontario Vineyard during the grape season in 1970. I made no quantitative evaluations, but I was told that the number of Robins was small, and the damage to grapes was unusually light.

Evidently, Av-Alarm is an effective bird-scaring system. It is also an expensive

**Table 31**

Bird damage at picking time (or up to July 28) with Av-Alarm (1970) and without (1968 and 1969), to the cherries on Victoria Farm plots V4 and V17.

Cultivar	Damage (%)		
	1968	1969	1970 (with Av-Alarm)
Vista	44.0	34.5	15.5*
48021	32.0	10.7	3.1
NY 1495	48.6	50.5	100.0
Richmond	—	45.8	19.3

\*This figure is certainly an overestimate, since some of the cherries on my sample branches had already been picked. A more accurate figure would be 5%.

one, however, and it may be beyond the reach of the average small-scale Niagara grower.

### Extermination systems

The killing of songbirds is always distasteful, but sometimes the damage which they cause locally to a crop leaves the grower with no alternative. Robins and Baltimore Orioles (but not Starlings, Grackles or Red-winged Blackbirds) are normally completely protected under the Migratory Birds Convention Act. But when it can be shown that they are causing damage, they may be killed by holders of a special permit. Section 39, subsection 1 of the Act states:

A game officer may issue to a person owning, leasing or managing land of an area not exceeding one thousand two hundred and eighty acres a permit describing the area and authorizing that person and his nominees to kill within the area migratory birds that are causing or likely to cause damage within the area.

But the legal difficulties are not the only objections to any extermination system. The purpose of this section is to examine systems of this kind and discuss their limitations.

### Shotgun patrols

Legally or illegally, if the average grower kills birds in his orchard or vineyard, it is with a shotgun. There is no doubt that shotgun patrols, if done really intensively,

can reduce bird damage. This was tried on a large scale in the Ontario Vineyard in late August and early September 1968, in order to protect the early grapes against Robins. Figure 4 shows that the damage to Seibel 13053 had reached 42.1 per cent by August 28, when the patrols started; the cumulative damage rate at once began to slow down, and there was negligible damage after September 2.

All the birds shot were Robins. Biologically speaking, it is probably safe to do this to a common species like the Robin, within a very restricted part of its range. It is probable that only a very small section of the population was affected. All the shot birds were juveniles, and to judge from the pattern of banding returns discussed earlier they were probably bred in the Niagara area. (Shooting had largely stopped by the time of the migrant influx at the end of September.) Farner (1945) notes that only 20 per cent of fledged Robins survive to breed, so it is likely that the shooting killed many birds which would have died later anyway, from starvation, predation or disease.

The objections to such a system are human rather than biological. The ethical objections do not need stating. But the economic objections are just as strong: labour costs are such that I doubt if the average commercial grower could afford shotgun patrols at the intensity necessary to bring damage to a halt.

### Trapping

Shooting is unlikely to have much effect on the very large Starling flocks which visit the cherry orchards from mid July onwards. It would be more efficient to trap them, if this could be done on a large enough scale. Shake (*in* Schneider and Jackson, 1968) has found this effective in the cherry orchards of Michigan. The birds are caught in very large Australian crow traps, attracted by decoy birds and by cherries spread as bait. The trapped birds are then removed and killed by automobile exhaust fumes. Banding data suggest that the Starlings in the Niagara orchards are local birds, and that flocks perhaps stay within quite a small area. So, given this relatively limited population, intensive trapping should have a significant effect on the numbers of birds visiting the orchards.

Since the birds in the orchards are mostly juveniles, it would appear most efficient to trap the adult birds at the start of the breeding season, before they have time to reproduce. In theory, this would be easiest in March, when the population is at its lowest, and lack of other food makes baiting easy. However, banding data show that many Starlings are still on migration at this time, and there is no guarantee the birds caught in the Niagara in March would be the ones whose young invade the orchards in July.

### Chemical techniques

A number of poisons have been developed in the United States and are commercially available there, under strict controls, for reducing bird populations. Starlicide (DRC 1339) and Avitrol are the best known of these (Schneider and Jackson, 1968); they are fed to the birds in bait, and when properly used specifically affect the pest species only. A less drastic approach is the development of a chemosterilant "pill" which, when fed to pigeons, significantly depresses the reproduction rate. A different technique has been the aerial spraying of Red-winged Blackbird roosts with a wetting agent; this destroys the birds' insulation, and they die of heat loss.

I have no experience of any of these techniques, but I doubt if they would have any application in the Niagara area. Poisons and chemosterilants can be used only on birds which take bait — that is, Starlings and Grackles, but not Robins and Baltimore Orioles. Even with these, it would be unacceptable to use poisons during the fruit season, and outside this period there is no guarantee that the poisoned birds are those which cause the damage. It might be possible to spray summer Starling roosts with wetting agents, but I doubt if the expense would justify it.

### Conclusions

I have discussed these protection systems very much from the point of view of the biologist. My criterion of effectiveness has been the proportion of the crop which a given system is likely to save. But to the grower, a protection system must not only be biologically efficient, but economically efficient as well. He needs something which will save him fruit worth more than the system itself cost. As I have suggested, the costs of acoustic apparatus or of hiring labour for a really effective shotgun patrol are likely to be more than the protection is worth.

The economic complexities of course go far beyond the scope of this study. Among other things, they vary not just with the crop but even with the cultivar to be protected. For instance, French hybrid wine grapes are more valuable, and more often damaged, than table grapes such as New York Muscats. Yet the grower may well feel more concerned about the Muscats, since he must remove by hand the empty husks that the birds have left, before the grapes can be marketed. Again, a man who has a couple of cherry trees in his garden, and grows the fruit as a hobby, will probably have criteria which differ from those of a small commercial grower, and a small grower from a large grower. There is even the possibility that a really efficient scarecrow, if used widely enough, would cause a glut of fruit on the market, and the

resulting drop in prices would make it economically inefficient again. In short, it is obvious that protection systems must be tailored to the grower as well as to the birds. The aim of this chapter has been to provide background information on the biological efficiency of various systems which will, I hope, be of use to experts in agricultural economics.

Accepting these limitations, it is useful to finish by summarizing the methods most likely to be effective with each of the species causing damage.

### Robins

Anyone who has watched Robins feeding in a cherry tree festooned with children will realize that these birds are very hard to drive away. There is in fact no simple way to prevent the damage they cause. Exploders are useless. Acoustic systems such as Av-Alarm are effective, but also expensive. Shotgun patrols work, but have to be done very intensively. Netting would probably be effective for grapes, but impractical on a large scale in cherry orchards.

### Starlings

Figure 2b shows the advantage to be gained by getting rid of Starlings: the Jordan Farm sour cherries had negligible damage in July 1969, when the Starlings arrived late, compared with other years when they came earlier. Fortunately, Starlings are the easiest to deal with of all the damage-causing species. Even exploders have some effect on them, and more sophisticated acoustic devices are also effective. If necessary, the population in the orchards can be reduced by large-scale trapping; this is probably best organized by agricultural extension departments, or perhaps by growers' co-operatives.

### Grackles

Grackles have for the most part left the fruit belt by early July, and therefore damage only the early sweet cherries. They are bolder birds than Starlings, and my impression is that they are less disturbed by

# Summary

exploders. The answer might be to organize shotgun patrols during the relatively short period when they are causing damage. They could also be trapped, in the same way as Starlings.

## Baltimore Orioles

I can at present see no way of dealing with these birds, apart from netting the vines. The birds are so secretive that shotgun patrols are unlikely to be much use, and I doubt if exploders would work either. More sophisticated acoustic systems might be more effective. Fortunately, the grapes are vulnerable to oriole damage for only a short period.

## The bird damage problem

- The commercial fruits suffering most bird damage in the Niagara Peninsula are cherries and grapes. Apples, peaches, apricots and nectarines are also sometimes taken, and the birds feed extensively on wild and garden fruits.
- Cherry damage varies with year, orchard and cultivar, but the loss of a quarter or more of the crop is not uncommon. Damage rates increase sharply in the week or so before picking, especially with the later-ripening cultivars.
- Grape damage also varies among years, vineyards and cultivars, but the damage is usually less than 10 per cent of the crop. French hybrid cultivars are particularly susceptible. In most cases the daily damage rates stay constant over the whole season, but some table grapes are damaged only in late August and early September.
- It is important to realise that bird damage is an inescapable side-effect of fruit growing. Fruits are designed to be eaten, so that the tree's seeds can be dispersed through being carried off in the stomachs of the birds and mammals which eat them. The more attractive we make a fruit for our own purposes, the more attractive it is likely to be to the birds.

## Bird populations and migrations

- Most of the damage to early cherries is done by adult Robins and, to a lesser extent, by Grackles. Later cherries are taken mainly by Starlings, though flocks of juvenile Robins also cause some damage.
- Grapes are taken mainly by Robins; for the early cultivars, most of the damage is done by juvenile birds. Starling flocks cause sporadic damage. Table grapes damaged in late August are probably being taken by migrating Baltimore Orioles.
- In theory, an individual Robin, feeding exclusively on cherries, could eat something of the order of 850 fruits during a season. If a pair fed themselves and their young exclusively on cherries, they could in theory take 150 to 200 fruits a day. But both figures are certainly overestimates of

the amount eaten, though not necessarily of the amount damaged, since the birds damage more fruit than they eat.

- The Robin population in the Niagara Peninsula is high in June and July, but low in August. The birds reappear in the vineyards in early September, and numbers build up from then onwards. Large numbers move through the area in mid October. Counts from other parts of southern Ontario, and analysis of the banding returns, suggest that there is little or no migration of Robins into the Niagara Peninsula during the fruit season; the implication is that most of the damage is done by local birds.
- The general trend of the Starling population is a large increase in late July, followed by a decline after all the cherries are picked. Even during the cherry season, Starlings are more abundant in the pastureland parts of the Niagara Peninsula than in the orchard areas. There is no evidence of any significant migration of Starlings into the fruit-growing areas during the season when the fruit is ripe. The timing of the increase in numbers of Starlings in the cherry orchards varies from year to year, and this makes for dramatic differences in the amount of damage to the later cultivars.
- Most Grackles leave the orchard areas by the end of June, and few are seen after the end of July. The banding returns suggest that birds may move south through the Niagara Peninsula later in the year, but if they do, they cause no damage to fruit.

## The stimuli influencing cultivar preferences

- Observations in orchards and vineyards containing cultivars with different coloured fruits show that the birds tend to take the darkest red cherry and the blackest grape available to them. White grapes, and cherries which are pink or yellow when ripe, are largely ignored.
- There is no evidence of an absolute threshold of redness, at which birds start to eat fruit. On the contrary, Robins will feed on pink, unripe cherries early in the season,

but ignore the ripe fruit of pink cultivars later on. The stimulus is therefore a relative one.

- Observations on caged Robins and Starlings confirm that the birds choose the reddest cultivar given to them. They are probably using redness as an index of sweetness; many birds trained to eat yellow, sweet Maraschino cherries came to prefer these to red, sour cultivars, and one Robin retained this preference when re-tested a year later. However, not all birds made this shift: the reason could be due to individual physiological differences, or to differences in feeding experience before capture.
- Caged Robins and Starlings showed no preference between two equally red cherry cultivars presented to them, even when observations showed that they preferred one to the other in the field. Therefore, redness is not the only factor which influences the amount of damage which birds will do to a cultivar.
- Caged Robins and Starlings preferred black to green grapes, confirming the field observations. They showed no preferences when given a choice between a cherry cultivar and mulberries, a wild fruit.
- Taken together, the experiments and field observations suggest that the degree of redness or blackness is at best only a very crude way of predicting whether or not a cultivar will be damaged. The relative nature of this colour stimulus makes it seem unlikely that one could develop a cherry or grape whose colour would always fail to attract birds.

### **Diet and foraging behaviour**

- Analysis of the faeces of adult Robins shows that insects and worms are taken all through the season. The birds' switch to fruit-eating in late June seems due to a positive preference for this food, rather than through the absence of anything else. The faeces of nestling Robins contain relatively more animal food than those of adults, suggesting that the parents feed their young on a higher protein diet than

they take for themselves. Starlings, like Robins, also eat significant amounts of animal food during the fruit season.

- Stomach analyses of Robins collected in August, September and October show that fruits form the most important part of their diet at this period, though the birds are still taking insects and worms as late as mid October. Published reports suggest that the proportion of fruit increases during the winter; in fact, it seems that Robins are basically fruit-eaters, and that animal food forms the main part of the diet only from April to June.
- Direct observations on Robins hunting for animal food on lawns confirm that the rates at which they find animal prey do not change significantly during the season, and that the switch to fruit-eating must be a matter of positive preference. There was in fact no correlation between the rates at which Robins found animal food in an orchard, and the frequency of their visits to cherry trees.
- The concentration of sugar in a fruit is nutritionally very suitable for quick conversion into fat. It is likely that the Baltimore Orioles which take grapes in late August, and the Robins which take them in September and October, are building up fat reserves for migration. However, this does not explain the early damage to sweet cherries by resident adult Robins, or to sour cherries and early grape cultivars by what appear to be non-migratory flocks of juveniles, or any of the damage caused by Starlings. It is possible that these birds are using fruit at least partly as a water supply during the summer drought, though in fact there is no apparent correlation between fruit-eating rates and rainfall.
- The damage which Robins do to a cultivar or an orchard is influenced by their foraging behaviour. The birds apparently learn to take the first sweet cherry cultivar to ripen in a plot, and often ignore the others until the first cultivar has been thoroughly eaten or picked. Their area of search can be extremely localized; in one case, Robins fed extensively in two Vista

sweet cherry trees, but largely ignored a third which stood in between. The observed preference of individual birds for foraging in limited areas both for fruit and animal food seems to be characteristic of Robin feeding behaviour, and presumably increases the efficiency with which they can find food. It is possible that the switch from animal food to fruit in June may represent a switch to a food which, in time-and-motion terms, can be more economically collected; however, the differences in nutritional content make it hard to assess this.

### **Protective systems**

- The strong positive preference for fruit shown by many species (especially Robins) means that any protective system must, in biological terms, be highly meaningful to them. It is important to avoid the anthropomorphic approach which assumes that something which scares us will also scare the birds. It is also important to realize that devices which work for one species will not necessarily work for another. In any case, the efficiency of any scarecrow system is bound to be affected by the birds' capacity for both long and short-term habituation to it.
- The ideal should be to take a long-term approach, and alter the orchard or vineyard habitat in some way which will discourage the birds' visits. This approach has been fairly successful in removing birds from airfields, but it is hard to see how it could be used here. Because the birds' preferences for fruit colours are relative, not absolute, there is little point in trying to develop a grape or cherry cultivar whose colour would not attract them. The provision of a "spoil" crop to distract the birds' attention is unlikely to be effective: although birds feed extensively on wild fruits, there is no evidence that they prefer them to cultivated ones; even if they did, mass plantings of wild fruit trees would probably not be economic. Even the presence of a vulnerable sweet cherry cultivar in an orchard seems to have little effect on



- the amount of damage done to other trees.
- Acetylene and gas-powered exploders are the protective devices most commonly used in the Niagara Peninsula. These work quite well with Starlings, but have little or no effect on Robins. Hanging trees with strips of aluminum foil is a folk remedy which has no effect whatever. Suspended silhouettes of flying hawks had some success in protecting grapes from Baltimore Orioles, but their effect was so local that they can hardly be regarded as a practical system. Protective netting was effective in both a cherry orchard and a vineyard, but is probably too expensive to be economically feasible. Workers in France and the United States have claimed considerable success in dispersing birds with broadcast alarm and distress calls, and several such systems are commercially available; however, the results of some pilot tests in the Niagara area were not encouraging. The only system tested which seemed effective against Robins was "Av-Alarm", an arrangement which broadcasts electronic pulses; this may, however, be too expensive for all but large-scale growers.
  - Robins and Baltimore Orioles (though not Starlings and Grackles) are normally protected under the Migratory Birds Convention Act; they may, however, be shot under permit when they cause damage to crops. Intensive shooting at one vineyard effectively stopped damage by Robins. However, ethical considerations aside, the labour costs for such an approach might well be prohibitive. On the other hand, work in cherry orchards in Michigan has shown that the trapping and killing of Starlings is both efficient and economical. Workers in the United States have also developed various chemical techniques for killing pest species, but it is unlikely that these would be feasible in fruit-growing areas.
  - It must always be remembered that any protective system must satisfy two criteria: it must not only protect the crop, but do so at a cost which is less than the price of the fruit that is saved.

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