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RE EARCH NTO THE BIO OGY OF THE LEADING TO M THODS FO MINIMIZING GRAP DAMAGE IN VINE ARDS OF SOUTH-W ST AUSTRALIA

CONTENTS

INTRODUCTION

During May, 1978, a meeting was held at Cullen's Winery, Willyabrup, between vignerons from the south-west of W.A. and scientists from the Agriculture Protection Board of Western Australia, the University of W.A. Zoology Department, and C.S.I.R.O. Division of Wildlife Research. Following that meeting, a research programme was commenced during September, 1978, to study the biology of the silvereye with the particular aim of alleviating damage caused by this bird to grape crops.

The main concerns were to define the magnitude of the problem by assessing the status of the bird and to design and test appropriate measures of control that were based on an understanding of the bird's behaviour and ecology.

During the following four and a half years knowledge of the silvereye's biology has accumulated and, from this basis, a number of control measures have been tested and/or proposed. The following account describes the results of the study and discusses their practical application.

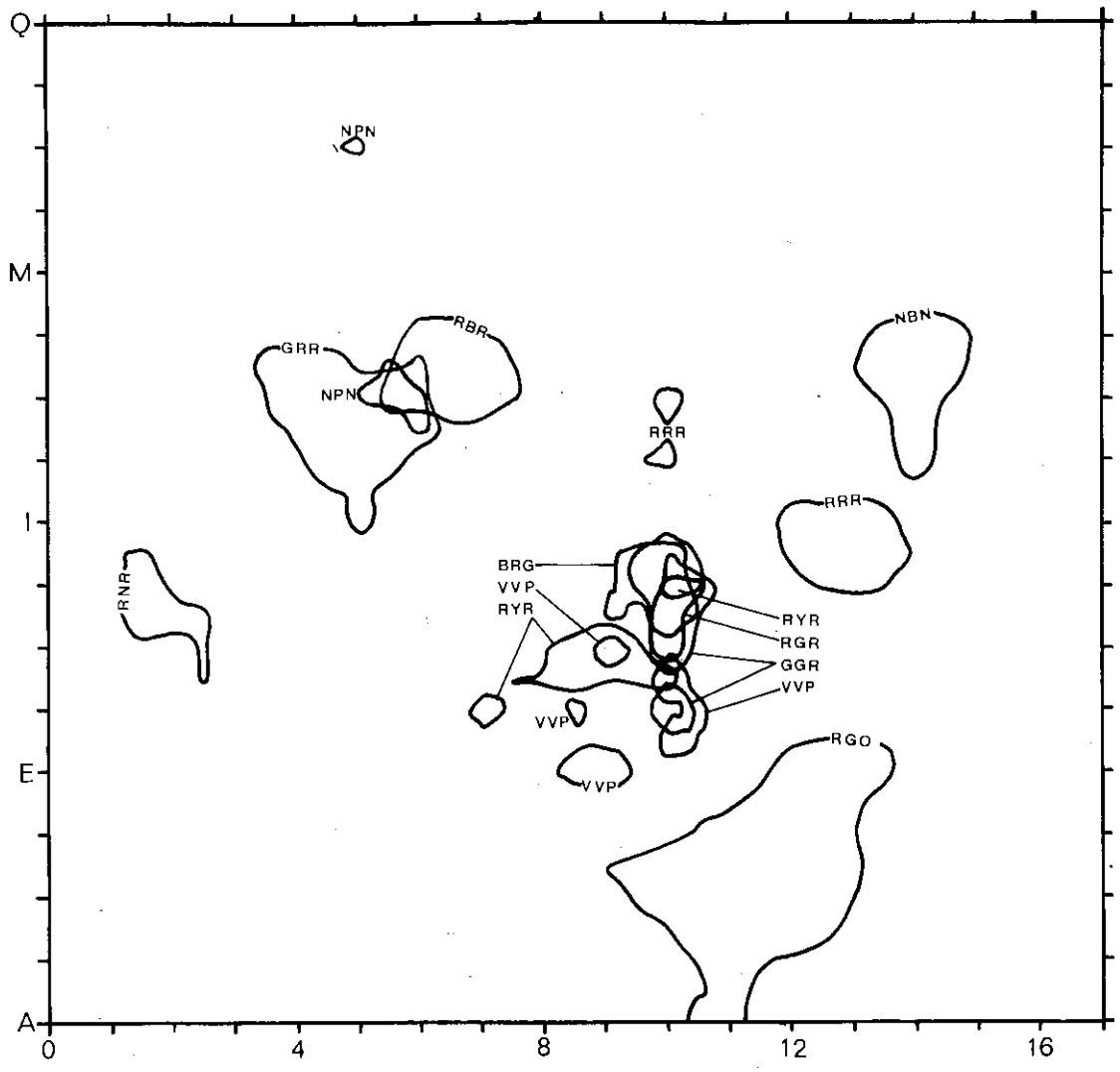

Fig. 1. Territories of breeding male Silvereyes at Prevelly Park study area – Sept. 1980 to Jan. 1981. (Letters are colour combinations of leg bands which enabled recognition of individuals, eg. NBN = black/blue/black.

RESULTS OF THE RESEARCH

Biology of the Silvereye

The initial thrust of the programme was to study the biology of the bird throughout the breeding season to learn what they ate, how often they nested, how many young they produced, what their predators were and how much space they used for breeding.

To this end, the silvereye residents of a 3.25 hectare study area at Prevelly Park near Margaret River were studied intensively between September and January for three years. Each resident was banded with a unique sequence of coloured legbands so that individuals could be recognised. Some of the results for the 1980-81 season follow:

Territories

Figure 1 shows the areas where breeding males were most often seen (data are presented for males only for clarity; data for the mated female was similar.) These areas can be considered their territories. Some are discrete but others overlap with that of their neighbour.

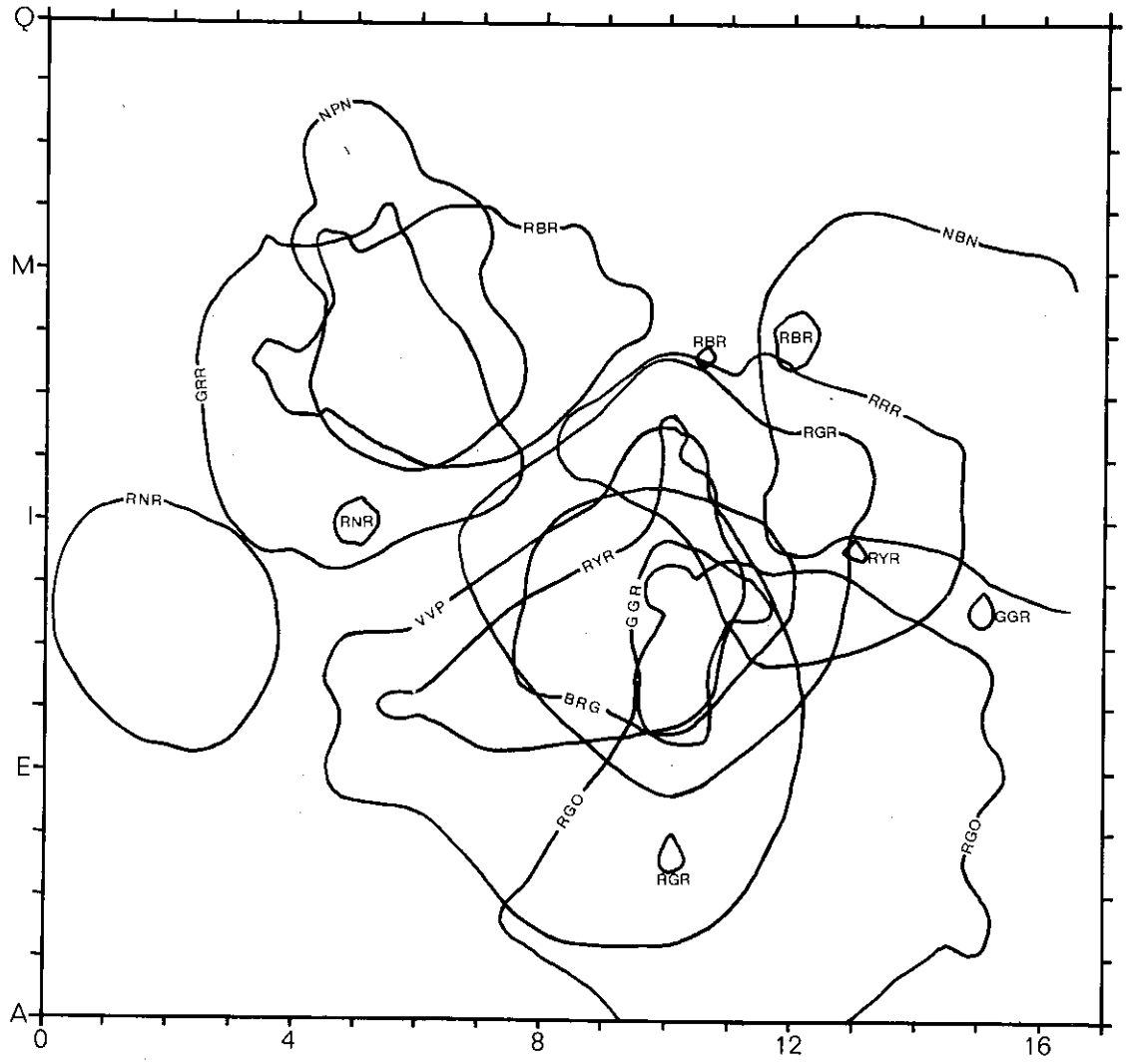

Fig. 2. Home ranges of breeding male Silvereyes at Prevelly Park Study area – Sep. 1980 to Jan. 1981. (Letters denote colour leg bands of individuals as in Fig. 1)

Figure 2 shows the area that encompassed 90 percent of the sightings of each male. This area may be called their home range. It shows that the ranges of many of the silvereyes in the study area overlapped. The places where they coincided often contained the most important food sources. Birds moved surprising distances to collect food, even when the same food was available within their own territories. Whilst this appears, on the surface, to be a waste of time and energy, it may be an important way of reducing the chance of predators finding their nests. In addition some areas may provide higher quality food than others.

The areas that were visited often for food were not used for breeding, perhaps because they were visited by many birds. To nest in such areas would have increased the possibility of interference by other silvereyes and increased the risks of predation. Predatory birds in particular would be attracted to areas that contained higher densities of prey.

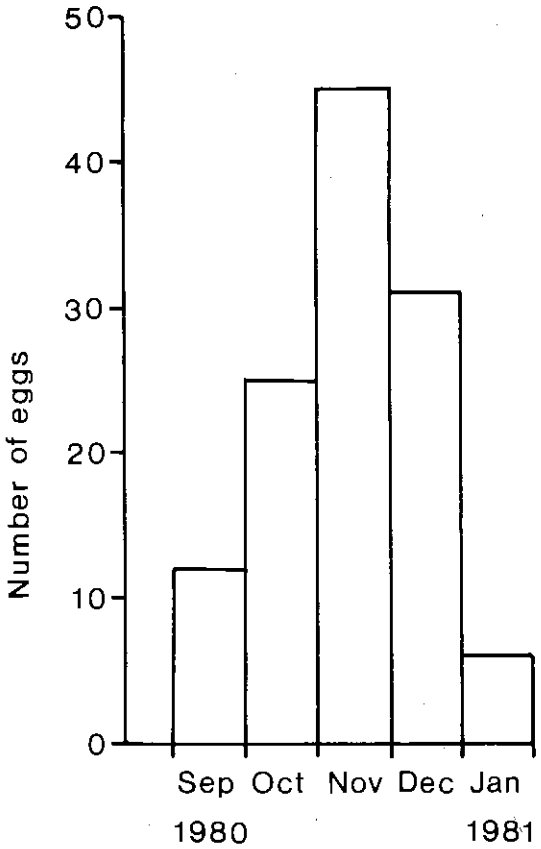

Fig. 3. Number of Silvereye eggs laid each month at Prevelly Park study area – Sept. 1980 to Jan. 1981.

Breeding

Nesting occurred from September to January with peak egg-laying in November (Figure 3). One particularly successful pair nested four times between September and January and raised 10 fledglings.

Table 1 summarises the information on nesting.

Predators, including square-tailed kites, goannas, mice, rats and cats, took 17 percent of eggs and 10 percent of nestlings. Four percent of nestlings and three percent of fledglings died due to cold weather.

Juveniles were difficult to observe when they were older than two weeks, even when some of them were coloured with bright red dye. This was because they ranged widely from their birthplace and eventually out of the study area.

The reproductive output from silvereyes at Prevelly Park was high (Figure 4); thirty-nine breeding adults produced 80 fledglings. Even if half the fledglings died before they were completely independent, the population would have doubled in that area. Following this, other sites along the coast were investigated to determine whether Prevelly Park was truly representative of silvereye breeding potential.

During 1981-82 silvereyes were counted each week at two sites (Gracetown and Redgate) along fixed transects to gain a relative measure of population size. A number of birds were also

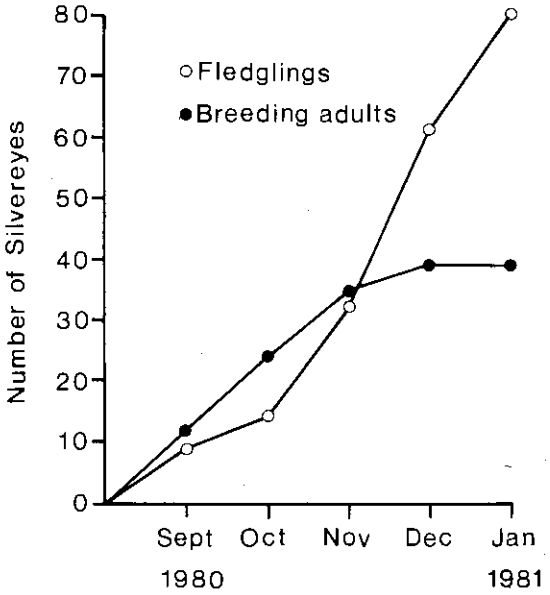

Fig. 4. Cumulative number of breeding adults and fledglings produced by these adults at Prevelly Park study area – Sep. 1980 to Jan. 1981.

caught with mist-nets, aged and assessed for breeding condition. Monthly totals of adults and juveniles are shown in Figure 5.

As expected, the numbers of young birds increased throughout the breeding season, reaching a maximum during January. The high proportion of juveniles to adults during January, however, was not expected. It suggests an extremely high juvenile recruitment and consequent population increase. However there are three other possible explanations: adults could have been leaving the area; juveniles could have been moving in from other areas or adults could have been more difficult to catch than juveniles.

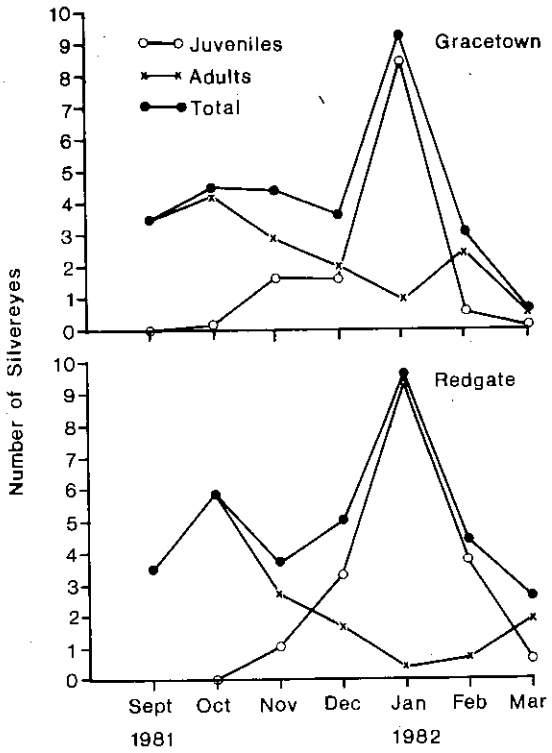

Fig. 5. Number of Silvereyes per hectare along fixed transects at Gracetown and Redgate – Sept. 1981 to Mar. 1982. Proportions of adults and juveniles were determined by sampling the populations with mist-nets.

At Prevelly Park some adults left the study area toward the end of the breeding season, but so too did some juveniles. It is probable that there is a general movement at this time of the year and other adults (and juveniles) would probably move in as well as the previous residents move out. Movements in would not have been detected at Prevelly Park because new birds were not colour-banded at that time of the year, unless they were nesting. However, some residents remained throughout the autumn and perhaps the winter too.

The most likely explanation for the marked decrease in numbers of adults in January is, therefore, that adults were more difficult to catch. Resident birds had experienced our presence for four months by that time and many had been caught more than once. They were well aware of our activities and probably were better able to avoid the nets than were the juveniles.

What was needed was a less biased method of sampling birds. For this reason, work along the coast at four sites (The Gallows, Gracetown, Ellensbrook and Contos) was continued for the 1982-83 season, only this time, birds were sampled by shooting rather than with mist-nets. Mist-netting was continued at Redgate to serve as a control. Shooting gave similar results to mist-netting. There were more juveniles during January than there were adults during any other month showing that the population was at least doubling as a result of breeding.

Movements

Over eleven thousand silvereyes were banded in the Witchcliffe/Margaret River/Cowaramup area. Figure 6 shows the movements of these birds that were recorded. One bird was caught 100 km to the south-east, at Manjimup, one year after it was banded at Margaret River. Two others were recovered at Busselton but no other known movement exceeded 30 km.

During March some birds were recaptured up to 20 km from their banding place within a few days. Movement could have been even more rapid than this because they might have been at the recapture site some time before they were caught. Many birds were retrapped several times at their banding site, indicating that they did not

Table 1. Nesting data for 39 breeding silvereyes within 3.25 ha study area at Prevelly Park, W.A., September 1981-January 1982

Nests	Eggs	Nestlings	Fledglings
48	119	96	80

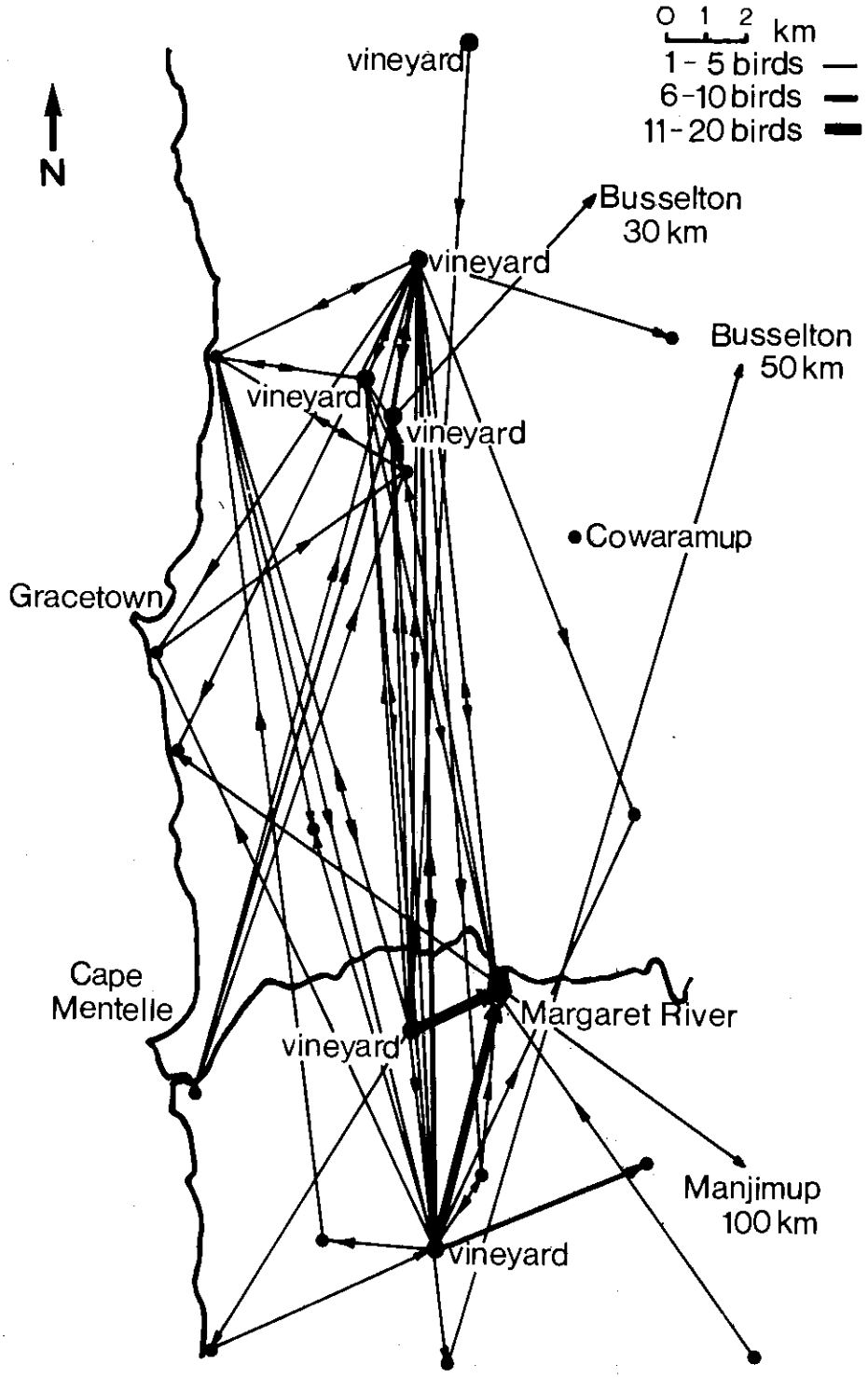

Fig. 6. Movements of Silvereyes that were banded near Margaret River, W.A.

move or that they moved consistently to the same places.

The limitations of the method that yielded these results should be recognised. Figure 6 illustrates where most recapturing of silvereyes occurred but it should not be taken to mean that these are the only places where silvereyes moved. In addition, bands on dead silvereyes are only occasionally found either because the bands are so small or because they are eaten, with the bird, by predators and scavengers. The results do suggest, however, that we are dealing with a relatively localised population within which some individuals move quite rapidly, particularly in late summer and early autumn

Other silvereyes were banded in the Mount Barker and Rocky Gully areas. The data obtained from Waterman's Vineyard, Mount Barker, suggest that few birds are residents. Most stayed not more than one month and did not return the following year.

During January and February the food supply in the coastal breeding areas decreases and silvereyes move inland. It is then that they are likely to eat grapes if no marri nectar is available. This situation continues through March and early April, except in years when seaberry saltbush *(Rhagodia)* produces a significant crop of berries on the coast. Then, the birds will return to the coast when the marri finishes flowering. Throughout the rest of autumn and winter saltbush berries keep them on the coast, or, failing this crop, they range widely through forests and farmlands feeding mainly on insects. During some autumns and winters karri flowers and many silvereyes move into the karri forests to eat this nectar supply. At the start of spring, nectar from *Diplolaena dampieri* becomes available once again on the coast and the silvereyes return there to start breeding again.

Food

Silvereyes eat many small insects throughout the year, taking them from the ground, leaves, flowers, on and under bark and in the air. They eat most of whatever is abundant at the time. They also eat nectar and berries when available. They are extremely opportunistic and thorough in their feeding habits, even licking the sweet exudate from scale insects and taking advantage of any food scraps left by humans. They have been seen trying to drink milk from a bucket.

Experiments were conducted to determine the types of food that silvereyes prefer. The foods that were tested were red and white grapes, figs, nightshade berries, nectarines and sugar water (in place of nectar).

Caged silvereyes preferred the sugar water, followed by nightshade berries, then figs. They liked nectarines and red and white grapes least of all and showed no difference in their preference for red and white grapes.

The timing of silvereye damage to grape crops in relation to the availabililty of nectar and other fruit and berry crops, also demonstrates that silvereyes do not have a strong preference for grapes. They eat grapes only when their natural foods and other preferred fruit crops are not available.

Since the silvereye research programme was started they have not caused heavy damage to grapes. There was some damage in 1979 and 1980, particularly in some small vineyards, but in 1981, 1982 and 1983 damage was negligible.

Since 1971 there has been a negative relationship between estimated silvereye damage at one vineyard and the marri honey crop extracted in the south-west by Frank O'Keefe of Busselton. When vineyard damage was high, the honey crop was poor and vice versa. The suggestion that it is marri nectar which attracts silvereyes away from grapes is supported by observations of silvereyes probing marri flowers, the finding that during March 1981 and 1982 silvereyes were carrying heavy loads of marri pollen on their faces and by the food preference experiments described above.

It appears that silvereyes also prefer saltbush berries to grapes because, in April 1982 when the marri finished flowering and grape-picking had not yet been completed, silvereyes went back to the coast instead of into the vineyards. The areas of saltbush that grow along the coast are, therefore, very important in protecting vineyards from damage and should be valued and protected, as much as the marri.

Frank O'Keefe's honey crop, from 1955 to 1980, was analysed with reference to rainfall and temperature data from Cape Naturaliste, Cape Leeuwin and Bridgetown. Three significant correlations were found. The honey yield was positively correlated with Bridgetown's mean spring maximum temperature (Figure 7), positively correlated with Bridgetown's mean autumn minimum temperature (Figure 8) and negatively correlated with Cape Naturaliste's mean February-March maximum temperature (Figure 9).

These results suggest that warm autumns and springs contribute to increased nectar yields and that hot weather during production inhibits the yield.

Silvereyes are in poor physiological condition when feeding on grapes in vineyards and will die

in captivity if fed on grapes alone. The vineyard birds were found to be dehydrated but the caged birds were not. The caged birds probably died due to shortage of protein, but it was not known why the vineyard birds were in such poor condition. They were not suffering from too much dietary sugar from grapes, or salt from the saline water in creeks and dams.

Physiological studies during 1982, a year when silvereyes did not enter vineyards during autumn, provided data to suggest an explanation for this phenomenon. During March stress hormones were high and body fat content low. When natural food is scarce during March it would be expected that the silvereyes' condition would be even worse. This may explain why birds are found dead and comatose in vineyards. Their need for large amounts of water may explain their dehydration. The grapes eaten, to satisfy the birds' hunger may not contain sufficient water and they may have to move to and fro between water and grape supplies. This extra energy drain, at a time when they are already physiologically stressed, may be too much.

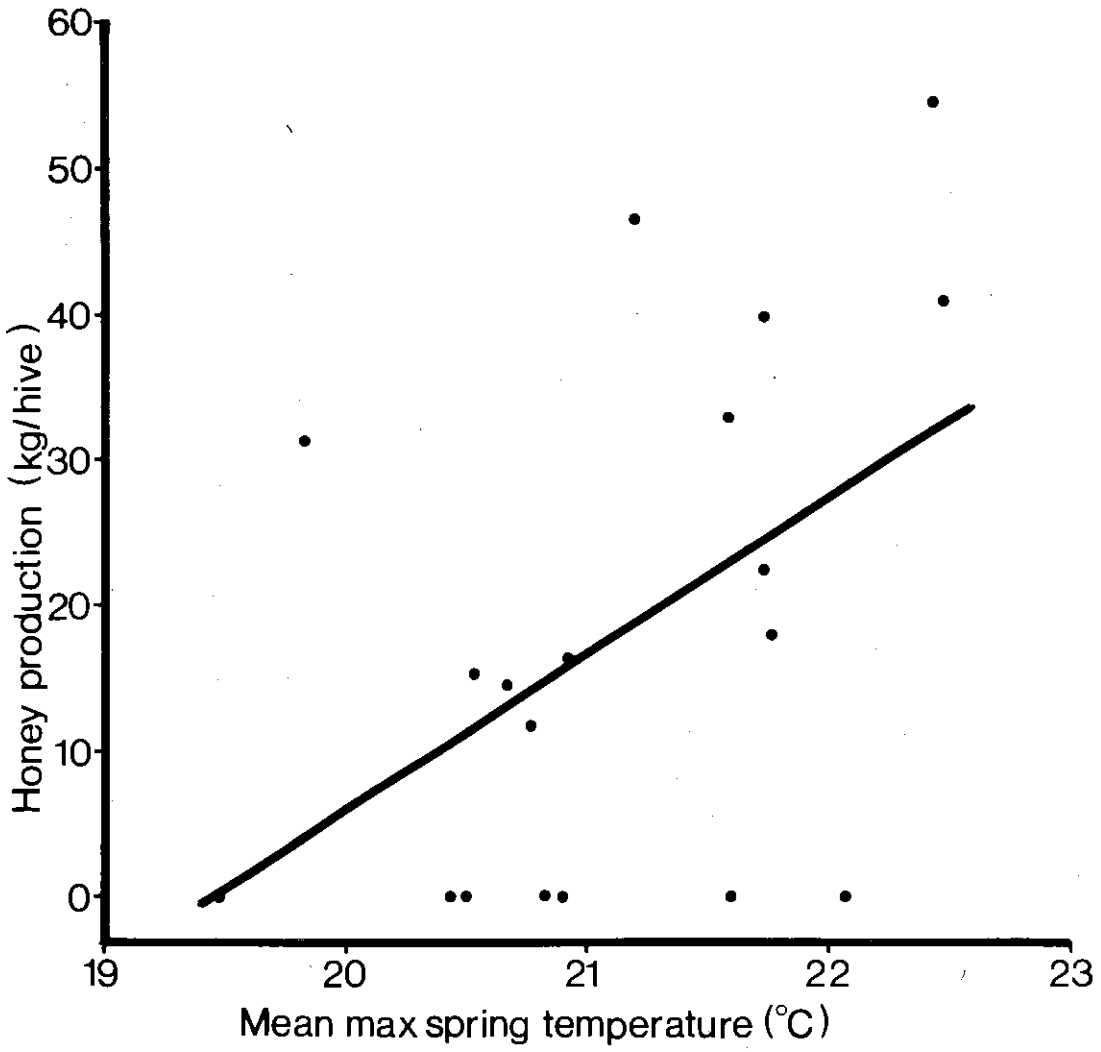

Fig. 7. Relationship between honey production and Bridgetown's mean spring maximum temperature. Spring temperatures used were those immediately preceding the year of honey production.

METHODS OF REDUCING SILVEREYE DAMAGE TO GRAPES

Mesurol

Cage Experiments

After eating grapes that were treated with Mesurol, caged silvereyes that had had previous experience eating grapes avoided treated grapes but ate untreated grapes. Birds that had never eaten grapes prior to the experiment avoided all grapes.

These results suggest that when Mesurol is used in vineyards, silvereyes that have eaten grapes previously (i.e. older birds) will search for untreated grapes. In such circumstances, therefore, spraying would need to be thorough and all grapes would need to be sprayed.

Young birds that have not eaten grapes before will avoid grapes after eating treated ones. It is important though, that the first grapes that they eat are treated. This means that the outside rows should be treated and that the birds should not have been to an untreated vineyard previously

Field Experiments

Four experiments were conducted during the 1980 season to evaluate the use of Mesurol in vineyards. None of the trials established that Mesurol prevents silvereyes from damaging grapes. Table 2 summarizes the results of three of these trials. There was no significant difference in

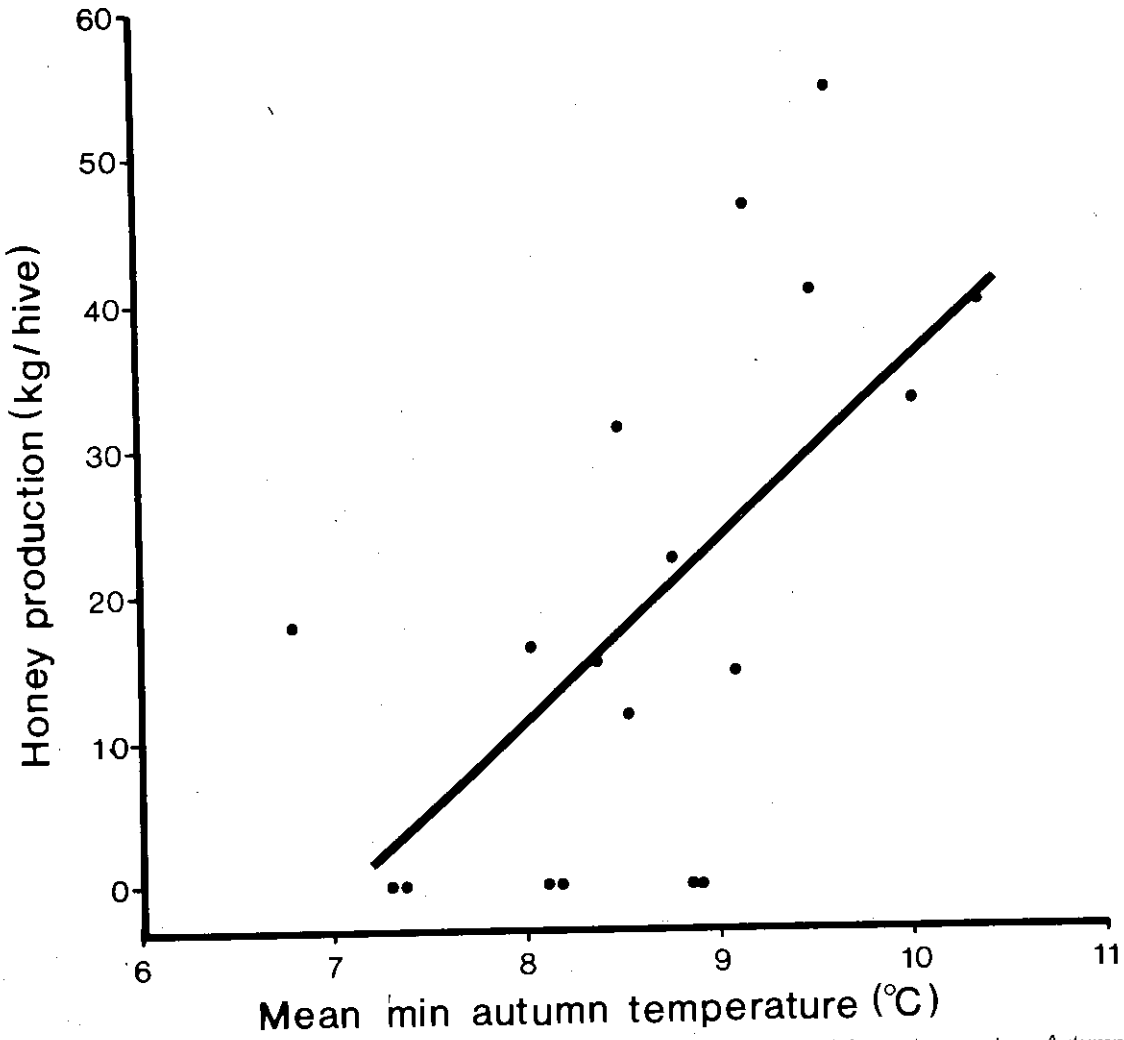

Fig. 8. Relationship between honey production and Bridgetown's mean autumn minimum temperature. Autumn temperatures used were those immediately preceding the year of honey production.

damage between treated and untreated plots in any trial. The damage during the fourth trial, at Bramley Research Station, was too slight to yield an adequate comparison. The results from the Frankland experiments were inconclusive, perhaps because the plots weren't sprayed as often as specified. At Cape Mentelle the birds attacked heavily at one end of the vineyard and did not penetrate to the centre of the experimental area. There was no damage near the centre of the vineyard, that suggested that silvereyes might have flown over the experimental areas.

In each of the following three years another trial was prepared in an ideal situation at Leuwin Vineyard. Unfortunately during this period silvereyes made little attempt to attack the grapes.

Acoustic Jamming System

The system used, designed by Terry Knight and Norman Robinson of C.S.I.R.O., relies on preventing the silvereyes from hearing each other's communication calls. This is achieved by producing sound at the same frequency as that used by the birds for communication.

An experiment to test the effectiveness of the acoustic jamming system was carried out at Leeuwin Vineyard during March 1979. The device was alternately turned on and off for 24 hour periods. After each 24 hours all damaged grapes were picked off the area. This procedure was continued for 16 days. The mean number of

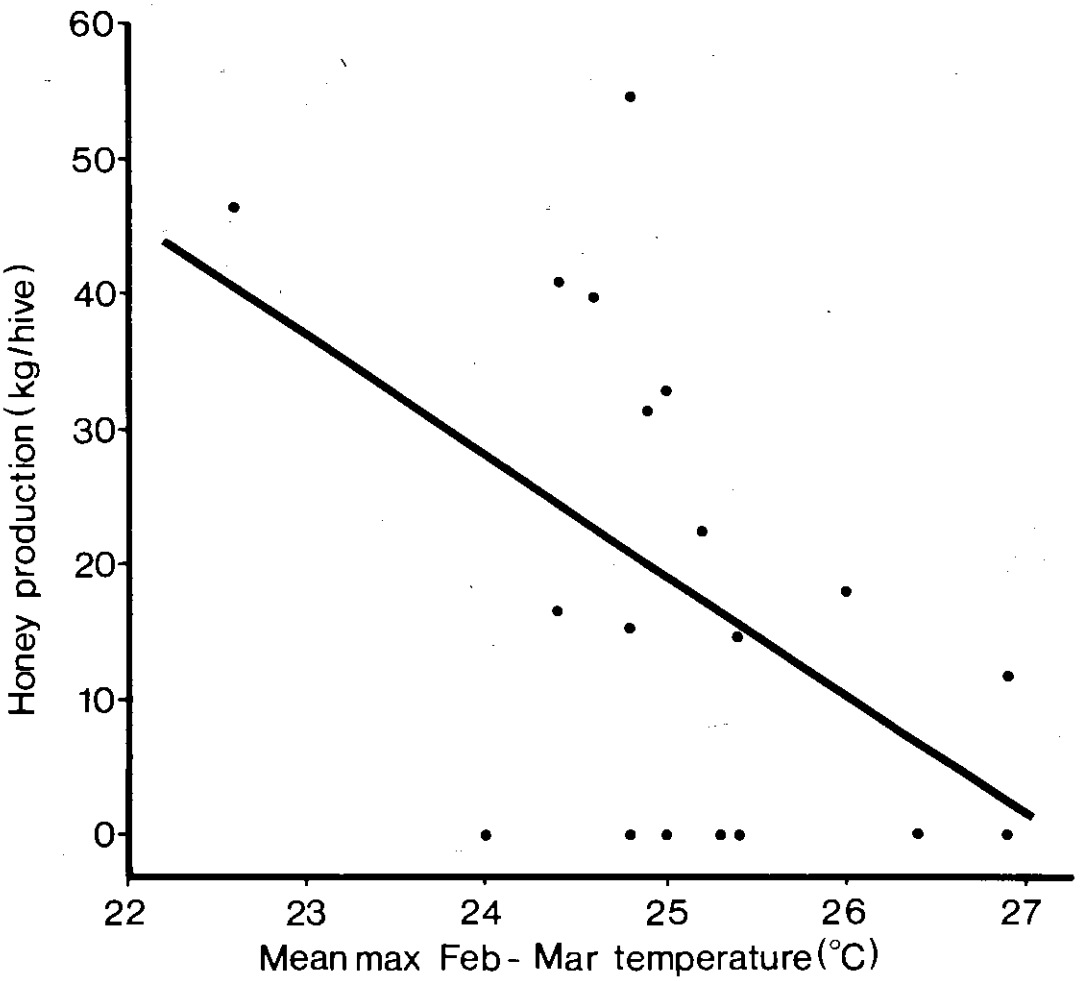

Fig. 9. Relationship between honey production and Cape Naturaliste's mean Feb. – March maximum temperature. Feb. – March temperatures coincided with the period of honey production.

damaged grapes per 24 hours when the system was off was 11,500 compared to 9,400 when the system was turned on. These means are not statistically different. In addition the number of birds flying into the test area were counted for half hour intervals. When the sound was on, an average of 279 birds flew in compared to 519 when the sound was off. The difference is not significant because of the variability in the data. Neither measurement showed the device to be effective.

Two other trials were conducted during 1980 but both failed to yield results. In one of the experiments a suitable control became unavailable and, in the other, an accurate assessment was not possible because Mesurol was used on the control area.

Attempts were made to test the system again during 1981 and 1982, but damage during these years was insufficient.

Alternative Feeding

During 1980 two attempts were made to keep silvereyes out of vineyards by supplying sugar water in large flat troughs. This failed, however, because bees emptied the troughs of their 25 litres of sugar water in two days and birds could not approach the trough because of the large number of bees.

Netting

Polypropylene netting has been used successfully in several vineyards. This was purchased from Nylex Corporation in rolls 4 m wide and 500 m long. The original mesh size was 10 mm but recent supplies are larger at 15-16 mm.

The netting was unrolled along the trellis and allowed to hang down either side. Each edge of the netting was then secured to the ground by placing a shovelful of earth on the edge at approximately one metre intervals. Each end was secured in the same way. An alternative fixing method was tried of stapling both edges together underneath the vines. This was not successful because silvereyes were able to get through spaces left by this method, especially close to the trunks of the vines.

If the netting is handled carefully, particularly during removal, it will last at least four seasons. The time it spends on the vines must be kept as short as possible to minimise deterioration due to sunlight and also to limit the number of tendrils which grow through and grip the netting. These can tear holes in the net during removal. It must be stored undercover because ultra-violet light causes the material to deteriorate.

The initial cost of the netting is $1,700-2,000/ha ($700-800/ac). Nylex Corporation state that significant discounts are available for bulk orders.

THE PRACTICAL APPLICATION OF THESE RESULTS

Limiting the Population

Silvereyes have been killed (mainly by shooting) in vineyards since the beginning of the century without causing any appreciable reduction in either the population or in grape damage. Any temporary reduction in numbers at one locality is soon swamped because of the mobility of silvereyes. The population is resilient because it is large and because silvereyes are opportunistic and generalised feeders. Therefore, they are not limited by a shortage of a particular food item in the same way as a more specialised feeder. In addition, they have a high reproductive output, so that any depletion of the population can easily be replaced during the following breeding season.

Similarly, any small-scale destruction of their breeding or feeding areas would be ineffective and large-scale habitat destruction would remove most other species before the silvereye was affected. Destruction of habitat is risky because such activity may remove one item in their diet. This might exacerbate the problem in vineyards or cause the silvereye to be a pest in some other crop which they do not interfere with at present. Even if it were possible to significantly reduce the silvereye population, it may not be desirable because they are important predators of a wide range of insects, some of which could be pests if not controlled by them.

Table 2. Mean percentage damage by silvereyes to grapes in three trials to evaluate Mesurol

Trial	Mean Percentage damage treated plots	Mean percentage damage untreated plots
Cape Mentelle cabernet	16.2	16.4
Frankland cabernet	72.4	64.0
Frankland shiraz	53.1	55.7

Attempts to reduce damage by reducing the silvereye population is, therefore, not recommended because it would be too difficult, any benefits would be shortlived and additional problems, such as insect plagues might result.

Natural Food Supply

The evidence is clear that if the late summer/autumn natural food supply of the silvereye (marri nectar and saltbush berries) is available in adequate amounts, then silvereyes will not eat grapes. This contention is supported by the food preference experiments that showed that silvereyes do not prefer grapes to other foods, the physiological studies that showed that silvereyes are in poor condition when feeding in vineyards, and by the negative correlation between honey production and damage in a vineyard.

The obvious question that arises is why does the natural food supply sometimes fail? Whilst an answer to this question would require a study at least as great as the silvereye study, it is useful to be able to predict when the natural food will be plentiful and when it will fail. Such a prediction allows vignerons to either prepare to either pick their crop early, protect it or to relax with the assurance that their vineyards will not be invaded, thus saving the cost of netting and/or spraying for that year.

It appears that a large crop of marri nectar often follows warm autumn and springs and that hot weather during flowering limits production. It should be emphasised that the date that gave rise to these predictions are not particularly robust and do not show that these climatic conditions actually cause the resultant marri production. It is hoped that a study will be initiated soon to study flower and nectar production of the marri at a range of fixed sites and to relate this to climate at the same sites. Such information must be collected to provide an accurate and reliable prediction.

To ensure a maximum long-term supply of marri nectar and saltbush berries, the habitats where these species grow need to be protected. Clearing or too frequent burning will undermine the health of these habitats and therefore reduce these critical food supplies which would in turn minimise vineyard losses.

Alternative Food Supply

In anticipation of years when the natural food supply fails, it is recommended that vignerons provide alternative food, for example, figs, nightshade, nectar and saltbush which silvereyes prefer to grapes.

Figs have been tried in at least one vineyard. Different varieties ripen at different times so, with the help of water during dry periods, a fig supply could be provided throughout the critical period. Nightshade grows in most vineyards already and, under the right conditions, will fruit and ripen at the appropriate time.

Banksia occidentalis is being tried in one vineyard as a nectar-producing plant. It flowers in its second year and should produce nectar throughout the grape season.

Saltbush grows as a low hedge and could easily be grown along fence-lines.

An obvious argument against alternative feeding is that such a practice may help the survival of silvereyes at a time when they would otherwise die. Measurement of hormone levels indicate that March is their most stressful time of the year. In addition, the physiological studies and observations of dead and dying birds in vineyards suggest that they are then in poor condition.

The relative sizes of the populations along the coast in 1981 and 1982, however, does not support this argument. The marri nectar and saltbush berry crops during the late summer/autumn of 1982 were sufficient to minimise damage to grapes by silvereyes, certainly as well as an alternative food crop would do. The population on the coast during the breeding season of 1982, however, was lower than for the same period during 1981. If a good late summer/autumn food supply had the potential to increase the population then it should have done so in 1982. The physiological studies showed that silvereye protein reserves were lower during June and July and their fat reserves were as low in June as in March. It may be, therefore, that winter and/or autumn are periods when silvereye populations are limited.

REPELLENTS

Mesurol

The experiments with caged silvereyes indicate that Mesurol should repel Silvereyes from grapes. If the season produces no marri blossom, such that older birds come into the vineyard, then all grapes would need to be sprayed. In a year when there is some blossom, and only the juveniles come to vineyards, then border treatment should be sufficient.

The field trial at Cape Mentelle, March 1980, showed that Mesurol did not reduce damage. These results are difficult to explain. Two possibilities are that the grapes were not adquately coated with mesurol and that the majority of attacking birds were in their first year. The grapes were sprayed, until dripping, with a hand-wand,

and at an interval of two weeks. If this method of application is not sufficient then Mesurol is quite difficult to use in the field. If most of the attacking birds were young, and if there were many of them, each bird may have fed from a few grapes, become affected, developed an aversion to grapes and then left. Successive birds, each doing a small amount of damage, could have built up the damage to the average found of about 16%. If adult birds had been attacking the grapes it would have been expected that, after sampling treated grapes, they would have searched until they found untreated grapes which were only one panel away. This would have given results in which the damage in untreated plots was very high.

It may be premature to reach a conclusion based on this one experiment, since Peter Bailey has shown in South Australia that Mesurol reduced damage to grapes in vineyards there. More field experiments unfortunately could not be completed because there were not enough hungry silvereyes in subsequent years.

If vignerons use Mesurol and observe that the birds go away, they should be cautious in concluding that it is effective. It is possible that the birds have left for some other reason and the application of the control measure was coincidental.

Acoustic Jamming System

The experimental design of the trial that was conducted at Leeuwin Vineyard during 1979 may have been inadequate. The sound was turned off for successive 24-hour periods; this may have allowed the birds to become familiar enough with the area to be able to disregard the effects of the sound when it was turned on. In other words a bird had a reasonable idea of where the others were because of past experience, even though the sound prevented it from making contact with its mates. A better design would use one area with the system operating continually and an adjacent, comparable area as a control. This design was attempted in succeeding years without success.

It is possible that the system is not always effective. The birds may be prepared to enter the sound area by relying on visual communication. This could occur in areas where the leaf cover of the vines was less dense. It is also possible that the system will not work when the birds have no other food to eat. In such a situation food would become more important to a bird than communication. Because Knight and Robinson found the system to be effective, however, it is difficult to draw definite conclusions without further trials.

Frightening Devices

Devices designed to frighten birds, such as model (or tame) birds of prey, flashing lights, coloured streamers, objects that rotate in the wind, etc., are unlikely to be effective against silvereyes. Silvereyes experience similar types of phenomena in their natural habitat and their behavioural repertoire is well adapted to cope with them. Most animals quickly learn to ignore a device that does no harm to them, and to avoid those that do; silvereyes are no exception. These devices are designed from the point of view of the designer who imagines what would be frightening if he/she were a bird, rather than from study of the behaviour of birds.

BARRIERS

Netting

There is no more effective method than netting, provided it totally encloses the fruit and has a mesh size of not more than 15 × 15 mm. No holes should be left larger than this mesh size, whether at ground level or higher, because silvereyes will persist in probing all over a net, attempting to get through.

The initial cost of netting is high but, when this is averaged over the life of the net (at least 4 years with careful handling and storage) and considering that it does not need to be used every year, it is probably not prohibitive.

Netting is not the answer for protecting large areas, but it is recommended for protecting the more valued varieties, such as Chardonnay, which often amount to only a few hectares in a vineyard. The early ripening varieties such as Chardonnay, Pinot noir, Traminer, etc., are usually grown in small quantities and are often attacked by silvereyes early in the season because they may be ripe enough to eat before the marri produces any nectar.

Planning and Management of Vineyards

The study made no direct analysis of planning and management practices, but a few general comments can be made in view of the understanding of the silvereye that the study provided.

It is likely that vineyard planning and management will have no influence during a season when there is no natural food, because then the silvereyes have nothing to eat but grapes. It is during intermediate years, when silvereyes need some grapes to supplement a small natural food supply, that these practices may reduce damage to some degree.

Siting of Water Supplies

It appears that silvereyes eat grapes primarily to

gain sugar. Water is consumed as a consequence of eating sugar. If this is true then silvereyes need a source of free water to drink while they are eating grapes. It follows, therefore, that vines should be planted as far as possible from a water source.

Clearing Surrounding Vegetation

Because silvereyes enter vineyards from surrounding vegetation and because they use camouflage and hiding to escape from predators, removing vegetation around vineyards might reduce damage in the vineyard. The argument seems plausible, but in areas where this has been practised damage has not been appreciably reduced. All that has been achieved is that the flight paths have been altered.

The question of clearing surrounding vegetation is a complex one made up of conflicting issues. On the one hand, clearing should discourage silvereyes by removing cover and by increasing the distance, and therefore the energy, that they need to fly into and out of the vineyard. On the other hand, removing vegetation removes silvereye food and increase energy costs to the bird also increases the amount of food required. Silvereyes remain in vineyards longer when food is in shorter supply. If the energy costs of moving is too high they may choose to remain in the vineyards, only flying out for water.

The benefits of clearing would probably be negligible unless the clearing was massive and total, i.e. all trees and shrubs for 1 km in every direction. In addition, the cleared area would need to be maintained because re-growth is preferred habitat. If the clearing was massive, however, the silvereyes might take up residence in the vineyard especially when natural food was in short supply.

Configuration of Rows

It has been suggested that planting rows of vines parallel with peripheral areas which are likely to harbour silvereyes may reduce the distance the birds will penetrate into the vineyard. This suggestion is based on the idea that silvereyes prefer to remain under cover. They are, therefore, more likely to move along a row rather than cross open ground to another row. It is true that silvereyes like cover, but they also fly quite readily across open spaces.

The probable consequence of this suggested configuration of rows is that the damage would be confined to a small area. The total damage in terms of pecked berries, however, would be the same whichever way the rows were planted.

Hedging

Hedging is the practice of trimming the lateral growth from vines to reduce the leaf cover. The consequences of hedging are similar to those of clearing around vineyards. Thus, hedging is likely to shift damage from hedged vines to unhedged ones, but it is unlikely to reduce total damage. It may be a useful method for shifting damage from the highly-prized variety to one that is not so prized and, therefore, could be a useful manipulative tool.

It is a common belief amongst vignerons that silvereyes prefer red grapes to white grapes, because more reds are damaged than whites. This is probably due to the fact that red varieties usually have a denser leaf cover and silvereyes prefer the better protection this affords. This situation could be changed by hedging.

The Bird Break

One grower has adopted the practice of prematurely picking all the grapes except the outside row, or its equivalent, from the periphery of his vineyard in a strip three or four rows wide. The birds were then more inclined to stay and feed in the outside row rather than cross the "bird break" to the inner section. In principle, the method is similar to providing preferred alternative food. The outside row of grapes is preferred because it requires a lower expenditure of energy to reach.

Growers who use this method, must be willing to sacrifice the outside row entirely and to compromise the quality of wine by early picking some of the grapes.

CONCLUSION

Although some questions have been left unanswered, the research programme has defined the status of the silvereye and determined enough about the birds biology to recommend appropriate control measures, both long-term and short-term.

The silvereye is a rapid-breeding, persistent generalist that would be extremely difficult to control by reducing its population size or by destroying its habitat. Birds have been accused of having small brains but, it is clear, they will continue to out-wit humans unless the environment is managed appropriately. The biological integrity of natural areas, particularly coastal heath and areas containing marri trees, must be maintained to provide an adequate late summer/autumn food supply. To compensate for years in which this natural food supply fails, vignerons need to plant alternative food crops on the edges of their vineyards.

In the short term, netting is the only certain control. Mesurol probably provides some protection especially during intermediate years but its effect, as well as that of the acoustic jamming system, will always be enhanced by the provision of alternative food.

Autumn, spring and summer temperatures may influence the flowering and nectar production of the marri. It is hoped that better data can be obtained in future on this aspect of the study, so that more accurate predictions can be made and, perhaps, so that the environment can be managed more appropriately.

This study illustrates how agricultural crops cannot be grown successfully without understanding and taking into account the state and management of the surrounding natural environment.

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