STATUS OF MESUROL® AS A BIRD REPELLENT FOR CHERRIES AND OTHER FRUIT CROPS

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ABSTRACT

A single application of Mesurol at 1.5 lb (AI) /ac to ripening cherries reduced bird damage in a field test in the mid-Hudson Valley of New York, 1986. Treated trees averaged 8.9% damage compared to 17.5% damage for untreated trees. An average of 7.4 birds flew into treated blocks per 15-min count versus an average of 19.8 birds that flew into control blocks. These results support the various evaluations over the past 15 years of Mesurol as a bird repellent for fruit crops. The consensus of these tests is that Mesurol often provides an effective nonlethal means of reducing conflicts between fruit growers and federally protected, depredating birds. However, the continued federal registration of Mesurol for blueberries and cherries is uncertain, and the expansion of the label to include grapes and other fruits is doubtful because of health and environmental concerns, regulatory uncertainties, and limited market opportunities for the proprietary chemical company. Mesurol illustrates the difficulties often encountered in trying to register minor-use pesticides, particularly for vertebrate pest control. Possibilities for alleviating these difficulties are discussed.

INTRODUCTION

Migratory birds cause substantial damage to ripening fruit crops in the United States (Mott and Stone 1973, Stone 1973, DeHaven 1974, Crase et al. 1976), and few methods provide growers with satisfactory relief. Currently,no lethal toxicants are registered in the United States for use against avian fruit pests. Decoy traps have been used in the western United States to reduce European starling (*Sturnus vulgaris*) and house finch (*Carpodacus mexicanus*) damage to fruit (Elliot 1964, Larsen and Mott 1970, Palmer 1972), but cost-benefit data rarely have been provided (Dolbeer, in press). Trapping is costly, often ineffective for reducing damage, and requires a permit when used against most species of depredating songbirds. Shooting also requires a permit for most species of birds, as well as being labor intensive and impractical for most commercial farming operations. Propane exploders, electronic noise makers, kite-hawk models, and other scaring techniques may provide limited protection for short periods, but birds usually habituate rapidly to such nonlethal frightening devices (Spanier 1980, Hothem and DeHaven 1982, Conover 1985a). There is a continued interest in the use of nonlethal chemical repellents to deter birds from damaging crops (Griffin and Baumgartner 1959, Stanton 1962, Luckwill and Weaver 1964, Rogers 1978a, Tobin and Crabb 1985).

During the past 15 years particular attention has been focused on Mesurol[3] (3,5-dimethyl-4-(methylthio)phenol methylcarbamate), a broad spectrum carbamate insecticide that has shown promise for repelling birds from damaging a variety of crops (Guarino 1972, Crase and DeHaven 1976). Numerous tests have demonstrated its effectiveness for reducing bird depredations to ripening cherries (Guarino et al. 1973, 1974,DeHaven et al. 1979), blueberries (Bollengier et al. 1973, Dolbeer et al. 1973, Courter et al. 1974,

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Stone et al. 1974, Conover 1985b), and grapes (Bailey and Smith 1979, Hothem et al. 1981, Tobin and DeHaven 1984).

In 1986 the U.S. Environmental Protection Agency (EPA) reduced the residue tolerance limits for Mesurol on cherries from 25 ppm to 5 ppm and lowered the allowable application rate of this product to 1.5 lb (AI) /ac (EPA 1987). Previous tests in cherry orchards have demonstrated the efficacy of Mesurol when applied at 2-4 lb (AI) /ac (Guarino et al. 1973, 1974, DeHaven et al. 1979), but we know of no studies that have evaluated Mesurol when applied at the new, lower rate. During 1986 we conducted a field test to evaluate the efficacy of Mesurol applied at 1.5 lb/ac.

METHODS

We conducted the study in nine orchards in the mid-Hudson Valley of New York: six in Columbia County and three in Ulster County. The study sites varied in size from 0.7 to 6.5 ac, with each orchard containing a mixture of interplanted varieties. All sites except one contained a majority of sweet cherries, but most sites also had a few interplanted tart cherry trees.

We randomly selected one half of each site for a single treatment with Mesurol at the rate of 1.5 lb (AI) /ac. The growers applied the treatments with airblast sprayers as soon as possible after they saw the first cherries begin to turn red, 7 to 8 days before harvest. Applications were from 4 to 26 June.

From 1 to 3 days before harvest began at each orchard, we assessed bird damage on 20 randomly selected trees in each of the treatment and control blocks. Where treatment and control blocks were contiguous, we excluded from our sample in each block either the two rows or the three trees within each row that were on the border with the adjacent block. For each tree, we randomly selected two directions (either north and south or east and west) and took two samples from opposite sides in the upper half of the tree. For each sample, we followed a main branch away from the trunk until we came to a branching point beyond which there were approximately 50 cherries or empty stems. We then counted the number of 1) cherries pecked but not totally removed by birds, 2) empty stems, and 3) undamaged cherries. We assumed that any stems with missing cherries were damaged by birds. One person climbed a ladder to assess damage while another person recorded the damage.

We evaluated bird usage of the blocks by conducting 30-min bird counts at each orchard on 2 days during the period from 1-2 days after Mesurol application to 2-3 days before damage assessment. During each count, an observer watched with binoculars the treated and control blocks each for 15 min, with the order in which the blocks were watched determined randomly for each count. The observer recorded the numbers and species of birds flying into the block across one or more borders, depending on the main access routes used by the birds at each orchard. At the end of the 30-min count, the observer slowly walked down one row selected at random in each block and recorded all birds heard or seen in the block.

We used a paired-difference T-test to evaluate differences in damage and Wilcoxon's signed-ranks test to evaluate differences in bird counts between the Mesurol and control blocks. For the damage data, we used an arcsine transformation for the proportion of cherries pecked or missing from each sample. For the bird count data, we combined the two counts for each treatment block within an orchard.

RESULTS

Two of the nine orchards were excluded from the analysis because they were harvested early, before we could assess damage. For the remaining seven orchards, bird damage was significantly lower on the Mesurol blocks than on the control blocks ($t = 3.29$, $p < 0.025$, 6 d. f.). Birds pecked or removed an average of

8.9% of the cherries on the Mesurol blocks versus 17.5% on the control blocks (Table 1).

Bird activity also was lower on the blocks sprayed with Mesurol than on the control blocks, ($p < 0.02$). An average of 19.8 birds of all species flew into the control blocks during each 15-min count, versus an average of 7.4 birds in Mesurol blocks. European starlings, American robins *(Turdus migratorius)*, house finches, and common grackles *(Quiscalus quiscula)* were the most numerous and most frequently recorded birds (Table 2). We recorded the first three species at all seven orchards, and common grackles at four of the seven orchards. No other species was recorded at more than two orchards.

An application of 1.5 lb Mesurol (AI) /ac costs a grower approximately $16.00 for labor, equipment, and fuel (M. Castaldi, pers. comm.) and $40.00 for chemical. In 1985 the mean yield of sweet cherries in eastern New York was 1.3 tons /ac (New York Agricultural Statistics Service 1985). At a market price of $0.70/lb, a reduction in bird damage from 17.5% to 8.9% represents a savings of $156.00. Thus, the cost:benefit ratio of using Mesurol averaged 1: 2.8.

Table 1. Average percent of cherries damaged by birds on Mesurol-treated and untreated blocks at each of seven orchards in the mid-Hudson Valley of New York, 1986.

Orchard	No. of days : application to assessment	Treated block % Peck	% Removed	Total % loss	Untreated block % Peck	% Removed	Total % loss
Eger	7	1.1	2.7	3.8	0.7	14.5	15.2
Fix	8	1.3	1.7	3.0	1.0	0.7	1.7
Bartolotta	8	2.9	4.6	7.5	4.8	11.6	16.4
Smith	7	7.8	18.4	26.2	3.8	37.5	41.3
Clarke	8	1.1	1.7	2.8	4.7	5.4	10.1
Delaurentis	8	1.2	2.2	3.3	3.0	3.2	6.2
Pape	8	5.4	10.1	15.5	12.3	19.8	32.1
TOTAL		3.0	5.9	8.9 [a]	4.3	13.2	17.5 [a]

[a]Significantly different ($p < 0.025$, t-test).

Table 2. Mean number of birds flying into Mesurol-treated and untreated in blocks cherry orchards during 15-min observation periods. A total of 7 treated and untreated blocks were observed twice during the 7- and 8-day period between treatment and damage assessment.

Block	Number	European starling	American robin	House finch	Common grackle	All other	Total
Treated	7	0.9	1.6	1.6	0.9	2.4	7.4[a]
Untreated	7	4.9	4.1	2.8	4.6	3.4	19.8[a]

[a]Significantly different ($p < 0.02$), Wilcoxon's signed-ranks test.

DISCUSSION

Efficacy in Cherry Orchards:

Most growers in the mid-Hudson Valley believe birds are a serious problem and that they need an effective repellent to grow cherries profitably. Our results confirm not only that bird pressure can be substantial in this area, but also that Mesurol can provide cost-effective relief, even at the reduced rate of 1.5 lb (AI) /ac. Bird damage was reduced by an average of 49% on the blocks sprayed with Mesurol, while 63% fewer birds were counted flying into these blocks than into the control blocks. One of the growers in this study had lost more than 40% of his crop on the control block at the start of harvest. Our estimates of damage probably are conservative, because birds continued to do damage while the growers harvested the cherries over a period of 10-20 days after our damage assessment.

Mesurol seems to provide an effective means of reducing conflicts between fruit growers and federally protected, depredating birds: it mitigates damage while still allowing for beneficial activities of birds, such as eating insects and providing enjoyment for bird watchers. Mesurol protects crops not by killing birds, but by modifying their behavior (Rogers 1978b, Mason and Reidinger 1983, Avery 1984, Tobin 1985 a,b). The active ingredient temporarily impairs the transmission of nerve impulses (Schlagbauer and Schlagbauer 1972). Birds that ingest sublethal doses apparently suffer no permanent or long-lasting adverse effects (Schafer et al. 1975); instead they switch to alternative, untreated food (Rogers 1974).

Problems with Registration:

Unfortunately, the continued federal registration of Mesurol for blueberries and cherries is uncertain, and the expansion of the label to include grapes and other fruits is doubtful. The current federal registrations of Mesurol for use on blueberries and cherries expire on 31 March 1988, and the EPA has requested additional data before it will reregister the product for these crops (EPA 1987). Temporary tolerances that were established to cover residues on grapes under an experimental use permit expired on 31 December 1980, and Mobay Chemical Corporation, the proprietary company, does not intend to support the registration of Mesurol for use on grapes or other fruit crops except possibly blueberries and cherries (C. Childers, pers. comm.). Thus, in spite of over 15 years of research in the U.S. on the use of Mesurol as a bird repellent, its use is limited to only corn seed and two fruit crops, of which the latter registrations may be lost within a year. A number of health, environmental, financial, and regulatory obstacles impede the registration of this chemical as a bird repellent.

Health -- The use of Mesurol on crops intended for human consumption has raised questions about its safety for humans. The EPA contends that the residue tolerances of 25 ppm previously established for blueberries and cherries were based on studies that can no longer be toxicologically supported, and the Agency wants to evaluate more animal and plant metabolism studies before it extends the current temporary tolerances of 5 ppm past 31 March 1989 (EPA 1987). Specifically, the EPA is concerned about the metabolism of two primary active metabolites, methiocarb sulfoxide and methiocarb sulfone. In addition, the Agency questions the appropriateness of the methods available for enforcement of methiocarb tolerances and for collection of residue data in plant commodities, and it will issue no new permanent tolerances until it can ascertain and validate an appropriate analytical method for the enforcement of tolerances (EPA 1987).

Environmental -- Possible environmental hazards also are of concern. Because of Mesurol's high acute toxicity to birds, fish, and aquatic organisms (Schafer 1972, Kenaga 1979), the EPA has classified it as a Restricted Use Pesticide and is calling for additional studies to measure avian repellency and to monitor aquatic residues to support the continued registration of all outdoor uses of this pesticide (EPA 1987). Aquatic hazards would appear to be of limited concern in orchards since most are located in upland sites. A restriction in the label limiting use to non-aquatic sites would further reduce any possible hazard to fish and aquatic organisms. The largest remaining impediment to registration is EPA's requirement for a replicated, large scale avian field hazard study. However, the agency has not provided specific guidelines and has never approved a protocol for any avian field hazard study. Mobay, therefore is hesitant to commit the large investment required for such a study.

We feel that in the case of Mesurol, a common sense approach should prevail, and the EPA should waive the requirements for the avian field hazard study for the following reasons. First, the Agency has no reports of any significant fish or wildlife kills (EPA 1987), and it is doubtful that wild birds foraging in treated orchards would ever ingest enough chemical to kill them. We saw no evidence of bird mortality during this study, and searches during other studies in cherry orchards and wine grape vineyards have uncovered no dead birds in Mesurol-treated plots (Teklehaimanot 1973,Rogers and Ingram 1978, Bailey and Smith 1979, Hothem et al. 1979, 1980,1981).

Second, previous work by Mobay (T. Olson, pers. comm.) and Tobin and DeHaven (1981) indicates that the residue levels on ripening cherries and grapes are unlikely to exceed 5 ppm, even immediately after application. At 5 ppm, a European starling would have to eat 51 4-g cherries, and a common grackle 55 4-g cherries, to consume their respective LD_{50} values for methiocarb (Table 3). In order to ingest its LD_{50} value, a house finch would have to eat 2.5 4-g cherries, or 50% of its body weight. That house finches do not consume whole cherries, but rather peck at

Table 3. Number of cherries needed to obtain LD_{50} value of methiocarb for three species of birds.

Weight of cherry (g)	PPM methiocarb on cherries 15	10	5	2	Bird species[a]
2	34	51	101	254	European
3	23	34	68	170	starling
4	17	25	51	127	wt = 90 g
					LD_{50} = 11.3 mg /kg
2	37	55	110	275	Common grackle
3	24	37	73	183	wt = 110 g
4	18	27	55	137	LD_{50} = 10 mg /kg
2	1.7	2.5	5.0	12.4	House finch
3	1.1	1.7	3.3	8.3	wt = 21 g
4	0.8	1.2	2.5	6.2	LD_{50} = 2.37 mg /kg

[a] LD_{50} values from Schafer et al. 1983
Body weights from Dunning 1984.

the fruit, further reduces the chances of their ingesting a lethal dose.

Third, tests with captive birds also suggest that birds usually become averted to treated food well before they ingest lethal doses (Schafer et al. 1967, Schafer and Brunton 1971). Captive house finches, American robins, and European starlings that had been denied food for over 12 hr and were thus highly motivated to eat still developed aversions to Mesurol-treated grapes before consuming a lethal dose (Tobin and DeHaven 1984).

Financial -- The limited potential market for Mesurol as a bird repellent on fruit may not generate enough profits to justify Mobay maintaining its current registrations. Mesurol used for bird control generates about $1 million in revenue for Mobay, but about $3-5 million would be required to support the current registration requirements and make the product profitable (C. Childers, pers. comm.). The escalating costs of developing and registering pesticides have encouraged private industry to focus on broad-use chemicals with the potential for large markets and sizable profits.

Applications for registration of Mesurol products as a bird repellent have been pending with the EPA for more than 10 years, and Mobay and the Denver Wildlife Research Center (DWRC) of the U.S. Department of Agriculture (formerly of the U.S. Department of the Interior) probably have spent $10-20 million to develop and register Mesurol as a bird repellent in the United States (E. Schafer, pers.comm.). Investors are becoming increasingly hesitant to spend such enormous sums on minor-use chemicals like Mesurol that have only a limited potential for profits (Samuel et al. 1983).

Regulatory -- The Federal Insecticide, Fungicide and Rodenticide Act of 1947 (FIFRA) and its amendments have resulted in increasingly strict controls on the testing, registration, and use of pesticides in the United States. While this increased governnment involvement has helped protect consumers, producers, and the environment, it also has prolonged the registration process, created uncertainty about the final disposition of applications for registration, and increased the costs of developing new pesticides (Council for Agricultural Science and Technology 1981).

The U.S. Congress addressed some problems of registering minor-use pesticides when it passed the Federal Pesticide Act of 1978. This act has provisions for waiving efficacy requirements under certain conditions, increasing state authority to register pesticides, easing labeling requirements, and allowing conditional registrations. During the 1970's and early 1980's, many uses of Mesurol were authorized by the issuance of Section 18 registrations, which allowed for special or emergency use "clearances," and state 24C registrations, which recognized special local needs. However, amendments to FIFRA now require all uses of a pesticide to be fully registered and all uses to be prescribed on the label (Brosten 1987), and most of the special clearances for Mesurol have been withdrawn.

Recommendations for Registration:

Better communication among agrichemical companies, regulatory agencies, and government researchers would facilitate the development and registration of minor-use avian pesticides. Because most birds causing the depredations are federally protected, growers are limited in the methods they can use to control damage. We argue, therefore, that the federal government has an obligation to assist in the registration of products that safely reduce damage without killing birds. This assistance can come in two forms. First, chemical companies and governmental research laboratories such as DWRC should continue to cooperate in generating data needed for registration. This could help address many of the problems still impeding the full registration of Mesurol as a bird repellent on ripening fruit crops. Second, the U.S. Congress and the EPA must address the special problems faced by growers of crops being depredated by federally protected bird species and facilitate the development and registration of appropriate minor-use pest control materials. For example, they might provide financial incentives to commercial companies to develop minor-use pesticides by expediting the registration process and reducing the time to make a regulatory decision, by waiving certain registration fees, or perhaps in some cases by eliminating some registration requirements. For Mesurol registration on fruits, we specifically feel the aquatic and avian field hazard studies could be waived for the reasons outlined above.

CONCLUSION

The case history of Mesurol as a bird repellent illustrates many of the problems encountered by companies trying to register pesticides for the control of avian pests. The localized nature of most bird depredations in fruit crops has led to the perception that losses are insignificant and inconsequential, even though locally such losses may be significant (Mott and Stone 1973, Stone 1973, Crase et al. 1976). Individual growers need relief from such depredations, and without such relief they may take illegal actions such as poisoning birds (e.g. Stone 1979, Stone et al. 1984). A cooperative regulatory, research, and market atmosphere must be created that encourages the development of newer and safer technologies for controlling avian pests.

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LITERATURE CITED

Avery, M.L. 1984. Relative importance of taste and vision in reducing bird damage to crops with methiocarb, a chemical repellent. Agric. Ecosys. Environ. 11: 299-308.

Bailey, P.T., and G. Smith. 1979. Methiocarb as a bird repellent on wine grapes. Aust. J. Exp. Agric. Husb. 19: 247-250.

Bollengier, R.M., J.L. Guarino, and C.P. Stone. 1973. Aerially applied methiocarb spray for protecting wild lowbush blueberries from birds. Proc. Bird Control Semin. 6: 216-220.

Brosten, D. 1987. What's next for minors. Agrichemical Age. 31: 6-8

Conover, M.R. 1985a. Protecting vegetables from crows using an animated crow-killing owl model. J. Wildl. Manage. 49: 643-645.

Conover, M.R. 1985b. Using conditioned food aversions to protect blueberries from birds: comparison of two carbamate repellents. Appl. Anim. Behav. Sci. 13: 383-386.

Council for Agricultural Science and Technology. 1981. Impact of government regulation on the development of chemical pesticides for agriculture and forestry. Report No. 87. 20 pp.

Courter, J.W., G.E. Larson, and R. Randell. 1974. Reducing songbird damage to blueberries with a carbamate repellent. Trans. Ill. State Hort. Soc. 107: 79-83.

Crase, F.T., and R.W. DeHaven. 1976. Methiocarb: its current status as a bird repellent. Proc. Vertebr. Pest Conf. 7: 46-50.

Crase, F.T., C.P. Stone, R.W. DeHaven, and D.F. Mott. 1976. Bird damage to grapes in the United States with emphasis on California. U.S. Fish and Wildl. Serv., Spec. Sci. Rpt. Wildl. No. 197. 18 pp.

DeHaven, R.W. 1974. Bird damage to wine grapes in Central California. 1973. Vertebr. Pest Conf. 6: 248-252.

DeHaven, R.W., D.F. Mott, J.L. Guarino, J.F. Besser, C.E. Knittle, and E.W. Schafer, Jr. 1979. Methiocarb for repelling birds from ripening sweet cherries. Int. Pest Control. 21: 12-14, 21.

Dolbeer, R.A. (in press). Current status and potential of lethal control for reducing bird damage in agriculture. Proc. 19th International Ornithological Congress, Ottawa, Canada

Dolbeer, R.A., C.R. Ingram, and A.R. Stickley, Jr. 1973. A field test of methiocarb efficacy in reducing bird damage to Michigan blueberries. Proc. Bird Control Semin. 6: 28-40.

Dunning, J.B. 1984. Body weights of 686 species of North American birds. Western Bird Banding Assoc. Monograph No. 1.

Elliot, H.N., 1964. Starlings in the Pacific Northwest. Proc. Vertebr. Pest Conf. 2: 29-39.

Environmental Protection Agency. 1987. Guidance for the reregistration of pesticide products containing methiocarb as the active ingredient. Office of Pesticide Programs, Washington, D.C. 127 pp.

Griffin, D.N., and F.M. Baumgartner. 1959. Evaluation of certain chemicals as bird repellents. Proc. Okla. Acad. Sci. 39: 78-82.

Guarino, J.L. 1972. Methiocarb, a chemical bird repellent: a review of its effectiveness on crops. Proc. Vertebr. Pest Conf. 5: 108-111.

Guarino, J.L., W.F. Shake, and E.W. Schafer, Jr. 1974. Reducing bird damage to ripening cherries with methiocarb. J. Wildl. Manage. 38: 338-342.

Guarino, J.L., C.P. Stone, and W.F. Shake. 1973. A low-level treatment of the avian repellent, methiocarb, on ripening sweet cherries. Proc. Bird Control Semin. 6: 24-27.

Hothem, R.L., and R.W. DeHaven. 1982. Raptor-mimicking kites for reducing bird damage to wine grapes. Proc. Vertebr. Pest Conf. 10: 171-178.

Hothem, R.L., R.W. DeHaven, and J.P. Skorupa. 1979. Effectiveness of Mesurol® as a bird repellent on wine grapes in California. Unpubl. Bird Damage Res. Rep. No. 100. Denver Wildl. Res. Ctr. 13pp. (Typed).

Hothem, R.L., D.F. Mott, R.W. DeHaven, and J.L. Guarino. 1981. Mesurol as a bird repellent on wine grapes in Oregon and California. Am. J. Enol. Vitic. 32: 150-154.

Hothem, R.L., J.P. Skorupa and R.W. DeHaven. 1980. Mesurol as a bird repellent on wine grapes in California: effectiveness of a partial treatment form. Unpub. Bird Damage Res. Rep. No. 138. Denver Wildl. Res. Ctr. 14pp. (Typed).

Kenaga, E.E. 1979. Acute and chronic toxicity of 75 pesticides to various animal species. Down to Earth. 35 :25-31.

Larsen, K.H., and D.F. Mott, 1970. House finch removal from a western Oregon blueberry planting. Murrelet 51: 15-16.

Luckwill, L.C., and P.S. Weaver. 1964. Techniques for the study of bird repellents. Ann. Rpt. Long Ashton Res. Sta. Pp. 64-72.

Mason, J.R., and R.F. Reidinger, Jr. 1983. Importance of color for methiocarb-induced food aversions in red-winged blackbirds. J. Wildl. Manage. 47: 383-393.

Mott, D.F., and C.P. Stone. 1973. Bird damage to blueberries in the United States. U.S. Fish and Wildl. Serv., Spec. Sci. Rpt.-Wildl. No. 172. 15 pp.

New York Agricultural Statistics Service. 1985. New York orchard and vineyard survey 1985. U.S. Dept. Agric. and N.Y.S. Dept. Ag. Markets, Albany. 90pp.

Palmer, T.K., 1972. The house finch and starling in relation to California's agriculture. Proc. General Meeting of Working Group on Grainivorous Birds, Holland, 1970. p. 275-290.

Rogers, J.G., Jr. 1974. Responses of caged red-winged blackbirds to two types of repellents. J. Wildl. Mange. 38: 418-423.

Rogers, J.G., Jr. 1978a. Repellents to protect crops from vertebrate pests: some considerations for their use and development. Pg. 150-165 *in* (R.W. Bullard-ed.) Flavor chemistry of animal foods. ACS Symp. Series, No. 67.

Rogers, J.G., Jr. 1978b. Some characteristics of conditioned aversion in red-winged blackbirds. Auk. 95: 362-369.

Rogers, J.G., Jr., and C.R. Ingram. 1978. A field evaluation of methiocarb as a bird repellent in sour cherries - Michigan 1976. Unpub. Bird Damage Res. Rep. No. 85. Denver Wildl. Res. Ctr. 17pp. (Typed).

Samuel, A.C.I., B.W. Cox, and H-H. Cramer. 1983. Implications of rising costs of registering agrichemicals. Crop Prot. 2: 131-141.

Schafer, E.W. 1972. The acute oral toxicity of 369 pesticidal, pharmaceutical and other chemicals to wild birds. Toxicol. Appl. Pharmacol. 21 :315-330.

Schafer, E.W., W.A. Bowles, and J. Hurlbut. 1983. The acute toxicity, repellency, and hazard potential of 998 chemicals to one or more species of wild and domestic birds. Arch. Environ. Contam. Toxicol. 12:355-382.

Schafer, E.W., Jr., and R.E. Brunton. 1971. Chemicals as bird repellents: two promising agents. J. Wildl. Manage. 35: 569-572.

Schafer, E.W., Jr., R.B. Brunton, N.F. Lockyer, and D.J. Cunningham. 1975. The chronic toxicity of methiocarb to grackles, doves, and quail and reproductive effects in quail. Bull. Environ. Contamin. Toxicol. 14: 641-647.

Schafer, E.W., R.I. Starr, D.J. Cunningham, and T.J. DeCino. 1967. Substituted phenyl N-methylcarbamates as temporary immobilizing agents for birds. J. Agr. Food Chem. 15: 287-289.

Schlagbauer, B.G.L., and A.W. J. Schlagbauer. 1972. The metabolism of carbamate pesticides - a literature analysis. Part I. Resid. Rev. 42: 1-84.

Spanier, E. 1980. The use of distress calls to repel night herons *(Nycticorax nycticorax)* from fish ponds. J. Appl. Ecol. 17: 287-294.

Stanton, F.W. 1962. Bird and Mammal Repellents. Oregon State Game Comm. Misc. Wildl. Publ. No. 5. 20pp.

Stone, C.P. 1973. Bird damage to tart cherries in Michigan, 1972. Proc. Bird Control Semin. 6: 19-23.

Stone, C.P., W.F. Shake, and D.J. Langowski. 1974. Reducing bird damage to highbush blueberries with a carbamate repellent. Wildl. Soc. Bull. 2: 135-139.

Stone, W.B. 1979. Poisoning of wild birds by organophosphate and carbamate pesticides. N.Y. Fish and Game J. 26: 37-47.

Stone, W.B., S.R. Overman, and J.C. Okoniewski. 1984. Intentional poisoning of birds with parathion. Condor 86: 333-336.

Teklehaimanot, A. 1973. Evaluation of methiocarb efficacy in reducing bird damage to blueberries in southwestern Michigan. M.S. thesis, Bowling Green State University. 50 pp.

Tobin, M.E. 1985a. Cues used by European starlings for detecting methiocarb-treated grapes. J. Wildl. Manage. 49: 1102-1108.

Tobin, M.E. 1985b. Cues used by house finches for detecting methiocarb-treated grapes. Crop Prot. 4: 111-119.

Tobin, M.E., and A.C. Crabb. 1985. Bird damage control: are chemical repellents the answer? CAL-NEVA Wildl. Trans.: 37-46.

Tobin, M.E., and R.W. DeHaven. 1981. Methiocarb residues resulting from field and laboratory applications of Mesurol® to wine grapes. Unpub. Bird Damage Res. Rep. No. 197, Denver Wildl. Res. Ctr. 12pp. (Typed).

Tobin, M.E., and R.W. DeHaven. 1984. Repellency of methiocarb-treated grapes to three species of birds. Agric. Ecosys. Environ. 11: 291-297.