PROTECTING HONEY BEES FROM PESTICIDES

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The Importance of the Honey Bee

The honey bee is just one of the many kinds of bees endemic to Florida. However, it is the most important bee to Florida agriculture and to that of the United States as a whole. The honey bee is credited with approximately 85% of the pollinating activity necessary to supply about one-third of the nation's food supply. Well over 50 major crops are either dependent on these insects for pollination or produce more abundantly when honey bees are plentiful. Although some beekeepers routinely supplement their income by renting colonies of bees for pollination, most honey bee activity is a service provided free of charge. This "intangible" benefit from the keeping of honey bees, however, is no small contribution to agriculture. In fact, it is estimated to be somewhere between ten to twenty times the total value of honey and wax produced by these insects.

There are an estimated 10,000 to 12,000 beekeepers in the state of Florida, managing a total of 350,000 to 400,000 colonies and producing between 20-30 million pounds of honey annually. Each year, this industry is affected by use of chemicals called pesticides, marketed to control populations of weeds, plant pathogens, nematodes, insects, rodents, birds, and other pests. This publication is written to inform beekeepers, commercial growers and the general public about the often complex relationship between honey bees and pesticides and to suggest how honey bees can better be protected from the potential hazards of these chemicals.

Honey bees are vegetarians, usually consuming only pollen and nectar from plant blooms or sweets like sugar syrup and honey dew. These insects are highly social and a colony may contain as many as 10,000 to 100,000 individuals, depending on the time of year, prevailing weather conditions and availability of nectar- and pollen-bearing blossoms. Each colony consists of three kinds of individuals. A single fertile queen is usually present to provide replacement bees, and there may be from a few to several thousand drones. The latter are male bees whose major function is to mate with virgin queens to ensure survival of the species.

Finally, the vast majority of the bees in a colony are sterile females called workers. As the name suggests, they are responsible for doing all the work, including gathering and processing food, caring for the brood of young bees, defending the colony and maintaining the colony's temperature.

Poisoning and Developmental Stages

Worker bees are those primarily affected by pesticides. The symptoms of poisoning can vary depending on the developmental stage of the individual bee and kind of chemical employed (see Figure 1).

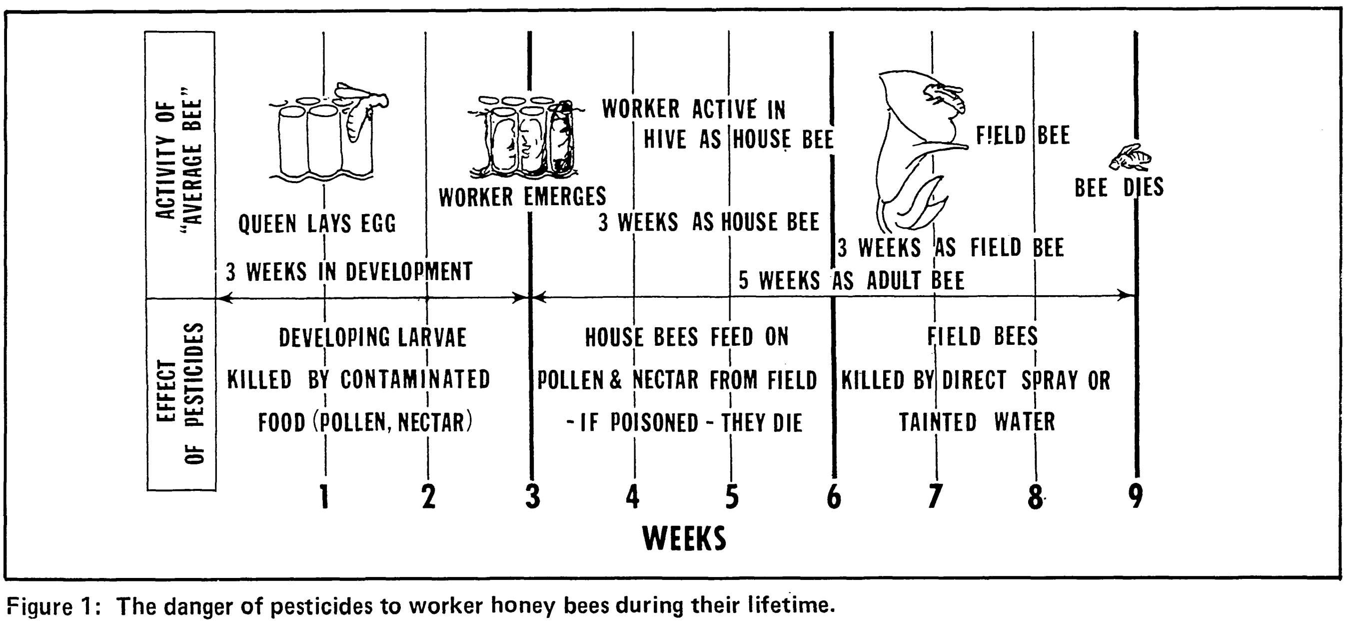

Figure 1: The danger of pesticides to worker honey bees during their lifetime.

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Development of adult: It takes worker bees about twenty-one days to develop from egg to adult. During this process, each individual passes through a larval (feeding) stage followed by a pupal (transformation) stage. The larval stage is the most susceptible to pesticide poisoning during development.

House bees: These bees are emerged worker adults up to twenty-one days of age. They care for the brood, process pollen and nectar gathered in the field by older workers, and clean the nest. Eventually, they too will become field bees. House bees are usually poisoned by contaminated pollen which is collected in the field, brought back and stored in the hive. As house bees are killed, there are fewer bees to tend the brood and further decline in population results.

Field bees: These bees are workers twenty-one to approximately forty-two days of age. There appears to be no greater risk in bee society than to be a field bee. Should the insect avoid all the potential pitfalls due to predators like spiders, toads or skunks, it is still vulnerable at all times to the numerous pesticides applied in commercial agriculture, mosquito control, and home gardens. Most times, field bees are killed by contact with pesticides in the field, but other times they collect contaminated nectar and pollen and contribute to poisoning their sisters in the colony. If field bees are killed, then young bees are forced into the field earlier than normal, disrupting and thus disorienting the colony.

While foraging, field bees may range as far as two to five miles from a colony. They usually seek nectar and pollen systematically, not randomly, and once a food source is found, bees prefer to work that particular source to exhaustion before changing plants. This kind of resource partitioning by bee colonies accounts for the inconsistency observed many times between colonies undergoing pesticide poisoning in the same location. The bees are not all working the same plants and so some are affected more than others. Often it is those bees with established flight patterns located in an area before a pesticide is applied that are most damaged. Those placed in a field immediately after application are less affected by the pesticide because it takes some time for the bees to scout an area and locate food sources.

Recognizing Bee Kills

Pesticides can affect honey bees in different ways. Some kill bees on contact in the field; others may cause brood damage or contaminate pollen, thus killing house bees. Before dying, poisoned bees can become irritable (likely to sting), paralyzed or stupified, appear to be 'chilled' or exhibit other abnormal behavior. Queens are likely to be superseded when a colony is being poisoned. Sometimes solitary queens, banished as if they were somehow "blamed" for poisoning, may be found near a colony. These symptoms are not always distinct and they cannot be taken as definite signs of pesticide poisoning. Many chronic management problems such as starvation, winter kill, chilled brood or disease may result in the same symptoms. Often these problems may be caused by pesticides in an indirect manner. So it is difficult in many instances to categorically state that bees have been poisoned.

Only one readily recognized symptom is good evidence of pesticide damage; the presence of many dead or dying bees near a colony's entrance. In a short period of time, however, these dead bees may dry up and the remains be blown away and eaten by ants or other scavengers. A beekeeper, therefore, who visits his yards only occasionally may not see these dead bees and thus not be aware that his colonies have been poisoned.

Reporting Bee Kills

Although it is sometimes difficult to detect poisoning of bees by pesticides, those cases that are "clear cut" or "borderline" should be reported. In the past, there have been few commonly accepted or uniform reporting procedures for bee kills, and this lack has contributed to the small amount of good data on bee kills which the industry can point to in justifying its concern about such incidents.

At the present time every bee kill can and should be reported using the pesticide incident report (see page 15). The form is self-explanatory. The main rule to follow when filling it out is to be as specific as possible. Section II is particularly important; therefore, include as much as is known, even if nothing else than a garden spray trade name is available.

Besides sending in the aforementioned form to the Environmental Protection Agency (EPA), it would be valuable to send a photocopy or duplicate copy to: Extension Apiculture, IFAS, University of Florida, 202 Newell Hall, Gainesville, FL 32611. In cases where dead and dying bees are observed, a sample of dying insects (more than a cup if possible) and a 2 × 2 inch square of comb containing pollen should be collected and frozen. Indicate on the form that samples have been taken. Information should be requested about where and how to send samples in order to be tested. It is usually suggested that "uninterested" third parties be asked to actually take samples of bees suspected of being killed by pesticides. These persons may include County Extension Agents, Agriculture Stabilization and Conservation Service (ASCS) personnel, State Bee Inspectors, or other local officials whose role is usually construed as being more objective in the sampling process.

Protecting Bees From Pesticides

Most major bee poisoning incidents occur when plants are in bloom. However, bees can be affected in other circumstances as well. Keep the following suggestions in mind when applying pesticides.

Use pesticides only when needed: Foraging honey bees, other pollinators, and insect predators are a natural resource and their intrinsic value must be taken into consideration. Vegetable, fruit, and seed crop yields in nearby fields can be adversely affected by reducing the population of pollinating insects and beneficial insect predators. It is always a good idea to check the field to be treated for populations of both harmful and beneficial insects.

Do not apply pesticides while crops are in bloom: Insecticide should be applied only while target plants are in the bud stage or just after the petals have dropped (Figure 2).

CONTROL SPRAYING TO PREVENT BEE LOSSES.

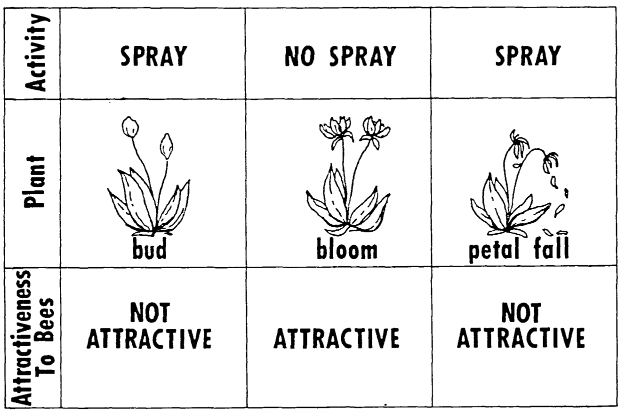

Figure 2: Control spraying to prevent bee losses.

Apply pesticide when bees are not flying: Bees fly when the air temperature is above 55-60°F and are most active from 8 a.m. to 5 p.m. Always check a field for bee activity immediately before application. Pesticides hazardous to honey bees must be applied to blooming plants when bees are not working, preferably in the early evening. Evening application allows time for these chemicals to partially or totally decompose during the night.

Do not contaminate water: Bees require water to cool the hive and feed the brood. Never contaminate standing water with pesticides or drain spray tank contents onto the ground, creating puddles.

Use less toxic compounds: Some pest control situations allow the grower-applicator a choice of compounds to use. Those hazardous to honey bees must state so on the label. Select other materials or vary dosages, based on the honey bee mortality predictor model to be discussed in a later section of this publication. When in doubt, consult your County Agricultural Extension Agent for details, recommendations and further information about the toxicity of specific compounds to honey bees.

Use less toxic formulations: Not all insecticides have the same effects when prepared in different formulations. Research and experience indicate:

- New microencapsulated insecticides are much more toxic to honey bees than any formulation so far developed. Because of their size, these capsules are carried back to the colony and there can remain poisonous for long periods. These insecticides should never be used if there is any chance bees might collect the microcapsules. Always consider using another formulation first.
- Dusts are more hazardous than liquid formulations.
- Emulsifiable concentrates are less hazardous than wettable powders.
- Ultra-low-volume (ULV) formulations are usually more hazardous than other liquid formulations.

Identify attractive blooms: Before treating a field with pesticides, it is a good idea to check for the presence of other blooming plants and weeds which might attract bees. In many instances bees have been killed even though the crop being sprayed was not in bloom. Many times these attractive blooms can be mowed or otherwise removed, although mowing can result in destroying other beneficial insect habitat or force destructive insects into the crop being cultivated.

Notify beekeepers: If beekeepers are notified in advance of application, colonies can be moved or loosely covered with burlap or coarse cloth to confine the bees and yet allow them to cluster outside the hive under the cloth. Repeated sprinkling each hour with water prevents overheating (Figure 3). **Never screen or seal up colonies and do not cover with plastic sheeting.** This can result in overheating leading to bee suffocation and death. Florida law requires every apiary or bee yard to be plainly marked with the owner's name, address and telephone number.

Specific Problems

The following problem areas concerning application of pesticides deserve special attention.

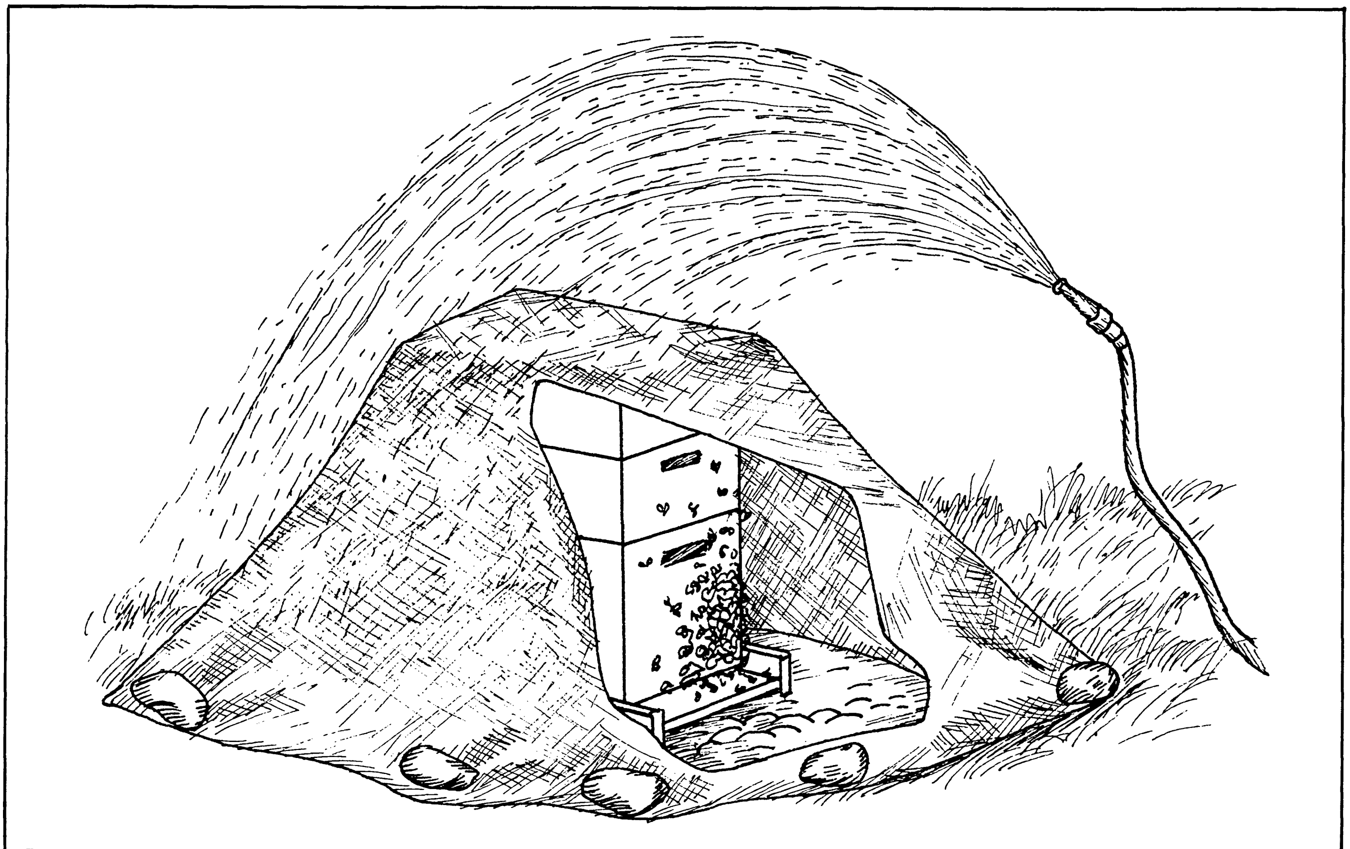

Figure 3: Cover colonies with burlap or coarse cloth and keep cover soaked. A tent-like arrangement allows the bees to cluster outside the hive but inside the tent. Repeated waterings with sprinkler prevents bees from becomming overheated.

Malathion for insect control: The use of malathion for mosquito and other insect control has sometimes resulted in many dead or weakened bee colonies. Losses usually have resulted from:

1. Daytime air applications of ULV malathion at times when large numbers of bees are flying.
2. Failure to provide adequate warning to beekeepers.
3. Failure to follow a publicized spray schedule.

Although substantial amounts of malathion have been and are being used around the United States, if applied and publicized properly, few honey bees are usually affected.

Carbaryl (Sevin®) for insect control: Often Sevin® does not kill field bees immediately, but allows them time to take contaminated nectar and pollen back to the colony. Some crops treated with Sevin® under the wrong conditions (i.e., in bloom using a dust formulation with large numbers of bees in the field) have been responsible for disastrous kills.

Sevin® is one of the nation's most widely used insecticides for a wide variety of insect pests. It is also one of the most toxic to honey bees in certain formulations. There are formulations, however, which are determined to be less toxic (see tables). Usually, applicator-beekeeper communication can effectively be used to adequately protect bees from Sevin® poisoning.

Encapsulated methyl parathion (PennCap M®): By far the most potentially damaging pesticides for honey bees are those packaged in tiny capsules (microencapsulated). Microencapsulated methyl parathion (PennCap M®), for example, is a liquid formulation containing capsules approximately the size of pollen grains which contain the active ingredient. When bees are out in the field, these capsules can become attached electrostatically to the pollen-collecting hairs of the insects and at times are collected by design. When stored in pollen, the slow-release feature of the capsules allows the methyl parathion to be a potential killer for several months.

At the present time, there is no way to detect whether bees are indeed posioned by microencapsulated methyl parathion, so a beekeeper potentially could lose replacement bees for those already poisoned by the pesticide. It is, therefore, strongly recommended that this formulation be used only when honey bee exposure is not a possibility.

Other considerations: In general, botanical materials, dinitro compounds, fungicides and herbicides are relatively nontoxic to honey bees. However, some of these materials may affect bee development, and environmental considerations make it mandatory that all pesticides be used with utmost caution and **only** as indicated on the label.

Predicting Honey Bee Mortality

The following description and use of ways to predict honey bee mortality are extensively adapted from Leaflet 2883, revised February 1981, Division of Agricultural Sciences, University of California. Special thanks is given to E. L. Atkins, D. Kellum and K. W. Atkins of the University of California at Riverside for permission to use this material.

Tables 1 and 2 can be used to predict the degree of toxicity hazard to honey bees in the field when the pesticide is applied as an **early morning** spray. In most instances, the LD_{50}* in micrograms per bee (ug/bee) can be directly converted to the equivalent number of pounds of chemical per acre when applied as a spray to the aerial portions of plants. [For kilograms per hectare (kg/ha), multiply ug/bee by 1.12]. For example, since the LD_{50} of parathion is 0.175 ug/bee, we would expect that 0.17 lb/acre (0.2 kg/ha) of parathion would kill 50 percent of the bees foraging in the treated field at the time of application or shortly afterwards.

Generally speaking, some pesticides can be made safer to honey bees by slightly lowering the dosage. Conversely, by increasing the dosage only slightly the pesticide may become highly hazardous to bees. This information is particularly useful when the LD_{50} in micrograms per bee is approximately equal to the normal dosage in pounds per acre needed in the field to control pest populations. For example, consider a pesticide, which is normally applied at dosages of 0.5 to 1.5 lb/acre, having an LD_{50} of 1.0 ug/bee. Furthermore, suppose that the pesticide has a slope value of 4.0 probits. Then, if this chemical is applied at 0.5 lb/acre, we would expect a 12 percent kill of bees; at 1 lb/acre, we would expect a 50 percent kill; and, at 1.5 lb/acre, we would expect a 72 percent kill.

Table 3 shows additional examples of anticipated bee mortalities at other selected slope values with increasing and decreasing dosages of a pesticide having an LD_{50} value of 1.0 ug/bee. Any pesticide having a known LD_{50} value can be similarly read by substituting the LD_{50} (the 1.0 or center column) of Table 3 and multiplying the LD_{50} value by the other factors (0.1, 0.25, 0.5, 0.75, 1.25, 1.5, 3.0, and 10.0) to obtain the proper range of dosages in pounds per acre. By using the value closest to the known slope value for the particular pesticide, the percent mortalities for that chemical can be predicted.

It is emphasized that the method described is a rule-of-thumb, and that some pesticides are more or less hazardous than one can anticipate from the laboratory data. Most of these are pesticides which have very short or very long residual characteristics.

The Honey Bee Mortality Predictor A Rapid Method

The nomogram (Figure 4) provides a quicker method of predicting the mortality of honey bees from field applications of pesticides than the one just discussed (Table 3), which requires mathematical calculations. The method is also useful for predicting potential hazards to honey bees when applying pesticides for mosquito abatement and for pest control in forest, rangeland, recreational areas, and home gardens.

An example of how the Predictor works: Let us say that parathion has an LD_{50} of 0.175 ug/bee; slope value of 4.96 probits. We intend to apply parathion at the rate of 0.25 lb/acre a.i. (active ingredient) to control pest populations of insects in an area which contains colonies of honey bees for pollinating the crop. How hazardous will this dosage be to the bee colonies if they cannot be protected during application or removed to safety?

Read the instructions given with the Predictor. Note that an LD_{50} of 0.175 ug/bee is equivalent to 0.175 lb/acre a.i. and that 0.175 appears in the LD_{50} or "× 1" column in the dosage table. You want to apply 0.25 lb/ acre; in the dosage table this dosage appears under the "1.5 times the LD_{50}" column. The 1.5 indicates that 0.25 lb/acre is 1.5 × the LD_{50} rate of 0.175 lb/acre. Place a straightedge even with the "1.5 dosage increase" level on the left vertical scale. Since the slope value is 4.97 probits (approximately 5 probits) rotate the straightedge through the 5-probit point of the "slope value" guide line. The straightedge now will intersect the right vertical scale, which is the "predict percent mortality of honey bees in the field". You will note that the straightedge intersects the mortality scale at 78 percent. Therefore, the application of 0.25 lb/acre of parathion is predicted to kill approximately 78 percent of the bees that contact the treated foliage or that are flying through the treated area during the application of the spray.

Remember that bee mortality would be reduced approximately 50 percent (to 39 percent in the example) if the parathion application was made during

*LD_{50} is the experimental dosage at which 50% of a test bee population died.

the night (from darkness to 4 a.m.), and that bee mortality would be increased approximately two times if the parathion application was made after 7 a.m. and later into the day (more than 98 percent in the example). Also notice that by reducing the dosage only slightly to .22 lb/acre, the mortality is reduced from 78 percent to 65 percent.

Cooperation and Communication Keys to Bee Protection

In order to adequately protect honey bees from pesticides, there must be a good deal of cooperation between applicators, growers, beekeepers, extension workers and government officials. The key to this cooperation is constant communication fostered by trust on the part of all involved.

It should be realized that protecting honey bees from pesticides is often extremely difficult in spite of the fact that most of these chemicals are not considered hazardous to bees. There are many variables which must be pondered in the decision-making process leading to pesticide use. If those which contribute to honey bee safety are given due consideration, application of pesticides and protection of honey bees are not mutually exclusive. Generally it is only when decisions are based on insufficient information and/or made without regard to the safety of honey bees that they result in damaging bee colonies.

The purpose of this publication is to provide the necessary information to consider when contemplating use of pesticides and the potential effects on honey bees. If it contributes to saving even one bee, which can then expend energy in the service of pollination to agriculture, this effort will not have been wasted.

Table 1—Relative Toxicity of Pesticides to Honey Bees Determined by Laboratory and Field Tests (California, 1950 through 1980.)

(Number keyed notes on their uses can be found at bottom of table)

Group I—highly toxic: Severe losses may be expected if used when bees are present at treatment time or within a day thereafter, except where noted to the contrary.

Pesticide (trade name and/or common name)

aldrin[2]	Dursban®[2], chlorpyrifos	Nemacur®[5], fenamiphos
Ambush®[2,18], permethrin	Ekamet®, etrimfos	Nudrin®[2], methomyl
arsenicals [1,2]	EPN[1,2]	Orthene®[2], acephate
Avermectin®[17]	Ethyl Guthion®, azinphos-ethyl	parathion[1,2]
Azodrin®[1,2], monocrotophos	Famophos®, famphur	Pay-Off®
Baygon®[2], propoxur	Ficam®, bendiocarb	Phosdrin®[1,2,3], mevinphos
Baytex®[2], fenthion	Folithion®, fenitrothion	phosphamidon[2], Dimecron®
Bidrin®[1,2], dicrotophos	Furadan®[2,5], carbofuran	Pounce®[2,18], permethrin
Bux®, bufencarb	Gardona®[1,2], stirofos	Pydrin®[2], fenvalerate
carbosulfan[2], FMC-35001	Guthion®[1,2], azinphos-methyl	resmethrin, Synthrin®
Cygon®[2], dimethoate	heptachlor[1,2]	Sevin®[2], carbaryl
Cythion®[2,4], malathion	Imidan®[2], phosmet	Spectracide®[2], diazinon
Dasanit®[5], fensulfothion	Lannate®[2], methomyl	Sumithion®, fenitrothion
DDVP®[2], dichlorvos	Lorsban®, chlorpyrifos	Sumithrin®, *d*-phenothrin
Dibrom®[2,3], naled	malathion[2,4]	Supracide®[2], methidathion
Decis®[2], decamethrin	Matacil®, aminocarb	Tamaron®[2], methamidophos
De-Fend®[2], dimethoate	Mesurol®, methiocarb	Temik®[1,2,5,7], aldicarb
diazinon[2], Spectracide®	methyl parathion[1,2,11,12]	tepp[1,2,3]
dieldrin[1,2]	Monitor®[2], methamidophos	Vapona®[2], dichlorvos
Dimecron® [2], phosphamidon		

Group II—moderately toxic: Can be used around bees if dosage, timing, and method of application are correct, but should not be applied directly on bees in the field or at the colonies.

Insecticide (trade name and/or common name)

Abate®[2], temephos	DDT[1,2,10]	Pyramat®
Agritox®, trichloronate	Di-Syston®[1,2,6,18], disulfoton	Sevin® 4-Oil[2], carbaryl
Bolstar®, sulprophos	Dyfonate®, fonofos	Sevimol®[2], carbaryl
Carzol®[2], formetanate hydrochloride	endrin[1,2]	Systox®[1,2,18], demeton
chlordane[2]	Korlan®, ronnel	Thimet®[1,2,6], phorate
Ciodrin®, crotoxyphos	Larvin®[2], thiodicarb	Thiodan®[2], endosulfan
Counter®, terbufos	Metasystox-R®[2], oxydemeton-methyl	Trithion®[2], carbophenothion
Croneton®, ethiofencarb	Mocap®, ethoprop	Vydate®[2], oxamyl
Curacron®, profenofos	Perthane®, ethylan	Zolone®, phosalone

Group III—relatively nontoxic: Can be used around bees with minimum injury.

Insecticides and Acaracides (trade name and/or common name)

Acaraben®, chlorobenzilate
allethrin, Pynamin®
Altosid®[17], methoprene
Baam®, amitraz
Bacillus thuringiensis[17], Bactur®, Bactospeine®, Bakthane®, Dipel®, Thuricide®
Birlane®, chlorfenvinphos
Comite®, propargite
cryolite[2], Kryocide®
Delnav®, dioxathion
Dessin®, dinobuton
Dimilin®[17], diflubenzuron
Dylox®[2], trichlorfon
ethion
Fundal®, chlordimeform
Galecron®, chlordimeform
Heliothis polyhedrosis virus
Kelthane®[1], dicofol
Mavrik®[2], fluvalinate
methoxychlor[2], Marlate®
Mitac®, amitraz
Morestan®, oxythioquinox
Morocide®, binapacryl
Murvesco®, fenson
nicotine[2]
Omite®, propargite
Pentac®, dienochlor
Pirimor®[2], pirimicarb
Plictran®[2], cyhexatin
pyrethrum (natural)
rotenone[2]
sabadilla[2]
Sayfos®, menazon
Sevin® SL[2], carbaryl
Sevin® XLR[2], carbaryl
Smite®, sodium azide
Tedion®, tetradifon
Tetram®
Tokuthion®, prothiophos
Torak®, dialifor
toxaphene[1,2]
Zardex®, cycloprate

Fungicides (trade and/or common name)

Afugan®[2], pyrazophos
Arasan®, thiram
Bayleton®, triadimefon
Benlate®, benomyl
Bordeaux mixture[2]
Bravo®, chlorothalonil
captan[11]
copper oxychloride sulfate
copper 8-quinolinolate
copper sulfate
Cuprex®, dodine
cupric oxide
cupric hydroxide, Kocide®
Delan®, dithianon
Dessin®, dinobuton
Difolatan®, captafol
Dithane® D-14, nabam
Dithane® M-22, maneb
Dithane® M-45, manzeb
Dithane® Z-78, zineb
Du-Ter®, fentin hydroxide
Dyrene®, anilazine
ferbam
glyodin
Hinosan®, edifenphos
Indar®, butrizol
Karathane®, dinocap
Lesan®, fenaminosulf
Morestan®, oxythioquinox
Morocide®, binapacryl
Mylone®, dazomet
Phaltan®, folpet
Plantvax®, oxycarboxin
Polyram®, metiram
Ridomil®
Sisthane®, fenapanil
Smite®, sodium azide
sulfur[2]
thiram, Thylate®
thyfural
Vitavax®, carboxin
ziram, Zerlate®

Herbicides, Defoliants, and Desiccants (trade and/or common name)

AAtrex®, atrazine
alachlor
Alanap®, naptalam
Alopex®, clofop-isobutyl
Amex® 820, butralin
Amiben®, chloramben
amitrole
Ammate®, AMS
Aquathol K®, endothall, dipotassium
Avenge®, difenzoquat
Balan®, benefin
Banvel®, dicamba
Basagran®, bentazon
Basalin®, fluchloralin
Betanal®, phenmedipham
Betanex®, desmedipham
Bladex®, cyanazine
Blazer®, acifluorfen
butachlor
butam
cacodylic acid[1]
Cambilene®[1], 2,3,6-TBA
Caparol®, prometryn
Casoron®, dichlobenil
dichlorprop[1], 2,4-DP
dinoseb[9], dinitrobutylphenol
diquat[8,9]
Dual®, metolachlor
endothall, sodium salt, Accelerate®
Eptam®, EPTC
Eradicane®, EPTC + safener
Evik®, ametryn
Evital®, norflurazon
Folex®[1,8], merphos
Garlon®, triclopyr
Goal®, oxyfluorfen
Hoelon®, diclofop-methyl
Hydrothol 191®, endothall monopotassium salt
Hyvar®, bromacil
Igran®, terbutryn
IPC®, propham
Karmex®, diuron
Kerb®, pronamide
Lasso®, alachlor
Lorox®, linuron
Maloran®, chlorbromuron
MCPA[1]
Paarlan®, isopropalin
paraquat[1,9]
Planavin®, nitralin
Pramitol®, prometon
Preforan®, fluorodifen
Princep®, simazine
Probe®, methazole
Prowl®, pendimethalin
Ramrod®, propachlor
Randox®, CDAA
Ronstar®, oxydiazon
Roundup®, glyphosate
Sancap®, dipropetryn
Sencor®, metribuzin
silvex[1], 2,4,5-TP
Sinbar®, terbacil
Smite®, sodium azide
Surflan®, oryzalin
Sutan® +, butylate
2,4,5-T[1,2]
Telvar®, monuron
Tenoran®, chloroxuron
TOK®, nitrofen
Tolban®, profluralin

Chloro IPC®, chlorpropham	Methar®[1], DSMA	Tordon®, picloram
Cotoran®, fluometuron	Milogard®, propazine	Treflan®, trifluralin
2,4-D[1,2]	Modown®, bifenox	Turf Herbicide®, endothall, disodium
DEF®[8]	MSMA[1]	Vegadex®, CDEC
Desiccant L-10®[1,9], arsenic acid	Mylone®, dazomet	Zorial®, norflurazon
Devrinol®, napromamide	Nortron®, ethofumesate	

Nematicides and Miscellaneous (trade and/or common name)

endothall[13]	Mocap®[5], ethoprop	Polaris®[16], glyphosine
Exhalt® 800[14]	Mylone®[5], dazomet	Smite®[5], sodium azide
gibberellic acid[13]	N-Serve®[15], nitrapyrin	Sustar®[13,16]

Number-keyed Notes on Pesticide Uses

1. Florida state regulations require permits for most uses of these chemicals.
2. Laboratory- and field-tested mainly on alfalfa, citrus, cotton, ladino clover, milo and sweet corn; all other chemicals were laboratory-tested only.
3. Dibrom®, Phosdrin®, and tepp have such short residual activity that they kill only bees contacted at treatment time or shortly thereafter. Usually safe to use when bees are not in flight; not safe to use around colonies.
4. Malathion has been applied on thousands of acres of alfalfa in bloom without serious loss of bees. However, occasional heavy losses have occurred, particularly under high temperature conditions. If applied to alfalfa in bloom, it should be only as a spray, and application should be made during the night or early in the morning when bees are not foraging in the field. Undiluted technical malathion spray (ULV) should not be used around bees.
5. Nematicide.
6. Di-Syston® (disulfoton) and other systemic pesticides used as seed treatments have not caused bee losses.
7. Temik® (aldicarb), although highly toxic to bees as a contact poison, is used only in granular form, and extensive field usage has not caused bee losses.
8. Defoliant.
9. Desiccant.
10. DDT has been withdrawn for most uses in the U.S.A.
11. Field dosages have caused brood damage.
12. The microencapsulated formulation of methyl parathion, known as Penncap-M®, is highly toxic to foraging bees, young hive bees, and brood. Overall, it is 13 times more hazardous to honey bees than the EC (emulsifiable concentrate) formulation. Penncap-M® is too hazardous to be applied to any area at any time when bees are present in the field or within one mile of the area to be treated.
13. Plant growth regulator.
14. Sticker/extender.
15. Nitrification inhibitor.
16. Chemical ripener.
17. Insect growth regulator.
18. Honey bee repellent.

Table 2—Data for Use of Honey Bee Mortality Predictor (see Figure 5)

NOTE:

Bee hazard and residual toxicity information is based on field tests (1950-1980) for dosages normally recommended and utilized as dilute sprays in water on agricultural crops for controlling pest insects and mites. This information is usually applicable for mosquito abatement, forest, rangeland, recreational, and residential treatments but not for low-volume, no-water sprays (ULV).

Night applications (darkness until 4 A.M.) will reduce bee kill approximately 50% and reduce overall bee hazard at least one category from sprays applied as early morning applications (daylight to 7 A.M.): applications made after 7 A.M. will increase the overall bee hazard approximately two times, raising the hazard to at least the next higher category.

Group I—highly toxic pesticides (LD_{50} = 0.001 to 1.99 ug/bee): Severe losses may be expected if these pesticides are applied when bees are present at treatment time or within a day thereafter, except as indicated by footnotes. (Listed in order of toxicity: first named is most toxic.)

Pesticide* (trade and/or common name)	Laboratory data		Field test data: Toxicity of residues to bees†	
	Slope, probits	LD_{50}	No. days	Hazard
tepp[1,3]	0.68	0.002	0.5(H)	ML
bioethanomethrin	3.95	0.035	0.5(H)	L
resmethrin	4.17	0.062	—	—
decamethrin, Decis®	4.88	0.067	1.5(H)	NIL
Pay-Off®	3.37	0.078	0.5(M)	NIL
chlorpyrifos, Lorsban®, Dursban®	10.17	0.110	2-3.5(H)	M-MH
methyl parathion[1]‡	5.13	0.111	0.5(H)	H-VH‡
dieldrin[1]	2.51	0.133	1.5-5(H)	H
carbofuran[5], Furadan®	6.14	0.149	3>5(H)	M-H
permethrin[18], Ambush®, Pounce®	5.52	0.159	>5(VH)	L
parathion[1]	4.96	0.175	1(H)	H-VH
fenitrothion, Sumithion®	5.75	0.176	—	—
dimethoate[1], Cygon®, De-Fend®	5.84	0.191	1-3.5(H)	M-VH
methidathion[1], Supracide®	8.48	0.237	2.5(H)	MH
EPN[1]	4.31	0.237	1.5-3(H)	H
methyl parathion[1]‡, encapsulated, Penncap-M®	5.13	0.241	>5(H)	H-VH‡
etrimfos, Ekamet®	2.52	0.264	—	—
aldicarb[1,5,7], Temik®	5.00	0.272	NIL	NIL§
mexacarbate, Zectran®	4.87	0.302	3(H)	H
dicrotophos[1], Bidrin®	15.86	0.305	2-4(H)	M-MH
mevinphos[1,3], Phosdrin®	7.77	0.305	<1-1.5(H)	M-H
fenthion, Baytex®	6.14	0.319	—	—
fensulfothion[5], Dasanit®	4.78	0.337	—	—
aldrin	5.06	0.352	—	—
monocrotophos[1], Azodrin®	8.31	0.357	2-3.5(H)	MH-VH
diazinon, Spectracide®	8.03	0.372	1-2(H)	H
methiocarb, Mesurol®	3.35	0.372	—	—
fenvalerate, Pydrin®	4.46	0.408	1(L)	NIL
famphur, Famophos®	4.85	0.414	—	—
azinphos-methyl[1], Guthion®	7.43	0.428	5(H)	M-VH
bendiocarb, Ficam®	3.28	0.428	—	—
naled[3], Dibrom®	16.43	0.485	<1-1.5(H)	MH-VH
dichlorvos, DDVP, Vapona®	8.61	0.501	—	—
heptachlor[1], Drinox®	5.94	0.526	—	—
isofenphos, Amaze®, Oftanol®	6.61	0.606	—	—
carbosulfan, FMC-35001	4.69	0.678	3.5(H)	ML
malathion[4], Cythion®	7.83	0.726	1-2(M)	L-MH
azinphos-ethyl, Ethyl Guthion®	7.92	0.958	—	—
aminocarb, Matacil®	3.61	1.12	—	—
phosmet, Imidan®	3.55	1.13	3.5(H)	MH-VH

acephate, Orthene®	8.26	1.20	2.5(H)	M-MH
methomyl[5], Lannate®, Nudrin®	2.39	1.29	1.5(H)	L-M
propoxur, Baygon®	3.23	1.34	—	—
methamidophos, Monitor®	10.61	1.37	1(M)	LM
stirofos, Gardona®	13.96	1.39	3.5-5(L)	LM-M
fenamiphos[5], Nemacur®	5.25	1.43	—	—
phosphamidon, Dimecron®	12.74	1.45	2-5(M)	M-VH
carbaryl, Sevin®	3.04	1.54	3-7(H)	M-VH
bufencarb, Bux®	4.95	1.65	—	—
pyrazophos, Afugan®	3.48	1.85	—	—
arsenicals[1]	1.22	27.15	—	—

Group II—moderately toxic pesticides (LD_{50} = 2.0 to 10.99 μg/bee): These can be used in the vicinity of bees if dosage, timing, the method of application are correct, but should not be applied directly on bees in the field or at colonies. (Listed in order of toxicity to honey bees; first named is most toxic).

Pesticide* (trade and/or common name)	Laboratory data: Slope, probits	Laboratory data: LD_{50}	Field test data: Toxicity of residues to bees†: No. days	Field test data: Toxicity of residues to bees†: Hazard
temephos, Abate®	2.56	1.40	0-3(M)	L
demeton[1,18], Systox®	10.02	1.71	1(L)	L
trichloronate, Agritox®	4.28	2.00	—	—
endrin[1], Endrex®	4.06	2.04	1-3(M)	L-M
crotoxyphos, Ciodrin®	15.42	2.31	—	—
Pyramat®	5.08	2.62	—	—
oxydemeton-methyl, Metasystox-P®	2.49	2.86	0.5(L)	M-H
profenofos, Curacon®	5.96	3.46	—	—
terbufos, Counter®	3.54	4.09	—	—
ethylan, Perthane®	4.01	4.57	—	—
ethoprop, Mocap®	4.66	5.56	—	—
ronnel, Korlan®	2.11	5.62	—	—
disulfoton[1,6,18], Di-Syston®	1.19	6.12	1(L)	NIL
DDT[1,10]	4.74	6.19	1(L)	L
ethiofencarb, Croneton®	1.99	6.85	NIL	NIL
Larvin®, thiodicarb	3.52	7.08	NIL	ML
sulprofos, Bolstar®	5.53	7.22	—	—
endosulfan, Thiodan®	3.15	7.81	2(L)	L-MH
fonofos, Dyfonate®	4.87	8.68	—	—
chlordane	2.34	8.80	—	—
phosalone, Zolone®	3.67	8.97	—	—
formetanate hydrochloride, Carzo®	4.21	9.21	2(L)	L
phorate[1,6], Thimet®	1.27	10.25	<1-1(L)	L¶
oxamyl, Vydate®	5.81	10.26	3-4(H)	VH
carbophenothion, Trithion®	2.78	12.99	<1(M)	L
Sevin® SL, carbaryl	1.57	13.72	6(MH)	H
Primor®, pirimicarb	2.87	18.72	0.5(L)	L
Sevin® SLR, carbaryl	1.14	26.53	>6(H)	M
Mavrik®, fluvalinate	1.85	65.85	0.5(L)	L-ML

Source: *Toxicity of Pesticides to Honey Bees,* Leaflet 2286, and *Toxicity of Pesticides and Other Agricultural Chemicals to Honey Bees,* Leaflet 2287. (University of California Agricultural Sciences publications).

* See Table 1 for key to numbers 1-18.

† Toxicity of residue to honey bees: No. days = average time in days that residue is toxic to bees; Hazard = severity of the honey bee hazard (L = low; M = moderate, H = high, ML = moderately low, MH = moderately high, VH = very high. NIL = no toxicity and/or no hazard, — = no verified information available). NOTE: Night application (darkness until 4 A.M.) will reduce bee kill at least 50% and reduce bee hazard at least one category from sprays applied as early morning treatments (daylight to 7 A.M.); applications made after 7 A.M. will increase overall bee hazard approximately two times, raising the hazard to at least the next higher category.

‡ The encapsulated methyl parathion formulation, Penncap-M®, is highly toxic to foraging bees, young hive bees, and brood. Overall, it is 13 times more toxic to honey bee colonies than the EC formulation (emulsifiable concentrate). Penncap-M® is too hazardous to be applied to any area at any time when bees are present in the field or within 1 mile of the area to be treated.

§ Used only as soil application and/or as granules.

¶ When used as soil application of granules: No. days toxic, NIL; Hazard, NIL.

Table 3—Examples of Anticipated Honey Bee Mortality When a Pesticide With a LD_{50} Value of 1.0 is Applied at Selected Slope Values and Increasing and Decreasing Dosages

Slope value	Percent mortality at following dosage (lb/acre):									
	0.1	0.25	0.5	0.75	1.0	1.25	1.5	1.75	3.0	10.0
	Below LD_{50}				LD_{50}	Above LD_{50}				
2	3	12	28	42	50	57	64	68	82	97
4	-	1	12	32	50	66	72	82	96	-
6	-	-	2	17	50	76	91	97	-	-
16	-	-	-	3	50	93	-	-	-	-

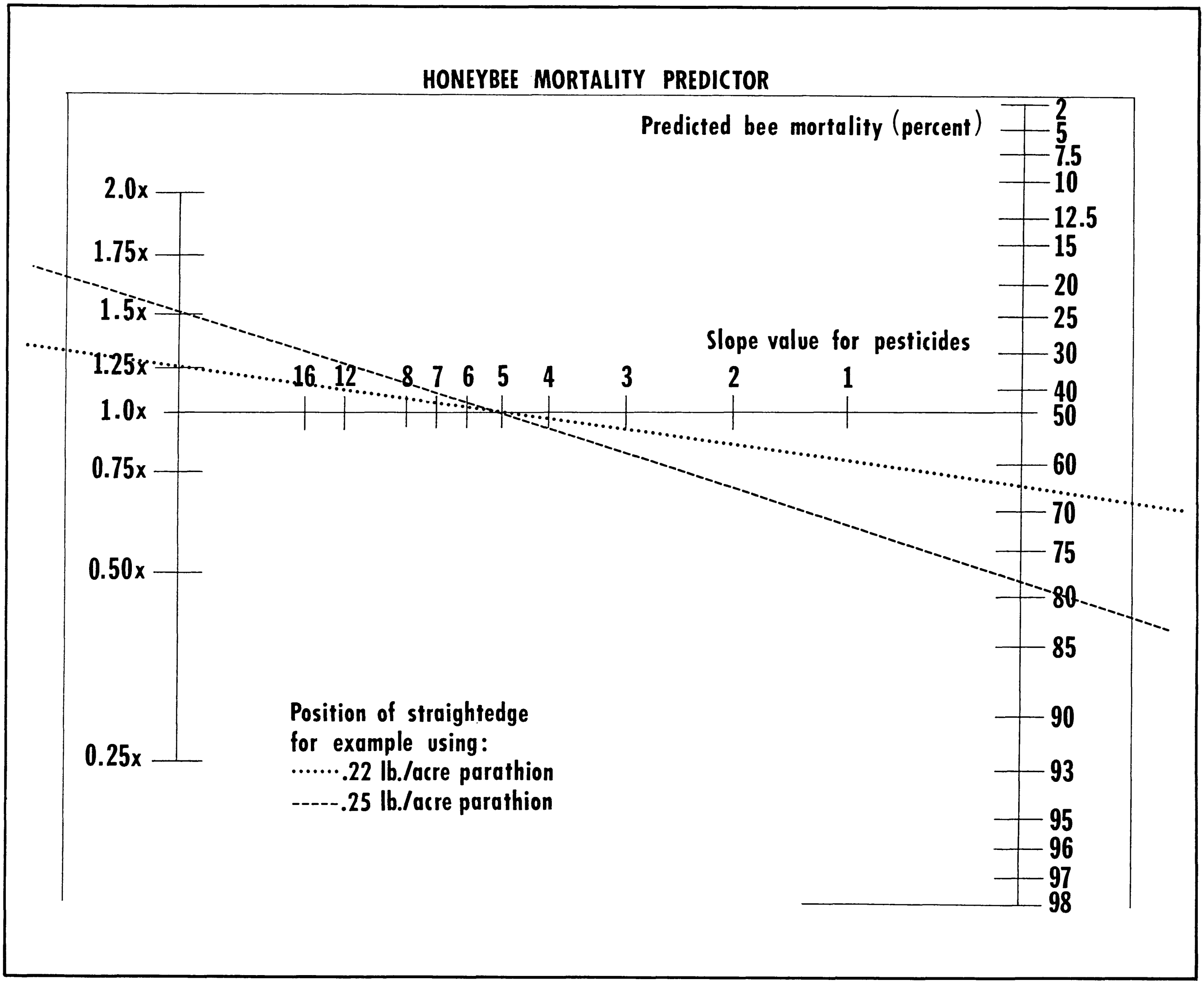

Figure 4.

HONEY BEE MORTALITY PREDICTOR

Instructions for Figure 4

A. Look up the LD_{50} in Table 2 for the pesticide you are going to use. Find this value, or the value closest to it in Section 1 below.

B. Read to the right on the same line into Section 2 and find the dosage, or the closest dosage to the one you intend to actually use in the field.

C. From the actual dosage (Section 2), read down the column into Section 3. This figure represents how much more or less than the LD_{50} your actual dosage is. Find this figure on vertical line of left side of the Predictor (Figure 4).

D. Look up the Slope Value in Table 2 for the pesticide you are going to use, and locate it on the Slope Value line on Figure 4.

E. Use a ruler or other straightedge to connect the point on the Dosage Factor line to the point on the Slope Value line in Figure 4. Extend the straightedge to intersect the vertical line on the right in the Predictor. At the point of intersection, you can read the predicted percent mortality of honey bees in the field for the type and dosage of pesticide you intend to use.

NOTE: By rotating your straightedge and working backwards, you can determine how much to lower the dosage to avoid serious bee kill.

(continued)

Section 1. LD$_{50}$ of pesticide (lb/acre-a.i.)	Section 2. Actual dosage you intend to use in pounds of active ingredient (a.i.) per acre							
0.175	0.04	0.09	0.13	0.175	0.22	0.26	0.31	0.35
0.30	0.08	0.15	0.23	0.30	0.38	0.45	0.53	0.60
0.40	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80
0.50	0.13	0.25	0.38	0.50	0.63	0.75	0.88	1.0
0.70	0.18	0.35	0.53	0.70	0.88	1.00	1.23	1.4
1.00	0.25	0.5	0.75	1.00	1.25	1.50	1.75	2.0
1.25	0.31	0.63	0.94	1.25	1.56	1.88	2.19	2.5
1.50	0.38	0.75	1.13	1.50	1.88	2.25	2.63	3.0
2.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
2.5	0.63	1.25	1.88	2.5	3.13	3.8	4.4	5.0
3.0	0.75	1.5	2.25	3.0	3.75	4.5	5.25	6.0
4.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0
5.0	1.25	2.5	3.8	5.0	6.3	7.5	8.8	10.0
6.0	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0
7.5	1.9	3.8	5.6	7.5	9.4	11.0	13.0	15.0
10.0	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0
	Section 3. Factor representing how much more or less than the LD$_{50}$ you intend to use							
	0.25x	0.5x	0.75x	1.0x	1.25x	1.5x	1.75x	2.0x

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This report is authorized by law *(7 U.S.C. 135)*. Although you are not required to respond, your cooperation will help assure that our information is comprehensive, accurate, and timely. Use Section X on the reverse for a brief description of the circumstances leading to the incident and for additional comments. Please read the instructions before completing this report.

SECTION I – IDENTIFICATION

NAME OF REPORTER	ASSOCIATION/AGENCY	DATE OF INCIDENT	DATE OF REPORT

ADDRESS *(street, city, state, and ZIP code)*	PHONE NO.	LOCATION OF INCIDENT *(city, county, and state)*
	( )	

SECTION II – PESTICIDE DESCRIPTION

IF MORE THAN ONE PRODUCT INVOLVED, CHECK HERE ☐ AND LIST ON BACK.	PRODUCT TRADE NAME	EPA REGISTRATION NUMBER
		— —
	ACTIVE INGREDIENTS	

TYPE OF PESTICIDE		FORMULATION OF PESTICIDE	
☐ INSECTICIDE	☐ UNKNOWN	☐ BAIT	☐ EMULSIFIABLE CONCENTRATE
☐ HERBICIDE	☐ OTHER *(specify)*:	☐ DUST	☐ TECHNICAL GRADE
☐ FUNGICIDE		☐ GRANULATED	☐ AEROSOL
☐ RODENTICIDE		☐ WETTABLE POWDER	☐ UNKNOWN
☐ DISINFECTANT		☐ LIQUID	☐ OTHER *(specify)*:

SECTION III – HOW EXPOSED	SECTION IV – CIRCUMSTANCE	SECTION V – LOCATION
☐ ACCIDENTAL INGESTION	☐ HOUSEHOLD USE	☐ HOME OR YARD AREA
☐ ACCIDENTAL SPILL	☐ FORMULATION, MIXING, OR LOADING	☐ AGRICULTURALLY RELATED AREA
☐ SPRAY DRIFT	☐ APPLICATION: GROUND*(1)*; AERIAL*(2)*	☐ INDUSTRIALLY RELATED AREA
☐ EQUIPMENT FAILURE/MAINTENANCE	☐ FIELD REENTRY	☐ BUILDING: OFFICE, SCHOOL, ETC.
☐ SUICIDE OR HOMICIDE ATTEMPT	☐ DISPOSAL*(1)*; TRANSPORTATION*(2)*	☐ POND, LAKE, STREAM OR RELATED AREA
☐ UNKNOWN	☐ FIRE*(1)*; FLOOD*(2)*; OTHER DISASTER*(3)*	☐ NURSERY OR GREENHOUSE
☐ OTHER *(specify)*:	☐ UNKNOWN	☐ UNKNOWN
	☐ OTHER *(specify)*:	☐ OTHER *(specify)*:

SECTION VI – HUMAN(S) EXPOSED

	SEX (M=male; F=female)	AGE (years)	OUTCOME: POSSIBLY EXPOSED; NO SYMPTOMS	SYMPTOMS, NOT TREATED (by M.D.)	TREATED BY PHYSICIAN	TREATED IN EMERGENCY ROOM	HOSPITALIZED	FATAL	OUTCOME UNKNOWN	MAJOR SYMPTOMS: NO SYMPTOMS	HEADACHE	NAUSEA OR VOMITING	DIFFICULTY BREATHING	ABDOMINAL PAIN AND/OR DIARRHEA	SKIN OR EYE IRRITATION	DIZZINESS	SYMPTOMS UNKNOWN	OTHER SYMPTOMS (specify on reverse)	PRIMARY ROUTE OF EXPOSURE: ORAL	DERMAL	INHALATION	PRIMARY ROUTE UNKNOWN	PHYSICIAN DIAGNOSIS OF PESTICIDE POISONING	LAB TESTS DONE (1=yes; 2=no)	AT WORK WHEN EXPOSED	CERTIFIED APPLICATOR	OCCUPATION *(specify)*:
1																											
2																											
3																											
4																											

SECTION VII – ANIMAL(S) EXPOSED

TYPE: ☐ LIVESTOCK ☐ POULTRY ☐ WILDLIFE ☐ BIRDS ☐ FISH ☐ PETS ☐ BEES ☐ OTHER *(specify)*:

COMMON NAME(S)	NO. EXPOSED	NO. AFFECTED	NO. TREATED	NO. FATALITIES	WERE LAB TESTS DONE?
					☐ YES ☐ NO ☐ UNKNOWN

PRIMARY ROUTE OF EXPOSURE	LIST MAJOR SYMPTOMS
☐ ORAL ☐ DERMAL ☐ INHALATION ☐ UNKNOWN	

SECTION VIII – PLANTS EXPOSED

TYPE: ☐ CROP ☐ ORCHARD ☐ FORESTS ☐ NURSERY/GREENHOUSE ☐ PASTURE/RANGE ☐ HOME VEGETABLE GARDEN
☐ LAWN ☐ FLOWERS ☐ TREES ☐ COMMERCIAL TURF ☐ SHRUBS ☐ OTHER *(specify)*:

COMMON NAME(S)	WERE LAB TESTS DONE?	AMOUNT OF PLANTS *(number, acres, 20 foot rows, bushels, etc.)*
	☐ YES ☐ NO ☐ UNKNOWN	

SECTION IX – MEDIUM OR OBJECT CONTAMINATED

☐ WATER ☐ FOOD ☐ VEHICLE ☐ BUILDING ☐ SOIL ☐ OTHER *(specify)*:

AMOUNT OF AREA CONTAMINATED *(specify units of measure)*	DESCRIBE WHAT WAS CONTAMINATED

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