Appendix K. Terrestrial Ecological Effects Data

This appendix is a summary of the data evaluated for ecological effect on terrestrial organisms. Each section consists of several sets of data. Tables presenting the data submitted with the application for registration are presented first. The lowest value from this data is used to set a "benchmark" that was used in evaluating the data from the open literature—from EPA's ECOTOX database. Only the studies associated with the ECOTOX database that have values less than these benchmarks are examined further. If any of these latter values are acceptable, then that value becomes the final value in the risk assessment for that particular taxonomic group.

I. Acute Exposure Studies with Birds

Submitted Data for Avian Acute Oral Toxicity

An acute oral toxicity study using the technical grade of the active ingredient (TGAI) is required to establish the toxicity of endosulfan to birds. The preferred test species is either mallard duck (a waterfowl) or bobwhite quail (an upland game bird). Since the LD50 for mallard ducks (28 mg/kg), falls in the range of 10 to 50 mg/kg, endosulfan is categorized as highly toxic to avian species on an acute oral basis (Table K-1). The avian acute oral toxicity study requirement (Guideline 71-1) is fulfilled (MRID 137189, 136998, 160000).

Table K-1 Summary of avian acute oral toxicity data for endosulfan

Species	% ai	LD50 (mg/kg)	Toxicity Category	MRID No./ Author Year	Study Classification[1]
Northern bobwhite quail *(Colinus virginianus)*	97.2	42	highly toxic	137189/ Roberts and Phillips 1983	acceptable
Mallard duck *(Anas platyrhynchos)*	97.2	28	highly toxic	136998/ Roberts and Phillips 1983	acceptable
Mallard duck *(Anas platyrhynchos)*	96	33	highly toxic	160000/ Hudson et al. 1984	acceptable
Mallard duck *(Anas platyrhynchos)*	96	31.2	highly toxic	160000/ Hudson et al. 1984	acceptable
Mallard duck *(Anas platyrhynchos)*	96	45	highly toxic	160000/ Hudson et al. 1984	acceptable
Ring-necked pheasant *(Phasianus colchicus)*	96	<160	not categorized	160000/ Hudson et al. 1984	acceptable

Species	% ai	LD50 (mg/kg)	Toxicity Category	MRID No./ Author Year	Study Classification[1]
Ring-necked pheasant *(Phasianus colchicus)*	96	190	moderately toxic	160000/ Hudson et al. 1984	acceptable
Ring-necked pheasant *(Phasianus colchicus)*	96	>320	not categorized	160000/ Hudson et al. 1984	acceptable

Two subacute dietary studies using the TGAI are required to establish the toxicity of endosulfan to birds. The preferred test species are mallard duck and bobwhite quail. Since the LC50 for quail, i.e., 805 ppm, falls in the range of 501 to 1,000 ppm, endosulfan is categorized as moderately toxic to avian species on a subacute dietary basis (Table K-2) The avian subacute dietary toxicity testing requirement (Guideline 71-2) is fulfilled (MRID 22923).

Table K-2. Summary of avian subacute dietary toxicity data on endosulfan

Species	% ai	5-Day LC50 (ppm)[a]	Toxicity Category	MRID No./ Author Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*	96	805	moderately toxic	22923/ Hill et al. 1975	acceptable
Mallard duck *(Anas platyrhynchos)*	96	1,053	slightly toxic	22923/ Hill et al. 1975	acceptable
Ring-necked pheasant *(Phasianus colchicus)*	96	1,275	slightly toxic	22923/ Hill et al. 1975	acceptable
Japanese quail *(Coturnix japonica)*	96	1025	slightly toxic	22923/ Hill et al. 1975	supplemental

[a]Test organisms observed an additional three days while on untreated diet.

Results from registrant-submitted studies on the toxicity of endosulfan sulfate to avian species are summarized in (Table K-3). Based on the comparison of parent endosulfan and sulfate degradate acute dietary toxicity with bobwhite quail and mallard duck, endosulfan sulfate appears about equal in toxicity to waterfowl (mallard) and at least a factor of 4 less toxic to game birds (quail).

Table K-3. Comparison of acute toxicity of endosulfan and endosulfan sulfate to birds.

	Acute Oral Toxicity				Acute Dietary Toxicity			
	Endosulfan		Endosulfan Sulfate		Endosulfan		Endosulfan Sulfate	
Species	LD50 (ppm)	Toxicity Category (MRID)	LD50 (ppm)	Toxicity Category (MRID)	5-day LC50 (ppm)	Toxicity Category (MRID)	5-day LC50 (ppm)	Toxicity Category (MRID)
Northern bobwhite quail (*Colinus virginianu)s*	--	--	44	highly toxic 46430501/ Stoughton 2004	805	moderately toxic 22923	>3528	46430502[a]/ Sabbert 2004
Mallard duck (*Anas platyrhynchos)*	28	highly toxic 136998	---	--	1053	slightly toxic 22923	1642	46382601/ Christ & Larn 2004

[a]Study classified as supplemental.

Additional Open Literature (ECOTOX) Data for Avian Acute Oral Toxicty

There were no additional acceptable open literature studies that were lower than the bird acute benchmark of 28 mg/kg.

II. Chronic Exposure Studies With Birds

Registrant Submitted Data for Avian Reproductive Toxicity

Avian reproduction studies using the TGAI are required for endosulfan because the following conditions are met: (1) birds may be subject to repeated or continuous exposure to the pesticide, especially preceding or during the breeding season, (2) the pesticide is stable in the environment to the extent that potentially toxic amounts may persist in animal feed, (3) the pesticide is stored or accumulated in plant or animal tissues, and/or, (4) information derived from mammalian reproduction studies indicates reproduction in terrestrial vertebrates may be adversely affected by the anticipated use of the product. The preferred test species are mallard duck and bobwhite quail. In chronic toxicity studies of technical grade endosulfan involving mallard ducks (MRID 40335001), at 64 ppm there were treatment related effects upon reproductive parameters (reduction in the number of eggs laid and hatchability), adult body weight and feed consumption (Table K-4). The guideline (71-4) is fulfilled (40335001, 40335002, 146843).

Table K-4. Summary of avian reproductive toxicity studies using technical grade endosulfan.

Species/ Study Duration	% ai	NOEC/LOEC (ppm)	LOEC Endpoints	MRID No. Author/Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*/ 27 weeks	96	NOEC = 64 LOEC = 134	Increase in # of cracked eggs	40335002/ Beavers et al. 1987a	acceptable
Mallard duck *(Anas platyrhynchos)*/ 22 weeks	96	NOEC = 30 LOEC = 64	Eggs laid, eggs set, embryo viability	40335001/ Beavers et al. 1987b	acceptable
Mallard duck *(Anas platyrhynchos)*	tech	NOEC <30		146843/ Roberts et al. 1985	supplemental

Additional Open Literature (ECOTOX) Data for Avian Acute Oral Toxicty

There were no additional acceptable open literature studies that were lower than the bird chronic benchmark of 30 ppm endosulfan in the diet.

III. Acute and Chronic Exposure Studies With Mammals

Submitted Data for Mammals

Wild mammal testing is required on a case-by-case basis, depending on the results of lower tier laboratory mammalian studies, intended use pattern and pertinent environmental fate characteristics. In most cases, rat or mouse toxicity values obtained from the Agency's Health Effects Division (HED) substitute for wild mammal testing. The acute oral LD50 values for the laboratory rat (*Rattus norvegicus*) were 10 and 40 mg/kg for females and males, respectively (MRID 38307). Since acute toxicity estimates fall in the range of 10 to 50 mg/kg, endosulfan is classified as highly toxic on an acute exposure basis. A two-generation rate reproduction study measured the NOAEC and LOAEL as 15 and 75 ppm, respectively, with decreased body weight as the most sensitive endpoint (MRID 148264).

Endosulfan was evaluated for acute oral toxicity in male and female rats according to the criteria of the Federal Hazardous Substances Act, 16 CFR, part 1500.3. Six groups of five male and eight groups of five female albino rats were fed test material administered orally. Males received dosage levels of 15.9, 25.1, 39.8, 63.1, and 100.0 mg/kg. Females received dosages levels of 3.98, 6.31, 10.0, 15.9, 25.1, 39.8, 63.1, and 100.0 mg/kg. Rats of all groups were monitored for mortality and signs of toxicosis immediately after dosing, at one and four hours post-dosing, and once daily thereafter for a total of 14 days. The acute oral LD50 was calculated to be 40.38 and 9.58 mg/kg of body weight for the male and female rats, respectively. Endosulfan is considered to be highly toxic to mammals.

Chronic effects of endosulfan on reproductive performance and development of the rat was determined through continuously administered, dietary concentrations of 0 (control), 3, 15, and 75 ppm. This study comprised two adult generations (F0 and F1B) with two mating phases in each.

Among parent animals at 75 ppm there were no mortalities in either generation, no signs attributed to treatment, and no consistent effect on food or water comsumption. Weekly bodyweight gain of F0 generation females and of F1B males and females was marginally lower than among control animals, but generally the differences were not statistically significant. At termination there was a clear tendency in both generations for slightly increased mean liver weight among males and females and for slightly increased kidney weight among males. However, in the absence of any treatment –related microscopic changes among tissues from F1B adults, the differences in liver and kidney weights were considered to represent a marginal effect of treatment.

There was no adverse effect on mating performance, pregnancy rate, or the mean duration of gestation, in either generation. In both generations litter parameters at birth appeared essentially unaffected by treatment. However, through lactation to weaning there were consistently lower litter weight, and for both matings of the F0 generation differences from control values were statistically significant. This tendency occurred in the absence of a consistent underlying pattern of differences among values for pup weight or litter size and pup mortality, which generally appeared unaffected by treatment. The no observable effect level for this endpoint was 15 ppm, with a lowest observable effect concentration of 75 ppm.

Among offspring there was no clear effect on incidences of macroscopic changes at autopsy and no consistent effect on organ weights. Microscopic examination of tissues from F2B weanlings showed no changes considered attributable to treatment.

Additional Open Literature (ECOTOX) Data for Mammals

There were not additional acceptable open literature studies that reported acute oral LC50 values less than that presented above. There also were no data comparable to that from the reproductive study above. However, there were two studies listed in the ECOTOX database that provide some supplemental LC50 data for both mice (*Mus musculus*) and rats (*Rattus norvegicus*). In the first study, Chugh et al. (1991—ECOTOX reference # 93211) injected Swiss albino mice intraperitoneally with various doses of a commercial end-use product of endosulfan (35% EC). The 24-h LD50 was 4.9 mg/kg. Ten animals were used per dose; however, the number of treatments and the control mortality were not reported. The second study (Gupta 1976—ECOTOX reference #103467) also exposed animals via intraperitoneal injection of endosulfan, but the source of the endosulfan was not given. The author only used four animals per treatment and only four dose levels. Both mice (*Mus musculus*) and rats (*Rattus norvegicus*) were used, and animals were observed for 7 days after injection. For both species endosulfan was more toxic with alcohol as the vehicle then with 10% alcohol in ground nut oil (Table K-5). As with the submitted data above, female rats were more sensitive than males; however with mice there was no gender difference in sensitivity to endosulfan.

Table K-5. Summary of results for rats and mice from Gupta 1976—ECOTOX #103467.

Species	Sex	Vehicle	LD50 (mg/kg)
Rat	F	alcohol	22.1
	M	alcohol	46.7
	F	10% alcohol in ground nut oil	48.6
	M	10% alcohol in ground nut oil	89.4
Mouse	F	alcohol	7.5
	M	alcohol	6.9
	F	10% alcohol in ground nut oil	13.5
	M	10% alcohol in ground nut oil	12.6

Although there were no studies from the open literature comparable to the two-generation rat study listed in the last section, there were several reports in the ECOTOX database that evaluated sub-lethal effects. A 24 month dietary exposure of rats (*Rattus norvegicus*) and mice (*Mus musculus*) examined effects on survival, growth and carcinogenic potential (Hack et al. 1995—ECOTOX reference #103384). Effects on reproduction were not examined. The authors also concluded, based on a variety of organs and tumor types, that endosulfan has no carcinogenic potential in rats or mice. Rats were fed diets containing endosulfan (96.7% purity) at 0, 3, 7.5, 15, or 75 ppm. There were 50 rats per treatment group, and there was no effect on survival of either males or females due to endosulfan treatment. However, males fed the highest concentration were only 83% of the body weight of control males, and females from this treatment group were 82% of the final body weight of control females. The authors concluded that the no-effect-level-for rats was 15 ppm based on weight. Mice were fed diets containing endosulfan at 0, 2, 6 or 18 ppm. There were 60 mice per treatment group, and there was no statistical significant effect on growth in mice with any endosulfan treatment. Survival in females was significantly less than the controls at the highest treatment level (45% survival in controls vs. 28% at 18 ppm). There was no statistically significant effect on survival in males, but their survival rate was less at the highest treatment levela (55% survival in controls vs. 42% survival at 18 ppm). The authors concluded that the no-effect-level-for rats was 15 ppm based on weight, and the NOEL for mice was 6 ppm, based on survival.

Two other studies exposed rats via oral intubation to various concentrations of technical grade endosulfan using either peanut oil (Sinha et al. 1995—ECOTOX reference # 103592) or olive oil (Singh et al., 2007—ECOTOX reference # 103238). The first study

used three-month-old Druckrey rats (*Rattus norvegicus*) and exposed four groups of 15 male rats to endosulfan (95.3% purity) at 0, 2.5, 5.0 and 10 mg/kg body weight. Doses were given 5 days a week for a total period of 70 days. Mean sperm count at the end of the 70 days was significantly reduced relative to the controls with all three treatments (78, 56, and 53% of the controls at 2.5, 5.0 and 10 mg/kg, respectively). Sperms counts were based on five animals from each group. The other animals were used to evaluate the concentrations of various enzymes associated with male reproduction. The authors concluded that endosulfan impairs testicular function by altering the enzyme activities responsible for spermatogenesis.

The second oral intubation study (ECOTOX # 103238) exposed sexually mature female Wistar rats (ca. 180 g) to endosulfan (>99.98% purity) at the rate of 1 mg/kg body weight. Treatments were given to pregnant rats from day 6 to day 20 of pregnancy. There were 10 females per treatment. The endosulfan treated animals weighed significantly less than the controls, as well as had a significant decrease in the percentage of live fetuses. In addition, the weight of the fetuses was less in the endosulfan treatment. Finally, there was about a 10% rate of fetal abnormalities in the endosulfan treatment compared to no abnormalities observed in the controls.

IV. Terrestrial-phase Amphibians and Reptiles

There were no acceptable studies available for the effect of endosulfan on terrestrial-phase amphibians or reptiles. One study listed in ECOTOX used juvenile leopard frogs (Christin, et al. 2003—ECOTOX reference # 70218); however the frogs were exposed to endosulfan as part of a mixture of six different pesticides. There was also a study in the database using eggs of the broad-snouted caiman (*Caiman latirostris*). Eggs were treated with a single dose of 1.5, 150 or 1500 μg endosulfan/egg (technical grade 96.3% purity). There was no effect on sex ratio due to any treatment. In addition, there was only a difference of a few percent relative to controls for changes in egg weight between treatment and hatch (40 to 49 days) or in the weight of hatchlings expressed as a percent of initial egg weight (Beldomenico, et al. 2007—ECOTOX reference # 103221).

V. Beneficial Insects--Acute Exposure Studies on Honey Bees

Submitted Data for Beneficial Insects

A honey bee acute contact study using the TGAI is required for endosulfan because its use will result in honey bee exposure. The acute contact LD50, using the honey bee *Apis mellifera* is a single-dose laboratory study designed to estimate the quantity of toxicant required to cause 50% mortality in a test population of bees. The TGAI is administered by one of two methods: whole body exposure to technical grade in a non-toxic dust diluent; or topical exposure to technical grade via micro-applicator. The median lethal dose (LD50) is expressed in micrograms of active ingredient per bee. Results of these tests are tabulated below (Table K-5). The acute contact toxicity study requirement (Guideline 141-1) is fulfilled. Toxicity category descriptions for honey bee acute contact toxicity are the following:

If the LD50 is less than 2 ug a.i./bee, then the test substance is *highly toxic.*

If the LD50 is between 2 and 11 ug a.i./bee, then the test substance is *moderately toxic.*
If the LC50 is 11 ug a.i./bee or greater, then the test substance is *practically non-toxic.*

The acute oral LC50 for the honey bee *Apis melliferai* is a single-dose laboratory study designed to estimate the quantity of toxicant required to cause 50% mortality in a test population of bees. The TGAI is administered by feeding bees the technical pesticide in a sugar water (and possibly solvent) solution using a feeding tube inserted into a cage. The LD50 is expressed in micrograms of active ingredient per bee. Results of this test also are tabulated in Table K-5. The Office of Pesticides Programs (OPP) does not have a categorization scheme for acute oral toxicity to honey bees. However, the following scheme based on ICBB (1985) categorization is provided for informational purposes:

If the LD50 is less than 1.0 ug a.i./bee, then the test substance is *highly toxic.*
If the LD50 is between 1.0 and 10 uga.i./bee, then the substance is *moderately toxic.*
If the LD50 is between 10 and 100 ug a.i./bee, then the substance is *slightly toxic.*
If the LD50 is greater than 100 ug a.i./bee, then the test substance is *virtually non-toxic.*

A honey bee foliar residue toxicity study is required on an end-use produce for any pesticide intended for outdoor application when the proposed use pattern indicates that honey bees may be exposed to the pesticide and when the formulation contains one or more active ingredients having an acute contact honey bee LD50 which falls in the moderately toxic or highly toxic range. Usually, pesticides toxic to honey bees require precautionary labeling specific to bees on all end-use formulations and registrants are required to submit data in accordance with Guideline 141-2 (Honey Bee Toxicity Residues on Foliage). The purpose of this guideline study is to develop data on the residual toxicity to honey bees. Bee mortality determinations are made from bees exposed to treated foliage harvested at various time periods after treatment. The avaiable study on foliar residue toxicity for endosulfan are listed in Table K-5.

Table K-5. Summary of foliage reside toxicity studies for honey bees (*Apis mellifera*) using endosulfan.

Type of Study	% a.i.	LD/LC50 (µg a.i./bee)/duration	Category	Reference	Study Classification
Acute contact	tech	7.1 24 hr	moderately toxic	MRID 05004151/ Stevenson 1968	acceptable
Acute contact	tech	4.5	moderately toxic	MRID 0001999/Atkins and Anderson 1967	acceptable
Acute oral	tech	6.9 24 hr	moderately toxic	MRID 05004151/ Stevenson 1968	acceptable

Type of Study	% a.i.	LD/LC50 (µg a.i./bee)/duration	Category	Reference	Study Classification
Foliar residue	35 EC	> 0.77 lb/a (0% mortality at this rate after 24 hr)	--	MRID 05008936/ Cinch 1967	supplemental
Foliar residue	17.5	> 1.10 lb/a (15 bees dead after 5 days out of ca. 4500 bees exposed)[a]	--	MRID 05012881/ Gorecki 1973	supplemental

[a]Original value listed as 7.00 kg/ha of commercial preparation.

Additional Open Literature (ECOTOX) Data for Honey Bees

There was one additional study from the open literature that presented data on the acute contact toxicity of endosulfan to honey bees, *Apis mellifera* (Kumar and Kumar 1994—ECOTOX reference # 91623).These authors present the LD50s for 14 tests with technical grade endosulfan using a micro-applicator. The LC50s ranged from 4.43 to 9.50 ug a.i./bee with a geometric mean of 5.83 ug a.i./bee.

VI. Additional Open Literature Information on Non-Target Terrestrial Invertebrates

The ECOTOX database was examined for toxicity data using non-target species with endpoints expressed in terms similar to those for the standard test with honey bees. The stingless bee and Indian honey bee (Table K-6) were more sensitive than the standard honey bee in comparable tests (Macieira and Hebling-Beraldo 1989—ECOTOX reference #51755; Kumar and Kumar 1994—ECOTOX reference # 91623). However, both of these bees are smaller than the traditional honey bee. Three different foliar residue studies using three different species of parasitic wasps also are listed in Table K-6. Significant mortality occurred at the reported application rates (0.50 to 1.50 lb/a).

Several studies listed in the ECOTOX database used earthworms as the test organism. Mosleh et al (2003—ECOTOX reference # 86741; note this is the same data that the authors also report in Mosleh et al. 2002—ECOTOX reference #87129) report LC50s using a commercial end-use product mixed with natural soil for the earthworm *Lumbricus terrestris*. The LC50s declined as the duration of exposure increased.

Table K-6. Additional Open Literature Information on Non-Target Terrestrial Invertebrates.

Species	Type of Study/Duration	% a.i.	Effect	Reference	Study Classification
Stingless bee (*Trigona spinipes*)	Acute contact 24 hr	tech	LC50 = 0.2097 ug a.i./bee[a]	Macieira and Hebling-Beraldo 1989/ECOTOX 51755	supplemental
Indian Honey Bee (*Apis cerana indica*)	Acute contact 24 hr	tech	LD50 = 1.60 ug a.i./bee	Kumar and Kumar 1994/ ECOTOX 91623	supplemental
Indian Honey Bee (*Apis cerana indica*)	Acute contact 24 hr	tech	LD50 = 1.15 ug a.i./bee	Kumar and Kumar 1994/ ECOTOX 91623	supplemental
Indian Honey Bee (*Apis cerana indica*)	Acute contact 24 hr	tech	LD50 = 1.40 ug a.i./bee	Kumar and Kumar 1994/ ECOTOX 91623	supplemental
Indian Honey Bee (*Apis cerana indica*)	Acute contact 24 hr	tech	LD50 = 1.34 ug a.i./bee	Kumar and Kumar 1994/ ECOTOX 91623	supplemental
Indian Honey Bee (*Apis cerana indica*)	Acute contact 24 hr	tech	LD50 = 1.23 ug a.i./bee	Kumar and Kumar 1994/ ECOTOX 91623	supplemental
Indian Honey Bee (*Apis cerana indica*)	Acute contact 24 hr	tech	LD50 = 1.58 ug a.i./bee	Kumar and Kumar 1994/ ECOTOX 91623	supplemental
Indian Honey Bee (*Apis cerana indica*)	Acute contact 24 hr	35% EC	LC50 = 0.513 ug a.i./bee[a]	Lingappa et al. 1985/ECOTOX 94337	supplemental
Parasitic wasp (*Cotesia marginiventris*)	Foliar residue 24 hr	Thiodan (% not given)	100% mortality at 0.93 lb/a[b]	Tillman and Scott 1997/ ECOTOX 64166	supplemental
Parasitic wasp (*Catolaccus grandis*)	Foliar residue 72 hr	3 EC (% not given)	females: 37.5 % mortality/ males: 83.3% mortality after at 1.5 lb/a[b]	Elzen et al. 2000/ ECOTOX 58583	supplemental

Species	Type of Study/Duration	% a.i.	Effect	Reference	Study Classification
Parasitic wasp (*Trichogramma pretiosum*)	Foliar residue 24 hr	not given	90% mortality after aging 1 da; 30% mortality after aging 3 da; no effect on mortality after aging 7 da of 0.50 lb/a[b]	Jacobs et al. 1984/ ECOTOX 37276	supplemental
Earthworm (*Lumbricus terrestris*0	soil exposure 2 da	35%	LC50 = 12.29 mg/kg	Mosleh et al. 2003/ ECOTOX 86741	supplemental
Earthworm (*Lumbricus terrestris*0	soil exposure 7 da	35%	LC50 = 5.82 mg/kg	Mosleh et al. 2003/ ECOTOX 86741	supplemental
Earthworm (*Lumbricus terrestris*0	soil exposure 15 da	35%	LC50 = 3.36 mg/kg	Mosleh et al. 2003/ ECOTOX 86741	supplemental

[a]Presumed to be active ingredient since table used endosulfan, but authors did not explicitly state.
[b]Originally expressed as kg/ha.

VI. Additional Open Literature Information on Targeted Insects

No data have been submitted to the Agency that evaluates the effect of endosulfan on targeted insects. There are; however, numerous studies available from the open literature (Table K-7). These data are from EPAs ECOTOX database and were selected because they were from studies conducted using methods similar to those using the standard honey bee. These studies also represent insects more closely related to the listed insects (bay checkerspot butterfly and valley elderberry longhorn beetle) than the more traditionally tested honey bee. As expected, overall these studies show that applications of formulated endosulfan are likely to reduce the numbers and possibly eliminate populations of arthropods.

There was one additional study using flea beetle adults (*Phyllotreta cruciferae*) collected from the field (Weiss et al. 1991—ECOTOX reference #89123). This was a foliar residue study using a formulated end use product and reported a 48 h LC50 value of 0.75 lb a.i./acre (original value based on kg/h).

Table K-7. Additional Open Literature Information on Target Insects

Species/life stage	Source	Type of Study/ Duration	% a.i.	LD50 (n)	units	Reference
Cotton bollworm [a] (*Helicoverpa armigera*) 30-40 mg F1 larvae	laboratory reared	acute contact/ 6 d	94	16.9 (4)	µg a.i./g[f]	Armes et al. 1996/ECOTOX 74171
Cotton bollworm (*Helicoverpa armigera*) 30-40 mg F1 larvae	field collected	acute contact/ 6 d	94	82.9 (47)	µg a.i./g[f]	Armes et al. 1996/ECOTOX 74171
Cotton bollworm (*Helicoverpa armigera*) 3rd instar larvae	laboratory reared	acute contact/ 6 d	96	20.9 (4)	µg a.i./g[f]	Kranth, et al. 2002/ECOTOX 66869
Cotton bollworm (*Helicoverpa armigera*) 3rd instar larvae--30-40 mg	laboratory reared	acute contact/ 3 d	commercial formulation	37.1 (3)	µg a.i./g[f]	Buès et al. 2005/ECOTOX 87785
Cotton bollworm (*Helicoverpa armigera*[d]) 4th instar larvae	laboratory reared	acute contact/24 h	tech [b]	25.8	µg/g	Leonova and Slynko 1996/ECOTOX 103049
Cotton bollworm (*Helicoverpa armigera*[d]) Adult moth	laboratory reared	acute contact/24 h	tech [b]	3.14	µg/g	Leonova and Slynko 1996/ECOTOX 103049
Cotton bollworm (*Helicoverpa armigera*) 20-30 mg larvae	laboratory reared--reference site	acute contact/ 6 d	95	1.8	µg a.i./g	Wu and Guo 2004/ECOTOX 101076
Cotton bollworm (*Helicoverpa armigeria*) 20-30 mg F1-F9 larvae	laboratory reared--contanimated site	acute contact/ 6 d	95	14.8 (4)	µg a.i./g	Wu and Guo 2004/ECOTOX 101076
Cotton bollworm (*Helicoverpa armigera*) 20-30 mg F17-F33 larvae	laboratory reared--contanimated site	acute contact/ 6 d	95	5.5 (3)	µg a.i./g	Wu and Guo 2004/ECOTOX 101076
Cotton bollworm (*Helicoverpa armigera*) 20-30 mg F38 & F44 larvae	laboratory reared--contanimated site	acute contact/ 6 d	95	1.1 (2)	µg a.i./g	Wu and Guo 2004/ECOTOX 101076
Cotton bollworm (*Helicoverpa armigera*) 30-40 mg 3rd instar larvae	laboratory reared--F1	acute contact/48 h	Thiodan (35% EC) [b]	48.0 (35)	µg/g[f]	Torres-Vila, et al 2002/not in ECOTOX

Species/life stage	Source	Type of Study/ Duration	% a.i.	LD50 (n)	units	Reference
Beet webworm (*Pyrausta sticticalis*), Adult moths	laboratory reared	acute contact/24 h	100	0.15	µg a.i./g	Leonova and Slynko 2004/ECOTOX 100430
Beet webworm (*Pyrausta sticticalis*), fifth instar larvae	laboratory reared	acute contact/24 h	100	263	µg a.i./g	Leonova and Slynko 2004/ECOTOX 100430
Beet armyworm (*Spodoptera exigua*) larvae, 25 mg	laboratory reared—F1	acute contact/3d	100	0.36	µg a.i./g[g]	Naveed et al. 2002/ECOTOX 81618
Tobacco budworm (*Heliothis virescens*), 25 mg 3rd instar larvae	laboratory reared--F1 or F2	acute contact/ 3d	tech [b]	100 (7)	µg/g[b,g]	Terán-Vargas et al. 2005/ECOTOX 96523
Colorado potato beetle (*Leptinotarsa decemlineata*), 4th stage	laboratory reared	acute oral/3d	tech [b]	4.27	µg/g[b]	McDonald 1976/ECOTOX 52052

[a] also known as corn earworm, tobacco budworm, old world budworm.
[b] not certain if the results are based on active ingredient.
[d] formerly *Heliothis armigera*.
[e] concentration of foliar spray.
[f] calculated using authors original data in ug/larva using an average larva weight of 0.035 g.
[g] calculated using authors original data in ug/larva using an average larva weight of 0.025 g.

VII. Terrestrial Plants

No data have been submitted to the Agency to evaluate the effects of endosulfan on terrestrial plants because historically, terrestrial plant toxicity studies and associated risk analysis of plants were not required for registration of a pesticide unless it met specific use and pesticide classification criteria which would trigger potential concerns. In addition to the lack of registrant-submitted data, no studies demonstrating significant adverse effects of endosulfan to any terrestrial plant have been identified in the open literature. Although a number of studies involving terrestrial plants and endosulfan were identified in the open literature, none of these studies provide reliable estimates of toxicity that may be used in this risk assessment. Reasons that these studies were deemed unacceptable for use were primarily because these studies were associated with efficacy studies in which observations were confounded by the presence of an insect pest complex. As such, plants in these tests generally did not demonstrate any adverse effects at any test levels, but did not test up to the maximum allowable rate. For a comprehensive consideration of all potential effects data and additional information for terrestrial plants please refer to the detailed spreadsheet of the available ECOTOX open literature data that can be found in **Appendix H**.

References

The references that refer to an ECOTOX number can be found in the reference list for Appendix H. The references listed below are for the data submitted to the Agency.

MRID Terrestrial Citation References

Guideline 71-1. Avian Single Dose Oral Toxicity

102038 Hudson, R.; Tucker, R.; Haegele, M. (1972) Effect of age on sensitivity: Acute oral toxicity of 14 pesticides to mallard ducks of several ages. Toxicology and Applied Pharmacology (22):556- 561. (Also In unpublished submission received Oct 26, 1977 under 1016-69; submitted by Union Carbide Corp., Arlington, VA; CDL:096397-E)

136997 Roberts, N.; Phillips, C. (1983) The Acute Oral Toxicity (LD50) of Endosulfan--Technical (Code: HOE 002671 OI ZD97 0003) to the Bobwhite Quail: HST 224/83566. (Unpublished study received Dec 27, 1983 under 8340-13; prepared by Huntingdon Research Centre, Eng., submitted by American Hoeschst Corp., Somerville, NJ; CDL: 252043-E)

136998 Roberts, N.; Phillips, C. (1983) The Acute Oral Toxicity (LD50) of Endosulfan--Technical (Code: HOE 002671 OI ZD97 0003) to the Mallard Duck: HST 226/83493. (Unpublished study received Dec 27, 1983 under 8340-13; prepared by Huntingdon Research Centre, Eng., submitted by American Hoeschst Corp., Somerville, NJ; CDL: 252043-F)

137189 Roberts, N.; Phillips, C. (1983) The Acute Oral Toxicity (LD50) of Endosulfan Technical (Code: Hoe 002671 OI ZD97 0003) to the Bobwhite Quail: HST 224/83566; A27035. (Unpublished study received Jan 16, 1984 under 11678-5; prepared by Huntingdon Research Centre, Eng., submitted by Makhteshim Beer Sheva Chemical Works, Ltd., New York, NY; CDL:252229-A)

160000 Hudson, R.; Tucker, R.; Haegele, M. (1984) Handbook of toxicity of pesticides to wildlife: Second edition. US Fish and Wildlife Service: Resource Publication 153. 91 p.

46430501 Stoughton, T. (2004) Endosulfan Sulfate Technical: An Acute Dietary LD50 with Northern Bobwhite. Project Number: ES/711701, 200618. Unpublished study prepared by Bayer Corp. 36 p.

Guideline 71-2. Avian Dietary Toxicity

101251 U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center (1962) Toxicity: Phosphamidon. (Unpublished study; CDL: 090672-U)

22923 Hill, E.F.; Heath, R.G.; Spann, J.W.; et al. (1975) Lethal Dietary Toxicities of Environmental Pollutants to Birds: Special Scientific Report--Wildlife No. 191. (U.S. Dept. of the Interior, Fish and Wildlife Service, Patuxent Wildlife Research Center; unpublished report)

46382601 Christ, M.; Larn, C. (2004) Technical Endosulfan-Sulfate (A Metabolite of Endosulfan): A Subacute Dietary LC50 with Mallards. Project Number: ES720801, 201058, B004669. Unpublished study prepared by Bayer Corp. 29 p.

46430502 Sabbert, T. (2004) Endosulfan Sulfate Technical: A Subactute Dietary LC50 with Northwhite Bobwhite. Project Number: ES/721701, 200619. Unpublished study prepared by Bayer Cropscience LP. 36 p.

Guideline 71-4. Avian Reproduction

146843 Roberts, N.; Phillips, C.; Dawe, I.; et al. (1985) The Effects of Dietary Inclusion of Endosulfan--Technical on Reproduction in the Mallard Duck. HRC Report No. HST 228b/841012. Unpublished study prepared by Huntington Research Centre plc. 211 p.

148992 Roberts, N.; Phillips, C.; Almond, R.; et al. (1984) The Effects of Dietary Inclusion of Endosulfan--Technical (Code: Hoe 002671 OI ZD97 0003) on Reproduction in the Bobwhite Quail: HRC Report No. HST 227/84362. Unpublished study prepared by Huntingdon Research Centre plc. 285 p.

155199 Leist; Ebert (1985) Comments on Endosulfan - EPA Ecological Effects Branch Review of Avian Toxicology. Unpublished study prepared by Hoechst Aktiengesellschaft. 23 p.

40335001 Beavers, J.; Frank, P.; Jaber, M. (1987) Endosulfan Technical Sub- stance (Code: HOE 002671 OI ZD95 0005): A One-generation Reproduction Study with the Mallard (*Anas platyrhynchos*): Lab Project No. 125-137. Unpublished study prepared by Wildlife International Ltd. 146 p.

40335002 Beavers, J.; Frank, P.; Jaber, M. (1987) Endosulfan Technical Sub- stance (Code: HOE 002671 OI ZD95 0005): A One-generation Reproduction Study with the Bobwhite (*Colinus virginianus*): Lab Project No. 125-134. Unpublished study prepared by Wildlife International Ltd. 144 p.

Guideline 81-1. Acute oral toxicity in rats

38307 Reno, F.E. (1975) Final Report: Acute Oral Toxicity Study in Rats: Project No. 915-108. (Unpublished study received Jul 28, 1980 under 2749-487; prepared by Hazleton Laboratories America, Inc., submitted by Aceto Chemical Co., Inc., Flushing, N.Y.; CDL: 243082-A)

Guideline 83-4. Two-generation reproduction in the rat

148264 Edwards, J.; Reid, Y.; Offer, J.; et al. (1984) Effect of Endosulfan--Technical on Reproductive Function of Multiple Generations of the Rat: Report No. HST 204/83768. Unpublished study prepared by Huntingdon Research Centre plc. 422 p.

Guideline 141-1. Honey Bee Acute Contact Toxicity

1999 Atkins, E.L.,Jr; Anderson, J.D. (1967). Toxicity of pesticides and other agricultural chemicals to honey bees: laboratory studies. (Unpublished study received Jan. 30, 1969 under 9G0802; prepared by Univ. of California-Riverside, Dept. of Entomology, submitted by Hercules, Inc., Agricultural Chemicals, Wilmington, Del.; CDI: 093111-D).

Guideline 141-2. Honey Bee Toxicity of Residues on Foliage

5004151 Stevenson, J.H. (1968) Laboratory studies on the acute contact and oral toxicities of insecticides to honeybees. Annals of Applied Biology 61 (3): 467-472.

5008936 Clinch, P.G. (1967) The residual contact toxicity to honey bees of insecticides sprayed on white clover (Trifolium repens L) in the laboratory. New Zealand Journal of Agricultural Research 10(2): 289-300.

5012881 Gorecki, K. (1973) Zatrucia Pszczoly Miodnej—Apis mellifica L. (Hym. Apidae) Insektycydami Stosowanymi W Kraju. [Harmful effects of insecticides used in Poland on the honey bee—Apis Mellifica L. (Hym. Apidae).] Polskie Pismo Entomologiczne. [Polish Journal of Entomology] 4(1):201-210.