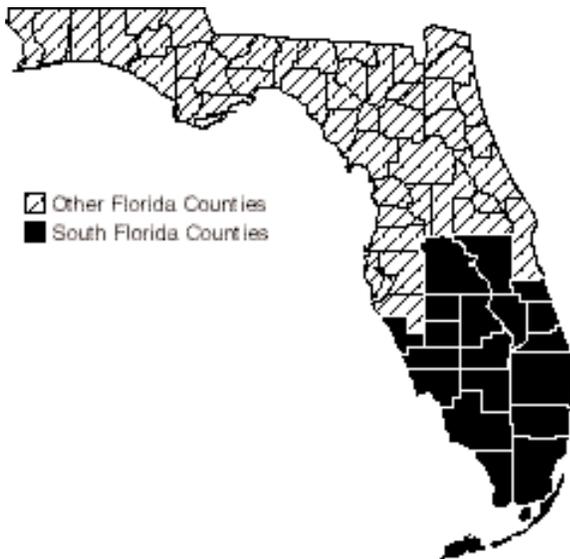

Eastern Indigo Snake

Drymarchon corais couperi

Federal Status:	Threatened (January 31, 1978)
Critical Habitat:	None Designated
Florida Status:	Threatened
Recovery Plan Status:	Contribution (May 1999)
Geographic Coverage:	South Florida

Figure 1. Florida distribution of the eastern indigo snake.



The eastern indigo snake is a large, black, non-venomous snake found in the southeastern U.S. It is widely distributed throughout central and South Florida, but primarily occurs in sandhill habitats in northern Florida and southern Georgia. The eastern indigo snake was listed as a threatened species as a result of dramatic population declines caused by over-collecting for the domestic and international pet trade as well as mortalities caused by rattlesnake collectors who gassed gopher tortoise burrows to collect snakes. Since its listing, habitat loss and fragmentation by residential and commercial expansion have become much more significant threats to the eastern indigo snake.

This account represents South Florida's contribution to the range-wide recovery plan for the eastern indigo snake (FWS 1982).

Description

The eastern indigo snake is the longest snake in the United States (R. Hammer, Metro Dade Park and Recreation, personal communication 1998), reaching lengths of up to 265 cm (Ashton and Ashton 1981). Its color is uniformly lustrous-black, dorsally and ventrally, except for a red or cream-colored suffusion of the chin, throat, and sometimes the cheeks. Its scales are large and smooth (the central 3 to 5 scale rows are lightly keeled in adult males) in 17 scale rows at midbody. Its anal plate is undivided. Its antepenultimate supralabial scale does not contact the temporal or postocular scales.

In the Florida Keys, adult eastern indigo snakes seem to have less red on their faces or throats compared to most mainland specimens and those in north Florida typically have little to no red (Lazell 1989; P. Moler, GFC, personal communication 1998).

Taxonomy

The indigo snake (*Drymarchon corais*) ranges from the southeastern U.S. to northern Argentina (Moler 1992). This species has eight recognized subspecies, two of which occur in the U.S. (Conant 1975, Moler 1985a): the eastern indigo (*D. c. couperi*) and the Texas indigo (*D. c. erebennus*).

The eastern indigo snake was originally described as *Coluber couperi* by Holbrook in 1842 and was later reassigned to the genus *Georgia* by Baird and Girard in 1853. Cope transferred it to the genus *Spilotes* in 1860 and later (1862) described it as a subspecies of *Spilotes corais*. Cope assigned the species *corais* to the genus *Compsosoma* in 1900. In 1917, Stejneger and Barbour resurrected the genus name *Drymarchon*, (*Drymarchon corais*; Daudin 1827), including the eastern indigo snake as *Drymarchon corais couperi*.

Distribution

Historically, the eastern indigo snake occurred throughout Florida and in the coastal plain of Georgia, Alabama and Mississippi (Löding 1922, Haltom 1931, Carr 1940, Cook 1954, Diemer and Speake 1983, Moler 1985a). It may have occurred in southern South Carolina, but its occurrence there cannot be confirmed. Georgia and Florida currently support the remaining, endemic populations of the eastern indigo snake (Lawler 1977). In 1982, only a few populations remained in the Florida panhandle, and the species was considered rare in that region. Nevertheless, based on museum specimens and field sightings, the eastern indigo snake still occurs throughout Florida, even though they are not commonly seen (Moler 1985a) (Figure 1).

In South Florida, the eastern indigo snake is thought to be widely distributed.. Given their preference for upland habitats, eastern indigos are not commonly found in great numbers in the wetland complexes of the Everglades region, even though they are found in pinelands, tropical hardwood hammocks, and mangrove forests in extreme South Florida (Duellman and Schwartz 1958, Steiner *et al.* 1983).

Eastern indigo snakes also occur in the Florida Keys. They have been collected from Big Pine and Middle Torch Keys, and are reliably reported from Big Torch, Little Torch, Summerland, Cudjoe, Sugarloaf and Boca Chica Keys (Lazell 1989). Moler (GFC, personal communication 1996) documented eastern indigo snakes on North Key Largo and feels they are probably restricted to Crocodile Lake NWR and the protected hammock areas on that Key. Given the ubiquitous nature of the eastern indigo snake throughout the remainder of its range, we believe it probably occurs on other keys.

Habitat

Over most of its range, the eastern indigo snake frequents several habitat types, including pine flatwoods, scrubby flatwoods, high pine, dry prairie, tropical hardwood hammocks, edges of freshwater marshes, agricultural fields, coastal dunes, and human-altered habitats. Eastern indigo snakes need a mosaic of

Eastern indigo snake. *Original photograph courtesy of U.S. Fish and Wildlife Service.*



habitats to complete their annual cycle. Interspersion of tortoise-inhabited sandhills and wetlands improves habitat quality for this species (Landers and Speake 1980, Auffenberg and Franz 1982). Eastern indigo snakes require sheltered “retreats” from winter cold and desiccating conditions. In laboratory experiments, they appear to be especially susceptible to desiccation (Bogert and Cowles 1947). Wherever the eastern indigo snake occurs in xeric habitats, it is closely associated with the gopher tortoise (*Gopherus polyphemus*), the burrows of which provide shelter from winter cold and desiccation (Bogert and Cowles 1947, Speake *et al.* 1978, Layne and Steiner 1996). This dependence seems especially pronounced in Georgia, Alabama, and the panhandle area of Florida, where eastern indigo snakes are largely restricted to the vicinity of sandhill habitats occupied by gopher tortoises (Diemer and Speake 1981, Moler 1985b, Mount 1975). Reliance on xeric sandhill habitats throughout the northern portion of the eastern indigo’s range can be attributed primarily to the availability of thermal refugia afforded by gopher tortoise burrows during winter. Few such refugia are widely available off of the sandhill regions of southern Georgia and northern Florida. In wetter habitats that lack gopher tortoises, eastern indigo snakes may take shelter in hollowed root channels, hollow logs, or the burrows of rodents, armadillo (*Dasypus novemcinctus*), or land crabs (*Cardisoma guanhumí*) (Lawler 1977, Moler 1985b, Layne and Steiner 1996).

In the milder climates of central and southern Florida, eastern indigo snakes exist in a more stable thermal environment, where availability of thermal refugia may not be as critical to the snake’s survival. Throughout peninsular Florida, this species may be found in all terrestrial habitats which have not suffered high-density urban development. They are especially common in the hydric hammocks throughout this region (Moler 1985a). In central and coastal Florida, eastern

indigos are mainly found within many of the State's high, sandy ridges. In extreme South Florida, these snakes are typically found in pine flatwoods, pine rocklands, tropical hardwood hammocks, and in most other undeveloped areas (Kuntz 1977). Eastern indigo snakes also use some agricultural lands (*e.g.*, citrus) and various types of wetlands (Layne and Steiner 1996).

Even though thermal stress may not be a limiting factor throughout the year in South Florida, eastern indigo snakes still seek and use underground refugia in the region. On the sandy central ridge of South Florida, eastern indigos use gopher tortoise burrows more (62 percent) than other underground refugia (Layne and Steiner 1996). Other underground refugia used by this species include burrows of armadillos, cotton rats (*Sigmodon hispidus*), and land crabs; burrows of unknown origin; natural ground holes; hollows at the base of trees or shrubs; ground litter; trash piles; and in the crevices of rock-lined ditch walls (Layne and Steiner 1996). These refugia are used most frequently where tortoise burrows are not available, principally in low-lying areas off of the central and coastal ridges.

Smith (1987) radio-marked hatchling, yearling, and gravid eastern indigo snakes and released them in different habitat types on St. Marks NWR in Wakulla County, Florida. Smith monitored the behavior, habitat use, and oviposition sites selected by gravid females and concluded that diverse habitats, including high pineland, pine-palmetto flatwoods, and permanent open ponds, were important for seasonal activity. In this study, habitat use also differed by age-class and season; adult snakes often used gopher tortoise burrows during April and May, while juveniles used root and rodent holes. The eastern indigo snake used gopher tortoise burrows as oviposition sites in high pineland areas, but stump holes were chosen in flatwoods and pond edge habitats (Smith 1987).

Monitoring of radio-marked eastern indigo snakes on the central ridge of South Florida indicates that they use a wide variety of natural, disturbed, and non-natural habitat types in this part of the state throughout the year. On the ridge itself, eastern indigos favor mature oak scrub, turkey oak sandhill, and abandoned citrus grove habitats, whereas snakes found off of the sandy ridges use flatwoods, seasonal ponds, improved pasture, and active and inactive agricultural lands. There was no apparent selection for one habitat type over another, as the use of habitats closely reflected the relative availability and distribution of the vegetation types in these areas (Layne and Steiner 1996).

In extreme South Florida (the Everglades and Florida Keys), eastern indigo snakes are found in tropical hardwood hammocks, pine rocklands, freshwater marshes, abandoned agricultural land, coastal prairie, mangrove swamps, and human-altered habitats (Steiner *et al.* 1983). It is suspected that they prefer hammocks and pine forests, since most observations occur there and use of these areas is disproportionate compared to the relatively small total area of these habitats (Steiner *et al.* 1983).

Behavior

Reproduction

Most information on the reproductive cycle of eastern indigo snakes is from data collected in north Florida. Here, breeding occurs between November and April,

and females deposit four to 12 eggs during May or June (Moler 1992). Speake *et al.* (1987) reported an average clutch size of 9.4 for 20 captive bred females. Eggs are laid from late May through August, and young hatch in approximately 3 months. Peak hatching activity occurs between August and September, and yearling activity peaks in April and May (Groves 1960, Smith 1987). Limited information on the reproductive cycle in south-central Florida suggests that the breeding and egg laying season may be extended. In this region, breeding extends from June to January, laying occurs from April to July, and hatching occurs during mid-summer to early fall (Layne and Steiner 1996).

Female indigo snakes can store sperm and delay fertilization of eggs. There is a single record of a captive snake laying five eggs (at least one of which was fertile) after being isolated for more than four years (Carson 1945). It has long been assumed that this event resulted from sperm storage. However, there have been several recent reports of parthenogenetic reproduction by virginal snakes. Hence, sperm storage may not have been involved in Carson's (1945) example (P. Moler, GFC, personal communication 1998). There is no information on how long eastern indigo snakes live in the wild; in captivity, the longest an eastern indigo snake lived was 25 years, 11 months (Shaw 1959).

Feeding

The eastern indigo snake is an active terrestrial and fossorial predator that will eat any vertebrate small enough to be overpowered. Layne and Steiner (1996) documented several instances of indigos flushing prey from cover and then chasing it. While rare, these snakes may also climb shrubs or trees in search of prey. An adult eastern indigo snake's diet may include fish, frogs, toads, snakes (venomous as well as nonvenomous), lizards, turtles, turtle eggs, juvenile gopher tortoises, small alligators, birds, and small mammals (Keegan 1944, Babis 1949, Kochman 1978, Steiner *et al.* 1983). Juvenile eastern indigo snakes eat mostly invertebrates (Layne and Steiner 1996).

Movements

Indigo snakes range over large areas and into various habitats throughout the year, with most activity occurring in the summer and fall (Smith 1987, Moler 1985b, Speake 1993). In Georgia, the average range of the eastern indigo snake is 4.8 ha during the winter (December to April), 42.9 ha during late spring and early summer (May to July), and 97.4 ha during late summer and fall (August to November) (Speake *et al.* 1978). Warmer weather during the winter months in South Florida may afford the eastern indigo snake a larger range than 4.8 ha (D. Breininger, Dynamac Corporation, personal communication 1998). Adult males have larger home ranges than adult females and juveniles; their ranges may encompass as much as 224 ha and 158 ha in the summer (Moler 1985b, Speake 1993). By contrast, a gravid female may use from 1.4 to 42.9 ha (Smith 1987). These estimates are comparable with those found by Layne and Steiner (1996) in south-central Florida, who determined adult male home ranges average about 74 ha (max. 199.2 ha), whereas adult female home ranges average about 19 ha (max. 48.6 ha).

Relationship to Other Species

Eastern indigo snakes require a sheltered “refuge” from winter cold and dry conditions. Wherever the eastern indigo snake occurs in xeric habitats, it is closely associated with the gopher tortoise, the burrows of which provide shelter from winter cold and the desiccating sandhill environment (Bogert and Cowles 1947, Speake *et al.* 1978). This dependence seems especially pronounced in Georgia, Alabama, and the panhandle area of Florida, where eastern indigo snakes are largely restricted in the winter to sandhill habitats occupied by gopher tortoises (Diemer and Speake 1981, Moler 1985b, Mount 1975). In more mesic habitats that lack gopher tortoises, eastern indigo snakes may take shelter in hollowed root channels, rodent burrows, armadillo burrows, hollow logs, or crab burrows (Lawler 1977, Moler 1985b).

Status and Trends

As stated earlier, the eastern indigo snake was listed because of a population decline caused by habitat loss, over-collecting for the pet trade, and mortality from gassing gopher tortoise burrows to collect rattlesnakes (Speake and Mount 1973, Speake and McGlincy 1981) (43 FR 4028). At the time of listing, the main factor in the decline of this species was attributed to exploitation for the pet trade. As a result of effective law enforcement, the pressure from collectors has declined but still remains a concern (Moler 1992).

The eastern indigo snake will use most of the habitat types available in its home range, but prefers open, undeveloped areas (Kuntz 1977). Because of its relatively large home range, this snake is especially vulnerable to habitat loss, degradation, and fragmentation (Lawler 1977, Moler 1985b). Lawler (1977) noted that eastern indigo snake habitat has been destroyed by residential and commercial construction, agriculture, and timbering. He stated that the loss of natural habitat is increasing because of these threats; in Florida, indigo snake habitat is being lost at a rate of five percent per year (Lawler 1977). Low density residential housing is also a potential threat to this species, increasing the likelihood of snakes being killed by property owners and domestic pets. Extensive tracts of wild land are the most important refuge for large numbers of eastern indigo snakes (Diemer and Speake 1981, Moler 1985b).

Additional human population growth will increase the risk of direct mortality of the eastern indigo snake from property owners, domestic animals, and highway mortality. Pesticides that bioaccumulate through the food chain may present a potential hazard to the snake as well. Pesticides used on crops or for silviculture would pose a pulse effect to the indigo (Speake 1993). Secondary exposure to rodenticides used to control black rats may also occur (Speake 1993). Considering the low numbers of this species, any additional threats to its survival could cause local extirpations.

The wide distribution and large territory size of the eastern indigo snake complicate evaluation of its population status and trends. We believe that activities such as collecting and gassing of tortoise burrows have been largely abated through effective enforcement of protective laws. However, despite these apparent gains, the threats described above are acting individually and

synergistically against the eastern indigo snake. Although we have no quantitative data with which to evaluate the trend of eastern indigo snakes in South Florida, we surmise the population as a whole is declining because of current rates of habitat destruction and degradation.

Natural communities continue to be altered for agricultural, residential, and commercial purposes, most of which are incompatible with the habitat needs of eastern indigo snakes (Kautz 1993). Habitat destruction and alteration are probably most substantial along the coasts, in the Keys, and along the high ridges of south-central Florida, where human population growth is expected to continue to accelerate. Agricultural interests (principally citrus) continue to destroy large expanses of suitable natural indigo snake habitat throughout much of South Florida.

Even with continued habitat destruction and alterations, this species will probably persist in most localities where large, unfragmented pieces of natural habitat remain. Unfortunately, current and anticipated future habitat fragmentation will probably result in a large number of isolated, small groups of indigo snakes. Fragmented habitat patches probably cannot support a sufficient number of individuals to ensure viable populations.

Management

To protect and recover the eastern indigo snake, large expanses of unaltered habitat must be protected. Unfortunately, the amount of land required and its distribution over the landscape is not known because population viability analysis or spatially explicit modeling have not been completed. We know nothing, therefore, of the minimum population size required to maintain and recover eastern indigo snakes or of the size and distribution necessary for effective preserves.

We have no information on population viability and habitat needs; therefore, several “educated guesses” have been made regarding the amount of land needed to protect eastern indigo snakes. Early estimates suggested several thousand hectares may be sufficient to ensure the local survival of a small number of individuals (Speake *et al.* 1978). More recently, Moler (GFC, personal communication 1996), Jackson (1984), and Speake (1993) suggest that preserves must be at least 4,000 ha. If we assume an average home range to be about 75 ha for males and 19 ha for female eastern indigo snakes, preserves of this size may be able to support about 53 males and 210 females. These estimates assume total overlap of home ranges between males and females and that all of the preserve area would be suitable habitat. Population modeling will be needed to determine if isolated populations of this size can be expected to persist.

Most of the large protected lands in South Florida have been purchased for the protection of sensitive natural and cultural resources. Presumably, management of these lands is directed towards maintaining and enhancing the diversity of plant and animal assemblages within these properties. If these management goals are achieved, eastern indigo snakes, as well as other species, will directly benefit because of improved habitat conditions. Unfortunately, many interests are now competing for the use of public lands.

Land managers must consider these uses and their effect upon the eastern indigo snake and other imperiled species.

We do not know whether the size and distribution of protected public lands will ensure the persistence of viable populations of this species. As mentioned above, population viability analysis or spatially explicit modeling are needed to determine the number and distribution of habitats and population density necessary to recover the eastern indigo snake. If more or larger preserves are required to maintain and recover this species, it will be important to disseminate this information to agencies and institutions that are able to influence land acquisition and protection efforts.

In instances where land use changes may adversely affect the eastern indigo, land managers or private landowners should develop protective measures to minimize impacts. The South Florida Field Office of the FWS has developed a set of protective measures to minimize potential adverse effects to the eastern indigo snake resulting from land development projects. These measures include the creation and distribution of educational materials regarding eastern indigo snake identification, biology and habitat requirements, the standardization of gopher tortoise burrow survey techniques, and the establishment of snake release protocols.

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Recovery for the Eastern Indigo Snake

Drymarchon corais couperi

Recovery Objective: ENSURE numerous populations exist and are protected

South Florida Contribution: STABILIZE and increase population.

Recovery Criteria

There is a general lack of information on the status and trends of eastern indigo snakes in South Florida. Although the primary threat identified when the eastern indigo snake was listed has been ameliorated, we believe that an additional threat of habitat loss and fragmentation continues to affect the survival and recovery of this species. The objective to stabilize and increase numbers of eastern indigo snakes in South Florida will require protection of individuals as well as the habitat where they are known to occur. Additional research and monitoring of the snake's life history will also be necessary. More data on the demographics of this species are needed before we can determine an appropriate amount of habitat to ensure persistence of the species. One measure of demographic data that could determine an increasing population would be a rate of increase (r) greater than 0.0 as a 3-year running average over at least 10 years.

Once it is determined that sufficient, suitable habitat exists in South Florida for the eastern indigo snake population to stabilize or increase, delisting criteria can be considered. The development of delisting criteria will require the analysis of demographic data to demonstrate that there are adequate, contiguous tracts of upland habitat in South Florida to ensure at least a 95 percent probability of persistence for the eastern indigo snake for 100 years.

Species-level Recovery Actions

S1. Determine the distribution of the eastern indigo snake in South Florida.

The distribution of the eastern indigo snake in South Florida is poorly documented. However, because this species is wide-ranging throughout a variety of habitats, we feel it is infeasible to survey all terrestrial habitats it could occupy.

S1.1. Compile distribution data for eastern indigo snakes from all available sources.

Existing data sources on the distribution of indigo snakes throughout South Florida should be compiled and entered into a Geographic Information System database.

S2. Protect and enhance existing populations of indigo snakes in South Florida.

S2.1. Support land acquisition programs through Federal, State, and private efforts.

The 1982 recovery plan estimated that at least 4,000 ha is needed to sustain a viable population of eastern indigo snakes. The acquisition of diverse habitat will increase the potential for recovery of this and other listed species in South Florida.

- S2.2. Protect eastern indigo snakes on public lands.** The eastern indigo snake utilizes a variety of upland habitat types in Florida, particularly pine flatwoods, high pine, scrubby flatwoods, and scrub communities. Habitat management practices should be implemented to maintain biodiversity and minimize impacts from motor vehicles and commercial forestry practices. Ecotonal areas between upland/xeric habitats should be maintained using controlled burns at intervals appropriate for specific community types.
- S2.3. Protect eastern indigo snakes on private lands.** Landowners should be informed about indigo snakes and their habitat requirements. Include this information in general habitat management guidelines that address the needs of other listed species, and suggest management options to landowners. Encourage favorable management practices such as controlled burning whenever possible. The possibility of long-term renewable leases and conservation agreements involving Federal, Tribal, State, and local government agencies should be investigated where outright acquisition is not acceptable to the landowner.
- S2.4. Identify, evaluate, and eliminate other threats to the survival of the indigo snake.** Regulations are in place to control the pet trade and gassing of gopher tortoise burrows. In addition to the outright loss of habitat associated with conversion to residential or agricultural uses, potential threats such as predation from domestic animals and pesticide contamination may become more problematic and threaten the continued persistence of eastern indigo snakes in some areas. Because pesticide use on adjacent agricultural and residential lands poses a potential risk to eastern indigos, management plans should consider these risks and alleviate threats whenever possible. Trapping efforts may be needed on public lands where free-ranging domestic animals threaten this species.
- S2.5. Enforce available protective measures.**
- S2.5.1. Conduct section 7 consultations on Federal activities that may affect eastern indigo snakes.** Federal agencies should consult with the FWS on any activity (authorized, funded, or carried out) that may affect the eastern indigo snake. Such activities include, but are not limited to, pesticide use, road building, construction of new facilities, military training exercises, wetland fill, clearing for new runways, etc. Because this species is found in a variety of habitats, it should be considered in almost all consultations.
- S2.5.2. Implement the FWS South Florida Field Office's eastern indigo snake guidelines.** The guidelines should be used for section 7 and section 10 consultations, and be incorporated into permits where feasible.
- S3. Continue studies on the biology and ecology of the indigo snake.** Adequate long-term protection of the eastern indigo snake depends on a thorough understanding of its life history. Because this species occurs in low densities naturally, it is difficult to survey and study. As a result, many aspects of its life history are poorly understood.
- S3.1 Investigate techniques to effectively survey eastern indigo snakes.** The use of subterranean cameras or scopes to investigate gopher tortoise burrows, particularly during winter months, has proven useful in some circumstances. However, other methods, such as the use of pheromones to attract males, should be investigated.

This information is necessary to assess population levels and status of this species, and to accurately monitor existing populations and the response to management prescriptions.

- S3.2. Continue research to better evaluate home range size, age of dispersal, and dispersal distance of the eastern indigo snake.** More data are needed on these biological requirements to develop and evaluate management actions. Information on movements is critical for the development and management of conservation reserves for this species.
- S3.3. Conduct additional life history studies to build the general knowledge base for the eastern indigo snake.** Information on reproductive success, fecundity, longevity, and other basic population demographics is needed to assess the status and trends of the population.
- S3.4. Conduct population modeling** (*i.e.* risk assessment) once basic demographic data are known.
- S3.5. Determine the status and distribution of eastern indigo snakes in disturbed habitat.** Identify whether eastern indigo snakes are able to persist in habitats modified by residential, commercial, and agricultural uses.
- S4. Monitor populations.** Once standardized survey techniques are developed, begin long-term monitoring on conservation lands where eastern indigo snakes are known to occur. This information is needed to determine status and trends for the population.
- S5. Improve public attitude and behavior towards the eastern indigo snake.** Public opinion concerning snakes in general and eastern indigo snakes in particular should be improved so that the common tendency to kill snakes on sight will be decreased. The general public can be reached through videos, television programs, lectures, and articles in newspapers and magazines. For South Florida, educational materials should be made available in Spanish and Creole. Emphasis should be placed on the harmless and beneficial nature of the species and the threats to its survival and recovery.
 - S5.1 Discourage the use of rat poison in or near eastern indigo snake habitat.** The use of poison to control rats in areas inhabited by this species should be discouraged as indirect poisoning of may occur.

