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THE HERPETOFAUNA OF JEFFERSON COUNTY: ANALYSIS OF AN AMPHIBIAN AND REPTILE COMMUNITY IN SOUTHEASTERN INDIANA

Daryl R. Karns
Biology Department
Hanover College
Hanover, Indiana 47243

INTRODUCTION

The herpetofauna of southeastern Indiana (Jefferson, Jennings, Ripley, Dearborn, Ohio, and Switzerland Counties) has not been well studied. Hay (1892) in his classic survey of the Indiana herpetofauna notes a number of species collected in the area. Dury (1932) presents an account of species collected in Clifty Falls State Park near Madison, Indiana. Minton (1972) and Minton, *et al.* (1892) summarize current information on the status and distribution of amphibians and reptiles in Indiana.

Southeastern Indiana is a herpetologically rich area of the State. The region is especially notable for the abundance and variety of plethodontid salamanders and of snakes. The biogeographic affinities of the herpetofauna of southeastern Indiana are clearly with the south and eastern United States and are very different from the amphibian and reptile community found north of the Shelbyville moraine (Minton, 1972; Smith and Minton, 1957).

This report will summarize the results of a survey of the amphibian and reptile community of Jefferson County. The objectives of this study were to examine the distribution and abundance of different species in the common habitats of southeastern Indiana. The survey period ran from late spring through early fall (May through September) and provides a record of the composition and habitat utilization of the herpetofauna during the summer months. The effectiveness of different sampling methods was also documented.

STUDY AREA

Jefferson County, located in the southeastern corner of Indiana, is approximately 36.2 km wide and 41.8 km across with an area of about 948 square km. Information on physiography, vegetation, climate, geology, and soils can be found in Lindsey (1966), Homoya, *et al.* (1985), and Nickell (1985).

Jefferson County is a topographically diverse area that was not glaciated during the Wisconsin glacial advance. The county is located in the Bluegrass Natural Region (Homoya, *et al.*, 1985). This survey was concentrated in the Muscatatuck Flats and Canyons Section of that region. This section occupies the western half of the county and consists of a broad, gently sloping plain that breaks into the canyons that feed into the Ohio River valley. The flatlands are characterized by acidic, poorly drained soils, and the vegetation is dominated by the southern flatwoods community. The limestone canyons support a diverse, mixed mesophytic forest community. The Switzerland Hills Section occupies the eastern half of the county and consists of deeply dissected uplands. The ravine systems of this section are characterized by mixed mesophytic forests (Homoya, *et al.*, 1985).

MATERIALS AND METHODS

Drift fences were the primary sampling tool employed in this study. A drift fence is an artificial barrier with pitfall and funnel traps. Drift fences are effective at sampling small animals that move along the ground; small mammals and a variety of invertebrates are trapped as well as amphibians and reptiles. Data from ten drift fence sites are analyzed and form an important part of the data presented here. Drift fencing has inherent biases and shortcomings (Campbell and Christman, 1982; Gibbons and Semlitsch, 1981; Karns, 1986; Vogt and Hine, 1982). Hand collecting, road surveys, breeding call surveys, and turtle trapping were employed to supplement drift fence trapping.

Traditional hand collecting by overturning rocks, logs, and debris was employed throughout the survey in conjunction with checking drift fence sites. Separate collecting trips to sites of special interest were also made. Hand collecting was the primary method of sampling rocky creekbed environments.

Road surveys consisted of driving slowly along secondary roads at night looking for live animals. In addition, all roadkills encountered were identified and recorded. Commercial nylon-mesh turtle traps were used for turtle trapping. Anuran breeding sites were regularly visited and calling species identified.

A representative sample of the amphibians and reptiles collected were preserved as a voucher collection. This sample of about 350 animals is deposited in the Hanover College Biology Department collection.

Drift fence trapping. Each fence was a 15-m long section of 50-cm wide aluminum flashing (.019 gauge rolled aluminum). In habitats with no clear ecological gradients (e.g., large patch of woods), fences were set at right angles to each other about 50-m apart. This procedure corrects for directional bias in drift fence placement (Gibbons and Semlitsch, 1981). At other sites where there was a strong ecological gradient involving water (e.g., woods adjacent to a stream), both fences were set parallel to the water source. Previous experience showed that movement would be primarily to and from the water source (Karns, 1986).

A standard array of traps was employed at each fence. Each fence had two 20-L plastic bucket pitfalls (one at each end), four 7.6-L can pitfalls (two 3-lb. coffee cans taped together; two pitfalls on each side), and two funnel traps (1-m long, window screen cylinders with plastic funnels; one funnel trap on each side). Karns (1986) discusses drift fence construction.

Traps were checked at least once a week depending on the weather. For each amphibian and reptile trapped, the following information was recorded: species, length, weight, sex (if possible), side of fence trapped, and type of trap. Animals were toe-clipped (one digit) to allow recognition of previously trapped animals. Recaptured animals were excluded from the analysis.

Two 15-m drift fences in a given habitat were considered to be one fence site, and each day a site was open was counted as one trap day. Trap-rate was calculated as the number of animals trapped at a site divided by the number of trap days. Species diversity was calculated using the Shannon Diversity Index (H_s; Wilson and Brosset, 1977).

A total of 12 drift fences sites (two fences each) were placed in representative Jefferson County habitats (see below). These sites formed a rough north-south transect running through the central Muscatatuck Flats and Canyon Section of the County. Eight of these sites were open for over 100 days and are the primary source of information for this study. Two old field sites adjacent to small ponds were intermittently operational due to flooding and were open for a reduced number of days. Two forested sites were excluded from the final analysis due to vandalism. The trapping period was from May through September 1985 and April 15 through May 1986.

Drift fence site descriptions. The eight drift fence sites are described below. For each site, the location is indicated to the nearest $^1/_4$-$^1/_4$ section on 7.5 minute U.S.G.S. topographic maps. A brief qualitative description of the vegetation, topography, and soil-type at each site is given. The soil information is from Nickell (1985).

HV: HAPPY VALLEY (174 trap days): Madison West Quad. T3N, R10E, S7, NE$^1/_4$, SW$^1/_4$. Mature bottomland woods dominated by maple and beech in the upper canopy; maples dominate the understory; poison ivy and graminoids abundant. Fallen trees common due to extensive tornado damage in 1974. Happy Valley Creek runs through the site; fences located parallel to the creek; creek flow is intermittent depending on rain. Diverse soil types.

CF: CLIFTY PARK FIELD (123 trap days): Clifty Falls Quad. T4N, R10E, S33, NW$^1/_4$, NE$^1/_4$. Extensive field undergoing secondary succession; mosaic of shrubby and graminoid-dominated patches. Gently rolling field; fences located in patch with some shrubs, mostly graminoids. Cincinnati silt loam: deep, well drained soil; seasonal perched water table.

CW: CLIFTY PARK MATURE WOODS (135 trap days): Clifty Falls Quad. T4N, R10E, S29, NW$^1/_4$, NE$^1/_4$. Mature woods on bluff along Clifty Creek ravine; dominated by maple and basswood in the upper canopy; understory dominated by maples; poison ivy and mayapple common in ground layer. Fences located on level area overlooking Clifty Creek ravine. Cincinnati silt loam: deep, well drained soil; seasonal perched water table.

WW: WEBSTER WOODS (174 trap days): Kent Quad. T3N, R8E, S13, SW$^1/_4$, NW$^1/_4$. Forty-acre plot of second growth deciduous woods and planted pines; deciduous woods dominated by white oak, shagbark hickory, black oak, red oak; understory dominated by dogwood, beech, and maple saplings; common understory herbs: persimmon, poison ivy, greenbriar, and false Solomon's seal. Small creek runs through the site; fences located parallel to creek; creek flow is intermittent depending on rain. Bonnell silt loam: well-drained, strongly acid soil.

CP: CLIFTY PARK OLD FIELD POND (62 trap days): Clifty Falls Quad. T4N, R10E, S29, NE$^1/_4$, SE$^1/_4$. Large old field adjacent to mature maple-basswood forest. Shrubby field with a central wet area dominated by graminoids; two small ponds in wet area were active amphibian breeding sites. Fences set near pools adjacent to woods. Rossmoyne silt loam: level, deep, moderately well-drained upland soil. Site was prone to flooding.

HP: HORTON OLD FIELD POND (39 trap days): Clifty Falls Quad. T4N, R10E, S20, SW1/4, SE1/4. Shrubby old field adjacent to mature maple-basswood forest. Moderate sized (20-m diameter) shallow pond set in a depression. Pond dominated by cattails; active amphibian breeding site in the spring. Fence set near pond adjacent to woods. Cincinnati silt loam: sloping site with deep, well-drained soil. Site prone to flooding.

In following four descriptions, JPG refers to Jefferson Proving Ground, the U.S. Army Munitions Testing Base located in Jefferson, Ripley, and Jennings Counties.

JF: JPG FIELD (126 trap days): Clifty Falls Quad. T4N, R10E, S5, NW1/4, SE1/4. Extensive old field maintained by controlled burnings and mowing; diverse graminoid-dominated field being invaded by sweet gum and some sycamore; ragweed very common; area bordered by mixed hardwood forest. Level area with Avonburg silt loam: deep, poorly drained soil; seasonal perched water table.

JY: JPG YOUNG WOODS (126 trap days): Clifty Falls Quad. T4N, R10E, S6, NE1/4, NE1/4. Early successional, twenty year old patch of woods dominated by sweet gum and red maple in the upper canopy; oak and tulip in the understory; canopy trees of uniform age and height (6-10 m), forming open canopy; ragweed, flat-topped white aster, Joe-Pye weed common in understory; wetness of site indicated by large patches of moss (*Dicranium*) and numerous crayfish burrows. Extensive level area with Cobbsfork silt loam: deep, poorly drained soil subject to flooding; seasonal perched water table.

JM: JPG MATURE WOODS (126 trap days): Clifty Falls Quad. T5N, R10E, S31, SE1/4, SE1/4. Extensive patch of hardwoods located north of JY; subject to selective cutting in recent years but much older than JY. Upper canopy dominated by red maple; dogwood, pin oak, and sweet gum important; dogwood, ash, and tulip saplings abundant; graminoids, ferns, poison ivy, and partridgeberry common in understory. Level site; same soil as JY but better drainage.

JG: JPG GRAHAM CREEK (160 trap days): Holton Quad. T7N, R10E, S34, SE1/4, SE1/4. Riparian mature forest along Graham Creek. Diverse woods with no strong dominants: tulip, sugar maple, hickory, sycamore, black maple, and red and black oak all common; pawpaw thicket in immediate area of fence. Common understory plants: wingstem, Virginia knotweed, and stinging and false nettle. Fences located in woods immediately adjacent to the creek. Graham Creek is a permanently flowing stream. Holton loam: level, deep, somewhat poorly drained.

RESULTS

Species list. Table 1 is a list of the amphibian and reptile species of Jefferson County. The primary list of 49 species includes species collected during this study

TABLE 1. Species list of amphibians and reptiles for Jefferson County, Indiana. Species records from Minton (1972), Minton, *et al.* (1982), and this survey. Nomenclature follows Collins (1990).

	I	II	III	IV
CLASS AMPHIBIA (25 SPECIES)				
SALAMANDERS (13 species)				
Ambystoma barbouri (Kraus and Petranka, 1989)	K	I	D H	W
Ambystoma jeffersonianum (Spotted Salamander)	K ML	A	D	E
Ambystoma maculatum (Spotted Salamander)	K M	A	D	E
Ambystoma texanum (Smallmouth Salamander)	MR	U	NC	W
Notophthalmus viridescens (Red-spotted Newt)	K ML	A	D H	E
Desmognathus f. fuscus (N. Dusky Salamander)	K M	A	D H	E
Plethodon glutinosus (N. Slimy Salamander)	K ML	A	D H	S
Plethodon cinereus (Redback Salamander)	K MR	A	D H	E
Plethodon d. dorsalis (E. Zigzag Salamander)	K M	A	D H	S
Plethodon richmondi (Ravine Salamander)	K M	S	H	E
Eurycea cirrigera (S. Two-lined Salamander)	K M	A	D H	E
Eurycea l. longicauda (Longtail Salamander)	K M	S	D H	S
Eurycea lucifuga (Cave Salamander)	K M	S	D H	S
ANURANS (12 species)				
Bufo a. americanus (E. American Toad)	K ML	A	D H R	E
Bufo woodhousii fowleri (Fowler's Toad)	K M	A	D H R	W
Acris crepitans blanchardi (Blanchard's Cricket Frog)	K ML	S	D H	S

	I	II	III	IV
Pseudacris triseriata (Western Chorus Frog)	K M	A	D H	S
Pseudacris c. crucifer (N. Spring Peeper)	K ML	A	D H	E
Hyla chrysocelis (Cope's Gray Treefrog)	K ML	A	D	E
Rana clamitans melanota (Green Frog)	K M	A	D H R	E
Rana u. utricularia (Bullfrog)	K MR	A	H R	S
Rana sphenocephala (S. Leopard Frog)	K ML	A	D H R	S
Rana pipiens (N. Leopard Frog)	NC ML	U	NC	S
Rana palustris (Pickerel Frog)	K M	S	D H	E
Rana sylvatica (Wood Frog)	K M	A	D H	N
CLASS REPTILIA (24 SPECIES)				
TURTLES (7 species)				
Chelydra s. serpentina (Common Snapping Turtle)	K MR	A	R T	S
Sternotherus odoratus (Common Musk Turtle)	NC M	I	NC	S
Terrapene c. carolina (E. Box Turtle)	K M	A	D H R	E
Chrysemys picta marginata (Midland Painted Turtle)	K MR	A	R	S
Trachemys scripta elegans (Red-eared Slider)	K MR	I	T	S
Apalone m. mutica (Midland Smooth Softshell)	NC M	I	NC	S
Apalone s. spinefera (E. Spiny Softshell)	NC M	I	NC	S
LIZARDS (3 species)				
Sceloporus undulatus hyacinthinus (N. Fence Lizard)	K M	S	D H	S

	I	II	III	IV
Eumeces fasciatus (Five-lined Skink)	K MR	A	D H R	E
Eumeces laticeps (Broadhead Skink)	K M	U	D R	S
SNAKES (14 species)				
Nerodia sipedon pleuralis (Midland Water Snake)	K M	A	H	E
Regina septemvittata (Queen Snake)	K M	S	H	E
Clonophis kirtlandii (Kirtland's Snake)	K MR	S **	D H R	N
Storeria dekayi wrightorum (Midland Brown Snake)	K MR	U	H	S
Thamnophis s. sirtalis (E. Garter Snake)	K M	A	D H R	W
Coluber constrictor priapus (S. Black Racer)	K M	A	D H R	S
Elaphe o. obsoleta (Black Rat Snake)	K M	A	D H R	E
Lampropeltis triangulum (Milk Snake)	K MR	S	H R	S
Lampropeltis getula nigra (Black Kingsnake)	K MR	U	H	S
Opheodrys aestivus (Rough Green Snake)	K M	U	H	S
Diadophis punctatus edwardsii (N. Ringneck Snake)	K M	A	D H	E
Carphophis amoenus helenae (Midwest Worm Snake)	NC M	U	NC	S
Heterodon platirhinos (E. Hognose Snake)	K M	U	R	E
Agkistrodon contortrix mokason (N. Copperhead)	K M	S	H R	S

Symbols preceding species are as follows:

I. Source:	K	=	Voucher specimen record from Karns.
	NC	=	Not collected during this survey.
	M	=	Voucher specimen record from Minton.
	ML	=	Literature record from Minton.
	MR	=	Range could include Jefferson County, but not actually collected from the county (from Minton).
II. Status:	A	=	Widespread and abundant in suitable habitats.
	S	=	Spotty distribution, abundant at specific sites.
	U	=	Uncommon.
	I	=	Insufficient collecting effort for this species.
	C	=	New record for Jefferson County based on Minton.
	***	=	Indiana endangered species list.
	**	=	Indiana threatened species list.
III. Method:	D	=	Collected by drift fence.
	H	=	Collected by hand.
	R	=	Collected by road survey.
	T	=	Collected by turtle trapping.
	NC	=	Not collected.
IV. Biogeography:	Geographic affinities of species according to Minton (1972).		
	N	=	Northern
	S	=	Southern
	E	=	Eastern
	W	=	Western

(44 species) and other species verified by Minton (1972; Minton, *et al.*, 1982) on the basis of voucher specimens and literature records from the county. Species of possible occurrence in the county (11 species) are included in Table 2. The source of information, status, method of collection, and biogeographic affinity for each species is indicated on these tables. Nomenclature follows Collins (1991). Note that no attempt was made to search museum collections for additional records.

Many of the taxa listed in Table 1 are wide ranging species that are generalists in terms of their ecological requirements (Minton, 1972). The biogeographic affinities of the herpetofauna of Jefferson County are with the south and eastern United States. Minton's (1972) analysis of geographic derivations indicates that 24 species (49%) can be classified as southern, 19 species (39%) as eastern, four species (8%) as western, and two species (4%) as northern.

Comparison of drift fence sites. Ten drift fence sites were compared. The sites fall into four categories: 1) forest adjacent to streams; 2) forest without adjacent water; 3) old field with small ponds; and 4) old field without ponds. Note that the two old field pond sites were open for a reduced number of days compared to other sites.

Table 3 presents a comparison of the different sites. The three forested sites with an adjacent water source were the most productive sites in terms of species richness, abundance of animals, and species diversity. The richest site (JG) was the only forest site with a permanent water source (Graham Creek); WW and HV

TABLE 2. Species that may occur in Jefferson County, Indiana. Species noted by Minton (1972) as having ranges that could include Jefferson County that were not collected in the course of this survey. Numbers indicate my estimate of the probability of occurrence (1 = high; 2 = moderate; 3 = low). Source, status, and biogeography codes are the same as in Table 1.

Cryptobranchus a. alleganiensis (E. Hellbender)	3, ML, ***, E
Necturus m. maculosus (Mudpuppy)	3, MR, S
Gyrinophilus porphyriticus (Spring Salamander)	2, MR, S
Pseudotriton r. ruber (N. Red Salamander)	2, MR, ***, S
Ambystoma t. tigrinum (E. Tiger Salamander)	2, MR, W
Ambystoma opacum (Marbled Salamander)	2, MR, E
Scaphiopus h. holbrookii (E. Spadefoot)	3, MR, S
Graptemys geographica (Common Map Turtle)	1, MR, S
Nerodia erythrogaster neglecta (Copperbelly Water Snake)	1, MR, **, S
Thamnophis s. sauritus (E. Ribbon Snake)	2, MR, S
Crotalus horridus (Timber Rattlesnake)	2, MR, S

were adjacent to intermittently flowing creeks. The three forested sites without water were lower in species richness and abundance but similar in diversity index values to the forest creek sites.

Amphibians dominated the herpetofauna at the six forest sites; 93.3% of the forest animals trapped (n = 667) were amphibians, representing 20 species. Only 46 reptiles representing six species were trapped. The forest sites were generally similar in species composition. However, there was considerable variation in the abundance of particular species among sites.

Wood frogs were the most widespread and abundant woodland anuran (17.9% of the total 667 forest animals trapped; 6/6 forest sites) followed by American toads (11.5%; 4/6 forest sites) and green frogs (7.3%; 6/6 forest sites). Redback salamanders were the most widespread forest salamander (6/6 forest sites) and comprised 13.0% of the total trapped. Zigzag salamanders were found at fewer sites (3/6 forest sites) but were numerically more abundant (20.1% of the total trapped). Slimy salamanders, long-tail salamanders, cave salamanders, and red-

TABLE 3. Comparison of drift fence trapping at different sites in Jefferson County, Indiana, 1985-1986. See Materials and Methods for descriptions of the sites and calculations. Forest Creek refers to wooded sites adjacent to streams, Forest to wooded sites without adjacent water, Old Field Pond to early successional fields with small ponds, and Old Field Dry to fields without adjacent water. The mean ($\bar{X}$) and standard deviation (S.D.) for each category are shown. Sites JF, JY, JM, and JG form a successional sequence from old field to climax forest. Note that the Old Field Pond sites were open for a reduced number of days.

Habitat	Site (days open)	Number of Species Trapped	Number of Animals Trapped	Trap-Rate	Diversity Index (H_S)
Forest Creek	JG (160)	17	203	1.27	2.26
	WW (174)	11	102	0.67	1.94
	HV (174)	13	219	1.26	1.37
$\bar{X}$ (S.D.)		13.7 (3.06)	174.7 (63.44)	1.1 (0.34)	1.86 (0.45)
Forest	JM (126)	9	71	0.56	1.80
	JY (126)	10	28	0.22	2.13
	CW (135)	8	44	0.33	1.32
$\bar{X}$ (S.D.)		9.0 (1.0)	47.7 (21.73)	0.37 (0.17)	1.75 (0.41)
Old Field Pond	CP (62)	6	16	0.23	1.87
	HP (39)	5	100	2.56	0.64
$\bar{X}$ (S.D.)		5.5 (0.71)	58 (59.4)	1.4 (1.65)	1.26 (0.87)
Old Field Dry	JF (126)	4	5	0.04	1.33
	CF (123)	3	5	0.04	1.05
$\bar{X}$ (S.D.)		3.5 (0.71)	5.0	0.04	1.19 (0.20)

spotted newts (eft form) were trapped in relatively low numbers and exhibited a spotty distribution.

Reptiles were infrequently trapped at forest sites (6.7% of the total forest animals trapped). Five-line skinks were the most commonly trapped lizard species (3/6 forest sites; 17 specimens). Garter snakes were the most frequently trapped snake (4/6 sites; 10 specimens). Broadhead skinks, southern black racers, ring-neck snakes, and Kirtland's snakes were occasionally trapped. Black rat snakes were collected but not trapped at forest sites. Box turtles were observed at all forest sites; one juvenile box turtle was trapped.

The old field sites were lower in species richness and diversity values than forested sites. The presence of water had a significant effect on the composition and abundance of the herpetofauna in old fields. The old field pond sites (HP, CP) exhibited a much higher trap-rate than dry old field (JF, CF) and were dominated by amphibians (only one southern black racer was trapped). The particularly high trap-rate at HP (2.6 animals per day) was due primarily to the emergence of recently metamorphosed green frogs from the pond. Cope's treefrogs, American toads, spring peepers, cricket frogs, pickerel frogs, zigzag salamanders, and spotted salamanders were also trapped.

These amphibians cannot be considered residents of the open field habitat. These are woodland species that are presumably using the field in a transient manner in movements associated with the pond, involving feeding, reproduction, and moisture requirements. The field pond data presented here are an underestimate of species richness and abundance at these sites due to the reduced number of trapping days and the fact that the survey did not include the major period of amphibian breeding in the spring. These data, although incomplete, demonstrate the influence of water resources on herpetofaunal utilization of old fields.

The dry old field sites (JF, CF) were depauperate compared to all other sites and were dominated by reptiles. The few reptiles (n = 10) trapped were garter snakes, southern black racers, and black rat snakes. However, these snakes and eastern box turtles were regularly observed. Only three amphibians were trapped in the dry old fields (two green frogs and an unidentified juvenile ambystomid).

A subset of the drift fence sites (JF, JY, JM, and JG) at Jefferson Proving Ground formed an old field successional sequence (Table 3). Changes in the herpetofauna were correlated with the successional stage of these sites. The reptile-dominated dry old field (JF) was the poorest of the four sites by all measures. The young (JY) and mature (JM) wooded sites were far more productive and had similar sets of species. The trap rate was higher at the mature (JM) wooded site indicating a larger amphibian and reptile population, but the younger (JY) site was more diverse. The oldest site with permanent water (JG) was the richest site by all measures employed. As noted above, amphibians dominated the forested sites. The Jefferson Proving Ground successional sequence did not include an old field pond site.

Species notes. The following observations are based on drift fence trapping, hand collecting, road surveys, and breeding call surveys.

Two species of the genus *Bufo* were collected. American toads were more common than Fowler's toad (4/6 forest sites) and were fairly abundant at three forest sites (HV, WW, and JM). Both species can be found in a range of habitats from woodland to open grassland, but Fowler's toad exhibits a habitat preference for loose, sandy soil (Minton, 1972). Site JG was the only site with this kind of substrate and the only site where Fowler's toad (21 trapped) was more common than the American toad (one trapped).

Frogs of the genus *Rana* are an important component of the Jefferson County herpetofauna. Bullfrogs, green frogs, pickerel frogs, and leopard frogs were often found in association with ponds, pools, and creeks. All these species may wander under appropriate weather conditions, and all ranid species except bullfrogs were trapped at sites distant from a water source. As noted above, the relatively terrestrial wood frog was the most widespread and abundant anuran. Southeastern Indiana is a zone of sympatry for the three local representatives of the *R. pipiens* complex (northern and southern leopard frogs, pickerel frog). The ecological interactions of these species are currently under investigation (Karns, unpublished data).

Breeding call surveys showed that species of the family Hylidae (spring peepers, chorus frogs, Cope's treefrog, and cricket frog) were common in the area. They were not well represented in the drift fence trapping due to their ability to escape from pitfall traps. The chorus frog was the most commonly trapped treefrog at forest sites (4/6 sites; 14 specimens).

Southeastern Indiana is rich in species of the family Plethodontidae. As noted above, redback and zigzag salamanders were the common woodland species. These species tended to have disjunct local distributions. Zigzags and redbacks comprised 96.2% (n = 126/131) and 2.3% (n = 3/131) respectively of the total salamanders trapped at HV. Rednecks comprised 59.3% of the salamanders trapped (n = 54/91) and 24.1% of those collected by hand (n = 45/187) at JG; no zigzags were collected. Hand collecting at several localities revealed this asymmetrical distribution. Zigzag and redback salamanders were collected in roughly equal numbers (zigzags: n = 7/120; redbacks: n = 10/120) at only one site in eastern Jefferson County.

Individuals of the all-red "scarlet" or "erythristic" color phase of the redback salamander were discovered at JG. This appears to be the only locality in Indiana where this color phase has been recorded. The nearest published locality for the color phase is in northeastern Ohio. Experimental studies indicate that erythristic redback salamanders may be a Batesian mimic of the toxic eft (Tilley, *et al.*, 1982). Preliminary surveys show that about 10% of the redbacks at the JG site are erythristic (Karns, unpublished data). This is the only site studied where efts were relatively common.

Other plethodontid species were locally abundant. Long-tail salamanders dominated the creekbed environment at JG (85.8%; n = 103/120 salamanders collected). Dusky salamanders dominated at West Fork Creek in the Switzerland Hills Section of eastern Jefferson County (81.7%; n = 98/120). Two-lined salamanders were dominant at Wolf Run Creek in the Switzerland Hills (100.0%; n = 27/27). These common creekbed species were rarely trapped in drift fences adjacent to streams. Cave salamanders exhibited the most unpredictable distribution of the salamanders collected. They were sampled in creekbeds, caves, and forests.

The secretive, burrowing salamanders of the genus *Ambystoma* are likely to be encountered on the surface only during movements associated with reproduction and overwintering. Spotted salamanders were trapped near breeding pools (CP) in the late spring. Jefferson's salamander was found only at one woodland site (JM) during this survey but has since been encountered in high numbers at drift-fenced ponds and appears to be common in the area. The tiger salamander and the marbled salamander may occur in Jefferson County, but they have not been detected.

A new species of ambystomid, *A. barbouri*, was described in 1989 (Kraus and Petranka, 1989). This species is a sibling species of *A. texanum*, the smallmouth salamander; it is a stream-breeding form found in southeastern Indiana, southwestern Ohio, and north-central Kentucky. Ambystomid larvae were observed in several streams in southern Jefferson county (Karns, unpublished observations), suggesting that *A. barbouri* is common.

The range map provided by Kraus and Petranka (1989) indicates that these sibling species are parapatric along the southwestern border of Jefferson County and that the range of *A. barbouri* includes the western half of Jefferson County (Switzerland Hills). The northwestern third of the county is shown outside the range of both species. I trapped one adult salamander near a pond in northwestern Jefferson County in November 1989 that was identified as *A. barbouri* on the basis of tooth morphology. This specimen indicates that the distributional limits of this species pair are in need of further study.

The red-spotted newt is the only member of the family Salamandridae found in Indiana. The aquatic form of the species (newts) were collected at several farm ponds. The terrestrial form (efts) were trapped at two forest sites (JG and HV). Efts were relatively common at JG (23.1% of the salamanders trapped; n = 21/91).

Lizards exhibited a spotty distribution. Five-lined skinks were trapped and observed at woodland sites with adjacent water (HV, JG, and WW). Broadhead skinks were trapped, but never observed, at only one woodland site (HV). Northern fence lizards were hand collected in drier, open sites.

Garter snakes, black rat snakes, and southern black racers were the most frequently encountered snakes in all habitats. Ringneck snakes were commonly encountered in moist woodlands. Kirtland's snake was restricted to woodland sites prone to flooding, where crayfish burrows were common (sites JW and JM). This species is known to use crayfish burrows as refuges, for estivation, and perhaps as overwintering sites (Sellers, 1986). The aquatic midland banded watersnake and queen snake were commonly encountered in creekbed sampling but never in drift fences. Ten other species were encountered infrequently and collected by hand or road surveys (Table 1).

Turtles were not adequately surveyed in this study; relatively little effort was put into turtle trapping. Snapping turtles, red-eared sliders, map turtles (Jennings County), and midland painted turtles were collected by turtle trapping and road surveys. The eastern box turtle was the most commonly encountered species. This terrestrial species was observed in all habitats.

Comparison of methods. Table 4 compares the effectiveness of the different sampling methods employed in generating the species list. Table 1 shows the methods of collection for each species. Because drift fences were the primary sampling tool, these are not comparisons of equal collecting effort. In spite of this inequality, drift fences and hand collecting produced a roughly comparable species list. Hand collecting was noticeably more effective than drift fences for snakes (twelve versus five species). The road survey was about half as effective as the other methods.

Table 5 presents a comparison of the effectiveness of the different traps employed with the drift fences. There was a significant difference in trap-rate among

TABLE 4. Comparison of effectiveness of different collecting methods for detecting species. The number of species collected by each method is shown. See Materials and Methods for a description of the techniques. Unique species refers to species collected only by that technique. The method of collection of each species is listed in Table 1. Drift fences were the primary sampling tool in this survey.

Taxon	Drift Fence	Hand Collecting	Road Survey
Salamanders	11	9	0
Anurans	10	11	6
Turtles	1	1	3
Lizards	3	2	2
Snakes	5	12	7
Total Species	30	35	18
Unique Species	3	6	2

trap-types (χ^2 = 489.46, df = 2, $P < 0.001$). Overall, funnel traps were most effective followed relatively closely by 20-L buckets. The 7.6-L cans were a distant third.

The great majority of animals trapped were amphibians (95.5% of the total). Traps differed in their effectiveness with different amphibian taxa. Funnel traps were the most effective trap for salamanders. The primary reason for this is that some salamanders can crawl out of the buckets or cans. The drawback of funnel traps is that animals can quickly dessicate under dry conditions unless special precautions are taken. Twenty-liter buckets were about twice as effective at trapping anurans as either cans or funnel traps.

Relatively few reptiles were trapped in drift fences (4.5% of the total trapped). Medium-to-large sized snakes can easily slither out of buckets or cans; large snakes can go over fences. A few large snakes were trapped in funnel traps. Buckets or cans were effective with lizards, small-sized snake species, and juvenile snakes.

DISCUSSION

The herpetofauna of Jefferson County. It is common to discuss the animal community of a given area in terms of the plant community. However, with amphibians and reptiles, this approach probably gives the specific vegetation a greater role in determining the community composition of an area than is warranted. In their analysis of the herpetofauna of the Florida sandhills and scrub, Campbell and Christman (1982) noted that species responded to the physical characteristics of the habitat rather than to particular plant associations. My observations in southeastern Indiana agree with this conclusion.

In this study, three physical characteristics emerged as being of primary importance in determining site quality: 1) wetness of the site as determined by the presence and permanence of surface water and by soil type; 2) structural complexity of the habitat; and 3) microclimate as moderated by the first two factors. Thus, the fact that a site is a mature forest with a closed canopy and Cobbsfork silt loam (a poorly drained soil subject to flooding) is more important

TABLE 5. Comparison of effectiveness of different drift fence traps. Total number of animals of each taxon trapped by each type of trap is shown; numbers in parentheses are percentages. See Materials and Methods for a description of the traps. The data are a summary from 12 drift fence sites over a seven month period. Each site consisted of two fences with four cans, two buckets, and two funnels. Trap-rate is the total number of animals trapped divided by the total number of buckets deployed.

Taxon	7.6-L Can (n=96)	20-L Bucket (n=48)	Funnel Trap (n=48)	Total
Salamanders	53 (10.3)	129 (25.0)	333 (64.7)	515 (50.3)
Anurans	107 (23.2)	235 (50.9)	120 (26.0)	462 (45.2)
Turtles	0 —	1 (100.0)	0 —	1 (0.1)
Lizards	7 (31.8)	4 (18.2)	11 (50.0)	22 (2.2)
Snakes	0 —	2 (8.7)	21 (91.3)	23 (2.2)
Total	167 (16.3)	371 (36.3)	485 (47.4)	1023
Trap-Rate	1.7	7.7	10.1	

in predicting the composition of the herpetofauna than knowing that the forest is a maple-basswood climax community.

The classification of site wetness in Jefferson County is confounded by the high clay content of the soil and perched water tables (Nickell, 1985). Large areas of the County are level and poorly drained. These areas periodically become upland wetlands, whose continued existence is dependent on rainfall.

Another aspect of site quality is the distinction between primary and secondary habitat (Harris, 1984). Primary habitat is habitat in which a given species can meet all its life history needs. Secondary habitats fulfill only some of these requirements. For example, rocky creeks are primary habitat for dusky salamanders; they can feed, reproduce, and overwinter at these sites.

These different concepts of site quality are useful in discussing the survey data presented here. Structurally complex woodlands with forest moderated microclimate and adjacent water were the richest sites surveyed. The structurally simple, open field sites without adjacent water were the poorest sites. The nature of the water resource in a given habitat (stream, permanent pond, or temporary pools) is important in defining it as secondary or primary habitat, depending on the life history of a species.

Site quality obviously changes as ecological succession proceeds in abandoned farmland. For example, structural complexity increases and temperature fluctuations decrease (Smith, 1980). Secondary habitat may become primary habitat for some species as these changes occur. Old field succession is an extremely important process in Jefferson County, where acreage devoted to agriculture is decreasing, and farmland is being abandoned (Nickell, 1985). Changes in the herpetofauna associated with succession have received relatively little attention (Bennett, *et al.*, 1980; Harris, 1984).

The successional series examined in this study (Table 3) indicates that reptile-dominated, relatively low biomass, low diversity old field herpetofaunal communities are replaced by higher biomass, higher diversity amphibian-dominated communities as woodlands develop. This shift in community composition is not unexpected given the physiological differences between amphibians and reptiles. The situation is more complicated in old fields with water resources. Permanent and temporary ponds in fields attract amphibians and reptiles from adjacent woodlands for feeding and reproduction. The old field habitat becomes an important movement corridor in these cases.

The time period of the survey is important to consider in the interpretation of the data presented here. Southern Indiana has a relatively moderate climate. Large scale movements associated with amphibian breeding begin in January. Many species are active well into the fall, and some species are intermittently active all winter, depending on the weather (Minton, 1972; Karns, unpublished data). This survey compared habitats during the summer months only; movements associated with breeding and overwintering are largely excluded. The data presented here provide a portrait of the herpetofauna, when the majority of animals are presumably in summer feeding ranges. A survey conducted during the period of active breeding movements in the late winter and spring would provide a very different community portrait.

Methods of community analysis. Amphibians and reptiles are difficult to sample due to their secretive habits, sensitivity to environmental conditions, and seasonal patterns of activity (Vogt and Hine, 1982). This survey was not intended as a controlled comparison of sampling methods. However, in spite of the emphasis on drift fences, hand collecting provided a somewhat higher species count and comparable information on habitat utilization. Drift fences provide kinds of information not easily obtained by hand collecting (e.g., activity patterns and directionality of movement), but if the goal is a simple record of species occurrence and habitat utilization, the expense of drift fences may not be warranted.

The drift fence data show differences in trap success. Vogt and Hine (1982) suggest various arrangements of 20-L buckets, 7.6-L cans, and funnel traps for trapping different taxa in different habitats. The data presented here suggest that the 7.6-L cans could be eliminated. Some combination of 20-L buckets and funnel traps would be more effective. However, funnel lids on cans were not used in this study. Vogt and Hine (1982) found that funnel lids did improve the trapping effectiveness of the 7.6-L cans.

Future work. This survey has identified a number of questions that deserve further study: the distribution and status of the erythristic redback salamander, the ecological interactions of redback and zigzag salamanders, and the distribution of *A. barbouri* and *A. texanum*. For logistic reasons, this study concentrated on the Muscatatuck Flats and Canyons Section of Jefferson County. To the east lie the extensive uplands of the Switzerland Hills Section (Hay, 1892). This area is herpetologically understudied and warrants further investigation.

The data presented here clearly show the importance of woodlands for the amphibian and reptile community. The ecological reality of the herpetofauna of southeastern Indiana is a severely disturbed and fragmented habitat compared to the relatively continuous forest of pre-settlement times. The implications of habitat fragementation for the structure of amphibian and reptile communities is an important question for future study.

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