

REPTILIA: SQUAMATA: COLUBRIDAE

THAMNOPHIS RADIX

Catalogue of American Amphibians and Reptiles.

Walley, H.D., T.L. Wusterbarth, and K.M. Stanford. 2003. *Thamnophis radix*.

Thamnophis radix (Baird and Girard)

Plains Gartersnake

Eutania radix Baird and Girard 1853:34. Type locality, "Racine, Wisconsin," restricted to "vicinity of Chicago, Cook County, Illinois" by Smith and Brown (1946). Holotype, National Museum of Natural History (USNM) 719, collected by P.R. Hoy, date unknown. Location of type unknown.

Eutania radix: Kennicott 1855:256. *Error typographicus*.

Eutaenia haydenii Kennicott 1860a:298. Type locality, "Fort Pierre, Nebraska." Holotype, National Museum of Natural History (USNM) 707, collected by Dr. Evans, date unknown (examined by HDW). See **Remarks**.

Tropidonotus sirtalis var. *radix*: Jan 1863:69.

Tropidonotus sirtalis var. *Haydeni*: Jan 1863:69.

Tropidonotus (Eutania) glaphyros Jan 1863:70. Type locality, "Amer. Settentr." Holotype in Museo Civico di Storia Naturale, now apparently lost.

Tropidonotus (Eutania) Kennicotti Jan 1863:70. Type locality, "North (or northern) America;" restricted to "Racine, Wisconsin" by Smith and Brown (1946). Type specimen lost.

Eutaenia radix: Cope 1875:40.

Eutaenia radix twiningii Coues and Yarrow 1878:279. Type locality "Two Forks on Milk River." Holotype, National Museum of Natural History (USNM) 9537, received from A.W. Butler, 15 July 1874. See **Remarks**.

Eutaenia radix: Hay 1881:738.

Eutaenia radix melanotaenia Cope 1888:400. Type locality, "Indiana," received from A.W. Butler, date unknown. Location of type unknown. See **Remarks**.

Tropidonotus ordinatus var. *radix*: Boulenger 1893:211.

Thamnophis radix: Jordan 1899:193.

Thamnophis radix radix: Blanchard 1925:18.

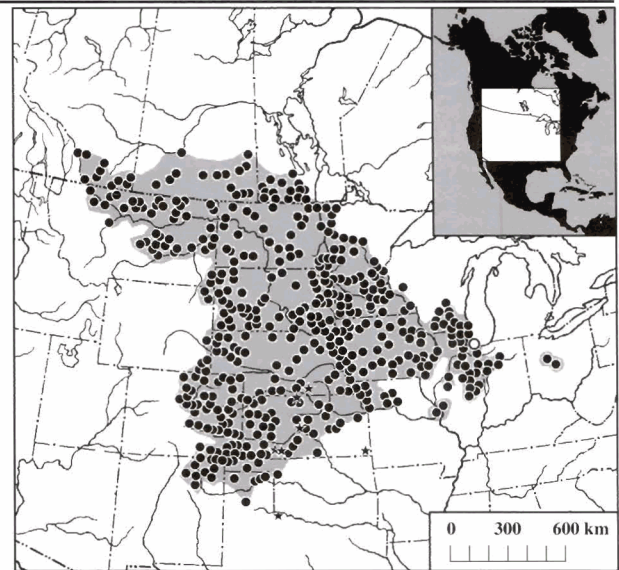
Thamnophis radix haydenii: Smith 1949:285.

Thamnophis radix haydeni: Gehlbach and Collette 1959:143.

• **CONTENT.** No subspecies are recognized. See **Remarks**.

• **DEFINITION.** *Thamnophis radix* is a medium-sized snake reaching a maximum TL of 1095 mm, with SVL in adult females ranging from 350–865 mm (mean 607.5 mm) and adult males ranging from 325–658 mm (mean 491.5). The strongly keeled dorsal scales normally are in 21–21–17 or 19–21–17 rows with occasional specimens having 23–21–17 rows. Males have 138–175 ventrals (mean 156.5) and 64–88 (mean 76) subcaudals; females have 135–174 ventrals (mean 154.5) and 54–74 (mean 64.0) subcaudals. The head is relatively short, but distinct from the neck. Dorsal head scales consist of a rostral, 2 internasals, 2 prefrontals, a medial frontal, 2 supraocular, and 2 parietals. Scales on the sides of the head consist of 2 nasals, 1 (rarely 2) loreal scales (in broad contact with the second supralabial), 1 preoculars (rarely 2), 3 postoculars (rarely 2 or 1), 7–8 supralabials (rarely 6), and 9–10 infralabials (rarely 8 or 11). Two pairs of long chin shields are present with the anterior pair in broad contact and the posterior pair larger in size.

Dorsal body color varies from black or gray to dark brown or olive. The middorsal stripe is yellow, orange, or orangish yellow, and the lateral stripes vary from yellowish gray to bluish cream, and involve the 3rd and 4th scale rows on each side. Two rows of dark spots usually occur above the lateral stripes, and another



MAP. Distribution of *Thamnophis radix*: the circle marks the approximate site of the restricted type locality, dots denote other records, and fossil records are marked with stars.



FIGURE 1. Adult *Thamnophis radix* from Chicago, Cook County, Illinois (photograph by Mike Redmer).



FIGURE 2. Adult male *Thamnophis radix* from Nebraska (photograph by Mike Redmer).

row of dark spots below them. The top of the head is usually dark, with two tiny pale spots on the parietal scales. The supralabials are yellow or cream in coloration, with prominent dark lines along the scale edges. The ventral surface is yellow to greenish, often with black spots at the outer edges of the ventral scutes.

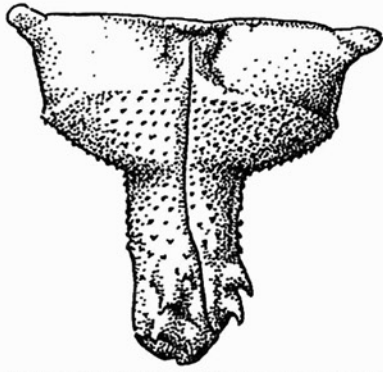


FIGURE 3. Spinose hemipenis of *Thamnophis radix* (from Dowling and Savage 1960).

Maxillary teeth range in number from 20–27, 24.5–24.9 in males and 23.3–24.4 in females.

The karyotype is $2N = 36$, all macrochromosomes (Baker et al. 1972).

• **DIAGNOSIS.** *Thamnophis radix* can be distinguished from potentially sympatric congeners by the following combination of characters: lateral light stripes usually involving only the 3rd and 4th scale rows, 21 dorsal scale rows at midbody, ≤ 27 maxillary teeth, and no light keels on dark dorsal scales.

• **DESCRIPTIONS.** In addition to references cited in the synonymy and state and regional guides listed under **Distribution**, general descriptions are in Garman (1892), Boulenger (1893), Cope (1900), Ruthven (1908), Wright and Wright (1957), A. Smith (1949), Conant (1958, 1975), Cochran and Goin (1970), Behler and King (1979, 1995), Stebbins (1985), Ernst and Barbour (1989), Conant and Collins (1991, 1998), Rossman et al. (1996), Tennant and Bartlett (2000), and Ernst and Ernst (2003).

• **ILLUSTRATIONS.** Lithographic drawings are in Baird (1859), Kennicott (1859), and Duméril et al. (1870). Color photographs and color illustrations are in Dickinson (1949), Schmidt and Inger (1957), Behler and King (1979, 1995), Baxter and Stone (1980), Vogt (1981), Preston (1982), Smith and Brodie (1982), Stebbins (1985), Tennant (1985, 1998), Christiansen and Bailey (1986, 1990), Hammerson (1986, 1999), Johnson (1987, 2000), Sievert and Sievert (1988), Ernst and Barbour (1989), Coborn (1991, 1994), Conant and Collins (1991, 1998), Hoberg and Gause (1992), Collins (1993), Collins and Collins (1993), Russell and Bauer (1993), Mara (1994), Oldfield and Moriarty (1994), Perlowin (1994), Reichel and Flath (1995), Rossi and Rossi (1995), Busby et al. (1996), Rossman et al. (1996), Phillips et al. (1999), Thompson and Backlund (1999), Christoffel et al. (2000), Harding (2000), Russell and Bauer (2000), Tennant and Bartlett (2000), Werler and Dixon (2000), Minton (2001), Denny (2002), and Ernst and Ernst (2003). Oldfield and Moriarty (1994) provided a color photograph of an albino from Hennepin County, Minnesota, and Gray (1980) an albino from Sedgwick County, Kansas. Color morphs were illustrated by Rossman et al. (1996) and Hallmen and Chlebowy (2001). Coborn (1994) provided a photograph of a *T. radix* feeding on *Rana* sp., and Perlowin (1994) provided a photograph of an individual feeding on a *Bufo americanus* and another photograph of shedding. Black and white photographs are in Ditmars (1907), Over (1923), Pope and Dickinson (1928), Schmidt and Davis (1941), Smith (1950, 1956), Conant (1951), Smith (1961), Pope (1964), Wheeler and Wheeler (1966), Minton (1972), Collins (1974), Ernst and Barbour (1989), Collins (1993), and Dixon (2000). Preston (1982) illustrated shedding.

Guthrie (1929) illustrated a bicephalic neonate, and Hudson (1942) provided an illustration of a female with 27 newborn young. Conant (1951) provided habitat photographs for Marion County, Ohio. Basic structure of hemipenes was illustrated in Dowling and Savage (1960). Karyotypes were figured in Baker et al. (1972).

Holman (2000) illustrated dorsal, ventral, anterior, and posterior views of a trunk vertebra of a specimen from Late Pleistocene, Williams Local Fauna, Kansas. Bullock and Tanner (1966) illustrated osteological features of the atlas, axis, first thoracic, anterior, middle and ventral vertebra, and dorsal, lateral, ventral, and posterior views of the cranium. Varkey (1979) provided an illustration of a dorsal view of the posterior region of the skull and the anterior region of the vertebral column showing the attached muscles. Baird (1970) illustrated a lateral view of the left otic region showing varying closure of the ophidian circumfenestral crest.

• **DISTRIBUTION.** *Thamnophis radix* occurs from southern Alberta, southern Saskatchewan, and southern Manitoba south through the Great Plains to northeastern New Mexico, northern Texas, and northern Oklahoma, and eastward through northern and central Illinois and northern Indiana, with disjunct, relictual colonies in north-central Ohio and on the Illinois–Missouri border. In Saskatchewan, *T. radix* is restricted to grasslands and aspen parklands in the southern portion of the province (Secoy 1976). Jones et al. (1981) included marshes, swamps, and grassy areas along streams and around ponds in this species' habitat in Nebraska. Conant (1958, 1975), Behler and King (1979, 1995), Conant and Collins (1991, 1998), Rossman et al. (1996), Tennant and Bartlett (2000), and Ernst and Ernst (2003) provided distribution maps of the entire range.

This species has been listed in several regional guides and annotated bibliographies: **Arkansas** (Dellinger and Black 1938, Schwarzt 1938, Dowling 1957), **Colorado** (Hammerson 1981,

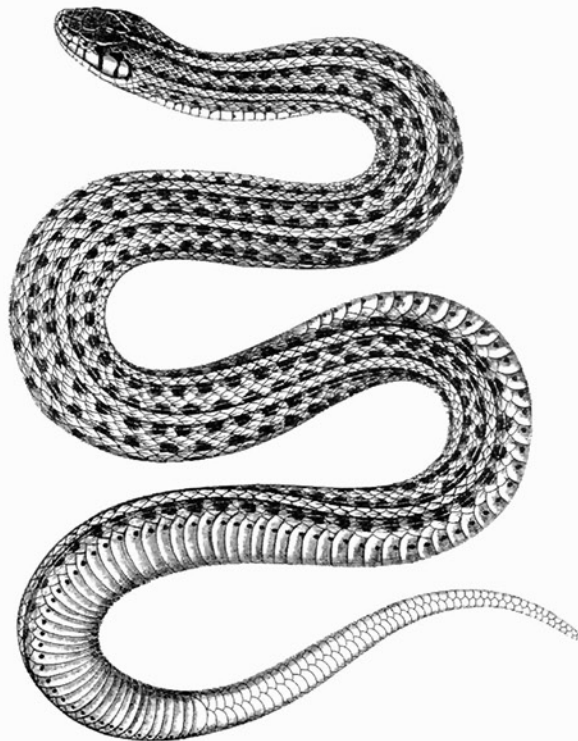


FIGURE 4. *Thamnophis radix* (from Kennicott 1860).

1986, 1999), **Illinois** (Davis and Rice 1883a,b; Garman 1892; Van Cleave 1928; Schmidt and Necker 1935; Necker 1939; Smith 1947, 1961; Leuth 1949; Smith and Minton 1957; Pope 1964; Phillips et al. 1999; Harding 2000; Mauger and Anton 2003), **Indiana** (Hay 1892; Myers 1926; Minton 1966, 2001; Harding 2000), **Iowa** (Ruthven 1912, 1919; Christiansen and Bailey 1986, 1990; LeClere 1998; Harding 2000; Walley 2002), **Kansas** (Smith 1950, 1956; Collins 1974, 1993; Collins and Collins 1993; Busby et al. 1996; Potts et al. 1999), **Minnesota** (Breckenridge 1944, Oldfield and Moriarty 1994, Karns 1996, Blasus 1997, Harding 2000), **Missouri** (Hurter 1911; Johnson 1987, 2000), **Montana** (Reichel and Flath 1995, Maxell et al. 2003), **Nebraska** (Hudson 1942, Ballinger et al. 1979, Lynch 1985), **New Mexico** (Degenhardt et al. 1996), **North Dakota** (Wheeler 1947, Wheeler and Wheeler 1966, Hoberg and Gause 1992), **Ohio** (Conant 1951, Dalrymple and Reichenbach 1981, Harding 2000, Denny 2002), **Oklahoma** (Webb 1970, Sievert and Sievert 1988), **South Dakota** (Over 1923, Thompson and Backlund 1999, Ballinger et al. 2000), **Texas** (Brown 1950; Raun 1965; Tennant 1985; Dixon 1987, 2000; Werler and Dixon 2000), **Wisconsin** (Higley 1889, Pope and Dickinson 1928, Dickinson 1949, Casper 1996, Vogt 1981, Christoffel et al. 2000), **Wyoming** (Baxter and Stone 1980), **Canada** (Mills 1948, Logier and Toner 1961, Froom 1972), **Alberta** (Lewin 1963; Russell and Bauer 1993, 2000), **Manitoba** (Preston 1982), **Saskatchewan** (Secoy 1976, Cook 1978). For a list of state and provincial guides for the United States and Canada, see Moriarty and Bauer (2000). Davis (1932) opined that the more aggressive *T. radix* had displaced *T. butleri* from its former range in Wisconsin, Illinois, and northwestern Indiana. Fitch and Maslin (1961) stated that the "streams in the High Plains are suitable habitat for *T. radix* because they are in the eroded channels, and have a variable and uncertain water supply, which is unsuited for *T. sirtalis*." Dowling (1956) cited *T. radix* as occurring in the Ozark Plateau region. Dowling (1957) questioned the validity of the specimens from Washington County, Arkansas that were allocated to this species by Dellinger and Black (1938), Schwaradt (1938), and Dowling (1956), noting that they were misidentified *T. sirtalis*.

• **FOSSIL RECORD.** Holman (1964) recorded vertebrae from the Pleistocene Groesbeck Creek beds in Hardeman County, Texas. Ford (1992) and Rogers (1984) recorded Pleistocene vertebrae from the Big Springs and Hornet's Nest quarries of northeastern Nebraska. Holman (1995) recorded material from the Albert Ahrens Local Fauna in Nucholls County, southeastern Nebraska, as being from the only significant Irvingtonian Pleistocene site within the state. In Pleistocene sites in Kansas, *T. radix* has been recorded from the Williams Local Fauna of Rice County (Preston 1979; Holman 1984, 1995), Mt. Scott Local Fauna in Meade County (Preston 1979; Holman 1987a, 1995), Butler Spring Local Fauna, Meade County (Preston 1979; Holman 1986a, 1995), Courtland Canal/Hall Ash Assemblage, Jewel County (Rogers 1982), and Robert Fauna, Meade County (Holman 1987b, 1995). *Thamnophis radix* was cited from the Early Illinoian of Oklahoma by Holman (1986b). Holman (2000) provided a summary of known localities from both Pleistocene and Pliocene deposits in North America.

• **PERTINENT LITERATURE.** Ruthven (1908), Smith (1949), and Rossman et al. (1996) provided the most comprehensive reviews available on the biology of the species. **Taxonomic, systematic, or phylogenetic studies** include Kennicott (1860), Jan (1863, 1865), Coues and Yarrow (1878), Yarrow (1883), Cope (1892, 1895), Boulenger (1893, 1896), Stejneger and Barbour (1917, 1923, 1933, 1943), Werner (1929), Smith (1942), Conant (1950), Parsons (1959b), Marx and Rabb (1972), Lombard et al. (1986), Shine (1991), de Queiroz and Lawson

(1994), Beltz (1995), Rossman (1995), Rossman et al. (1996), Buckley et al. (2000), Crother (2000), Bronikowski and Arnold (2001), Burghardt (2001), Collins and Taggart (2002), de Queiroz et al. (2002), and Highton et al. (2002). Morris (1975) discussed the possibility of habitat destruction in prairie habitat in Champaign County, Illinois, as disrupting speciation in what he considered a genetically isolated population. Current scientific and common names were provided by Collins et al. (1978), Collins et al. (1982), Collins (1990, 1997), Frank and Ramus (1994, 1995), Crother (2000), and Collins and Taggart (2002).

Works on **historical biogeography** include Cope (1896), Schmidt (1938), Lambert and Reid (1981), Ford and Schofield (1984), Bailey and Christiansen (1993), Busby et al. (1996), Busby and Parmelee (1996), and Brodman et al. (2002). **Biogeographical studies** were undertaken by Smith (1957), Smith and Minton (1957), and Ford and Schofield (1984).

Information on **ecology and distribution** is in Duméril et al. (1870), Coues (1875), Yarrow (1875), Hay (1881, 1892), Davis and Rice (1883b), Garman (1883), Cope (1896), Higley (1889), Brown (1901), Ditmars (1907, 1910, 1931, 1933, 1936, 1939), Ruthven (1912, 1919), Strecker (1915), Blanchard (1921), Burt (1927, 1929, 1933, 1935), Ortenburger (1927), Gloyd (1928), Pope and Dickinson (1928), Burt and Hoyle (1935), Schmidt and Necker (1935), Necker (1939), Schmidt and Davis (1941), Edgren (1944), Marr (1944), Conant et al. (1945), Breukelman and Smith (1946), H. Smith, (1946, 1950, 1963), P. Smith (1947, 1961), Loomis (1948), Mills (1948), Klimstra (1950), Breukelman and Clarke (1951), Fouquette and Lindsay (1955), Schmidt and Inger (1957), Wright and Wright (1957), Adler (1959, 1961), Clarke et al. (1959), Gehlbach and Collette (1959), Maslin (1959), Fishbeck and Underhill (1960), Christiansen (1961), Fitch and Maslin (1961), Moll (1962), Harper (1963), Lewin (1963), Tinkle and Knopf (1964), Smith et al. (1965), Smith et al. (1966), Dunlap (1967), Jordan (1967), Wintraub (1967), Collins (1974, 1979, 2002), Chiszar and Carter (1975), McCoy (1976), McNaughton (1976), Secoy (1976), Malaret (1977), Ballinger et al. (1979), Dalrymple and Reichenbach (1981), Jones et al. (1981), Vogt (1981), Lardie (1982), Powell and Smith (1983), Christiansen and Mabry (1985), Olson (1987), Redmer and Zaworski (1987), Obst et al. (1988), Russell and Bauer (1991), Hooper (1992), Sweeney (1992), Bavetz (1993), Chiszar and Smith (1993), David et al. (1994), Mara (1994), Perlowin (1994), Tucker (1994), Manning (1995), Redmer and Ballard (1995), Rossi and Rossi (1995), Busby et al. (1996), Casper (1996), Ford (1996), Rossman et al. (1996), Steinhilber (1996), LeClere (1998), Petzing et al. (1998), Ballinger et al. (2000), Christoffel et al. (2000), Dixon (2000), Irwin and Collins (2000), Werler and Dixon (2000), Markezich and Beckett (2001), Meyer and Trester (2001), Giazzone (2002), Walley (2002), Mauger and Anton (2003) and Maxell et al. (2003). Many of the papers cited in the distribution section above also provide ecological information.

Studies of **reproduction and life history** include the following: **general** (Breckenridge 1944, Wright and Wright 1957, Pope 1964, Fitch 1970, Smith 1975, Crews 1980, Seigel and Fitch 1985, Tennant 1985, Seigel et al. 1986, Scudder-Davis and Burghardt 1987, Seigel and Ford 1987, Ernst and Barbour 1989, Burghardt 1990, Rossi and Rossi 1995, Rossman et al. 1996, Mattison 1998, Werler and Dixon 2000, Stanford 2002), **age determination** (Taylor 1982, Wayne and Gregory 1998, Stanford 2002), **brood size** (Marr 1944; Wright and Wright 1957; Fitch 1970, 1985; Morris 1973; Dalrymple and Reichenbach 1981; Seigel and Fitch 1985; Seigel et al. 1986; Seigel and Ford 1987; Mattison 1998; Stanford 2002), **clutch mass/size** (Gloyd 1928; Breckenridge 1944; Fitch 1970, 1985; Collins 1974; Seigel and Fitch 1984; Engeman et al. 2002; Stanford 2002), **copulatory plugs** (Ross and Crews 1977, Mason 1992), **courtship and**

copulation (Davis 1936, Noble 1937, Blanchard and Blanchard 1942, List 1950, Pope 1964, Devine 1977, Turner 1977, Kubie et al. 1978, Morris 1978, Ross and Crews 1978, Dalrymple and Reichenbach 1981, Vogt 1981, Whittier and Tokarz 1992, Collins 1993, Johnson 2000, Stanford 2002), **development** (Billett et al. 1985, Stanford 2002), **developmental disorders** (Smith and Fitzgerald 1983), **female reproductive cycle** (Noble 1937, Cieslak 1945, Ross and Crews 1977, Aldridge 1979), **growth and maturity** (Seibert and Hagen 1947, Fitch 1970, Turner 1977, Ernst and Barbour 1989, Naulleau 1994, Velhagen and Savitzky 1998, Stanford 2002), **hemipenial structure** (Dowling and Savage 1960), **hybridization** (Ruthven 1904; Davis 1932; Smith 1946; Mertens 1950, 1968, 1972; Steehouder 1983; Good et al. 1994; Casper 1996), **incubation/parturition** (Breckenridge 1944, Seibert and Hagen 1947, Hebard 1951, Pope 1964, Fitch 1970, Morris 1973, Ernst and Barbour 1989, Stanford 2002), **longevity** (Bowler 1977, Ernst and Barbour 1989, Snider and Bowler 1992, Slavens and Slavens 1993), **male reproductive cycle** (Ross and Crews 1978, Ernst and Barbour 1989), **maximum size** (Nero 1957, 1960; Conant 1958; Collins 1974, 1993; Conant and Collins 1991; Rossman et al. 1996; Werler and Dixon 2000), **mortality** (Breckenridge 1944, Gregory 1977, Dalrymple and Reichenbach 1981, Reichenbach and Dalrymple 1986, Seigel and Fitch 1984, Reichenbach and Dalrymple 1986), **neonates** (Seigel and Ford 1987; Conant and Collins 1991, 1998; Velhagen and Savitzky 1998; King et al. 1999; Cline 2000; Stanford 2002), **oviposition** (Collins 1974), **parthenogenesis** (Murphy 2000), **population density and structure** (Seibert 1950, Bauerle 1972, Gregory 1977, Turner 1977, Secoy 1979, Dalrymple and Reichenbach 1981, Peters and Wassenberg 1983, Reichenbach and Dalrymple 1986, Parker and Plummer 1987, Naulleau 1994, Stanford 2002), **sex ratio/sexual dimorphism** (Smith 1946; Seibert and Hagen 1947; Clark 1967; Fitch 1981; Shine 1991, 1993; Kissner et al. 1998; King et al. 1999; Cline 2000; Kissner et al. 2000; Stanford 2002), **survivorship** (Seigel and Ford 1987, Stanford 2002), and **umbilical scar closure** (Smith 1947, Ernst and Barbour 1989).

Studies of **habitat relationships and behavior** include **activity patterns** (Heckrotte 1962, 1975; Jordan 1967; Buikema and Armitage 1969; Dill 1972; Minton 1972, 2001; Heckrotte 1975; Gregory 1977; Hart 1979; Dalrymple and Reichenbach 1981; Avery 1982; Furth and Turner 1982; Dalrymple and Reichenbach 1984; Reichenbach and Dalrymple 1986; Gibbons and Semlitsch 1987; Lillywhite 1987; Ernst and Barbour 1989; Naulleau 1994; Rossman et al. 1996; Blasus 1997; Stanford 2002), **aggressive behavior** (Davis 1932, Arnold and Bennett 1984, Garland 1988, Graves and Halpern 1988), **antipredator behavior** (Arnold and Bennett 1984, Redmer and Zaworski 1987, Brodie 1989, Schieffelin and de Queiroz 1991, Brodie and Garland 1993, Greene 1994, Flowers and Graves 1997), **chemically elicited behavior** (Noble 1937, Porter and Czaplicki 1974, Kubie and Halpern 1978, Secoy 1979, Lang 1982, Graves and Halpern 1988, Mason 1992, Matity et al. 1994, Flowers and Graves 1997, Greene 1997), **circadian rhythm** (Heckrotte 1975), **escape behavior** (Seigel and Fitch 1984), **hibernacula and hibernation** (Criddle 1937; Breckenridge 1944; Bailey 1949; Nero 1957; Goin and Goin 1962, 1971; Pope 1964; Young 1973; Dalrymple and Reichenbach 1981, 1984; Jones et al. 1981; Gregory 1982; Reichenbach and Dalrymple 1986; Ernst and Barbour 1989; Holtzman et al. 1989; Larsen and Hare 1992; van het Meer 1996), **learning behavior** (Andry and Luttges 1972, Fuenzalida and Ulrich 1975, Burghardt 1977, Terrick, et al. 1995), **locomotor activity** (Heckrotte 1975, Arnold and Bennett 1988, Brodie and Garland 1993), **pheromonal responses** (Fuenzalida et al. 1974; Porter and Czaplicki 1974; Kubie and Halpern 1978; Meredith and Burghardt 1978; Ford 1979, 1981, 1982; Secoy 1979; Gartska and Crews 1981; Ford and Low 1984; Ford and Schofield

1984; von Achen and Rakestraw 1984; Lawson 1985; Ridlon 1985a,b; Gregory et al. 1987; Scudder-Davis and Burghardt 1987; Begun et al. 1988; Graves and Halpern 1988; Ten Eyck and M. Halpern 1988; Mason 1992; Weldon et al. 1994; Greene 1997), **stereotypic behavior** (Carpenter and Ferguson 1977), **territorial needs** (Saint Girons and Saint Girons 1959), **social behavior** (Hudson 1942; Seibert and Hagen 1947; Wright and Wright 1957; Goin and Goin 1962, 1971; Pope 1964; Webb 1970; Porter and Czaplicki 1974; Chiszar and Carter 1975; Gregory 1977, 1982; Preston 1982; Lawson 1985; Stebbins 1985; Tennant 1985; Hammerson 1986, 1999; Graves and Halpern 1988; Ernst and Barbour 1989; Conant and Collins 1991, 1998; Yeager and Burghardt 1991; Mason 1992; Ford and Burghardt 1993; Cline 2000; Tennant and Bartlett 2000; Werler and Dixon 2000), **spatial and movement patterns** (Seibert and Hagen 1947, Gregory et al. 1987), **tongue flicking rate** (Chiszar et al. 1977, Chiszar et al. 1981, Greene 1997), **orientation** (Lawson and Secoy 1991), **use of celestial cues** (Lawson 1985, Gregory et al. 1987, Lawson and Secoy 1991), and **winter emergence** (Smith and Chiszar 1981).

Data on **food habits and diet** are organized by topic: **general** (Coues and Yarrow 1878; Ditmars 1912; Burt 1929; Burt and Hoyle 1935; Breckenridge 1944; Marr 1944; Wright and Wright 1957; Webb 1970; Smith 1961; Minton 1972, 2001; Gregory 1977; Ballinger et al. 1979; Hart 1979; Baxter and Stone 1980; Dalrymple and Reichenbach 1981; Jones et al. 1981; Preston 1982; Cebula 1983; Seigel 1984; Tennant 1985; Stebbins 1985; Hammerson 1986, 1999; Scudder-Davis and Burghardt 1987; Halloy de Grosse 1987; Ernst and Barbour 1989; Christiansen and Bailey 1990; Shine 1991; Rossi and Rossi 1995; Rossman et al. 1996), **cannibalism** (Weldon 1982), **competition among young** (Steehouder 1983, Yeager and Burghardt 1991, Greene 1997), **food poisoning** (Sights 1949), **food preferences** (Burghardt 1968, Dalrymple and Reichenbach 1981, Cebula 1983, Grosse 1987, Scudder-Davis and Burghardt 1987, Burghardt 1990, Lyman 1990, Yeager and Burghardt 1991), **foraging behavior** (Noble 1937, Secoy 1979, Chiszar et al. 1981, Ford 1981, Heller and Halpern 1981, Seigel 1984, Seigel and Fitch 1984, Lyman 1990, Mason 1992, Matity et al. 1994, Greene 1997), **herbivory** (Bruynonckx 1985), **predation** (Coues and Yarrow 1878, Guthrie 1932, Breckenridge 1944, Seibert and Hagen 1947, Gregory 1977, Gregory, et al. 1980, Dalrymple and Reichenbach 1981, Redmer 1988, Smith et al. 1999, Anton 2000), **prey recognition** (Terrick et al. 1995), and **prey selection and handling** (Gregory et al. 1980, Seigel and Fitch 1984, Greene 1997).

Parasites were discussed by Stewart (1960), Fitch (1965), Wacha and Christiansen (1974), Palmieri (1977), and Rossi and Rossi (1995); **diseases** by Gebhardt et al. (1966), Goldstein et al. (1981), and Zwart and van Moppes (1983).

Conservation and management were addressed in Dalrymple and Reichenbach (1984), Dodd (1987), Rossman et al. (1996), Levell (1997), and Burghardt (2001). *Thamnophis radix* was listed as an endangered species in Ohio by Ashton (1976), Frank and Ramus (1994), Levell (1997), Burghardt (2001), and Stanford (2002). Studies of **field techniques** include: **marking/collecting** (Ferner 1979, Simmons 1987, Seigel 1993), **population assessment** (Vogt and Hine 1982), and **recapture rates** (Seibert and Hagen 1947, Parker and Plummer 1987, Stanford 2002).

Anatomical studies have addressed: **aberrant head scalation** (Secoy 1970, Murphy et al. 1987), **chemoreceptors** (Halpern 1976, 1992; Wang and Halpern 1980a,b; Smith and Fitzgerald 1983; Zwart and van Moppes 1983; Kissner et al. 2000), **cranial and vertebral osteology** (Bullock and Tanner 1966, Marx and Rabb 1972, Varkey 1979), **cranial myology** (Varkey 1979), **dicephalism** (Guthrie 1929), **ear** (Baird 1960),

fetal membranes (Gerrard 1974, Yaron 1985), **glands** (Harrison and Denning 1929, Hellbaum 1936, Siler 1936, Cieslak 1945, Clark 1970, Gabe 1970, Lynn 1970, Kissner et al. 1998, Kissner et al. 2000), **integumentary vessels** (White 1957), **nasal structure** (Parsons 1959a, 1959b, 1970), **olfactory bulb** (Halpern 1976), **osteological repair and wound healing** (Irwin and Ferguson 1986), **tongue** (Ridlon 1985a,b, Yin et al. 1996), **vertebral duplication and osteological anomaly** (Cunningham 1937, King 1959, Zwart and van Moppes 1983), and **vertebral skeletochronology** (Taylor 1982, Wayne and Gregory 1998).

References to **physiology** include: **airborne odor discrimination** (van Achen and Rakestraw 1984, Weldon et al. 1994, Begun et al. 1998, Mason 1992), **amino acid studies** (Benyajati and Dantzler 1986), **ascorbic acid** (Chatterjee et al. 1975, Vosburgh et al. 1982, Allen and Oftedal 1994), **circulation** (Burggren 1977, Rauch 1978, Jacob 1980, Bartholomew 1982), **effects of chemical repellents** (Secoy 1979), **energetics and physiological ecology** (Reichenbach and Dalrymple 1986, Lillywhite 1987), **evaporative water loss** (Dalrymple and Reichenbach 1981), **heart and lung ventilation** (Burggren 1977, Jacob 1980), **hormonal effects** (Halpern 1992, Cline 2000), **lipid studies** (Burken et al. 1985), **placental transmission** (Gerrard 1974, Yaron 1985), **renal functions** (Benyajati and Dantzler 1986), **temperature** (Lueth 1941, Bailey 1949, Carpenter 1956, Heckrotte 1962, Fitch 1965, Dill 1972, Hart 1979, Dalrymple and Reichenbach 1981, Avery 1982, Gregory 1982, Gibbons and Semlitsch 1987, Lillywhite 1987, Doughty 1994, Kerfin 2001), and **water permeation** (Burken et al. 1985).

May (1952), Hensley (1959), Dyrkacz (1975, 1981), Hallmen and Chlebowy (2001), and Hallmen (2002) recorded **albinism**. Morris (1976) and Morris (1975) described **melanism**. Hallmen and Juergen (2001) described **color pattern polymorphism**.

Studies of **husbandry, management, and captive breeding** include Zwart and van Ham (1980), Quartero (1982), Mattison (1982, 1992, 1998), Quartero (1982), Zwart and van Moppes (1983), van Ormondt and van Lennepkade (1984), Bruynonckx (1985), Wolverkamp (1985), Van het Meer (1986, 1996), Sweeney (1992), Mara (1994), Perlowin (1994), Mutschann (1995), Potts (1995), Rossi and Rossi (1996), and Kaplan (1996).

The species was included in **keys** by Cagle (1968), Ballinger and Lynch (1983), Rossman et al. (1996), and Powell et al. (1998).

• **REMARKS.** Kennicott (1860b) described *Eutaenia haydenii* type from "Fort Pierre, Nebraska." Cope (1875) changed the name to *Eutaenia haydenii* (= *Thamnophis radix*). Cochran (1961), in her catalogue of type specimens in the United States National Museum, designated USNM 707 as the holotype for *Eutaenia haydenii* (= *Eutaenia radix haydenii*) and gave the type locality as "Fort Pierre, Stanley County, South Dakota." Schmidt (1953) synonymized *E. radix twiningii* Coues and Yarrow 1878 and *Thamnophis haydenii*, and designated USNM 9537 from "Two Forks of Milk River (Montana)" and collected by E. Coues on 15 July 1874 as the holotype. Cochran (1961) also designated four paratypes (USNM 9538 from "Mouse River, North Dakota, USNM 9539 from "Turtle Mountain, North Dakota," and USNM 9540-1 from "near Frenchman's River, Montana," all collected by E. Coues in 1873 and 1874. Smith (1949) stated that the type specimen of *T. radix haydenii* was in such poor condition that he designated CA 14498 as a lectotype (*lapsus* for neotype), and CA 14499, 14500, and 13858 as "paralectotypes" (*lapsus*; no ancillary types are recognized by the Code for neotypes). These specimens were all from near the type locality. Two of these, CA 14498 and 14499, were sent to the United States National Museum, where they were renumbered USNM 128137 and 128138, respectively. The neotype (USNM 128137) was collected at Whitlock Crossing, Davey County, South Dakota,

by A.M. Jackley on 6 October 1947 (Cochran (1961, Degenhardt et al. 1996). A ledger note by Stejneger questioned whether plate 14 in Kennicott (1860b) was the type specimen for *T. haydenii*.

R.I. Crombie (pers. comm.) stated that, "Doris Cochran had a curious concept of what constituted a type, which has added significantly to the volume of comments that have evolved in trying to update the USNM type catalogue, and the "paratypes" of *T. twiningii* are a good example. Coues and Yarrow (1878) were inconclusive as to which specimens are paratypes, as both *T. r. radix* and *T. r. twiningii* were represented in their table of additional material, but their comments in the original ledger, along with Cochran's (1961) annotations on the specimens from the same localities as paratypes without any dedication, is confusing."

The type of *T. haydenii* is a juvenile in fair condition, but not so bad, in Crombie's opinion, "that a neotype designation was necessary." According to Crombie (pers. comm.), "Smith's (1949) designation of a lectotype was fraught with a very poor understanding of nomenclatural procedure and only further confused a bad situation." This was followed by Cochran's correction (without comment) of this error to a neotype designation of USNM 128137 and a paraneotype designation of 128138 (both from Whitlock Crossing, Davey County, South Dakota, collected by A.M. Jackley et al. on 6 October 1847), which was certainly not helpful.

Two subspecies, *T. r. radix* and *T. r. haydenii* were formally recognized by Smith (1949), but the diagnostic characters he used to distinguish the two taxa do not apply to male *T. r. radix* (Rossman et al. 1996).

According to Schmidt (1953), the type locality, Racine, Wisconsin, was probably in error, and he restricted it to the "vicinity of Chicago, Illinois." According to Casper (1996), the species is still found throughout the southern tier of counties in Wisconsin, and Schmidt's (1953) restriction was unnecessary.

Cope gave the field numbers 90 and 312 to *Eutaenia radix melanotaenia*, both collected by A.W. Butler from "Brookville, Indiana," although neither of these numbers are cited in Cope (1900) and both specimens apparently were lost. The present number USNM 90 is a specimen of *Ambystoma jeffersonianum* from Wisconsin, whereas USNM 312 has no identity.

Minton (2001) questioned Cope's (1888) records for *Eutaenia melanotaenia* from Franklin County, Indiana. Hay's (1881) record of *T. radix* from Irvington, Marion County, Indiana, and Gaines's (1894) record from near Vincennes, Indiana, possibly represent former relictual populations of *T. radix* that have since been extirpated. Two of A.G. Smith's (1949) Indiana records are incorrect. The specimen of *T. radix* recorded from Wolf Lake, Noble County, Indiana, is based on a specimen from Wolf Lake on the Indiana-Illinois line between Whiting and Calumet City, Illinois, and the specimen from Honey Creek, Vigo County, Indiana, is a *T. sirtalis*.

• **ETYMOLOGY.** The name *radix* is from the Latin for "root," a possible reference to the Root River, near Racine, Wisconsin.

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HARLAN D. WALLEY, THERESA L. WUSTERBARTH,
and **KRISTIN M. STANFORD**, Department of Biology, North-
ern Illinois University, Dekalb, Illinois 60115 (hdw@niu.edu).

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