———. 1955. *Lampetra zanandreai*, a new species of lamprey from northern Italy. Copeia 1955:215–223.
———, AND W. I. FOLLETT. 1958. Redescription of *Lampetra ayresii* (Günther) of western North America, a species of lamprey (Petromyzonidae) distinct from *Lampetra fluviatilis* (Linnaeus) of Europe. J. Fish. Res. Bd. Canada 15:47–77.
———, AND ———. 1965. *Lampetra richardsoni*, a new nonparasitic species of lamprey (Petromyzonidae) from western North America. *Ibid.* 22:139–158.
———, AND ———. 1967. The teeth of lampreys (Petromyzonidae): their terminology and use in a key to the Holarctic genera. *Ibid.* 24:1067–1075.
ZANANDREA, G. 1959. Speciation among lampreys. Nature, Lond. 184:380.
———. 1961. Studies of European lampreys. Evolution 15:523–534.

DEPARTMENT OF FISHERIES AND WILDLIFE, OREGON STATE UNIVERSITY, CORVALLIS, OREGON.

A New Pliocene Snake, Genus *Elaphe*, from Oklahoma

J. ALAN HOLMAN

A partial skeleton of a large colubrine snake, *Elaphe buisi* n. sp., from the Upper Middle Pliocene of Beaver County, Oklahoma, consists of a few lumbar and thoracic vertebrae, an atlas; and part of a skull consisting of a parietal, frontal, nasal, basisphenoid, quadrate, pterygoids, palatine, maxilla, mandibles and a dentary. The fossil is assigned to the genus *Elaphe* on the basis of vertebral structure, and it is similar to *E. kansensis* (skull unknown) of the Lower Pliocene of Kansas from which it differs by having less dilated hypapophyseal tips of the thoracic vertebrae. *Elaphe buisi* vertebrae appear to be indistinguishable from those of Recent *E. obsoleta* and *E. subocularis*. The skull of the fossil is distinct from all Recent United States *Elaphe*, but it appears to be most similar to *E. obsoleta* and *E. subocularis*.

North American fossil snakes are known mainly from fragmentary bones, and most new forms have been described only from vertebral remains. Thus the recovery of a partial skull and vertebral column from the Upper Middle Pliocene of Oklahoma is of much interest as it is probably the most complete New World Pliocene snake known.

The snake was discovered by Claude Hibbard and William Akersten in May 1968, and is currently housed in the University of Michigan Museum of Paleontology. The fossil was found in a quarry on the Buis Ranch along the west side of Buckshot Arroyo (NE ¼ SW ¼ Sec. 5 T 5 N, R 26 E. C. M. or 36°45′ N, 100°30′ W), Beaver County, Oklahoma. The deposit is part of the Ogallala Formation and the Buis Ranch quarry is considered Upper Middle Pliocene in age. Local geology was discussed by Hibbard (1954) who described the mammalian remains, noted the occurrence of a few salamander fragments, some frog and toad bones, a number of snake vertebrae, some lizard jaws and a small tortoise, *Geochelone riggsi*.

Brattstrom (1967) identified the following snakes from the Buis Ranch deposit on the basis of vertebrae: *Thamnophis* sp., *Heterodon plionasicus* (an extinct species), *Coluber constrictor, Crotalus* cf. *viridis, Elaphe* near *obsoleta* (these vertebrae probably represent another individual or individuals of the snake described herein) and *Lampropeltis triangulum*. The fossil is described because of its unique skull characters.

Comparative skeletal material examined in the present study includes the following species: *Abastor erythrogrammus*(2), *Arizona elegans*(4), *Boiga dendrophilus*(3), *Coluber constrictor*(12), *Drymobius margaritiferus*(3), *Drymarchon corais*(7), *Dryophis nasutus*(4), *Elaphe dione*(1), *Elaphe guttata*(10), *E. longissima*(1), *E. obsoleta*(13), *E. quatuorlineata*(1), *E. scalaris*(1), *E. situla*(1), *E. subocularis*(1), *E. taeniurus*(1), *E. triaspis*(1), *E. vulpina*(8), *Farancia abacura*(5), *Ficimia olivacea*(1), *Hypsiglena torquata*(3), *Lampropeltis calligaster*(9), *L. getulus*(9), *L. pyromelana*(2), *L. triangulum*(14), *L. zonata*(1), *Masticophis bilineatus*(1), *M. flagellum*(15),

M. lateralis(3), *M. mentovarius*(1), *M. taeniatus*(4) and *Pituophis melanoleucus*(17).

Terminology for skull parts and for regions of the vertebral column is from Bullock and Tanner (1966); terminology for parts of individual vertebrae is from Auffenberg (1963). All measurements are in millimeters.

Elaphe ***buisi*** n. sp.

Diagnosis.—The fossil is assigned to the genus *Elaphe* rather than to *Lampropeltis* or *Pituophis*, because 1) the vertebrae have thinner neural spines and hypapophyses, less robust subcentral ridges and a more vaulted neural arch than in *Lampropeltis*; and 2) thicker neural spines and hypapophyses, more robust subcentral ridges and a less vaulted neural arch than in *Pituophis*.

The vertebrae of *E. buisi* are nearly identical to those of Recent *E. obsoleta* and *E. subocularis* and they are quite similar to those of the fossil *E. kansensis* of the Lower Pliocene Republican River Formation of Phillipps County, Kansas. The vertebrae differ from Recent *E. guttata, E. vulpina, E. triaspis*, and the fossil species *E. nebraskensis* from the Mio-Pliocene Valentine Formation of Brown County, Nebraska, and *E. pliocenica* from the Upper Pliocene Glenns Ferry Formation of Twin Falls County, Idaho, in having a higher neural spine, accessory processes and prezygapophyseal faces almost at right angles to the long axis of the centrum, and a distinct but relatively thin hemal keel. All of the latter group of species have a lower neural spine; *E. nebraskensis* has the accessory processes and prezygapophyseal faces oblique to the long axis of the centrum; and *E. pliocenica* has a thick hemal keel. A difference between the thoracic vertebrae of *E. buisi* and *E. kansensis* is that the distal ends of the hypapophyses of *E. buisi* are less dilated.

Unfortunately, the skull bones of *E. buisi* cannot be compared to *E. kansensis* which is known only from vertebral remains. The skull of *E. buisi* differs from all living North American *Elaphe* as follows: 1) posterior portion of braincase flatter with a second very pronounced crest lying behind the postorbital crest of the parietal; 2) antorbital process of frontal more robust; 3) external tubercle of nasal less hook-like; 4) lateral prominences of basisphenoid better developed; 5) otic notch deeper and tuberosities on squamosal end of quadrate more robust; and 6) portion of pterygoid anterior to lateral processes much shorter and stouter.

Holotype.—A partial skeleton, University of Michigan Museum of Paleontology, V-57403 consisting of a parietal, right frontal, left nasal, basisphenoid, right quadrate, pterygoids, right palatine, right maxilla, mandibles (includes fused articulars, surangulars, prearticulars), left dentary, axis, 29 thoracic vertebrae, 2 lumbar vertebrae and 87 tiny fragments mainly of vertebrae and ribs.

Type-locality.—Ogallala Formation, Upper Middle Pliocene. Buis Ranch local fauna, Beaver County, Oklahoma, NE ¼ SW¼ Sec. 5 T 5 N, R 26 E. C. M. 36°45′ N, 100°30′ W, Collected by W. A. Akersten and C. W. Hibbard, May 1968.

Description and comparisons.—Individual skeletal elements are described and compared with fossil and Recent *Elaphe* from the United States.

Parietal.—The right side of the fossil (Fig. 1a) is complete, but part of the left side is missing. The V-shaped parietal crests are pronounced and meet at the midline near the posterior end of the bone as in Recent *Elaphe*. In the fossil the posterior braincase is flatter and less vaulted than in any United States *Elaphe*. Dorsally, there is much more bone exposed lateral to the parietal crests in the fossil than in Recent species. The supraorbital crest of the fossil is well-developed and there is a very produced postorbital process. In posterior view, this process has three lateral tubercles, two smaller dorsal ones and a large ventral one. The most distinctive feature of the fossil is a second very pronounced crest curving sharply ventrad that lies just behind the postorbital crest. This crest is obsolete in all Recent *Elaphe* examined except *E. subocularis*, in which it is developed, but is not as pronounced as in the fossil. Measurements: greatest median length 12.0 mm; straight line distance from preorbital to postorbital process 5.9; straight line distance from postorbital process through second crest 7.2.

Frontal.—The supraorbital crest is distinctly developed on the right frontal (Fig. 1b). An antorbital process is present with only a single tubercle. Internally, the frontal is deeply grooved for the oflactory tracts. The

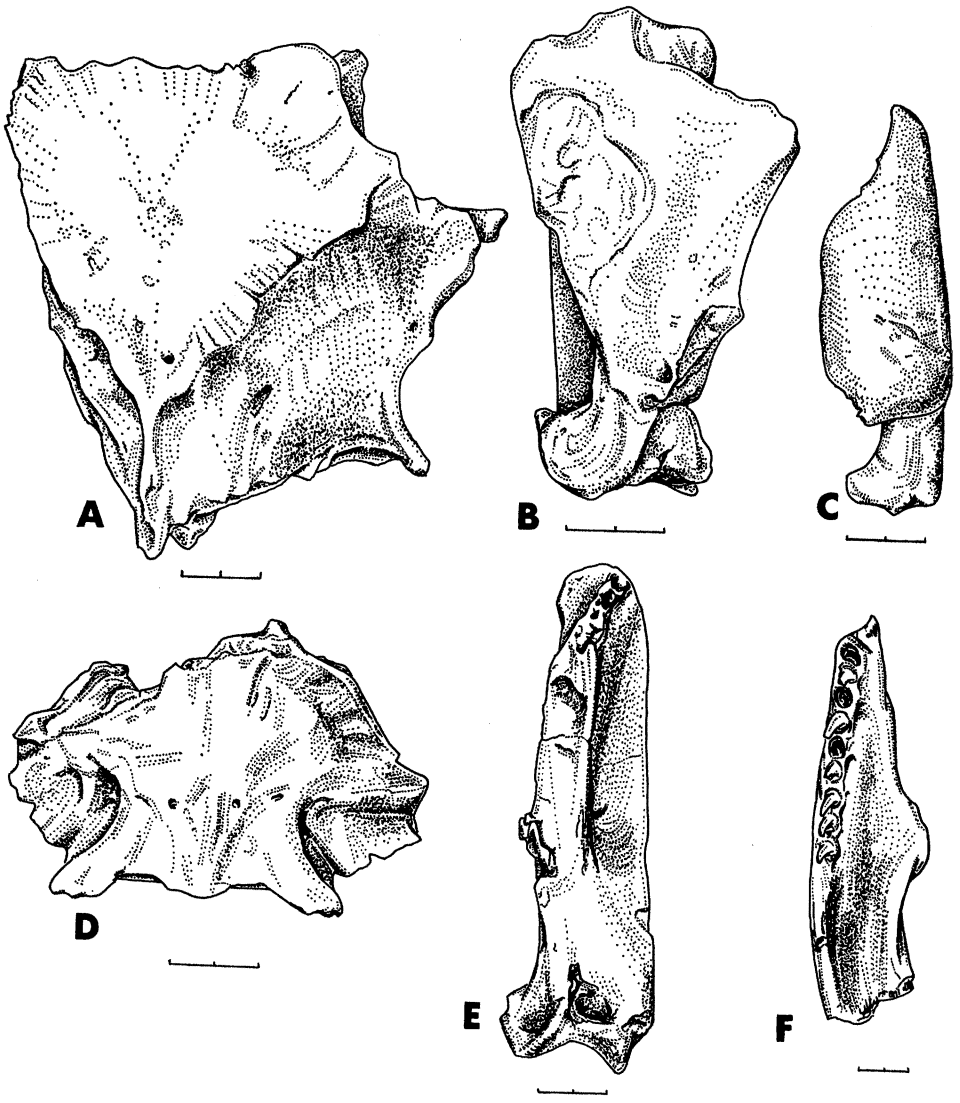

Fig. 1. Cranial elements of holotype of *Elaphe buisi* n. sp., University of Michigan Museum of Paleontology V-57403. A. parietal; B. right frontal; C. left nasal; D. basisphenoid; E. right quadrate; F. left pterygoid. A, B, and C are in dorsal view; E is in posterior view; D and F are in ventral view. Lines equal two millimeters.

anterior wall of the frontal is penetrated by a large fossa for the olfactory tract, and the ventral wall of this fossa has a pair of small trochleae separated by a distinct groove. In medial view, there is a narrow bridge anteriorly connecting the dorsal surface of the frontal with the ventral portion. This bridge forms the medial wall of the anterior fossa for the olfactory tract. The ventral surface of the frontal is narrowly grooved. In general, the distinctive features of the frontal are similar in all United States *Elaphe*, but the antorbital process of the fossil appears more robust than in any United States species. Measurements: greatest length of frontal 10.2 mm; greatest width of frontal through antorbital process 6.2.

Nasal.—The posterior process of the left nasal has three tubercles (Fig. 1c), the most external of which is reflected laterally as a hook, that can best be seen in dorsal view.

This tubercle is much less hook-like in Recent *Elaphe* studied. This character is obscured by the articulated condition of the single available *E. triaspis* skull. Measurements: greatest width of nasal 4.0 mm; length of posterior process 2.6.

Basisphenoid.—The parasphenoidal part of the basisphenoid is lost. One of the most prominent features of this bone is the large, deep pituitary fossa in its dorsal surface. In ventral view (Fig. 1d), the posterior border has three prominences, two lateral and one median. The two lateral prominences are well-developed and both extend farther posteriad than the median. In the Recent species the lateral prominences are reduced and the median prominence is even with or extends well posteriad of the lateral prominence. Among the Recent species of *Elaphe, E. subocularis* has the lateral prominences best developed. Measurements: greatest width through basisphenoid 9.2 mm; greatest width through lateral prominences 6.3.

Quadrate.—Prominent features of the quadrate (Fig. 1e) are a distinct otic notch on its posterior surface, an external and internal trochlea separated by a trochlear groove on the mandibular end, a tubercle for the articulation of the stapes about half way ventrad on the posteromedial surface and an anterolateral and a posteromedial tuberosity on its squamosal end. Recent North American *Elaphe* tend to have a relatively short, stout quadrate. The fossil resembles *E. obsoleta* in its proportions, but it differs from *E. obsoleta* (and other United States species) in having the otic notch much deeper, both tuberosities on the squamosal end more robust and the entire squamosal extremity rotated more anteroventrally. The fossil resembles *E. obsoleta* and differs from *E. guttata* in having the cavity on the anteromedial surface of the squamosal extremity less excavated, the anterolateral tuberosity less distinct and hook-like, and the middle of the bone less constricted. The fossil resembles *E. obsoleta* and differs from *E. triaspis* in being longer and narrower and in having a concave rather than a convex anterior border. Unfortunately, my only reference specimen of *E. subocularis* was skeletonized from a road kill and the squamosal ends of both quadrates were damaged so that comparisons could not be made. The fossil differs from *E. subocularis* in that the mandibular end of the quadrate is much more robust. Measurements: greatest length 15.1 mm; greatest width of squamosal end 5.7; greatest width of mandibular end 4.3.

Pterygoids.—In dorsal view the palatine articular processes are grooved. There is a prominent lateral process about midway down the lateral edge of the bone, and a prominent dorsolateral groove just posterior to the lateral process. The teeth are prominent in palatal view. Medial to the teeth the bone is excavated and it is especially well-excavated posterior to the lateral process. The left pterygoid (Fig. 1f) differs from Recent *Elaphe* species in that the portion anterior to the lateral process is much shorter and stouter. Moreover, the fossil differs from *Elaphe obsoleta* and *E. subocularis* is possessing a lateral process that is much rounder and less pointed in outline. The fossil differs from *E. guttata* and *E. triaspis* in having the lateral processes much better developed. The posterior parts of the fossil are broken so that accurate tooth and alveolar counts are impossible. Measurements: greatest width through anterior end 2.5 mm; greatest width through lateral process 4.7.

Palatine.—The right palatine (Fig. 2a) has a broad medial process directed slightly anteriad, and a narrower lateral process directed slightly posteriad. The lateral process has large foramina both anterior and posterior to it. The posterior extremity of the palatine is bifurcate. The fossil has a tooth count of 9 (two teeth and seven alveoli). The tooth count is 9 in *E. guttata,* 10 in *E. obsoleta,* 11 in *E. triaspis* and *E. subocularis* and ranges from 9–11 with a mean of 10.5 in *E. vulpina.* The fossil differs from *E. obsoleta, E. guttata, E. triaspis* and *E. subocularis* in having the internal fork at its posterior end shorter and more robust. The fossil differs from *E. vulpina* in having both posterior forks shorter and more robust. Measurements: length of palatine 15.4 mm; greatest width of palatine through lateral process 3.4.

Maxilla.—Only the tip of the right maxilla is available, but it is more robust and massive than in Recent North American *Elaphe.*

Mandibles.—Both mandibles of the fossil were recovered. These consist of the co-

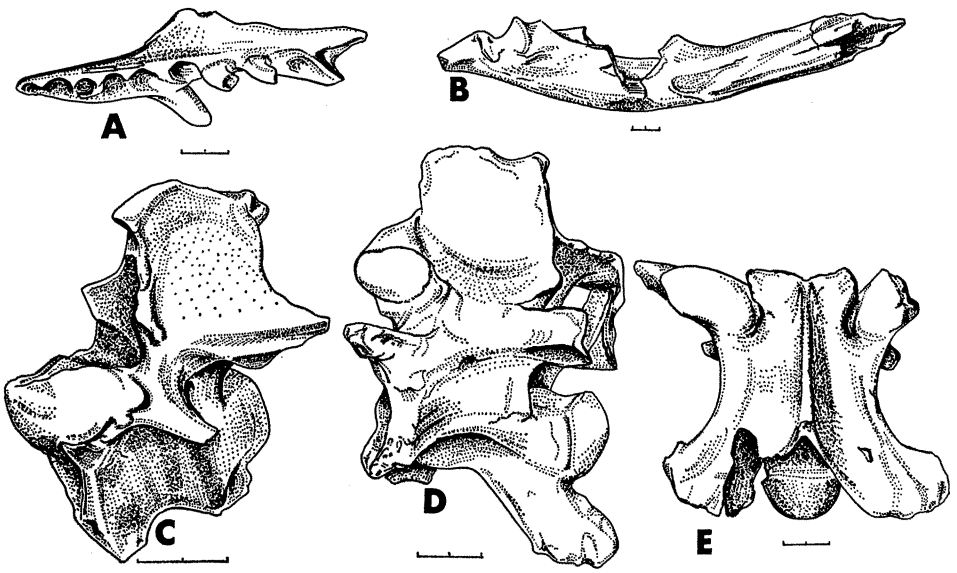

Fig. 2. Cranial and vertebral elements from holotype of *Elaphe buisi* n. sp., University of Michigan Museum of Paleontology V-57403. A. right palatine; B. left mandible; C. axis; D. thoracic vertebra; E. lumbar vertebra. A is in ventral view; B is in medial view; C and D are in lateral view; E is in dorsal view. Lines equal two millimeters.

alesced articular, surangular and prearticular bones. The medial wall of the surangular region of the left mandible (Fig. 2b) is damaged and both the lateral and the medial walls of the right mandible are damaged. The postarticular process resembles *E. subocularis* most closely and differs from *E. triaspis, E. obsoleta, E. guttata* and especially from *E. vulpina* in being shorter, stouter, and more blunt. Measurements: length of mandible 34.5 mm; width through anterior end 3.3; length of glenoid facet 3.8; length of postarticular process 2.8.

Dentary.—The dentary is so eroded and worn that comparisons with Recent material would be meaningless, but it does appear more robust than in living forms.

Axis.—The tip of the neural spine and the distal parts of both the anterior and posterior hypapophyses are broken (Fig. 2c). The axis differs from the Recent species in that the epizygapophyseal spine is longer and better developed and the neural arch is more depressed. The axis of *E. obsoleta* appears most similar to the fossil, with one specimen having the epizygapophyseal spines almost as well-developed and the neural arch almost as depressed. Measurements: width through epizygapophyseal spines 6.2 mm.; length through odontoid process and condyle 5.4.

Thoracic vertebrae.—The hypapophyses are complete in only four of the fossils (Fig. 2d), and these all have the distal ends less dilated than in the Lower Pliocene *E. kansensis.* Some thoracic vertebrae of Recent *E. obsoleta* and *E. guttata* approach the condition in *E. kansensis,* but none have quite as much dilation as in *E. kansensis* (Gilmore, 1938, p. 65, Fig. 24b). The thoracic vertebrae of the fossil are otherwise similar to living species. Measurements: From a posterior thoracic vertebrae; height through neural spine and hypapophysis 13.9 mm; length through condyle and cotyle 7.6; width through prezygapophyses 10.0; width through postzygapophyses 9.9.

Lumbar vertebrae.—The lumbar vertebrae (Fig. 2e) appear to have had high neural spines (although their tips are broken) and thus differ from the Mio-Pliocene *E. nebraskensis,* and from the Upper Pliocene *E. pliocenica.* In addition, the angles of the accessory processes and prezygapophyses make much more of an angle with the long axis of the centrum in *E. buisi* than in *E. nebraskensis.* This angle in *E. buisi* is about 90 degrees, whereas in *E. nebraskensis* it is

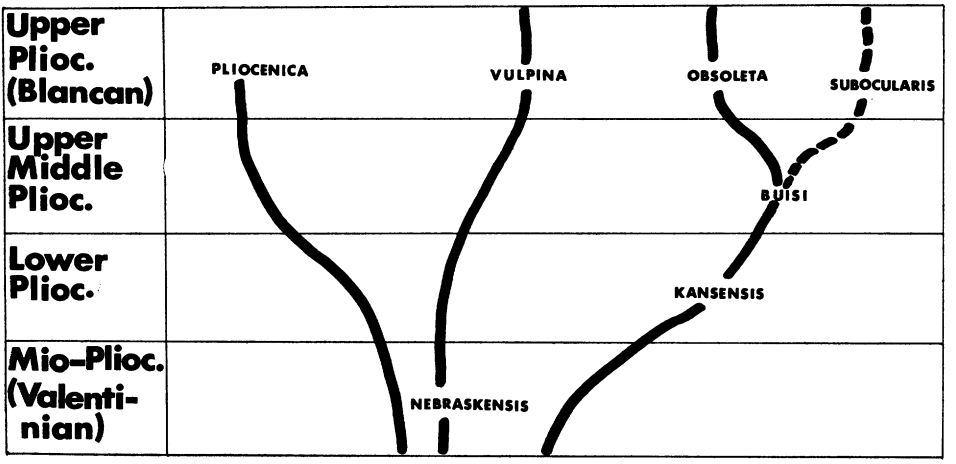

Fig. 3. Hypothetical relationships of fossil and certain Recent species of *Elaphe*. *Elaphe subocularis* is unknown as a Pliocene fossil, but it shows some vertebral and cranial relationships to *E. buisi*. *Elaphe guttata* is not included because its relationships to the fossil forms is obscure.

about 45 degrees. The neural spines and hemal keels of *E. buisi* are thinner and less robust than in *E. pliocenica*. Of the fossil forms *E. kansensis* resembles *E. buisi* most closely. Among Recent species *E. obsoleta* and *E. subocularis* have high neural spines like *E. buisi* and differ from *E. guttata, E. triaspis* and *E. vulpina* with lower neural spines. Measurements: The most complete lumbar vertebra measures 9.5 mm through the condyle and cotyle; length through pre and postzygapophyses 10.1; width through postzygapophyses 12.5.

Referred Material.—Fifty-four fragmentary and complete lumbar vertebrae and a single rib fragment (UMMP V-59816) were collected from the same deposit by the same collectors. These bones appear to represent a second individual. The vertebrae are similar to Recent *E. obsoleta* and *E. subocularis* comparative material; they represent a snake that was about as large as the holotype. These remains are tentatively assigned to *E. buisi*.

Discussion

On the basis of skull characters it appears that *E. buisi* may be closer to *E. obsoleta* and *E. subocularis* than to the other Recent species examined. Unfortunately, all other fossil *Elaphe* from North America are known only from vertebrae. Among these forms *E. buisi* appears most closely related to *E. kansensis* which has the thoracic vertebrae with more dilated distal hypapophyses. Comparative vertebral sizes would indicate that the holotype of *E. buisi* was a large snake, probably more than two meters.

A very tentative phylogenetic diagram of known fossil (Gilmore, 1938; Holman, 1964 and 1968) and some Recent species (Brattstrom, 1967; Holman, 1968) of *Elaphe* from the United States is presented in Fig. 3. *Elaphe pliocenica* from the Upper Pliocene of Idaho appears to represent a dead-end form. *Elaphe nebraskensis* from the Mio-Pliocene of Nebraska may be ancestral to living *E. vulpina*, a species whose history extends back to the Upper Pliocene of Idaho. *Elaphe kansensis* of the Lower Pliocene of Kansas may have given rise to *E. buisi* of the Upper Middle Pliocene of Oklahoma, and it seems possible that *E. buisi* could have given rise to both *E. subocularis* (unknown from the Pliocene) and *E. obsoleta*, which is known from several Upper Pliocene localities in Kansas. Fossils similar to *E. guttata* or to *E. triaspis* have not been found in the Pliocene.

Acknowledgments

I wish to thank C. W. Hibbard for the privilege of studying the fossils. Donna Ray Holman made the drawings.

Literature Cited

Auffenberg, W. 1963. The fossil snakes of Florida. Tulane Stud. Zool. 10:131–216.

Brattstrom, B. H. 1967. A succession of Pliocene and Pleistocene snake faunas from the

High Plains of the United States. Copeia 1967:188–202.
BULLOCK, R. E., AND W. W. TANNER. 1966. A comparative osteological study of two species of Colubridae (*Pituophis* and *Thamnophis*). Brigham Young Univ. Sci. Bull. Biol. Ser. 8: 1–29.
GILMORE, C. W. 1938. Fossil snakes of North America. Geol. Soc. Amer. Sp. Paps. 9:1–96.
HIBBARD, C. W. 1954. A new Pliocene vertebrate fauna from Oklahoma. Paps. Mich. Acad. Sci. Arts, Letrs. 1954:339–359.
HOLMAN, J. A. 1964. Fossil snakes from the Valentine Formation of Nebraska. Copeia 1964:631–637.
———. 1968. Upper Pliocene snakes from Idaho. Copeia 1968:152–158.

MUSEUM, MICHIGAN STATE UNIVERSITY, EAST LANSING, 48823

A New Colubrid Snake (*Boiga*) from Southeastern Asia

CHARLES KROON

Boiga ocellata **n. sp. can be distinguished from *B. cynodon*, with which it has been previously placed, by lower ventral counts (*B. ocellata* $\bar{x}$ = 256.5, *B. cynodon* $\bar{x}$ = 278.7), subcaudal counts (*B. ocellata* $\bar{x}$ = 122.1, *B. cynodon* $\bar{x}$ = 151.1), different color patterns (*B. cynodon* yellowish with dark cross bars or dark with light cross bars, *B. ocellata* grayish brown with light and dark cross bars and numerous markings along sides) and a distinct geographic range. A matrix key is provided to allow identification of *B. ocellata* from six other species of Boiga which occur within its range.**

An investigation of morphologic variation within the genus *Boiga* has shown that specimens currently identified as *Boiga cynodon* (Boie) include more than one species. Examination of materials assigned to *B. cynodon* as well as new material shows that two distinct species are involved. The location of the type-specimen of *B. cynodon* is not known and therefore was not examined.

B. cynodon has been reported from Bengal, Assam, Burma, Thailand, Cambodia, the Malay Peninsula and Archipelago (Smith, 1943); Viet Nam (Campden-Main, 1970); the Philippine Islands (Leviton, 1970); and Borneo (de Rooij, 1917).

B. cynodon was described by Boie (1827) as *Dipsas cynodon* with the type-locality given as Java. This being the case, the morphotype which is found in the Philippine Islands, Borneo, Java, Sumatra and their associated islands and in the Malay Peninsula north to the Isthmus of Kra, must be called *Boiga cynodon*. North of the Isthmus of Kra in the Malay Peninsula, east to Viet Nam, north and west to Bengal and Assam ranges an undescribed species.

Boulenger (1896) described three color forms of *B. cynodon* as follows: a) yellowish or pale reddish brown above, with dark brown or black cross-bars; b) black or brown above with more or less distinct lighter cross-bars; c) fawn colored without spots or markings or just traces of darker cross-bars. Form a, which is the most common, resembles the undescribed species only in having dark cross-bars and the stripes behind the eyes. The ground color of *B. cynodon* is lighter and it has none of the other spotting that distinguishes the undescribed species. In *B. cynodon* the cross-bars on the body are about 3–5 scale rows wide at the vertebral row and narrow ventrolaterally. The tail has wide dark bars which are only separated by narrow light interspaces. The number of dark bars ranges from about 50 to 90 while in the undescribed snake the figure is somewhat higher. In the undescribed species cross-bars are more uniform in width and form anterior facing V-shaped bands. Differences in the skulls of the two species are as follows: In the undescribed form the parietal ridges do not meet while in *B. cynodon* they meet and form a median crest about two-thirds down the parietal. The medial arm of the ectopterygoid extends forward of the palatine-pterygoid junction in the undescribed snake while it lies posterior to that point in *B. cynodon*. The rostral in *B. cynodon* is higher than wide while equal in the undescribed species. Five specimens of *B. cynodon* have two to three fewer dentary teeth and one to two more maxillary teeth than the undescribed form.