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A New Species and the First Record of the Genus *Anillinus* (Carabidae: Trechinae: Bembidiini) from the Ozark Region

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Abstract

A new species of *Anillinus* is described from the Ozark Region of central United States. ***Anillinus aleyae*** **new species**, is based on specimens collected in southern Missouri (36.5585°N, 92.8134°W). The discovery of this species extends the western part of the range of *Anillinus* approximately 170 km north of its closest known congeners from the Ouachita Mountains and is the first documented record of the genus from the Ozark Region. A key is provided that will allow separation of *Anillinus* species west of the Mississippi River.

The genus *Anillinus* Casey, in spite of its wide range, is one of the most incompletely known genera of carabid beetles in the United States. Blind, litter or soil-dwelling representatives of the genus inhabit a huge area from the Potomac River in the north to Florida Panhandle in the south, and from eastern Oklahoma in the west to the Piedmont hills of North Carolina in the east. Among the 30 species described to date only five are known west of the Mississippi River. Ranges of all five species are situated inside the boundaries of the Ouachita Mountains, thus forming a wide gap with the western-most points of the main (eastern) part of genus' range, the Cumberland Plateau in southeastern Tennessee/northern Alabama and southern Indiana. The discovery of a new species of *Anillinus* in the Ozark Region at least partly fills the gap between the eastern and western parts of the genus' range. Among western species of *Anillinus*, the new species seems to be most similar to *A. lescheni* Sokolov & Carlton from eastern Oklahoma, based on the distinctive form of the aedeagal median lobe. In addition to describing this new species, we provide a key for all known western species of *Anillinus*.

Materials and Methods

Specimens of the new species were collected using soil-washing/flotation to separate the beetles and other organic material from heavier mineral soil, followed by Berlese extraction of the floated residue. All specimens were measured electronically using a Leica Z16 APO microscope equipped with a Syncroscopy AutoMontage photomicroscopy system (SYNCROSCOPY, Synoptics Ltd.). Measurements for various body parts are encoded as follows: ABL = apparent body length, from clypeus to apex of elytra; WH = width of head, at level of first orbital setae; WPm = maximal width across pronotum; WPa = width across anterior angles of pronotum; WPp = width across posterior angles of pronotum; LP = length of pronotum from base to apex along midline; WE = width of elytra, at level of 2nd discal setae; LE = length of the elytra, from apex of scutellum to apex of left elytron. ABL measurements are given in mm; others are presented as seven ratios: mean widths—WH/WPm and WPm/We and body parts—WPa/WPp, WPm/WPp, WPm/LP, LE/ABL and WE/ABL. All values are given as mean ± standard deviation. Verbatim label data are given for all type specimens with label breaks indicated by a slash ("/"). Type deposition is indicated under the species treatment.

Dissections of genitalia and terminology of genitalia structures follow earlier publications (Sokolov *et al.* 2004, 2007).

Photograph of the dorsal habitus of the new species was taken using an AutoMontage system. Line drawings of genitalia parts were made using a camera lucida on an Olympus BX 50 compound microscope.

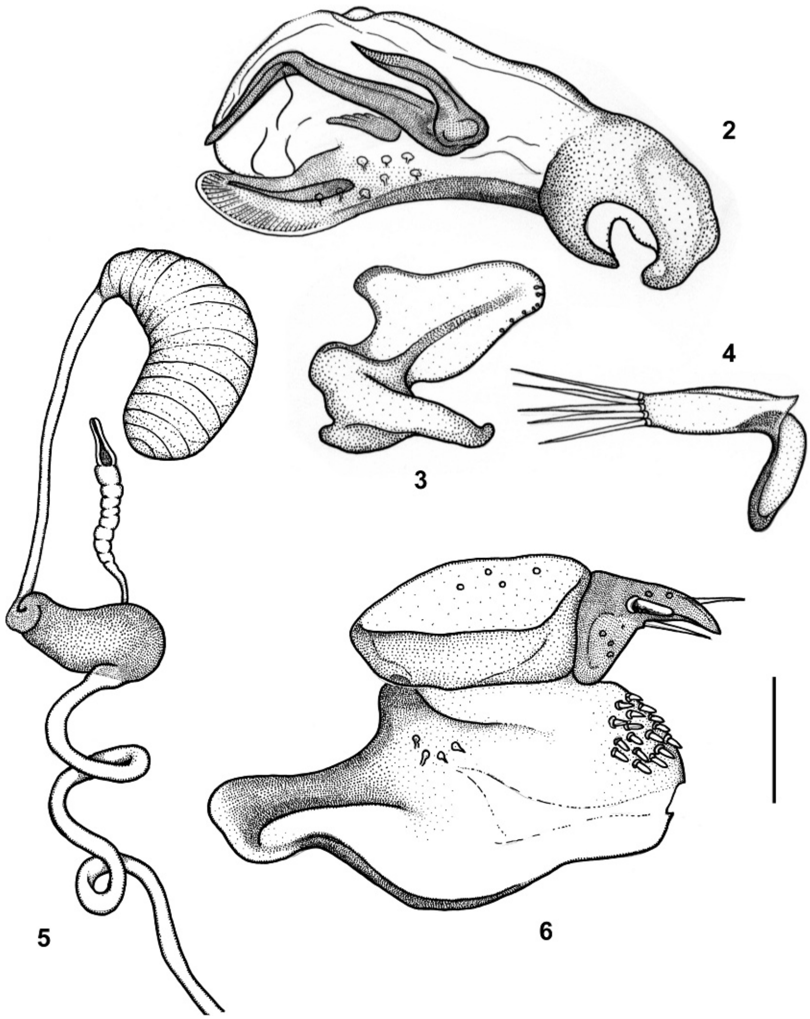
Anillinus aleyae **Sokolov and Watrous, new species**
(Fig.1–6)

Description. Holotype, male. Small for genus (ABL range 1.56–1.83 mm, mean 1.68 ± 0.083 mm, n = 12). Males noticeably larger than females: male size—ABL range 1.73–1.83 mm, n = 2; female size—ABL range 1.56–1.74 mm, mean 1.66 ± 0.071 mm, n = 10. Habitus (Fig. 1) subdepressed, elongate and subparallel (WE/ABL 0.34 ± 0.012), with noticeably enlarged head (WH/WPm 0.83 ± 0.023), and narrow pronotum and elytra (WPm/WE 0.84 ± 0.030). Body color light, from rufotestaceous to testaceous, appendages testaceous. Dorsal microsculpture distinct, covering pronotum and head except the forehead parts along the clypeal suture and clypeus. *Pronotum* moderately convex and comparatively elongated (WPm/LP 1.29 ± 0.032), with margins markedly constricted posteriad (WPm/WPp 1.42 ± 0.032) and barely sinuate before posterior angles. Anterior angles evident, slightly prominent. Posterior angles slightly obtuse (105–110°). Width between anterior angles distinctly greater than between posterior angles (WPa/WPp 1.16 ± 0.029). *Elytra* slightly convex, widely depressed along suture, relatively short (LE/ABL 0.54 ± 0.013), with traces of 4–5 interneurs. Humeri rounded, oblique, in outline forming an obtuse angle with longitudinal axis of body. Margins parallel across most of elytra length, in the last one-fourth evenly rounded to apex. Elytra without subapical sinuation. Vestiture of elytra short (less than one-third of discal setae). *Prothoracic leg* of males with strongly dilated tarsomere 1 and 2. Profemur moderately swollen. Metafemora unmodified. *Ventrite VII* of males unmodified. *Median lobe* (Fig. 2) evenly arcuate and twisted, its apex enlarged and elongated, curved dorsally in shape, with slightly narrowed and rounded tip. Ventral margin of median lobe weakly enlarged and lacking poriferous canals. Canals present on walls of median lobe itself near the base of its apex. Dorsal copulatory sclerites large, formed by two plates, combined together only at base. The larger plate elongate, with nearly rectangular curvature at apical one-third, its shortly pointed apex extending slightly lateral to internal sac. The smaller plate 0.5× length of larger, slightly curved and blade-like. Ventral sclerite plate-like with wavy anterior contour, occupying position ventral to dorsal sclerites. Spines of internal sac absent. *Left paramere* (Fig. 3)

Fig. 1. Habitus of *Anillinus aleyae,* new species, dorsal aspect, female.

slightly enlarged, paramere apex with poriferous canals, but without visible setae (at ×400). Right paramere (Fig. 4) elongated, sharply curved near the middle, with subparallel apical half, bearing five long setae, nearly equal in length to the apical half; setae occupy entire apex of paramere. *Spermatheca* (Fig. 5) moderately sclerotized, with three well-developed parts. Distal part, the cornu, is sclerotized and bean-like in form, more than two times longer than its width. Proximal part of cornu unsclerotized and straight, without traces of coils. Nodulus and ramus well-developed, sclerotized; nodulus elongated, ramus rounded. Spermathecal duct comparatively long, with defined wide coils. *Stylomers* and ventrite IX as in Fig.6. Stylomer of approximately equal width and length, with thick ensiferous seta. Ventrite bearing 14–17 setae.

Holotype. Male labeled / USA—MO: Taney Co., Ozark Underground Lab., 36.5585°N, 92.8134°W, 800 m, soil near rock outcrop, # 1006, 21 Oct 2007



Figs. 2–6. *Anillinus aleyae* male aedeagus and female genitalia. Scale bar for figures 2–4 equals 100 μm, for figures 5–6 equals 50 μm. **2)** Median lobe; **3)** Left paramere; **4)** Right paramere; **5)** Spermatheca; **6)** Right stylomere and sternum IX.

L.E.Watrous / / HOLOTYPE, Anillinus aleyae Sokolov and Watrous, des. 2007/. Deposited U.S. National Museum (USNM).

Paratypes. (12). Four females with same data as holotype; 6 females with the same locality and date as holotype, but with different collecting codes; one male and one female labeled / USA—MO: Barry Co., 1.9 mi N Eagle Rock, 36.5759°N, 93.7558°W, 13.VI.2007, #889, glade soil, L.E.Watrous/. Deposited Louisiana State Arthropod Museum (LSAM).

Differential diagnosis. *Anillus aleyae*, with its elongate, subparallel habitus and distinct microsculpture, is similar to *A. lescheni* Sokolov & Carlton and *A.*

stephani Sokolov & Carlton from Oklahoma. With the former species, *A.aleyae* shares the general contour of the median lobe (Sokolov *et al*. 2004, p.194, fig. 30), particularly its distinctive curved apex, but differs in the details of armature of internal sac and especially by its body size (1.56–1.83 mm of *A. aleyae* versus 2.20–2.50 mm of *A. lescheni*). *Anillinus stephani*, by contrast, is of similar size, but possesses a quite different median lobe (*l.c*, p.195, Fig. 36). Besides differences in the armature of the inner sac, the median lobe of *A. stephani* bears a row of long setae in the position of the poriferous canals of *A. aleyae*. The similar habitus of these species may reflect their endogean habitats. Specimens of *A. stephani* and *A. lescheni,* as far as known, were taken only from beneath large rocks during rainy weather (Sokolov *et al*. 2004) and, presumably, normally are associated with such habitats as soil-rock interfaces or soil pore spaces.

Etymology. The specific epithet honors Cathy Aley, who assisted in selecting the site and digging up the first specimens found at the type locality. Cathy and Tom Aley are ardent supporters of biology research and education, and are very generous hosts at their Ozark Underground Laboratory and Tumbling Creek Cave Foundation property.

Distribution. Known from Taney and Barry Counties, Missouri.

Habitat. Beetles from Taney Co. were collected in soil below rock outcrops and small bluffs along Bear Cave Hollow in a relatively mesic wooded valley. Bear Cave Hollow is a sinking stream, tributary to Big Creek and thence to the White River (impounded in this area as Bull Shoals Lake). Many soil samples from other habitats were taken in the Ozark Underground Laboratory area; anillines were found only in the soil immediately below the small bluffs and rock outcrops along Bear Cave Hollow. The Barry Co. specimens were collected at a limestone outcrop area, in soil from a small glade. The rock outcrop is associated with a valley leading to Roaring River and thence to the White River (impounded in this area as Table Rock Lake). This sample was taken from very moist soil following a rainy period. Although the surface habitat is very different from Bear Cave Hollow, they are similar in proximity to exposed limestone associated with the White River basin.

Key to species of *Anillinus* known to date from west of the Mississippi River (Arkansas, Missouri, and Oklahoma).

1. Microsculpture indistinct or absent from pronotal disc. Median lobe with large axiniform apex. Beetles from Ouachita Mountains of Arkansas........ .... *Anillinus robisoni* Sokolov & Carlton

1′. Pronotal disc with distinct microsculpture. Apex of medial lobe not forming any kind of protrusion. Beetles from Ouachita Mountains of Arkansas and other locations.. 2

2. Elytra more oval (WE/ABL 0.35–0.39). Clypeus and head covered with distinct microsculpture. Median lobe with simple round apex. Armature of internal sac simple: dorsal sclerites in form of arcuate blade-like structures, ventral sclerites and spines absent. Beetles from Mt. Magazine, Arkansas.. .... *Anillinus magazinensis* Sokolov & Carlton

2′. Elytra more parallel (WE/ABL 0.29–0.35). Clypeus partly smooth, head with indistinct microsculpture along the clypeal suture. Median lobe often with enlarged apex. Armature of internal sac more complex: dorsal sclerites often enlarged, with ventral sclerites or/and spines present......................... 3

3. Large species, body length > 2.1 mm. Beetles from Ouachita Mountains of Oklahoma .... *Anillinus lescheni* Sokolov & Carlton
3′. Small species, body length < 1.9 mm 4
4. Head narrower (WH/WPm 0.75–0.80). Pronotum wider across the base (WPa/WPp 1.03–1.07). Armature of internal sac with spines. Beetles from Ouachita Mountains of Arkansas... *Anillinus tishechkini* Sokolov & Carlton
4′. Head broader (WH/WPm 0.80–0.86). Pronotum narrower across the base (WPa/WPp 1.06–1.20). Armature of internal sac lacking spines. Beetles from Oklahoma or Missouri 5
5. Median lobe with enlarged bill-shaped apex, its tip deflexed ventrally. Walls of median lobe bearing a row of long setae. Beetles from Ouachita Mountains of Oklahoma .... *Anillinus stephani* Sokolov & Carlton
5′. Median lobe with elongated, laterally curved apex, its tip reflexed dorsally. Walls of median lobe bearing poriferous canals without setae. Beetles from Missouri .... *Anillinus aleyae* new species

Biogeographical notes. The discovery of *Anillinus aleyae* in the Ozark Region is biogeographically important. This finding partly fills the gap between the eastern part of the range of *Anillinus* and the range occupied by the western representatives of the genus (Fig. 7). Taking into account that (1) the modern center of *Anillinus* diversity is in the southern Appalachians, (2) anillines with similar chaetotaxy patterns inhabit Western Europe and Mediterranean countries (Jeannel 1963*a*), and (3) anillines from Texas and California apparently belong to another morphological lineage (Jeannel 1963*b*), we assume an eastern U.S. origin of western representatives of *Anillinus*. Theoretically, two distributional tracks of *Anillinus* ancestors between the Ozark Plateau and Ouachita Highlands and Appalachians might have been in place (Fig. 7). The northern track would have extended between the Ozark Region and upland areas of southern Indiana and western Kentucky. The southern track would have extended from the southern Appalachian foothills of central Tennessee and northern Alabama to the Ouachita Mountains, as proposed for Interior Highlands members of the staphylinid genus *Arianops* (Carlton and Cox 1990). Also, the two known *A. aleyae* localities are about 85 km apart, near the eastern and western limits of the White River basin, where it loops through southwest Missouri. The land snail *Patera perigrapta* (Pilsbry) has a similar distribution in Missouri, with the White River basin representing the northern limit of a much wider southern and southeastern distribution (Oesch *et al.*, in press). If *A. aleyae* follows a similar pattern, it may occur further south in Arkansas, but not be more widespread in the Ozark Region of Missouri. This distribution pattern supports a closer association with the southern *Anillinus* in the Ouachita Mountains than with anilline species along a northern distribution track through southern Indiana and western Kentucky.

Interestingly, most of the Ouachita Mountains are inhabited by *Anillinus* with allopatric distributions (three described and probably two undescribed species). But the two western Oklahoma species, *A. lescheni* and *A. stephani*, can be found together, even under the same rock. This may reflect a history of allopatry and subsequent sympatry if the two species are phylogenetically closely related. Or, their similarities might be superficial and *A. lescheni* might share a common ancestry with *A. aleyae*. These two species are very close morphologically, judging by similarities in the shapes of median lobes and in the structure of dorsal sclerites. If the latter alternative is borne out through phylogenetic analyses, we

Fig. 7. Schematic distribution of the *Anillinus* species. 1—range of eastern species; 2—range of western species; solid circles–sampling sites of *A. aleyae*, new species. From Sokolov *et al*. (2004) and original data.

will need to propose the presence in the past of a trans-Arkansas River track to accommodate an Ozark-Ouachita lineage.

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