

**Catalogue of American Amphibians and  
Reptiles 930**

Mahrtdt, C. R., K. R. Beaman, J. H. Valdez-Villavicencio, and T. J. Papenfuss. 2022.  
*Bipes biporus*.

***Bipes biporus* (Cope)**  
Five-Toed Worm Lizard

*Chirotos canaliculatus*: Streets 1877:37 (in part, by implication).

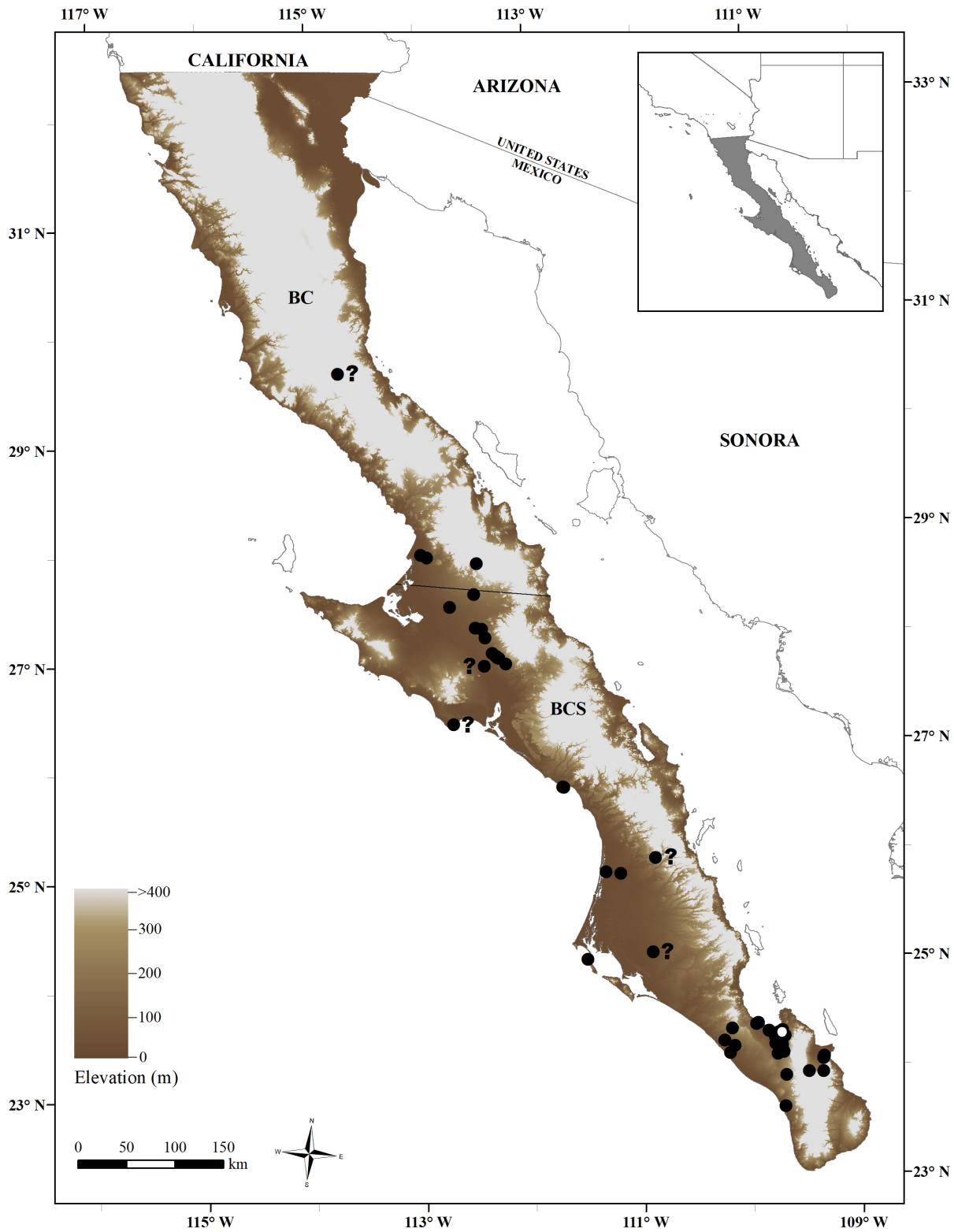
*Euchirotos biporus* Cope 1894:436. Type Locality, “Cape St. Lucas, Lower California” (= Cabo San Lucas, Municipality of Los Cabos, Baja California Sur, México) collected by G. Eisen; holotype not stated. Syntypes, 13 specimens; Cope 1900,

United States National Museum, one specimen (USNM) 8568 by Streets (1877) and 12 specimens (USNM) 12599 collected by Lyman Belding in 1882. See **Remarks**. Lectotype designated by Cochran (1961:110), United States National Museum (USNM) 21324 (formally USNM 12599), La Paz, Baja California Sur, México, adult of unknown sex collected by Lyman Belding in 1882 (not examined by authors). See **Remarks**. The type locality of “Cape St. Lucas, Lower California” given in error in the original description and corrected by Stejneger and Barbour (1917) as “La Paz, Lower California.” See **Remarks**.

*Euchirotos diporus*: Cope 1896a:313 and Cope 1896b:1012. *Lapsus*.



**FIGURE 1.** Adult *Bipes biporus* observed on a sidewalk at 2200 h on 5 June 2011 in the City of La Paz, Municipality of La Paz, Baja California Sur, México. This species is primarily fossorial; this is one of those rare occurrences observed above ground (see **Comments**). Photograph by Jorge H. Valdez-Villavicencio on 7 June 2011.



**MAP.** Geographic distribution of *Bipes biporus*. The open circle marks the type locality. Black dots indicate other known localities accessed from VertNet or derived from other reliable sources. Some dots represent two or more proximate localities or multiple individuals. Question marks indicate unverified locality records (see **Distribution**). Most specimens were examined by one of us (TJP) to validate identification. BC = Baja California; BCS = Baja California Sur.



*Bipes biporus*: Stejneger and Barbour 1917:72.

First use of combination in print.

*Bipes biporum*: Alvarez 1966:145. *Lapsus*.

*Bipes biporous*: Minnich 1972:539. *Lapsus*.

*Bipes biporum*: Langner 2019:28. *Lapsus*.

**CONTENT.** This species is monotypic.

**DESCRIPTION.** The Five-toed Worm Lizard, *Bipes biporus*, attains an adult body size of 190–240 mm in length. Hatchlings range 90–130 mm and juveniles 130–185 mm in body length (Papenfuss 1982). This fossorial species has relatively short, wide forelimbs up to 8 mm in length positioned far forward behind the head. Five, well-developed, claw-bearing digits are present on each limb. External hind limbs are absent. The extremely elongated body is cylindrical in cross-section. Lateral view of head is bluntly rounded and convex across the dorsal surface (Kearney 2003a) and not distinct from the neck. The anterior head scales are plate-like with a greatly enlarged frontal and a single pair of parietals and preoculars. The rostral is in contact with the frontal and weakly sep-

arated by a pair of nasals. Postmental scale is greatly enlarged and rectangular in shape and in contact with the mental and two sublabials and a single infralabial. There are four infralabials and four supralabials. The eye is small with a round pupil. Posterior head scales (ocular scales) are small and square to rectangular-shaped. Unlike other squamates, the dorsal and ventral scales along the entire length of the body are arranged in annuli (rings) with 242–261 dorsal annuli, 143–167 ventral annuli, 2–6 lateral annuli, 2–13 intercalated quarter annuli (present dorsally and ventrally), and 24–31 caudal annuli on non-autotomized tails. Dorsal midbody annulus segments range from 27–32 and ventral midbody annulus segments from 24–30. Six preanal scales are present in a single transverse row with the median pair greatly enlarged. A scale with one preanal pore is located on each side of the transverse row. The tail is blunt and short, 9.5–10.5 percent SVL. External sexual dimorphism is absent in *Bipes biporus* (Grismer 2002; Papenfuss 1982; Smith and Smith 1977).



**FIGURE 2.** A juvenile *Bipes biporus* (178 mm SVL) from Rancho Los Quijotes, 4.4 km SE San Juan de los Planes, Municipality of La Paz, Baja California Sur, México. Photograph by Bradford D. Hollingsworth on 22 November 2015.



**FIGURE 3.** Adult *Bipes bipes* collected on 22 November 2015 from Rancho Los Quijotes, 4.4 km SE San Juan de los Planes, Municipality of La Paz, Baja California Sur, México. During initial soil penetration in early stage burrowing, the limbs are typically pressed against the sides of the body by which the anterior body may assume a more vertical position (Gans 1974; personal observations). Photograph by Clark R. Mahrtdt on 27 May 2016.

Color of the head, body, and tail in adults is typically pink. Some individuals are white on the ventral surface. Juveniles are usually pale pink.

**DIAGNOSIS.** The genus *Bipes* is comprised of three small-sized (<240 mm) fossorial species occurring in either western mainland México (*Bipes canaliculatus* and *Bipes tridactylus*) or endemic to the southern half of the Baja California peninsula (*Bipes bipes*). The presence of short, stout external forelimbs positioned far forward (at or anterior to third vertebra) directly behind the head and polyphalangy are features that distinguish the genus *Bipes* from other members of the Amphisbaenia (Kearney 2003a). The adults and juveniles of both sexes of *Bipes bipes* can be distinguished from its two mainland Mex-

ican congeners by possessing five, well-developed, claw-bearing digits on each limb and a unique phalangeal formula of 3-3-3-3-3. *Bipes tridactylus* has three well-developed claw-bearing digits on each limb, first and fifth digit reduced or absent, and a phalangeal formula of 0-3-3-3-2; *Bipes canaliculatus* has four well-developed claws (rarely five) on each limb, fifth digit reduced usually without a claw, and a phalangeal formula of 3-3-3-3-2. Two precloacal pores are present in *Bipes bipes* (usually six precloacal pores in *Bipes tridactylus* and *Bipes canaliculatus*). Dorsal annuli count is highest in *Bipes bipes* (242–261) and lower in both *Bipes canaliculatus* (202–231) and *Bipes tridactylus* (152–163). In nonautotomized tails, the relationship of tail length to body length of 10–12 percent of SVL distinguishes *Bipes bipes* from *Bi-*



*pes canaliculatus* (14–16 percent of SVL) and *Bipes tridactylus* (19–30 percent of SVL) (Papenfuss 1982).

**PHYLOGENETIC RELATIONSHIPS.** Of the six families of amphisbaenids currently recognized, only Bipedidae is unique in possessing highly specialized forelimbs to facilitate burrowing. The monophyletic genus *Bipes*, the only member of the family Bipedidae, contains three allopatric species: *Bipes biporus* (Five-toed Worm Lizard), *Bipes canaliculatus* (Four-toed Worm Lizard) and *Bipes tridactylus* (Three-toed Worm Lizard). Originally placed in the subfamily Amphisbaeninae in the family Amphisbaenidae (Vanzolini 1951a, 1951b; see Gans 1967), *Bipes* was subsequently placed in the family Bipedidae defined by the possession of well-developed forelimbs (Gans 1978). The first molecular study of *Bipes* (Kim et al. 1976) used electrophoretic analyses of 22 allozyme loci, but failed to recover a robust phylogenetic hypothesis in support of a close relationship between *Bipes biporus* and the two Mexican mainland species, *Bipes canaliculatus* and *Bipes tridactylus*. Genetic variation was observed to be low in all three species of *Bipes*, although evidence for northern populations of *Bipes biporus* differing from populations sampled in the south was reported by Kim et al. (1976). That intraspecific genetic differentiation was further supported by studies based on morphology (Papenfuss 1982) and DNA sequence data (Macey et al. 2004). The first cladogram based on an analysis of karyotypes and detailed descriptions of macro- and microchromosomes of all three species of *Bipes* was provided by Cole and Gans (1987) and provided evidence for *Bipes canaliculatus* and *Bipes tridactylus* as sister species, contrary to Kim et al. (1976). Relationships among the three species of *Bipes* were reported as unresolved by Grismer (1994a, 1994b, 1994c), who hypothesized that a phylogenetic

hypothesis would likely be consistent with a vicariant origin of *Bipes biporus* rather than over-water colonization on the peninsula. The first DNA sequence-based phylogenetic study of the genus was conducted by Macey et al. (2004) using complete mitochondrial genomes from the three *Bipes* species as well as multiple representatives of Amphisbaenia. That analysis supported the recognition of both Rhineuridae as sister to other extant amphisbaenians and Bipedidae as the sister taxon to a clade composed of both Amphisbaenidae and Trogonophidae. Mitochondrial genomes recovered *Bipes tridactylus* as sister to a clade containing *Bipes canaliculatus* and *Bipes biporus* which support the occurrence of an early primary vicariance isolating northern and southern populations of *Bipes* prior to the tectonic movement of Baja California away from the mainland of México (Macey et al. 2004).

**PUBLISHED DESCRIPTIONS.** The original description of *Bipes biporus* was published by Cope (1894). Early descriptions also appeared in Cope (1900), Lockington (1879), and Van Denburgh (1895, 1922, 1978). Additional descriptions were published by Alaniz-Garcia and Valdez-Villavicencio (2008), Ditmars (1933), Gans (1978), Grismer (2002), Kearney (2003c), O'Shea and Halliday (2001, 2002), Papenfuss (1979, 1982), Samaniego-Herrera et al. (2007), Smith (1946, 1949a, 1965, 1971), Smith and Smith (1977), Stebbins (1985a, 1985b, 2003), and Zug et al. (2001).

**ILLUSTRATIONS.** **Black-and-white line drawings** of skeletal morphology were presented by Augé (2012: dorsal view of a trunk vertebra), Caldwell (2003: forelimb, pectoral girdle, and rear limb skeleton), Cope (1900: hyoid bone), Gans (1974a, 1974b: cross-section through the skull showing the otic capsule), Gans and Montero (2008: dorsal,



**FIGURE 4.** Habitat of *Bipes biporus* approximately 35 km west of San Ignacio, Vizcaíno Desert Biosphere Reserve, Baja California Sur, México. Typical habitat is xerophilic scrub vegetation and unconsolidated, fine-grained soil. Photograph by Clark R. Mahrtdt, July 2015.

lateral, and ventral views of the skull and a lateral view of the mandible), Guibé (1970: osteology of cloacal region), Kearney (2002) and Kley and Kearney (2007: ventral view and right lateral view of the pelvic girdle), K. Smith (2009: left dentary), Vanzolini (1951a: dorsal, ventral, lateral views of the skull and lateral and lingual views of the mandible), Wever (1978) and Wever and Gans (1972: middle ear), Wu et al. (1993, 1996: ventral and lateral views of the skull), and Zangerl (1945: sternum, pectoral girdle, and forelimb). Black-and-white line drawings of external morphology were presented by Cope (1894, 1900), Smith (1946, 1949a, 1965, 1971), Sanborn and Loomis (1976: anterior dorsolateral view of the head and body), and Smith and Smith (1977: dorsal, ventral, and pectoral views of the body, lateral view of the head, annuli at midbody, and a ventral view of the tail). Line drawings showing the for-

ward progression of tunneling in *Bipes biporus* were presented by Gans (1974a, 1974b), Kley and Kearney (2007), and Pough et al. (1998). A line drawing showing the relative proportions of the major visceral anatomy including the heart, liver, pancreas, spleen, colon, gonads, kidneys, lung, and fat bodies was provided by Crook and Parsons (1980). **Black-and-white photographs** of live specimens were published by Anonymous (1966), Carr (1963), Crump (2011), De Sola (1940), Ditmars (1933), Franklin (2001, 2014), Freiberg (1972), Kearney (2002, 2003a), Kearney and Stuart (2004), Leviton (1972), Mattison (1989, 1992, 1998, 1999, 2004, 2009), Rodda (2020), Shaw (1962b), and Wever and Gans (1972). Additional black-and-white photographs were published by Bellairs (1969, 1970: an individual “walking”), Bogert (1964: vestigial eyes), Cole and Gans (1987: karyotypes), Dial et al. (1987:



dorsal view showing concertina locomotion), Gauthier et al. (2012: braincase of the skull), Lynn and Komorowski (1957: thyroid glands), and Schwenk (1988: transverse view through the mid-tongue). **Color illustrations** were published by Discovery Channel (2000), Jackson and Chinery (2008, 2015, 2020), Johnson (2010), Kearney (2003c), Mattison (2005), McGinnis and Stebbins (2018), Stebbins (1985a, 1985b, 2003) and Whitfield (1983). **Color photographs** of the dorsal, frontal, or ventral view of live specimens of *Bipes biporus* were presented by Alaniz-García and Valdez-Villavicencio (2008), Carr (1963), Franklin (2014), Frye (1981, 1991), Gans (1975a, 1975b, 1976, 1980, 1986a, 1986b, 1992a, 1992b, 1998a, 1998b, 2002a, 2002c, 2004a, 2011), Gilbert (1987),

Gómez-Pompa et al. (1995), Grismer (2002), Hikida (1993), Hollingsworth et al. (2015), Johnson et al. (2017), Kearney (2003c), Love (2009), Lovich and Grismer (2009), Mattison (2014, 2015, 2017), Mattison and Crombie (2001), McGinnis and Stebbins (2018), McPeak (2000), Mertz (2005), Obst et al. (1988), Ochoa-Ochoa et al. (2009), O'Shea (2021), O'Shea and Halliday (2002), Pough et al. (2016), Prosdocimi (2011), Rundquist (1994), Samaniego-Herrera et al. (2007), Uetz et al. (2022), Valle-Jiménez (2018), Vitt and Caldwell (2009, 2014), Walls (1979), Wynne (1981), and Zug et al. (2001). A color photograph unlabeled as *Bipes biporus* but identifiable to species was published by Taylor and O'Shea (2004, 2006, 2011, 2014, 2021). A color photograph of *Bipes biporus*



**FIGURE 5.** Natural habitat of *Bipes biporus* 2.5 km E of Villa Jesús María, Baja California, Municipality of Ensenada, Valle de los Cirios Protected Area in the northern Vizcaíno Desert region with sparse vegetation and generally fine-grained soil. Photo by Clark R. Mahrtdt, July 2015.





**FIGURE 6.** Natural habitat of *Bipes biporus* from Rancho Los Quijotes (33 m elev.) near San Juan de los Planes, Municipality of La Paz, Baja California Sur, México. Photo by Clark R. Mahrtdt, November 2015.

emerging from a burrow was published by Alaníz-García (2011). Color photographs of *Bipes biporus* feeding on a caterpillar, in simulated burrow, and in a defensive posture were presented by Franklin (2014). **Black-and-white images of electron micrographs** were provided by Gundy (1977; three images of the normal eye, photoreceptor cells, and retina, and two images of degenerating retina and photoreceptor cells) and Rhoten (1970; pancreatic cell types); **black-and-white radiographs** were published by Bogert (1964; whole-body radiograph), Kearney (2002; pectoral girdle and forelimbs), and Wever and Gans (1972; photomicrograph of a transverse section of the ear). Photographs of the **habitat** were published by Franklin (2001, 2014), Grismer (1994c, 2002), Grismer et al. (1994), Langner (2019), Leviton and Banta

(1964), Papenfuss (1982), and Valle-Jiménez (2018).

**DISTRIBUTION.** *Bipes biporus* is endemic to Baja California, ranging throughout the western portion of the southern half of the peninsula and west of the peninsular ranges, from approximately 17 km north of Jesús María (lat. N28° 17') in the state of Baja California south to Todos Santos (lat. N23° 27'), Baja California Sur (Grismer 2002; Papenfuss 1982). The species ranges southward along the Magdalena Plain and eastward across the sandy flats of the Isthmus of La Paz to the Gulf of California at Bahía de La Paz. This taxon occurs on the Pacific island of Magdalena (Peralta-García et al. 2007). Elevation distributions range from near sea level to nearly 400 m with most populations



occurring below 100 m. *Bipes biporus* is absent north of the Vizcaíno Desert where the Sierra Columbia contacts the Pacific Ocean. There is an unconfirmed record of a specimen (SDSNH 61182) from 100 km southeast of El Rosario, Baja California and nine specimens (one at UMMZ, three at FMNH, five at MCZ) considered doubtful from Rancho La Palmita in the foothills of the Sierra La Giganta, Baja California Sur (see **Comments**). Anecdotal accounts of the species occurring in the vicinity of Cabo San Lucas are invalid (Stejneger and Barbour 1917, see **Remarks**).

The habitat of *Bipes biporus* consists primarily of open, flat terrain, stabilized dunes and hummocks, and arroyos associated with sparse, xerophilic vegetation and mesquite thickets (Grismer 2002). The distribution of this species in arid regions of Baja California is generally associated with weakly developed, unconsolidated, fine-grained sandy soils of minimal organic horizon and profile development. In some locations where the species occurs, there is evidence of stratification characterized by distinct layers of top soil. In few coastal localities, unconsolidated saline soils consist of a high concentration of soluble salts. Typically, these soil types occur in association with alluvial, aeolian, lacustrine, and marine deposits and are of recent origin (IUSS Working Group WRB 2015). There are a few localities where the species is present in alluvial drainages in the foothills of mountain ranges (e.g., Sierra La Libertad, Rancho La Esperanza, elevation 365 m) of the Vizcaíno Desert. *Bipes biporus* is known only from a few localities south of Bahía San Juanico in the Valle Santo Domingo and southern Magdalena Plain, a distance of 320 km. Consolidated soil, rocky substrate, and geological characteristics contribute to gaps within the species geographic distribution (see **Map**). Large series of specimens ( $n=2854$ ) collected from the vicinity of La Paz account for nearly 96 percent of all institutional records (Papenfuss 1982).

Activity times on the surface were reported between 2200 h and 0400 h (Franklin 2001).

*Bipes biporus* has been observed buried around the base of fence posts (Papenfuss 1982, 1984), on the underside in a decaying cardon (*Pachycereus pringlei*; Leviton and Banta 1964), in damp earth beneath rocks (Shaw 1962a), in junkyards (Franklin 2001), under surface debris such as tin and cardboard (Franklin 2001; Grismer 2002; Peralta-García et al. 2007), and plywood (F. Isai Valle-Jiménez, personal communication).

Comments on the species distribution in Baja California have been published by Anonymous (2004), Banta and Leviton (1963), Campbell (1990), CONANP (2003), Cope (1887, 1896a, 1900), Enderson et al. (2009), Flores-Villela (1993), Freiberg (1972), Gadow (1905), Galina et al. (1991), Gans (2005), Gómez-Pompa et al. (1995), Grismer (1994a, 1994b, 1994c, 2002), Hodges and Perez-Ramos (2001), Hollingsworth and Frost (2007), Hollingsworth et al. (2015), Leviton (1972), Lockington (1879), Lovich et al. (2009), Maccey et al. (2004), Mills (1982), Murphy and Méndez de la Cruz (2010), Nelson (1921), Papenfuss (1979, 1982), Ramírez-Acosta et al. (2012), Schmidt (1922), Shaw (1962a), Smith and Taylor (1950b, 1966), Van Denburgh (1895, 1922), and Wilson and Johnson (2010). **Distributional records** were published by Cope (1900), Kim et al. (1976), Leviton and Banta (1964), Linsdale (1932), Lockington (1880), Loomis et al. (1974), Murray (1955), Papenfuss (1982), Peralta-García et al. (2007), Schmidt (1922), and Smith and Smith (1977). **Range maps** were published by Alaniz-García and Valdez-Villavicencio (2008), Bogert (1964), Flores-Villela and Hodges (1999), Gans (1990), Grismer (1994a, 1994b, 1994c, 2002), Hollingsworth and Frost (2007), Kearney (2003c), Kim et al. (1976), Mattison (1989, 1992, 1998, 1999, 2004, 2005, 2009), Mattison and Crom-

bie (2001), McGinnis and Stebbins (2018), Mertz (2005), Murphy (1982, 1983), Ochoa-Ochoa et al. (2009), Papenfuss (1979, 1982), Pough et al. (2016), Samaniego-Herrera et al. (2007), Smith and Smith (1977), Stebbins (1985a, 1985b), Valle-Jiménez (2018), and Zug et al. (2001).

Shaw (1962a) and Bogert (1991) reported placing advertisements in the La Paz newspaper or speaking with local ranchers regarding their observations of *Bipes biporus*. Similarly, Papenfuss (1984) used “wanted dead or alive” posters written in Spanish and placed in strategic locations as a means of determining the species distributional limits.

Unverified claims for *Bipes* in Arizona were mentioned by Lowe (1994) and Taylor (1994) and in Sonora, México by Lemos-Espinal et al. (2019). A review and analysis of the unverified observation of *Bipes* by Edwin James during an 1820 expedition to north-eastern Colorado was presented by Horstman (1998).

**FOSSIL RECORD.** No fossils are known.

**PERTINENT LITERATURE.** The most comprehensive studies on the natural history of *Bipes biporus* were published by Papenfuss (1979, 1980, 1982), and included external morphology, geographic variation, predation, tail autonomy, growth and reproduction, seasonal activity, and thermal requirements. Additional observations on natural history were published in Grismer (2002).

The **anatomy and morphology** of *Bipes biporus* include summaries and descriptions of the **appendicular skeleton and pectoral girdle** (Brandley et al. 2008; Caldwell 2003; Casteñada Peña 1967; Castañeda and Alvarez 1970; Cope 1892; Fedak and Hall 2004; Gans 1974a, 1974b, 1978; Greer 1992; Greer and Gans 1983; Kearney 2002, 2003a; Kley and Kearney 2007; Russell and Bauer 2008; Smith 1949b; Westphal et al. 2019), **brain** (Schwab 1979), **cranial skeleton** (Atkins 2014; Bellairs

and Kamal 1981; Gans 1974a, 1974b, 1978; Gans and Montero 2008; Gauthier et al. 2012; Jollie 1960; Kearney 2003a; Lee 1998; Palci and Caldwell 2013; Rieppel et al. 2008; Vanzolini 1951a; Wu et al. 1993, 1996; Zangerl 1944), **dentition and egg tooth** (Berkovitz and Shellis 2017; Bogert 1964, 1991; Edmund 1969; K. Smith 2009), **ear** (Baird 1970; Gans 1978; Gans and Wever 1972, 1975; Miller 1966; Sánchez-Martínez et al. 2021; Wever 1978; Wever and Gans 1972, 1973), **dermal-vertebral correlates** (Alexander and Gans 1966), **eye** (Gundy 1977), **hemipenes** (Gans 1978), **hyoid skeleton** (Bellairs and Kamal 1981; Gans 1978; Wever and Gans 1972), **neonatal ossification of the skeleton** (Maisano 2000, 2001), **pancreas** (Miller and Lagios 1970; Rhoten 1969, 1970, 1971, 1972), **post-cranial skeleton** (Kearney 2003a; Zangerl 1945), **sacrum and pelvic arch** (Cope 1892; Grassé 1970; Guibé 1970; Urben et al. 2014), **thyroid gland** (Lynn and Komorowski 1957), **tongue** (Schwenk 1988), **ulnar innervations** (Estes et al. 1988), **vertebrae** (Hoffstetter and Gasc 1969), and **visceral anatomy** (Cope 1896b; Crook and Parsons 1980). The relationships in morphology and osteology were compared to both **recent and fossil forms** of amphisbaenids by Folie et al. (2013), K. Smith (2009), Taylor (1951), and Wu et al. (1993, 1996).

Literature relevant to the biology and natural history of *Bipes biporus* include the following topics: **biogeography** (Cope 1896a; Enderson et al. 2009; Fernández-Badillo et al. 2014; Gans 1990; Grismer 1994a, 1994b, 1994c, 2002; Grismer et al. 1994; Longrich et al. 2015; Murphy 1975, 1982, 1983; Murphy and Aguirre-Leon 2002; Novosolov and Meiri 2013; Savage 1960; Seib 1980; Taylor 1951; Walker and Taylor 1966; Welsh 1988); **biomechanics, burrowing behavior and locomotion** (Bellairs 1969, 1970; Bogert 1964; Carr 1963; Dial et al. 1987; Echternacht 1977a, 1977b; Galis et al. 2010; Gans 1974a, 1974b, 1975a, 1975b, 1976, 1980, 1992a,



1992b, 1998a, 1998b; Gans and Shaw 1963; Gundy 1977; Kley and Kearney 2007; Langner 2019; Papenfuss 1981, 1984; Pough et al. 1998; Renous 1977; Walls 1979), **captive longevity** (Bowler 1977; Mills 1982; Slavens 1980, 1983, 1989; Slavens and Slavens 1990, 1992, 1993, 1994, 1997, 1998, 2000; Snider and Bowler 1992), **climate change model** (Lara-Reséndiz et al. 2020), **collecting techniques** (Bogert 1991; Franklin 2001; Miller 1966; Papenfuss 1979, 1982; Shaw 1962a, 1962b), **commercial reptile trade** (Mellink 1995), **comparison of external morphology** with *Bipes canaliculatus* (Smith 1949b) and *Bipes tridactylus* (Smith and Necker 1944); **conservation and conservation status** (Blázquez-Moreno et al. 2012; Franklin 2014; Hollingsworth and Frost 2007; Johnson et al. 2017; Lovich et al. 2009; Murphy and Méndez de la Cruz 2010; Ramírez-Acosta et al. 2012; SEMARNAT 2002, 2008, 2010, 2019; Wilson and Townsend 2010; Wilson et al. 2013), **diet and feeding habits** (Franklin 2014; Gomes et al. 2009; Kearney 2003b), **experimental biology** as it relates to the species visual response to light intensity (Gundy 1977), **folklore** (Belding 1887; Franklin 2001, 2014; Grismer 1990, 2002; O'Shea 2021; Wright and Mason 1981; Zweifel and Norris 1955), **forelimb evolution** (Brandley et al. 2008; Galis et al. 2010; Greer 1992), **genetics** (Boore 1999; Gorman and Renzi 1979; Kim et al. 1976; Macey et al. 1997a, 1997b, 1998, 2005; Olmo 1981, 1984; Seligmann 2011a, 2011b; Seligmann and Krishnan 2006), **habitat** (Alvarez-Cardenas et al. 1988; Flores-Villela and Gerez 1988, 1994; Franklin 2001, 2014; Langner 2019; Leviton and Banta 1964; Lovich and Grismer 2009), **husbandry** (Franklin 2001, 2014; Frye 1991; Mills 1982), **karyology** (Cole and Gans 1987; Gans 1978; Gans et al. 1967; Gilboa 1975; Gorman 1973; Huang and Gans 1971; Huang et al. 1967; MacGregor and Klosterman 1979; Sokolovskiy 1972), **parasites** (Goldberg and Bursey 2012), **physiology** (Minnich 1972;

Mullen 1967), **predation** (Franklin 2014; Greene 1988, 1994; Papenfuss 1982; Rodriguez-Robles et al. 1999), **reproductive biology** (Andrade et al. 2006; Franklin 2001, 2014; Papenfuss 1981), **sexual dimorphism** (Papenfuss 1982; Kearney 2003b), **taxonomy, systematics, and phylogenetics** (Bogert 1965a, 1965b; Brandley et al. 2008; Conrad 2008; Douglas et al. 2006; Estes et al. 1988; Gauthier et al. 2012; Gorman et al. 1971; Grismer 1994a, 1994b, 1994c; Harris et al. 1999; Hembree 2007; Hipsley and Müller 2014; Kearney 2001, 2003a; Kearney and Stuart 2004; Kim et al. 1976; Lee 1998; Longrich et al. 2015; Macey et al. 2004; Mulcahy et al. 2012; Papenfuss 1982; Podnar et al. 2009; Pyron 2017; Pyron et al. 2013; Reeder et al. 2015; Rui et al. 2009; Saint et al. 1998; Sánchez-Martínez et al. 2021; Streicher and Wiens 2017; Townsend et al. 2004; Vaconcelos et al. 2006; Vanzolini 1951a, 1951b; Vidal and Hedges 2005; Vidal et al. 2008; Wiens et al. 2006, 2012; Zheng and Wiens 2015, 2016), **thermal ecology** (Lara-Reséndiz et al. 2020; Valle-Jiménez 2018), and **winter activity** (Blázquez and Ortega-Rubio 1996).

The species has been included in numerous **general works, geographic checklists, taxonomic keys, faunal accounts and field guides** (Alaniz-García 2011; Alaniz-García and Valdez-Villavicencio 2008; Allyn 1952, 1956, 1961, 1977; Alvarez et al. 1997; Alvarez-Cardenas et al. 1988; Anonymous 2011, 2017; Barker 1964; Blázquez-Moreno et al. 2012; Bogert 1964; Bostic 1971; Carabias Lillo et al. 2000; CONABIO 2009; CONANP 2003; Cope 1887, 1896b; Crosswhite and Crosswhite 1982; Crump 2011; Cuesta Terron 1920, 1921; De Sola 1940; Discovery Channel 2000; Ditmars 1907, 1910, 1922, 1933, 1946; Dobrowolska 1990; Enderson et al. 2009; Felix 1988; Flores-Villela 1993; Flores-Villela and Gerez 1988, 1994; Flores-Villela and Hodges 1999; Flores-Villela et al. 1995; Frank and Ramus 1995; Gadow 1905; Galina et al. 1991; Gans 1967, 1975a, 1975b, 1975c, 1976,

1980, 1986a, 1986b, 1992a, 1992b, 1993a, 1993b, 1998a, 1998b, 1999, 2002a, 2002b, 2002c, 2002d, 2004a, 2004b, 2005, 2011; Gans and Mathers 1977; Hall 2004, 2011; Hikida 1993; Hollingsworth et al. 2015; Jackson and Chinery 2008, 2015, 2020; Johnson 2010; Kearney 2003c; Lemos-Espinal et al. 2019; Leviton and Banta 1964; Liner 1994, 2007; Liner and Casas-Andreu 2008; Loomis et al. 1974; Love 2009; Lovich et al. 2009; Mattison 1989, 1992, 1998, 1999, 2004, 2005, 2009, 2014, 2015, 2017; Mattison and Crombie 2001; McGinnis and Stebbins 2018; McPeak 2000; Mertz 2005, Mills 1982; Nelson 1921; Obst et al. 1984, 1988; Ochoa-Ochoa et al. 2006; O'Shea 2001, 2021; O'Shea and Halliday 2001, 2002, 2009; Pough et al. 1998, 2001, 2004, 2016; Prosdocimi 2011; Rodda 2020; Roth 1997, 2000; Samaniego-Herrera et al. 2007; Sanborn and Loomis 1976; Shaw 1962b; Smith 1946, 1949a, 1965, 1971; Smith and Smith 1976, 1977, 1993; Smith and Taylor 1950a, 1950b, 1966; Stebbins 1985a, 1985b, 2003; Stejneger and Barbour 1917, 1923, 1933, 1939, 1943; Taylor and O'Shea 2004, 2006, 2011, 2014, 2021; Uetz et al. 2022; Van Denburgh 1922; Van Denburgh and Slevin 1921; Vanderplank et al. 2016; Whitfield 1983; Yarrow 1883; Zug et al. 2001; Zwinger 1983) and in **bibliographies** (Gans 1967, 1978, 2005; Gilboa 1975; Liner 2010; Smith and Smith 1976, 1977, 1993). The **holotype** was listed by Cochran (1961), Gans (1967, 2005), Smith and Smith (1977), and Smith and Taylor (1950a).

**REMARKS.** The first specimen of *Bipes bipes* was reported by Streets (1877) as *Chirotetes canaliculatus* (USNM 8568) (Latreille 1801; see Flores-Villela et al. 2004), “obtained through the agency in the United States consul at La Paz” in Baja California Sur, México. The collector and date of collection is unknown. This species was the only member of the genus occurring in neighboring mainland México at the time Streets made his second

expedition along the coast of Baja California in 1874–1875. In 1876, two additional specimens were collected by W. J. Fisher, a friend of the California Academy of Sciences, in La Paz and identified by Cope as “*Chirotetes* sp.?” (Lockington 1879, 1880). The specimens were obtained by David Turner, who served in the U. S. Consul at La Paz (1865–1878) and presented them to the California Academy of Sciences. One specimen was catalogued as CAS 128 (Van Denburgh 1895, 1978) and was later destroyed in the 1906 San Francisco earthquake. The deposition of the second specimen is unknown. Lockington (1879) questioned the validity of Streets’ taxonomy and provided a general description of *Chirotetes* as possessing “two little legs, each furnished with five toes ending in pointed claws.” Despite Lockington’s implication of an undescribed species, the name *Chirotetes canaliculatus* was maintained by Belding (1887), Cope (1887, 1892), and Yarrow (1883). The genus *Chirotetes* was challenged by Stejneger (1893:157–158) who formally proposed “there can be no doubt but that the generic name for the *Chirotetes* must stand as *Bipes*, and the family name will, accordingly, be Bipedidae.” However, Cope proposed to retain the family name Euchirotidae “so as to disturb the existing custom as little as possible”. In 1894, Cope, having assumed that *Bipes* [*Chirotetes*] *canaliculatus* was valid, actually represented an undescribed species of Amphisbaenid, naming the new genus and species *Euchirotetes bipes* from “Cape St. Lucas, Lower California” collected by G. Eisen. A holotype was not designated by Cope (1894), although an illustration from Cope’s original description and the holotype (USNM 12599) was provided in Cope (1900:680, Figure 140) in addition to 11 “cotypes” collected by Belding in 1882 in La Paz. Confounded with Cope’s taxonomy, Gadow (1905:220) stated that “to split these creatures into three genera [*Bipes*, *Euchirotetes* and *Hemichirotetes* (= *Bipes tridactylus*)] is ridiculous.” Subsequently, *Euchirotetes bipes*



was used by several authors (Cope 1896a, 1896b, 1900; Cuesta Terron 1920, 1921; Ditmars 1907, 1910; Van Denburgh 1895, 1922, 1978; Van Denburgh and Slevin 1921). First use of the present combination, *Bipes biporus*, was published in Stejneger and Barbour (1917) and was later accepted by Nelson (1921), Schmidt (1922), Ditmars (1933), and used in subsequent editions of the checklists by Stejneger and Barbour (1923, 1933, 1939, 1943).

Yarrow (1883) and Cope (1900) assigned a lot number for 12 “cotypes” of Belding (USNM 12599) in addition to one specimen (USNM 8568) acquired by Streets (1877), for a total of 13 specimens all from La Paz, Baja California Sur. However, in the original catalogue of the United States National Museum, there are a total of 12 types listed including two specimens that were exchanged, one to MCZ and one to CAS. The Belding series from a lot of 11 specimens (USNM 12599) was recatalogued in March 1894 as USNM 21316–21325. The specimen USNM 21318 was exchanged to the MCZ on 2 May 1916 and catalogued as MCZ R-11813. The specimen USNM 21319 was later sent to Julius Hurter in June 1912. This specimen was returned by Hurter in June 1917, recatalogued as USNM 58745, and then exchanged to John Van Denburgh by Doris Cochran in July 1921, where the specimen was catalogued as CAS 50187. The type (USNM 21324) was examined by Cope and later returned to USNM in February 1894. Cochran (1961) listed the holotype as USNM 21324 (formerly USNM 12599) and two paratypes USNM 12599 (Belding 1887) and USNM 8568 (Streets 1877). The fixation of the lectotype by inference of the holotype (Cochran 1961) was published by Gans (1967) citing Cochran’s designation of the lectotype and designating the remaining syntypes as paralectotypes. However, Gans (1967) listed the lectotype (USNM 21324) and 12 paralectotypes of Belding, where the lectotype was duplicated and incorrectly as-

signed to the paralectotype series. This error was repeated by Smith and Smith (1977) and again by Gans (2005). In the USNM database (Addison Wynn, personal communication, 15 June 2018), the Belding series consists of a lectotype and 10 paralectotypes and an additional paralectotype (USNM 8568) of Streets (1877). The first authoritative fixation of *Bipes biporus* was given by Gans (1967), so credited by Smith and Smith (1977).

Cope (1887) listed *Chirotetes canaliculatus* from Cape Saint Lucas, Lower California, and John Xantus as collector. Xantus made collections of reptiles, birds, plants, and invertebrates for the Smithsonian Institution in the Cape Region, including Cape San Lucas and San Jose del Cabo, from April 1859–August 1861 (Nelson 1921; Zwinger 1986). In the USNM archives, field notes and letters by Xantus contained no records of *Chirotetes* from Baja California (Kevin de Queiroz, personal communication, 20 November 2015; see Zwinger 1986). The original description of *Bipes biporus* (Cope 1894) was based on a specimen collected by Gustav Eisen of the California Academy of Sciences, from “Cape St. Lucas, Lower California. U.S. National Museum.” Van Denburgh (1895:136; 1978:[60])) noted that “the Academy has a single specimen (No. 128) from La Paz. The type came from Cape San Lucas.” To add further confusion, Cope (1900) reported that the species “seems to be not uncommon at Cape St. Lucas” despite listing Streets (1877) and Belding (1887) series from La Paz. Gadow (1905:220), following the erroneous comment of Cope (1900), stated that the species is “said also to be common at Cape Lucas” and living in the sand dunes. Stejneger and Barbour (1917:72) first questioned the validity of the Cape San Lucas record and reassigned the type locality as “La Paz, Lower California”, commenting “given in error in original description as Cape St. Lucas.” The reassignment was supported by Cochran (1961), Gans (1967), and Smith and Smith (1977). The occurrence of

*Bipes biporus* in the southern Cape Region (i.e., San José del Cabo, Cabo San Lucas) is herein considered doubtful since there are no historical or recent records (VertNet accessed 2 June 2015) available in institutional collections.

Liner (2007:20) cited an unidentified 1905 paper by Stejneger, rather than Stejneger (1893), as the first published proposal to use the family Bipedidae to replace Chirotidae which included *Chirotes* (= *Bipes*) *canaliculatus* (Latreille 1801) and Cope's (1894) description of *Hemichirotes* (= *Bipes*) *tridactylus* (Duges, in Cope, 1894) and *Euchirotes* (= *Bipes*) *biporus*.

A diploid number of  $2n=40$  for *Bipes biporus* was reported by Huang et al. (1967) based on the analysis of lung tissue, but was later corrected as  $2n=42$  by Huang and Gans (1971) using blood samples.

The conservation status of the species is listed under the category of "special protection" in Baja California (SEMARNAT 2002, 2008, 2010, 2019). The species was considered at a level of least concern (IUCN) by Hollingsworth and Frost (2007) while the species was placed in the medium vulnerability category based on ecology and its occurrence in a protected area by Murphy and Méndez de la Cruz (2010). A reassessment of the high vulnerability category of the species endemic to peninsular Baja California, which occupies a single physiographic region, was provided by Johnson et al. (2017) and Wilson et al. (2013). The impact of human persecution from the pet trade was found to be minimal. Currently, *Bipes biporus* is afforded special protection in extreme southern Valle de los Cirios and El Vizcaíno Biosphere Reserve (Ramírez-Acosta et al. 2012). The population trend was assessed as stable (Hollingsworth and Frost 2007).

**ETYMOLOGY.** The specific name *biporus* is derived from the Latin prefix *bi* meaning

"two" or "double" and suffix *porus* meaning "a pore" or a small opening through the skin, in reference to two preanal pores situated forward of the cloacal opening. The gender is masculine.

**ADDITIONAL VERNACULAR NAMES:**

The Spanish name, Ajolote, has been used for over 140 years since the first discovery of *Bipes biporus* by Streets (1877). As noted by Streets (1877:38), the name "cannot be considered as specific or even generic, as it is applied to several species of Amphisbaenidae." Ajolote was used in reference to the vernacular of *Elgaria paucicarinata*, *Xantusia vigilis gilberti* (CONANP 2003) and by locals in Sonora, Mexico for the scincid lizard *Eumeces callicephalus* (Zweifel and Norris 1955). Ajolote was applied in the generic sense by Gans (2011), Grismer (2002), Kearney (2003c), Mattison (2005), Samaniego-Herrera et al. (2007), and Wrobel (2004). The name is widely used by local ranchers and residents of Baja California.

Several Spanish names have been associated with *Bipes biporus* including Culebrita con Manitas (Bogert 1964; Freiberg 1972; Gadow 1905), Culebrita de Orejas (Liner 1994), Ajolotito de dos Manos (Blázquez-Moreno et al. 2012), Ajolotito dos Manos (Carabias Lillo et al. 2000; Galina et al. 1991), Dos Manos de Cinco Dedos (Hollingsworth et al. 2015; Liner and Casas-Andreu 2008; Uetz et al. 2022), Culebrilla Ciega Mejicana (Gans 2011), Largartija con Oreillas [sic] (Gans 1975a), Lagartijas con Orejas (Gans 1986a, 1986b, 2002a, 2004a, 2011), Lagartija Topo (Blázquez-Moreno et al. 2012), and Lagartija Topo Cinco Dedos (SEMARNAT-2010; Ochoa-Ochoa et al. 2009). Zwinger (1983) and Chace (1982) incorrectly applied the name "axolote" (= *Ambystoma mexicanum*) of Aztec origin (see Smith 1971) to the species *Bipes biporus* or the Spanish vernacular "ajolote." The name ajolote and Culebras con



Manitas (Flores-Villela and Hodges 1999) is also used in the generic sense, referring to all three species of the genus *Bipes*.

The currently recognized standard common name, Five-toed Worm Lizard, was first used by Liner (1994) and adopted by Fotolulu (2018) [in German: Fünffingrige Handwühle], Frank and Ramus (1995), Grismer (2002), Hollingsworth et al. (2015), Samaniego-Herrera et al. (2007), Uetz et al. (2022), and Wrobel (2004). Several common names have been used for the species including Two-footed Worm Lizard (Ditmars 1933; Frye 1981, 1991; Grismer 1994b; Wrobel 2004), a name also applied to the family Bipedidae (Liner 1994); Two-handed Blind “Snakes,” a name applied to the genus *Bipes* (Ditmars 1933), Five-fingered Ajolote (O’Shea 2021), Mole Lizard (Stebbins 1985a, 1985b, 2003; Kearney 2003c; McPeak 2000; O’Shea and Halliday 2001, 2002, 2009), Mole-limbed Worm Lizard (Vitt and Caldwell 2009), Mexican Worm Lizard (Gans 1986a, 1986b, 2004a, 2011), Two-legged Worm Lizard (Discovery Channel 2000; Leviton 1972; Wrobel 2004), Common Two-legged Worm Lizard (Gans 1975c; Gotch 1986; Sokolov 1988; Wrobel 2004), Mole Lizard (Wrobel 2004), Belding’s Mole Lizard (Van Denburgh 1922; Shaw 1962a, 1962b), and Two-handed Ground Snake (Yarrow 1883). The vernacular “hand-eared lizard” was used by Lockington (1879) and “two-handed burrowing snake” was used by Bogert (1964). “*Bipes à deux pores*” (French) and “Tweepotige wormhagedis” (Dutch) were used by Gans (1975b) and Gans (1976), respectively. Sokolov (1988) provided vernacular names in Russian (айолоп), German (Hanwühle), and French (*bipes à deux pores*).

**COMMENTS.** As currently understood, *Bipes biporus* ranges from just north of Jesús María in the Vizcaíno Desert, Baja California south to Todos Santos, Baja California Sur. A preserved specimen (SDSNH 61182)

received from Mexican associates of Doña Anita “mama” Espinosa of El Rosario is questionable (see **Map**). The locality and habitat was conveyed to L. C. Eaton (a former student of Benjamin H. Banta) by the late D. Espinosa as “100 km southeast of El Rosario in the vicinity of [Rancho] Santa Inés” north of Cataviña via Mexico Hwy. 1, Baja California in March 1977. This locality is approximately 200 km north of the El Vizcaíno Desert Biosphere Reserve. Photographs of *Bipes biporus* were presented to nearby residents and ranchers from Rancho Santa Inés north along 60 km of Mexico Hwy 1, with mixed response. Despite additional field work in the vicinity of Cataviña by one of us (CRM), the record remains unverified.

Georeferenced records (VertNet, accessed 2 June 2015) at Rancho La Palmita in the foothills of the Sierra la Giganta, Municipality of Comondú, are considered doubtful. Soils at this location are typical of mountainous regions characterized by very thin soils rich in coarse fragments over continuous rock (IUSS Working Group WRB 2015). The locality is reassigned to the Cape Region at Rancho La Palmita (=El Mantal) in the foothills of the Sierra La Gata, Municipality of La Paz, 16 km east of San Antonio. This locality was presented in a distribution map by Smith and Smith (1977) as “Rancho La Palmita, San Antonio” based on four records in the Field Museum of Natural History (FMNH 18049–18051) and the University of Michigan, Museum of Zoology (UMMZ 71991). An additional five records from Rancho La Palmita are catalogued in the Museum of Comparative Zoology (MCZ R-32088–32092), collected 21–28 June 1931 by L. Gonzales Rubio who had also collected *Bipes biporus* four days later in the vicinity of La Paz on 3 July 1931, a distance of over 140 linear km south. The potential distribution of *Bipes biporus* south of La Paz in the bajada of San Juan de los Planes was identified by Ochoa-Ochoa et al (2009). Five specimens discovered during

October–November 2015 and a sixth specimen found September 2016 from the sandy alluvium located between San Juan de Los Planes and San Antonio (P. Galina-Tessaro, B. Hollingsworth, and F. Isaí Valle-Jiménez, personal communication) confirmed the species presence south to near Rancho La Palmita west of the Sierra La Gata foothills. During field work by CIBNOR and the San Diego Natural History Museum at Rancho La Palmita in November 2017, ranchers described a “snake” with two little hands and pink in color observed near the ranch.

*Bipes biporus* is a fossorial species rarely observed above ground. Of the approximately 2700 specimens collected by Papenfuss (1982), only three were seen on the surface. Five road-killed individuals were noted by Grismer (2002) in mid-June west of San Ignacio in the Vizcaíno Desert. An individual was encountered in the evening on 3 May 1997 crossing the highway 32 km north of Todos Santos (B. Hollingsworth, personal communication).

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