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Notes

Aspidoscelis neotesselatus (Colorado Checkered Whiptail): Dietary Observations and Biology in the Northern Part of the Range

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***Abstract.*—Triploid parthenogenetic *Aspidoscelis neotesselatus* (Colorado Checkered Whiptail) is endemic to southeastern Colorado and has one of the smallest natural continental distributions of a species in the genus *Aspidoscelis*. Further, it is a species of conservation concern in the state. Recent investigations of *A. neotesselatus* in the 55,000-ha Fort Carson military installation (mostly in Pueblo County, Colorado) have generated a wide number of studies relevant to mitigation of military training activities on habitats occupied by this vulnerable species. Surveys of *A. neotesselatus* in metropolitan Denver (Denver and Adams counties) assessed the distribution of introduced arrays of *A. neotesselatus*. Together, these projects involved numerous investigators who collectively spent hundreds of hours in the field systematically studying a variety of biological attributes of this all-female species based on capture-release or binocular-aided observation methodologies. Despite the extensive studies involving this species, the diversity of prey consumed in more northerly parts of the range has receive no attention. This report describes photographically documented instances of prey capture by *A. neotesselatus* in the northern part of its natural range as well as in an area where the species is introduced. We observed *A. neotesselatus* predation of an adult cicada, an adult noctuid moth, large larval lepidopterans, and adult orthopterans. Historically, studies of diploid parthenogenetic *Aspidoscelis tesselatus* (Common Checkered Whiptail) and triploid parthenogenetic *A. neotesselatus* (Colorado Checkered Whiptail) in Colorado have used large samples of preserved specimens. This study demonstrated how useful information pertinent to the conservation of this species can be obtained in the absence of specimen collection.**

Key Words.—Colorado; feeding; introduced species; prey capture; whiptail lizards

Recent publications based on intensive field investigations have contributed to clarification of many aspects of the biology and conservation status of triploid parthenogenetic *Aspidoscelis neotesselatus* (Colorado Checkered Whiptail) in the extreme northern part of its distribution in Colorado. Several of these reports were focused on controlled access sites in the approximately 55,000-ha U.S. Army Fort Carson (FC) military installation, which encompasses parts of El Paso, Fremont, and Pueblo counties, Colorado (Fig. 1). These publications addressed demographics (Aubry et al. 2019), competing reproductive and physiological investments (Aubry et al. 2020), variations in steroid hormones, energetic state, and immunocompetence across reproductive contexts (Hudson et al. 2020), age dependent search behavior (Kusaka et al. in press), and habitat-dependent search behavior (Utsumi et al. 2020). Although it seemed that the approximate northern limits of *A. neotesselatus* had been documented along Fountain Creek in El Paso County (Fig. 1) by Taylor et al. (2015a, 2016), Livo et al. (2019) reported introduced arrays of the species that are now well-established in metropolitan Denver (MD) along a 4-km stretch of the South Platte River and vicinity in Adams and Denver counties. This new area reported for the species, which is within a heavily industrialized area in sight of downtown Denver, represents an approximately 125 km northern range extension from the Fountain Creek site in El Paso County (Fig. 1). This species is also established at a distant site in Grant County, Washington (Weaver et al. 2011).

Importantly, the aforementioned studies have provided information that will help mitigate the effects of military training activities on substantial parts of the habitat occupied by *A. neotesselatus* in FC and throughout its natural range, and the studies were done without sacrificing lizards. It is noteworthy that Colorado Checkered Whiptail has one of the smallest natural continental distributions of a species in the genus *Aspidoscelis*, which includes published documentation of parts of only seven counties, all in southeastern Colorado (i.e., Crowley, El Paso, Fremont, Las Animas, Otero, Pueblo, and Teller). Moreover, with few exceptions

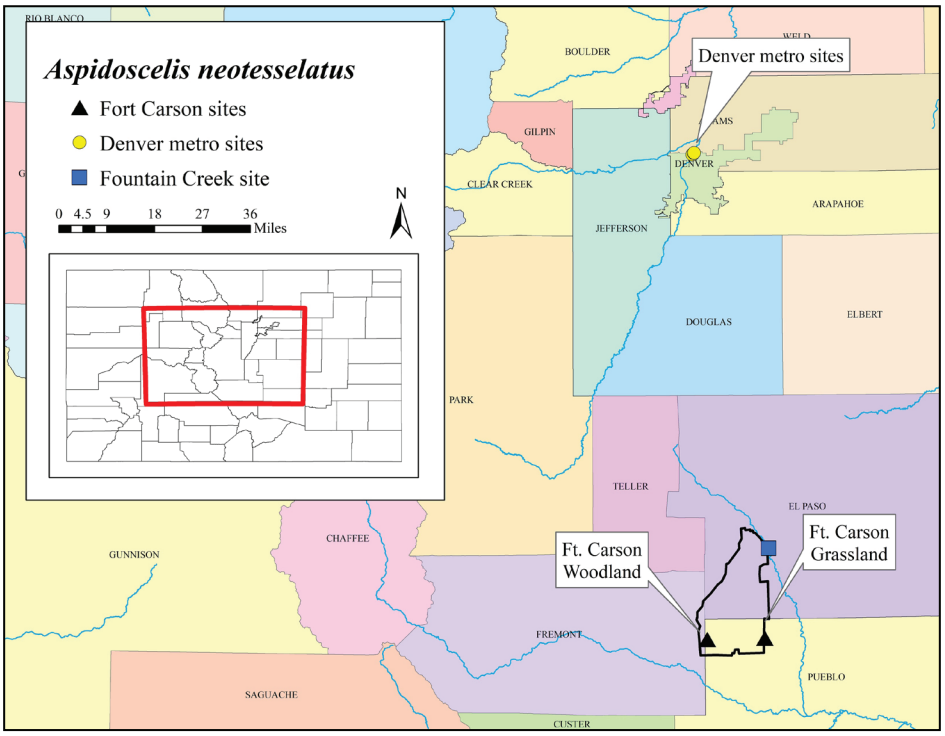

Figure 1. Aspects of the distribution of *Aspidoscelis neotesselatus* (Colorado Checkered Whiptail) in Colorado: general area of the state under consideration (red rectangle); two sites of prey capture in Pueblo County (black triangles); U.S. Army Fort Carson military installation (black outline); northernmost natural distribution record at Fountain Creek, El Paso County (blue square); and recently discovered arrays in metropolitan Denver and Adams and Denver counties (yellow circles).

this distribution area is entirely contained within areas of Colorado which are intensively used and/or altered by humans, including the U.S. Army training area in the 95,464-ha Pinon Canyon Maneuver Site (PCMS), in the 55,000-ha FC military installation, in several cities such as La Junta and Pueblo, and in MD (Walker et al. 1997; Taylor et al. 2006, 2015a; Aubry et al. 2019; Livo et al. 2019).

Feeding strategy studies by Utsumi et al. (2020) and Kusaka et al. (in press) were only the second and third reports on any aspect of food acquisition in the species but did not include observations on either capture of prey or the food choices of *A. neotesselatus*. Paulissen et al. (1993) provided the only report of diet composition in this Colorado endemic lizard. The study included data from sites of syntopy with diploid parthenogenetic *A. tesselatus* (Common Checkered Whiptail), the maternal progenitor of the triploid species, as well as sites of occurrence allopatric to other teiid species in Colorado. Published prior to the description of *A. neotesselatus* by Walker et al. (1997), Paulissen et al. (1993) compared stomach contents from preserved specimens in what was then recognized as diploid and triploid clones of the *A. tesselatus* complex (Parker and Selander 1976; Walker et al. 1995). In addition to the foregoing review of recent research activities on *A. neotesselatus*, this report adds the first observations of prey capture events for juveniles and adults of the species. These captures of prey in *A. neotesselatus*, with emphasis on the ingestion of large insect larvae and flight-capable insects, were photographically recorded in FC and in MD. Not only are the seizure and ingestion phases of feeding rarely observed in food studies, some of the events reported herein also involved unusual prey based on the dietary list published for *A. neotesselatus* by Paulissen et al. (1993).

The nomenclatural status of triploid parthenogenetic Colorado Checkered Whiptail (*Aspidoscelis neotesselatus*), referred to as *A. neotesselata* in many publications following the erroneous emendation by Reeder et al. (2002), was technically clarified by Tucker et al. (2016). Based on Article 30.1.4.2 International Code of Zoological Nomenclature in 1999, the name *Aspidoscelis* must be treated as grammatically masculine rather than feminine as presumed by Reeder et al. (2002). This clarification also impacted the suffixes of specific epithets of the maternal progenitor of *A. neotesselatus* (diploid normally parthenogenetic *A. tesselata* was returned to *A. tesselatus*) and paternal progenitor (gonochoristic *A. sexlineata* was returned to *A. sexlineatus*). We use the term array for local groups of parthenogenetic *A. tesselatus* and *A. neotesselatus* (e.g., Cordes and Walker 2006; Walker et al. 2012; Taylor et al. 2015b; Livo et al. 2019). We reserve the term population for groups of males and females of gonochoristic (= bisexual) species such as *A. sexlineatus viridis* (Prairie Racerunner).

The foraging and prey capture events in FC were rare observations during other research objectives that employed field data collection, lab assays, and statistical

Figure 2. Second year juvenile *Aspidoscelis neotesselatus* (Colorado Checkered Whiptail) of pattern class A (estimated < 60 mm snout-vent length) foraging in thick ground litter; photographed 25 June 2019 at a woodland study site TA55 in U.S. Army Fort Carson military installation, Pueblo County, Colorado. (Photographed by Carina Kusaka).

modeling to better inform *A. neotesselatus* conservation concerns. Many of these activities were parts of a larger project in FC led by LMA of Colorado State University on the demography and physiology of *A. neotesselatus*. Binoculars permitted collection of data for statistical analyses of search behaviors in lizards of different size classes from distances that would not distract the lizards from normal activities. Other field activities were led by LJL to access the extent of the distribution and impact of the newly discovered arrays of *A. neotesselatus* in Adams and Denver counties. Neither *A. tesselatus* nor *A. sexlineatus* were syntopic with *A. neotesselatus* at any of the study sites in FC, although *A. sexlineatus* was syntopic with *A. neotesselatus* in parts of Adams and Denver counties.

We opportunistically photographed lizards to ascertain their pattern class affiliation and document unusual prey captures; we did not capture any of the lizards described in this paper. We surmised that photographed lizards from FC, based on Walker et al. (1997, 2012), Taylor et al. (2015b), and Aubry et al. (2019), were from arrays of *A. neotesselatus* pattern class A (Fig. 2–3), whereas both pattern classes A (Fig. 4) and B (Fig. 5) were photographed in Denver County (Livo et al. 2019). Observations in FC in May through July revealed that individuals of *A. neotesselatus*, under favorable environmental conditions, typically begin to emerge from overnight retreats by 0800–0830 (Mountain Daylight Time), usually bask to elevate body temperature, and then typically forage with intermittent basking until 1100–1130. On 25 June 2019 at 1015, we photographed an example of foraging by a second-year subadult lizard (Fig. 2). We identified it as an individual of pattern class A of Colorado Checkered Whiptail based on the dorsal pattern of six complete pale-colored primary stripes, a series of pale-colored vertebral components rather than

Figure 3. Two *Aspidoscelis neotesselatus* (Colorado Checkered Whiptail) in the U.S. Army Fort Carson military installation, Pueblo County Colorado. (A) A near maximum sized adult with a problematic dorsolateral color pattern for pattern class A (estimated > 92 mm snout-vent length [SVL]) with a large Putnam's Cicada (*Platypedia putnami*, family Cicadidae); photographed 28 May 2018 at a woodland study site TA55. (Photographed by Maria Eifler). (B) Adult of pattern class A (estimated > 80 mm SVL), based on six persistent primary stripes and absence of a complete vertebral line, with a moderately large Miller Moth (*Euxoa auxiliaris*, family Noctuidae); photographed 9 June 2019 at the grassland study site. (Photographed by Carina Kusaka).

a complete line between the paravertebral stripes, and a boldly striped tail. The lizard had created and then focused on a small, cleared area in the extensive ground litter in searching for prey. It was photographed at a woodland site designated Training Area (TA) 55 in FC in Pueblo County (see Aubry et al. 2020; Fig. 1). Additional instances of foraging and feeding were observed in lizards from a distance as they searched for prey either on relatively barren substrate (e.g., Fig. 3) or sorting through deep accumulations of ground litter (e.g., Figs. 2, 3).

On 28 May 2018 at approximately 1100, we encountered an adult lizard with a color pattern not previously reported for *A. neotesselatus* pattern class A. It appeared to be at or near the maximum body size for an adult of *A. neotesselatus*. The exposed left side of the body of the lizard has alternating black and gray-white vertical bars and no evidence of a lateral stripe (Fig. 3A). Such ontogenetic modifications are more characteristic of pattern class C of diploid *A. tesselatus* (Walker et al. 1997, 2019), but possibly could also occur in large (i.e., very old) adults of *A. neotesselatus* pattern class B (Walker et al. 1997, 2012; Taylor et al. 2015b). The lizard was observed at a woodland site designated TA 55 (Fig. 1), which we plotted in Pueblo County using Google Earth (also see photograph in Aubry et al. 2019; Fig. 2). It was observed under a tree branch in a sandy area essentially devoid of ground litter with an unusually large prey item in its jaws. It was later determined that the large adult of *A. neotesselatus* had captured an individual of Putnam's Cicada (*Platypedia putnami*). It likely represented what is at or near the maximum-sized prey that could be consumed by even the largest adult *A. neotesselatus*.

On 9 June 2019 at approximately 1035, we encountered a prey-capture event involving an adult *A. neotesselatus* with six unfragmented primary dorsal stripes typical of pattern class A (Walker et al. 1997). The lizard was observed at the grassland site in Pueblo County designated TA48 (see habitat photograph in Aubry et al 2019, Fig. 2; Fig. 1 this study). Although the area was characterized as a predominantly grassland site in the study of habitat-dependent search behavior in *A. neotesselatus* (Utsumi et al. 2020), towards the edge of the plot was a mixed assemblage of One-seed Juniper (*Juniperus monosperma*) and Pinyon Pines (*Pinus edulis*). The lizard was observed in a thick layer of woody debris that had accumulated under the canopy of a large One-seed Juniper (Fig. 3B) with a winged insect in its jaws. The lizard remained stationary with an eye trained on the observer. Individual *A. neotesselatus* often can be closely approached by stealth, thus the observer saw that the lizard continued to chew on and orally manipulate the insect before it was swallowed. The prey was subsequently identified as a Miller Moth (*Euxoa auxiliaris*) in the family Noctuidae, members of which often achieve what some observers consider a ubiquitous and noxious presence in Colorado in spring and summer, especially after mild winters (see Colorado State University Extension fact sheet 5.597).

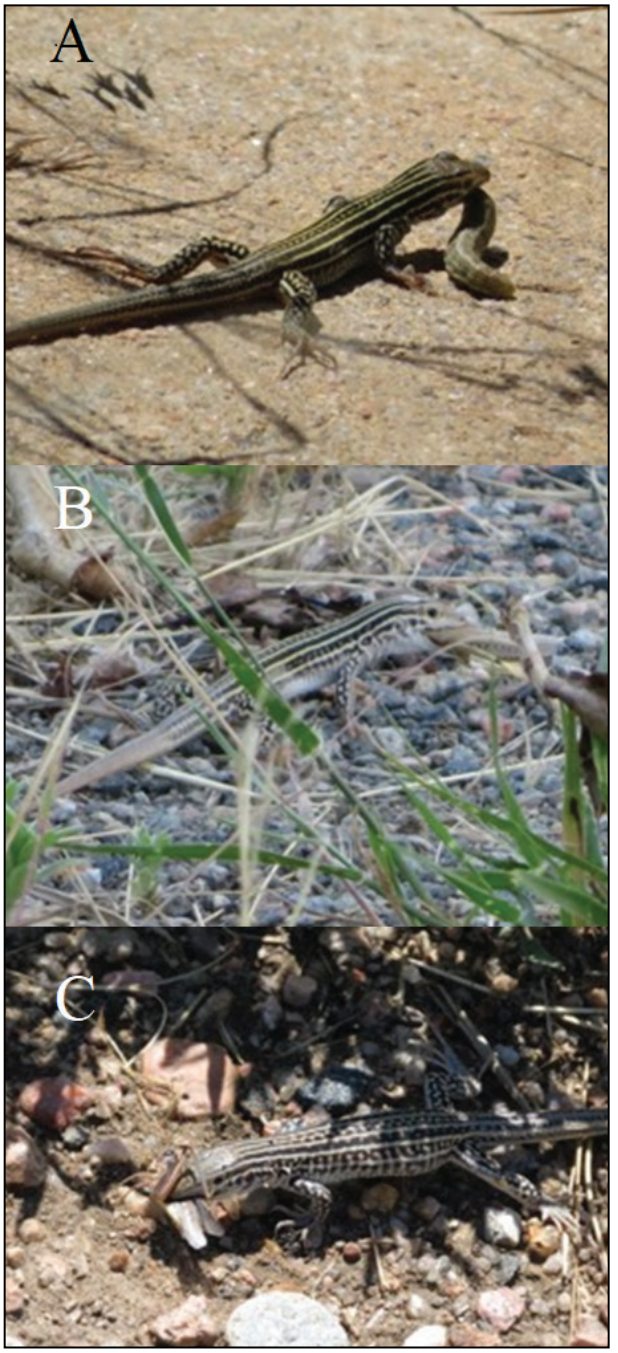

Figure 4. Second year juvenile *Aspidoscelis neotesselatus* (Colorado Checkered Whiptail) from an introduced array in Denver County, Colorado. (A) Individual of pattern class A (estimated > 55 mm snout-vent length [SVL]), based on the dorsal pattern, with a large larval lepidopteran; photographed 1 June 2018. (B) Individual of pattern class A (estimated > 50 mm SVL), based on the dorsal pattern, with an adult orthopteran; photographed 29 June 2019. (C) Individual of pattern class A (estimated > 65 mm SVL), based on the dorsal pattern, with an adult orthopteran; photographed 21 July 2019. (Photographed by Lauren J. Livo).

We observed and photographed four prey-capture events for *A. neotesselatus* in the recently discovered

Figure 5. A third or fourth year adult *Aspidoscelis neotesselatus* (Colorado Checkered Whiptail) of pattern class B (estimated > 75 mm SVL), based on zig-zag continuous vertebral line, with a giant lepidopteran larva; photographed 12 August 2019 from an introduced array in Adams County, Colorado. (Photographed by Lauren J. Livo).

arrays in MD including parts of Denver and Adams counties (Fig. 1). On 1 June 2018 at 0909, we encountered a second season juvenile in Denver County with the head of a large larval lepidopteran in its jaws. The lizard was initially encountered on an open slope with scattered grass. It dropped the insect at least twice before picking it up and beginning to ingest it (Fig. 4A). On 29 June 2019 at 1052, we encountered another second season juvenile with a lengthy regenerated tail in Denver County, along the edge of a level gravel path with a partly (and then more fully) ingested orthopteran prey (Fig. 4B). On 21 July 2019, we observed a third second season juvenile in Denver County, struggling with a grasshopper on the open ground near weedy plants (Fig. 4C); the lizard pressed the grasshopper into the ground and adjusted the insect in a more headfirst position and then finished consuming it within about a minute. On 12 August 2019 at 1213, we encountered a third or fourth season adult of pattern class B in Adams County; the lizard was clasping the head of a large larval lepidopteran in its jaws. Over the approximately 3 min of observation, on two occasions the lizard dropped the caterpillar, adjusted its position, and resumed its efforts to consume it (Fig. 5).

Individual *Aspidoscelis neotesselatus* are sensitive to differences in habitat types while foraging. In a study on FC taking place on two habitat types, foraging adult *A. neotesselatus* differed in movement patterns, with longer first passage times observed in shrub grassland compared to Pinyon Pine–Juniper woodland, correlating with percentage ground cover and negatively correlating with tree cover (Utsumi et al. 2020). In addition, step length and path length were shorter at the shrub grassland site (Utsumi et al. 2020). Kusaka et al. (in press) found significant differences between search behaviors in adults and juveniles of *A. neotesselatus* that would influence habitat selection and reduce intraspecific competition. Adults moved greater distances, made use of larger areas, and had longer step-lengths than juveniles. Adults and juveniles also differed in habitat use when foraging. Adults were found more frequently in the open and in association with Mountain Mahogany (*Cercocarpus montanus*), while juveniles spent more time in deadwood, grass, and One-seed Juniper. Regardless of body size, however, we observed that lizards typically ingested numerous small prey organisms rather than large prey.

Diet-based studies have revealed that both diploid *A. tesselatus* and triploid parthenogenetic *A. neotesselatus* are opportunistic predators, feeding mainly on a variety of arthropods (Paulissen et al. 1993; this study). The stomach contents analysis of preserved specimens of *A. neotesselatus* from several sites in southeastern Colorado revealed a pattern of consumption of either grasshoppers or termites depending on the habitat and season sampled. Some mature cicadas are too large to be consumed by other than one of the largest adults of *A. neotesselatus*. Moreover, capture of this homopteran would most likely be possible only if one should become available by accidental grounding or at emergence and then attract a forging lizard before taking flight. Based on observations by JMW in Ninemile Valley of the Purgatoire River at Higbee, Otero County, capture of grasshoppers by both *A. tesselatus* and *A. neotesselatus*, and reported herein by the latter species, is an energy-intensive activity that likely succeeds because of the explosive seasonal density of several species of orthopterans in southeastern Colorado.

Based on samples of lizards from Otero and Pueblo counties (Paulissen et al. 1993), capture of adult lepidopterans is a rare occurrence for both diploid *A. tesselatus* (which does not occur in the FC study area), and triploid *A. neotesselatus*, which is widely distributed

in FC (Aubry et al. 2019; Utsumi et al. 2020). We found that capture of sizable, calorie-rich moths by this whiptail species probably is an expected consequence of the seasonal abundance of this noctuid in southeastern Colorado in recent years. Miller Moths tend to be most abundant after a mild winter as occurred in southeastern Colorado in 2017–2018. As such, they are also often found in great numbers, either stationary or crawling about on the ground, which would periodically make them a readily available food source for *A. neotesselatus*, assuming they are palatable.

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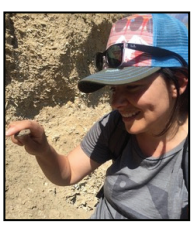
Maria Eifler is a Research Biologist with Erell Institute and also is a Collection Manager for mammals with the University of Kansas Biodiversity Institute, both based in Lawrence, Kansas, USA. She has a strong emphasis on mentoring and training women in field-based ecology and behavior research, emphasizing projects based on lizards in deserts of the world. Her research focuses on movement ecology, foraging behavior and network analysis of animals, and desert community ecology. (Photograph by Mitchell Eifler).

Lauren J. Livo for several years conducted research on *Anaxyrus boreas* (Boreal Toad) in collaboration with the Colorado Division of Wildlife. After receiving a Ph.D. from the University of Colorado, Boulder, USA, she continued her work on the Boreal Toad as a post-doctoral fellow at the University of Colorado. Subsequent to retiring, she has been documenting the geographic distribution and phenology of amphibian and reptile species in Colorado, especially that of various introduced species including *Trachemys scripta* (Pond Slider), *Aspidoscelis neotesselatus* (Colorado Checkered Whiptail), *A. velox* (Plateau Striped Whiptail), and *A. exsanguis* (Chihuahuan Spotted Whiptail). (Photographed by Steve Wilcox).



Lise M. Aubry, a native of France, received B.S. and M.S. degrees from the University of Toulouse, France. Her doctoral dissertation was completed at Max Plank Institute for Demographic Research, Germany, on life-history trade-offs and senescence in vertebrates. Postdoctoral research at Utah State University, Logan, USA, focused on wildlife management and human-wildlife conflicts. In 2017 she joined the Fish, Wildlife & Conservation Biology Department, Colorado State University, Fort Collins, USA. She has received funding from the National Science Foundation, National Geographic Society, and the U.S. Fish and Wildlife Service. (Photographed by Caylee Falvo).

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