TETRACHA CAROLINA (L.) (COLEOPTERA: CICINDELIDAE) ASSOCIATED WITH POLYPIPE IRRIGATION SYSTEMS IN SOUTHEASTERN MISSOURI AGRICULTURAL LANDS

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INTRODUCTION

The occurrence of *Tetracha carolina* (L.) in Missouri is not well understood. Pearson et al. (2006) suggested its occurrence in the state was a result of vagrants migrating into southeast Missouri. However, from 2007–2010 we routinely encountered *T. carolina* in association with polypipe irrigation systems during the course of agricultural research in southeast Missouri. Considering that *T. carolina* is a "flight challenged" species (Spomer et al. 2008), regular occurrence of the species in southeast Missouri suggests it may be a resident in the state.

Southeast Missouri encompasses the northern terminus of the Mississippi Delta physiographic region (USGS 2003) and differs substantially from other areas in its flora, fauna, climate, and agriculture. Historically, the area consisted primarily of cypress and gum tupelo swamp (Nolen 1912). Currently, nearly all of the land area has been converted to agricultural use, with 60% of the agricultural area devoted to soybeans, corn, and cotton (NASS 2010a, U.S. Census Bureau 2010) and the remainder to rice, sorghum, orchards, melons, livestock, and other uses.

The association of *T. carolina* and agriculture was first noted in the mid-19th century. Comstock (1879) cited Glover (1855), describing *T. carolina* as "beneficial to the cotton plant". Comstock (1879) also mentions that he received many *T. carolina* specimens during "last summer" (presumably 1878) in Alabama cotton fields from Dr. A. Hunt, including it on a list of cotton-worm predators from Perry Co.,

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Tennessee. More recently, Torres and Ruberson (2007) found that *T. carolina* dominated samples of ground-dwelling arthropods from cotton fields in Georgia (USA).

Polypipe irrigation systems are commonly used in southeast Missouri (NASS 2010b) for in-furrow flood irrigation due to their increased efficiency, control, and labor savings over traditional irrigation methods (Ensico and Peries 2010). Polypipe is primarily used on tilled ground and is typically installed after planting and removed prior to harvest.

As a ground-dwelling predator, the presence of *T. carolina* in agricultural fields may be an important indicator of agro-ecosystem health (Torres and Ruberson 2007). Because of this, we conducted a survey of polypipe in southeast Missouri to better understand the status of *T. carolina* in Missouri. Summaries of adult and larval specimens collected prior to and during the study are also provided to more fully characterize *T. carolina* occurrence in Missouri.

METHODS

Idle polypipe irrigation systems within agricultural fields were sampled for the presence of *T. carolina* during two forays in the known period of adult activity (Pearson et al. 2006) (23–25 July 2010 and 28–29 August 2010) in each of the eight counties that comprise the Mississippi Delta in Missouri (Butler, Cape Girardeau, Dunklin, New Madrid, Mississippi, Pemiscot, Scott, and Stoddard Counties) (Table 1). In each county, up to ten irrigation systems were sampled. Five sample areas of 3 m each were delineated with stakes along the polypipe (Figure 1) which was lifted, and all species of tiger beetles under the lifted sections were censused. Live and dead adults were counted and recorded separately. Adults were identified using Pearson et al. (2006). Tiger beetles on or near the pipe were also noted. Individuals that did not move upon discovery and subsequent handling were considered dead. There was at least a 0.5-km distance between systems sampled when possible, although in some counties a shorter distance was allowed due to low frequency of polypipe use within those counties. Irrigation system locations were recorded using a Garmin eTrex GPS (Garmin Ltd., Olathe, KS, USA). Irrigation

Table 1. Locations of polypipe irrigation systems surveyed for *Tetracha carolina* and other tiger beetle presence in southeast Missouri agricultural systems during 2010.

SITE #	County	N°	W°	SITE #	County	N°	W°
1	Butler	36.58820	90.21146	35	New Madrid	36.42451	89.64780
2	Butler	36.58115	90.22063	36	New Madrid	36.43360	89.71111
3	Butler	36.58184	90.25710	37	New Madrid	36.42636	89.61756
4	Butler	36.63067	90.26522	38	New Madrid	36.45509	89.60387
5	Butler	36.63067	90.26522	39	New Madrid	36.48321	89.65936
6	Butler	36.76905	90.20933	40	New Madrid	36.71164	89.55910
7	Butler	36.67925	90.20957	41	Pemiscot	36.41426	89.69769
8	Butler	36.63935	90.25777	42	Pemiscot	36.39407	89.65870
9	Butler	36.63994	90.31915	43	Pemiscot	36.39251	89.62445
10	Butler	36.61710	90.27444	44	Pemiscot	36.40202	89.61375
11	Cape Girardeau	37.14468	89.76698	45	Pemiscot	36.39466	89.61122
12	Cape Girardeau	37.15508	89.76682	46	Pemiscot	36.40947	89.70220
13	Cape Girardeau	37.21494	89.68336	47	Pemiscot	36.39496	89.61214
14	Cape Girardeau	37.21877	89.67258	48	Pemiscot	36.40089	89.61304
15	Cape Girardeau	37.25283	89.65138	49	Pemiscot	36.40203	89.60803
16	Cape Girardeau	37.20493	89.71004	50	Scott	36.89046	89.61542
17	Cape Girardeau	37.21846	89.67344	51	Scott	36.88888	89.67392
18	Dunklin	36.54241	90.13329	52	Scott	36.86828	89.63690
19	Dunklin	36.09299	89.95948	53	Scott	36.86781	89.64736
20	Dunklin	36.09030	89.05785	54	Scott	36.87094	89.66904
21	Dunklin	36.13416	89.09090	55	Scott	36.86753	89.65889
22	Dunklin	36.13395	90.12310	56	Scott	36.87182	89.66893
23	Dunklin	36.56786	90.16670	57	Scott	36.87864	89.68740
24	Dunklin	36.55950	90.15569	58	Scott	36.90720	89.68395
25	Dunklin	36.54762	90.14050	59	Stoddard	36.80031	90.07412
26	Dunklin	36.53481	90.12378	60	Stoddard	36.81862	89.91692
27	Dunklin	36.15525	90.13947	61	Stoddard	36.83138	89.91296
28	Mississippi	36.84890	89.27675	62	Stoddard	36.83115	89.87249
29	Mississippi	36.84855	89.30405	63	Stoddard	36.82348	89.86164
30	Mississippi	36.90636	89.47542	64	Stoddard	36.98845	89.77995
31	Mississippi	36.90645	89.48297	65	Stoddard	36.91676	89.79683
32	New Madrid	36.49365	89.81800	66	Stoddard	36.90623	89.79591
33	New Madrid	36.49551	89.83453	67	Stoddard	36.90242	89.80651
34	New Madrid	36.42595	89.71120	68	Stoddard	36.82019	89.89726

Figure 1. A typical polypipe irrigation system in a cotton field in New Madrid Co., Missouri. A tent stake across the pipe from the clipboard and a portion of 3-m sampling line are shown. Under this section of polypipe is one *Tetracha carolina*.

systems associated with corn ($n = 18$), cotton ($n = 11$), and soybean ($n = 39$) crops were sampled. Fields were selected as encountered while traveling through the counties. By August, polypipe systems had been removed in most of the fields planted to corn and some cotton fields in preparation for harvest. Some locations were sampled during both July and August; however, most were sampled only once. This is because many polypipe systems sampled during the July foray were in use during the August foray due to the prevalence of drought conditions. Voucher specimens were collected from at least one location within each county and are deposited in the personal collections of Kelly V. Tindall (KVTC) and Ted C. MacRae (TCMC). Chi square analysis of polypipe survey data was performed as described by Snedecor and Cochran (1980).

Survey data were augmented with data on location and date of occurrence of previously collected *T. carolina* specimens deposited in the Enns Research Museum, University of Missouri (UMRM), University of Missouri Delta Research Center collection (DRCC), Mike Smart personal collection (MSC), Christopher R. Brown personal collection (CRBC), Cory B. Cross collection (CBCC), KVTC, and TCMC. BugGuide (http://www.bugguide.net) was also searched for records of *T. carolina* from Missouri.

On 25 September 2010, presumed *T. carolina* 3rd instar larval burrows were censused in a bare area on the grounds at the University of Missouri Delta Research Center (Figure 2) using 0.4-m^2 quadrats within the larval habitat. Twelve larval burrows were excavated from this population to determine burrow occupancy. Wire inserted into the larval burrow to guide excavation was also used to measure depth of burrow. Voucher specimens were preserved in 70% ethanol, identified using the characters given in Drew and Van Cleave (1962), and deposited KVTC and TCMC.

RESULTS

Sixty-eight polypipe systems were examined during the course of the study, five of which were sampled on both forays. Of these, 14 were positive for presence of *T. carolina.* A total of 66 individuals were found,

Figure 2. Larval habitat of *Tetracha carolina* in an unvegetated area of landscaping at the University of Missouri Delta Research Center in Pemiscot Co., Missouri.

with the species encountered in all counties surveyed except Mississippi Co. (Table 2, Figure 3).

Chi-square analysis of *T. carolina* crop preference shows a near significant influence of crop type ($df = 2$, $0.10>P>0.05$). However, 41 of the 66 individuals came from two forays on a single irrigation system in a soybean field in Pemiscot Co. Excluding this field from the analysis, Chi-square analysis of numbers of *T. carolina* in the three crops shows no influence of crop type on populations under polypipe ($df = 2$, $P>0.05$).

Ten of the 66 *T. carolina* found under polypipe were dead, and Chi-square analysis of numbers of dead *T. carolina* in the three crops shows no influence of crop type on the likelihood of finding dead *T. carolina* ($df = 2$, $P>0.05$).

Thirteen individuals of *T. virginica* (L.) were found during 12 irrigation system samples, and Chi-square analysis showed that *T. virginica* occurred under polypipe without regard for the presence of *T. carolina* ($df = 1$, $P>0.05$).

One individual of *Cicindela punctulata* Olivier was found under polypipe in a Scott Co. corn field, and ten fields had *C. punctulata* noted as present nearby while sampling.

Tetracha carolina is now known to occur in nine Missouri counties (Figure 2). Previous to this study specimens were collected in southeast Missouri at the following locations: **Cape Girardeau Co.**: 16.ix.1957, D. M. Stout [UMRM]; Neely's Landing, vii.2006, M. Smart [MSC]; **Dunklin Co.**: Senath, 17.viii.1961, J. Wilson [UMRM]; Missouri Rice Research Farm, 8.vii.2009, C. B. Cross [CBCC]; **Mississippi Co.**: Big Oak Tree State Park, 7.vii.2007, at ultraviolet (UV) light, K. V. Tindall & K. Fothergill [KVTC]; **New Madrid Co.**: I-55 at Portageville, 26.vii.1997, at building light, T. C. MacRae [TCMC]; Portageville backyard, 10.vii.2008 & 24.vii.2009, K. Fothergill [KVTC]; same locality, 27.vii.2009, C. B. Cross [CBCC]; Stewart Towhead, 23.vi.2007, K. Fothergill [KVTC]; same locality, 7.vii.2007, C. R. Brown [CRBC];

Table 2. Results of polypipe surveys for *Tetracha carolina* and other tiger beetle presence in southeast Missouri agricultural systems during 2010.

Date	County	Crop association	Site[1]	*Tetracha carolina*[2]	*Tetracha virginica*[2]	*Cicindela punctulata*[2, 3]
23-Jul	Butler	soybeans	1–5	2 (2)	1 (1)	-
25-Jul	Cape Girardeau	corn	11,12,14,15	-	-	-
25-Jul	Cape Girardeau	soybeans	13	-	-	Present
23-Jul	Dunklin	corn	18	-	1 (2)	-
25-Jul	Dunklin	cotton	21	-	-	-
25-Jul	Dunklin	soybeans	19,20,22	-	-	-
23-Jul	Mississippi	corn	28,29	-	-	-
25-Jul	Mississippi	soybeans	30	-	1 (2)	-
23-Jul	New Madrid	corn	32	-	-	-
23-Jul	New Madrid	soybeans	33	-	1 (1)	-
24-Jul	New Madrid	cotton	34,35	1 (5)	2 (3)	-
24-Jul	New Madrid	soybeans	36		1 (2)	
24-Jul	Pemiscot	corn	43	-	-	-
24-Jul	Pemiscot	cotton	42	-	-	-
24-Jul	Pemiscot	soybeans	41,44,45	2 (18)	-	-
23-Jul	Scott	corn	50,51	-	-	1 (1)
25-Jul	Scott	corn	52	-	-	-
25-Jul	Scott	cotton	53,54	-	1 (1)	-
23-Jul	Stoddard	corn	59	-	-	Present
23-Jul	Stoddard	cotton	62	-	1 (1)	-
23-Jul	Stoddard	soybeans	60,61,63	1 (1)	-	Present
28-Aug	Pemiscot	corn	47	-	-	-
28-Aug	Pemiscot	soybeans	41,46,48,49	2 (28)	-	Present
28-Aug	New Madrid	corn	39	-	-	-
28-Aug	New Madrid	soybeans	36,37,38,40	2 (3)	-	-
29-Aug	Mississippi	soybeans	30	-	-	-
29-Aug	Scott	cotton	53,55	-	-	-
29-Aug	Scott	soybeans	56,57,58	1 (1)	1 (2)	Present
29-Aug	Cape Girardeau	soybeans	13,16,17	1 (2)	-	Present
29-Aug	Stoddard	corn	67	-	-	Present
29-Aug	Stoddard	cotton	66	-	-	-
29-Aug	Stoddard	soybeans	64,65,68	1 (1)	-	-
29-Aug	Butler	corn	6	1 (2)	-	Present
29-Aug	Butler	soybeans	7,8,9,10	1 (2)	1 (1)	-
29-Aug	Dunklin	corn	24	-	-	-
29-Aug	Dunklin	cotton	25,27	-	-	-
29-Aug	Dunklin	soybeans	23,26	1 (1)	-	Present

[1] See Table 1 for site locations.
[2] Number of systems with species (total number of individuals of the species encountered).
[3] Present indicates adults occurring near but not under polypipe.

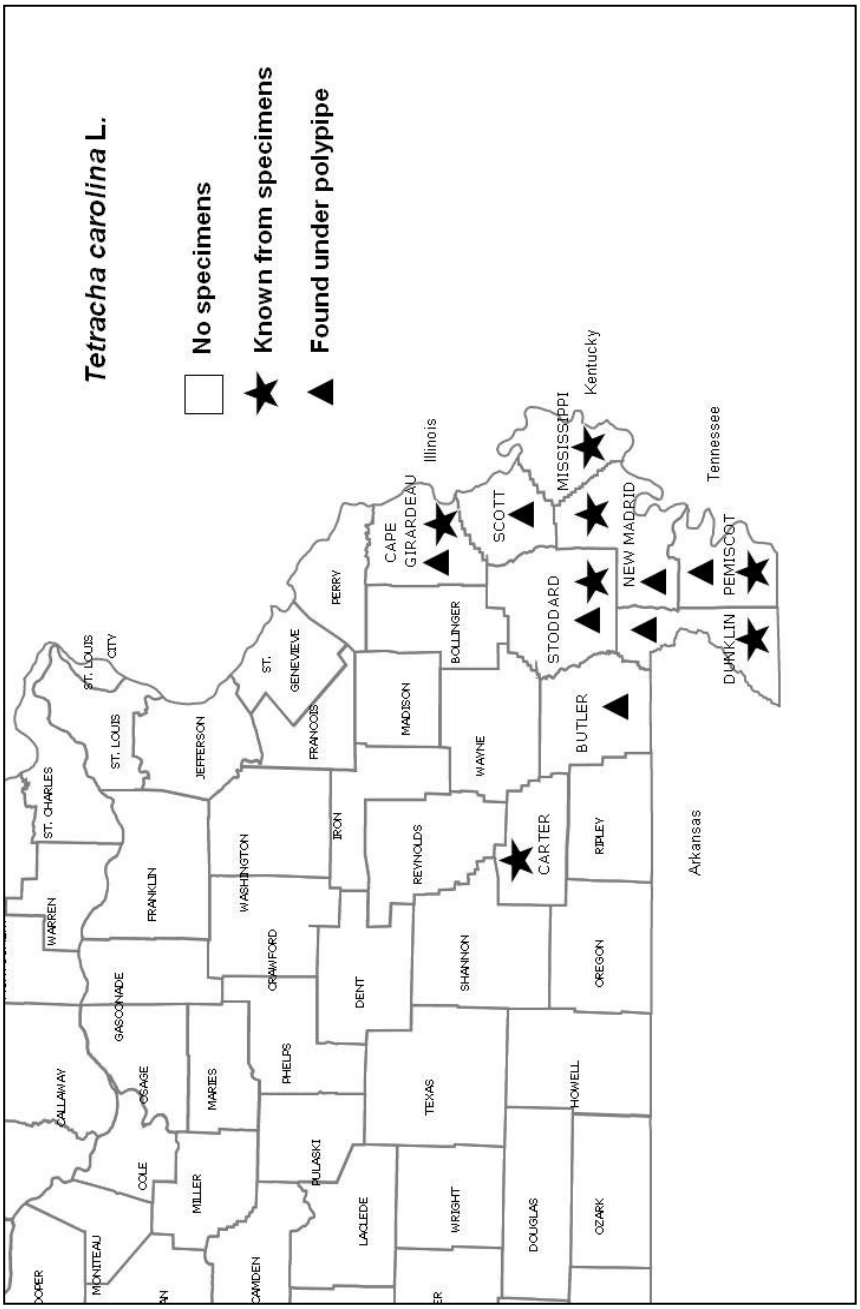

Figure 3. Known occurrence of *Tetracha carolina* in Missouri by county.

same locality, 29.vi.2007, in pitfall trap, T. C. MacRae [TCMC]; **Pemiscot Co.**: University of Missouri Delta Research Center, 26.vii.1997, at UV/building lights, T. C. MacRae and S. R. Penn [TCMC]; same locality, 23.vii.2009, in offices [DRCC]; same locality, 27.vii.2009, in fields, C. B. Cross[CBCC]; University of Missouri Delta Research Center Lee Farm, 14.vii.1976, 23.vii.197?, & 29.vii.1976, in light trap, R. Sheeley [DRCC]; same locality, 3.vii.2008, in rice field [DRCC]; same locality, 7.vii.2008, in cotton field [DRCC]; same locality, 14.viii.2008, in soybean field [DRCC]; 10.vii.2009, 25.vii.2009, & 4.ix.2009, same locality, in moth pheromone trap [DRCC]; **Stoddard Co.**: Dexter, 6.x.2004, S. Wang [UMRM]; same locality, 28.vii.2010, in corn field, K. Fothergill [KVTC]. A BugGuide image (http://bugguide.net/node/view/69239) documents an adult taken at a blacklight on 6.viii.2006 by Daniel Swofford in Eastwood (Carter Co.). No *T. carolina* were found in the Southeast Missouri State University insect collection.

Larval censuses revealed 10.8 ± 2.9 (mean ± S.E.) larval burrows per 0.4-m^2 quadrat (n = 5, range = 5–21). Larval burrows were straight and had depths ranging from 33–43 cm.

DISCUSSION

This study focused on adults under irrigation system piping to demonstrate the presence of *T. carolina* in Missouri. These data suggest that *T. carolina* should be considered established as a resident species in agro-ecosystems within southeast Missouri. Additionally, the BugGuide image from Carter Co. and a specimen from Neely's Landing (Cape Girardeau Co.) (MSC) confirm the occurrence of the species outside of the Mississippi Delta physiographic region, indicating it may be more widespread in southern Missouri outside of the Mississippi Delta.

Sampling under polypipe systems had both advantages and disadvantages compared to use of pitfall traps. Advantages included capture only of specimens desired, speed of sampling, and savings of labor. Disadvantages of sampling polypipe are that it does not compare directly with pitfall trapping studies or allow description of epigeal community.

The density of *T. carolina* burrows found suggest that larvae also are abundant near and possibly within these agricultural habitats. The larval biology of *T. carolina* is not well known, but it is presumed that two years are required to complete development (Brust et al. 2005). The Pemiscot Co. site that had 41 adult *T. carolina* in two sampling forays and surrounding fields receive annual soil disturbance in the form of disking and hipping. These disturbances are common for fields that utilize polypipe irrigation. Farm roads at the site were also disked and ditches re-constructed in 2010 prior to adult emergence. Larval burrow depths documented in this study are deeper than the 12–30 cm depth stated in Pearson et al. (2006), suggesting that larvae may be able to avoid negative impacts from these annual soil disturbances.

Tetracha carolina has been recognized as a beneficial predator in agricultural systems (Comstock 1879, Torres and Ruberson 2007). The burrowing activities of dung beetles (Brown et al. 2010), termites (Elkins et al. 1986), and ants (Laundre 1990, Cerda et al. 2009) can improve hydrologic properties of soils. Thus, it is possible that *T. carolina,* and perhaps other tiger beetles as well, could be important soil inhabitants that contribute to maintaining healthy soils. While this had not been documented in regards to tiger beetles, it is possible that their larval burrowing habits enhances water percolation and subsequently water holding capacity, decreasing runoff and increasing the productivity of the soil. These benefits may also extend beyond agricultural lands to pasture, natural lands, etc.

The goal of this study was to more precisely define the occurrence and distribution of *T. carolina* in agricultural habitats in southeast Missouri. The data presented here, along with the recent documentation of *T. carolina* in Kentucky (Laudermilk et al. 2010), further demonstrate that this species is established in areas further north than previously understood. More remains to be learned about the interrelationship of *T. carolina* and agriculture and its distribution in Missouri and surrounding states, value as a bioindicator of epigeal community health, larval biology, and habitat preferences.

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