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THE ECOLOGY OF THE ODONATA AT A SMALL CREEK IN SOUTHERN OKLAHOMA

GEORGE H. BICK AND JUANDA C. BICK
Southwestern Louisiana Institute, Lafayette, and University of Oklahoma Biological Station, Willis

INTRODUCTION

During the summer of 1954, while at the University of Oklahoma Biological Station, we became interested in the odonates of Cowan Creek, a stream approximately 1.5 miles long, located half a mile west of Willis in Marshall County, Oklahoma. The creek flows into Lake Texoma, a 94,874 acre impoundment formed by damming the Red and Washita Rivers. Lake Texoma first reached power pool elevation (617 feet) in 1942 and the description of Cowan Creek is based on observations made during June and July, 1955, when the lake deviated only slightly (615-618) from that elevation. Conditions were very different in the summer of 1956 when lake level dropped to 599 feet and in 1957 when it rose to 644 and flooded the lower half of the creek to a depth of 25 feet.

Cowan Creek originates 1.5 miles north of Lake Texoma as a slight depression in a heavily grazed area of Bermuda grass and girdled willows. A short distance southward the creek cuts a gully 20 feet deep, shaded with overarching trees. This condition continues to half a mile from the mouth where the immediate banks are about one foot high and overarching vegetation is absent (fig. 1). Most of the creek is less than six inches deep, 10 feet wide, and almost devoid of aquatic vegetation. The average rate of flow is two feet per second. At least 20 small springs empty into the stream at various points. There are a few shallow pools where debris blocks the flow, a two-foot artificial dam, and one six-foot waterfall. The creek bottom is sand, for most of its length, rock near the waterfall, and clay at the lower end. Near the mouth the channel was approximately five feet deep and 50 feet wide at lake elevation of 615 (fig. 2) but at 618 feet, a wide grassy bank was covered with one foot of water resulting in a total width of 125 feet. This lower one quarter mile is in reality a small arm of Lake Texoma and, in contrast with the upper portion, presents many of the physical characteristics of a large open pond.

The following 38 species were collected in the immediate vicinity of the creek during the summer of 1954: *Progomphus obscurus, Dromogomphus spoliatus, Erpetogomphus designatus, Gomphus militaris, Anax junius, Epicordulia princeps, Peri-*

themis tenera, Orthemis ferruginea, Libellula comanche, L. croceipennis, L. incesta, L. luctuosa, L. pulchella, Plathemis lydia, Sympetrum vicinum, Erythemis simplicicollis, Pachydiplax longipennis, Dythemis velox, Tramea lacerata, T. onusta, Pantala hymenea, Hetaerina americana, Agrion maculatum, Argia agrioides nahuana, A. apicalis, A. immunda, A. moesta, A. sedula, A. violacea, A. vivida plana, Enallagma basidens, E. civile, E. signatum, Telebasis salva, Ischnura posita, I. ramburi, I. verticalis, Anomalagrion hastatum.

P. lydia was found throughout the length of the creek. Twenty-seven species occurred along the upper three quarters

Fig. 1. Cowan Creek one half mile above its mouth, facing upstream at station A.

but rarely at the mouth and *A. maculatum* was limited to one small shady upstream area. The remaining nine species, *D. spoliatus, G. militaris, E. princeps, T. lacerata, T. onusta, E. basidens, E. civile, I. ramburi, A. hastatum,* were found near the wide, pond-like mouth but never at the adjacent lotic portion.

The occurrence of 38 species along 1.5 miles of stream which superficially appeared unproductive was most impressive and especially so was the occurrence of seven species of *Argia* in such a limited area. However, there was a shallow pond, a spring, and a deep impoundment adjacent to the creek. Cursory study showed that certain species seemed to be associated with each of these habitats. We became interested in measuring the degree of association of the various species with the available habitats. These data were obtained between June 19 and July 28, 1955.

Weather during June and July 1955 was hot and dry with rain only on July 16 and 17. Odonates were always counted on sunny days when temperatures were very high, probably always over 100°F. in the sun. Temperatures recorded in the sun near noon on July 15 and 28 were 127 and 111°F. respectively.

Description of Habitats

An area half a mile above the mouth was chosen for study because here, within a radius of 80 feet, were four distinct habitats, a shallow creek, pond, and spring, and a deeper im-

Fig. 2. The expanded pond-like mouth of Cowan Creek, facing towards Lake Texoma.

poundment. These habitats were designated stations, A, B, C, and D respectively.

Station A (fig. 1) was a stretch of creek 200 feet long, 10 feet wide, and fully exposed to sun. The clear water, seldom more than one inch deep, flowed over a sand bottom almost devoid of aquatic vegetation. Low herbaceous marginal vegetation was present but not abundant.

Station B, an artificial pond 50 feet wide and two feet deep, was constructed in 1937 by erecting a low earthen dam approximately 30 feet from the creek. There was at least nine inches of organic material on the bottom, yet the water, from a small spring and rain, was very clear. *Spirodela* and *Lemna* covered the surface and approximately half of the margin was shaded by willows.

Station C was a shallow depression 50 feet wide and not more than six inches deep. Clear, cold water from three springs, flowing over a clay and sand bottom towards the creek, formed a shallow depression covered with water cress and densely shaded by willows.

Station D, an impoundment 120 by 35 feet, was formed in 1937 by the construction of a concrete wall across the east end of a gully 60 feet from the creek. North and south banks were 20 feet high and almost perpendicular. The west end, which sloped gently towards the impoundment, was red clay and sand with a few grasses and willows. In contrast with the pond (B), the water in the impoundment was four feet deep, very muddy, devoid of aquatic vegetation, and fully exposed.

Chemical data, summarized in table 1, were similar for creek, pond, and impoundment (A, B, D). The spring (C) differed

Table 1. Chemical conditions at the four stations, July 4, 1955.

	Station A Creek	Station B Pond	Station C Spring	Station D Impoundment
Temperature Degrees C	24.0	27.5	14.0	26.5
Oxygen, p.p.m.	5.3	5.7	3.9	6.0
Percent saturation	60	70	36	74
pH	7.9	7.1	6.8	7.8
Free CO_2, p.p.m.	5	6	40	0
Bicarbonates, p.p.m.	190	210	160	140
Carbonates, p.p.m	0	0	0	0

somewhat in that the sample, taken just as the water emerged from the ground, was colder, lower in oxygen, and higher in free carbon dioxide. In contrast, physical factors such as water movement, turbidity, character of bottom, amount of vegetation, and amount of shade differed greatly among the four stations. For this reason we judge that such physical factors, though not measured quantitatively, probably influenced species composition more than the chemical factors studied.

Unfortunately changes occurred at the stations during the study. By the end of July the water level at the pond (B) had dropped 18 inches and at the impoundment (D) about two feet. On June 28 many willows were girdled and some were felled at both pond and spring (C). Hogs were released in the area during June and by July 1 their wallowing had destroyed almost all of the watercress in the spring. Rains on July 16 and 17 scoured out most of the remaining organic matter from the spring leaving only clay and muddy water. Run-off from these rains brought into the impoundment a thick layer of soft, red clay from the gully making collecting at the west end very difficult. The creek (A) remained unchanged during the study period.

METHODS

Sampling methods were not quantitatively exact but we believe that results derived therefrom show the relative abundance of each species at the four habitats. At every weekly visit we divided each station into half and each of us counted all anisopterans, mostly in flight, in his half. The only counts of unmarked Anisoptera adults known to us are by Moore (1953). Zygoptera perched frequently and at length and were counted by slowly walking around the margins of each station and recording numbers of individuals of each species except females of *Argia* and *Ischnura* which we could not determine to species in the field. Because studies by Borror (1934), Corbet (1952), and Moore (1953) state that most adults at water are males, our omission of females of these two genera should not invalidate our data on relative abundance. Published counts of unmarked Zygoptera adults are unknown to us.

Nymphs were collected at stations B, C, and D by dipping and sorting at one spot for 20 minutes. At station A the entire 200 feet was sampled by dip netting at the margins. After July 15, the muck of the pond and the impoundment was sifted through a 14-mesh sieve and many more anisopterans were obtained than previously. All nymphs were counted in the laboratory where some were reared and some preserved in 70 percent alcohol. The following were reared and ultimate exuviae associated with adults: *H. americana* (1 reared), *A. a. nahuaana*[1] (12), *A. immunda* (10), *A. moesta* (6), *A. vivida plana*[1] (6), *T. salva* (4), *E. civile* (10), *E. signatum* (1), *I. posita* (11), *I. ramburi* (1), *A. hastatum* (9). Specific determinations for these species were made by comparing preserved nymphs with reared exuviae.

SPECIES-HABITAT ASSOCIATIONS

Numbers of individuals of each species at each station are shown in table 2. Of the 38 species from the creek area, 24 were recorded from the stations when counts were made; nine as both adults and nymphs, 10 as adults, five as nymphs.

A total of 1,012 adults but only 396 nymphs were recorded from all stations during the seven weeks. This discrepancy is the result of the great difference between the total number of nymphs (83) and adults (552) of all species of *Argia*. Either our technique was inadequate for collecting *Argia* nymphs or they were present above or below the study area as will be discussed

[1]Calvert (1901 considers **plana** a variety of **vivida** and **nahuana** a variety of **agrioides**. However, Mrs. L. K. Gloyd who determined some of our adults of **Argia** in 1954 states (personal communication) that both should be elevated to specific rank. Until Mrs. Gloyd publishes we believe it best to follow Calvert as we have done in our (1957) Dragonflies of Oklahoma.

Table 2. The total number of adults and of nymphs of each species at each station during the seven weeks.

	Station A Creek	Station B Pond	Station C Spring	Station D Impound-ment	Total
Adults					
Hetaerina americana	31	1	0	0	32
Argia agrioides nahuana	263	1	3	2	269
Argia apicalis	5	1	0	21	27
Argia immunda	92	0	3	0	95
Argia moesta	19	0	1	0	20
Argia sedula	11	0	0	0	11
Argia violacea	1	0	0	0	1
Argia vivida plana	5	5	118	1	129
Telebasis salva	4	20	6	1	31
Ischnura posita	12	126	5	4	147
Ischnura verticalis	0	0	0	1	1
	443	154	136	30	763
Perithemis tenera	0	0	0	24	24
Orthemis ferruginea	1	1	0	1	3
Libellula croceipennis	0	0	1	1	2
Libellula luctuosa	1	2	0	7	10
Plathemis lydia	9	64	34	19	126
Erythemis simpliciocollis	1	18	9	2	30
Pachydiplax longipennis	1	48	0	0	49
Dythemis velox	0	1	0	4	5
	13	134	44	58	249
Total adults	456	288	180	88	1012
Nymphs					
Hetaerina americana	22	0	0	0	22
Argia agrioides nahuana	6	1	14	0	21
Argia immunda	3	0	2	0	5
Argia vivida plana	24	0	33	0	57
Telebasis salva	1	26	5	0	32
Enallagma signatum	0	1	0	1	2
Ischnura posita	0	48	0	5	53
	56	76	54	6	192
Progomphus obscurus	7	0	0	0	7
Erpetogomphus designatus	1	0	0	0	1
Anax junius	1	4	0	0	5
Plathemis lydia	6	117	1	51	175
Erythemis simplicicollis	0	11	0	1	12
Pachydiplax longipennis	0	3	0	0	3
Pantala hymenea	1	0	0	0	1
	16	135	1	52	204
Total nymphs	72	211	55	58	396
Total adults and nymphs	528	499	235	146	1408

for station A. We do not believe that the number of *Argia* nymphs collected represents the true population and in the following discussion we carefully weigh data based on numbers of these nymphs.

Total number of adults (456) at the creek (A) greatly exceeded that all other stations. This high count was due to the large number (443) of Zygoptera and more specifically to the abundance of *A. a. nahuana* (263) and *A. immunda* (92). On July 15, 113 adults of *nahuana* including 14 pairs in tandem were counted and on July 22, 81 adults including 14 pairs. On these dates counts for *immunda* were 33 and 22 including five pairs on the first date, one pair on the second. In contrast, a total of only 56 Zygoptera nymphs were collected from the creek and but six were *nahuana* and three *immunda*. Because adults of these two species were abundant at station A and because they were so often observed coupling and ovipositing there and nowhere else, it is difficult to account for the small number of nymphs of both *nahuana* and *immunda* at the creek. Adults of these two species reached a peak of abundance on July 15 (table 3). Assuming a two week pre-reproduction flight away from water (Borror, 1934; Corbet, 1952) there is no reason based on life history why nymphs were not abundant in the creek during June. However, a year later, on June 19, 1956, 41 nymphs of *immunda* were collected in only a few dips among a small patch of watercress in the creek just below the study area. This suggests that nymphs of *nahuana* and *immunda* are carried downstream by the current until shelter is met. Station A provided no aquatic vegetation as shelter for nymphs but did provide emergent marginal grass for perching adults. *H. americana* occurred almost exclusively at the creek but was never as abundant as *nahuana* or *immunda*. The burrowing nymphs of *P. obscurus* were not deliberately searched for and few were taken in the weekly collections but were common at other times at station A.

At the pond (B) total number of individuals of Anisoptera (134 adults, 135 nymphs) exceeded that of Zygoptera (154 adults, 76 nymphs). The more numerous species were *P. lydia, I. posita, P. longipennis,* and *T. salva*. A total of 64 adults and 117 nymphs of *lydia* were recorded and on July 15 alone, 18 adults and 45 nymphs were counted, the nymphs always in the bottom organic material. However, *lydia* adults occurred along the entire length of creek including station A, where nymphs were collected and ovipositing observed, and at all other stations. The most common zygopteran at the pond was *I. posita* with a total of 126 adults and 48 nymphs; the highest count was 27 adults and 18 nymphs on June 19. Nymphs of *posita* nearly always clung to roots of *Spirodela* and *Lemna*. Adults of *posita* and *salva* were found at other stations but were abundant only at station B.

The smallest number of species was recorded at the spring (C) where, as at station A, Zygoptera were more abundant (136 adults, 54 nymphs) than Anisoptera (44 adults, 1 nymph). *A. v. plana* was the only abundant (118 adults, 33 nymphs) species but a few adults of the ubiquitous *P. lydia* were counted each week. On June 19, 33 adults of *plana* were recorded, and 36 on July 1 including eight coupled pairs. Adults of *plana* were scarce at all other stations but nymphs were common at the creek probably because they were washed there from the spring. Kennedy

(1915, 1917) found *A. vivida* (probably *A. v. vivida*) most frequent about springs and Williamson (1932) states that *vivida* (probably *A. v. plana*) is so dependent on springs that its presence anywhere may be taken as positive proof of adjacent spring water. It seems clear that both subspecies are closely associated with springs. The number of adults of *plana* was greatly reduced after July 1 (table 3) probably as a result of the habitat changes previously mentioned yet there was no evidence that adults shifted to any other habitat.

The smallest number of individuals was recorded at the impoundment (D). This seems to be correlated with high turbidity and with scarcity of aquatic vegetation and of bottom organic material, factors which we consider unfavorable to the survival of nymphs of many species. As with the pond (B), Anisoptera (58 adults, 52 nymphs) exceeded Zygoptera (30 adults, six nymphs). *P. tenera* was limited to station D. where it was the most abundant adult. *A. apicalis* and *P. lydia* adults were also common but, of these three, nymphs of only *lydia* were taken at the impoundment.

Table 3. Weekly records of number of adults of each species at all stations.

	VI-19	VI-24	VII-1	VII-8	VII-15	VII-22	VII-28	Total
Hetaerina americana	7	7	8	1	1	3	5	32
Argia agrioides nahuana	8	8	6	20	115	82	30	269
Argia apicalis	0	0	0	2	12	6	7	27
Argia immunda	9	4	1	11	35	22	13	95
Argia moesta	2	4	1	1	2	6	4	20
Argia sedula	0	0	0	0	6	3	2	11
Argia violacea	1	0	0	0	0	0	0	1
Argia vivida plana	35	26	37	7	6	10	8	129
Telebasis salva	9	1	1	2	7	5	6	31
Ischnura posita	31	24	27	22	19	10	14	147
Ischnura verticalis	0	0	1	0	0	0	0	1
Perithemis tenera	3	0	3	2	4	6	6	24
Orthemis ferruginea	0	0	1	0	1	0	1	3
Libellula croceipennis	1	0	0	0	0	1	0	2
Libellula luctuosa	0	0	1	0	3	3	3	10
Plathemis lydia	5	6	20	13	38	22	22	126
Erythemis simplicicollis	1	1	3	2	6	5	12	30
Pachydiplax longipennis	10	11	8	8	2	4	6	49
Dythemis velox	0	0	0	1	1	3	0	5
Total	122	92	118	92	258	191	139	1012

Table 2 shows that the majority of the species was present at more than one station and one, *P. lydia,* occurred both as nymphs and as adults at all four. On the other hand, even though none of the four stations was more than 80 feet away from any other, a distance within the flight range of even the weakest flying zygopteran, adults of certain species, especially Zygoptera, occurred primarily at one habitat and were scarce at all others. The percentages of association of adults of these species with particular habitats were: clear, sunlit, sandy, shallow creek devoid of aquatic vegetation (A) – *H. americana* (97), *A. a. nahuana* (97), *A. immunda* (97), *A. moesta* (95); heavily vegetated, clear, shallow, mud-bottomed pond (B) – *P. longipennis* (98), *I. posita* (85), *T. salva* (65); shaded, shallow, cold-water spring with abundant vegetation (C) – *A. v. plana* (91); deep, muddy impoundment with little aquatic vegetation (D) – *P. tenera* (100), *A. apicalis* (77). These 10 species totaled 823 of the 1,012 adults counted. In other words, 81 percent of all adults were closely associated with a particular station, suggesting a high degree of habitat selectivity.

Total numbers of adults at all stations (table 3) increased irregularly from 122 on June 19 to 258 on July 15 and decreased thereafter. This change was due primarily to a great increase in numbers of *A. a. nahuana* between July 8 and 15, to a lesser increase of *A. immunda* and *P. lydia*, and to a decrease in all three after July 15. *I. posita* decreased irregularly during the study. Numbers of individuals of most other species remained relatively stable during the seven weeks but *A. v. plana* was greatly reduced after July 1 as a result of man-made disturbance at the spring.

The weekly density of all species at station A was calculated as number of adults per 100 yards. Density of Anisoptera varied from 0 to 7.6 and averaged 3.0; density of Zygoptera varied from 24.2 to 268.1 and averaged 96.0. Moore (1953) records an average density of 13.5 Anisoptera per 100 yards at a very sluggish stream in England and suggests that this fairly constant density is maintained by rapid dispersal following overcrowding and consequent clashes. Rapid dispersal following clashes of Anisoptera was not observed along Cowan Creek, undoubtedly because of low density. But neither were clashes nor dispersal noted for Zygoptera at a density of 268 per 100 yards. This is prehaps correlated with the small size, more limited movement, and probable smaller range of movement perception in the Zygoptera.

Weekly counts were between 10:30 a.m. and 2:30 p.m. In addition, diurnal variation in abundance was determined by counting adults at 7 a.m., 11 a.m., 2 p.m., and 7 p.m. on July 28. Numbers of individuals of each species, total numbers, and air temperatures at these times are shown in table 4. Moore (1953) states that counts of adult Anisoptera were considerably higher near noon than at mid morning and at mid afternoon. Our total counts near noon were much higher than either 7 a.m. or 7 p.m. but the count at 11 a.m. slightly exceeded that at 2 p.m. Most species were more abundant near noon. However, adults of *H. americana* were approximately equal in number at all four times and were in rapid flight at both 7 a.m. and 7 p.m. *I. posita* and *T. salva* were also relatively abundant during the early morning or late evening counts. Moore (1953, 1954) states that odonates leave the water in the evening to roost in vegetation rarely more than 200 yards from the breeding place. If *H. americana* leaves the creek area to roost, it apparently does so later than 7 p.m. and returns earlier than 7 a.m. It also appears that *posita,* and perhaps *salva* also, remain for the night in the grass at the immediate margin of the pond because they were easily flushed during the early morning or late evening counts. However, at these hours vigorous shaking of grass,

Table 4. Diurnal variation in numbers of adults at all stations on July 28, 1955.

	7 a.m. (77-82°F)	11 a.m. (91-108°F)	2 p.m. (95-111°F)	7 p.m. (84-86°F)	Total
Hetaerina americana	8	6	5	8	27
Argia agriodes nahuana	0	41	30	1	72
Argia apicalis	0	2	7	0	9
Argia immunda	0	13	13	1	27
Argia moesta	1	1	4	2	8
Argia sedula	0	0	2	0	2
Argia vivida plana	0	6	8	2	16
Telebasis salva	4	31	6	16	57
Ischnura posita	14	28	14	10	66
Progomphus obscurus	2	0	0	0	2
Perithemis tenera	0	6	6	0	12
Orthemis ferruginea	1	2	1	0	4
Libellula croceipennis	0	1	0	0	1
Libellula luctuosa	0	3	3	0	6
Plathemis lydia	1	16	22	2	41
Erythemis simplicicollis	4	9	12	4	29
Pachydiplax longipennis	0	2	6	3	11
Dythemis velox	0	1	0	0	1
Number of species	8	16	15	10	
Number of individuals	35	168	139	49	391
Percent of total count	9	44	35	12	

shrubs, and trees bordering the stations yielded scarcely any other odonates. It seems that the other species do not roost in vegetation adjacent to the stations but neither were they found in the extensive, heavily-grazed pasture beyond the bordering vegetation of the creek. We can not account for the location of 91 percent of the population at 7 a.m. and 88 percent at 7 p.m.

NOTES ON OVIPOSITING

In addition to the weekly counts, numerous other visits to Cowan Creek yielded information on ovipositing for four species. Walker (1953) states that he has no data on mating or ovipositing for *I. posita.* Bick (1957) describes the process for this species at a pond in Louisiana. Ovipositing was also observed at Cowan

Creek on June 19 at the partly shaded pond (B). Unattended by the male, the female perched on the edge of a *Spirodela* pad and curved her abdomen into the water under the plant. Whether she deposited eggs on or in the under surface of the pad, or on the roots was not determined. As she perched she gently probed with her abdomen for a few seconds, then remained motionless for 1.5 minutes. She abruptly flew to another pad and after briefly probing, remained motionless for four minutes. A water strider disturbed her and then she was collected to be sure of specific determination. This pattern is similar to that previously described except that in Louisiana eggs were deposited six inches above the water in a small succulent plant.

On June 19 *A. a. nahuana* was observed ovipositing. We know of no previous data on egg-laying for this subspecies. Male and female perched in full sunlight on a blade of grass six inches from the margin of the creek (A) where the water was one inch deep. As usual for the genus, the male was almost vertical; his legs clasped the grass and the apex of his abdomen clasped the prothorax of the female. The abdomen of the female was bent at a sharp angle and its tip touched the plant one half inch below the water surface where eggs were apparently deposited. She probed for a few seconds with the tip of her abdomen, remained motionless for two and one half minutes, probed briefly and remained motionless for five minutes. The pair visited three more blades of grass where the female alternately probed and remained motionless but for only 30 seconds at each blade. The pair then flew off and was collected.

There are aparently no previous descriptions of ovipositing for *A. v. plana*. On July 1 we watched eight coupled pairs ovipositing at the spring (C). They were in deep shade a few inches from where the clear spring water emerges from a steep bank and runs over the clay bottom at a depth of not more than one half inch. Seven pairs were lined up along a small dead twig lying horizontally on the wet clay, the female of each pair clasping the twig, the male upright supported only by the prothorax of the female. With abdomen slightly curved, eggs were apparently deposited on or in the clay. The curvature of the abdomen seemed insufficient to permit deposition of eggs in the dead twig. All pairs remained almost motionless for 15 minutes with very little probing and no shifting of position. The female of another pair, a foot from the others seemed to oviposit in the damp clay over which no water was flowing.

On July 15, ovipositing of *O. ferruginea* was observed at the western edge of the impoundment (D) where the water was two inches deep, muddy, exposed, and devoid of aquatic vegetation. The male circled two feet above the female who was never more than 10 inches above water. She dipped her abdomen five to 10 times at one spot, shifted her position slightly, dipped again approximately the same number of times, then moved again. She continued this procedure until interrupted after two minutes by three *P. lydia* males. The male of *ferruginea* does not always circle over the female, for on three other occasions ovipositing was observed with no male in sight.

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