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Carrion Beetles (Coleoptera: Silphidae) of the Konza Prairie Biological Station

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ABSTRACT: Pitfall traps were used to determine diversity, seasonality, and numbers of burying beetles on the Konza Prairie Biological Station (KPBS) during the summers of 1997 and 1998. Traps were baited with either beef liver (1997) or whole mouse carcasses (1997 and 1998); significantly more carrion beetles were found in traps baited with carcasses. A total of 1003 carrion beetles, representing 8 species, were trapped over the course of 1556 trap nights. One of these species, *Necrophila americana* Linneaus, had not previously been recorded in Riley County. One additional species was found at sites where pitfall trap bait was discarded, bringing the total number of KPBS silphid species to 9. Bait age was an important determinant in attracting silphids to pitfall traps, as numbers of beetles in the trap continued to increase with bait age up to 6 days. Grassland topography (upland vs. lowland trap sites) significantly affected the numbers of carrion beetles trapped. Grassland burn history did not affect number of carrion beetles trapped, but did seem to influence species diversity.

KEY WORDS: Silphidae, Konza Prairie Biological Station, *Nicrophorus marginatus*, seasonal occurrence, pitfall trap

Diversity and seasonality have been measured for only a few terrestrial invertebrates on KPBS, which is a 3487 hectare tallgrass prairie site located south of Manhattan (Riley County) in the Flint Hills of Kansas (see Fig. 1). This study focuses on the carrion beetles (Coleoptera: Silphidae), which have been widely studied for other reasons (Scott, 1998). These beetles have a well-defined ecological role as scavengers of vertebrate carcasses. However, their role in the tallgrass prairie ecosystem remains to be determined. Furthermore, the largest North American carrion beetle, *Nicrophorus americanus* (Olivier), is a federally-listed endangered species, apparently persisting in low densities in relatively undisturbed sites at the periphery of its former range (Kozol, 1991). Since this species was rediscovered in Kansas in 1996 after a 56-year hiatus (Miller and McDonald, 1997), it was thus of some interest to census the carrion beetles of the KPBS to determine if this endangered species was present on this tallgrass prairie site. This species was last collected in in Riley County in 1904 (B. Brown, pers. comm.). Finally, since historical records indicated that 13 species of carrion beetles existed in Kansas, and that 9 of these had been found in Riley County, it was of interest to examine the effects of topography, burn history, and seasonality on carrion beetle species diversity and distribution. Many of the other Nicrophorine species are found on undisturbed prairie remnants, although the extent to which they coexist with each other is not well documented. Since many of these beetles compete for the same resources, co-existence of a number of Nicrophorine species could be due to niche partitioning on the basis of habitat, seasonality, or other factors such as soil type or land use practices (Anderson, 1982 and Bishop *et al.*, 2002).

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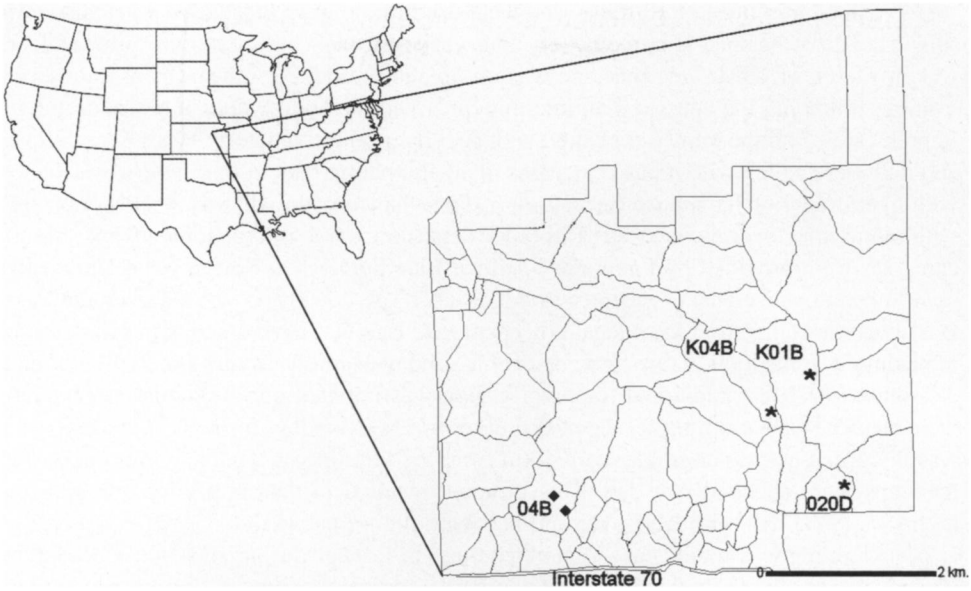

Fig. 1. Map of Konza Prairie Biological Station. Individual watersheds, each with a specific treatment of grazing and/or burning, are outlined; only the watersheds where trap lines for this study were placed are labeled. Diamonds indicate position of trap lines in 1997; stars indicate position of trap lines in 1998.

In this study we examined the patterns (both within a year and between years) of occurrence and diversity of carrion beetles, the effect of bait age and bait type (beef liver or mouse carcass) on success in trapping these beetles, and the effect of topography (upland or lowland prairie) on diversity and abundance of carrion beetles. We documented 9 species of carrion beetles on KPBS, but these did not include the endangered *Nicrophorus americanus*.

Materials and Methods

BOTH YEARS: Data in this study are primarily the result of collections made in non-lethal, carrion-baited pitfall traps, supplemented with some results from blacklighting efforts and observations made at carrion bait dump sites. Pitfall traps were constructed according to the method described by Kozol (1991) for censusing of the endangered American Burying Beetle (*Nicrophorus americanus*). Traps were placed at 50 meter intervals; see Fig. 1 for the specific locations of the traplines on KPBS. Plastic containers (Fisher Scientific Company #02-544-215A) were buried flush with the surface of the ground, angled wooden rain covers approximately 1 foot square were placed over each trap. Carrion bait was aged in the sun in glass containers (Fisher Scientific Co #0572712) covered with tightly-fitted metal mesh screens. After appropriate aging, screened bait containers were placed in the traps approximately 1–2 hours before sunset and traps were left open (shielded from rainfall with wooden rain covers) overnight. All traps were checked and beetles were removed within 1–2 hours after sunrise the next day. The wooden rain covers were then used to cover the traps during the day, precluding the trapping of beetles during that time. Beetles were identified and typically released several km away from the trap lines; voucher specimens were killed and added to the KPBS reference collection.

1997: Two trap lines of 10 traps each were used; these were located on watershed 04B (Fig. 1). This watershed is burned every four years; the last controlled burn prior to 1997 was in March of 1994. One trap line was on upland prairie; the other was at a lower elevation, following the course of an intermittent stream below the upland prairie trap line. In both cases, half the traps were baited with beef liver (approximately 50 gm in each trap), and half were baited with mouse carcasses in an alternating pattern (e.g., trap 1 was baited with liver, trap 2 with a mouse carcass, etc.). Traps baited with liver one week were baited with mouse carcasses the next week in order to minimize trap microhabitat effects. Mouse carcasses were provided by Laboratory Animal Care Services at Kansas State University; mice were euthanized using accepted protocols (AMVA, 1993) and stored frozen until use. Beef liver was purchased from local grocery stores. Bait was aged one day in the sun prior to placing it in the traps. Traps were baited on Sunday evenings from 8 June 1997 through 3 August 1997; one additional trapping session was initiated on 24 August 1997. Traps were checked each morning for the next four mornings (Mondays through Thursdays); bait was discarded at sites approximately 4 km from the trap line on Thursday mornings after the traps were checked that day. This protocol resulted in data collection for 800 trap nights in 1997; half with beef liver and half with mouse carcasses.

Blacklighting was conducted a total of ten times in 1997 at various sites on KPBS, but no silphids were collected at the light. Bait dump piles, containing carcass and liver baits from all the traps, were checked regularly and silphids at these sites were collected and identified.

1998: Three trap lines of seven traps each were placed on upland sites in three watersheds which varied in the frequency of controlled burning. One trap line was placed on a watershed (K01B), which had been burned annually since 1980. Another trap line was placed on a watershed (K04B) that was burned at four-year intervals; the last controlled burn on this site was in 1996. A third trap line was placed on a watershed (020D) scheduled to be burned at 20-year intervals; the last (uncontrolled) burn on this site was in 1993. See Fig. 1 for specific locations of these traplines on KPBS. Data collected in 1997 (see below) indicated that mouse carcasses were superior to beef liver in attracting carrion beetles. Therefore all traps were baited with mouse carcasses in 1998. Data collected in 1997 indicated that no beetles were attracted to the mouse carcass bait unless it had been aged at least three days. Therefore bait was aged two days in the sun prior to placing it in the traps in 1998. In all other respects the baiting, trapping, and monitoring schedules were similar to those described above for 1997. Traps were baited and monitored for 9 consecutive weeks, starting on 2 June 1998 and ending 6 August 1998. This protocol resulted in data collection for 756 trap nights in 1998.

Results

Table 1 lists all the silphid beetle species found on KPBS in 1997 and 1998. The species list includes those species found at carrion dump sites or otherwise encountered during those years, as well the beetles found in pitfall traps. The numbers in this table, and in subsequent tables and figures, include only those beetles found in pitfall traps.

In both years *Nicrophorus marginatus* (Fabricius) was the most commonly encountered silphid on Konza Prairie. Figure 2 shows beetles trapped per week in 1997 and 1998, with data for *Ni. marginatus* and all other beetles shown separately. These data are normalized (beetles per 50 trapnights) to allow comparison between the two years, since different trap numbers were used in 1997 and 1998. Peak trapping of *Ni. marginatus* occurred approximately one month earlier in 1998 than in 1997, and normalized peak numbers were much higher in 1998 than in 1997.

Table 1. Silphids found on Konza Prairie Biological Station in 1997 and 1998.

Species	1997	1998
Necrodes surinamensis	1	30
Necrophila americana	*	3
Nicrophorus carolinus	—	1
Nicrophorus marginatus	131	803
Nicrophorus orbicollis	3	—
Nicrophorus pustulatus	—	1
Nicrophorus tomentosus	3	2
Oiceoptoma inequale	22	3
Oiceoptoma novaboracense	1	—

* Indicates a species not collected in a pitfall trap, but found elsewhere that year.

The type of bait used in the pitfall traps significantly affected the number of beetles found in 1997, when two types of bait (beef liver and mouse carcasses) were used. Table 2 shows the number of *Ni. marginatus* and the number of all other silphids found on each bait type. Significantly more beetles were found in the traps containing mouse carcasses in 1997 (χ^2 test, $P < 0.001$). For this reason we used only mouse carcasses as bait during the 1998 season.

The age of the mouse carcass bait used in the pitfall traps appeared to be positively correlated with the number of beetles trapped in both 1997 and 1998. However, this correlation was not statistically significant (ANOVA; $P > 0.15$), most likely due to substantial weekly variation in the number of beetles trapped, as shown in Fig. 2. Figure 3 compares the number of *Ni. marginatus* with the number of individuals of all other silphid species found on bait aged for different periods.

The local topography (upland vs. lowland trap sites) also affected the number or diversity of beetles trapped in 1997. For *Ni. marginatus*, a total of 59 beetles was found in traps on the two upland trap lines, and 72 were found on the lowland trapline. This distribution is significantly different from a random distribution (χ^2 test, $P < 0.005$). For all other silphids combined, a total of 10 beetles was found on the upland sites, and 20 on the lowland sites. This distribution is significantly different from a random distribution (χ^2 test, $P < 0.01$). This is somewhat surprising, since most silphids are strong flyers, and can detect carcasses at a distance of up to two miles (Scott, 1998). The average distance between upland and lowland traps at our 1997 study site was approximately 350 m. In 1998 all traps were located on upland sites.

The effect of burn treatment and history was examined by placing trap lines on watershed with different burn treatments in 1998. Since we were unable to replicate treatments, statistical tests were not performed. Table 3 shows the number of *Ni. marginatus* and all other silphid species as a function of watershed burn treatment in 1998.

Species Accounts

Necrodes surinamensis *(Fabricius):* Only one specimen of this species was collected in 1997, on 25 June in a lowland pitfall trap; however, 30 specimens were collected in pitfall traps in 1998. Four were collected on 1 July, and the rest were collected from 7–9 July. 21 of these 30 specimens were found on watershed 20D. Lingafelter (1995) found that this species was widespread across the state of Kansas, preferring open habitats, and was found in May and July (but not June). Additionally, he noted that although this species could

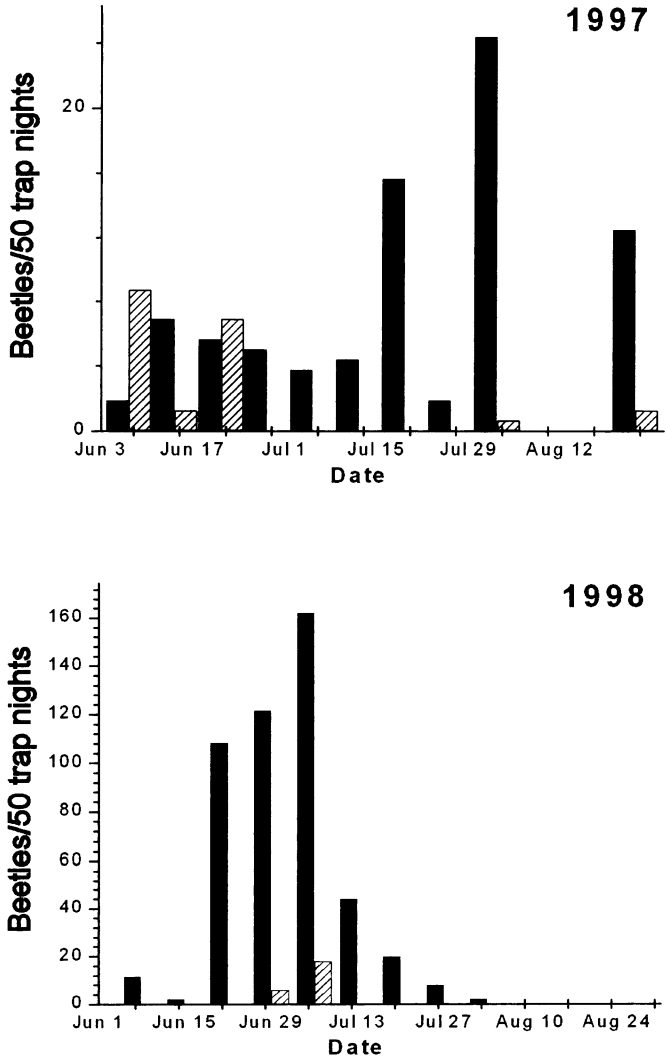

Fig. 2. Seasonal abundance of silphids on KPBS. Upper graph shows data for the 1997 season; lower graph shows data for the 1998 season. Solid bars are data for *Nicrophorus marginatus*; hatched bars are data for all other silphid species.

be collected in pitfall traps, it was particularly abundant at blacklights. As noted above, no silphids were collected during blacklighting in 1997, although it is possible that this species was not particularly abundant on KPBS that year.

Necrophila americana *(Linnaeus):* Individuals of this species were found at a bait dump pile in July 1997, and collected on 2 July, 6 July and 7 July 1998 in pitfall traps. All of these pitfall traps were located on watershed 20D. Lingafelter (1995) did not find this species in Riley County; in fact, there are no prior records for this species in Riley County. Necrophila americana is thought to prefer oak-hickory forests and mosaics of these forests with tallgrass prairies. Our observations indicate that it can also be found in a very open, but relatively undisturbed, tallgrass prairie site.

Table 2. Effect of bait type on silphids found in pitfall traps in 1997.

	Ni. marginatus:		Other silphids:	
Week starting on	mouse bait	liver bait	mouse bait	liver bait
June 8	1	2	13	1
June 15	11	0	2	0
June 22	9	0	11	0
June 29	8	0	0	0
July 6	6	0	0	0
July 13	7	0	0	0
July 20	25	0	0	0
July 27	3	0	0	0
August 3	39	0	1	0
August 27	20	0	2	0

Nicrophorus carolinus *(Linnaeus):* No individuals of this species were found in 1997. A single individual was found in a pitfall trap on watershed K04B on 8 July 1998. Lingafelter (1995) found this species to be distributed primarily west of the Flint Hills in Kansas, preferring open, sandy prairies. All of his records were from mid-July, which is consistent with our findings.

Nicrophorus marginatus *(Matthews):* As noted above, *Ni. marginatus* was the most abundant silphid nearly throughout the season and on all watersheds during both 1997 and

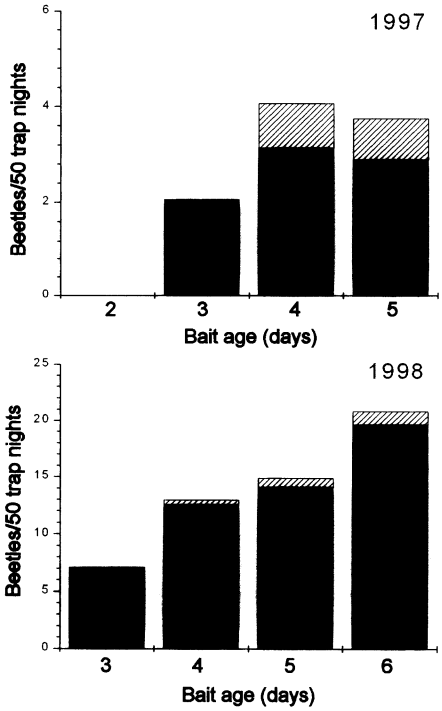

Fig. 3. Effect of bait age on pitfall trapping of silphids on KPBS. Upper graph shows data for the 1997 season; lower graph shows data for the 1998 season. Solid bars are data for *Nicrophorus marginatus*, hatched bars are data for all other silphid species.

Table 3. Total number of silphids collected as a function of watershed burn treatment on KPBS.

Watershed burn treatment	*Ni. marginatus*	Total individuals of other silphid species
Annual burn	327	8 (2.4%)
Burned every fourth year	194	2 (1.0%)
Burned once per 20 years	282	30 (9.6%)

1998. Lingafelter (1995) concluded that this species was the most widespread species of the genus in Kansas, and that it preferred open sandy prairies. As seen in Fig. 2, it was collected from early June through late August. This is consistent with Lingafelter's finding that Ni. marginatus is active from May to "as late as October in southern Kansas." While KPBS cannot be classified as a sandy prairie, the abundance of this species on this site is consistent with a preference for open habitats, as noted by Anderson (1982) for Ontario, and Schubeck (1983) for New Jersey. Additionally, Scott (1998) notes that *Ni. marginatus* is typically found in areas where "they have to contend with relatively hard, dry soil and a thick mat of grass roots"; this accurately describes much of the habitat on KPBS, Bishop *et al.* (2002) concluded that *Ni. marginatus* is a "habitat generalist"; this species avoided riparian areas but was relatively abundant in both pasture land and agricultural land in Nebraska. D. Mulhern (pers. comm.) and J. Keating (pers. comm.), who have conducted silphid surveys in the Flint Hills of Kansas (including nearby Fort Riley), also find that this is the most abundant silphid species on tallgrass prairies.

Nicrophorus orbicollis *(Say):* One individual of this species was found in a lowland pitfall trap on 6 Aug 1997, and two more were found in pitfall traps (one lowland, one upland) on 28 Aug 1997. This species was not observed in 1998. Lingafelter (1995) found this to be the most abundant silphid in Kansas, occurring from May through August in woods, sandy prairies, and marginal areas between woods and non-sandy prairies. Anderson (1982), Shubeck (1983) and Bishop *et al.* (2002) all found that this species has a strong preference for forested habitats, which could explain its low abundance on KPBS.

Nicrophorus pustulatus *(Herschel):* This species was encountered only once during the course of this study, on 8 July 1998, in a pitfall trap on watershed 20D. Lingafelter (1985) found this species to be uncommon in Kansas, as he collected only 5 specimens during the course of his surveys. Previous studies (Anderson, 1982; Schubeck, 1983; Bishop *et al.,* 2002) indicated that this species strongly prefers wooded habitats. Our observations, and Lingafelter's survey, which found the species only in eastern Kansas, are consistent with this habitat preference.

Nicrophorus tomentosus *(Weber):* This species was found in both 1997 and 1998. The three 1997 specimens were found on 11 June, 12 June and 25 June; two of these were found in pitfall traps on upland sites and the other was in a trap on the lowland site. Two individuals of this species were found in pitfall traps on 30 Jun 1998; one was from watershed K01B and the other on watershed 20D. This widespread species is known to be diurnal, in contrast to the other members of its genus, and prefers open habitats (Lingafelter, 1995; Shubeck, 1983; Bishop *et al.,* 2002). Since all of our traps were covered during the day, it is possible that this species is more abundant on KPBS than would be indicated by our observations.

Oiceoptoma inequale *(Fabricius):* This species was relatively abundant in 1997, with 12 specimens found in pitfall traps on 11 and 12 June 1997, 1 on 19 June 1997, and 9 on

25 and 26 June 1997. It was much less abundant in 1998, as one specimen was found in a pitfall trap 1 July 1998, and two more on 2 July 1998. This species was also commonly observed at bait dump sites in 1997. Since this bait dump site was within 50 m of King's Creek, a permanent stream on KPBS, and Bishop *et al.* (2002) found that this species preferred riparian woodlands in Nebraska, our data are consistent with these previous observations. Lingafelter (1995) found that this widespread species was observed in Kansas only until early July, which is also consistent with our observations on KPBS.

Oiceoptoma novaboracense *(Forster):* One individual of this species was found in a pitfall trap on 18 June 1997; none were found in pitfall traps in 1998. This species was also found at bait dump sites in 1997. Lingafelter (1995) found that this species was primarily found in the northeastern corner of Kansas, and is predominantly a woodland species. Bishop *et al.* (2002) also documented the preference of this species for riparian woodland habitat in Nebraska, so the occurrence of this species at a bait dump site near a stream on KPBS is consistent with previous observations.

Discussion

The number of beetles trapped in 1997 included 131 *Ni. marginatus* and 30 silphids of 5 other species (Table 1). Many more beetles were trapped in 1998, 803 *Ni. marginatus* and 40 silphids of 6 other species. As demonstrated by the data in Fig. 2, the peak numbers of *Ni. marginatus* were trapped in late July in 1997 and in early July in 1998. Peak numbers of other silphid were found in early June in 1997 and in early July in 1998, reversing the pattern seen for *Ni. marginatus*. Over 5 times as many total silphids were found in 1998 compared to 1997 (55.8 per 50 trapnights in 1998 vs. 10.1 per 50 trapnights in 1997). This difference becomes less if we only compare traps baited with mouse carcasses (55.8 per 50 trapnights in 1998 vs. 20.1 per 50 trapnights in 1997), but is still remarkable. Temperature and precipitation patterns vary considerably from year to year on KPBS, but there were no obvious meteorological differences between 1997 and 1998 that would help to explain this pattern. This difference is also not explained by the inclusion of different watershed treatments in 1998. One of the watersheds censused in 1998 was similar to the watershed censused in 1997 (burned every fourth year, last burned three years before the census), but more beetles were collected in 1998 (38.5 per 50 trapnights) than in 1997 (20.1 per 50 trapnights). It is interesting to note that this difference in population of silphids between years on KPBS was confined to *Ni. marginatus*, as approximately the same number of other silphids was collected in both years (3.6 per 50 trapnights in 1997 and 2.6 per 50 trapnights in 1998). This observation implies that the population differences observed in 1997 vs. 1998 probably cannot be explained by differences in carcass availability, since one would expect that a change in carcass availability would affect populations of all silphid species. Scott (1998) notes that "Except for very small or very large carcasses, different species use a completely overlapping range of carcass sizes."

Various authors have commented on the effectiveness of various baits, but few, if any, published accounts have approached this question in a systematic manner. Ratcliffe (1996) notes that "Whole animal remains seem to attract more carrion beetles than when only parts (e.g., beef liver, pieces of fish, or chicken gizzards) are used." Our data (Table 2) corroborate this impression rather strikingly; only 3 beetles were found in traps baited with beef liver, while 158 were found in traps baited with mouse carcasses. In 1997 one of the authors (Krueger) observed an individual *Ni. marginatus* landing on the lid of a trap baited with beef liver, examining the bait container, and then flying away. These results would

indicate that investigators planning surveys for burying beetles would be well advised to use whole carcasses for bait, if possible.

Bait age is another parameter that has been widely discussed in an anecdotal manner in the literature, but has not been systematically addressed. Various authors report that greater trapping success is achieved with bait that is aged longer. Again, our data (Fig. 3) tend to corroborate this anecdotal conclusion. No beetles were attracted to mouse carcass bait aged less than three days, and the number of beetles in the pitfall traps increased with the age of bait in both 1997 and 1998. It should also be noted that the three beetles attracted to the beef liver bait in 1997 were found in traps where the bait was maximally aged (5 days). It is likely that there is a point beyond which aging of the carcass bait is not effective, but our data would indicate that this point is beyond 6 days.

The distribution of silphid species across the mosaic of watersheds on KPBS is intriguing. As noted in Table 3, *Ni. marginatus* seems to be equally abundant across all watershed treatments. However, the distribution of the other silphid species may be biased, with more of these low abundance species being found on the watersheds which are burned less often. As noted above, several of the low abundance species seemed to be most commonly found on watershed 20D, which is scheduled for controlled burning every 20 years. Since we did not have replicate watersheds in our study plan for 1998, there is no way to test the statistical significance of this observation, and further studies will be needed in order to test this hypothesis.

In conclusion, nine of the thirteen silphid species reported from Kansas have been found on KPBS. The most abundant of these is *Nicrophorus marginatus*, and its abundance varies substantially from year to year. Results from experiments using different pitfall trap baits indicated that mouse carcasses were superior to beef liver in attracting silphid beetles. Bait age is also an important parameter; in general, beetle numbers may be positively correlated with the number of days that the bait is aged. Preliminary observations indicate that silphid diversity may be higher on watersheds which are burned less often. Additional studies are needed in order to address this question, as well as to determine any seasonal changes in silphid abundance and diversity before June and after August.

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