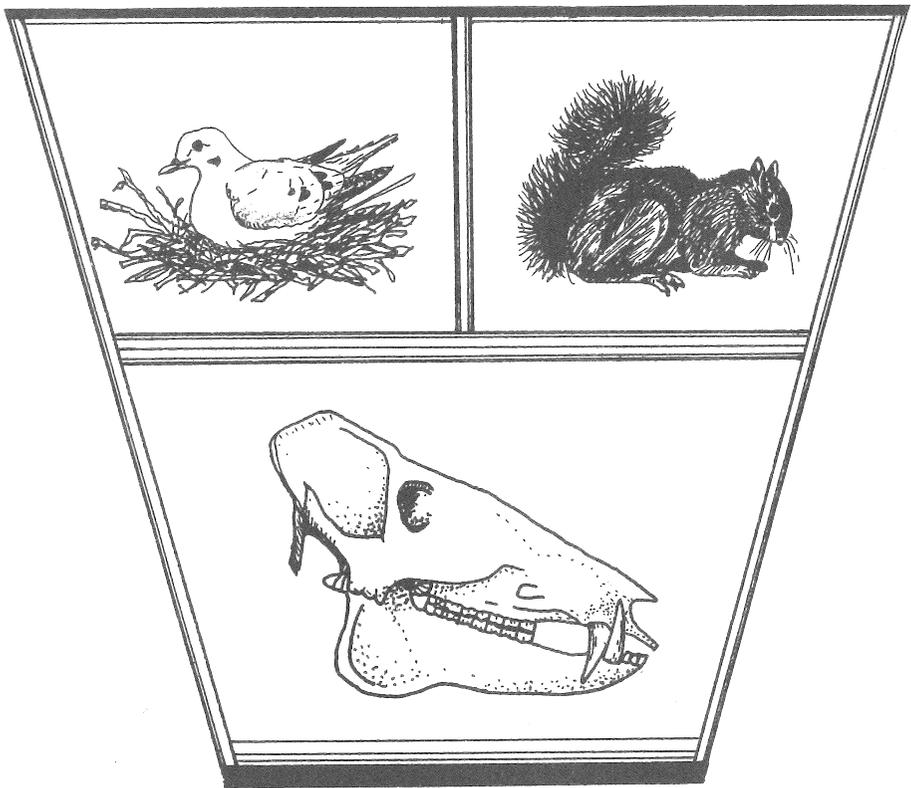


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**TRANSACTIONS OF
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Vol. 19, 1985

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Diel Activity Patterns of Fishes in Lowland Hardwood Wetlands

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Abstract: Diel activity patterns of larval, juvenile and small adult fishes in a variety of lowland hardwood wetland habitats were assessed by comparing day and night catches from activity traps. Juvenile and adult *Fundulus notti*, juvenile and adult *Gambusia affinis*, juvenile *Esox americanus*, juvenile *Centrarchus macropterus* and juvenile *Micropterus salmoides* were predominantly day-active. Juvenile *Ictalurus nebulosus* and larval and juvenile *Elassoma zonatum* were primarily night-active. Only adult *E. zonatum* exhibited any change in diel activity pattern across seasons and habitats. In seasonally flooded habitats adult *E. zonatum* were night-active in late winter before spawning, but became primarily day-active during the spawning season. In semipermanently flooded habitats adult *E. zonatum* were predominantly day-active throughout the sampling period.

Key Words: fishes, early life history, lowland hardwood wetlands, diel activity, *Elassoma zonatum*

Introduction

The inundation forests of temperate lowland hardwood wetlands are widely believed to be important spawning, nursery and foraging habitats for many fishes (Lambou 1959, Pardue et al. 1975, Bryan et al. 1976, Hall 1979). However, little detailed information exists on the spatiotemporal distribution of fishes within these seasonally and semipermanently flooded habitats. As part of a study designed to document fish use of lowland hardwood wetlands, we sampled larval, juvenile and small adult fishes with activity traps during both day and night periods. Because fish capture in activity traps requires active fish movement, comparison of day and night capture rates provides an assessment of diel variation in fish activity patterns. In this paper we document these patterns for several life history stages of fishes that utilize lowland hardwood inundation forests.

Methods

This study was conducted at Mingo National Wildlife Refuge and adjacent Duck Creek Wildlife Management Area in southeastern Missouri from mid-April to early August in 1981 and from late February to early August in 1982. Two seasonally flooded sites (inundated 1-6 mo/yr) and two semipermanently flooded sites (continuously inundated in most years) were sampled. Detailed descriptions of sampled habitats, as well as analyses of annual variation in species abundances and habitat-specific use patterns are in Stewart (1983) and Finger and Stewart (in press). Because no fishes except adult *Elassoma zonatum* exhibited differences in diel activity patterns across habitats, seasons or years, all samples were pooled for most analyses herein.

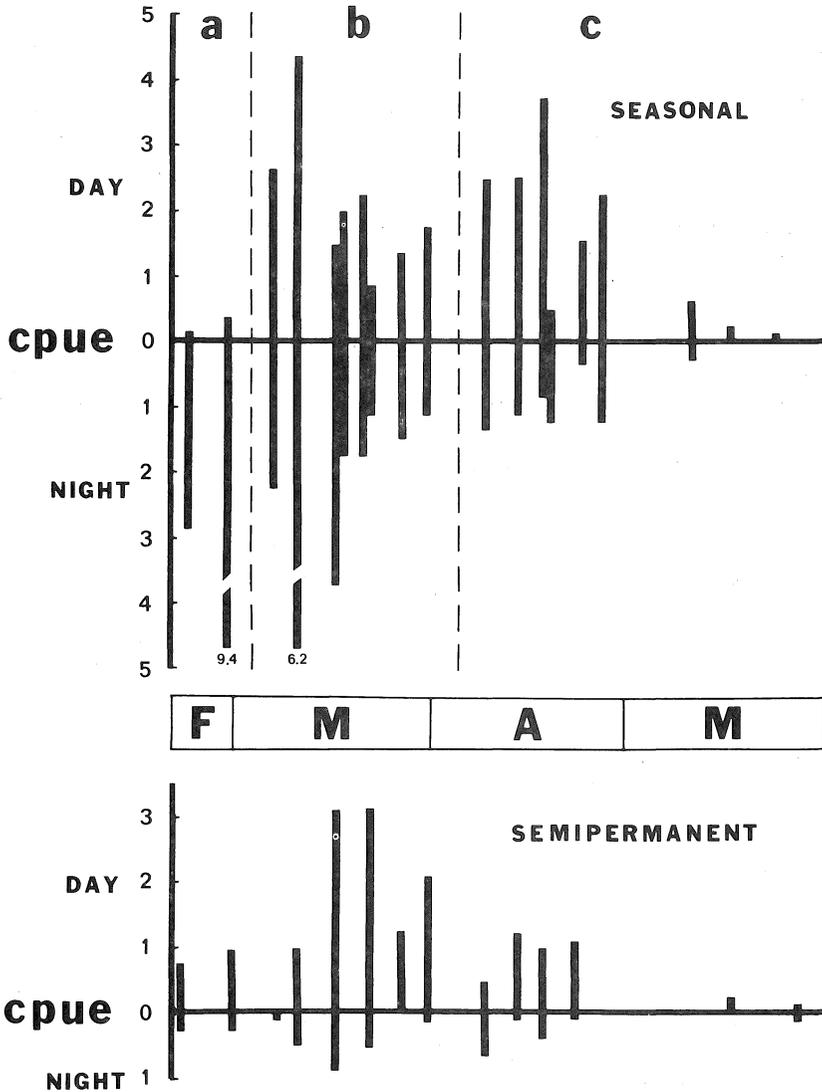


Fig. 1. Day (D) and night (N) catch per unit effort (CPUE) for adult *Ellassoma zonatum* in seasonally and semipermanently flooded habitats from late February through May 1982. Dashed lines separate distinct periods of diel activity in seasonally flooded habitats: (a) N CPUE > D CPUE; (b) D CPUE = N CPUE, (c) D CPUE > N CPUE. In semipermanently flooded habitats, overall D CPUE > N CPUE (all Mann-Whitney tests with $P = 0.05$). Only data from 1982 are shown because sampling in 1981 began too late (mid-April) to observe the late winter shift in diel activity.

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Estimates of Minimum Area Requirements for Missouri Forest Birds

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Abstract: The birds breeding on 15 upland forest sites in central Missouri in 1983 and 1984 were surveyed in a search for area-sensitivity in species distributions. Thirteen of these sites were forest fragments ranging in size from 1.2 to 341 ha, and 2 sites were parts of large forest tracts (>1000 ha). Total bird species richness was correlated with forest area. Neotropical migrants and forest interior specialists showed the greatest sensitivity to reduced forest area, whereas permanent residents and forest edge species predominated on small forest fragments. Two statistical techniques identified 19 species as area-dependent. Minimum area requirements estimated from this study for these species often contrast with estimates for the same species in other regions. These observations suggest that wildlife managers must incorporate the occurrence of area-sensitive species within management plans on a regional basis. Characteristics of habitat size and dispersion may be as important as habitat quality to the survival of area-sensitive species.

Key Words: birds, habitat requirements, island biogeography, nongame management

Introduction

Studies of island biogeographic theory and species-area relationships have spawned some of the most useful, pervasive and controversial findings in ecology during the last 2 decades. The recognition that species diversity, composition and occurrence may be limited by area (MacArthur and Wilson 1963, 1967) has important implications for present-day conservation practices and problems (Diamond 1975, 1978). Numerous attempts have been made to differentiate among the relative effects of stochastic processes, habitat heterogeneity, isolation and area on species diversity and occurrence (Connor and McCoy [1979] listed over 100 species-area studies). Although this body of material has generated much controversy, 2 observations have become clear. One is that community composition and diversity can be related to habitat area. The other is that the occurrence of some species may be limited by area; i.e., there may be some minimum area of habitat below which these "area-sensitive" species are unable to maintain viable populations.

These 2 observations have important conservation and wildlife management implications. To date, most work on this topic has focused on avian species-area relationships. In an examination of Maryland bird distributions, Whitcomb et al. (1981) found that Neotropical migrants and forest interior specialists were most

likely to suffer population reductions because of forest fragmentation. Robbins (1979) attributed the observed local declines in members of these 2 avian groups to land use trends that resulted in forest loss and fragmentation. Whitcomb et al. (1981) and Wilcove (1985) summarized various mechanisms that may be at work limiting these groups in fragmented habitats. Whatever the mechanisms, this trend toward species loss due to habitat fragmentation dramatizes the need to understand habitat area requirements of area-sensitive species, as these may be the species most in need of preservation efforts in the future.

Before these observations can be used for land-use planning, area-sensitive species must be identified and their habitat area requirements defined, probably on a regional basis. The objectives of this paper are to identify area-sensitive bird species in the upland hardwood forests of Missouri and to make initial estimates of the minimum forest area required to maintain populations of these species. Because these estimates are based on presence/absence data, they provide only a crude approximation of minimum area requirements. Long-term studies are necessary to actually establish area requirements for viable populations; these are currently underway.

Study Areas and Methods

Breeding bird species occupying 15 upland deciduous forest sites in Boone, Callaway and Audrain counties in Missouri were determined during the summers of 1983 and 1984. Thirteen of the forest study sites were selected because they were isolated from other similar forest sites by pastures or cropfields. These pastures and cropfields are unsuitable breeding habitats for most forest-dwelling bird species. Two forest study sites were within contiguous forest tracts larger than 1000 ha. Isolated forest tract sizes were 1.2, 1.5, 2.2, 4.6, 5.6, 7.8, 8.0, 12.6, 14.9, 42.2, 44.6, 53.6 and 341 ha (see Hayden 1985 for exact locations of these tracts). All study areas were relatively mature, oak/hickory dominated, upland forests with no recent significant disturbance. The 1.5 and 5.6 ha sites were not surveyed in 1984 because of intensive firewood cutting in those areas.

Each forest fragment was visited at least 3 times on a rotating basis between late May and July during each field season. Surveys were conducted from sunrise until about 1200 hours by 1 or 2 observers who slowly traversed the forest interior and edge. In some cases, surveys were augmented by mist netting. All of the isolated forest blocks and their perimeters were surveyed; the large forest blocks were also completely surveyed but edge was unavailable. Generally, all species encountered in a study area were considered breeding residents, because most territorial forest species would be unlikely to wander among forest fragments during their nesting period. If wide-ranging species such as the common crow (all scientific names are listed in Table 1) showed significant activity or fidelity to an area during a survey period, it was included in the list. However, individuals flying over or only briefly visiting a forest fragment were not included. Although this survey method may be considered "quick and dirty," the majority of species in each study area were observed during the first and subsequent surveys and only once were more than 2 new species added to an area during the third survey. Mist netting added only 1 species not previously observed.

Table 1. Occurrence and characteristics of species recorded on study sites.

Species	Percentage occurrence	Habitat preference	Migration strategy
Cardinal (<i>Cardinalis cardinalis</i>)	100	FE ^a	PR
Eastern wood pewee (<i>Contopus virens</i>)	96	FE	NT
Brown-headed cowbird (<i>Molothrus ater</i>)	96	E	SD
Red-headed woodpecker (<i>Melanerpes erythrocephalus</i>)	96	E	PR
Blue jay (<i>Cyanocitta cristata</i>)	96	FE	PR
Field sparrow (<i>Spizella pusilla</i>)	92	E	SD
Black-capped chickadee (<i>Parus atricapillus</i>)	88	FE	PR
Rufous-sided towhee (<i>Pipilo erythrophthalmus</i>)	85	FE	SD
Tufted titmouse (<i>Parus bicolor</i>)	85	FE	PR
Red-bellied woodpecker (<i>Centurus carolinus</i>)	77	FE	PR
Indigo bunting (<i>Passerina cyanea</i>)	73	E	NT
White-breasted nuthatch (<i>Sitta carolinensis</i>)	69	FI	PR
Yellow-billed cuckoo (<i>Coccyzus americanus</i>)	61	FE	NT
Great crested flycatcher (<i>Myiarchus crinitus</i>)	61	FE	NT
Gray catbird (<i>Dumetella carolinensis</i>)	61	FE	SD
Rose-breasted grosbeak (<i>Phaeucticus ludovicianus</i>)	58	FE	NT
Bobwhite quail (<i>Colinus virginianus</i>)	58	E	PR
Common yellowthroat (<i>Geothlypis trichas</i>)	58	FE	NT
Red-winged blackbird (<i>Agelaius phoeniceus</i>)	54	E	SD
Common grackle (<i>Quiscalus quiscula</i>)	54	E	SD
American robin (<i>Turdus migratorius</i>)	54	E	SD
Downy woodpecker (<i>Picoides pubescens</i>)	50	FE	PR
Brown thrasher (<i>Toxostoma rufum</i>)	50	E	SD
Summer tanager (<i>Piranga rubra</i>)	50	FE	NT
Common crow (<i>Corvus brachyrhynchos</i>)	50	E	PR
Red-eyed vireo (<i>Vireo olivaceus</i>)	46	FE	NT
Northern oriole (<i>Icterus galbula</i>)	38	E	NT
Hairy woodpecker (<i>Picoides villosus</i>)	38	FI	PR
Kentucky warbler (<i>Oporornis formosus</i>)	31	FI	NT
Common flicker (<i>Colaptes auratus</i>)	31	FE	PR
Mourning dove (<i>Zenaida macroura</i>)	27	E	SD
Eastern bluebird (<i>Sialia sialis</i>)	23	E	SD
Wood thrush (<i>Hylocichla mustelina</i>)	23	FE	NT
Pileated woodpecker (<i>Dryocopus pileatus</i>)	19	FI	PR
Louisiana waterthrush (<i>Seiurus motacilla</i>)	15	FI	NT
Ovenbird (<i>Seiurus aurocapillus</i>)	15	FI	NT
Worm-eating warbler (<i>Helmitheros vermivorus</i>)	15	FI	NT
Mockingbird (<i>Mimus polyglottos</i>)	15	E	SD
American goldfinch (<i>Carduelis tristis</i>)	11	E	SD
Northern parula (<i>Parula americana</i>)	11	FE	NT
Warbling vireo (<i>Vireo gilvus</i>)	8	E	NT
Yellow-throated vireo (<i>Vireo flavifrons</i>)	8	FE	NT
Cedar waxwing (<i>Bombycilla cedrorum</i>)	4	E	SD
Turkey (<i>Meleagris gallopavo</i>)	4	FE	PR
House wren (<i>Troglodytes aedon</i>)	4	FE	SD
Starling (<i>Sturnus vulgaris</i>)	4	E	PR
Eastern phoebe (<i>Sayornis phoebe</i>)	4	FE	SD
White-eyed vireo (<i>Vireo griseus</i>)	4	FE	SD

Table 1 (continued).

Species	Percentage occurrence	Habitat preference	Migration strategy
Acadian flycatcher (<i>Empidonax vireescens</i>)	4	FI	NT
American redstart (<i>Setophaga ruticilla</i>)	4	FI	NT
Blue-gray gnatcatcher (<i>Poliophtila caerulea</i>)	4	FE	SD
Ruffed grouse (<i>Bonasa umbellus</i>)	4	FE	PR
Blue-winged warbler (<i>Vermivora pinus</i>)	4	E	NT

^aHabitat Preference: FE = forest edge and interior, E = forest edge, FI = forest interior.

Migration Strategy: PR = permanent resident, NT = Neotropical migrant, SD = short-distance migrant.

Many species associated with forest habitats were not considered in the analysis for area dependence because of difficulty in observation or because their activities encompassed habitat types different from deciduous upland forests. These included raptors, nocturnal and crepuscular species, aerial insectivores, shorebirds and waterfowl.

The above process resulted in a list of breeding species for each forest study site for each year. Each species also was categorized by migration strategy (from the literature) and habitat preference (from our own field observations). Migration strategies included permanent residents (those that do not migrate), short-distance migrants (those migrating generally to the southern United States) and Neotropical migrants (those wintering south of the Tropic of Cancer). Habitat preference categories included forest interior species, forest edge and interior species and forest edge species. Although we did not quantify habitat preferences, our overall categorizations agree with habitat traits measured by Kahl et al. (1985) in central Missouri. Regression analysis was used to examine the relationship between forest area and the relative (%) contribution of each migration and habitat category to the total species lists. Although such regressions are not independent and are not classical species-area regressions, they demonstrate how species composition changes as area changes.

Two separate tests were made in an attempt to determine area sensitivity among individual bird species. The first was a X^2 analysis of species occurrence relative to area. All the areas surveyed were segregated into 1 of 4 size classes: 1.2-2.2, 4.6-14.9, 42.2-53.6 and >340 ha. Data from 1983 and 1984 were pooled, and the number of areas in which a species was a breeding resident was determined for each size class. These values were used to determine if species occurrence was independent of area. The power of the X^2 test was somewhat limited because of low degrees of freedom and the small number of observations. For this reason, a method using incidence functions (Diamond 1975, 1978) also was used to plot a species' occurrence as a function of area. Under this system, the probability of occurrence of an area-dependent species will increase with increasing area. Each species % occurrence in each of the 4 size classes was plotted against area. A species that showed a consistent increase in its incidence of occurrence as area increased was considered area dependent.

All statistical tests are from Snedecor and Cochran (1967) and Walpole (1982).

Results

The number of bird species was significantly positively related to forest area for samples taken in 1983 and 1984, and for both samples combined (Fig. 1). This is consistent with both theoretical models of species-area relationships (MacArthur and Wilson 1963, 1967) and with reported correlations between bird species number and eastern deciduous forest area (Galli et al. 1976, Whitcomb et al. 1981, Blake 1983).

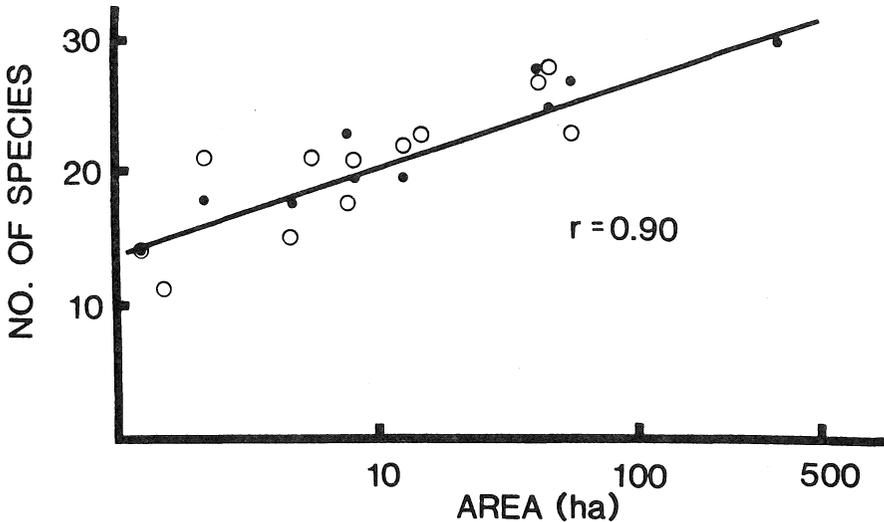


Fig. 1. Species-area data (1983 is open circles, 1984 solid circles) and species area regression for the pooled data.

That the relationship between species number and forest area is not a sampling artifact is shown by shifts in species composition with increasing area. Characteristics of migration strategy and habitat preference were significantly related to area. Neotropical migrants became an increasingly important component of the avifauna as forest area increased (Fig. 2). Short-distance migrants were predominant in the avian communities of small forest fragments, whereas the relative contribution of permanent residents remained constant with increasing forest size.

The relative contribution of forest interior species to the avifauna decreased as forest area decreased (Fig. 3). Forest/forest edge species were lost at a slower rate as forest size decreased while forest edge species comprised a greater proportion of the forest avifauna as forest size decreased.

These community-wide traits were the result of patterns of area-sensitivity by the individual forest species. We had sufficient observations to perform X^2 analyses on 40 of the 53 species observed. Twelve of these 40 species were identified as dependent on increasing forest area ($p < 0.25$; Table 2). The inclusion of species with a level of significance of $p < 0.25$ is statistically questionable, but this allowed comparisons with species considered area-dependent in other studies.

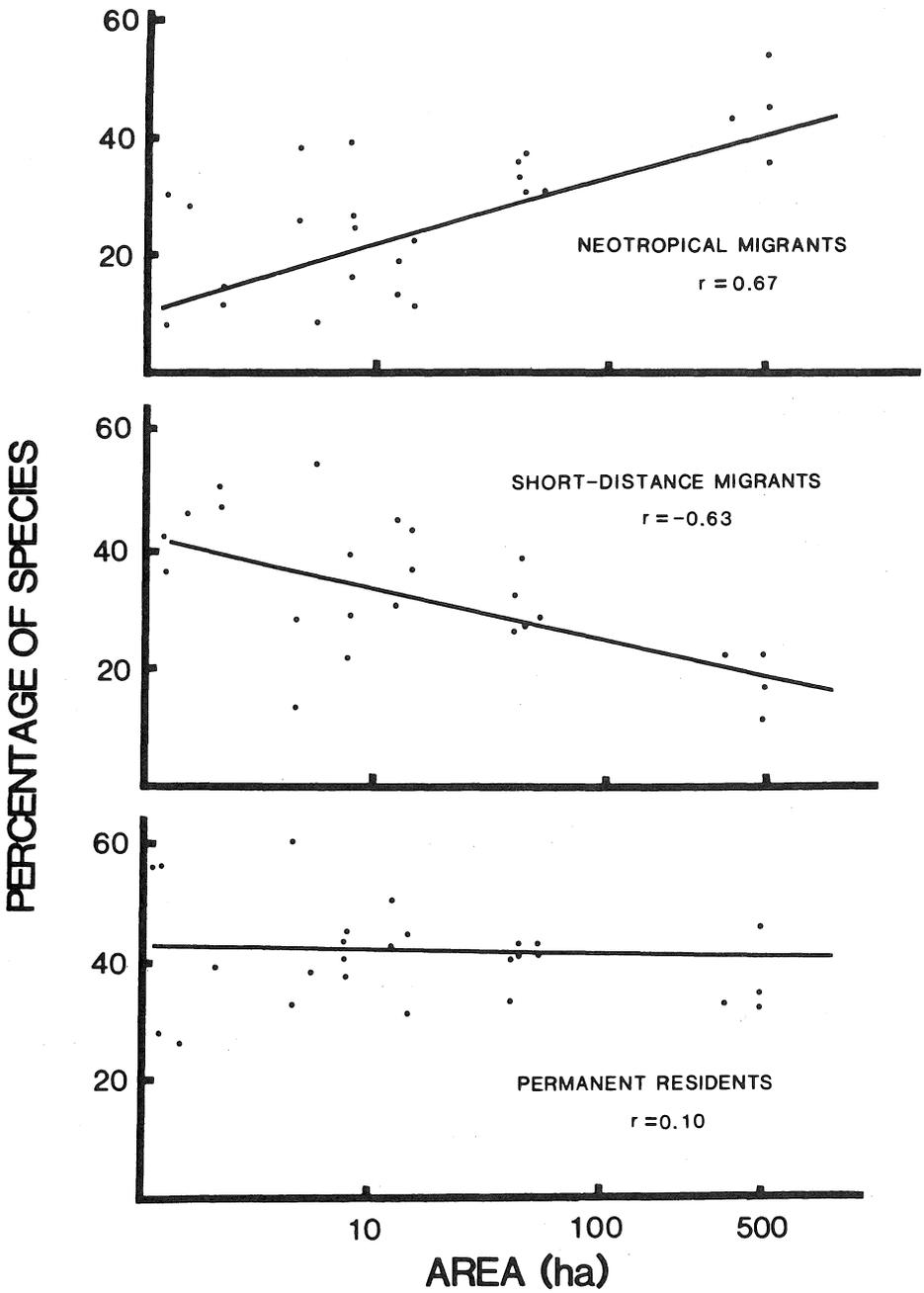


Fig. 2. Regressions of migration strategy against area for the pooled data (see text for methods).

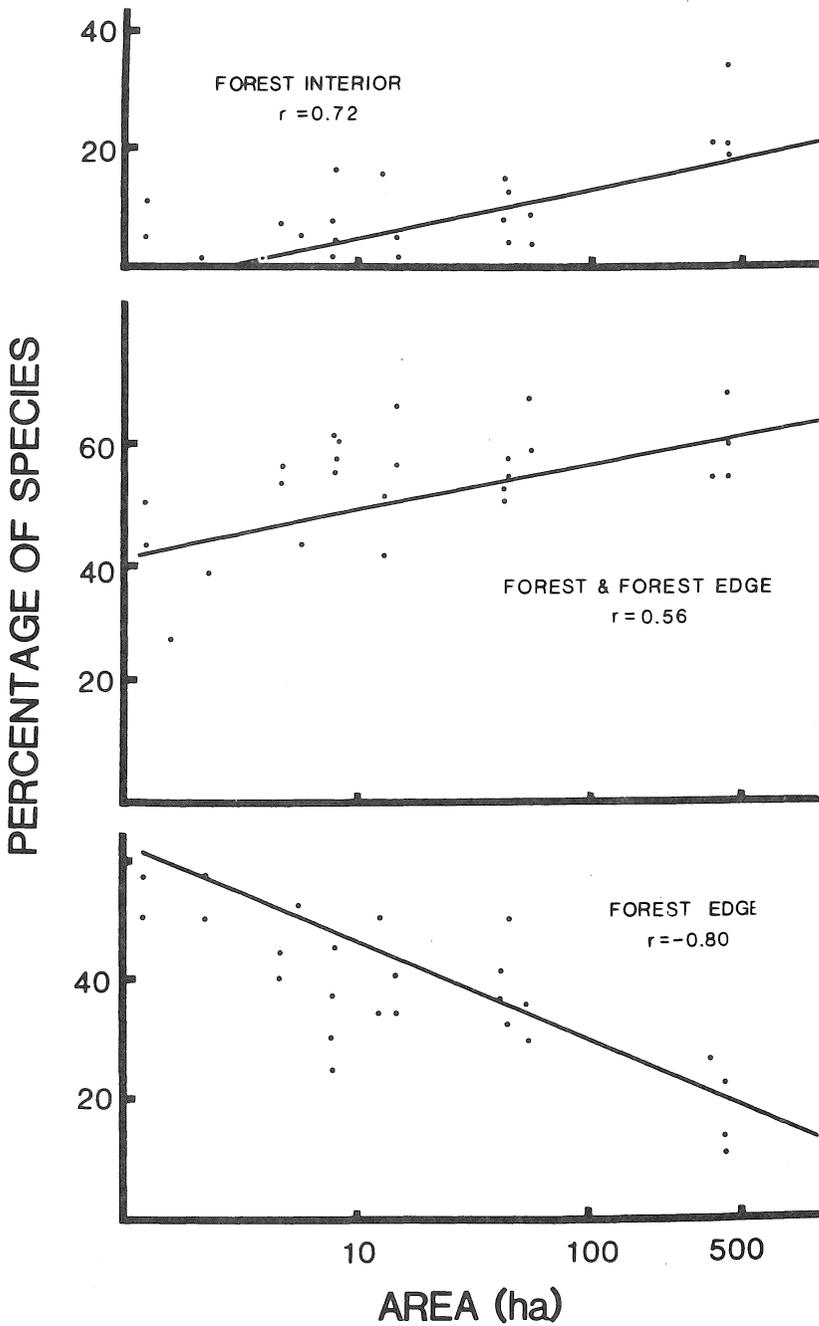


Fig. 3. Regressions of habitat preferences against area for the pooled data (see text for methods).

The incidence function approach judged that 7 additional species were area-dependent (Table 2). Not surprisingly, 13 of these 19 species were Neotropical migrants or forest interior specialists. The 19 species can be compared with species considered area-dependent in other US. studies (Table 3). The minimum areas established by Galli et al. (1976) in New Jersey and Blake (1983) in Illinois probably reflect minimum territory requirements. Robbins' (1979) minimum area estimates for bird species in Maryland included the forest area he considered necessary to maintain viable populations.

Table 2. Species considered area-dependent in this study.

Species	χ^2 significance
Wood thrush	p<0.005
Louisiana waterthrush	p<0.025
Ovenbird	p<0.025
Worm-eating warbler	p<0.025
Kentucky warbler	p<0.05
Northern parula	p<0.05
Yellow-billed cuckoo	p<0.25
Summer tanager	p<0.25
Red-eyed vireo	p<0.25
Great crested flycatcher	p<0.25
Rose-breasted grosbeak	p<0.25
Gray catbird	p<0.25
Rufous-sided towhee	p>0.25*
Tufted titmouse	p>0.25*
Red-bellied woodpecker	p>0.25*
White-breasted nuthatch	p>0.25*
Common crow	p>0.25*
Hairy woodpecker	p>0.25*
Downy woodpecker	p>0.25*

*Species considered area-dependent from incidence function curves (see text).

Discussion

Minimum Area Requirements

A minimum area requirement for a forest species may reflect the occurrence of forest fragments smaller than the minimum acceptable territory size for a species, or it may be the result of some form of island population equilibrium. In the latter case, the species' minimum area of occurrence is considerably larger than its territory requirements. For this area to actually serve as a minimum area requirement, it must be able to sustain viable populations of the species over some reasonably long period of time. The areas measured suggest minimum areas of occurrence that may serve as first approximations for minimum area

Table 3. Minimum area estimates (ha) for area-dependent Missouri species

Species	Area estimates: this study ^a		Estimates from other states ^b		
			IL	NJ	MD
Wood thrush	341	>340	—	0.8	100
Worm-eating warbler	341	>340	—	—	300
Louisiana water-thrush	42.2	>340	—	—	100
Ovenbird	341	>340	—	4.0	2650
Kentucky warbler	8	>340	—	—	30
Northern parula	53.6	N ^c	—	—	100
Yellow-billed cuckoo	1.2	42.2-53.6	—	4.0	—
Summer tanager	4.6	>340	—	—	100
Red-eyed vireo	4.6	>340	—	0.8	100
Great crested flycatcher	1.2	42.2-53.6	—	0.8	10
Rose-breasted grosbeak	2.2	42.2-53.6	—	1.2	—
Gray catbird	5.6	>340	—	0.2	—
Rufous-sided towhee	2.2	42.2-53.6	4.7	0.2	—
Tufted titmouse	1.2	42.2-53.6	4.7	0.2	4
Red-bellied woodpecker	1.2	42.2-53.6	4.7	3	4
White-breasted nuthatch	2.2	42.2-53.6	4.7	2	—
Common crow	4.6	N	—	0.2	—
Hairy woodpecker	2.2	N	16.2	2	4
Downy woodpecker	1.2	N	1.8	1.2	—

^aFirst column is smallest area in which a species occurred; second column is size class where a species reached 100% occurrence.

^bIL is from Blake 1983, NJ from Galli et al. 1976 and MD from Robbins 1979.

^cN = Species did not reach 100% occurrence in any size class.

requirements; only long-term demographic studies will show the area required to maintain viable populations on a regional basis.

In this study, the smallest area in which several species occurred greatly exceeded their territorial requirements (i.e., wood thrush, ovenbird, worm-eating warbler, Louisiana waterthrush and northern parula). None of these species occurred in sites smaller than the 42.2-ha tract, and most were found only in the 341-ha and larger tracts. Preliminary banding data suggested that even on the 341-ha area these species may have lower densities than on "mainland" sites (Hayden 1985). The worm-eating warbler was virtually absent from the 341-ha area, although fairly common in the 2 large contiguous forests. Robbins' (1979) minimum area estimate of 300 ha probably is too low for this species in Missouri. His estimate of 2650 ha for the ovenbird appears to be an overestimate, whereas his 100-ha minimum for the wood thrush probably is too small for this species in Missouri.

The Louisiana waterthrush and northern parula are characteristic of mesic or bottomland forests (Bond 1957, Smith 1977), and accordingly, were uncom-

mon in this survey of upland forests. These species occurred only in association with the limited mesic parts of the study sites. Although the yellow-throated vireo, American redstart and blue-gray gnatcatcher have been listed as area sensitive in other studies, these species were too uncommon on our study sites to be included here.

The Kentucky warbler is among the most flexible of area-sensitive species in its selection of habitats by size. Robbins (1979) estimated that it had a 30-ha minimum area requirement in Maryland, and this study found it in smaller fragments than the previously-mentioned species. Yet, it reached 100% occurrence only on the largest size class fragments. Continued occupation of small areas may depend on the influx of surplus birds from centers of productivity in large forest tracts (the "rescue effect" of Brown and Kodric-Brown 1977).

The other species listed in Table 3 occurred in areas equaling or exceeding that of a territory in size. As long as the regional forest mosaic and total forest coverage remain about the same, we would expect these species to occur regularly in fragments within the range of 9.2-46.8 ha. Two possible exceptions might be the red-eyed vireo and summer tanager, which attain a 100% occurrence only in the largest size class. Their populations also may depend on subsidization from centers of productivity in larger forest tracts, which may explain the 100-ha minimum area requirement given these species by Robbins (1979).

Management Implications of Minimum Area Requirements

The simplest conclusion from the species-area relationships observed in this study is that species richness increases with forest area. However, this simple approach is complicated by several observations. First, in this study a tenfold increase in forest area (from 40 to 400 ha) resulted in only a 28% increase in the number of species. In addition, the total number of species in several small fragments actually can be greater than the species number in 1 larger forest fragment of a size equal to the sum of the smaller fragments. Might it be wiser, as suggested by Simberloff and Abele (1976), to manage for several small forest fragments rather than 1 large one if the former increases species diversity? The answer from our data is no, because migration strategy and habitat preference correlations clearly show that the avian community in a forest fragment is not a random subset of the regional species pool. Although relatively fewer species may be added as forest size increases, it is precisely the species added (Neotropical migrants and forest interior species) that are most sensitive to forest fragmentation and that have shown signs of population declines with increasing fragmentation. Many studies have shown such qualitative patterns of extinction with decreasing "island" area (Diamond 1975, Faaborg 1979, Terborgh and Winter 1980). The only acceptable conclusion is that some species require large areas for survival.

What are the critical forest parameters for area-sensitive bird species in central Missouri? Our data show that areas of at least 300 ha are needed to support the total available species pool found in this study. Upland forest areas of less than 53.6 ha are clearly inadequate to support populations of the worm-eating warbler, ovenbird, wood thrush and possibly the Kentucky warbler and Louisiana waterthrush. Banding data (Hayden 1985 and unpubl.) and territory mapping suggest that areas >340 ha support much greater densities of area-sensitive species than smaller forest fragments. In Illinois, where forest

fragments are more isolated, a relatively complete forest interior avifauna was found only in a 600-ha forest (Blake and Karr 1984). Neither of these studies examined actual demographic data to ensure that populations of small fragments were stable. Actual minimum areas needed may be larger than the above estimates to accommodate all potential forest species. In this regard, Robbins et al. (pers. comm.) suggested a 3000-ha minimum area for total preservation of forest birds in Maryland.

The application of minimum area requirements to management plans is made more difficult by the fact that preservation of large habitat areas for area-sensitive species generally conflicts with management principles applicable to game species (Faaborg 1980). Classical game management favors forest fragmentation to increase edge, a practice obviously detrimental to area-sensitive species. Whereas management goals for each specific managed area will dictate the manner in which minimum area parameters are applied, the decisions for each area must be coordinated on a regional basis to ensure the survival of area-sensitive species (termed a "regional landscape approach"; Noss 1983).

Although the above ideas may seem to constrain managers to retain large forest tracts, several options may be available. This study has suggested that the occurrence of each species on any particular site is some form of probability function, with key factors being size and characteristics of the habitat and its context within the regional habitat distribution. For example, forest areas with a 50% chance of supporting a particular species may be used to meet management goals in 2 ways. In the first case, sufficient numbers of these areas could be interspersed throughout a region so that extinctions within 1 location would be restored by colonization from other populations. The other extreme would involve a very large, centrally-located regional refuge that would ensure the existence of colonists for a smaller number of the satellite forest blocks with 50% incidence. Both of these options have strengths and weaknesses. Further work is needed to determine the exact factors at work in determining area-sensitivity and how best to resolve conflicting management interests.

Acknowledgments

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A Seven-Year Study of Mourning Dove Call-Counts and Nesting Activity in Central Missouri

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Abstract: In an earlier 2-year study, we found no consistent relationships between numbers of cooing male mourning doves (*Zenaida macroura*) heard at 2 stops of a call-count survey route in Missouri, and the numbers of current nests in 61-ha circular plots surrounding these 2 stops. In the present study, we added 5 years to the data base in the same study area. During the entire 7 years, mean numbers of calling males tallied during 20 May-10 June at 1 stop were not significantly correlated ($r = 0.06$, $P > 0.10$) with the numbers of active nests found in the circular plot surrounding it. At the other stop, numbers of calling doves and nests were significantly correlated ($r = 0.857$, $P < 0.03$), but only 1 nest was found during the last 4 of the 7 years. Call-count data may help detect gross differences in numbers of dove nests and breeding doves from year to year and habitat to habitat. However, it is unlikely that such data are adequate for precise predictions of nesting effort or production of young on small (ca 61 ha) areas surrounding listening stops, and extrapolation of such estimates to larger areas seems doubly hazardous.

Key Words: mourning dove, *Zenaida macroura*, call counts, nesting activity

Introduction

Mourning dove populations are annually monitored in the 48 conterminous states through a call-count survey conducted on more than 1000 randomly located 32-km routes (Dolton 1985). Each route consists of 20 stops located at 1.6-km intervals. Numbers of male doves singing the familiar 5-syllable perch coo are recorded at each stop for 3 minutes. Routes are censused once each year between 20 May and 10 June. The resultant data are analyzed to produce population indices and trend information for the individual states and for each of

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3 management units (groupings of eastern, central and western states) (Dolton 1985).

In addition, call counts or similar audio-census procedures have been used to relate numbers of cooing doves to estimated numbers of breeding pairs, nests or even production of young on small study areas, ca 40-61 ha (e.g., Hopkins and Odum 1953, McGowan 1953, Lowe 1956). Our paper is concerned with the validity of using dove call-count data for limited purposes of this sort, an issue not entirely resolved. Other investigators have shown no regular relationship between numbers of males heard cooing and doves counted or nests found by direct search on small study areas (reviewed by Stone 1966); a recent example is Olson et al. (1983) in Colorado.

We have previously reported a lack of consistent correlation between numbers of perch-cooing males and mourning doves nesting on 61-ha plots (Armbruster et al. 1978). These circular plots surrounded 2 stops of an official call-count survey route in Osage County, MO; data were collected in 1971 and 1972. In the present paper, we report on an additional data set for 1973-77 for the same area, and reexamine our earlier conclusions on the basis of the entire 7-year run of data.

Area and Methods

The study was conducted near Freedom, Osage County, in an area of rolling farmland interspersed with wooded hillsides and creek-bottom fields. Woodlands were oak (*Quercus*)-hickory (*Carya*), with eastern red cedar (*Juniperus virginiana*), honeylocust (*Gleditsia triacanthos*), elm (*Ulmus* spp.), hackberry (*Celtis occidentalis*), hawthorn (*Crataegus* spp.) and boxelder (*Acer negundo*) commonly associated. Farmland included permanent pasture, hayfields and corn or wheat fields. Woodlands were usually grazed.

Study plots 4 and 5 (61-ha circular areas surrounding stops 4 and 5 of an official call-count survey route) were selected for study of nesting activity. Peak morning cooing activity generally occurs just before local sunrise (Baskett et al. 1978) when these 2 stops were surveyed. Plot 4 was about 25% woodland and 75% cropland; plot 5 was about 50% in each of these types, but was altered by timber removal during the study (Armbruster 1983). Lowe (1956) determined that a stationary observer could effectively census perch-cooing mourning doves over an area of 150 a (approximately 61 ha) in rural Georgia. Similarly, a 61-ha plot, with radius about 440 m, was probably the maximum area of effective audibility in our study, considering the rolling and wooded terrain.

All standard call-count procedures (Dolton 1985) were followed except that we shortened route length to 10 stops. Study plots 4 and 5 were visited from 2 to 4 times each year during the call-count period (20 May-10 June), to search for active dove nests. Nests were located by slowly searching potential nesting habitat from early morning through late afternoon.

Results and Discussion

In addition to the 25 runs made in 1971-72, 18 runs of the first 10 stops on the survey route were completed between 20 May and 10 June, 1973-77 (Table 1). Numbers of doves heard perch cooing varied considerably among years and stops (Table 1), and among runs within years. The greatest variation occurred

Table 1. Mean and range (in parentheses) of number of males heard perch cooing by stop at the first 10 stops of a call-count survey route in Osage County, MO, 20 May-10 June, 1971-77.

Stop	1971 (13) ^a	1972 (12)	1973 (4)	1974 (4)	1975 (2)	1976 (4)	1977 (4)
1	1.60 (0-3)	1.58 (0-4)	1.75 (1-3)	2.50 (2-4)	3.50 (3-4)	2.75 (0-5)	1.25 (1-2)
2	1.60 (0-3)	4.00 (2-4)	0.75 (0-1)	2.50 (2-4)	0.00 -	3.25 (1-7)	2.25 (1-3)
3	4.46 (2-6)	4.58 (3-6)	4.00 (3-5)	3.25 (2-5)	4.00 (-) ^b	6.50 (5-8)	2.50 (1-3)
4	4.15 (3-6)	4.50 (3-7)	5.00 (4-6)	3.25 (1-5)	6.00 (5-7)	3.75 (0-6)	4.25 (4-5)
5	2.30 (0-4)	3.33 (2-5)	3.75 (3-4)	1.50 (1-3)	2.00 (-) ^b	1.50 (1-2)	0.00 -
6	2.46 (0-7)	1.42 (0-3)	0.75 (0-2)	1.50 (0-3)	1.00 (-) ^b	0.75 (0-2)	0.50 (0-1)
7	0.77 (0-3)	0.83 (0-2)	1.00 (0-2)	1.25 (0-2)	2.00 (-) ^b	0.50 (0-1)	0.00 -
8	0.69 (0-3)	0.58 (0-3)	0.75 (0-2)	0.50 (0-2)	0.00 -	0.00 -	0.00 -
9	0.46 (0-2)	1.25 (0-3)	1.25 (0-3)	0.50 (0-2)	0.00 -	0.25 (0-1)	1.00 (0-3)
10	0.92 (0-2)	0.25 (0-1)	1.75 (0-3)	1.25 (0-2)	0.50 (0-1)	0.75 (0-2)	2.00 (0-4)
$\Sigma \bar{X}$	19.41	22.32	20.75	18.00	19.00	20.00	13.75
Minimum- maximum ^c	12-31	14-31	16-27	12-24	19 ^b	18-23	11-17

^a Sample size.

^b Identical number in each sample.

^c Minimum-maximum total number for 1 day's run.

between runs in 1971 (minimum 12, maximum 31 doves per run, N=13). Considering stops 4 and 5, variation was greatest at stop 4 in 1976 (range 0-6 doves, N=4 runs). In the main, annual trends in counts at stop 4 corresponded with those for all stops totaled, but those for stop 5 differed by trending downward after 1973.

Forty-nine dove nests—43 on study plot 4, and 6 on plot 5—were active during the 20 May-10 June call-count period, 1973-77. We compared data for these nests with those from 1971-72 (Armbruster et al. 1978), and with the numbers of males recorded perch cooing at stops 4 and 5 (Table 2). Numbers of active nests were converted to mean numbers of active nests for display purposes by identifying the numbers of active nests on each plot on the day a call-count run was completed, summing these data and then dividing by the numbers of runs. (Most nests were active through several runs.)

Table 2. Mean numbers of doves recorded perch cooing at stops 4 and 5, and mean numbers of active nests found on 61-ha circular plots around each stop, 20 May-10 June, 1971-77.

Year	Stop 4		Stop 5	
	Doves cooing	Active nests	Doves cooing	Active nests
1971 ^a	4.15	6.70	2.30	2.90
1972 ^a	4.50	4.50	3.33	5.00
1973	5.00	3.25	3.75	3.25
1974	3.25	3.25	1.50	0.25
1975	6.00	7.00	2.00	0.00
1976	3.75	7.50	1.50	0.00
1977	4.25	6.75	0.00	0.00

^a Data for 1971-72 from Armbruster et al. (1978).

In an exploratory analysis, we combined mean numbers of doves heard cooing and numbers of active nests on the days of the survey (Table 2) at both stops 4 and 5, 1971-77. Numbers of cooing doves and active nests were significantly correlated (Spearman's rank correlation, $r=0.82$, $P<0.03$). However, we believe that this combination of data from the 2 study plots is unjustified because of the vastly different history of dove nesting activity on the 2 plots during the 7 years. Numbers of active nests found on plot 4 varied without apparent trend over the years (Table 3), and mean numbers per year were usually greater than on plot 5 (Table 2). At plot 5, on the other hand, nesting habitat was diminished (Armbruster 1983), and active nests trended sharply downward (Tables 2 and 3). Only 1 nest was found during the call-count period in the last 4 years. Yet, some calling males were recorded there until 1977.

Because of the unique properties of the data for each plot, and because we were interested in the relationships of calling and nesting data for individual small areas, we then analyzed the data separately for the 2 plots.

Nonparametric analysis of mean numbers (Table 2) of doves cooing and active nests on the days of the survey at stop 4, 1971-77, showed no significant correlation (Spearman's rank correlation, $r=0.06$, $P>0.10$). For stop 5, there was a significant correlation ($r=0.86$, $P<0.03$).

We are wary of comparing mean numbers of cooing males with mean numbers of active nests during a brief period, 20 May-10 June, especially if the objective is to estimate size of a breeding dove population whose nesting season may extend from March into September in central Missouri (Armbruster et al. 1978). Another concern is the mobility of mourning doves. The 1.6 km between stops 4 and 5 is well within the known maximum distances between cooing perches of some males (Sayre et al. 1980). Although it is unlikely that males heard cooing at stop 4 would be recorded again at stop 5 (3 minutes later) on the same morning, individual males could have been recorded at both stops on different mornings, and the mean numbers could thus be confounded.

Table 3. Numbers of mourning doves recorded perch cooing, and numbers of active nests found on 61-ha circular plots surrounding stops 4 and 5 of an official call route, 1973-77.

Date	Stop 4		Stop 5	
	# males	# nests	# males	# nests
1973				
May 26	5	6	4	3
June 1	5	5	4	3
June 6	6	1	4	4
June 8	4	1	3	3
1974				
May 21	1	4	3	1
May 27	3	3	1	0
June 1	4	3	1	0
June 2	5	3	1	0
1975				
May 23	7	6	2	0
June 3	5	8	2	0
1976				
May 26	0	8	2	0
May 28	5	7	1	0
June 2	6	7	1	0
June 9	4	8	2	0
1977				
May 23	4	5	0	0
May 25	4	7	0	0
June 3	4	8	0	0
June 7	5	7	0	0

Additional concerns relate to time patterns of nesting. Armbruster (1973) found that many unsuccessful nests lasted only a few days, and such nests may have been missed in the intervals between searches. Furthermore, pairs with active nests containing young about to fledge at the beginning of the call-count period (20 May) could conceivably have second active nests with eggs toward the end of the period (10 June). Conversely, pairs between nestings would not be recorded if a nest was not active during the call-count period. All these conditions could lessen the quality of analyses based on mean values for calling birds and active nests.

To avoid some of the difficulties inherent in the use of mean values, we made 2 supplementary analyses. In one, we compared the maximum numbers of doves heard cooing on any 1 day during the 20 May-10 June period of each year with the numbers of nests active on that date (data from Table 3, this paper, and from Table 4 in Armbruster et al. 1978). In the other supplementary analysis, we compared the maximum number of active nests found in any 1 day in each year with the numbers of doves heard cooing that morning. Because plot 4 had higher levels of cooing and nesting activity than plot 5, we selected all the dates used for both plots from plot 4 data.

The hypothesis that the maximum numbers of doves cooing were independent of the numbers of active nests on the same days could not be rejected either for plot 4 ($r=0.05$, $P>0.10$) or for plot 5 ($r=0.62$, $P>0.05$). Similarly, the maximum numbers of nests found each year on plot 4 were not demonstrably related to the numbers of cooing doves recorded on those days ($r=0.18$, $P>0.10$) and on plot 5 ($r=0.55$, $P>0.05$).

Our approach necessitated certain assumptions whose validity we could not competently evaluate:

1. We assumed the range of audibility of cooing doves to be about 440 m, and thus used 61-ha areas around call-count stops for nest searching. We used these figures for comparability with Lowe's (1956) study. Adjacent call-count stops were about 1610 m apart; thus, "dead" space was provided that should have reduced the possibility of interference. At any rate, the areas searched were held constant, and inaccuracy in estimated range of audibility should not have been a serious factor.

2. We assumed that all active nests were found in each search. Here again, searching effort was held nearly constant at each visit. This fact does not preclude the potential problems of active nests not found, or the presence of breeding pairs without active nests, as discussed above. More frequent searches would be required to locate all nests. However, in our previous 2-year study (Armbruster et al. 1978), nest searching intervals were much shorter, and we believe a very high proportion of nests was found. That study produced overall results similar to those reported herein.

3. We assumed that all cooing doves were counted, or at least a constant proportion. At high densities, observers may fail to tally large numbers of calling birds of various species including mourning doves (Bart and Schoultz 1984). This may be a problem with this study and all others that deal with call-count data.

Our data gathered during 1973-77 generally support the conclusions reached in our earlier paper (Armbruster et al. 1978) which were based on data for 1971-72. We doubt that call-count data are suitable for any precise estimations of densities of breeding pairs, nests or by extension, production of mourning doves on small areas (Armbruster 1983). Call-count data may provide an indication of very large changes in numbers of active nests as at stop 5, but the correlations themselves say nothing about our ability to predict numbers of nests from numbers of birds heard cooing. In fact, the lack of correlation at stop 4, with good-to-moderate densities of nests, plus the great variation in numbers of doves heard and nests found during individual runs, provided little hope for predicting numbers of active nests near the listening stops.

This view is strongly reinforced by the recent findings of Olson et al. (1983). They studied cooing activity and nesting of mourning doves along 1 call-count and 2 breeding-bird survey routes in northeastern Colorado. Regression analyses were based on cooing data gathered biweekly and numbers of active nests found in weekly searches, May through October, during 2 years. There was no consistent relationship between the numbers of doves cooing and the numbers of nests on study sites adjacent to the survey routes. These authors, too, concluded that there "is little evidence that the number of mourning dove nests in a local area can be estimated from call-count data" (Olson et al. 1983:335).

Table 3. Numbers of mourning doves recorded perch cooing, and numbers of active nests found on 61-ha circular plots surrounding stops 4 and 5 of an official call route, 1973-77.

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June 1	5	5	4	3
June 6	6	1	4	4
June 8	4	1	3	3
1974				
May 21	1	4	3	1
May 27	3	3	1	0
June 1	4	3	1	0
June 2	5	3	1	0
1975				
May 23	7	6	2	0
June 3	5	8	2	0
1976				
May 26	0	8	2	0
May 28	5	7	1	0
June 2	6	7	1	0
June 9	4	8	2	0
1977				
May 23	4	5	0	0
May 25	4	7	0	0
June 3	4	8	0	0
June 7	5	7	0	0

Additional concerns relate to time patterns of nesting. Armbruster (1973) found that many unsuccessful nests lasted only a few days, and such nests may have been missed in the intervals between searches. Furthermore, pairs with active nests containing young about to fledge at the beginning of the call-count period (20 May) could conceivably have second active nests with eggs toward the end of the period (10 June). Conversely, pairs between nestings would not be recorded if a nest was not active during the call-count period. All these conditions could lessen the quality of analyses based on mean values for calling birds and active nests.

To avoid some of the difficulties inherent in the use of mean values, we made 2 supplementary analyses. In one, we compared the maximum numbers of doves heard cooing on any 1 day during the 20 May-10 June period of each year with the numbers of nests active on that date (data from Table 3, this paper, and from Table 4 in Armbruster et al. 1978). In the other supplementary analysis, we compared the maximum number of active nests found in any 1 day in each year with the numbers of doves heard cooing that morning. Because plot 4 had higher levels of cooing and nesting activity than plot 5, we selected all the dates used for both plots from plot 4 data.

The hypothesis that the maximum numbers of doves cooing were independent of the numbers of active nests on the same days could not be rejected either for plot 4 ($r=0.05$, $P>0.10$) or for plot 5 ($r=0.62$, $P>0.05$). Similarly, the maximum numbers of nests found each year on plot 4 were not demonstrably related to the numbers of cooing doves recorded on those days ($r=0.18$, $P>0.10$) and on plot 5 ($r=0.55$, $P>0.05$).

Our approach necessitated certain assumptions whose validity we could not competently evaluate:

1. We assumed the range of audibility of cooing doves to be about 440 m, and thus used 61-ha areas around call-count stops for nest searching. We used these figures for comparability with Lowe's (1956) study. Adjacent call-count stops were about 1610 m apart; thus, "dead" space was provided that should have reduced the possibility of interference. At any rate, the areas searched were held constant, and inaccuracy in estimated range of audibility should not have been a serious factor.

2. We assumed that all active nests were found in each search. Here again, searching effort was held nearly constant at each visit. This fact does not preclude the potential problems of active nests not found, or the presence of breeding pairs without active nests, as discussed above. More frequent searches would be required to locate all nests. However, in our previous 2-year study (Armbruster et al. 1978), nest searching intervals were much shorter, and we believe a very high proportion of nests was found. That study produced overall results similar to those reported herein.

3. We assumed that all cooing doves were counted, or at least a constant proportion. At high densities, observers may fail to tally large numbers of calling birds of various species including mourning doves (Bart and Schoultz 1984). This may be a problem with this study and all others that deal with call-count data.

Our data gathered during 1973-77 generally support the conclusions reached in our earlier paper (Armbruster et al. 1978) which were based on data for 1971-72. We doubt that call-count data are suitable for any precise estimations of densities of breeding pairs, nests or by extension, production of mourning doves on small areas (Armbruster 1983). Call-count data may provide an indication of very large changes in numbers of active nests as at stop 5, but the correlations themselves say nothing about our ability to predict numbers of nests from numbers of birds heard cooing. In fact, the lack of correlation at stop 4, with good-to-moderate densities of nests, plus the great variation in numbers of doves heard and nests found during individual runs, provided little hope for predicting numbers of active nests near the listening stops.

This view is strongly reinforced by the recent findings of Olson et al. (1983). They studied cooing activity and nesting of mourning doves along 1 call-count and 2 breeding-bird survey routes in northeastern Colorado. Regression analyses were based on cooing data gathered biweekly and numbers of active nests found in weekly searches, May through October, during 2 years. There was no consistent relationship between the numbers of doves cooing and the numbers of nests on study sites adjacent to the survey routes. These authors, too, concluded that there "is little evidence that the number of mourning dove nests in a local area can be estimated from call-count data" (Olson et al. 1983:335).

Similar conclusions were reached by Rappole and Waggener (1986) in a study of white-winged doves (*Zenaida asiatica*) on 10 sites in the lower Rio Grande Valley in Texas. Estimates of numbers of breeding birds based on nest counts were poorly correlated ($r = 0.45$, $P = 0.19$) with those based on coo counts made earlier in a single breeding season. For 9 of the 10 sites, the numbers of breeding pairs per ha estimated by coo-counts exceeded nest-count estimates, and by as much as 15 times.

Possible reasons for uncertain relationship between calling and nesting are many and include the greater calling rates (up to 21x) of unmated compared to mated males, and differences in calling rates of mated males according to position in the nesting cycle (Baskett et al. 1978, Sayre et al. 1980). Problems in estimating numbers of breeding birds through counts of singing males are by no means confined to mourning doves, as elucidated by Mayfield (1981). His counts of doves were only 33% "efficient," i.e. doves were tallied only 10 of a possible 30 times on an intensively studied area.

Our results do not disprove the usefulness of the mourning dove call-count survey as an index to relative densities of doves or their population trends over large areas such as the 3 management units within the United States, nor within the individual states. Nor do they invalidate the approach to dove habitat assessment described by Grue et al. (1976, 1981, 1983). These authors related dove call-count data to habitat types on 133 24-km transects in 10 ecological areas in Texas. Some question remains, however, as to how well their audio data reflect population densities; they considered this problem carefully in their 1983 publication.

We believe that numbers of active nests found by direct search are the best available estimators of numbers of breeding pairs of doves on small study areas. Precise linkages, however, among numbers of active nests, breeding pairs and ultimate production of young are unknown. A large-scale effort, similar in scope to the one recently completed to assess seasonal patterns of nesting and effects of September hunting (U.S. Fish and Wildlife Service 1982) would probably be needed to settle, once and for all, the validity of using call-count data to assess breeding populations on limited areas, and for purposes other than approximating relative densities and trends.

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Ecological Characteristics of Small Mammals at 3 Sites in Southeast Missouri

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Abstract: The small mammal populations at 3 sites in southeast Missouri were sampled during the summer of 1984. A total of 4000 trap nights resulted in the capture of 7 small mammal species. *Peromyscus leucopus*, *Microtus pinetorum* and *Cryptotis parva* were captured at all 3 sites. *Peromyscus leucopus* was the most abundant species overall. The diversity of small mammals at the 3 sites differed considerably. A principal components analysis revealed significant differences in habitat utilization with respect to canopy cover, shrub cover and ground cover among the 7 species. Reduced body weights and number of reproductively active mice were observed for *P. leucopus* when this species occurred together with either *P. maniculatus* or *Ochrotomys nuttalli*.

Key Words: Small mammals, species diversity, habitat utilization, southeast Missouri

Introduction

The small mammal communities of southeast Missouri are of significant interest for several reasons. First, this portion of the state is composed of many different habitat types. Portions of the area are upland deciduous forests of the Ozark region while other portions are agricultural and oldfield habitats. A diversity of macro- and microhabitats are available for these small mammal communities.

Annual flooding in the lowland portions of southeast Missouri provides a unique opportunity to conduct "natural" experiments on faunal build up and community structure. Communities existing in flooded areas are subjected to severe perturbations every year and probably never reach a condition which even remotely resembles an equilibrium state. Information on temporal changes in these communities, habitat selection patterns and small mammal dispersal and invasions would provide a good foundation for long-term "natural" experiments on dynamic community structure.

In this study habitat utilization and abundance patterns of small mammals at 3 sites in southeast Missouri were determined. Ecological attributes of *P. leucopus* and *P. maniculatus* were characterized. This information will provide a foundation for future studies designed to explore small mammal community dynamics in southeast Missouri.

Methods

Three study sites were chosen in southeast Missouri including both upland and lowland habitats. The upland study site was located within the Holly Ridge Natural Area (northeast of Dexter, off Highway 25, Stoddard County) while the lowland sites were located at the Allred Lake Natural Area (24 km south of Poplar Bluff, and 9.7 km southeast of Neelyville, Butler County) and the Sand

Ponds Natural Area (6.4 km south of Naylor on Highway W and 0.8 km east on county road A, Ripley County). The general habitat characteristics of the 3 study sites differ considerably. Holly Ridge is composed of an upland deciduous forest, while Allred Lake and Sand Ponds are lowland areas subject to annual flooding. Also, Allred Lake is composed of deciduous forest and Bald Cypress swamp surrounded by an oldfield habitat and cultivated bean fields. The Sand Ponds site has considerable oldfield acreage with patches of deciduous forest containing "sand ponds."

Within each study site 3 areas were chosen at random for intensive study. These areas reflected the diversity of microhabitats present within each study site. Each trap line configuration consisted of 2 intersecting (45°) 40-station trap lines. For area "A" at the Holly Ridge site there were 15 m between trap stations, while at all other areas there were 10 m between trap stations. A single Sherman live-trap was placed at each trap station for 4 consecutive nights, and checked each morning and evening. Following the 4 nights of live-trapping, Museum Special and Victor mouse traps were used on 2 of the trapping configurations at Holly Ridge and Allred Lake, and on all 3 trapping configurations at Sand Ponds. Snap-trapping was conducted for 2 nights at each area. A total of 1280 trap nights were run at the Holly Ridge and Allred Lake study sites and 1440 trap nights were run at the Sand Ponds study site. Also, within each study site a complex of intersecting 30-m drift fences and 20-liter pit-fall traps (2 per fence) were installed and were operated for 7 consecutive days at each study site.

Each animal captured during the live-trapping phase was identified to species, weighed, sexed and toe clipped with a unique number. *Peromyscus leucopus* and *P. maniculatus* were distinguished on the basis of tail characteristics. The tails of mice classified as *P. maniculatus* were approximately $\frac{1}{3}$ of the total animal length and were strongly bicolored, while *P. leucopus* tails were approximately equal to $\frac{1}{2}$ of the total length and were only weakly bicolored (Schwartz and Schwartz 1981). The trap station at which each animal was captured was noted and the animal released at the point of capture. Animals captured during the snap-trapping sessions were identified, weighed and sexed.

The species diversity of each study site was estimated using the Shannon-Weaver diversity index (May 1976). Differences in body weights between the 3 *P. leucopus* populations and the *P. maniculatus* population were assessed using a 1-way ANOVA, followed by Tukey's Studentized Range Test (Neter and Wasserman 1974) to determine which populations differed significantly from one another.

The vegetation at each area within each study site was characterized by performing a 10-m plant transect at each trap station. Plant cover was estimated at 4 levels above the ground: 0-0.5 m (surface cover), >0.5-1.0 m (herbaceous cover), >1.0-2.0 m (shrub cover) and >2.0 m (canopy cover). Separate cover values were recorded for each 1-m segment of each plant transect. Coefficients of variation for plant cover at each of the first 3 levels above the ground were also computed. Thus, for each trap station, the average cover and variability of cover at various levels above the ground were computed.

Habitat selection by the small mammals was evaluated with the aid of a principal components analysis (Morrison 1976). The factor scores for each species were compared with those of all trap stations combined. Thus, in the

absence of habitat selection along a specific principal component, the mean factor score for a species will not differ significantly from 0. Using this methodology, it is possible to discern habitat use characteristics for species with sufficient numbers of captures. A canonical discriminant function analysis was performed on the vegetation data for those trap stations actually used by the small mammals. This analysis produced linear combinations of the vegetation variables which summarized between-species variation, thus permitting an evaluation of species differences with respect to the vegetation variables. Each linear combination of habitat variables was chosen to maximize the multiple correlation with the species, thus producing a canonical correlation. This procedure was repeated until the canonical correlations were no longer significant at the 0.05 level. All multivariate statistics were computed using SAS (Ray and Sall 1982).

Results

Three species of small mammals were captured at all 3 study sites: *P. leucopus*, *M. pinetorum* and *C. parva*. *Ochrotomys nuttalli* was captured only at the Holly Ridge study site while *Blarina brevicauda* was captured at Holly Ridge and Allred Lake. Both *P. maniculatus* and *Reithrodontomys megalotis* were unique to the Sand Ponds study site. The greatest abundance of *P. leucopus* was found at Allred Lake with 19 captures while Sand Ponds yielded only 15 captures. *Peromyscus maniculatus* was found only at Sand Ponds. All other species were considerably less abundant (Table 1). The Sand Ponds study site

Table 1. Capture summary for 7 species of small mammals at 3 sites in southeast Missouri.

Species	Holly Ridge	Allred Lake	Sand Ponds ^a
<i>Peromyscus leucopus</i>	15	19	14
<i>Peromyscus maniculatus</i>	0	0	20
<i>Ochrotomys nuttalli</i>	2	0	0
<i>Reithrodontomys megalotis</i>	0	0	2
<i>Microtus pinetorum</i>	5	3	1
<i>Blarina brevicauda</i>	1	1	0
<i>Cryptotis parva</i>	1	2	4

^aDenotes the use of 480 trap nights rather than 320.

supported the most diverse small mammal community ($H = 1.186$). Holly Ridge had a species diversity value of $H = 1.092$, while Allred Lake had a value of $H = 0.794$.

In the habitat utilization analysis, the first principal component was composed of cover at 2 m above the ground and variability of cover within the intervals 0.5-1.0 m and >1.0-2.0 m (Table 2). This component accounted for 28.8% of the variance within the data set. Principal component 2 was

Table 2. Principal components for the vegetation data across all trap stations at the 3 study sites.

Variable	PC 1	PC 2	PC 3	PC 4
Surface cover	0.044	0.619	0.161	-0.042
Herbaceous cover	0.301	0.550	0.171	-0.022
Shrub cover	0.265	0.243	-0.690	0.600
Canopy cover	0.490	-0.358	-0.099	0.131
Surface patchiness	0.323	0.311	0.470	0.615
Herbaceous patchiness	0.480	0.144	0.375	-0.077
Shrub patchiness	0.512	-0.098	-0.312	-0.485
Variance	0.288	0.258	0.133	0.114
Cumulative variance	0.288	0.546	0.680	0.794

dominated by plant cover between 0 and 1 m and explained 25.8% of the total variance. The third principal component loaded most heavily on plant cover between 1.0 and 2.0 m, while the fourth component was also dominated by this variable as well as the variability of surface cover. The third and fourth principal components explained 13.3 and 11.4% of the total variance, respectively.

The distributions of the principal component scores for each small mammal species were used as indices of habitat selection and are shown in Fig. 1. The principal component scores for the overall distribution are standardized about 0, thus species distributions which show deviation from 0 are indicative of habitat selection. Along the first principal component, the distributions for *P. leucopus* and *O. nuttalli* are primarily or entirely within the positive region of the component. Since the first component is a "forest canopy" and "understory patchiness" variable, *P. leucopus* and *O. nuttalli* selected microhabitats with extensive canopy cover and patchy or variable understory. *Peromyscus maniculatus* and *C. parva* occupied the negative portions of this component and thus selected habitats with less canopy cover and more homogeneous understory vegetation.

The second principal component consisted primarily of vegetation cover between 0 and 1 m or "surface and herbaceous cover." *Peromyscus maniculatus* showed a distinct trend toward areas with less extensive cover while *M. pinetorum* and *C. parva* showed strong associations with areas with extensive cover. The single capture for *B. brevicauda* also occurred in such an area.

Principal component 3 had a strong negative factor loading for vegetation cover between 1.0 and 2.0 m, or shrub cover. *Peromyscus maniculatus* and *O. nuttalli* occurred in areas with greater shrub cover, while *C. parva* occurred in areas with less shrub cover.

The fourth principal component consisted of shrub cover and variability of surface cover between 0 and 0.5 m. No strong trends are apparent for the 7 species along this axis. However, there is some tendency for *P. maniculatus* to occupy habitats with more shrub cover and less variable surface cover.

The results of the canonical discriminant analysis on the trap station vegetation actually utilized by the 7 species of small mammals are presented in

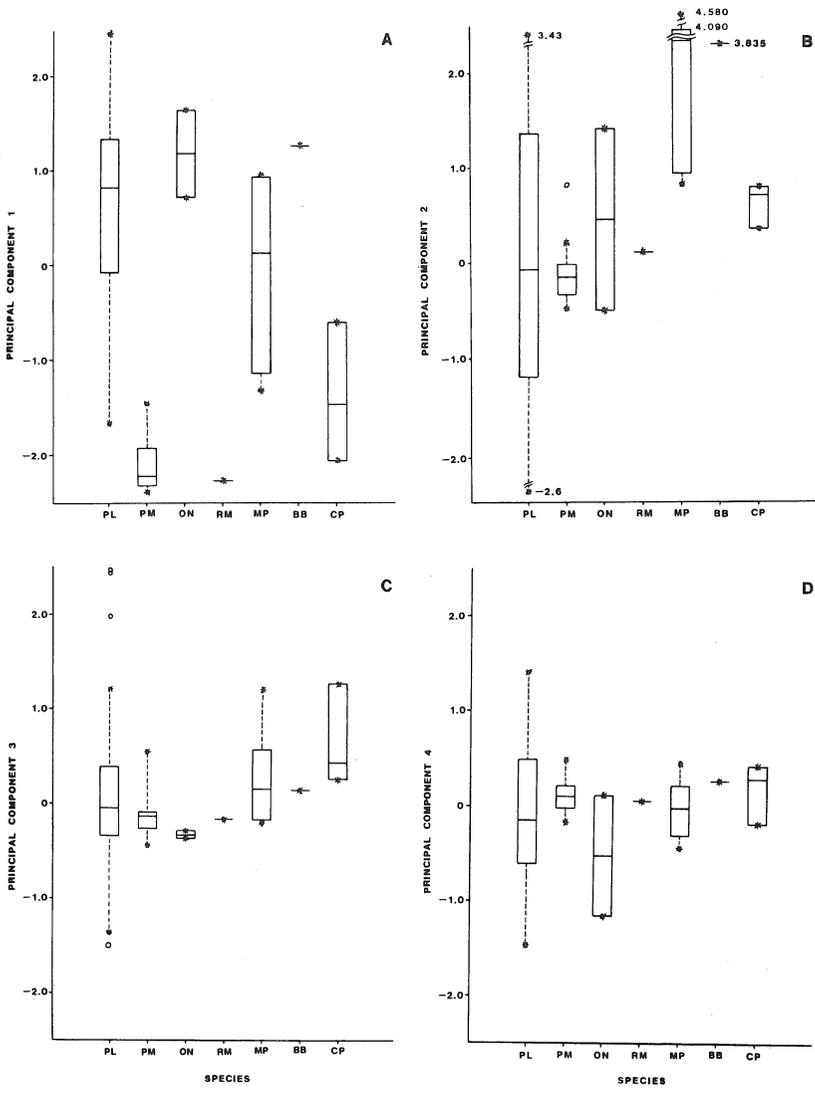


Fig. 1A-D. Nonparametric schematic plots (Tukey 1977) of principal axis factor scores. The principal components analysis was performed on the vegetation data for all trap stations at all 9 study areas. Coefficients for the factors are given in Table 2. The 3 horizontal lines in each box represent the third quartile, median and first quartile, respectively. The asterisks represent pseudo-standard deviations. PL = *Peromyscus leucopus*, PM = *Peromyscus maniculatus*, ON = *Ochrotomys nuttalli*, RM = *Reithrodontomys megalotis*, MP = *Microtus pinetorum*, BB = *Blarina brevicauda* and CP = *Cryptotis parva*.

Table 3. Because of the small sample sizes, these results must be interpreted with caution. As in the analysis of all trap station vegetation, the first canonical discriminant function is dominated by a positive coefficient for canopy cover. The second and third functions are influenced most strongly by herbaceous cover >0.5-1.0 m and variability of herbaceous cover between >0.5-1.0 m, respectively. Both of these coefficients are positive. The remaining canonical discriminant functions were not significant.

Table 3. Standardized canonical discriminant function coefficients for the vegetation data for trap stations at which the 7 species of small mammals were captured. The classification variable was species.

Variable	CDF1	CDF2	CDF3	CDF4	CDF5	CDF6
\bar{X} : 0.0-0.5 m	0.391	-0.005	0.541	-0.455	-0.408	1.015
\bar{X} : >0.5-1.0 m	-0.061	1.212	-0.512	0.251	-0.103	-0.739
\bar{X} : >1.0-2.0 m	0.283	-0.109	-0.283	0.029	0.807	0.623
\bar{X} : >2.0 m	1.152	-0.585	-0.438	-0.624	0.132	0.319
CV: 0.0-0.5 m	-0.043	0.150	0.264	1.059	-0.132	0.446
CV:>0.5-1.0 m	0.356	-0.036	0.879	-0.103	0.442	-0.543
CV:>1.0-2.0 m	0.698	0.045	0.029	0.149	-0.821	-0.394
R^2	0.739	0.388	0.059	0.025	0.008	0.002
F	3.912	1.466	0.341	0.208	0.116	0.055
P	0.0001	0.061	0.997	0.998	0.994	0.947

The plots of the first 3 canonical discriminant functions are given in Fig. 2. The distinct separation along the first 2 canonical discriminant functions is clear. *Peromyscus leucopus* and *O. nuttalli* and to a lesser extent *B. breviceauda* occupied areas with extensive canopy cover while *M. pinetorum* was intermediate and *C. parva*, *R. megalotis* and *P. maniculatus* were in low canopy cover areas. On the second function, *B. breviceauda* and *M. pinetorum* occurred in areas with extensive surface cover, while the remaining species were in areas with intermediate values for surface cover >0.5-1.0 m. Along the third canonical discriminant function *C. parva* occupied areas which exhibited considerable herbaceous cover variability, while *B. breviceauda* habitats were much less variable. The remaining species were intermediate.

Body weights for the small mammal species are presented in Table 4. The results of the ANOVA indicate significant differences ($F = 21.51$, $df = 3,60$, $p < 0.0001$) between the body weights of the 3 *P. leucopus* populations and the *P. maniculatus* population. A Tukey multiple range test showed that the mean body weights of *P. leucopus* at Holly Ridge were not significantly different from those at the Sand Ponds site and both of these populations had body weights which were significantly smaller than those of the *P. leucopus* at Allred Lake. Also, all *P. leucopus* mean body weights were significantly larger than those of *P. maniculatus*.

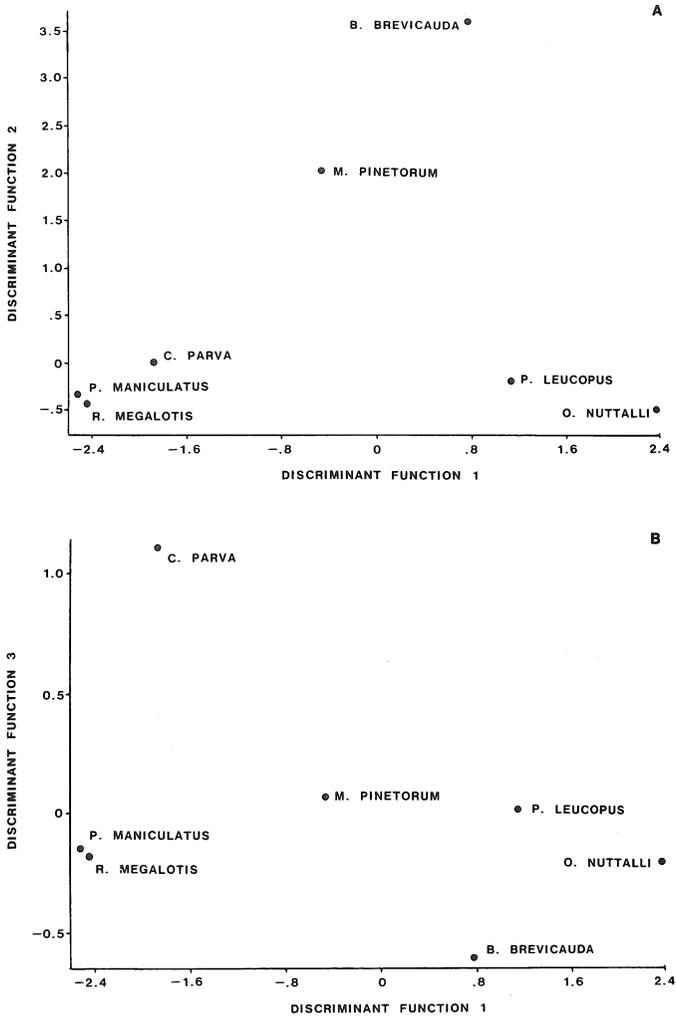


Fig. 2A-B. Plots of the 7 species in the space defined by the first 3 canonical discriminant functions for vegetation at those trap stations actually utilized by the small mammals. Coefficients for the discriminant functions are given in Table 3.

Table 4. Sample sizes, mean body weights and standard deviation of body weights for *P. leucopus* and *P. maniculatus*.

Parameter	<i>P. leucopus</i>			<i>P. maniculatus</i>		
	M ^a	F	Total	M	F	Total
Holly Ridge						
N	8	7	15	—	—	—
\bar{X}	19.81	18.00	18.97	—	—	—
sd	2.42	4.79	3.69	—	—	—
Allred Lake						
N	11	8	19	—	—	—
\bar{X}	25.18	24.00	24.68	—	—	—
sd	6.69	2.93	5.34	—	—	—
Sand Ponds						
N	9	3	12	11	7	18
\bar{X}	20.67	16.33	19.58	14.18	14.50	14.31
sd	2.74	2.08	3.18	2.44	3.01	2.66

^aMale = M, female = F, sample size = N, mean = \bar{X} and standard deviation = sd.

In addition to the differences in body weight for *P. leucopus* noted above, dramatic differences existed in terms of the number of reproductive adult *P. leucopus* at each site. At Holly Ridge, 14.3% of the females and none of the males were reproductively active as determined by palpitation, the presence of perforate vaginas or lactation for the females and scrotal testes for the males. At Sand Ponds, there were no reproductively active females and 11.1% of the males were reproductive. However, at Allred Lake, 62.5% of the females and 76.9% of the males were reproductive.

Discussion

Considerable separation occurred between *P. leucopus* and *P. maniculatus* along the first principal component. *Peromyscus leucopus* occurred in areas with significantly greater canopy cover than *P. maniculatus*. This suggests that *P. leucopus* occurs primarily in deciduous forest while *P. maniculatus* occurs in oldfield situations or open areas. Fleharty and Navo (1983) found that *P. maniculatus* and *R. megalotis* were resident species in irrigated cornfields in Kansas, while *P. leucopus* was transient. Also, Kirkland and Griffin (1974) found a significant negative correlation between "wet" trap sites and the abundance of *P. maniculatus*. Since the deciduous forest habitat at the Sand Ponds site is subjected to annual flooding, *P. maniculatus* may be responding to this feature of the habitat. Parren and Capen (1985) found that *P. maniculatus* utilized microhabitats which were relatively open while *P. leucopus* utilized more thickly vegetated microhabitats. These results are consistent with the findings of this study.

The habitat characteristics of *O. nuttalli* appear to be similar to those of *P. leucopus* (Figs. 1 and 2). However, Seagle (1985) found coexisting *O. nuttalli*

and *P. leucopus* in a cedar glade habitat to utilize significantly different microhabitats. Specifically, *P. leucopus* was associated with non-shrubby wooded microhabitats, while *O. nuttalli* was associated with edge microhabitats. Seagle (1985) did not find these 2 species coexisting in a deciduous forest habitat.

Most of the *M. pinetorum* were captured at the Holly Ridge study site, an upland habitat. Similar results were obtained by Miller and Getz (1969). They trapped both *P. leucopus* and *M. pinetorum* in upland oak forests and lowland swamps and found that only a small percentage of their captures for *Microtus* occurred in lowland swamp habitats.

The second shrew observed in this study, *C. parva*, was most similar in its habitat utilization to *P. maniculatus* and *R. megalotis* and most distinct from *P. leucopus* and *O. nuttalli* (Figs. 1 and 2). In general, it occupied habitats with reduced canopy cover, considerable surface cover and minimal understory vegetation. Golley (1962) found the least shrew to prefer grasslands even when woodlands were available. Likewise, Porter and Dueser (1982) found that *C. parva* utilized habitats with reduced shrub cover and extensive herbaceous cover. At the same time, *P. leucopus* occupied areas with a greater shrub cover and less herbaceous cover than *Cryptotis*. These results are consistent with those found in my study.

Aside from the habitat utilization data, there is some circumstantial evidence which may indicate a competitive shift between *P. leucopus* and *P. maniculatus*. The lowest mean body weights for *P. leucopus* (19.583 g, 18.967 g) occurred at Sand Ponds and Holly Ridge, respectively. These sites also had species diversity values ($H = 1.182$, $H = 1.092$) which were considerably greater than the species diversity value of the Allred Lake site ($H = 0.794$). Thus, low body weights for *P. leucopus* corresponded to high species diversity. This result is consistent with the predictions of the competition hypothesis (May 1976, Pianka 1974). Although other factors such as habitat productivity may be responsible for the shifts in body weight, it is interesting to note that at both the Holly Ridge and Sand Ponds study sites closely related species with similar dietary patterns coexist with *P. leucopus*. *Ochrotomys nuttalli* coexists with *P. leucopus* at Holly Ridge while *P. maniculatus* coexists with *P. leucopus* at Sand Ponds. Furthermore, the body weights of *P. maniculatus* were considerably smaller than the mean body weights reported in the literature (Myers and Master 1983, Drickamer and Bernstein 1972, Dunmire 1960) again suggestive of a competitive shift.

The differences in body weights do not appear to result from reproductive conditions of the female mice, since at all 3 sites, weights of the males reflected those of the females (Table 4). At the site with low species diversity (reduced diffuse competition) body weights were high and most of the mice were reproductively active, while at the high diversity sites (greater diffuse competition) body weights were reduced and reproduction was minimal. However, these results are consistent with the hypothesis that the Allred Lake study site was a more productive or better habitat for *P. leucopus*.

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Seasonal Tenancy of Artificial Nest Structures for Tree Squirrels

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Abstract: Seasonal occupancy data were compiled on 234 artificial nest structures installed for squirrels in 7 central Missouri woodlots during 1954-1977. Occupancy rate of 165 den boxes was 18% with 26% in winter, 21% in spring, 10% in fall and 4% in summer. Occupancy rate of 69 tire nest structures was 15% in spring, the only period of inspection. Of the den boxes with squirrels, 81% were occupied by fox squirrels (*Sciurus niger*) and 19% by gray squirrels (*S. carolinensis*); of these 14% housed litters (90% fox squirrels). Artificial nest structures offer squirrels a choice of housing, often an improvement over natural structures available, improving chances of survival of both young and adult, especially where foods are sufficient but suitable natural dens are scarce. Tire nests were less expensive, more durable and less attractive to other wildlife than nest boxes.

Key Words: Missouri, tree squirrels, artificial nest structures, tenancy, seasons

Introduction

A squirrel den has been defined as a tree cavity suitable for litter rearing and winter shelter (Sanderson 1975). Artificial nest structures have been used to supplement natural dens where deficiencies exist (Sanderson 1975, Nixon 1979). The use of artificial nest structures has been found to increase the carrying capacity of woods for gray squirrels as a result of improved survival of both young and adult (Barkalow and Soots 1965, Burger 1969). Response to nest boxes by fox squirrels has been less positive (Nixon et al. 1984). A study of artificial nest structures used in central Missouri woodlots was conducted to determine the nature of squirrel occupancy by season.

Description of Study Areas

The 7 woodlots selected for installation of nest structures were <20 acres and considered of average quality for private ownerships (5) and state-owned areas (2) in Missouri. Timber cruises were conducted on 5 of the areas in 1958 by Missouri Department of Conservation foresters and these data provided some indication of the quality and condition of the mixed hardwood stands (Table 1).

Materials and Methods

Occupancy data were compiled from 3894 seasonal inspections of 234 artificial nest structures. Structures were evenly distributed, about 5 chains apart, at the rate of 2.5 structures per acre in 7 central Missouri woodlots for the period

Table 1. Timber cruise description of study areas.

Woodlot, acres	Composition	Merchantable trees/acre	Near merchantable trees/acre	Growth rate years/inch	Harvestable timber b.f./acre	Cull trees/ acre	Condition
Ashland 8.4	White oak Northern red oak Hickory	35	14	7.0	530	9	No grazing; no recent fire
Glenn 10.8	White oak Post oak Northern red oak Shingle oak Hickory Walnut	41	26	7.5	700	4	Once lightly cut for stave bolts
Griffin 9.2	Northern red oak Sugar maple Elm Honey locust Sycamore	14	0	5.5	637	9	Considerable grazing damage
Ridge 8.0	White oak ½ pole timber	17	21	6.5	54	3	No evidence of grazing or fire damage
Robinson 20.0	White oak Northern red oak Elm Hickory Sycamore River birch Hackberry Basswood	34	4	6.5	1815	1	No grazing or fire damage

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Table 1 (continued).

Woodlot, acres	Composition	Merchantable trees/acre	Near merchantable trees/acre	Growth rate years/inch	Harvestable timber b.f./acre	Cull trees/ acre	Condition
Bennitt ^a 3.6	White oak Black oak Northern red oak Hickory					Probably high %	Evidence of cut-over and fire damage
Smar ^a 6.0	Mixed hardwoods	Few	Pole timber				Protected from grazing and fire

^aNot cruised.

1954-1977 (Fig. 1). Sanderson (1975) considered 1 den per 2 acres the minimum necessary to ensure suitable winter shelter for gray squirrels capable of providing average hunting success.

Nest boxes equipped with hinged tops, were constructed of 1-inch rough-cut cypress (Christisen 1964). Bennett Woodlot, in addition to boxes (9), received an installation of auto tire nests (69). Nest structures were erected facing a southerly direction with the entrance height at 17-27 feet; inspections were made by using

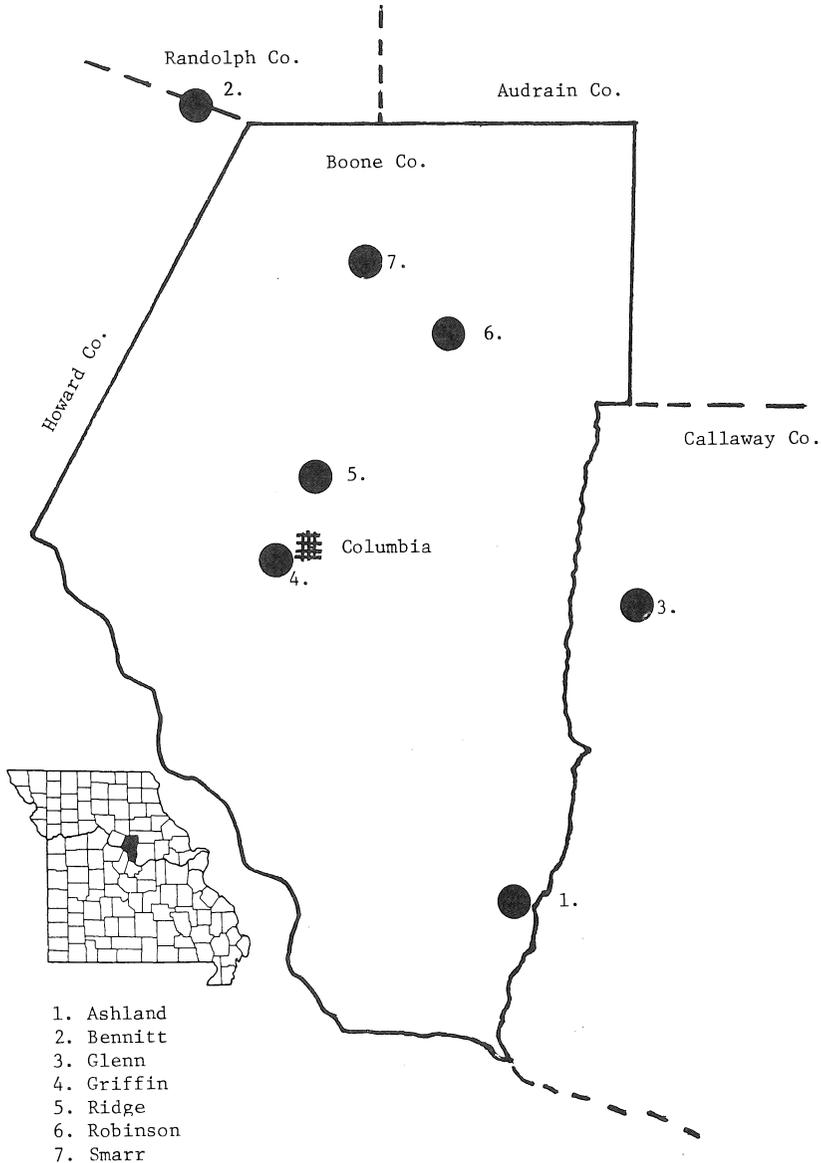


Fig. 1. Study area woodlots.

a 32-foot aluminum extension ladder. Nest structures created from used auto tires were installed in the same manner as the boxes (Shelton 1974).

Results and Discussion

A comparison of seasons on the basis of all woodlots combined showed the greatest occupancy of squirrels to be in winter (26%), followed by spring (21%), fall (10%) and summer (4%) (Table 2). Squirrel litters were found more frequently in the spring and winter seasons. Occupancy for all animals was greater in spring because of nesting birds.

Occupancy of the Ashland boxes for 11 winter seasons ranged from 0 to 57% and averaged 26.2%. Occupancy of the Glenn boxes for 11 winter seasons ranged from 7.7 to 68% and averaged 26.4%. Occupancy of the Griffin boxes for 8 winters ranged from 19 to 43% and averaged 26.8% and occupancy of Robinson boxes for 11 winters ranged from 10 to 38% with an average of 20.4%. The occupancy rate of Ridge boxes was exceptional for the 5 winter seasons 50, 55, 52.6, 27.8 and 55.6% with an average of 48.4%.

Tire nests were inspected only in the spring season; 14.5% were occupied by squirrels and 5.4% by flying squirrels. Of the 166 inspections, squirrels occupied tires 24 times and flying squirrels were present on 9 occasions. No other animals were observed. Tire structures tended to be mammal specific, mostly because they were unsuitable for bird nesting. These data were not included with the box occupancy tabulations.

Of the 684 inspections of boxes with squirrels, 80.6% were occupied by fox squirrels and 19.4%, by gray squirrels, probably a reflection of the species composition and habitat. Among 6 major study areas, the species occupancy ranged from 35% fox squirrel-65% gray (Smarr) to 100% fox squirrels (Glenn).

It was not uncommon to find 2 adult or yearling gray squirrels occupying a nest box; 15% of the gray squirrel occupancies were two-somes, 8% had 3 squirrels and 1.5% had 4. Even the smaller nest tires held 2 gray squirrels on occasions. The Ashland boxes were slightly larger than the standard box placed elsewhere; this may have encouraged aggregate housing. This trait was less common in fox squirrels, although 5% of the occupancies were two-somes and 0.5% were 3 squirrels. Of the boxes occupied by squirrels, 13.6% housed litters (90% fox squirrels) and comprised 11.3% of the occupancies.

Artificial nest structures for squirrels appeared to have greater impact on holding and increasing squirrel carrying capacity in winter and spring, the most critical time of year for survival, than in summer and fall. Squirrel occupancy in winter ranged from 20.4% (Robinson) to 48.9% (Smarr) and for spring from 13.3% (Griffin) to 52.2% (Smarr; Table 2). There were no discernible differences in acceptance of the artificial nest structures by species.

Flying squirrels, opossums, deer mice, screech owls, nuthatches, titmice, yellow-shafted flickers, red-bellied woodpeckers, eastern wood pewees, pilot black snakes, tree frogs, skinks, honeybees, bumblebees, wasps, termites and roaches were also observed to occupy boxes.

It appeared that nest structures could benefit screech owls (*Otus asio*) and flying squirrels (*Glaucomys volus*). Screech owls comprised 6.2% and flying squirrels 4.3% of the occupancies. The Glenn and Griffin woodlots in this study seemed to excel in populations of screech owls. Ridge and Robinson seemed to support more flying squirrels than the other woodlots.

Table 2. Nest box occupancy by squirrels and other animals by area and season.

Area/ season	Number of boxes	Number of boxes occupied						Total inspections	Percent occupancy	
		Fox squirrels	Gray squirrels	No. of litters	Flying squirrels	Screech owls	All animals		Squirrels	Animals
ASHLAND	21	44	54	13	1	1	101	564	17.4	17.9
Spring		9	26	6			36	167	21.0	21.6
Summer							0	63	—	—
Fall		1	2	1	1	1	5	105	2.9	4.8
Winter		34	26	6			60	229	26.2	26.2
BENNITT	9	1	11	0	5		17	43	27.9	39.5
Spring		1	6	0	2		9	25	28.0	36.0
Summer										
Fall										
Winter		0	5	0	3		8	18	27.8	44.4
GLENN	27	130	0	14		19	153	650	20.0	23.5
Spring		36	0	5		7	47	157	22.9	29.9
Summer		6	0	3			6	76	7.9	7.9
Fall		12	0	0		3	15	129	9.3	11.6
Winter		76	0	6		9	85	288	26.4	29.5
GRIFFIN	23	89	25	11	1	25	154	667	17.1	23.1
Spring		25	8	9	1	10	52	248	13.3	21.0
Summer		3	2	0			10	91	5.5	11.0
Fall		22	9	0		8	40	160	19.4	25.0
Winter		39	6	2		7	52	168	26.8	31.0
RIDGE	20	55	7	11	12	4	81	191	32.5	42.4
Spring		10	2	3	6	1	22	58	20.7	37.9
Summer										
Fall		3	1	0	2		6	38	10.5	15.8
Winter		42	4	8	4	3	53	95	48.4	55.8

Table 2 (continued).

Area/ season	Number of boxes	Number of boxes occupied						Total inspections	Percent occupancy	
		Fox squirrels	Gray squirrels	No. of litters	Flying squirrels	Screech owls	All animals		Squirrels	Animals
ROBINSON	50	215	5	37	16	0	264	1521	14.5	17.4
Spring		77	0	18	7		94	396	19.4	23.7
Summer		10	0	3	4		23	244	4.1	9.4
Fall		22	2	1	3		31	346	6.9	9.0
Winter		106	3	15	2		116	535	20.4	21.7
SMARR	15	17	31	7		2	52	92	52.2	56.5
Spring		7	19	3		1	29	47	55.3	61.7
Summer										
Fall										
Winter		10	12	4		1	23	45	48.9	51.1
GRAND TOTAL	165	551	133	93	35	51	822	3728	18.3	22.0
Spring		165	61	44	16	19	289	1098	20.6	26.3
Summer		19	2	6	4	—	39	474	4.4	8.2
Fall		60	14	2	6	12	97	778	9.5	12.5
Winter		307	56	41	9	20	397	1378	26.3	28.8

Tire nest structures were not conducive to bird nests, perhaps because of the shape and smaller dimensions for nest building. Other than tree squirrels, animal use was exclusively that of flying squirrels. Their durability and availability make tires desirable as nest structures.

Conclusions

Artificial nest structures were heavily used by squirrels in the winter and spring and to a lesser extent in the fall. Little use of artificial structures occurred in summer. Artificial nest structures enhanced habitat for squirrels by providing substantial protection from weather and predators, particularly for bearing and rearing young.

Tires, as nest structures for squirrels were more durable and less attractive to other wildlife. Tires likely are more resistant to shot and bullet penetration. Artificial nest structures of wood had greater aesthetic value than tires but proved more expensive and awkward to install.

Other authors have found that artificial nest structures improved survival of squirrels and thereby increased the squirrel population of woodlots deficient in natural dens but having sufficient foods.

Artificial nest structures were favored by greater numbers of gray squirrels per structure than fox squirrels. Use of slightly larger boxes in gray squirrel range would be an appropriate technique for offering protection to more squirrels.

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Characteristics of Coyote Dens and Den Sites in Central Missouri

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Abstract: Quantitative information is presented about 48 coyote (*Canis latrans*) dens studied on a 274 km² area in north-central Missouri during February-June 1975 and 1976. The area consists of broad ridges, mostly farmed, dissected by wooded draws tributary to 3 major creeks. Thirty-one dens contained pups and 17 others showed signs of recent use by coyotes. Thirty dens were burrows and 18 were cavities at bases of trees or inside hollow logs, or shallow depressions in thickets or under brush piles. Dens were in flat or gently rolling terrain. However, 48% were in shallow, steep banks of pond dams, small creek banks or gullies. Grasses were the dominant vegetation at 21 den sites, but 15 were in rose (*Rosa multiflora*) or bramble (*Rubus* sp. and *Ribes missouriense*) hedges or thickets. Thirty-four (71%) of the dens were in or on loamy soils; 73% were within 100 m of open water. Most (73%) dens were on southerly (135-225°) slopes. Although some tendencies in den-site selection are apparent, the findings reaffirm the opportunism of the coyote.

Key Words: Coyote, *Canis latrans*, den sites, Missouri

Introduction

It is surprising that published quantitative information on coyote den-site characteristics is quite scarce, despite the importance of the information both to students of coyote biology and to animal damage control personnel. "Den hunting" and destroying the pups is a traditional (Young and Dobyns 1937) and effective (Till and Knowlton 1983) means of reducing coyote depredations on livestock in the west.

Recently, Althoff (1980) provided data on locations, site characteristics and dimensions of coyote dens in an area of intensive cultivation in southeastern Nebraska, as did Harrison and Gilbert (1985) in a forested area in eastern Maine. In an unpublished MS thesis, Rock (1978) provided data about 23 dens in the mixed prairie of Saskatchewan.

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The purpose of this paper is to present detailed data about 48 coyote dens found in agricultural and forested land in north-central Missouri, and to evaluate them in the perspective of quantitative information from the above-mentioned 3 other locations.

Study Area and Methods

Dens were found on a 274 km² area near Columbia, Boone County, north-central Missouri. The study area is a mosaic of mixed hardwoods, rowcrops, pastures and old fields. Uplands are broad, flat or gently undulating ridges; before settlement, they were fingers of prairie (Schroeder 1981). The ridges are dissected by drainages leading to 3 creeks. Maximum relief, ridgetop to creek bottom, is about 100 m. During the study, 58% of the area was farmland; of this 45% was rowcrop.

We spent 1200 hours repeatedly searching all known denning areas, all areas containing coyote sign and areas where coyote pups were reported from February through June 1975 and 1976. Adult coyotes were also radio-tracked to some dens. No attempt was made to search randomly for dens.

Dens were considered to be the discrete areas used for whelping or rearing pups. By "den sites" we mean the immediate surroundings of dens. Dens were recorded as active if pups were present or within 100 m of them. Those classified as inactive showed signs of recent occupancy by coyotes, including scats, tracks, odor, trampled vegetation or litter near the entrance (see Sheldon 1950 and Foreyt and Rubenser 1980).

At each den, physical characteristics of the surroundings, aspect (direction of slope containing entrance or den site), dominant vegetation and den measurements were recorded. Topography was tallied as flat, rolling or steep. The major soil components within the tunnels or at dens without tunnels were the soil types of record.

We secured information on conformation of tunnels and location, arrangement and contents of den chambers at 9 dens by excavating them.

Results and Discussion

Den Locations

Forty-eight coyote dens were found; 31 (65%) contained coyote pups and 17 were inactive (Table 1). All dens were in flat or gently rolling terrain, usually at the junction of 2 or more cover types, 1 of them brush or woods. No dens were found in areas of large, abrupt relief such as the bluffs lining the major streams. Twenty-three (48%) dens in Missouri were in steep banks including 11 on pond banks, 7 in creek banks and 5 in sheer gully banks in fields or pastures. The remaining 25 dens were in fencerows (6), woody draws (5), grassy waterways (4) and miscellaneous (10) (Table 1).

Of 16 dens in an intensively farmed portion of Nebraska, 11 were in fencerows, native-grass patches, drainage ditches or draws and 5 were in thickets (Althoff 1980). Cropfields were within 10 m of all but 1 den and none were in woodlots. In contrast, 5 of 7 coyote dens studied in Maine (Harrison and Gilbert 1985) were in or near regenerating hardwoods. All but 1 of the 23 dens in Saskatchewan were found in native prairie which comprised only 37% of the area and was associated with stream valleys. Four dens were surrounded by

Table 1. Characteristics of 48 coyote dens and den sites in north-central Missouri, 1975-76.

Den location	Type of den	Dominant vegetation at den site	Aspect (°)	Soil	Distance to water (m)	Width of entrance (cm)	Tunnel depth (cm)
<i>ACTIVE</i>							
Grassy waterway	Depression under brush pile	None	315	Loam	60	NA*	NA
Creek bank	Cavity (500 x 25 cm) in live tree base	<i>Ribes missouriense</i> (Missouri gooseberry)	270	Loam	2	28	NA
Cropfield	Depression under brush pile	None	135	Sandy loam	120	20	10
Fencerow	Flattened area under 20 x 200 m hedge	<i>Rosa multiflora</i> (Multiflora rose)	180	Loam	200	NA	NA
Pasture	Flattened area under 2 x 15 m hedge	<i>Rosa multiflora</i>	135	Loam	30	NA	NA
Pond bank	Flattened area under 2 x 40 m hedge	<i>Rosa multiflora</i>	135	Loam	2	NA	NA
Grassy waterway	Cavity (30 x 60 cm) in live tree base	<i>Festuca elatior</i> (Meadow fescue)	225	Sandy loam	150	20	NA
Cropfield	Burrow under building	<i>Poa pratensis</i> (Kentucky bluegrass)	270	Loam	200	12	30
Fencerow	Burrow	<i>Poa pratensis</i>	225	Clay	400	24	107

Table 1 (continued).

Den location	Type of den	Dominant vegetation at den site	Aspect (°)	Soil	Distance to water (m)	Width of entrance (cm)	Tunnel depth (cm)
<i>ACTIVE</i> (continued)							
Creek bank	Burrow	<i>Diospyros virginiana</i> (Persimmon)	225	Loam	3	50	65
Pasture	Burrow under brush pile	<i>Quercus</i> sp. (Oak)	225	Loam	200	10	60
Grassy waterway	Burrow	<i>Festuca elatior</i>	360	Loam	61	20	122
Pond bank	Burrow	<i>Festuca elatior</i>	180	Loam	1	41	160
Gully bank	Gully under brush pile	None	180	Clay	400	ND	ND
Woody draw	Burrow	<i>Sassafras albidum</i> (Sassafras)	135	Loam	3	22	152
Pond bank	Burrow	<i>Rosa multiflora</i>	180	Sandy loam	1	24	60
Forest border	Hollow log (99 cm diam.)	<i>Ribes missouriense</i>	135	Loam	10	NA	NA
Old field	Depression in thicket	<i>Rubus</i> sp. (Blackberry)	270	Sandy loam	100	NA	NA
Pond bank	Burrow	<i>Festuca elatior</i>	360	Loam	1	30	90
Pond bank	Burrow under hedge	<i>Rosa multiflora</i>	270	Loam	100	20	ND
Pasture	Brush pile	<i>Festuca elatior</i>	180	Loam	60	NA	NA
Fencerow	Depression in thicket	<i>Rosa multiflora</i>	180	Loam	50	NA	NA

Table 1 (continued).

Den location	Type of den	Dominant vegetation at den site	Aspect (°)	Soil	Distance to water (m)	Width of entrance (cm)	Tunnel depth (cm)
<i>ACTIVE</i> (continued)							
Forest	Flattened area in thicket	<i>Ribes missouriense</i>	135	Clay	20	NA	NA
Woody draw	Flattened area in thicket	<i>Rubus</i> sp.	225	Loam	4	NA	NA
Gully bank	Burrow	<i>Festuca elatior</i>	180	Sandy loam	<1	50	60
Woody draw	Brush pile	<i>Quercus</i> sp.	135	Loam	5	NA	NA
Pond bank	Depression under hedge	<i>Rosa multiflora</i>	135	Loam	1	NA	NA
Woody draw	Burrow	<i>Festuca elatior</i>	90	Sandy loam	20	20	122
Woody fencerow	Burrow	<i>Quercus</i> sp.	225	Loam	500	41	92
Forest	Flattened area in thicket	<i>Quercus</i> sp.	225	Loam	500	NA	NA
Creek bank	Burrow	<i>Festuca elatior</i>	180	Loam	3	42	ND
<i>INACTIVE</i>							
Creek bank	Burrow	<i>Festuca elatior</i>	225	Loam	1	20	90
Grassy waterway	Depression under brush pile	None	135	Loam	150	NA	NA
Woody draw	Burrow	<i>Ribes missouriense</i>	225	Loam	2	9	127
Gully bank	Burrow	<i>Poa pratensis</i>	113	Loam	1	24	180

Table 1 (continued).

Den location	Type of den	Dominant vegetation at den site	Aspect (°)	Soil	Distance to water (m)	Width of entrance (cm)	Tunnel depth (cm)
<i>INACTIVE</i> (continued)							
Gully bank	Burrow	<i>Festuca elatior</i>	180	Sandy loam	50	30	90
Cropfield	Burrow under building	<i>Festuca elatior</i>	180	Loam	400	30	30
Pond bank	Burrow	<i>Rubus</i> sp.	270	Sandy loam	1	36	122
Creek bank	Burrow	<i>Poa pratensis</i>	270	Loam	1	41	92
Creek bank	Burrow	<i>Ulmus americanus</i> (American elm)	225	Loam	3	50	ND
Brushy fencerow	Burrow in thicket	<i>Rubus</i> sp.	135	Sandy loam	1	ND	ND
Pond bank	Burrow	<i>Festuca elatior</i>	180	Sandy loam	1	46	146
Pond bank	Burrow	<i>Festuca elatior</i>	225	Clay	3	24	ND
Gully bank	Burrow	<i>Festuca elatior</i>	270	Loam	1	30	70
Pond bank	Burrow	<i>Gleditsia triacanthos</i> (Honey locust)	225	Sandy loam	2	24	60
Pond bank	Burrow	<i>Festuca elatior</i>	180	Loam	1	30	122
Woody fencerow	Burrow	<i>Festuca elatior</i>	180	Loam	200	32	60
Creek bank	Burrow	<i>Festuca elatior</i>	270	Loam	500	42	92

*NA = not applicable; ND = no data.

cultivated fields, the predominant land-use type (Rock 1978). In Iowa, typical dens were generally within or very near timber or brush cover (Andrews and Boggess 1978).

Types of Dens

Thirty dens were burrows with a main entrance leading to a tunnel system (Table 1). These burrows were excavations made or appropriated by coyotes: 2 were short burrows under abandoned farm buildings and 3 were tunnels under a brush pile, hedge or thicket. At least 7 of the 30 burrows were dug by coyotes, 2 by badgers (*Taxidea taxus*), 2 were previously occupied by red foxes (*Vulpes fulva*) and 2 by woodchucks (*Marmota monax*).

The 18 dens that were not burrows were shallow depressions or flattened areas under brush piles (6), thickets (5), or hedges (4) or in cavities at the bases of live trees (2) and in a hollow log (1).

In Iowa, typical dens were short bank holes, hollow tree trunks and abandoned badger diggings (Andrews and Boggess 1978). In some instances, cupped-out pockets under thickets or brush piles and depressions at the bases of trees served as dens for coyotes in Kansas (Gier 1968) and in Maine (Hilton 1978, Harrison and Gilbert 1985). From the central plains to New England, coyotes use abandoned dens or those from which other animals have been evicted (Gier 1968, Hilton 1978, Althoff 1980, Harrison and Gilbert 1985).

Dominant Vegetation at Den Sites

Grasses (see Table 1 for scientific names) were the dominant vegetation at 21 den sites whereas 15 dens were in multiflora rose, gooseberry or blackberry hedges or thickets, 8 were under woody vegetation (oak, elm, locust, persimmon, sassafras) and 4 were nearly devoid of living vegetation.

Prominent vegetation near dens included brome grass (*Bromus* sp.) in Nebraska (Althoff 1980), native pasture in Saskatchewan (Rock 1978), black spruce (*Picea marina*) in Maine (Harrison and Gilbert 1985) and gooseberry (*Ribes* sp.) in Iowa (Andrews and Boggess 1978).

Aspect

Thirty-five (73%) den sites were on slopes facing southward (135-225°), 8 faced west (270°), 3 were oriented northward (315-360°) and 2 entrances were exposed to the east (90-113°) (Table 1). Juvenile coyotes in Missouri were observed sunning next to den entrances after 3 weeks of age (Hallett 1977); sunny locations seemed important in site selection.

In the Great Plains, coyote dens were reported on the warmer, south-facing slopes (Dobie 1949, Gier 1968, Lemm 1973, and Rock 1978). All 6 den openings recorded in Maine were southward-oriented (120-236°) (Harrison and Gilbert 1985), but in Nebraska Althoff (1980) reported that 14 openings in 10 dens faced north and east.

Soil

Thirty-four dens (71%) were situated in or on loamy soils, 10 (21%) were in sandy loam and only 4 were in clay (Table 1). All 6 dens observed in Maine by Harrison and Gilbert (1985) were in well-drained, sandy loam soils. Althoff (1980) found 12 of 16 coyote dens in Nebraska in loam soils, and suggested ease of digging as a factor. Our data support this suggestion.

Distance to Water

Thirty-five dens (73%) in north-central Missouri were within 100 m of open water and 22 of these were within 3 m. The mean distance between active dens and open water was 104 m. Coyote dens also were located near water sources in other areas (Young and Jackson 1951, Andrews and Boggess 1978, Hilton 1978, Rock 1978). However, Althoff (1980) reported over ½ of the coyote dens in Nebraska were ≥ 200 m from water, and Young and Jackson (1951) stated that dens in eastern Oregon may be nearly 10 km from water. Although coyotes in many areas including north-central Missouri locate their dens near water, presence of water may be an incidental feature of den-site location.

Den Arrangements and Dimensions

Dens varied from flattened areas or depressions 10 cm deep to multi-tunneled burrows as long as 4 m and up to 1.8 m deep. Entrances to active dens were usually 20-30 cm wide (mean = 29.4 cm) and rarely exceeded 41 cm (Table 1). Similar entrance sizes were reported for dens in Nebraska (Althoff 1980). Most burrows in Missouri were descending tunnels with 1-2 branches. In our study, 5 of 30 burrows had more than 1 active entrance. The mean number of actively used openings per den in Nebraska was 1.4 (Althoff 1980).

In our study, the mean depth (distance between main entrance and floor of tunnel or chamber) of dens was 92.7 cm. Tunnel length averaged 2.1 m. Soil depth to the main-chamber ceiling in coyote dens in Nebraska ranged from 61 to 122 cm (Althoff 1980). We found 1 den chamber in each of the 9 dens we excavated; similarly, Harrison and Gilbert (1985) recorded 1 chamber each in 5 of 7 dens in Maine. In our study, the chambers were either midway along a tunnel or at the end.

Heights of 5 den chambers ranged from 25 to 50 cm and widths from 50 to 99 cm. Althoff (1980) reported chamber heights ranging from 18 to 51 cm.

Entrances to 31 active dens and the chambers of 9 dens in Missouri were devoid of prey remains, adult scats or vegetation. These findings were similar to those of Harrison and Gilbert (1985) in Maine, but Gier (1975) reported that some female coyotes in Kansas prepared a grass, leaf or fur-lined nest.

Spacing

Distances between the nearest coyote dens in Missouri averaged 2.5 km in 1975 and 1.7 km in 1976. In Nebraska, Andelt et al. (1979) and Althoff (1980) reported spacings of 1.1-3.9 km between dens used by the same females but Gier (1968) stated that the distance between the nearest active coyote dens in Kansas ranged from 0.4 to 0.8 km.

Dispersion of dens, indicated by nearest-neighbor analyses (Clark and Evans 1954) was not random for 48 dens in Missouri ($P < 0.05$). Nearest dens were approximately half as far apart as expected under conditions of randomness ($R = 0.55$), suggesting that coyotes aggregate dens. Althoff (1980) also found a non-random dispersion pattern.

Conclusion

Coyotes display opportunism in den-site selection, but some selectivity is observed. Coyote dens in Missouri and in 3 other locations where quantitative information was provided show selection according to type and intensity of land

use. In Nebraska, coyotes in land dominated by agriculture denned in habitat not suitable for farming or grazing (Althoff 1980). In Saskatchewan, most dens were located in patches of native prairie surrounded by lands planted to cereal grains or associated with major drainages (Rock 1978). In Maine, coyotes selected den sites on well-drained knolls or hummocks in lowlands or bogs (Harrison and Gilbert 1985).

A predilection for south- and west-facing slopes for denning was shown in 3 of 4 studies. In Missouri (this study) and Nebraska (Althoff 1980) coyote dens were aggregated, but spacing in Saskatchewan may have been influenced by deliberate destruction of dens (Rock 1978). Most of the dens in all 4 studies were situated in well-drained soils. Proximity of open water was evidently not a factor in den selection in at least 1 study (Althoff 1980).

In north-central Missouri, coyote dens can most likely be found on south-facing slopes of pond dams or at heads of woody or brushy draws in agricultural land, and within 100 m of open water.

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Testicle Sizes and Their Correlations to Swine Traits

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Abstract: Purebred boars were used to evaluate the effect of breed on testicle size (length and width), days to 104 kg live weight, average daily gain, loin eye area, backfat thickness, index and feed efficiency. Analysis of variance indicated that breed had a significant influence on testicle length ($P < 0.0001$), testicle width ($P < 0.001$), days ($P < 0.02$), backfat thickness ($P < 0.004$), index ($P < 0.0003$) and feed efficiency ($P < 0.0001$). All possible trait correlation coefficients are reported and the trait least squares means were significantly separated.

Key Words: Testes measurement, correlation coefficients, swine performance traits

Introduction

The importance of testes size has been demonstrated in beef cattle. Coulter et al. (1976), Coulter (1980) and Neely et al. (1980), have demonstrated that testes measurements are highly heritable and are of some use for estimating sperm production, and Brinks et al. (1978) and Toelle (1984) suggest testicle measurements can be used in sire selection to produce more prolific heifers. Knight (1977) and Notter et al. (1981) found that testicular size can be measured accurately in live animals.

In swine, Hauser et al. (1952), Wilson et al. (1977), Neely et al. (1980), and Fent et al. (1983) have published significant heterosis effects for testicle width and sperm production. In mice studied by Islam et al. (1975) and in sheep by Land et al. (1979) a correlated improvement in female prolificacy from selecting for larger male testicle size was demonstrated.

Toelle (1984) used Duroc and Yorkshire boars to demonstrate a 0.16-0.25 heritability estimate for testicle size measurements at 168 days of age ranged from 0.16 to 0.36 for both breeds.

The major objective of this experiment was to study correlation coefficients between live animal testicle size and swine traits of economic importance. A secondary objective was to compare testicle size among different breeds of swine. In addition, the study examined the breed effect on traits of economic importance.

Materials and Methods

Data were obtained from 149 boars of 7 different breeds evaluated at the Southeast Missouri State University Swine Test Station in Cape Girardeau, MO. This represents boars evaluated in a 1-year period. Body weights and testicle length and width (right and left) were measured in intact boars at approximately 104 kg and 160 days of age. Testes measures were not adjusted for body weight at the time of measurement since they have been reported to be moderately to

highly correlated (Hauser et al. 1952). Adjustments may incorrectly consider genetics. Correlations were from analyses not including age in the model.

Backfat depth and loin eye area were measured with ultrasonics. Backfat thickness was reported as an average of 3 measurements from the first rib, last rib and last lumbar vertebra. The loin eye area measurement was obtained from the longissimus dorsi muscle between the tenth and eleventh ribs.

Boars were indexed for sale purposes upon completion of their official test. This index was used in the correlation model. The National Swine Improvement Federation Index was:

$$\text{Index} = 100 + 60(\bar{G}) - 75(\bar{F}) - 70(\bar{B})$$

where

\bar{G} = average daily gain of individual

\bar{G} = average daily gain of contemporaries

\bar{F} = feed efficiency of individual

\bar{F} = feed efficiency of contemporaries

\bar{B} = backfat thickness of individual

\bar{B} = backfat thickness of contemporaries

Feed efficiency was calculated on each animal. On-test weight was 31.75 kg and off-test weight was 104 kg. Boars were evaluated in a 3-boar sire group. Feed efficiency is an average of the group of 3.

Least squares means, correlations and analysis of variance were calculated from these data using a SAS package implemented by Helwig and Council (1979).

Results and Discussion

The mean squares and standard deviations for days to 104 kg average daily gain, loin eye area, backfat thickness, index and feed efficiency are presented in Table 1. Breed differences were important ($P < 0.05$ - $P < 0.001$) for days to 104 kg, backfat thickness, index and feed efficiency. Breed means were compared using the least significant difference test ($P < 0.05$). The means that display differences were separated by use of superscripts.

Table 2 reveals least squares means and standard deviations for testicle width and length by breeds. Breed was a significant influence on width ($P < 0.0001$) and length ($P < 0.0001$) as determined by the analysis of variance. Testes means were also separated by the least significant difference test ($P < 0.05$). Greater average width was displayed by the Yorkshire breed. Hampshire boars had the smallest testicle width and length and Spots had the longest testicles.

Table 3 contains correlation coefficients and their level of significance between various swine traits. Days to 104 kg was found to be significantly correlated to average daily gain, backfat, loin eye area, feed efficiency and testicle length. All these results have been reported by other authors (Lasley 1978) except the relationship between production traits and testicle length. Average daily gain was significantly correlated with days to 104 kg, backfat thickness, index, feed efficiency, testicle width and testicle length. The correlation between average daily gain and testicle width and length may indicate that faster gaining boars have larger testicles. Table 3 also displays that testicle width is positively correlated with testicle length, indicating that a boar with wider

Table 1. Least square means and standard deviations for boar traits.

Breed	N	Days*		ADG		LE		BF*		I*		F/G*	
		Mean	SD	Mean ¹	SD	Mean ²	SD	Mean	SD	Mean	SD	Mean ³	SD
Yorkshire	39	158 ^{b**}	10.1	0.95	0.10	2.22	0.07	0.77 ^{ad}	0.06	107.6 ^a	26.6	1.17 ^b	0.10
Spots	24	161 ^b	14.3	0.95	0.10	2.20	0.15	0.75 ^a	0.07	85.9 ^a	14.9	1.32 ^b	0.05
Duroc	42	160 ^b	14.0	0.93	0.10	2.22	0.08	0.73 ^{ae}	0.06	104.3 ^a	23.4	1.20 ^b	0.10
Landrace	14	150 ^b	7.8	0.93	0.09	2.20	0.08	0.77 ^a	0.07	90.5 ^b	16.7	1.27 ^a	0.05
Berkshire	3	142 ^a	2.3	0.92	0.02	2.22	0.09	0.86 ^{ab}	0.01	66.4 ^b	3.6	1.37 ^a	0.00
Chester White	6	167 ^c	23.9	0.08	0.10	2.15	0.02	0.71 ^b	0.02	81.9 ^b	24.6	1.30 ^a	0.09
Hampshire	21	161 ^b	14.6	0.96	0.16	2.21	0.09	0.74 ^{ac}	0.05	107.7 ^b	30.8	1.21 ^a	0.08

*Significance level for effect of breed from analysis of variance where designated.

**Means in the same column not sharing common superscripts differ ($P < 0.05$).

¹ADG = kilograms per day.

²LE = square centimeters.

³F/G = kilograms of feed per pound of gain.

Table 2. Least squares, means and standard deviations for testicle width and length by breeds.

Breeds	N	*Width of testicle pair (CM)	SD	*Length of testicle (CM)	SD
Yorkshire	39	11.49 ^{a**}	1.09	11.01 ^a	1.33
Spots	24	11.39 ^a	0.97	11.37 ^a	1.22
Duroc	42	10.74 ^{bcg}	1.24	10.14 ^{bc}	1.24
Landrace	14	10.67 ^{ae}	1.29	10.85 ^{ae}	1.34
Berkshire	3	10.13 ^a	0.61	10.50 ^a	1.14
Chester White	6	10.57 ^a	0.93	9.77 ^b	1.17
Hampshire	21	9.49 ^{bdfh}	1.27	8.95 ^{bdf}	1.10

*Significance level for effect of breed from analysis of variance where designated.

**Means in the same column not sharing common superscripts differ ($P < 0.05$).

testicles also has longer testicles. Toelle (1984) has demonstrated that larger testicles produce more total sperm. This indicates the possibility of faster gaining boars, yielding a higher female conception rate because of a higher sperm production. Performance index is also correlated with testicle width. This index is calculated using the economically important traits average daily gain, backfat thickness and feed efficiency. Thus, selection of herd sires with larger than average testicle width may lead to a more efficient swine herd.

Conclusions

Purebred boars evaluated at the Southeast Missouri State University Swine Test Station were used to study the correlation between testicle size and traits of economic importance. One hundred forty-nine boars of 7 different breeds were used in the experiment. Testes size was characterized by their combined width at the widest point and testicle length. Testicle width was found to be correlated ($P < 0.01$) with average daily gain and index ($r = 0.36$ and 0.26 , respectively). Testicle length was significantly ($P < 0.01$) correlated with average daily gain ($r = 0.26$). Additionally, testicle width and length were correlated ($r = 0.75$, $P < 0.01$). Data also revealed that among breeds used in the study, Yorkshire displayed the widest testes and Spots had the longest testicles. Results also indicated a significant breed influence on days to 104 kg live weight, backfat thickness, performance index, feed efficiency, testicle width and testicle length.

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Table 3. Correlation coefficients and their levels of significance between various traits.

	Days to 104 kg	Average daily gain	Loin eye	Back fat	Index	Feed per gain	Testicle width	Testicle length
Days to 104 kg								
Average daily gain		0.29 0.0003	0.004 0.95	0.27 0.0008	0.29 0.0003	0.25 0.002	0.13 0.12	0.21 0.01
Loin eye			0.11 0.19	0.16 0.04	0.77 0.0001	-0.36 0.0001	0.36 0.0001	0.26 0.001
Backfat				0.06 0.43	0.05 0.48	0.05 0.48	0.10 0.19	-0.01 0.93
Index					-0.05 0.57	-0.04 0.66	0.09 0.27	0.10 0.22
Feed per gain						-0.84 0.0001	0.26 0.001	0.13 0.11
Testicle width							-0.01 0.20	0.01 0.96
Testicle length								0.75 0.0001

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Ear Tags Containing Fenvalerate and Different Plasticizers for Control of Face Flies and Horn Flies¹ on Pastured Cattle²

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Abstract: Ear tags made from polyvinyl chloride (PVC) plastic and containing fenvalerate insecticide plus various dibasic acid ester plasticizing compounds were evaluated for control of face flies, *Musca autumnalis* De Geer, and horn flies, *Haematobia irritans* (Linnaeus), on pastured cattle. Few significant differences in the performance of fenvalerate could be attributed to any plasticizer tested; however, experimental tags containing plasticizer generally performed better than PVC-fenvalerate tags with no plasticizer. The concentration of fenvalerate had a significant effect on resultant fly control, with a higher concentration (8% active ingredient) generally superior to a lower (5% active ingredient) formulation. Seasonal control of face flies averaged between 43 and 76% when cattle were treated at the rate of 2 tags/head, and between 31 and 61% when 1 tag/head was used. Control of horn flies was greater than 98% when 2 tags/head were used, and averaged between 39 and 85% when tagging was reduced to 1/head.

Key Words: face fly, horn fly, insecticide, ear tags

Introduction

Cattle ear tags made from PVC plastic containing fenvalerate insecticide have been used throughout most of the United States for control of face flies and horn flies on pastured herds. The use of ear tags for fly control on cattle evolved from experiments employing dichlorvos-impregnated resin strips (Harvey and Brethour 1970). Various reports detail the efficacy and longevity of ear tags containing various concentrations of fenvalerate, permethrin and other compounds (Ahrens 1977, Ahrens and Cocke 1979, Knapp and Herald 1980, Schmidt and Kunz 1980, Williams and Westby 1980, Williams et al. 1981, Hall and Fischer 1984, Miller et al. 1984). In general, results for these trials indicate excellent (>95%) control of horn fly populations and 50-75% suppression of face flies. Recently, horn fly populations in some areas have become resistant to the insecticides used in commercial ear tags (Sheppard 1983, Quisenberry et al. 1984).

Solid plastic ear tags containing synthetic pyrethroid insecticides can be described as controlled-release, homogeneous, monolithic systems where active ingredient (AI) is dissolved in polymeric matrices. The diffusion coefficient of the plastic matrix is related to the rate of insecticide release from PVC tags (Miller et

¹Diptera: Muscidae.

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al. 1983). Plasticizers are added to basic resin for increased flexibility, impact resistance, resiliency and softness. They decrease resultant strength of the plastic, heat resistance, dimensional stability and solvent resistance. Many commonly-used plasticizers are esters of dibasic acids (e.g., phthalic, adipic, sebacic and succinic) (Simonds and Church 1963), and such compounds significantly influence the diffusion coefficient and thus the release rate of synthetic pyrethroid insecticides from a PVC matrix (Miller et al. 1983). In experiments with PVC tags containing 8% fenvalerate, Miller et al. (1983) found dibasic acid ester plasticizers to facilitate release of insecticide. In order of decreasing effectiveness in relation to insecticide release rate, the plasticizers studied were dioctyl sebacate (DOS), dioctyl adipate (DOA), dioctyl phthalate (DOP), butyl benzylphthalate (BBP), and tricresyl phosphate (TCP). Increase of DOP concentration from 30 to 50% in PVC ear tags results in significantly increased release of fenvalerate (Miller et al. 1983).

The present study was conducted to determine the relative face fly and horn fly control effectiveness of PVC ear tags containing fenvalerate and various dibasic acid ester plasticizing compounds.

Materials and Methods

Ear Tag Treatments

This study was a single-blind test in which all experimental ear tag treatments were assigned a code letter (Table 1) which was used for identification until the end of the trial. Allflex^R pliers and buttons were used to affix all ear tags while the cattle were restrained in a squeeze chute. No attempt was made to sterilize the tags, buttons or pliers; however, aerosol antiseptic was sprayed on the ears of those animals which bled significantly following treatment.

Table 1. Experimental and commercial plastic ear tags evaluated for control of flies on beef cattle in Missouri during 1984.

Code letter assigned	Active ingredient (AI) (%)	Source of AI ^a	Plasticizer (%)
A ^b	Fenvalerate (8)	1	Dioctyl adipate (28)
B	Fenvalerate (8)	2	Dioctyl adipate (28)
C	Fenvalerate (8)	1	Dioctyl adipate (32)
D	Fenvalerate (8)	1	Dioctyl sebacate (28)
E	Fenvalerate (8)	2	Dioctyl phthalate (34)
F	Fenvalerate (8)	1	Trioctyl phosphate (32)
G	Fenvalerate (8)	1	None ^c
H	Fenvalerate (5)	1	Dioctyl adipate (28)
I	Fenvalerate (5)	1	Dioctyl phthalate (34)
—	Flucythrinate (7.5)	— ^d	—

^aFenvalerate manufactured at 2 different locations (no. 1 or no. 2).

^bCommercial Ectrin^R tags.

^cTag with copolymer (polyvinyl chloride-ethylene vinyl acetate) base (82% pantalast); no plasticizer used.

^dCommercial Guardian^R tags.

Cattle Used, Locations and Dates of Treatment

The cattle used for this trial were beef breeds maintained on summer pasture. Separate pastures were used for all treatments. Ear tags were applied at the following rates on the dates indicated.

Boone County (central Missouri): tags code-lettered A, B, D, E, F, G, H and I were applied at the rate of 2 tags/head on separate herds of 7 mixed breed, yearling steers each. Application was made between 22 and 29 May. On 31 May, 50 mixed breed steers and heifers were treated at the rate of 2/head with tags code-lettered C. An additional herd of 28 mature, mixed breed cows was treated on 6 June with 2 flucythrinate tags each. The latter treatment was used as an identified standard. A proximate herd of ca. 12 mature, mixed breed cows was untreated and served as a control.

Linn County (north-central Missouri): tags code-lettered A, B, D, H and I were applied at the rate of 1 tag/head to herds of young, mainly Hereford, steers and heifers. The herds ranged in size from 38 to 78 head. Application was made between 23 and 30 May. A proximate herd of 36 similar animals was left untreated and served as a control.

Assessment of Fly Populations

The number of flies on all treated and control herds was assessed weekly by visual inspection of 15 head selected at random. With herds smaller than 15 head, cattle were resampled at random until a total of 15 counts was obtained. Face flies were counted on the entire face and horn flies on a single side of each animal chosen. All counts were made during mid-day using binoculars when necessary. Raw data were converted to $\log_{10}(n+1)$ prior to statistical analysis; however, arithmetic averages were tabulated. Monthly averages and average percent control were calculated from the original weekly data.

Results and Discussion

All ear tag treatments applied at the rate of 2/head during this study produced significant ($P < 0.05$) suppression of face fly populations when averaged over the season (Table 2). Average control of face flies ranged between 43 and 76%.

Few significant differences in face fly control could be attributed to fenvalerate ear tags containing different plasticizing compounds. In all cases, the higher concentration of fenvalerate (8% AI) produced seasonal control of face flies which was numerically superior to that afforded by the 5% AI concentration. This was expected, because increasing the concentration of fenvalerate in PVC ear tags results in greater release rates (Miller et al. 1983). The plasticizing compounds tested appeared to offer a slight advantage in resultant face fly control as evidenced by the relatively poorer performance of the copolymer tags (treatment G) which contained no plasticizer. It is interesting that little difference in field efficiency of 8% AI fenvalerate tags could be associated with the plasticizers tested. Previous studies have shown that the release rate of fenvalerate from PVC plasticized with DOS is ca. twice the rate which results when DOP is used as a plasticizer (Miller et al. 1983). It is possible that the plasticizers employed during this study produced differential release of fenvalerate from the PVC ear tags, but that the magnitude of such release was insufficient to affect resultant control of face flies.

Table 2. Average monthly face fly populations on beef cattle untreated or treated with 2 insecticidal plastic ear tags per head, Boone County, MO, 1984.

Tags used ^a	Avg. no. face flies/face ^b						Season avg.	Avg. % control
	May	Jun	Jul	Aug	Sep	Oct		
No tags	0.3 ab	5.9 a	9.3 a	25.2 a	5.4 a	1.8 a	10.1 a	—
A	0 b	0.8 b	3.2 bc	6.7 b	1.2 b	0.1 b	2.6 b	73.4
B	0 b	1.1 bc	2.3 cd	4.7 c	1.6 b	0.2 b	2.2 b	76.0
C	—	0.8 b	2.0 d	7.3 b	3.0 a	—	3.6 c	71.2
D	0 b	0.9 bc	2.7 cd	7.5 b	1.0 b	1.5 ac	2.8 b	72.7
E	0 b	1.2 bcd	5.3 be	7.2 b	1.4 b	0.9 cd	3.3 bc	65.6
F	0.5 a	1.5 cd	3.3 bc	5.0 c	1.3 b	0.4 bd	2.4 b	67.0
G	0 b	1.3 bcd	6.4 ae	11.3 d	1.5 b	0.7 bcd	4.5 c	62.4
H	0.1 ab	2.1 d	7.8 a	11.6 d	4.1 a	0.9 cd	5.5 d	43.0
I	0.1 b	2.3 d	4.4 b	7.3 b	4.5 a	0.4 bd	3.9 c	57.1
Guardian	—	2.4 d	4.6 bc	8.4 b	1.8 b	1.3 acd	4.3 c	57.5

^aSee Table 1.

^bAverages within columns not followed by a common letter are significantly different at the $P < 0.05$ level by the analysis of variance and Duncan's New Multiple Range (Duncan 1955) tests.

The face fly control produced by the flucythrinate ear tags (used as a standard) was roughly equivalent to that afforded by either the 5% AI fenvalerate tags or the 8% AI fenvalerate tags which incorporated no plasticizer. Fenvalerate ear tags (8% AI), containing those plasticizers tested, produced greater average percent control of face flies than did the flucythrinate treatment.

When tested at the rate of 1 tag/head in north-central Missouri, fenvalerate ear tags produced significant seasonal control of face flies (Table 3). The higher concentration (8% AI) generally offered control superior to that afforded by the 5% AI tag treatments. Little difference in seasonal efficacy against face flies could be attributed to the plasticizers included in this portion of the study. The average control of face flies ranged between 30.9 and 61.2%.

Control of horn flies with insecticide-impregnated ear tags applied at the rate of 2/head was very good throughout the experiment. No significant differences were evident between treatments when seasonal efficacy against horn flies was analyzed (Table 4). In all cases, average seasonal control of horn flies exceeded 98%. This level of control indicated that the population of horn flies studied was susceptible to fenvalerate and flucythrinate. It is interesting that average horn fly population levels on untreated cattle in both north-central and central Missouri were smaller than those recorded during previous studies (Thomas and Morgan 1972, Ronald and Wingo 1973).

The use of 1 fenvalerate ear tag/head in north-central Missouri produced less control of horn flies than did the 2 tag/head treatments in Boone County. Seasonal control in the former instance ranged between 39.2 and 84.9% (Table 5). Tags containing 5% AI fenvalerate produced significantly ($P < 0.05$) poorer control of horn flies than did the 8% AI treatments tested. No differences in

Table 3. Average monthly face fly populations on beef cattle untreated or treated with 1 insecticidal plastic ear tag per head, Linn County, MO, 1984.

Tags used ^a	Avg. no. face flies/face ^b					Season avg.	Avg. % control
	Jun	Jul	Aug	Sep	Oct		
No tags	1.4 a	11.3 a	13.3 a	3.7 a	1.3 a	7.6 a	—
A	0.6 b	3.7 b	6.7 b	1.4 b	0.9 ab	3.2 b	58.2
B	0.5 b	4.7 bc	7.4 b	1.4 bc	0.5 bc	3.6 bc	58.8
D	1.1 b	4.8 bc	5.4 b	1.3 b	0.3 c	3.1 b	61.2
H	1.2 a	6.6 cd	6.8 b	2.5 abc	0.9 ab	4.3 c	40.4
I	3.8 c	6.7 d	9.6 a	2.9 ac	1.0 ab	5.5 d	30.9

^aSee Table 1.

^bAverages within columns not followed by a common letter are significantly different at the $P < 0.05$ level by the analysis of variance and Duncan's New Multiple Range (Duncan 1955) tests.

Table 4. Average monthly horn fly populations on beef cattle untreated or treated with 2 insecticidal plastic ear tags per head, Boone County, MO, 1984.

Tags used ^a	Avg. no. horn flies/side ^b						Season avg.	Avg. % control
	May	June	Jul	Aug	Sep	Oct		
No tags	71.8 a	22.8 a	14.0 a	28.0 a	23.3 a	27.6 a	27.6 a	—
A	0 b	0.1 b	0 b	0 b	0 b	0 b	0.03 b	99.9
B	0 b	0 b	0 b	0 b	0 b	0 b	0 b	100.0
C	—	0 b	0 b	0 b	0 b	—	0 b	100.0
D	0 b	0.1 b	0 b	0 b	0 b	0 b	0.02 b	99.9
E	1.0 b	0.1 b	0 b	0 b	0 b	0 b	0.11 b	99.7
F	0 b	0.2 b	0 b	0 b	0 b	0 b	0.03 b	99.9
G	0.1 b	0 b	0 b	0 b	0 b	0 b	0.02 b	99.9
H	0 b	0.1 b	0 b	0 b	0 b	0 b	0.02 b	99.9
I	0.2 b	0.1 b	0.3 b	0 b	0 b	0 b	0.08 b	99.7
Guardian	—	0.6 b	1.0 b	0 b	0 b	0 b	0.32 b	98.4

^aSee Table 1.

^bAverages within columns not followed by a common letter are significantly different at the $P < 0.05$ level by the analysis of variance and Duncan's New Multiple Range (Duncan 1955) tests.

average efficacy of the 8% AI tags could be attributed to plasticizer content.

The results of this study indicated that the concentration of fenvalerate in PVC ear tags had a greater effect on resultant control of face flies and horn flies than did the type of plasticizer employed. The use of a plasticizing compound offered a slight advantage in resultant face fly control. Treatment of cattle with 2 fenvalerate ear tags/head provided face fly and horn fly control superior to that produced by treatment with 1 tag/head. None of the experimental ear tags

Table 5. Average monthly horn fly populations on beef cattle untreated or treated with 1 insecticidal plastic ear tag per head, Linn County, MO, 1984.

Tags used ^a	Avg. no. horn flies/side ^b					Season avg.	Avg. % control
	Jun	Jul	Aug	Sep	Oct		
No tags	22.3 a	25.4 a	36.7 a	22.1 a	11.9 a	25.2 a	—
A	2.5 bc	3.2 b	5.6 bc	1.7 b	2.5 b	3.3 b	79.7
B	1.4 b	4.4 c	4.9 bc	1.6 b	1.5 b	3.2 b	84.9
D	1.8 bc	6.1 d	4.1 b	2.6 b	3.0 b	3.9 b	79.5
H	1.3 b	6.3 de	6.0 c	12.5 c	28.2 c	10.5 c	55.6
I	2.8 c	7.7 e	24.5 d	31.8 d	58.4 d	24.7 a	39.2

^aSee Table 1.

^bAverages within columns not followed by a common letter are significantly different at the $P < 0.05$ level by the analysis of variance and Duncan's New Multiple Range (Duncan 1955) tests.

offered a significant ($P > 0.05$) advantage over the commercial fenvalerate formulation (treatment A).

The durability and retention of all tags tested was very good. No necroses or other adverse effects were reported by custodial personnel or noted during weekly inspections of the treated herds.

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An Annotated List of the Miridae of Missouri (Hemiptera: Heteroptera)¹

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Abstract: A list of the Miridae of Missouri is presented, based on field-collected specimens from 1979 to 1985, examinations of collections and a review of the literature. Of the 301 species reported, 69 represent new state records. County distribution and seasonal range are provided for all species. Observed host plants and other biological annotations are included.

Key Words: Heteroptera, Miridae, plant bugs, host plants, annotated list, Missouri

Introduction

Froeschner (1949) published the first comprehensive listing of Miridae, or plant bugs, from Missouri. He listed 295 species from the state, 80 of which were listed as "probable species." Since that time, the number of taxonomic reviews and revisions and much additional field work have warranted a new listing of Missouri Miridae. The present study was undertaken with the primary objective of compiling an up-to-date list of the known Missouri species and to add to the distributional knowledge of the North American Miridae. A second objective was to present biological information, mainly host plant records, that has been gathered over several years of collecting.

Reported here are 301 species, 87 genera, 18 tribes and 8 subfamilies of plant bugs. Sixty-nine of these species represent new state records. Admittedly this checklist is incomplete. Further collecting in specialized habitats such as the native prairies and glades of western and southwestern Missouri and the southeastern lowlands of the Missouri bootheel will reveal additional species.

This checklist is based primarily on field-collected specimens over the past 6 years; specimens in the Wilbur R. Enns Entomology Museum, University of Missouri-Columbia; and those in the W. S. Craig private collection. Species recorded in the literature from Missouri but not seen by the authors are also included. We have not included any "probable species." Although one new species of *Orthotylus* was discovered breeding on *Aesculus glabra*, it is not included in the present work, but will, instead, be described in a future paper by the senior author.

Useful keys for identifying Missouri mirids can be found in Knight (1923, 1941), Blatchley (1926) and Froeschner (1949). For additional county records, hosts and seasonal records the reader should consult Froeschner (1949).

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We use a higher classification similar to that in a recent list of West Virginia Miridae (Wheeler et al. 1983). It should be kept in mind that the higher classification of the Miridae is in a state of flux and recognition of several subfamilies and tribes is in dispute. The reader should refer to Schuh (1976) for a discussion on the higher classification in the family.

Taxa are listed alphabetically under each subfamily. For each species we give the Missouri distribution (alphabetically by county) and the seasonal range (earliest and latest collection dates of adults). For most species, a short discussion of host plants and other biological information is provided. The common names are those approved by the Entomological Society of America; host plant nomenclature follows Steyermark (1963).

Subfamily Isometopinae

Tribe Diphlebini

Diphleps unica Bergroth. Missouri records: 1 male from Marion County, 23 June. Collected in a no-till soybean field using a D-Vac. *Teratodia emoritura* Bergroth as reported by Froeschner (1949) is a junior synonym of *D. unica* (Henry 1977).

Tribe Isometopini

Corticoris signatus (Heidemann). STATE RECORD. Missouri records: 1 female from Randolph County, 22 June. Wheeler and Henry (1978a) reported obscure scale, *Melanospis obscura* (Comstock), as a host of this predator.

Myiomma cixiiforme (Uhler). STATE RECORD. Missouri records: 1 female from Boone County, 1 July. Collected on basswood, *Tilia americana* L. Wheeler and Henry (1978a) reported obscure scale, *Melanospis obscura* (Comstock), as a host of this predator.

Subfamily Phylinae

Tribe Hallodapini

Cyrtopeltocoris illini Knight. Missouri records: 7 specimens from Boone County, 24 May to 9 June. Collected by sweeping grasses close to the ground and with a D-Vac.

Teleorhinus tephrosicola Knight. Missouri Records: Froeschner (1949) recorded this species from Miller County on 25 May. We have seen no additional Missouri specimens.

Tribe Phylini

Amblytylus nasutus (Kirschbaum). Missouri records: 102 specimens from Atchison, Benton, Boone, Callaway, Cape Girardeau, Crawford, Dent, Holt, Monroe, Pike, Randolph, Reynolds, Shannon, St. Charles and St. Louis counties, 13 May to 17 July. This species breeds on Kentucky bluegrass, *Poa pratensis* L., and can be commonly swept along roadsides. First recorded from Missouri by Blinn and Yonke (1982).

Chlamydatus associatus (Uhler) (ragweed plant bug). Missouri records: 36 specimens from Boone, Pemiscott and St. Clair counties, 15 July to 11 October. Collected on common sunflower, *Helianthus annuus* L.

Chlamydatus pullus (Reuter). STATE RECORD. Missouri records: 37 specimens from Boone and St. Clair counties, 10 to 21 August. Thirty-six specimens collected with a D-Vac in a no-till soybean field in St. Clair County.

Chlamydatus suavis (Reuter). Missouri records: 3 specimens from Boone and Callaway counties, 17 June to 10 August. Kelton (1965b) reported giant ragweed, *Ambrosia trifida* L., as the host plant.

Criocoris saliens (Reuter). Missouri records: 51 specimens from Barry, Benton, Boone, Callaway, Cooper, Crawford, Gasconade, Morgan and Ozark counties, 7 May to 9 June. Collected on bedstraw, *Galium aparine* L.

Icodema nigrolineatum (Knight). Missouri records: 12 specimens from Boone and Crawford counties, 24 May to 1 June. Collected on white oak, *Quercus alba* L. Froeschner (1949) recorded this species as *Plagiognathus nigrolineatus* Knight.

Keltonia sulphurea (Reuter). Missouri records: 73 specimens from Boone, Callaway, Crawford, Pemiscott and St. Clair counties, 1 June to 30 September. Collected on common ragweed, *Ambrosia artemisiifolia* L.; giant ragweed, *A. trifida*; and common sunflower, *Helianthus annuus*. Froeschner (1949) recorded this species as *Reuteroscopus sulphureus* (Reuter) (Knight 1966).

Lepidopsallus miniatus Knight. Missouri records: 3 specimens from Boone County, 3 May and 27 June. One specimen was collected on shingle oak, *Quercus imbricaria* Michx.

Lepidopsallus rubidus (Uhler). Missouri records: 24 specimens from Boone, Gasconade, St. Francois and Wayne counties, 11 June to 12 July. Collected on sandbar willow, *Salix interior* Rowlee, and black willow, *S. nigra* Marsh.

Lopus decolor (Fallen). STATE RECORD. Missouri records: 7 specimens of this European species from Boone County, 29 June to 1 July.

Macrotylus amoenus Reuter. Missouri records: Froeschner (1949) recorded this species from Douglas, Stone and Taney counties, 29 to 30 May. We have seen no additional Missouri specimens.

Microphylellus maculipennis Knight. Missouri records: 1 specimen from Boone County, 25 June. Collected on smooth sumac, *Rhus glabra* L.

Microphylellus modestus Reuter. Missouri records: 62 specimens from Boone, Callaway, Monroe, Ozark and Pettis counties, 17 May to 24 June. Collected on a number of deciduous trees including maple, *Acer* sp.; Ohio buckeye, *Aesculus glabra* Willd.; hickory, *Carya* sp.; catalpa, *Catalpa* sp.; green ash, *Fraxinus pennsylvanica* Marsh.; black oak, *Quercus velutina* Lam.; and elm, *Ulmus* sp.

Plagiognathus albatus (Van Duzee). Missouri record: 22 specimens from Boone, Chariton, Monroe, St. Clair and Stoddard counties, 18 May to 19 June. Collected on sycamore, *Platanus occidentalis* L. Two specimens were collected on pecan, *Carya illinoensis* (Wang.) K. Koch., in Chariton County.

Plagiognathus albellus Knight. Missouri records: Knight (1953) described this species from 3 specimens collected in St. Louis during June. We have seen no additional Missouri specimens.

Plagiognathus albifacies Knight. STATE RECORD. Missouri records: 2 specimens from Barry County, 8 June. Knight (1941) listed leafcup, *Polymnia canadensis* L., as the host plant.

Plagiognathus annulatus Uhler. Missouri records: 7 specimens from Barry, Boone and St. Louis counties, 30 May to 12 June. Knight (1923) listed *Aster* sp. as the host plant.

Plagiognathus atricornis Knight. Missouri records: 1 specimen from Wayne County, 13 June. Knight (1941) listed river birch, *Betula nigra* L., as the host plant.

Plagiognathus blatchleyi Reuter. Missouri records: 102 specimens from Boone, Callaway, Howard, Osage, Pike, Reynolds, Stoddard and Wayne counties, 11 June to 26 September. Collected on common ragweed, *Ambrosia artemisiifolia*, and giant ragweed, *A. trifida*. Seventeen specimens were collected on sandbar willow, *Salix interior*, in Osage County.

Plagiognathus brevirostris Knight. STATE RECORD. Missouri records: 1 specimen from Boone County, 24 May. Collected on black walnut, *Juglans nigra* L. Wheeler et al. (1983) listed meadow rue, *Thalictrum polygamum* Muhl., as the host plant.

Plagiognathus cornicola Knight. Missouri records: 75 specimens from Benton, Boone, Holt and Stone counties, 27 May to 17 June. Collected on rough-leaved dogwood, *Cornus drummondii* Meyer.

Plagiognathus cuneatus Knight. Missouri records: Froeschner (1949) recorded this species from Barry, Jefferson, Phelps and St. Louis counties during June. Knight (1941) listed *Aster* sp. as the host plant. We have seen no additional Missouri specimens.

Plagiognathus davisii Knight. STATE RECORD. Missouri records: 7 specimens from Stone County, 14 June.

Plagiognathus delicatus (Uhler). Missouri records: 22 specimens from Boone County, 7 May to 8 June. Collected on honeylocust, *Gleditsia triacanthos* L.

Plagiognathus dispar Knight. Missouri records: 5 specimens from Barry, Benton, Boone and Randolph counties, 24 May to 17 June. Collected on hickory, *Carya* sp., in Boone County and on dogwood, *Cornus* sp., in Benton County.

Plagiognathus flavicornis Knight. STATE RECORD. Missouri records: 3 specimens from Holt County, 17 June. Collected on honeylocust, *Gleditsia triacanthos*.

Plagiognathus flavoscutellatus Knight. Missouri records: 11 specimens from Boone, Morgan and Phelps counties, 13 June to 17 July. Collected on sandbar willow, *Salix interior*, in Boone County.

Plagiognathus gleditsiae Knight. Missouri records: 43 specimens from Boone County, 9 to 31 May. Collected on honeylocust, *Gleditsia triacanthos*.

Plagiognathus guttulosis (Reuter). Missouri records: 3 specimens from Boone County, 27 April to 26 July. Knight (1941) listed oak, *Quercus* sp., as the host plant. All of our specimens were collected at black light sheets.

Plagiognathus negundinus Knight. Missouri records: Froeschner (1949) recorded this species from Boone County on 27 May. Knight (1941) listed box elder, *Acer negundo* L., as the host plant. We have seen no additional Missouri specimens.

Plagiognathus nigrinitens Knight. Missouri records: 115 specimens from Benton, Boone, Callaway, Gasconade, Henry, Holt, Pettis and Vernon counties, 7 May to 17 June. Collected on ash sunflower, *Helianthus mollis* Lam., on native prairies.

Plagiognathus obscurus Uhler. Missouri records: Froeschner (1949) recorded this species from Buchanan County on 16 September. We have seen no additional Missouri specimens.

Plagiognathus politus Uhler. Missouri records: 325 specimens from 22 counties throughout the state, 4 April to 22 October. This species occurs on a wide variety of herbaceous plants, usually in the Compositae.

Plagiognathus punctatipes Knight. Missouri records: 16 specimens from Bollinger, Boone, Morgan, Ralls and Wayne counties, 7 to 25 June. Collected on black walnut, *Juglans nigra*.

Plagiognathus repletus Knight. Missouri records: 18 specimens from Boone, Holt and Stoddard counties, 5 to 14 June. Collected on black walnut, *Juglans nigra*.

Plagiognathus rosicola Knight. Missouri records: 3 specimens from Bollinger and Boone counties, 11 to 15 June. Knight (1941) reported wild rose, *Rosa* sp., as the host plant.

Plagiognathus salicicola Knight. STATE RECORD. Missouri records: 9 specimens from Bollinger, Boone, Crawford and Wayne counties, 11 June to 2 July. Collected on sandbar willow, *Salix interior*.

Plagiognathus similis Knight. Missouri records: 8 specimens from Boone County, 22 May to 28 June. Collected on river birch, *Betula nigra*.

Plagiognathus tinctus Knight. Missouri records: 44 specimens from Barry, Crawford, Gasconade, Madison, Morgan, Osage, Randolph and Wayne counties, 8 June to 12 July. Collected on sandbar willow, *Salix interior*, in Barry and Crawford counties.

Plesiodema sericeum (Heidemann). Missouri records: 1 specimen from Boone County, 25 June. Knight (1941) reported basswood, *Tilia americana*, as the host plant. Froeschner (1949) recorded this species as *Plagiognathus sericeus* (Heidemann).

Psallus amorphae Knight. Missouri records: Froeschner (1949) recorded this species from St. Louis County on 3 June. Knight (1941) reported lead plant, *Amorpha canescens* Pursh, as the host. Repeated collecting on the host plant has yielded no additional Missouri specimens.

Pseudatomoscelis seriatus (Reuter) (cotton fleahopper). Missouri records: 21 specimens from Boone, New Madrid and Pemiscott counties, 15 July to October. Collected on cotton, *Gossypium herbaceum* L., in the Missouri bootheel. In Boone County it has been collected at a black light sheet. Snodgrass et al. (1984a) reported numerous host plants. Froeschner (1949) recorded this species as *Psallus seriatus* (Reuter).

Reuteroscopus froeschneri Knight. Missouri records: Knight (1953) described this species from material collected at Galena (Stone County), MO, on 28 May, 1947. We have seen no additional Missouri specimens.

Reuteroscopus ornatus (Reuter). Missouri records: 171 specimens from Bollinger, Boone, Callaway, Cape Girardeau, Crawford, Henry, Moniteau, Phelps, Randolph, Reynolds, Shannon, St. Clair and Wayne counties, 1 June to 14 October. Collected on common ragweed, *Ambrosia artemisiifolia*, and giant ragweed, *A. trifida*. One specimen was taken on black-eyed Susan, *Rudbeckia hirta* L. Commonly collected at black light sheets.

Rhinacloa forticornis Reuter (western plant bug). Missouri records: Knight (1927) recorded this species from Taney County, 5 to 10 September. We have seen no additional Missouri specimens.

Rhinocapsus vanduzeei Uhler (azalea plant bug). Missouri records: 1 specimen from Stone County, 31 May. Recorded from azalea, *Rhododendron* sp. (Wheeler et al. 1983).

Semium hirtum Reuter. Missouri records: 16 specimens from Boone County, 2 June to 11 October. Collected on spurge, *Euphorbia* sp.

Spanagonicus albofasciatus (Reuter) (whitemarked fleahopper). Missouri records: 4 specimens from Phelps, Randolph and Reynolds counties, 13 to 25 September. This species has been reported damaging grasses on golf greens (Knight 1941). Snodgrass et al. (1984a) reported numerous host plants. Froeschner (1949) recorded this species as *Leucopocila albofasciatus* Reuter.

Sthenarus mcateei Knight. STATE RECORD. 2 specimens from Barry County, 2 July.

Subfamily Orthotylinae

Tribe Ceratocapsini

Ceratocapsus apicalis Knight. Missouri records: Froeschner (1949) recorded this species from Linn County on 30 September. We have seen no additional Missouri specimens.

Ceratocapsus camelus Knight. Missouri records: 1 specimen from Boone County, 12 August.

Ceratocapsus complicatus Knight. Missouri records: 11 specimens from Boone, Pemiscott and Phelps counties, 8 July to 19 September. Collected on wild grape, *Vitis* sp.

Ceratocapsus digitulus Knight. Missouri records: Froeschner (1949) recorded this species from Pike County on 1 July. We have seen no additional Missouri specimens.

Ceratocapsus drakei Knight. STATE RECORD. Missouri records: 1 specimen from Boone County, 14 April.

Ceratocapsus fasciatus (Uhler). Missouri records: 6 specimens from Boone and Stoddard counties, 7 July to 9 September. Our Boone County specimens were collected at black light sheets. Knight (1941) listed hickory, *Carya* spp., as the host plants.

Ceratocapsus fuscinus Knight. Missouri records: 115 specimens from Boone, Callaway, Crawford, Gasconade, Morgan, Osage, Randolph, Reynolds, St. Francois, Stoddard and Wayne counties, 11 June to 18 August. Collected on black willow, *Salix nigra*, and sandbar willow, *S. interior*. Five Boone County specimens were taken on honeylocust, *Gleditsia triacanthos*. Commonly collected at black light sheets.

Ceratocapsus fuscognatus Knight. STATE RECORD. Missouri records: 1 specimen from Boone County, 9 October.

Ceratocapsus incisus Knight. Missouri records: 7 specimens from Boone, Crawford, Lewis, Randolph and Stoddard counties, 4 June to 13 July. Collected on willow, *Salix* sp., and elm, *Ulmus* sp., in Boone County.

Ceratocapsus lutescens Reuter. Missouri records: Froeschner (1949) recorded this species from Butler County on 4 July. We have seen no additional Missouri specimens.

Ceratocapsus modestus (Uhler). Missouri records: 8 specimens from Boone and Stoddard counties, 22 June to 2 August. Collected on wild grape, *Vitis* sp. Occasionally collected at black light sheets. Has been observed as a predator of grape phylloxera (Wheeler and Henry 1978b).

Ceratocapsus nigellus Knight. Missouri records: 14 specimens from Boone, Dade, Johnson, Maries, Randolph and St. Clair counties, 6 to 25 June. Most of our specimens were collected at black light sheets. One specimen taken in Boone County carries the ecological label "sticky board in oak hickory canopy." Two fifth-instar nymphs were collected singly within the oak-apple gall in Boone County. Knight (1941) listed hickory, *Carya* sp., as the host plant.

Ceratocapsus nigrocephalus Knight. Missouri records: 22 specimens from Boone County, 27 May to 3 July. All of our specimens were collected using a D-Vac in a tall fescue pasture.

Ceratocapsus piceatus Henry. STATE RECORD. Missouri records: 20 specimens from Bollinger, Johnson, Montgomery, Ralls, St. Clair and Shannon counties, 6 June to 4 August. The majority of our specimens were collected at black light sheets. Described from specimens collected on alder, *Alnus rugosa* (DuRoi) Spreng., and other deciduous trees (Henry 1979a).

Ceratocapsus pumilus (Uhler). Missouri records: 50 specimens from Atchison, Barry, Boone, Gasconade, Pemiscott and Phelps counties, 8 June to 19 September. Collected on sandbar willow, *Salix interior*; elm, *Ulmus* sp. and wild grape, *Vitis* sp. Commonly collected at black light sheets.

Ceratocapsus rubricornis Knight. STATE RECORD. Missouri records: 2 specimens from Boone County, 29 July. Our only specimens were collected at a black light sheet. Recorded from oaks, *Quercus* spp., Chinese chestnut, *Castanea mollissima* and basswood, *Tilia americana* (Henry 1979a).

Ceratocapsus seticornis Knight. Missouri records: Knight (1953) described this species from a unique male collected on 23 August, 1942, in Holcomb (Dunklin County), MO. We have seen no additional Missouri specimens.

Ceratocapsus setosus Reuter. STATE RECORD. Missouri records: 2 specimens from Boone and Phelps counties, 28 August and 19 September.

Ceratocapsus spinosus Henry. STATE RECORD. Missouri records: 1 specimen from Boone County, 13 June. Our only specimen was collected at a black light sheet. Described by Henry (1978) from 2 males collected in Pennsylvania. Recorded from sycamore, *Platanus occidentalis* (Henry 1979a).

Ceratocapsus taxodii Knight. Missouri records: 35 specimens from Pemiscott and Stoddard counties, 14 to 15 July. Collected on bald cypress, *Taxodium distichum* (L.) Rich., in the swamps of the southeastern bootheel.

Ceratocapsus uniformis Knight. Missouri records: 3 specimens from Bollinger, Boone and Stoddard counties, 11 June to 22 July. Recorded from black walnut, *Juglans nigra* (Wheeler et al. 1983).

Ceratocapsus vicinus Knight. Missouri records: Froeschner (1949) recorded this species based on a single specimen; however, the specimen lacked detailed label information. We have seen no additional Missouri specimens. Recorded from willow oak, *Quercus phellos* L. (Henry 1979a).

Ceratocapsus wheeleri Henry. STATE RECORD. Missouri records: 1 specimen from Boone County, 14 July. Described by Henry (1979a) from material collected on white oak, *Quercus alba*, and post oak, *Q. stellata* Wang., in North Carolina.

Tribe Halticini

Halticus bractatus (Say) (garden flea hopper). Missouri records: 96 specimens from Boone, Callaway, Cape Girardeau, Chariton, Crawford, Holt, Lewis, Morgan, Phelps and Pike counties, 1 May to 1 November. A common garden pest of beans, cucurbits and other garden vegetables. Also common on clover grown in lawns.

Tribe Orthotylini

Brooksetta althaeae (Hussey) (hollyhock plant bug). Missouri records: 3 specimens from Boone and Cole counties, 17 May to 12 June. Froeschner (1949) recorded this species as *Melanotrichus althaeae* (Hussey).

Diaphnocoris chlorionis (Say) (honeylocust plant bug). Missouri records: 109 specimens from Boone, Callaway and Randolph counties, 27 April to 17 June. Collected on honeylocust, *Gleditsia triacanthos*. Froeschner (1949) recorded this species as *Orthotylus chlorionis* (Say) (Kelton 1965a).

Diaphnocoris provancheri (Burque). STATE RECORD. Missouri records: 27 specimens from Adair, Bollinger, Boone, Monroe, Randolph and Stoddard counties, 11 June to 24 July. Collected on white oak, *Quercus alba*, in Boone County and 2 specimens on elm, *Ulmus* sp., in Monroe County. Occasionally collected at black light sheets. The species *Diaphnidia pellucida* Uhler, as reported by Froeschner (1949), is a junior synonym of *D. provancheri* (Burque) (Kelton 1980a).

Diaphnocoris ulmi (Knight). Missouri records: Froeschner (1949) recorded this species as *Orthotylus ulmi* Knight from Buchanan County on 28 June. We have seen no additional Missouri specimens.

Hadronema militare Uhler. Missouri records: Froeschner (1949) recorded this species from Linn County on 20 September. We have seen no additional Missouri specimens.

Heterocordylus malinus Slingerland. Missouri records: 2 specimens from Boone and St. Louis counties, 2 to 28 May. Wheeler (1983) has shown that authorship should be credited to Slingerland, not Reuter.

Ilnacora divisa Reuter. STATE RECORD. Missouri records: 1 specimen from Linn County, 20 May.

Ilnacora illini Knight. Missouri records: 36 specimens from Benton, Boone, Callaway, Pettis, Phelps, St. Clair and Vernon counties, 13 June to 16 August. Collected on ashy sunflower, *Helianthus mollis*, at Osage Prairie (Vernon County).

Ilnacora malina (Uhler). Missouri records: 53 specimens from Barry, Boone, Clay, Crawford, Gasconade, Madison, Monroe, Randolph and St. Francois counties, 2 to 30 June. Collected on giant ragweed, *Ambrosia trifida*, and sunflower, *Helianthus* sp.

Ilnacora stalii Reuter. Missouri records: 101 specimens from Bollinger, Boone, Callaway, Cass, Crawford, Gasconade, Miller, Monroe, Phelps, Pemiscott, Randolph, Sullivan and Wayne counties, 16 May to 2 October. Collected on sunflower, *Helianthus* sp. The Pemiscott County specimens were swept from a cotton field. Commonly collected at black light sheets.

Ilnacora vittifrons Knight. STATE RECORD. Missouri records: 21 specimens from Ozark County, 29 May. Found feeding on the folded, elongate leaves of

Maximilian sunflower, *Helianthus maximilliani* Schrad., on a cedar glade in extreme southern Missouri. Described by Knight (1963) in a review of the genus.

Lindbergocapsus allii (Knight) (onion plant bug). Missouri records: 68 specimens from Boone, Callaway, Cooper, Dent, Gasconade, Holt, Miller and Texas counties, 26 April to 22 June. Collected on wild onion, *Allium* sp. Froeschner (1949) recorded this species, and all other *Lindbergocapsus* spp. in the genus *Labopidea* (Henry 1985b).

Lindbergocapsus planifrons (Knight). STATE RECORD. Missouri records: 1 specimen from Lawrence County, 15 May. Collected in a tall fescue pasture. Kelton (1980b) recorded wild onion, *Allium stellatum* Fraser, as the host plant.

Lopidea amorphae Knight. Missouri records: 3 specimens from Barry, Boone and Holt counties, 7 June to 7 July. Collected on honeylocust, *Gleditsia triacanthos*, in Holt County. Recorded from false indigo, *Amorpha fruticosa* L. (Knight 1941).

Lopidea confluenta (Say). Missouri records: 68 specimens from Boone, Callaway, Cole, Gasconade, Howard, Macon, Montgomery, Pettis, Stoddard, Warren and Wayne counties, 20 May to 22 August. Collected on maple, *Acer* sp., and honeylocust, *Gleditsia triacanthos*.

Lopidea davisii Knight (phlox plant bug). Missouri records: 13 specimens from Boone, Callaway, Madison and Phelps counties, 10 June to 19 September. Collected on phlox, *Phlox* sp., in Phelps County.

Lopidea heidemanni Knight. Missouri records: 74 specimens from Barry, Boone, Cape Girardeau, Cooper, Crawford, Madison, Maries, Morgan, Phelps, Texas and Washington counties, 3 May to 27 June. Taken on a variety of deciduous trees, including Ohio buckeye, *Aesculus glabra*; green ash, *Fraxinus pennsylvanica*; wild plum, *Prunus americana* Marsh.; white oak, *Quercus alba*; jack oak, *Q. ellipsoidalis* Hill; black locust, *Robinia pseudoacacia* L.; and willow, *Salix* sp. Also taken on a number of herbaceous plants, including yarrow, *Achillea millefolium* L.; common ragweed, *Ambrosia artemisiifolia*; mouse-ear chickweed, *Cerastium vulgatum* L.; common sunflower, *Helianthus annuus*; sweet William, *Phlox divaricata* Wood; and wild grape, *Vitis* sp.

Lopidea hesperus (Kirkaldy). Missouri records: 5 specimens from Callaway County, 28 June to 20 August. Two specimens carry Malaise trap labels. *L. reuteri* Knight as recorded by Froeschner (1949) is a junior synonym of *L. hesperus* (Henry 1985b).

Lopidea incurva Knight. Missouri records: 5 specimens from Boone and Callaway counties, 26 June to 20 August. Collected on honeylocust, *Gleditsia triacanthos*, in Boone County. The Callaway County specimen was swept from Tucker Prairie.

Lopidea instabilis (Reuter). Missouri records: Froeschner (1949) recorded this species from 11 counties from 14 June to 4 July. We have seen no additional Missouri specimens.

Lopidea lathyri Knight. STATE RECORD. Missouri records: 1 specimen from Boone County, 5 July. Knight (1941) reported bushy vetch, *Lathyrus venosus* Muhl., as the host plant.

Lopidea marginalis (Reuter). STATE RECORD. Missouri records: 30 specimens from Barry, Camden, Carter, Gasconade, Moniteau, Pettis, Ste. Genevieve, Shannon, Stoddard, Stone and Wayne counties, 6 June to 17 July. The Carter

County specimen was taken on black-eyed Susan, *Rudbeckia hirta*. Several specimens carry "on red clover" and "on alfalfa" labels.

Lopidea media (Say). Missouri records: 102 specimens from 15 counties throughout the eastern half of the state, 5 May to 28 July. Collected on honeylocust, *Gleditsia triacanthos*, wild plum, *Prunus americana* and black locust, *Robinia pseudoacacia*. Occasionally collected at black light sheets.

Lopidea petalostemi Knight. STATE RECORD. Missouri records: 8 specimens from Benton County, 7 June. Swept from a native prairie tract where the host plant purple prairie clover, *Petalostemum purpureum* (Vent.) Rydb., was found growing.

Lopidea robiniae (Uhler). Missouri records: 44 specimens from Boone, Callaway, Morgan and Vernon counties, 22 June to 20 August. Collected on black locust, *Robinia pseudoacacia*, at several localities. Six Boone County specimens were hand picked from wood sage, *Teucrium canadense* L.

Lopidea salicis Knight. Missouri records: 2 specimens from Boone and Johnson counties, 6 to 24 June. Collected on willow, *Salix* sp., in Boone County.

Lopidea staphyleae Knight. Missouri records: 8 specimens from Barry and Boone counties, 8 to 27 June. Collected on American bladder-nut, *Staphylea trifolia* L., sycamore, *Platanus occidentalis* and willow, *Salix* sp.

Lopidea teton Knight. Missouri records: Froeschner (1949) recorded this species from Franklin and McDonald counties from 18 to 24 May. We have seen no additional Missouri specimens.

Melanotrichus catulus (Van Duzee). Missouri records: 3 specimens from Boone, Gasconade and Miller counties, 10 May to 16 May. Recorded from *Antennaria* spp., by Wheeler et al. (1983).

Melanotrichus flavosparsus (Sahlberg). Missouri records: 55 specimens from Boone and Callaway counties, 4 May to 1 August. Collected on pigweed, *Chenopodium album* L. Occasionally collected at black light sheets.

Orthotylus basicornis Knight. Missouri records: 17 specimens from Adair, Bollinger, Boone, Callaway and Wayne counties, 1 June to 7 July. Collected on willow, *Salix* sp. The Callaway County specimens were taken at Tucker Prairie and carry "light trap" labels.

Orthotylus dorsalis (Provancher). Missouri records: Froeschner (1949) recorded this species from Boone County on 29 May. We have seen no additional Missouri specimens. Recorded from willow, *Salix* sp. (Knight 1941).

Orthotylus juglandis Henry. STATE RECORD. Missouri records: 29 specimens from Boone County, 24 May to 8 June. Collected on black walnut, *Juglans nigra*. One specimen was taken at a black light sheet. Described by Henry (1979b) from Texas and Indiana.

Orthotylus lateralis Van Duzee. Froeschner (1949) recorded this species from Cape Girardeau County on 10 June from cottonwood, *Populus deltoides* Marsh. We have seen no additional Missouri specimens.

Orthotylus modestus Van Duzee. Missouri records: 69 specimens from Bollinger, Boone, Callaway, Holt, Lewis, Monroe, Randolph and St. Francois counties, 4 to 24 June. Collected on black willow, *Salix nigra*. Occasionally taken at black light sheets.

Orthotylus ornatus Van Duzee. Missouri records: 11 specimens from Boone and Maries counties, 10 to 20 May. The Boone County specimens were

collected at a black light sheet. Knight (1941) reported crack willow, *Salix fragilis* L., as the host plant.

Orthotylus ramus Knight. Missouri records: Froeschner (1949) recorded this species from Bollinger and Jefferson counties on 30 May and 7 June. We have seen no additional Missouri specimens. Recorded from pecan, *Carya illinoensis*, and hickory, *Carya* sp. (Knight 1941).

Orthotylus robiniae Johnston. Missouri records: 54 specimens from Atchison, Benton, Boone, Randolph and Shannon counties, 4 to 24 June. Collected on black locust, *Robinia pseudoacacia*, and honeylocust, *Gleditsia triacanthos*.

Orthotylus rossi Knight. STATE RECORD. Missouri records: 2 specimens from Boone and Callaway counties, 8 to 18 June. Our only specimens were collected at black light sheets. Recorded from willow, *Salix* sp. (Knight 1941).

Orthotylus submarginatus (Say). Missouri records: 22 specimens from Adair, Boone, Callaway, Monroe and Pike counties, 5 to 26 June. Collected on black locust, *Robinia pseudoacacia*.

Orthotylus viridis Van Duzee. Missouri records: 10 specimens from Barry, Bollinger, Stoddard and Wayne counties, 8 to 12 June. Recorded from willows, *Salix* spp. (Knight 1941).

Parthenicus juniperi (Heidemann). Missouri records: 65 specimens from Benton, Boone, Callaway, Monroe, Montgomery, Ozark and Ste. Genevieve counties, 7 June to 2 November. Collected on red cedar, *Juniperus virginiana* L. Occasionally collected at black light sheets.

Parthenicus taxodii Knight. Missouri records: 1 specimen from Stoddard County, 14 July. Taken on bald cypress, *Taxodium distichum*.

Pseudoxenetus regalis (Uhler). Missouri records: 84 specimens from Adair, Boone, Callaway, Cooper, Crawford, Dent, Jefferson, Johnson, Osage, Pike, Randolph, St. Clair, St. Louis and Stoddard counties, 28 April to 24 June. Collected on oaks, *Quercus* spp. *P. scutellatus* (Uhler) as recorded by Froeschner (1949) is a junior synonym of *P. regalis* (Uhler) (Henry 1985b).

Reuteria bifurcata Knight. Missouri records: Froeschner (1949) recorded this species from Boone and Iron counties from 19 to 29 June. We have seen no additional Missouri specimens. Recorded most often on hickory, *Carya* spp. (Henry 1976).

Reuteria irrorata (Say). Missouri records: 35 specimens from Boone County, 23 June to 24 July. Collected on elm, *Ulmus* sp. Commonly collected at black light sheets.

Reuteria querci Knight. Missouri records: 1 specimen from Clinton County, 7 July. Recorded from oaks, *Quercus* spp. (Knight 1941, Henry 1976).

Sericophanes heidemanni Poppius. STATE RECORD. Missouri records: 21 specimens from Boone, Callaway and Grundy counties, 17 May to 25 August. Taken while sweeping grasses close to the ground and with a D-Vac. Males are commonly collected at black light sheets; the females are brachypterous and incapable of flight. Recorded from *Carex rostrata* Stokes (Wheeler et al. 1983).

Slaterocoris ambrosiae (Knight). Missouri records: 10 specimens from St. Clair County, 9 to 15 August. All of our specimens were taken from a no-till soybean field using a D-Vac. Froeschner (1949) recorded this species, and all other *Slaterocoris* spp. in the genus *Strongylocoris*.

Slaterocoris atritibialis (Knight). Missouri records: 83 specimens from Boone, Butler, Callaway, Cooper, Crawford, Harrison, Hickory, Johnson, Monroe,

Randolph and St. Louis counties, 6 May to 19 June. Collected on goldenrod, *Solidago* sp.

Slaterocoris breviatus (Knight). Missouri records: 9 specimens from Boone, St. Francois and St. Louis counties, 4 May to 2 July. Collected on hollyhock, *Althaea rosea* L., in Boone County.

Slaterocoris fuscicornis Knight. Missouri records: 24 specimens from Crawford, Pettis, Stone and Vernon counties, 5 to 27 June. The Pettis and Vernon county specimens were collected on ashy sunflower, *Helianthus mollis*, on native prairies.

Slaterocoris hirtus (Knight). Missouri records: 31 specimens from Barry, Boone, Crawford, Gasconade and Montgomery counties, 1 June to 20 July. Collected on cup plant, *Silphium perfoliatum* L.

Slaterocoris mohri (Knight). Missouri records: 4 specimens from Barry and Phelps counties, 8 to 20 June. First recorded from Missouri by Knight (1970).

Slaterocoris stygicus (Say). Missouri records: 165 specimens from 16 counties throughout the state, 4 May to 7 July. Collected on giant ragweed, *Ambrosia trifida*; dogbane, *Apocynum androsaemifolium* L.; milkweed, *Asclepias* sp.; and sunflower, *Helianthus* sp.

Taxocoris nigrellus (Knight). Missouri records: 10 specimens from Boone County, 30 May to 7 June. Collected on a fruiting mulberry tree, *Morus* sp., and 1 specimen on Ohio buckeye, *Aesculus glabra*. Froeschner (1949) recorded this species as *Parthenicus nigrellus* Knight (Henry 1982).

Tribe Pilophorini

Alepidia gracilis (Uhler). STATE RECORD. Missouri records: 5 specimens from Boone, Carter, Grundy, Lewis and Randolph counties, 4 June to 12 August. The Boone County specimen was taken on pine, *Pinus* sp.; the Grundy County specimen at a black light sheet.

Pilophorus amoenus Uhler. STATE RECORD. Missouri records: 3 specimens from Boone and Iron counties, 19 July to 1 October. Recorded from scotch pine, *Pinus sylvestris* L., and Virginia pine, *P. virginiana* Mill. (Wheeler et al. 1983).

Pilophorus brunneus Poppius. Missouri records: 1 specimen from Boone County, 3 August. Collected on cottonwood, *Populus deltoides*.

Pilophorus crassipes Heidemann. STATE RECORD. Missouri records: 1 specimen from Iron County, 1 October. Knight (1941) recorded this species as *P. vanduzeei* Knight from *Pinus* spp.

Pilophorus juniperi Knight. Missouri records: 4 specimens from Boone and Stone counties, 24 June to 3 August. Collected on red cedar, *Juniperus virginiana*.

Pilophorus taxodii Knight. STATE RECORD. Missouri records: 2 specimens from Stoddard County, 14 July. Collected on bald cypress, *Taxodium distichum*.

Pilophorus walshii Uhler. Missouri records: 45 specimens from Boone County, 24 June to 3 August. Collected on honeylocust, *Gleditsia triacanthos*.

Subfamily Cylapinae

Tribe Fulvini

Fulvius imbecilis (Say). Missouri records: 6 specimens from Boone, Crawford and Franklin counties, 5 to 20 August. The Crawford County specimens were collected at a black light sheet.

Fulvius slateri Wheeler. STATE RECORD. Missouri records: 48 specimens from Boone County, 10 to 19 June. Collected under boards. Froeschner (1941) recorded this "probable species" as *F. brunneus* (Provancher) (Wheeler 1977).

Peritropis saldaeformis Uhler. STATE RECORD. Missouri records: 2 specimens from Boone and Randolph counties, 16 to 22 August. The Boone County specimen was collected at a black light sheet.

Subfamily Deraeocorinae

Tribe Clivinemini

Largidea grossa Van Duzee. STATE RECORD. Missouri records: 2 specimens from Callaway County, 14 and 18 September. Both specimens were taken at Tucker Prairie and carry Malaise trap labels.

Tribe Deraeocorini

Deraeocoris aphidiphagus Knight. Missouri records: 5 specimens from Barry, Boone, Gentry and Howard counties, 20 May to 7 July. The Gentry County specimen carries the ecological label "in leaf gall on elm of *Eriosoma americanum* (Riley)." Five specimens from Shenandoah, IA, carry the ecological label "predaceous on woolly apple aphid" and also bear H. H. Knight's determination label.

Deraeocoris davisii Knight. Missouri records: 2 specimens from Johnson and Ozark counties, 28 May to 6 June. The Ozark County specimen was hand picked from little bluestem, *Andropogon scoparius* Michx., at night on a cedar glade.

Deraeocoris glandis (Uhler). Missouri records: 35 specimens from Bollinger, Boone, Johnson, Montgomery, Ralls, Randolph and St. Clair counties, 24 May to 17 June. Collected on hickory, *Carya* sp., and black walnut, *Juglans nigra*. Commonly collected at black light sheets.

Deraeocoris histrio (Reuter). Missouri records: 51 specimens from Adair, Andrew, Bollinger, Boone, Callaway, Gentry, Grundy, Holt, Johnson, Lafayette and Randolph counties, 3 May to 12 September. Collected on smartweed, *Polygonum* sp. The Gentry County specimen was collected on 26 December under bark. Commonly collected at black light sheets.

Deraeocoris manitou (Van Duzee). Missouri records: 8 specimens from Benton, Boone and Ozark counties, 28 May to 8 June. Collected on red cedar, *Juniperus virginiana*.

Deraeocoris nebulosus (Uhler). Missouri records: 73 specimens from Boone, Butler, Callaway, Carroll, Chariton, Gentry, Howard, Johnson, Lewis, Montgomery, Pemiscott, Pettis and Stoddard counties, 5 April to 20 October. Collected on honeylocust, *Gleditsia triacanthos*; white oak, *Quercus alba*; willow, *Salix* sp.; cotton, *Gossypium herbaceum*; and horse weed, *Erigeron canadensis* L. Two specimens collected on 24 December and 8 January carry the ecological label "under bark." Commonly collected at black light sheets.

Deraeocoris ornatus Knight. Missouri records: Froeschner (1949) recorded this species from Buchanan and St. Louis counties during July and October. We have seen no additional Missouri specimens.

Deraeocoris poecilus (McAtee). Missouri records: 16 specimens from Boone, Gasconade, Montgomery, Nodaway, Pike, Randolph and Wayne counties, 9 March to 29 September. Collected on willow, *Salix* sp., in Nodaway County.

Deraeocoris quercicola Knight. Missouri records: 68 specimens from Boone, Johnson, Ozark, Pike, Randolph, St. Clair, St. Louis, Stoddard and Wayne counties, 24 May to 29 June. Collected on white oak, *Quercus alba*, and hickory, *Carya* sp. Commonly collected at black light sheets.

Deraeocoris sayi (Reuter). Missouri records: 54 specimens from Boone, Crawford, Hickory, Johnson, Randolph and St. Clair counties, 3 May to 13 June. Collected on oak, *Quercus* sp. Commonly collected at black light sheets.

Eustictus catulus (Uhler). STATE RECORD. Missouri records: 2 specimens from Boone and Holt counties, 11 August to 28 September.

Eustictus knighti Johnston. STATE RECORD. Missouri records: 1 specimen from Douglas County, 4 July.

Eustictus necopinus Knight. Missouri records: 3 specimens from Callaway and Warren counties, 1 July to 17 August. The Callaway County specimen was taken in a light trap.

Eustictus salicicola Knight. Missouri records: 1 specimen from Boone County, 29 July.

Eustictus venatorius Van Duzee. STATE RECORD. Missouri records: 1 specimen from Bollinger County, 11 June.

Tribe Hyaliadini

Hyaliodes harti Knight. Missouri records: 68 specimens from Atchison, Boone, Callaway, Dent, Gasconade, Holt, Lincoln, Ralls, St. Clair and St. Louis counties, 1 June to 11 October. Collected on white oak, *Quercus alba*, and other *Quercus* sp.

Hyaliodes vitripennis (Say). Missouri records: 18 specimens from Andrew, Barry, Boone, Callaway, Shannon, Stone and Wayne counties, 1 June to 26 August. Collected on grape, *Vitis* sp., hickory, *Carya* sp. and sycamore, *Platanus occidentalis*.

Subfamily Mirinae

Tribe Herdoniini

Barberiella formicoides Poppius. Missouri records: Froeschner (1949) recorded this species as *B. apicalis* Knight from Mississippi County on 19 August. We have seen no additional Missouri specimens. Recorded from apple, *Pyrus malus* L., and crabapple, *Malus* sp. (Wheeler and Henry 1980).

Paraxenetus guttulatus (Uhler). Missouri records: 8 specimens from Andrew, Atchison, Boone, Callaway, Jefferson and Pemiscott counties, 15 July to 6 August. Collected on wild grape, *Vitis* sp. Occasionally collected at black light sheets.

Tribe Mirini

Adelphocoris lineolatus (Goeze) (alfalfa plant bug). Missouri records: 450 specimens from 90 counties throughout the state, 20 May to 26 September.

Taken on a variety of herbaceous plants, primarily legumes. Many of the specimens bear the labels "on red clover" and "on alfalfa."

Adelphocoris rapidus (Say) (rapid plant bug). Missouri records: 650 specimens from 109 counties throughout the state, 5 May to 14 October. Taken on a variety of herbaceous plants, primarily legumes. Many of the specimens bear the labels "on red clover" and "on alfalfa."

Agnocoris pulverulentus (Uhler). Missouri records: 32 specimens from Madison, Ozark, Randolph and Reynolds counties, 26 April to 11 August. Collected on sandbar willow, *Salix interior*. One specimen examined collected on 9 October in Malcolm County, NE, carries the ecological label "in dried wood nettle leaf." Froeschner (1949) recorded this species in part as *Lygus rubicundus* (Fallen).

Agnocoris rossi Moore. Missouri records: 42 specimens from Bollinger, Boone, Crawford, Holt, Jefferson, Johnson, Osage, Reynolds and St. Clair counties, 3 June to 11 August. Collected on sandbar willow, *Salix interior*. Froeschner (1949) recorded this species in part as *Lygus rubicundus* (Fallen).

Bolteria luteifrons Knight. Missouri records: 29 specimens from Benton, Boone, Maries and Ozark counties, 27 April to 29 May. Collected on red cedar, *Juniperus virginiana*.

Capsus ater (L.). Missouri records: 18 specimens from Adair, Benton, Boone, Crawford and Randolph counties, 12 May to 17 June. Swept from roadside grasses and native prairies.

Coccobaphes frontifer (Walker). Missouri records: 6 specimens from Barry, Boone, Green, Randolph, St. Louis and Stoddard counties, 30 May to 23 June. Collected on maple, *Acer* sp. *C. sanguinarius* Uhler as reported by Froeschner (1949) is a junior synonym of *C. frontifer* (Walker) (Henry 1985a).

Dichrooscytus elegans Heidemann. Missouri records: 64 specimens from Boone, Carrol, Crawford, Maries, Phelps and Shannon counties, 28 April to 11 September. Collected on red cedar, *Juniperus virginiana*. Froeschner (1949) recorded this species as *D. tinctipennis* Knight (Wheeler and Henry 1975).

Dichrooscytus repletus (Heidemann). Missouri records: 69 specimens from Benton, Boone, Callaway, Monroe, Ozark, Phelps and Shannon counties, 26 April to 1 October. Collected on red cedar, *Juniperus virginiana* L. Froeschner (1949) recorded this species as *D. viridicans* Knight (Wheeler and Henry 1975).

Dichrooscytus suspectus Reuter. Missouri records: Froeschner (1949) recorded this species from Taney County on 15 September on cedar, *Juniperus* sp. We have seen no additional Missouri specimens.

Garganus fusiformis (Say). Missouri records: 31 specimens from Barry, Boone, Callaway, Dade, Macon, Randolph, Ste. Genevieve and Saline counties, 11 April to 2 October.

Lygidea obscura Reuter. Missouri records: 12 specimens from Boone, Crawford, Madison and Reynolds counties, 13 to 29 June. Collected on sandbar willow, *Salix interior*, and black willow, *S. nigra*.

Lygidea rosacea Reuter. Missouri records: 2 specimens from Boone and Lewis counties, 4 to 15 June. Knight (1941) listed sandbar willow, *Salix interior*, as the host plant.

Lygidea salicis Knight. STATE RECORD. Missouri records: 1 specimen from Boone County, 8 June. Collected on black willow, *Salix nigra*.

Lygocoris aesculi (Knight). Missouri records: 14 specimens from Boone County, 29 April to 1 June. Collected on Ohio buckeye, *Aesculus glabra*. Froeschner (1949) recorded this species and other *Lygocoris* spp., except *L. pabulinus* (L.), in the genus *Neolygus*.

Lygocoris atritylus (Knight). STATE RECORD. Missouri records: 3 specimens from Boone County, 19 May. Knight (1941) reported willow, *Salix* sp., as the host plant.

Lygocoris betulae (Knight). Missouri records: Knight (1953) described this species from material taken in Rosebud (Gasconade County) and Van Buren (Carter County), MO, during June. We have seen no additional Missouri specimens.

Lygocoris caryae (Knight) (hickory plant bug). Missouri records: 64 specimens from Benton, Boone, Callaway, Chariton, Johnson, Pike, Randolph, St. Clair and St. Francois counties, 23 April to 19 June. Collected on hickory, *Carya* sp.; pecan, *C. illinoensis*; post oak, *Quercus stellata*; shingle oak, *Q. imbricaria*; sumac, *Rhus* sp.; and sandbar willow, *Salix interior*. Occasionally collected at black light sheets.

Lygocoris geneseensis (Knight). Missouri records: 70 specimens from Boone, Callaway, Johnson, Randolph, St. Clair, Shannon and Stoddard counties, 18 May to 27 June. Collected on red oak, *Quercus rubra* L.; white oak, *Q. alba*; pecan, *Carya illinoensis*; and black walnut, *Juglans nigra*. The St. Clair County specimen was collected at a black light sheet.

Lygocoris hirticulus (Van Duzee). STATE RECORD. Missouri records: 23 specimens from Barry, Boone and Ozark counties, 10 May to 8 June. Collected on maple, *Acer* sp. One Boone County specimen carries the host label "in blossom of tulip tree." Occasionally collected at black light sheets.

Lygocoris inconspicuus (Knight). STATE RECORD. Missouri records: 21 specimens from Boone County, 21 May to 11 June. Collected on wild grape, *Vitis* sp.

Lygocoris invitus (Say). Missouri records: 64 specimens from Boone and Monroe counties, 6 May to 14 June. Collected on elm, *Ulmus* sp. A series of 33 specimens from Columbia (Boone County) are labeled "taken on flowering *Catalpa* tree."

Lygocoris omnivagus (Knight). STATE RECORD. Missouri records: 1 specimen from Boone County, 21 June. Knight (1941) listed oaks, *Quercus* spp., as the principal host plants.

Lygocoris pabulinus (L.). Missouri records: 5 specimens from Barry, Boone and Randolph counties, 8 June to 25 July. Kelton (1971b) reported a wide variety of host plants for this species. Froeschner (1949) recorded this species as *Lygus pabulinus* (L.).

Lygocoris quercalbae (Knight). Missouri records: 67 specimens from Boone, Callaway, Crawford, Johnson, Phelps, Pike, Randolph and Taney counties, 26 April to 18 June. Collected on white oak, *Quercus alba*; shingle oak, *Q. imbricaria*; post oak, *Q. stellata*; black oak, *Q. velutina*; hickory, *Carya* sp.; black walnut, *Juglans nigra*; and willow, *Salix* sp. Occasionally collected at black light sheets.

Lygocoris semivittatus (Knight). Missouri records: 9 specimens from Boone, Randolph and Wayne counties, 19 May to 21 June. Collected on sandbar willow, *Salix interior*, in Boone County.

Lygocoris tiliae (Knight). Missouri records: Froeschner (1949) recorded this species from Boone and Schuyler counties from 29 May to 23 June. Knight (1941) reported basswood, *Tilia americana*, as the host plant. We have seen no additional Missouri specimens.

Lygocoris tinctus (Knight). STATE RECORD. Missouri records: 22 specimens from Boone County, 31 May to 14 June. Collected on honeylocust, *Gleditsia triacanthos*.

Lygocoris vitticollis (Reuter). Missouri records: 28 specimens from Boone and Johnson counties, 13 May to 16 June. Collected on silver maple, *Acer saccharium* L., in Boone County. Occasionally collected at black light sheets.

Lygus elisus Van Duzee (pale legume bug). Missouri records: 2 specimens from Boone and Callaway counties, 14 August and 10 September. Collected on ragweed, *Ambrosia* sp.

Lygus lineolaris (Palisot de Beauvois) (tarnished plant bug). Missouri records: More than 4000 specimens from all 114 counties, 7 April to 28 October. This common species has been taken on a wide variety of herbaceous plants. Recorded from 169 host plants (Snodgrass et al. 1984b).

Lygus plagiatus Uhler. Missouri records: 42 specimens from Benton, Boone, Callaway, Dent, Randolph, Texas and Wayne counties, 16 April to 5 October. Collected on giant ragweed, *Ambrosia trifida*, and horse weed, *Erigeron canadensis*. Occasionally collected at black light sheets.

Metriorrhynchomiris dislocatus (Say). Missouri records: 158 specimens from 20 counties throughout the state, 21 April to 28 June. Collected on a number of herbaceous plants, usually growing along the wood border and in thick underbrush. Froeschner (1949) recorded this species, and all other *Metriorrhynchomiris* spp. in the genus *Horcias*.

Metriorrhynchomiris fallax (Reuter). Missouri records: Froeschner (1949) recorded this species from St. Louis and Franklin counties from 8 to 24 May. We have seen no additional Missouri specimens.

Metriorrhynchomiris illini (Knight). Missouri records: 20 specimens from Boone, Crawford and Franklin counties, 23 April to 30 May. An autotype of this species bearing H. H. Knight's determination label was examined in the W. S. Craig collection. First recorded from Missouri by Knight (1953).

Neocapsus cuneatus Distant. Missouri records: 37 specimens from Boone, Crawford, Franklin, Pike and Taney counties, 30 April to 12 June. Collected on post oak, *Quercus stellata*, and white oak, *Q. alba*.

Neurocolpus jessiae Knight. Missouri records: 12 specimens from Boone, Callaway, Gasconade, Pettis, Pike and Randolph counties, 6 June to 6 August. Collected on elderberry, *Sambucus canadensis* L.

Neurocolpus nubilus (Say) (clouded plant bug). Missouri records: 156 specimens from 21 counties throughout the state, 25 May to 26 September. Collected on button bush, *Cephalanthus occidentalis* L.; smooth sumac, *Rhus glabra*; cotton, *Gossypium hirsutum*; dogwood, *Cornus* sp.; willow, *Salix* sp.; viburnum, *Viburnum* sp.; horsemint, *Monarda russeliana* Nutt.; and glossy buckthorn, *Rhamnus frangula* L. *N. rubidus* Knight as reported by Froeschner (1949) is a junior synonym of *N. nubilus* (Henry and Kim 1984).

Neurocolpus tiliae Knight. Missouri records: Froeschner (1949) recorded this species from Boone, Buchanan and St. Louis counties, 29 May to 28 June.

Adults and nymphs were taken on basswood, *Tilia americana*. We have seen no additional Missouri specimens.

Orthops scutellatus Uhler. STATE RECORD. Missouri records: 4 specimens from Boone and Callaway counties, 20 June to 19 August. Two of the Callaway County specimens were taken in a light trap. Froeschner (1949) recorded this species as *Lygus campestris* (L.). Recorded from the Umbelliferae family (Knight 1941).

Pachypeltocoris conspersus Knight. Missouri records: Knight (1953) described this species from a female collected in Des Arcs (Iron County), MO, on 31 May 1943. We have seen no additional Missouri specimens.

Phytocoris albifacies Knight. STATE RECORD. Missouri records: 4 specimens from St. Clair and Stoddard counties, 7 to 10 June. The St. Clair County specimens were collected at a black light sheet.

Phytocoris antennalis Reuter. STATE RECORD. Missouri records: 3 specimens from Boone County, 26 June to 19 July. One specimen was taken at a black light sheet and one in a Malaise trap.

Phytocoris brevisculus Reuter. Missouri records: 9 specimens from Boone, Callaway, Cooper and Vernon counties, 5 June to 24 July. Collected on red cedar, *Juniperus virginiana* L., and apple, *Pyrus malus* L. Several of the Boone County specimens were collected at black light sheets.

Phytocoris canadensis Van Duzee. Missouri records: 9 specimens from Barry and Boone counties, 8 June to 28 August. Taken in Boone County on elm, *Ulmus* sp. Occasionally collected at black light sheets.

Phytocoris caryae Knight. STATE RECORD. Missouri records: 5 specimens from Bollinger, Boone and Callaway counties, 10 June to 20 August. Two specimens were taken at lights.

Phytocoris confluens Reuter. Missouri records: Froeschner (1949) recorded this species from Howell County on 2 August. We have seen no additional Missouri specimens.

Phytocoris conspurcatus Knight. Missouri records: 10 specimens from Boone and Reynolds counties, 5 June to 8 September. Two Boone County specimens were collected at black light sheets.

Phytocoris corticevivens Knight. Missouri records: 15 specimens from Boone, Crawford and Johnson counties, 14 May to 6 June. All specimens were collected at black light sheets.

Phytocoris depictus Knight. Missouri records: 13 specimens from Boone, Callaway, Cole, Gasconade and Randolph counties, 28 June to 14 October. Collected on oak, *Quercus* sp. Occasionally collected at black light sheets.

Phytocoris erectus Van Duzee. Missouri records: 14 specimens from Boone and St. Francois counties, 13 June to 1 October. Collected on black willow, *Salix nigra*, and sandbar willow, *S. interior*. Occasionally collected at black light sheets.

Phytocoris eximius Reuter. STATE RECORD. Missouri records: 3 specimens from Bollinger and Boone counties, 11 June to 19 July. The 2 Boone County specimens were collected at black light sheets. Froeschner (1949) recorded this species as *P. canadensis* Van Duzee. Henry and Stonedahl (1984) have recently shown that *P. canadensis* and *P. eximius* are valid species and that much of the literature, including Froeschner's (1949) record under the name *eximius*, is in error. We therefore consider our records of *eximius* a new state record.

Phytocoris infuscatus Reuter. Missouri records: 8 specimens from Bollinger, St. Clair and Stoddard counties, 7 to 13 June.

Phytocoris luteolus Knight. STATE RECORD. Missouri records: 2 specimens from St. Clair County, 7 June. Our only specimens were collected at a black light sheet.

Phytocoris minutulus Reuter. STATE RECORD. Missouri records: 1 specimen from Boone County, 24 June. Our only specimen was collected at a black light sheet.

Phytocoris neglectus Knight. Missouri records: Froeschner (1949) recorded this species from Iron County, on 29 May. We have seen no additional Missouri specimens.

Phytocoris onustus Van Duzee. STATE RECORD. Missouri records: 1 specimen from Ozark County, 28 May. Our only specimen was collected at a black light sheet.

Phytocoris oppositus Knight. Missouri records: 11 specimens from Boone and Callaway counties, 12 July to 24 October. This species has been taken using a D-Vac in tall fescue pastures. Males are occasionally collected at black light sheets. The females are brachypterous and incapable of flight. First recorded from Missouri by Blinn and Yonke (1982). Prior to this, it was only known from the type locality in Mississippi (Knight 1926).

Phytocoris osage Knight. Missouri records: Knight (1953) described this species from material collected in McDonald and Ste. Genevieve counties during June and September. We have seen no additional Missouri specimens.

Phytocoris pinicola Knight. Missouri records: Froeschner (1949) recorded this species from Iron County on 29 June. We have seen no additional Missouri specimens.

Phytocoris puella Reuter. Missouri records: 14 specimens from Bollinger, Boone, Callaway, Crawford, St. Clair and Shannon counties, 27 June to 18 September. Two Boone County specimens carry the host label "sweeping oak." The Callaway County specimen was taken in a Malaise trap. Occasionally collected at black light sheets.

Phytocoris purvus Knight. STATE RECORD. Missouri records: 21 specimens from Boone, Callaway, Crawford, Johnson, Montgomery and St. Clair counties, 14 May to 13 September. Commonly collected at black light sheets. One Boone County specimen carries the ecological label "sticky board in oak hickory canopy."

Phytocoris quercicola Knight. STATE RECORD. Missouri records: 3 specimens from Benton and Callaway counties, 21 to 27 June. One Callaway County specimen was taken in a Malaise trap.

Phytocoris rubellus Knight. Missouri records: 14 specimens from Adair, Boone, Callaway and Camden counties, 7 July to 7 October. Collected in Boone County on willow, *Salix* sp.

Phytocoris salicis Knight. Missouri records: 3 specimens from Bollinger and Boone counties, 11 to 17 June. Collected in Boone County on willow, *Salix* sp.

Phytocoris spicatus Knight. STATE RECORD. Missouri records: 1 specimen from Crawford County, 5 June. Collected on white oak, *Quercus alba*.

Phytocoris sulcatus Knight. STATE RECORD. Missouri records: 2 specimens from Bollinger and Boone counties, 11 to 19 June. The Boone County specimen carries the ecological label "sticky board in oak hickory canopy."

Phytocoris taxodii Knight. STATE RECORD. Missouri records: 1 specimen from Stoddard County, 14 July. Collected on bald cypress, *Taxodium distichum*.

Phytocoris tibialis Reuter. Missouri records: 27 specimens from Bollinger, Boone, Callaway, Holt, Polk, Randolph, St. Louis, Saline and Wayne counties, 13 June to 26 September. Swept from herbaceous plants along wood margins. Occasionally taken at black light sheets.

Phytocoris tuberculatus Knight. Missouri records: 3 specimens from Boone, Gasconade and St. Clair counties, 7 to 19 June. Occasionally collected at black light sheets. The Boone County specimen carries the ecological label "sticky board in oak hickory canopy."

Phytocoris tucki Knight. Missouri records: 2 specimens from St. Clair and Ozark counties, 28 May to 12 June. This species, first described by Knight (1953) from Missouri, has been collected only on cedar glades.

Phytocoris uniformis Knight. STATE RECORD. Missouri records: 1 specimen from Shannon County, 25 July. Our only specimen was collected at a black light sheet.

Poecilocapsus lineatus (Fab.) (fourlined plant bug). Missouri records: 130 specimens from 17 counties throughout the state, 29 April to 6 July. Collected on a variety of herbaceous plants. Wheeler and Miller (1981) provided an extensive list of host plants.

Polymerus basalis (Reuter). Missouri records: 104 specimens from Atchison, Benton, Bollinger, Boone, Callaway, Clay, New Madrid, Ozark, Pemiscott and Phelps counties, 15 May to 26 October. Collected on aster, *Aster* sp.; sandwort, *Arenaria* sp.; sunflower, *Helianthus* sp.; and tickseed, *Coreopsis* sp. Commonly collected at black light sheets.

Polymerus breviostris Knight. STATE RECORD. Missouri records: 1 specimen from Pettis County, 5 June.

Polymerus flavocostatus Knight. Missouri records: 29 specimens from Boone, Callaway, Hickory, Monroe, Pike and Randolph counties, 20 May to 29 July. The Monroe County specimens were swept from goldenrod, *Solidago* sp.

Polymerus froeschneri Knight. Missouri records: 8 specimens from Benton, Ste. Genevieve and Ozark counties, 25 May to 26 July. This species, first described by Knight (1953) from Missouri, has been collected only on cedar glades.

Polymerus proximus Knight. Missouri records: 60 specimens from Barry, Boone, Callaway, Randolph and St. Louis counties, 4 May to 13 June. Collected on bedstraw, *Galium aparine*.

Polymerus punctipes Knight. Missouri records: 9 specimens from Boone, Callaway, Crawford, Gasconade, Monroe, Morgan and Pettis counties, 10 May to 19 June. Knight (1941) listed loosestrife, *Lysimachia quadrifolia* Sims, as the host plant.

Polymerus venaticus (Uhler). Missouri records: 25 specimens from Adair, Boone, Callaway, Monroe and Randolph counties, 23 May to 29 July. Collected on goldenrod, *Solidago* sp., in Monroe County.

Stenotus binotatus (Fab.). Missouri records: 269 specimens from 36 counties throughout the state, 15 May to 29 July. Breeds on orchard grass, *Dactylis glomerata* L., and timothy, *Phleum pratense* L. Many of the specimens examined carry the labels "on alfalfa," "on bluegrass," "on red clover," "on hop clover" and "on white clover." Occasionally collected at black light sheets.

Taedia casta (McAtee). Missouri records: 2 specimens from Boone County, 14 July. Our only specimens were collected at a black light sheet. Froeschner (1949) recorded this species, and all other *Taedia* spp. in the genus *Paracalocoris*.

Taedia celtidis (Knight). STATE RECORD. Missouri records: 3 specimens from Randolph County, 17 July.

Taedia colon (Say). Missouri records: Carvalho (1959) listed this species from Missouri. We have seen no Missouri specimens.

Taedia evonymi (Knight). Missouri records: 4 specimens from Benton, Boone and Crawford counties, 31 May to 19 June.

Taedia gleditsiae (Knight). Missouri records: 7 specimens from Atchison and Boone counties, 20 May to 24 June. Collected on honeylocust, *Gleditsia triacanthos*.

Taedia limba (McAtee). Missouri records: 3 specimens from Crawford County, 19 to 29 June. Collected on sandbar willow, *Salix interior*.

Taedia multisignata (Reuter). Missouri records: Froeschner (1949) recorded this species on the flowers of muscadine, *Vitis rotundifolia* Michx., in Newton County on 22 June. We have seen no additional Missouri specimens.

Taedia salicis (Knight). Missouri records: 7 specimens from Boone and Morgan counties, 10 June to 13 July. Collected on willow, *Salix* sp., in Boone County.

Taedia scrupea (Say). Missouri records: 70 specimens from 15 counties throughout the state, 16 May to 5 July. Collected on smooth sumac, *Rhus glabra*, and wild grape, *Vitis* sp.

Taylorilygus pallidulus (Blanchard). Missouri records: 265 specimens from Barry, Bollinger, Boone, Callaway and Marion counties, 2 May to 18 September. All Callaway County specimens are from Tucker Prairie and carry the ecological label "light trap." Froeschner (1949) recorded this species as *Lygus apicalis* Fieber. Snodgrass et al. (1984a) provided an extensive host list.

Tropidosteptes adustus (Knight). Missouri records: 1 specimen from Randolph County, 23 May. Froeschner (1949) recorded this species and other *Tropidosteptes* spp., except where noted, in the genus *Neoborus*.

Tropidosteptes amoenus Reuter (ash plant bug). Missouri records: 8 specimens from Barry, Boone, Camden, Clark and Randolph counties, 9 May to 12 September. Collected on ash, *Fraxinus* sp. Occasionally collected at black light sheets.

Tropidosteptes canadensis Van Duzee. STATE RECORD. Missouri records: 12 specimens from Boone and Macon counties, 6 May to 8 June. Taken in Boone County on white ash, *Fraxinus americana* L.

Tropidosteptes cardinalis Uhler. Missouri records: 37 specimens from Benton, Boone, Callaway, Gasconade, Osage, Shannon and Stone counties, 26 April to 9 June. Collected on white ash, *Fraxinus americana*, in Boone County. Occasionally collected at black light sheets.

Tropidosteptes geminus (Say). STATE RECORD. Missouri records: 9 specimens from Boone and St. Louis counties, 26 May to 8 June. Collected on white ash, *Fraxinus americana*, in Boone County.

Tropidosteptes glaber (Knight). Missouri records: 25 specimens from Boone, Carrol, Callaway, Macon and Saline counties, 27 April to 8 June. Collected on white ash, *Fraxinus americana*, in Boone County.

Tropidosteptes palmeri (Reuter). Missouri records: 1 specimen from Randolph County, 30 August.

Tropidosteptes pettiti Reuter. Missouri records: 7 specimens from Boone and Macon counties, 22 May to 8 June. Collected on ash, *Fraxinus* sp. Froeschner (1949) recorded this species as *Xenoborus pettiti* (Reuter).

Tropidosteptes populi (Knight). STATE RECORD. Missouri records: 4 specimens from Boone County, 22 June to 17 July. Collected on green ash, *Fraxinus pennsylvanica*. Occasionally collected at black light sheets.

Tropidosteptes rufusculus (Knight). STATE RECORD. Missouri records: 1 specimen from Boone County, 25 June. Our only specimen was collected at a black light sheet.

Tropidosteptes selectus (Knight). Missouri records: 4 specimens from Boone County, 22 June. Collected on green ash, *Fraxinus pennsylvanica*. Froeschner (1949) recorded this species as *Xenoborus selectus* Knight.

Tropidosteptes tricolor Van Duzee. Missouri records: This species is listed from Missouri by Knight (1923, 1941) and Blatchley (1926). We have seen no additional Missouri specimens.

Tropidosteptes vittiscutis (Knight). Missouri records: A paratype of this species was reported by Knight (1923) from Mississippi County on 22 June. We have seen no additional Missouri specimens.

Tribe Pithanini

Mimoceps insignis Uhler. Missouri records: 3 specimens from Holt County, 17 June. Collected while sweeping a roadside ditch where grasses and sedges were abundant.

Tribe Resthenini

Opistheurista clandestina (Van Duzee). Missouri records: Froeschner (1949) recorded this species in the genus *Opistheuria* from Pemiscott and Mississippi counties during August and September. We have seen no additional Missouri specimens.

Prepops circumcinctus (Say). Missouri records: 3 specimens from Boone, St. Louis and Wayne counties, 11 to 26 June. Froeschner (1949) recorded this species, and all other *Prepops* spp. in the genus *Platytylellus*.

Prepops fraterculus (Knight). STATE RECORD. Missouri records: 2 specimens from Boone and Phelps counties, 4 July to 20 September.

Prepops fraternus (Knight). Missouri records: 48 specimens from Benton, Boone, Callaway, Crawford, Gasconade, Maries, Pettis, Pike, St. Francois, St. Louis, Ste. Genevieve, Texas and Vernon counties, 31 May to 13 August. One Boone County specimen collected on 19 June, bears the ecological label "under board."

Prepops insitivus (Say). Missouri records: 19 specimens from Boone, Callaway, Johnson, Monroe, Pike, Randolph and Ste. Genevieve counties, 21 May to 1 October. Collected on wild grape, *Vitis* sp.

Prepops nigricollis (Reuter). Missouri records: 13 specimens from Barry, Boone, Callaway, Camden and Lawrence counties, 5 June to 12 September. Several specimens bear Malaise trap labels.

Prepops nigroscutellatus (Knight). Missouri records: 4 specimens from Boone, Dent, Randolph and St. Louis counties, 10 to 25 June.

Prepops rubrovittatus (Stal). Missouri records: 1 specimen from Stoddard County, 12 June.

Tribe Stenodemini

Collaria meilleurii Provancher. STATE RECORD. Missouri records: 6 specimens from Barry, Crawford and St. Francois counties, 10 to 19 June. Recorded from grasses growing in damp situations (Knight 1941).

Collaria oculata (Reuter). Missouri records: 45 specimens from Barry, Benton, Boone, Callaway, Crawford, Phelps, Randolph, Ste. Genevieve, Monroe, Stoddard and Vernon counties, 6 May to 18 September. Recorded from various grasses growing in dry situations (Knight 1941).

Leptopterna dolabrata (L.) (meadow plant bug). Missouri records: 291 specimens from 114 counties throughout the state, 28 April to 22 June. This species breeds on a variety of forage grasses. Froeschner (1949) recorded this species as *Miris dolabratus* (L.).

Megaloceroea recticornis (Geoffroy). STATE RECORD. Missouri records: 11 specimens from Adair and Shannon counties, 1 June to 29 July. This species was swept from various grasses growing along a lake margin in Shannon County.

Stenodema trispinosum Reuter. Missouri records: 25 specimens from Boone, Callaway, Dent, Randolph, St. Charles, Ste. Genevieve, Stoddard and Wayne counties, 28 April to 8 August.

Teratocoris discolor Uhler. Missouri records: 2 specimens from Callaway County, 13 and 20 July. Both specimens carry the ecological label "light trap."

Trigonotylus coelestialium (Kirkaldy). Missouri records: 274 specimens from 33 counties throughout the state, 9 May to 26 October. This species was found on various grasses, usually in moist, low-lying areas. Commonly collected at black light sheets. First recorded from Missouri by Blinn and Yonke (1982). Recorded from numerous grass hosts (Wheeler and Henry 1985).

Trigonotylus doddi (Distant). Missouri records: Froeschner (1949) recorded this species as *T. brevipes* Jakovlev from Buchanan, Butler and Pemiscott counties from June to October. We have seen no additional Missouri specimens. Recorded from a number of grass hosts (Snodgrass et al. 1984a).

Trigonotylus pulcher Reuter. Missouri records: 3 specimens from Boone, Callaway and Franklin counties, 6 August to 14 October. The Callaway County specimen is from a Malaise trap.

Trigonotylus ruficornis (Geoffroy). Missouri records: Froeschner (1949) reported this species common in weedy fields and at lights between 8 June and 21 September. We have seen no additional Missouri specimens. Froeschner's records may refer to *T. coelestialium* (Kirkaldy).

Trigonotylus saileri Carvalho. Missouri records: Kelton (1971a) reported this species from Missouri. We have seen no additional Missouri specimens.

Trigonotylus tarsalis (Reuter). Missouri records: 9 specimens from St. Clair County, 12 July. Collected on slough grass, *Spartina pectinata* Link., at Taberville Prairie.

Subfamily Bryocorinae

Tribe Eccritotarsini

Halticoma valida Townsend (yucca plant bug). Missouri records: 93 specimens from Barry, Boone, Cape Girardeau and St. Louis counties, 9 June to 12 October. Collected on yucca, *Yucca* sp.

Pycnoderus convexicollis Blatchley. STATE RECORD. Missouri records: 34 specimens from Boone and St. Francois counties, 28 May to 31 October. Collected on spiderwort, *Tradescantia subaspera* Ker., in St. Francois County.

Pycnoderus medius Knight. Missouri records: 111 specimens from Barry and Boone counties, 21 June to 3 October. The majority of the Boone County specimens were taken on day-flower, *Commelina communis* L. The Barry County specimen was taken at a black light sheet.

Sixeonotus brevis Knight. STATE RECORD. Missouri records: 19 specimens from Boone and Callaway counties, 9 June to 7 October. The majority of the specimens bear Malaise trap labels.

Sixeonotus insignis Reuter. Missouri records: Froeschner (1949) recorded this species in Dunklin, St. Louis and Scott counties during June, August and September. We have seen no additional Missouri specimens.

Subfamily Dicyphinae

Cyrtopeltis modesta (Distant) (tomato bug). Missouri records: Listed for Missouri by Knight (1941) as *C. varians* (Distant). We have seen no additional Missouri specimens.

Cyrtopeltis notata (Distant) (suckfly). STATE RECORD. Missouri records: 50 specimens from Boone County, 16 August to 2 September. Collected on black nightshade, *Solanum americanum* Mill., in an abandoned pasture.

Dicyphus agilis (Uhler). Missouri records: Froeschner (1949) recorded this species on bramble, *Rubus* sp., in Bollinger County on 30 May. We have seen no additional Missouri specimens.

Dicyphus vestitus Uhler. Missouri records: Froeschner (1949) recorded this species from under leaves of mullein, *Verbascum* sp., in Boone and Maries counties during late March and early November. We have seen no additional Missouri specimens.

Macrolophus brevicornis Knight. Missouri records: 1 specimen from Boone County, 4 June.

Macrolophus separatus (Uhler). Missouri records: 1 specimen from Boone County, 7 September. Our only specimen was collected at a black light sheet.

Macrolophus tenuicornis Blatchley. Missouri records: Froeschner (1949) recorded this species from Buchanan County on 28 July. We have seen no additional Missouri specimens. Known from leaf cup, *Polymnia canadensis*, and hayscented fern, *Dennstaedtia punctilobula* (Michx.) Moore (Wheeler et al. 1979).

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The Pleistocene Peccary *Mylohyus fossilis* from Plummer Cave, Douglas County, Missouri

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Abstract: A nearly complete skeleton of the Pleistocene peccary *Mylohyus fossilis* was recently discovered in Plummer Cave, Douglas County, MO. This is the first record of *Mylohyus* in Missouri outside of Jefferson County and indicates *Mylohyus* inhabited the central Ozark region. The remains are probably latest Rancholabrean in age and if so, represent the westernmost latest Pleistocene occurrence of *Mylohyus* in the Midwest. *M. nasutus* may be a synonym of *M. fossilis*. A description of the location of Plummer Cave is here given for the first time.

Key Words: Pleistocene vertebrates, peccary, *Mylohyus fossilis*, *Mylohyus nasutus*

Introduction

On 11 or 12 June 1983, Golden, a palomino horse belonging to Mr. Mick Plummer of Douglas County, MO, broke through a mat of roots and leaves which covered a chimney-like entrance to a previously unknown cave (here named Plummer Cave). Searching for Golden, Mr. Plummer lowered himself down the 10 m deep shaft and found it led to a room 8 m in diameter, with several small passageways radiating outward. The carcass lay blocking the lowermost passageway, while at the mouth of another lay a nearly complete but disarticulated skull and skeleton of the Pleistocene peccary *Mylohyus fossilis*. Mr. Plummer returned to the surface with the skull and mandible and requested assistance in identification of the skeletal remains from the Department of Geography and Geology at Southwest Missouri State University.

Upon visiting the cave, the authors decided to delay collection of the post-cranial skeleton, as gases from the decaying horse carcass had reduced the amount of available oxygen (indicated by the failure of butane lighters to stay lit). In July, all large bones were individually removed from the cave-floor surface. The underclay was removed in buckets and screen-washed for small bones. A preliminary announcement of the discovery was given by Westgate et al. (1984).

Location

Plummer Cave is in northeast Douglas County, approximately 13 km south of Mountain Grove, southcentral MO. Map coordinates are the NW $\frac{1}{4}$, NE $\frac{1}{4}$, SW $\frac{1}{4}$ of Sec. 20, T.27N., R.12W., on the Mountain Grove, MO., S.E., USGS

7.5' Topographic Quadrangle (Fig. 1). The cave entrance is at an approximate elevation of 366 m (1200 ft) on a south facing slope bounded by the West Prong of Clifty Creek to the west and an unnamed seasonal tributary of that stream to the east. The cave system is developed in dolomitic rock of Ordovician age.

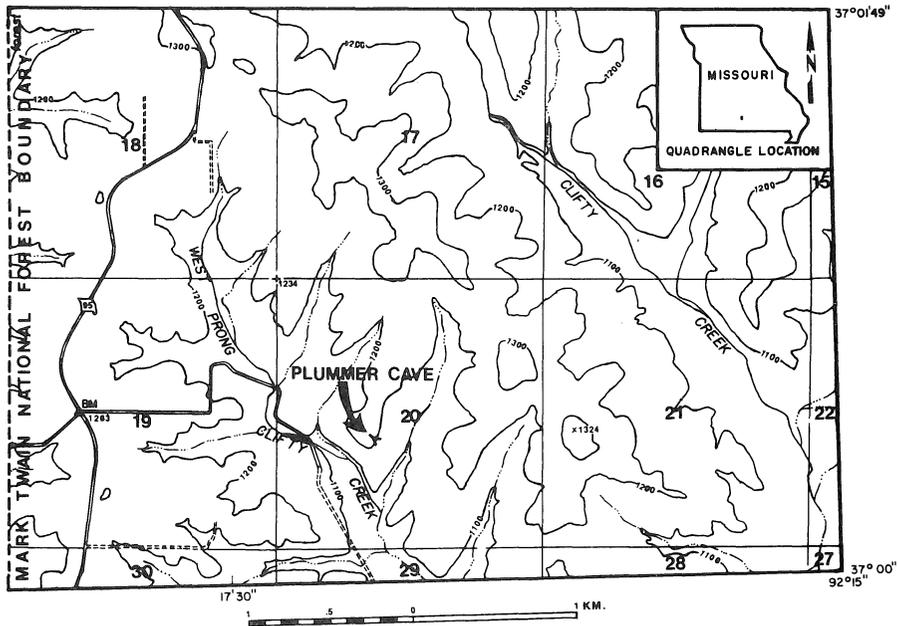


Fig. 1. Location of Plummer Cave in Douglas County, MO. (Adapted from the Mountain Grove, S.E., MO., 7.5' Topo. Quad., U.S.G.S. 1951.).

Skeletal Material

The Plummer Cave *Mylohyus* is the most complete specimen of the genus yet collected. The skull is in near-perfect condition, although the first pair of incisors are missing (Fig. 2, Table 1). The fragile nasal bones, preserved for the first time in a *Mylohyus* skull, are unusual in that they taper to a point anterior to the premaxillaries, unlike those of modern peccaries and previously reconstructed skulls of *Mylohyus*. The mandible is equally well preserved, although the left condyle is partially broken (Figs. 2A, 3, Table 1). The vertebral column is complete except for the axis, a posterior cervical and some caudals. All limb bones except some of the smaller elements of the manus are also preserved. Measurements of post-cranial skeletal elements (Table 2) are almost identical with those given for the nearly complete skeleton from Friesenhahn Cave (Lundelius 1960:36). Mr. Plummer has retained the specimen in his possession. However, casts of the skull and mandible and photographs of individual skeletal elements have been placed in the Vertebrate Paleontology collections of the Texas Memorial Museum.

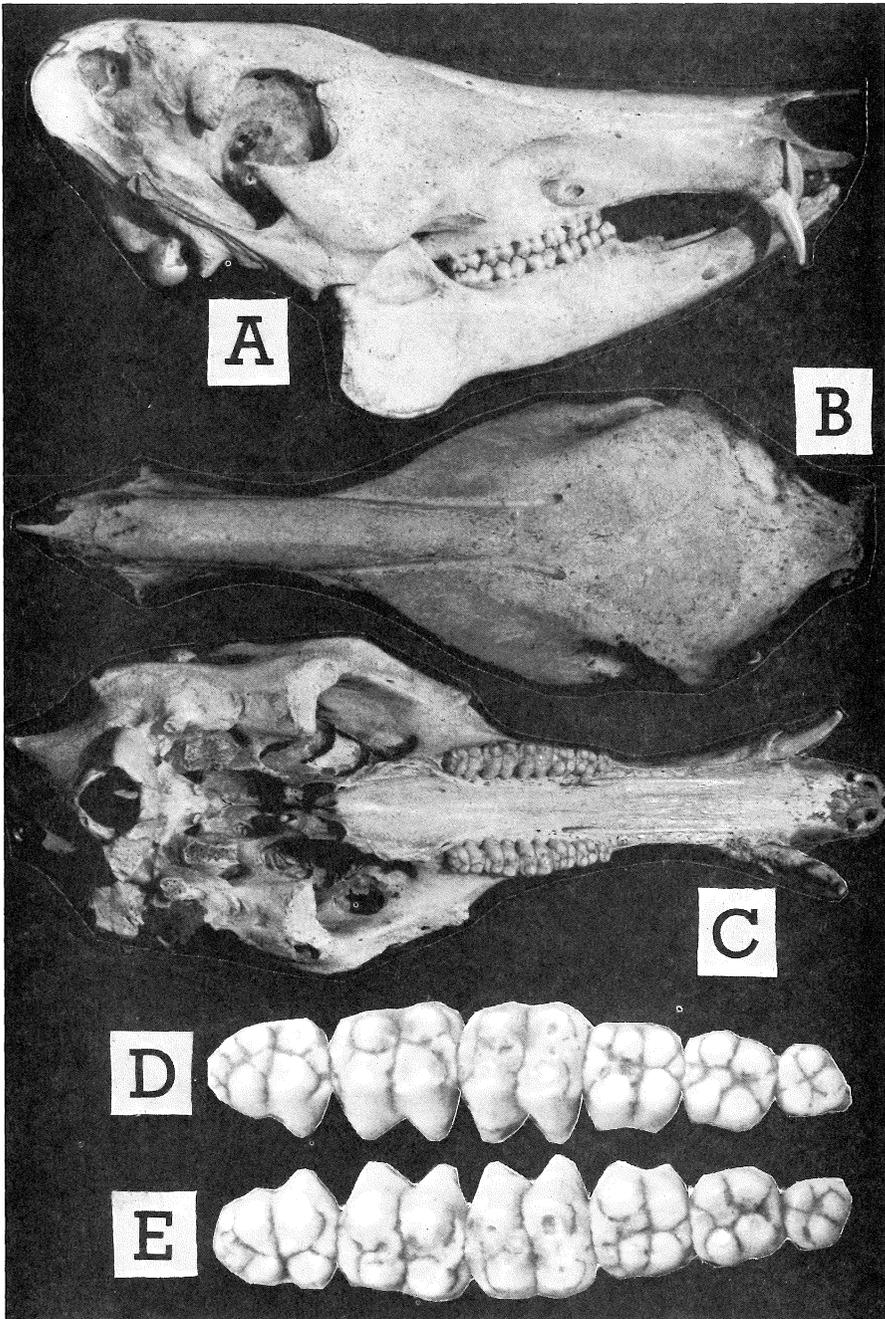


Fig. 2. Skull of *Mylohus fossilis* from Plummer Cave. A. Right lateral view of skull and mandible (X .3). B. Dorsal view (X .3). C. Ventral view (X .3). D. Right cheek teeth, anterior to right (X 1.1). E. Left cheek teeth, anterior to right (X 1.1).

Table 1. Measurements (mm) of the skull and mandible of *Mylohyus fossilis* from Plummer Cave.

Skull:		Left	Right
I ₂ /	L ^a	3.8	3.9
	W	3.7	3.7
Canine	L	11.7	11.8
	W	9.2	9.2
P ₂ /	L	7.8	7.3
	PW	8.2	8.2
P ₃ /	L	10.5	10.7
	AW	10.4	10.5
	PW	10.7	10.7
P ₄ /	L	11.7	11.4
	AW	12.4	12.5
	PW	12.5	12.6
M ₁ /	L	15.6	15.1
	AW	14.9	14.8
	PW	15.0	14.7
M ₂ /	L	14.7	14.6
	AW	15.4	15.5
	PW	14.6	14.9
M ₃ /	L	15.1	14.4
	AW	13.2	13.0
	PW	10.9	11.0
Premolars	TL	30.4	30.5
Molars	TL	45.8	45.9
Toothrow	TL	75.9	76.0
Length of diastema posterior to canine		70.4	71.5
Length of diastema anterior to canine		23.4	26.6
Width between canine alveoli		35.9	
Condyle to premaxilla, TL		348	
Mandible:		Left	Right
Molar and premolar series, TL		82.5	82.1
Premolars	TL	32.6	32.2
Molars	TL	49.5	50.0
Post canine diastema		76.7	76.9
Pre-canine diastema		8.3	8.2
Depth of jaw at M ₁		41.3	42.2
Thickness of jaw at M ₁		19.4	19.2
Width across jaws at M ₁		69.0	
Width of jaws at canine		34.5	
Width between canine alveoli		14.7	
Canine	L	11.4	11.3
	W	8.5	8.6
P ₂	L	8.7	8.6
	AW	5.3	5.4
	PW	6.4	6.5
P ₃	L	10.2	10.7
	AW	9.5	9.5
	PW	10.6	10.6
P ₄	L	12.5	11.2
	AW	11.8	11.5

Table 1 (continued).

	PW	12.9	12.7
M ₁	L	14.7	14.5
	AW	13.5	13.3
	PW	13.3	13.2
M ₂	L	15.2	15.3
	AW	13.9	14.0
	PW	13.6	13.7
M ₃	L	17.5	17.9
	AW	12.3	12.5
	PW	11.3	11.4
Mandible length, condyle to ant. end symphysis		260	
Narrowest width of symphysis		22.5	

^aL = length, W = width, PW = post. width, AW = ant. width, and TL = total length.

Missouri Occurrences and Chronologic Range

Mylohyus was first reported in Missouri by Olson (1940:56) on the basis of 3 isolated cheek teeth unidentifiable at the species level, found at Herculaneum Fissure in Jefferson County. Excepting the Plummer Cave record reported here, all other specimens of *Mylohyus* known from Missouri also come from Jefferson County. Parmalee et al. (1969:31-32) discovered a partial skull and skeleton and an isolated cheek tooth in Crankshaft Cave. They referred these specimens to *M. nasutus*. Dr. Russell Graham (Illinois State Museum) has also collected isolated *Mylohyus* teeth from Pleistocene deposits in Jefferson County at the Kimmswick site (pers. comm. 1983).

The genus *Mylohyus* is known from deposits as old as late Hemphillian (late Miocene), as shown by the occurrence of the relatively primitive *M. elmorei* in the Bone Valley Formation of Florida (Wright and Webb 1984). *Mylohyus* is present in the Blancan (Pliocene) as *M. floridanus* (Kinsey 1974). The genus has been considered to be represented in Irvingtonian and Rancholabrean (early and late Pleistocene) deposits by 2 contemporaneous species groups, *M. fossilis* and *M. nasutus* (Kinsey 1974:169). Parmalee et al. (1969:32) and Munson (1984) suggest that *Mylohyus* may have survived into early Holocene time.

The age of the Plummer Cave *Mylohyus* cannot be precisely determined due to the lack of an associated fauna or other means of dating the specimen. Cranial and dental morphology indicate it should be referred to *M. fossilis* and is probably no older than Irvingtonian. However, the fact that the skeleton was found lying exposed on the cave-floor surface, rather than being buried, suggests the remains are not of great antiquity. The specimen is most likely of latest Rancholabrean age and if so, represents the westernmost latest Pleistocene occurrence of *Mylohyus* in the Midwest. Lundelius et al. (1983:341) suggest the change from eastern woodlands to western grasslands in the Ozark area may have prohibited the latest Pleistocene range of eastern forest species from extending farther west.

Taxonomic Analysis

Ten species of *Mylohyus* were named between 1860 and 1929. Taxonomic confusion caused by this plethora of species was reduced by Lundelius (1960) in

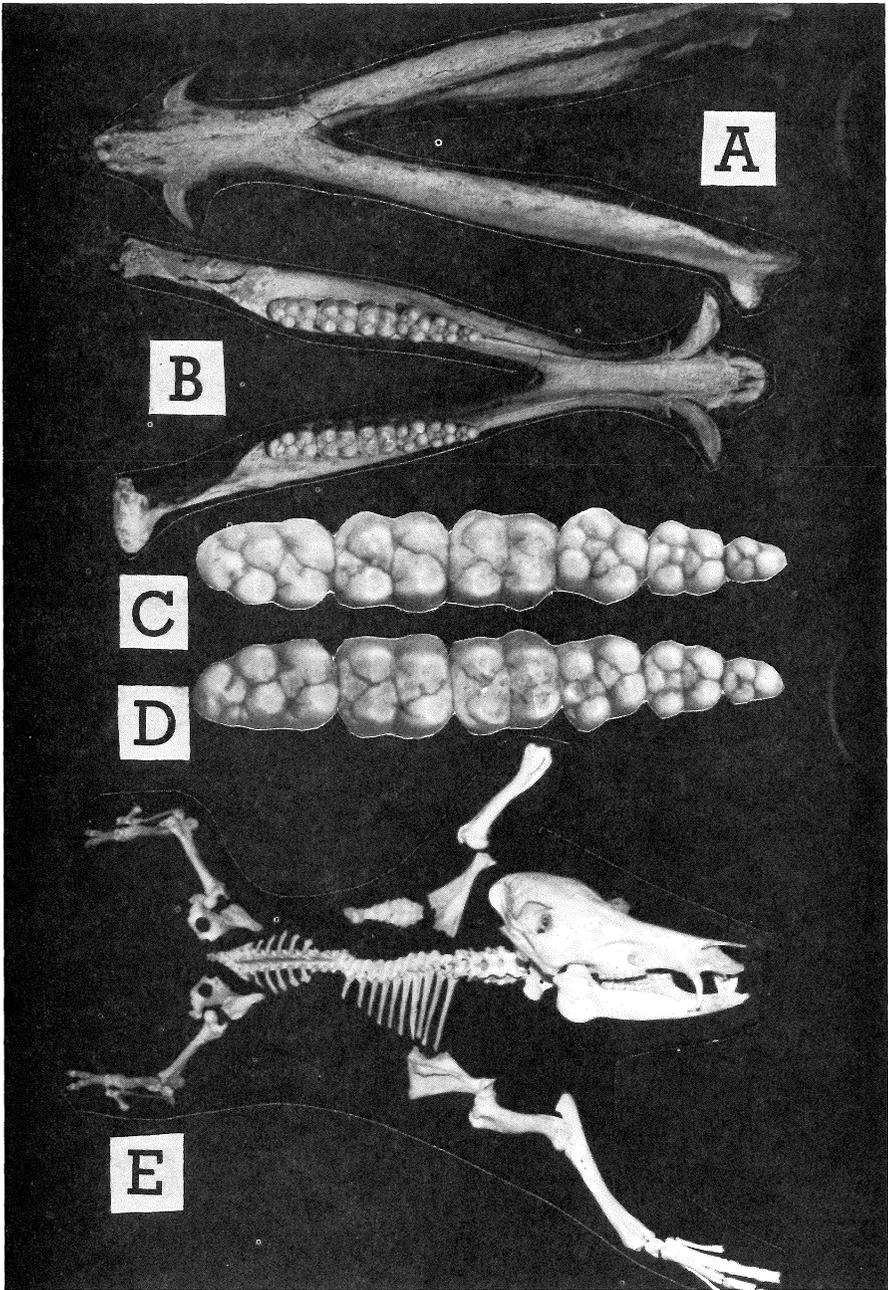


Fig 3. *Mylohyus fossilis* from Plummer Cave. A. Ventral view of mandible (X .4). B. Dorsal view of mandible (X .4). C. Left lower cheek teeth (X 1). D. Right lower cheek teeth (X 1). E. Reassembled skeleton, ribs and left radio-ulna not included (X .1).

Table 2. Postcranial measurements (mm) of *Mylohyus fossilis* from Plummer Cave.

	Left	Right
Scapula length	217+	219
Humerus, total length	220	222
articular to articular	192	192
Ulna length	239	242
Radius length	188	185
Metacarpal III, length	104	—
proximal width	21.0	—
distal width	15.4	—
Metacarpal IV, length	101	—
proximal width	16.8	—
Ilium, ant. end to acetabulum	122	127
Ischium, post. end to acetabulum	114	110
Acetabulum, ant.-post. diameter	32.1	31.3
Pelvis length	247	246
Femur length	221	222
proximal width	51.6	51.5
distal width	49.2	48.9
Tibia length	227	228
proximal width	—	52.1
distal width	32.4	32.4
Fibula length	215	—
distal width	17.3	—
Astragalus length	41.9	—
proximal width	23.4	—
Metatarsal III length	115	115
proximal width	13.0	13.3
distal width	14.9	15.2
Metatarsal IV length	114	113
proximal width	15.1	15.2
distal width	15.7	14.6
Metatarsals III and IV proximal width	27.9	—
distal width	33.6	—
Thoracic vertebrae 1-14 total length	390	
Lumbar vertebrae 1-5 total length	175	
Sacrum length	129	

an excellent review of the genus in which he invalidated 2 species (*M. temerius* and *M. obtusidens*) which lack specifically diagnostic characters, and placed 7 of the remaining 8 species in 2 species groups, *M. nasutus* and *M. fossilis*.

The *M. nasutus* group includes *M. nasutus* (Leidy), *M. brouni* Gidley and *M. pennsylvanicus* Leidy. It is characterized dentally by large M3/3, a long molar series relative to the length of the post-canine diastema, a large upper canine and I1/ a simple peg. The geographic range of this group extends from the Fall Line of the Atlantic Coastal States inland to the High Plains (Lundelius 1960:34, Semken and Griggs 1965).

M. tetragonus Cope resembles the *M. nasutus* group in sizes of the M/3, the lower molars and the post-canine diastema, but differs in possessing a tetragonal

cross-section of the lower canines and lacking a paraconulid (Lundelius 1960). Gidley (1921) suggested that the canine morphology of the type specimen represents an individual aberration. If true, this species would also fall within the *M. nasutus* group.

The *M. fossilis* group includes *M. fossilis* (Leidy), *M. lenis* (Leidy), *M. gidleyi* Simpson and *M. exortivus* Gidley. This group is characterized dentally by small M3/3, a short molar series relative to the length of the post-canine diastema, a small upper canine and a large oval I1/. The geographic range of this group has primarily been restricted to the Atlantic Coastal Plain from Maryland to Florida (Lundelius 1960:34, Semken and Griggs 1965).

The location of Plummer Cave in the Ozark Region of southern Missouri would lead one to expect that the affinities of the Plummer Cave *Mylohyus* would lie with the inland ranging *M. nasutus* group. Statistical "t"-tests comparing the lower canine antero-posterior length and lateral width, length of the left and right lower molar series and M3/ length of the Plummer specimen with those of the *M. nasutus* and *M. fossilis* groups were independently used to test this idea (Table 3). [See Sokal and Rohlf (1981:229-231) for a discussion on

Table 3. Statistical comparisons of dental character lengths of the Plummer Cave *Mylohyus*, with those of the *M. fossilis* and *M. nasutus* species groups.

Character	Test	Sp. group compared	N ^a	P
R. M ₃ /	"t"-test	<i>M. nasutus</i>	7	0.01 >p>0.001
R. M ₃ /	Mann-Whitney	<i>M. nasutus</i>	7	0.028
Lower canine	"t"-test	<i>M. nasutus</i>	7	0.9 >p>0.5
Lower canine	Mann-Whitney	<i>M. nasutus</i>	7	0.625
R. lower molars	"t"-test	<i>M. nasutus</i>	7	0.1 >p>0.05
R. lower molars	Mann-Whitney	<i>M. nasutus</i>	7	0.028
R. M ₃ /	"t"-test	<i>M. fossilis</i> (R. M ₃ /)	11	0.2 >p>0.1
L. M ₃ /	"t"-test	<i>M. fossilis</i> (R. M ₃ /)	11	0.5 >p>0.4
Lower canine	"t"-test	<i>M. fossilis</i>	5	0.2 >p>0.1
Lower canine	Mann-Whitney	<i>M. fossilis</i>	5	0.167

^aN=sample size; P=probability Plummer specimen is from the same group.

the use of a single specimen compared with a larger population sample using the "t"-test.] The results indicate there is some mixing of characters of both *M. fossilis* and *M. nasutus* in the Plummer specimen; however, those of *M. fossilis* predominate.

Due to the small sample size involved in comparing the Plummer Cave *Mylohyus* with the *M. nasutus* group, the Mann-Whitney U-Test was applied to check the values derived using "t"-tests (see Sokal and Rohlf 1981:432-440). Mann-Whitney results closely approached "t"-test probability values (Table 3).

The presence of an individual resembling *M. fossilis* at a Missouri locality conflicts with the coastal plain restriction of the geographic range of *M. fossilis*. *M. nasutus* has been reported from most states adjacent to Missouri: Arkansas (Brown 1908), Nebraska (Hay 1927), Oklahoma (Johnston 1935), Kansas (Semken and Griggs 1965), and Tennessee (Corgan 1976). With the exception

of 1 specimen which has since been lost (Cahn 1939), there have been no reports of *M. fossilis* in this region. One may account for the presence of a *Mylohyus* population in Missouri having characteristics of *M. fossilis* by presuming that this species maintained disjunct populations or that the Missouri population was connected with the Atlantic Coastal Plain population via an undiscovered Gulf Coastal Plain population. An alternative possibility is that the differences noted between *M. fossilis* and *M. nasutus* are not species level distinctions, but rather are clinal and temporal variations and the result of local environmental factors. This would account for the apparent mixing of *M. fossilis* and *M. nasutus* traits displayed in the Plummer specimen, and agrees with the suggestion of Ray (1967:146) that the variation observed in these groups may be due to "sexual, individual, geographic, and chronologic variation within a single species." Kurten and Anderson (1980:296) hold the same opinion and believe that only 1 species of *Mylohyus* lived in the eastern and central United States during Irvingtonian and Rancholabrean times.

Conclusion

The Plummer Cave *Mylohyus* displays characters of both the *M. fossilis* and *M. nasutus* groups. The specimen most resembles *M. fossilis* and is assigned to that species. Combined variation in dental characters of *M. fossilis* and *M. nasutus* samples seems nearly equivalent to that within a single species of living peccaries (see Konizeski 1953, Woodburne 1968). This small range in variation may indicate that the 2 groups represent a single species. If so, *M. fossilis* (Leidy 1860) has precedence over *M. nasutus* (Leidy 1868). Therefore the geographic range of *M. fossilis* throughout the Pleistocene would extend from the Atlantic Coastal Plain west to central Texas and northwest to Nebraska (see Semken and Griggs 1965:270).

Locally, the Plummer Cave *Mylohyus* represents the first occurrence of the genus in Missouri outside of the St. Louis area and appears to be the westernmost latest Rancholabrean occurrence of *Mylohyus* in the Midwest.

Acknowledgments

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Perceived Quality as the Determinant of the Price Differential Between U.S. and Japanese Automobiles: a Cursory Analysis

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ABSTRACT: Data are presented for 1985 model Japanese and U.S. automobiles that explain why U.S. consumers are willing to pay a higher price for Japanese automobiles. The data are based on a Consumer Reports questionnaire on 7 quality variables (based on experience of consumers with prior model years): price, passenger protection, driver protection, structural integrity, predicted reliability, fuel economy and size. The price that consumers pay is a weighted average of perceived quality with the mean predicted reliability of Japanese automobiles explaining most of the price differential. This perceived advantage in Japanese automobiles could be lost if trade is restricted.

Key Words: free trade, price differential, U.S. and Japanese automobiles, measures of quality, predicted reliability

Introduction

The purpose of this paper is to explore the underlying price differential between U.S. and Japanese automobiles. Do Americans buy Japanese automobiles because they are cheaper or because they are better?¹ The preliminary results seem to indicate that, on average, Japanese automobiles are more expensive than U.S. automobiles and in general the former are perceived to be better than the latter. What accounts for the price differential?

There are many explanations for price differential or the absence thereof. In the presence of free trade commodity and factor prices tend to equalize in all markets. But free trade has other advantages. Economic literature, going all the way back to 1776,² has maintained that trade is mutually beneficial. The basis for this is, *inter alia*, comparative advantage.³ Free trade makes it possible for each trading partner to produce more of the product it can produce more efficiently. Consequently, "free trade leads to a world distribution of consumption that cannot be altered in any way to improve the welfare of all trading participants (Caves and Jones 1985:20)." Hence it is efficient in the Pareto⁴ sense.

One explanation for a price differential is an artificial restriction of domestic supply by means of a quota. Three estimates of the effect of quotas upon U.S. automobile prices were made: (1) price as a function of input costs, (2) a hedonic model and (3) an annual increase in Consumer Price Index (Crandall 1984). The 3 estimates showed that quotas increased the price of domestic automobiles.

Other devices used to promote a domestic shortage are allegations of dumping and demands for domestic protection because of the trade deficit and unemployment

While not directly related to automobiles, the public tirade against Japan's trade policy has run the gamut from allegations of dumping⁵ to the perception that government's role in the private sector gives the Japanese company a competitive edge. Although dumping may exist, a mechanism already exists to deal with this problem, i.e., the Commerce Department and the U.S. International Trade Commission may issue an antidumping order which may result in the imposition of an antidumping duty against the offending exporter (Sarasohn 1981). Herander and Schwartz (1984) concluded that foreign firms have become more familiar with the threat of less-than-fair-value complaints and an affirmative U.S. material injury decision and "have been incorporating the threat of U.S. antidumping duties into their pricing behavior."

A sense of the general ire against Japan can be collected from the news media which report that the U.S. merchandise trade deficit in 1984 was \$123.3 billion, and some analysts feel that it will forge ahead to between \$140 and \$150 billion in 1985. Japan announced that she will export 2.32 million cars and trucks to the U.S.⁶ These imports will exacerbate the trade deficit with Japan to about \$50 billion. Two bills before Congress would impose a 15% restriction on foreign automobiles and another would levy a 20% surcharge on all imports.⁷ Of course, such a move would signify that domestic consumers would lose a price advantage, i.e., "a price of \$1300 less for Japan's small cars."⁸

This protectionist argument seems to rest on the need to benefit producers at the expense of consumers. A tradeoff of that sort may not be defensible, since domestic producers will be able to misuse domestic resources under a legal wall of protection. Moreover, domestic consumers will pay for it in terms of higher prices and reduced consumption.

Since American-made small cars, sporty cars and compact cars are perceived to be inferior to Japanese cars, the official restriction of Japanese cars will reduce the average quality of cars in the U.S. market resulting in Akerlof's (1970) effect, i.e., "bad products drive out good products." All of these devices are inefficient. They distort prices and misuse scarce resources.

This paper uses a hedonic approach which shows that the average price of Japanese automobiles is higher than comparable U.S.-made automobiles (for the 1985 model year) and that this higher price is due largely to the perceived greater predicted reliability of Japanese-made automobiles.

Data and Methodology

This study utilizes data from the April 1985 Consumer Reports (CR) for the 1985 model-year of U.S. and Japanese small cars, sporty cars, compact cars and medium-sized cars. Small cars and sporty cars were chosen for comparison because these may have had the greatest impact on an energy-conscious public. Small cars are characterized by the best fuel economy and the least room and comfort. Sporty cars, however, are hybrids or specialized versions of small and compact cars. Compact and medium-sized cars were selected because there is a trend back to them. No large cars were included because none are imported.

The data from CR were selected because of convenience and availability of price and various measures of quality, i.e., safety of driver and passenger (front), structural integrity of the automobile, fuel economy, predicted reliability and size. Fuel economy for the city and expressway is based on the number of gallons used in 15,000 miles on a 195-mile test trip. Predicted reliability (PR) is

based on responses to a CR Annual Questionnaire. Other measures of quality such as On the Road (OTR), Comfort and Convenience could have been assigned on/off binary values. For example, each component of OTR could have been assigned the value 1, for a total of 6 if an automobile had all of these characteristics. If they were present and "fair or better," it would be assigned a value of 1, otherwise it would get 0. These pseudo measures of quality were not possible for lack of data on OTR and Comfort and Convenience.

Quality for PR is measured on a scale of 1-5 with 1 being the highest repair frequency and 5 being the lowest repair frequency; 3 is the mean. Thus, if a report is average it is assigned a value of 3; if better than average, 4; if much better than average, 5; worse than average, 2 and much worse than average, 1. Driver protection and passenger protection were also measured on the scale of 1-5. The size of the automobile was computed from CR data by multiplying overall length times the overall width (given in inches) and dividing by 144, to obtain ft².

Finally, there are 108 observations on Japanese automobiles and 97 observations on American automobiles. Thus, Table 1 shows the means for the

Table 1. Summary of sample statistics.

Characteristics	Japan mean		U.S. mean	
Price ¹ (in U.S. \$)	9097.222	(3181.41) ²	8559.883	(2573.32)
Driver protection	3.370 ³	(1.10)	3.454	(1.72)
Passenger protection	3.426 ³	(0.88)	3.546	(1.20)
Structural integrity	3.333 ³	(0.89)	3.856	(0.35)
Predicted reliability	4.435 ³	(0.68)	1.247	(0.66)
Fuel economy (gallons)	29.426	(3.31)	28.041	(2.14)
Size (ft ²)	76.583	(4.26)	80.000	(5.80)

¹For 1985 model year, 3 major options: air-conditioning, automatic transmission and power steering (most cars had the first 2).

²Data in parentheses are standard deviations.

³On a scale of 5, with 5 being best and 1 being worst.

characteristics that provide a measure of quality for both U.S. and Japanese small, sporty and compact cars.

Driver and passenger protection and structural integrity were about average for both groups, although somewhat higher in U.S. automobiles. In other words, U.S. automobiles are safer than Japanese cars for both the driver and the front seat passenger. U.S. automobiles have greater structural integrity as well. However, data on predicted reliability show Japanese automobiles are better than average while U.S. automobiles are much worse than average. Finally, fuel economy is slightly greater in Japanese automobiles.

One of the surprising results is, of course, the higher average price of Japanese automobiles.⁹ This higher price would seem, at least initially, to suggest that U.S. consumers are willing to pay a higher price for what they believe are better Japanese automobiles. If Japanese cars were less expensive than U.S. cars, then we could infer that price was indeed the reason for the

demand for Japanese cars. However, the higher-priced Japanese product may be the outcome of a policy to restrict entry of Japanese cars.

Table 2 shows average manufacturer-suggested retail price and the resale value of Japanese and U.S. automobiles which are included in this paper. The data do not appear to strongly support the view that demand for Japanese automobiles is partly a function of their higher resale value relative to U.S. automobiles.

Table 2. Resale price of Japanese and U.S. automobiles, 1985.

Country	Sale price ¹	Resale price
Japan	9097.22	7024.19 (2196) ²
United States	8559.88	6919.77 (2841)

Source: N.A.D.A. central edition, official used car guide.

¹Price is in U.S. dollars.

²Data in parentheses are standard deviations.

Conclusions

This study attempted to provide a cursory analysis of the differential between prices of Japanese and U.S. sporty cars, small cars and compact cars.

The results are inconclusive because of the omission of quality measurements dictated by the lack of data. However, since U.S. consumers are in fact paying more for Japanese automobiles on average; preliminary evidence seems to indicate that they are in fact paying more for a perceived better good. This is despite the fact that American automobiles are safer. Furthermore, the consumer is probably motivated to pay a higher price for Japanese automobiles because these automobiles are perceived to be more reliable than comparable U.S. made automobiles. This perception may be a particularly strong motive—compare the mean predicted reliability of Japanese automobiles, 4.4, to the mean predicted reliability of U.S. automobiles, 1.2. Standard deviations seem to suggest very little variability of the data. Moreover, the generally low standard deviations imply that none of the variables in Table 1 are very responsive to price.

Finally, the data on resale price of Japanese and U.S. automobiles shown in Table 2, would not strongly suggest that part of the demand for Japanese automobiles stems from their higher resale value relative to U.S. automobiles.

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Notes

1. Of course some consumers will ignore price and quality and buy American automobiles for patriotic reasons, to save American jobs or because they feel negative toward the Japanese.

2. Adam Smith (1976:457) discusses gains from trade in terms of absolute advantage while David Ricardo (1960:82) espouses comparative advantage. The former basis states that trade is mutually profitable if 1 country is more "efficient than another in the production of 1 commodity but less efficient than . . . the other nation in producing a second commodity" (see Salvatore 1983: 17-19). Comparative advantage is based on the notion that even if 1 country is less efficient in producing both goods, trade will still be mutually beneficial if each country specializes in the production and exportation of the good in which each has the greatest relative advantage.
3. These are certainly not the only explanations for trade. Others include factor endowment, overlapping demand and the product cycle through which goods pass. See Carbaugh (1985, ch. 4) for a good discussion of these theories.
4. The Pareto optimum is a situation or position which cannot be changed without making at least 1 person worse off.
5. A more general classification of unfair trade practices is less than fair value and includes, in addition to dumping, export subsidization and below cost pricing. Dumping may benefit consumers because they pay a lower price for the commodity but it may eventually cause the domestic manufacturer of the imported good to go out of business, in which case the price may be subsequently raised by the exporting country—this is predatory dumping.
6. St. Louis Post-Dispatch, Friday, March 19, 1985.
7. Business Week, April 8, 1985, p.51.
8. Business Week, March 18, 1985, p.117.
9. There may be a public perception that Japanese cars are cheaper. As we have already indicated, production costs in Japan are lower than in the U.S. One possible explanation for the price paradox is the voluntary export restraint agreement which caused the overall price of automobiles to rise in the U.S. and permitted the Japanese to export their higher-priced line automobiles with impunity.

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**The 1985 Annual Meeting
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Senior Division**

Agriculture - Entomology

Johnson, G., L. Cowsert and K. McDonald, Department of Agriculture, Missouri Western State College, and Quaker Oats Company, St. Joseph, MO 64507. WHITE CORN VARIETAL TRIAL. Twenty-six varieties of white corn were researched while growing on a Marshall silt loam type soil. More specifically, data were collected concerning: (1) yield per acre, (2) test weight, (3) percent small kernels, (4) percent harneous endosperm, (5) grit/germ ratio, (6) kernel density, (7) kernel weight, (8) overall rating, (9) corn borers, (10) rootworms and (11) lodging. A "one-way analysis of variance, with multiple entries" type of statistical analysis was run on all varieties. The variety NC + 8141 gave the best yield during both years. Data for this research will enable farmers to grow not only higher-yielding white corn, but varieties that are best suited for use by the Quaker Oats Company.

Aide, M. T. and B. Blankenship, Southeast Missouri State University, Cape Girardeau, MO 63701. THE YIELD CHARACTERISTICS OF TWO SOYBEAN VARIETIES GROWN AT TWO DIFFERENT ROW-SPACES. Two soybean varieties (*Glycine max.*) were cultured at 30 and 15 inch row spaces. Measurements included: number of plants/ha, number of nodes per plant, number of pods per node, number of seeds per pod and seed weight. Essex soybeans were shorter, lower yielding and possessed fewer pods. Wide rows tended to produce a higher percentage of branches within the lowest portion of canopy. The variable which demonstrated greatest variation due to treatments was the number of pods per plant.

Journet, A. R. P., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701 and **M. K. Harris**, Department of Entomology, Texas A&M University, College Station, TX 77801. DO PECAN APHIDS RESPOND TO VARIATION IN FOLIAR NITROGEN CONCENTRATION? Many phytophagous insects respond to nitrogen, availability in the food plant. But there are several kinds of nitrogen, and there is more than one possible insect response. This paper explores different measures of foliar nitrogen (total protein N and total soluble N from Kjeldahl digestion and Technicon analysis, and soluble protein and soluble free amino acid analysis from an Amino Acid Analyzer) in relation to fluctuations in pecan aphid populations. It also considers the response of aphids in terms of both the log of aphid numbers and rate of aphid population increase. The conclusion presented is that total soluble protein nitrogen correlates well with a delayed potential for aphid population increase.

Calvert, P. D. and S. W. Wilson, Central Missouri State University, Warrensburg, MO 64093. LIFE HISTORY AND DESCRIPTIONS OF THE IMMATURE STAGES OF THE PLANTHOPPER *STENOCRANUS LAUTUS* (HOMOPTERA: DELPHACIDAE). The life history of *Stenocranus lautus* (Van Duzee) was studied at Perte Springs, Warrensburg, Johnson County, MO, with biweekly collections made from 15 April to 25 September 1985. *S. lautus* oviposits in stems of *Carex lurida* (Wahl.). This bivoltine planthopper apparently overwinters as eggs; nymphs for this planthopper were first found on 4 June and adults from 20 June to 25 July 1985. Field collected *S. lautus* adults kept on potted *C. lurida* in the laboratory laid eggs which hatched and were reared to adult. Field-collected and laboratory-raised nymphs and eggs were used for descriptions and illustrations. Nymphal instars differed in body size, number of pit-like sensoria, development of wing pads, number of metatibial and metatarsal teeth and shape and dentition of metatibial spurs. This project was supported by a CMSU faculty summer development grant.

Feir, D. and D. Lampe, Biology Department, St. Louis University, St. Louis, MO 63103. SEASONAL DISTRIBUTION OF TICKS AT TYSON RESEARCH CENTER, ST. LOUIS COUNTY. Ticks were trapped every other week from April to November 1984 at 2 sites in Washington University's Tyson Research Center. One site was an open field near a known deer run. The other site was a wooded area. Dry ice traps were placed at least 50 feet apart. The species and stage of development were determined for each captured tick. Temperature, relative humidity and wind speed were measured on each trapping day. Correlations were made between temperature and

number of ticks collected, season and number of ticks collected, season and stage of tick, season and species of tick and site of collection and number of ticks. The results showed that the stage of tick varied with time of year, and that the number of ticks varied with the season and site of collection. This study was supported by the Beaumont Fund of St. Louis University.

Biology

Cook, N. H., E. Blackwell, A. D. Gaskin and J. T. Clay, Department of Natural Sciences and Mathematics, Lincoln University, Jefferson City, MO 65101. FURTHER STUDY OF THE IN VITRO EFFECTS OF METHOXYETHYL CARBAMATE ON CHINESE HAMSTER FIBROBLASTS. Our previous studies have revealed the mutagenic potential of methoxyethyl carbamate (MEC) using dosages between 1 and 1000 μ /ml. This study was conducted to ascertain effects of lower dosages of MEC on the growth and chromosomes of Chinese hamster fibroblasts. Cultures were treated 3 hours with serum-free, McCoy's 5a medium containing an S-9 cofactor mix and MEC at 0 (control), 0.01, 0.1 and 1 μ g/ml. Cells were then grown in McCoy's 5a medium with 10% fetal bovine serum, and metaphase spreads were prepared at 24 hours post-treatment. Growth data, assessed by a metaphase-index method, showed no significant difference between MEC treatments and controls. Cells scored for numerical aberrations showed a significant increase over control only at 1 μ g/ml. All dosages of MEC produced a 2 to 3 fold increase in structural aberrations and a significant increase in cells with chromosomal breaks, with the isochromatid type being most frequent. Supported by NIH/DRR RR08202.

Ashley, D. C., D. J. Robbins, M. Marks and M. Miller, Missouri Western State College, St. Joseph, MO 64507. A PRELIMINARY REPORT ON PARASITES OF THE WHITE-TAILED DEER. There is little published information concerning parasites of white-tailed deer (*Odocoileus virginianus*) in Missouri. We initiated a study in northwest Missouri to determine the diversity and prevalence of parasites (primarily helminths) in this economically important game species. We have examined to date, 12 deer from 6 counties in northwest Missouri. Our results differ substantially from those of surveys conducted in other states. No intestinal helminths were recovered from any of the deer examined. White-tailed deer examined from northwest Missouri have been infected with a single species of parasite that is found in the body of the host. This nematode (*Setaria yehi*) occurred in 75% of deer examined. Infected animals contained from 1 to 45 worms. Mean number of worms per deer examined was 7.1, with a standard deviation of 12.6. This is the first report of the occurrence of *Setaria yehi* in Missouri and constitutes a new distribution record.

McMillen, S. K. and N. Babrakzai, Biology Department, Central Missouri State University, Warrensburg, MO 64093. A PRELIMINARY SURVEY OF EPIZOOICUS ON THE FRESHWATER SNAIL, *HELISOMA* SP. (GASTROPODA: PULMONATA). Epizooicosis were studied during March on about 100 *Helisoma* sp. specimens from Racehorse Lake, Johnson County, MO. Mean diameter of snail shells was 10.6 mm, standard deviation = 1.3 mm. Between 1 and 36 *Chaetogaster limnaei*, a freshwater oligochaete were present on every snail examined. Mean number was 14.2 *C. limnaei* per snail. There was a positive correlation between the number of epizooic species and the number of snails carrying them in the same habitat. No correlation occurred between shell diameter and number of epizooic species present, nor between shell diameter and number of *C. limnaei* present. Total number of epizooic species present appears to have no bearing on *C. limnaei* population per snail. Epizooic species diversity also seems to be influenced by seasons.

Castaner, D., Biology Department, Central Missouri State University, Warrensburg, MO 64093. A HYPHOMYCETE USING CELLULAR HOOK-LIKE APPENDAGES TO CAPTURE SOIL NEMATODES. A new nematode-destroying fungus from Oregon is described. The new hyphomycete differs from its closest relative, *Monacrosporium parvicollis*, by having unique cellular hook-like appendages formed on stalked adhesive knobs. The hooks are also adhesive and consist of 2-7 cells in a loop up to 1½ times. Both the stalked knobs and the "hooks" are capable of infecting nematodes; a penetration peg is formed at the contact point, from which intranematode absorptive hyphae are formed. Conidia are spindle-shaped, 3-4 septate, 45-55 x 10-14 μ . This device has not been previously reported as a nematode-capturing organ in any fungus.

Wallin, J. R., H. Minor and G. Rottinghaus, Department of Plant Pathology, USDA, ARS, Department of Agronomy and Veterinary Medicine, University of Missouri, Columbia, MO 65211. PREHARVEST AFLATOXIN CONTAMINATION OF MAIZE IN MISSOURI IN 1982, 1983 AND 1984. Maize hybrids were sampled from the 8 locations of the Missouri Corn Yield Test over a 3-year period. Kernels of 4 maize hybrids commonly grown in 1982 were subjected to long-wave ultra violet "black light" to predict bright green, yellow fluorescence (BGYF) and coincident aflatoxin (AFB₁) content. Kernels from 4 of the 6 locations sampled fluoresced in 1982. The BGYF test accurately predicted the presence of AFB₁ for 3 of 6 sites and accurately predicted the quantity of AFB₁. In 1983, kernels from 8 maize hybrids were sampled. Of these samples, 43 fluoresced, but only 16 accurately predicted AFB₁ levels from the BGYF test. The test was accurate in predicting AFB₁ levels in only 35% of the samples, but predicted the presence of AFB₁ in 93% of the samples. In 1984, 12 genotypes were sampled and BGYF predicted the incidence of AFB₁. The "black light test" levels were lower (0 to trace) than in 1983 or 1984 when levels were greater than 100 ppb.

Wallin, J. R., H. Minor and G. Rottinghaus, Department of Plant Pathology, USDA, ARS, Department of Agronomy and Veterinary Medicine, University of Missouri, Columbia, MO 65211. YIELDS AND AFLATOXIN LEVELS IN PREHARVEST MAIZE IN 1982-1984. The aflatoxin (AFB₁) content in maize in 1982 was none to a trace at 8 locations in Missouri. Yields of 4 hybrids sampled ranged from 5585 km/ha at Portageville (non-irrigated)

to 9912 km/ha at Marshall. In 1983 the AFB₁ levels of 6 hybrids at 8 locations ranged from 0 to >200 ppb. The highest levels occurred at Novelty, Spickard, Cape Girardeau, O'Fallon and Fairfax where yields were 878, 753, 3450, 3513 and 3764 km/ha, respectively. The highest AFB₁ levels in 1984 occurred at Novelty and Spickard where yields were 3011 and 3513 km/ha, respectively. These and past data indicate that high levels of AFB₁ contamination are associated with low yield and will likely occur in maize that yields less than 3762 km/ha.

Doudrick, R. L., M. F. Brown and D. F. Millikan, Department of Plant Pathology, University of Missouri, Columbia, MO 65211. SOME BIOLOGICAL AND PHYSICAL PROPERTIES OF THE AGENT CAUSING ROSE ROSETTE. Rose Rosette is a disease caused by an organism (RRA) that is extractable with 0.02 phosphate buffer, pH 8.0, from macerated leaf and shoot tissue from affected rose. When the crude extract is absorbed by the stems of healthy rose, typical symptoms of rose rosette develop in 6-14 weeks. However, partial purification of RRA by the method of Fulton (Phytopathology 57:1197) resulted in loss of infectivity. Transmission of RRA by grafting requires between 1 and 2 weeks of tissue contact. The identity of RRA has not been established, but these observations tend to support a mycoplasma-like organism rather than viral etiology.

Bader, J. A. Dallali and D. F. Millikan, Department of Plant Pathology, University of Missouri, Columbia, MO 65211. INCIDENCE AND EFFECTS OF LATENT VIRUSES ON TART CHERRY. In the early 1960's a rootstock tart cherry (*Prunus cerasus* L. cv. Montmorency) study was initiated at New Franklin, MO. These trees were free from detectable viruses and were productive. However, in the late 1970's fruit production became erratic, so the trees were tested for latent viruses. Nine trees were positive for virus infection in 1979 and 3 additional trees were found to be infected in 1980. No additional infections were found in 1981 and 1982. Except for 2 treatments that had reductions of -4 and 2.6%, overall reductions in yields on infected trees ranged from 22 to 26%. These studies show that latent virus infections reduce the yields of tart cherry, but the amount of reduction is dependent upon the rootstock. They also show that the incidence of latent virus spread in central Missouri is low, thus roguing of infected trees should provide control.

Rosenbrock, S. M. and T. D. Wyllie, Department of Plant Pathology, University of Missouri, Columbia, MO 65211. PREDICTING POPULATIONS OF THE CHARCOAL ROT FUNGUS IN SOIL. One hundred twelve soybean fields were sampled twice in 1984 to determine the effect of soil fertility, soil texture and weather on populations of *Macrophomina phaseolina*. Numbers of microsclerotia (MS) of the pathogen were determined in the upper 10 cm on the 224 samples. Soil samples were evaluated for soil type (% sand, silt and clay) using the hydrometer method. Soil fertility analysis was made by the soils laboratory. Temperature information was collected and transformed into degree days <32, <65 and >65°F. Multiple regression suggested that pH (0.0002), % silt (0.0001), number of degree days <32°F between October 1, 1983, and May 31, 1984 (0.0001) and geographic location (0.0001) of fields account for 45% of the observed variability in populations. Response surface function of soil parameters, with degree days held constant, indicated high numbers of MS developed with pH between 6.8 and 7.5 and silt between 50 and 70%. There was a significant (0.0001) decrease in MS with increased degree days <32°F.

Shaffer, W. H. and J. A. White, Department of Plant Pathology, University of Missouri, Columbia, MO 65211. CONTROL OF APPLE DISEASES WITH A POLYMER FILM THAT COATS PLANT SURFACES. When sprayed according to a seasonal schedule in the field, AKFS-84 (a copolymer of methyl methacrylate and ethyl acrylate) provided significant ($P=0.05$) control of apple scab on leaves and sooty blotch and fly speck on fruit. Scanning electron micrographs of surfaces of leaf and fruit specimens taken from field treated apple trees revealed that the polymer film was generally uniform and unbroken when applied at a 1:5 dilution with water. At a 1:10 dilution, the film contained numerous holes of various sizes. Stomatal openings were not covered by the film at 1:5, and stomatal structure did not appear to be affected by the polymer. Germination of conidia of *Venturia inaequalis* and the formation of appressoria were not affected by the polymer film sprayed on either glass cover slips or leaf surfaces. This suggests that AKFS-84 provides a physical barrier to fungal penetration.

Stefan, S. J. and D. F. Millikan, Department of Plant Pathology, University of Missouri, Columbia, MO 65211. FACTORS RESPONSIBLE FOR STAGE II IN THE MICROPROPAGATION OF BLACK WALNUT, *JUGLANS NIGRA* L. Media and cultural requirements for the establishment (Stage I) of black walnut explants have been reported previously. However, these explants would revert to callus or become necrotic and die. Recently (HortScience 19:507), a method for the micropropagation of paradox walnut (*J. hindsii* Sarg x *J. regia* L.) was reported. Use of this medium has improved the development and survival of explants in our work with *J. nigra*. Cultures initiated from 5 year-old trees began producing adventitious buds after approximately 4 months in culture. These buds are now being subcultured and will be used for an investigation on rooting requirements. Successful formation of rooted explants will permit the propagation of pathogen-free black walnut.

Weber, M. D., S. Murphy and G. D. Sells, Division of Science, Northeast Missouri State University, Kirksville, MO 63501. EFFECTS OF INCREASING TEMPERATURE ON RESPIRATION OF MITOCHONDRIA ISOLATED FROM MAIZE SHOOTS. Dekalb XL73 maize seeds were germinated at 30°C for 3 days then exposed to 40°C for 17 hours. Mitochondria were isolated and respiration rates, respiratory control (RC) and P/O ratios were determined. Maize germinated for 4 days at 30°C served as controls. The rate of state 3 respiration for both groups remained reasonably constant when succinate, exogenous NADH or malate plus pyruvate (M+P) were being oxidized; however, when proline was being oxidized the state 3 rate declined by 67%. The RC and P/O ratios changed slightly for succinate, NADH and M+P. The proline RC and P/O ratios decreased by 44 and almost 100%, respectively. Further analysis with selected inhibitors suggests that an alternative pathway may be initiated by the mitochondria for the oxidation of M+P and proline when the temperature rises to 40°C.

Dawson, J. T., Department of Biology, Pittsburg State University, Pittsburg, KS 66762. THE MINERAL AND ORGANIC NUTRITION OF THE GENUS *DYSMORPHOCOCCUS* TAKEDA (PHACOTACEAE). *Dysmorphococcus* is a little known genus of green algae. The genus shows best growth at a pH of 8.5 and a temperature of 35°C. Calcium, sulfate, Vitamin B₁₂, nitrogen and phosphate are necessary for growth. Thiamine slightly enhanced growth but is not essential. Such diverse forms as cas amino acids and ammonium chloride are suitable nitrogen sources. Utilization of organic compounds was tested using 10 sugars, 5 fatty acids, 5 krebs cycle intermediates, 5 alcohols and 8 amino acids. All compounds were tested under light and dark, aerobic and microaerobic conditions. Aerobic growth in the light was inhibited by 5 amino acids and propionate; growth in the dark occurred sparingly on acetate. Under microaerobic conditions growth occurred in the light on 3 krebs cycle intermediates, but no growth was recorded in the dark.

Myers, R. L. and R. R. Smith, Biology Department, Southwest Missouri State University, Springfield, MO 65804. REMOVAL OF AIRBORNE MICROORGANISMS WITH A PORTABLE AIR FILTRATION DEVICE. *Staphylococcus aureus* and *Escherichia coli* were used to test the efficiency of a portable air filter for removal of airborne microorganisms. A 3.6 x 3.6 x 2.4 m airtight room was constructed to house a filtration unit and simulate an operating facility. An aerosol challenge of known bacterial concentration was introduced into the room. Air samples were assayed for bacterial colony forming units using air filtration and surface collection methods. The results indicated that test microorganisms were not removed from the facility with equal efficiency or at the same rate. The Gram-positive bacterial count was reduced approximately 40% immediately with the filter operating, and this difference was maintained throughout the sampling period. However, the Gram-negative bacterial count was not reduced and reached background levels no faster than the control.

Bio-Medical

Nixon, D. A., M. A. Akasha and R. R. Anderson, University of Missouri, Columbia, MO 65211. EXTRACTION PROCEDURES FOR THYROXINE IN MILK. A method was developed for extracting milk to measure thyroxine. Two ml of 95% ethanol, adjusted to pH 2 with H₂SO₄, was added to 1 ml of milk. This mixture was vortexed and allowed to stand for 45 min and then centrifuged at 2500 g at 4°C for 90 min. The supernatant was decanted and dried. This product was reconstituted with 50 ul of barbitol buffer and radioimmunoassayed. To evaluate the method, I¹²⁵-labeled thyroxine was added to each sample and samples were counted at each step in the procedure. The method yielded a recovery of 81.8%. The only significant loss occurred in centrifugation. Since the pK_i of thyroxine is 5.56, the decreased pH of the milk-ethanol mixture caused the thyroxine to be less soluble and much was lost in the precipitate. The method was altered by using ethanol adjusted to pH 10.5 with NaOH and centrifugation raised to 5000 g. The resultant method yielded a recovery of 98.1% of added I¹²⁵-thyroxine.

Akasha, M. A., R. R. Anderson, T. E. Palomo and D. A. Nixon, University of Missouri, Columbia, MO 65211. CONCENTRATION OF THYROID HORMONES IN SERUM OF RATS INJECTED WITH RELAXIN, PROGESTERONE AND/OR ESTROGEN. An experiment was undertaken to investigate the effect of relaxin, progesterone and/or estrogen and their combinations on circulating thyroid hormones in ovariectomized rats. Blood samples were obtained after 20 days of daily subcutaneous injections. Serum samples were analyzed by radioimmunoassay for thyroxine (T₄), 3,5,3'-triiodothyronine (T₃) and 3,5',3'-triiodothyronine (rT₃). Analysis of variance showed significant decreases in T₄ in response to relaxin, estrogen and their combination (P<0.05) but no difference in T₄ to progesterone (P>0.05). The T₃ was significantly increased with estrogen, progesterone and the combination. There was no significant difference in T₃ with relaxin. Reverse T₃ showed a significant decrease with relaxin (P<0.05) and no significant difference with estrogen, progesterone and the combination (P>0.05). The decrease in T₄ was in response to the relaxin and estrogen. The increase in T₃ was postulated to be due to the conversion of T₄ to T₃ in response to progesterone and estrogen.

Palomo, T. E. and R. R. Anderson, University of Missouri, Columbia, MO 65211. DEOXYRIBONUCLEIC ACID (DNA), RIBONUCLEIC ACID (RNA) AND COLLAGEN IN THE UTERUS OF GUINEA PIGS DURING PREGNANCY, LACTATION AND RECURRING LACTATIONS. Albino guinea pigs were used to study changes in the uterus during pregnancy, lactation and recurring lactations to 6. Total DNA, RNA and collagen were related to total dry fat-free tissue. Percent and total DNA showed opposite patterns. Percent DNA decreased from 6.4 in the nulliparous uterus of mature animals (90 days old) to 0.31% at day 65 of pregnancy. It then increased to 5.4% at day 20 of lactation and decreased again to 3.16% at day 30 of lactation. During lactations 1-6 DNA measured at day 5 showed an up and down pattern around 4.5%, which was lower than day 20 of lactation. Total DNA increased from 11 mg in the nulliparous uterus to 106 mg at day 65 of pregnancy. A decrease to 19 mg at day 10 of lactation was noted, followed by an increase to 31 mg at day 20. RNA changed similarly. Total collagen increased from 46 mg in the virgin to 523 mg at 65 days of pregnancy. It then decreased to 51 mg on day 10 of lactation. Uterine collagen during recurring lactations peaked at 197 mg on day 5 of the fifth lactation.

Fayed, A. H. and R. R. Anderson, University of Missouri, Columbia, MO 65211. PROGESTERONE DETERMINATION IN SERUM AND MILK OF GUINEA PIGS AT DIFFERENT STAGES OF PREGNANCY AND LACTATION. Progesterone (P) concentration in the serum and milk was measured by radioimmunoassay in nonpregnant and pregnant guinea pigs. Serum samples from nonpregnant and 14-days pregnant animals were measured directly without prior extraction. Serum from 30- and 60-days pregnant animals was treated with sodium hydroxide to denature P binding globulin and then extracted with petroleum ether. P serum concentration from nonpregnant animals 30 days postpartum was 4.6 ng/ml and from animals at 14-days pregnancy was 4.9 ng/ml. At

30-days pregnancy the P concentration was approximately 20 times that at 14 days pregnancy (91.9 ng/ml). By 60-days pregnancy the P level in serum decreased to 49.1 ng/ml. The concentration of P was also determined in milk by RIA without extraction at several different stages of lactation. On the second day the concentration in milk was 5.02 ng/ml, while on the fourth day it was 5.50 ng/ml. The concentration reached 10.0 on the seventh day and dropped to 2.02 ng/ml on day 15. These changes reflect the 16-day estrous cycle in this species.

Bell, B., W. Hainen and H. D. Johnson, Dairy Science Department, University of Missouri, Columbia, MO 65211. RESPONSES OF PYGMY GOATS TO A HOT ENVIRONMENT. Five African Pygmy does were subjected to 19 and 37°C environmental temperature. Objectives were to measure heat production and vaporization at temperatures above the upper critical zone and to establish a breed profile for plasma thyroxine (T_4), triiodothyronine (T_3) and prolactin (PRL). Average heat production increased from 0.0389 Kw/hr at 19°C (TN) to 0.0573 Kw/hr at 37°C. Respiratory vaporization increased from 1.79 g/hr at TN to 5.61 g/hr at 37°C, while surface vaporization increased from 20.3 to 29.7 mg/hr/cm². Rectal temperature, respiration rate and ventilation rate also increased with heat treatment. Average T_3 concentrations decreased from 1.75 to 1.04 ng/ml with heat treatment while T_4 increased from 72.26 to 78.52 ng/ml. PRL increased with heat treatment from 5.79 to 102.13 ng/ml.

Reid, H. C. and L. Thompson, Southwest Missouri State University, Springfield, MO 65804. ACCEPTABILITY OF FROZEN STRAWBERRIES SWEETENED WITH ASPARTAME. The objective of this study was to determine acceptability of frozen strawberries sweetened with aspartame. Aspartame, a dipeptide composed of aspartic acid and phenylalanine, is marketed as an ingredient under the brand name NutraSweet® and as a tabletop sweetener under the brand name Equal®. The tabletop sweetener contains 0.96 g carbohydrate and 0.04 g aspartame per packet and provides 4 kilocalories. In Experiment I, strawberries were frozen plain and with sucrose, NutraSweet® and Equal®. In Experiment II, strawberries were frozen plain and with 4 levels of Equal®. After storage for 6 months at -18°C, samples were thawed and submitted to a taste panel for organoleptic evaluation. In Experiment II, half of the taste panelists were individuals with diabetes mellitus. Samples were scored for appearance, color, strawberry flavor, sweetness, texture and overall eating quality on a 9-point Hedonic scale. Strawberries frozen plain were significantly less acceptable than strawberries frozen with sucrose or aspartame. There were no significant differences in overall acceptability among the sweeteners. Kilocalorie reduction can be achieved without a loss of overall acceptability by substituting aspartame for sucrose.

Najafi, L. and M. L. Leavitt, Biomedical Sciences Department, Southwest Missouri State University, Springfield, MO 65804. EFFECT OF CENTRAL N-METHYL-4-PHENYL-1, 2, 3, 6-TETRAHYDROPYRIDINE (NMPTP) IN THE RAT. Peripheral administration of NMPTP causes Parkinsonian-like symptoms in humans and non-human primates but has been reported to be less effective in smaller species such as rats. These effects are believed to be due to a metabolite of NMPTP which causes destruction of dopaminergic cell bodies in the substantia nigra. To determine whether direct intracerebral injection of NMPTP would induce locomotor disturbances in the rat, Sprague-Dawley rats had 26 ga. stainless steel guide cannula implanted with the tip directed 1 mm above the left substantia nigra zona compacta. After 1 week of recovery, NMPTP (0.58 µg in 1 µl of vehicle) was injected daily for 4 days via a 33 ga. internal cannula. At 1 week following the last NMPTP injection, rats were injected with D-amphetamine (5 mg/kg, i.p.), an indirect dopamine agonist. Amphetamine caused rats to turn in circles toward the side of the brain treated with NMPTP. This ipsilateral rotation was not seen in vehicle-treated controls given amphetamine. Thus, intracerebral administration of low doses of NMPTP produces locomotor deficits in the rat which may be related to the postural asymmetry seen in Parkinson's disease. This small animal model should facilitate further studies on the neurotoxic actions of NMPTP.

Nunez, W. J. and J. L. Saverino, Missouri Western State College, St. Joseph, MO 64507. SUPPRESSION OF CHRONIC RELAPSING EXPERIMENTAL ALLERGIC ENCEPHALOMYELITIS (R-EAE) IN THE GUINEA PIG: ROLE OF A SOLUBLE SUPPRESSOR SUBSTANCE (SSS). Chronic relapsing EAE is an experimentally induced autoimmune disease which mimics Multiple Sclerosis in humans. Ten-eighteen days after challenge of animals with whole central nervous system (CNS) tissue in Freund's adjuvant, clinical symptoms of lethargy, weight loss, tremors, paralysis, etc. occur. This study was the *in vitro* production of a suppressor lymphokine from lymph node cells (LNC) by Con-A treatment, and this SSS to effect immunoregulation of the R-EAE disease in guinea pigs. Guinea pig LNC were incubated in culture with Con-A. After incubation, cell-free culture supernatant was treated to effect Con-A removal. The culture fluid was used to treat guinea pigs challenged with an encephalitogenic dose of CNS tissue. Following antigen challenge, test animals and controls were monitored over 30 days for EAE disease. Suppression of R-EAE occurred, with moderate and severe symptomatology suppressed in all animals studied. Con-A can successfully induce the production of SSS from LNC, and this can inhibit the EAE disease in guinea pigs.

Gittings, M., W. Sigmund and M. L. Leavitt, Biomedical Sciences Department, Southwest Missouri State University, Springfield, MO 65804. AN AUTOMATED MICROCOMPUTER CONTROLLED SYSTEM FOR CARDIOVASCULAR MONITORING OF MULTIPLE RATS. We have developed a system for direct measurement of cardiovascular parameters in conscious rats in which an Apple computer is used for system control, data acquisition/analysis and storage. The system is based on time sharing a single blood pressure transducer via a rotary fluid switch (Scanivalve) which is sequenced by the computer through 10-second steps. The rotary fluid switch can accommodate 2 calibration pressures and blood pressures from up to 8 rats which are measured via chronic polyethylene catheters implanted in the abdominal aorta. Data consists of systolic, diastolic and mean arterial blood pressures, as well as heart rate, determined from pressure pulses. The system allows up to 30 repetitions of the measurement cycle. Data display is via video monitor or printer. Long-term data storage is achieved by a disc

memory system allowing later analysis of graphical presentation. This automatic system is capable of unattended operation for extended periods and permits control of the data acquisition interval, number of sampling cycles and number of rats. Use of the microcomputer in conjunction with the rotary fluid switch increases efficiency while adding flexibility to the control of multiple experiments that may be conducted without expensive duplication of equipment.

Davis, R. T. and A. R. Gordon, Southwest Missouri State University, Springfield, MO 65804. CATALASE CHANGES IN OXYGEN-ACCELERATED AND NORMAL AGING INDIVIDUALS OF *DROSOPHILA MELANOGASTER*. *Drosophila* is used frequently in aging and oxygen toxicity research. Adult somatic cells are post-mitotic and can be directly exposed to higher oxygen atmospheres. Adults maintained in a sublethal 50% oxygen atmosphere mimic the characteristics of rapid aging, including reduced lifespan. These parameters of aging appear related to damage from peroxides and free radicals. Peroxidase, catalase and superoxide dismutase are expected to reduce this damage. This study compared protein, catalase and peroxidase in individuals maintained in normal and 50% oxygen atmospheres as a function of age. Peroxidase activity was not detected. Levels and changes in catalase as a function of age were similar in both groups. When complete development occurred in 50% oxygen, the adults had lower protein and catalase than flies developing in normal atmosphere. Catalase does not correlate positively with increased peroxides and free radicals that accompany an elevated oxygen atmosphere.

Katti, P., R. R. Gaddis and H. D. Johnson, Dairy Science Department, and Dalton Research Center, University of Missouri, Columbia, MO 65211. BOVINE MILK CATECHOLAMINES AS AN INDEX OF ENVIRONMENTAL STRESS. The use of milk catecholamine assay provides a trauma-free means of sampling for environmental stress. Bovine milk is deproteinized with perchloric acid and extracted with alumina. Alumina is washed on microfilter tubes and catecholamine fraction dissolved in perchloric acid. This filtrate is analyzed by a HPLC/electrochemical system. Peak heights of both internal and external standards are used to estimate milk catecholamines. The minimum detectable level is 1.0 pg and standard curve is linear from 0 to 5000 pg range. The mean values for milk obtained to date are in the range of 23.0 ± 8 pg/ml for epinephrine and 5.5 ± 0.7 pg/ml for norepinephrine. The recoveries for epinephrine and norepinephrine range from 74.8 ± 1.2 to $99.3 \pm 2.2\%$. These data indicate the technique has good potential as a trauma-free procedure to measure stress on dairy cows.

Chemistry

Gibbons, J. J., Analytical Services Laboratory, DAYCO Technical Center, PO Box 3258, G.S., Springfield, MO 65808. APPLICATIONS OF THERMAL ANALYSIS METHODS TO POLYMERS AND RUBBER ADDITIVES. Thermal analysis techniques have been applied to the study of polymeric materials and rubber compounds. Methods discussed include applications using 3 major thermal analysis techniques: (1) Differential Scanning Calorimetry (DSC), (2) Thermogravimetric Analysis (TGA), and (3) Thermomechanical Analysis (TMA). DSC measures heat flow into or out of the sample as a function of its temperature, whereas TGA measures the change in a sample's weight as a function of its temperature. Similarly, TMA determines the dimensional changes or alterations in modulus of the sample, also as a function of the temperature of the sample. Most applications discussed will be based on capabilities unique to Perkin-Elmer thermal analysis instrumentation.

Newman, S. C., S. E. Thompson and C. C. Thompson, Southwest Missouri State University, Springfield, MO 65804. MONTE CARLO SIMULATION OF HYDROGENIC ELECTRON DENSITIES. A microcomputer procedure has been developed to produce electron density diagrams for the ground and excited states of the hydrogen atom. The method utilizes a Monte Carlo technique based on calculations of random electron probabilities at randomly selected radial and angular coordinates. As presently structured, the program can display electron distributions for the 1s, 2s, 2p, 3s, 3p, 3d, 4s, 4p, 4d, and 4f states of the hydrogen atom. Computational procedures and the selection of parameters, scaling factors and display modes will be described, and representative electron density plots will be presented.

Thompson, S. E. and C. C. Thompson, Southwest Missouri State University, Springfield, MO 65804. PARTICLE IN A BOX MODEL FOR HETERONUCLEAR DIATOMIC MOLECULES. Previously (184th National ACS Meeting, 1982), 3-dimensional particle-in-a-box wave functions were used to construct a simple molecular orbital model for homonuclear diatomic molecules. This approach has been extended to include heteronuclear species. Polarization of the electron distribution in the x-direction is achieved by introducing into the total wave function a term of the form $Nk(a-x)^2$, where N is a normalization constant, k is a weighting factor and a is the x-dimension of the box. A second phase of the work illustrates various approximations of the polarizing term as linear combinations of orthonormal eigenfunctions obtained from the standard particle-in-a-box treatment.

Baker, R. and J. O'Brien, Southwest Missouri State University, Springfield, MO 65804. A STUDY OF THE MECHANISTIC PATH OF FIRST TRANSITION METAL SERIES +2 IONS. Recent measurements of the pressure dependence of the rate of solvent exchange reactions of first transition series metal +2 ions indicate a change of mechanism on going from Mn^{+2} to Ni^{+2} . These Volume of Activation Studies indicate that Mn^{+2} reacts by an associative mechanism while Co^{+2} and Ni^{+2} react by a dissociative path. Since the major difference in these species is in the population of the t_{2g} orbitals, it was felt that a molecular orbital study of these reactions would be worthwhile. Consequently, Extended Huckel Molecular Orbital Calculations were done in an attempt to examine the effect of t_{2g} electrons on the mechanistic path.

Nitz, M. C., S. Ellis, T. Locke and M. W. Mosher, Department of Chemistry, Missouri Southern State College, Joplin, MO 64801. THE ENZYMIC HYDROLYSIS OF O-NITROPHENYL- β -GALACTOSIDE: AN EXPERI-

MENT IN ENZYME KINETICS. A simple experiment has been designed to illustrate a number of principles of enzyme kinetics. The readily, commercially available enzyme, β -galactosidase, and the substrate, either *p*- or *o*-nitrophenyl- β -D-galactoside are used in the experiment. The experiment makes use of a number of techniques and principles from both analytical and bio-chemistry, but requires only simple instrumentation. The experimental data can be collected in a single 3-hour laboratory, or in a series on 3 1-hour laboratories, making the experiment also suitable for advanced high school labs. Treatment of the data can be either quite simple or rigorous, depending upon the level of the students.

Mosher, M. W. and J. L. Cox, Department of Chemistry, Missouri Southern State College, Joplin, MO 64801. THE REACTIONS OF ALKANES WITH LEAD TETRAACETATE. The free radical reactions of lead tetraacetate (LTA), with various alkanes has been examined. This reaction has a number of unusual properties as compared to other radical abstraction reactions. The abstracting radical from LTA exhibits a very high selectivity for 1° and 3° hydrogens as compared to those in 2° positions. The products formed from the reaction of LTA with pentane are 3-pentyl, and 2-pentyl acetate in a ratio of approximately 1.3-1. None of the 1-pentyl acetate was detected. Several mechanisms for this reaction will be discussed, based upon the observed relative reactivities of alkanes of different structures.

Computer Science

Schmidt, B., Southwest Missouri State University, Springfield, MO 65804. AN ALGORITHM FOR CALCULATING THE SQUARE ROOT OF AN INTEGER. A rather clever method for obtaining the square root of an integer has been given without proof, by Leo Scanlon. (*IBM PC & XT Assembly Language*, Robert J. Brady Co., Bowie, MD, 1983). This makes a good programming exercise for assembly language students. However, it is easy to make a subtle error in performing the required double precision arithmetic, and conventional testing techniques do not reveal the error. Because of this, most students—and Scanlon himself—write the program incorrectly. The purpose of this paper is to prove the validity of Scanlon's method and, in so doing, provide insight into how to develop an algorithm for correctly calculating the square root.

Patterson, R. S., Southwest Missouri State University, Springfield, MO 65804. INTERFACING AN ASTRONOMICAL DIGITAL PHOTOMETER TO AN APPLE IIe MICROCOMPUTER. The photoelectric photometer of the SMSU Department of Physics & Astronomy is based on a modified Pacific Photometric Instruments Model 124 digital photometer, which contains a high voltage power supply for the photomultiplier tube and a signal amplifier, as well as an analog-to-digital converter that produces a $3\frac{1}{2}$ digit output proportional to the current from the tube. Although the digital output has always been present, data were previously obtained by recording on a strip chart and later hand measurement of the chart deflections. An Apple IIe microcomputer was purchased in order to increase efficiency of the system. The model 124 photometer was interfaced to the Apple by using a commercially available card containing two 6522 VIA (Versatile Interface Adapter) integrated circuits. Since no appropriate software was available, it was necessary to write a program to allow the user to interact with the system while observations were being made and recorded. This system is being used in a research project involving measurement of the magnitudes of dozens of stars in which efficiency is a necessary part of the data-taking procedure. The research is supported by an SMSU Faculty Research Grant.

Conservation

Trease, F., Department of Zoology, Tulane University, New Orleans, LA 70118. REPRODUCTION IN RED EARED TURTLES, *PSEUDEMYS SCRIPTA ELEGANS*, OF LAKE SPRINGFIELD, MISSOURI. Red eared turtles' reproductive characteristics were studied in Lake Springfield, Greene County, MO, in the summer of 1982. Reproduction in a given year is related to the number of eggs per clutch and the number of clutches produced. Most Lake Springfield turtles produce multiple clutches at approximately 2-week intervals from April through June. The relationship of reproductive potential to length of female will be discussed.

Moll, D., Biology Department, Southwest Missouri State University, Springfield, MO 65804. STATUS OF THE MARINE TURTLES OF BELIZE. Aerial, boat and walking surveys were conducted in Belize during June and July 1983 and from January through April 1984 to ascertain status and locations of nesting and foraging habitats of resident marine turtles. The loggerhead, green and hawksbill marine turtles nest in Belize, but no nesting aggregations were seen. Most nesting occurs on the offshore cays of the barrier reef. Nearly unlimited foraging habitat occurs along the coastline, and both juvenile and adult turtles of all 3 species are relatively abundant. Leatherback sea turtles may travel through Belizean waters but are not known to nest there. All 3 species are caught and used for private consumption, or sold commercially in Belize. Despite laws regulating harvest, many individuals are taken illegally and their eggs taken during the closed summer nesting season.

Topping, M. S. and C. L. Peterson, Department of Biology, Southwest Missouri State University, Springfield, MO 65804. MOVEMENT IN THE HELLBENDER, *CRYPTOBRANCHUS ALLEGANIENSIS*. Reanalysis of extensive mark-recapture data for the hellbender (*C. alleganiensis*) to determine size-specific movement indicates a tendency for net upstream movement with rates of 2.3 m/day for animals less than 380 mm total length (TL), 2.9 for animals 380-480 mm TL and 25.7 for animals greater than 480 mm TL. The percent of cases involving movement decreased as a function of size with movement being observed in 32.8% of animals less than 380 mm TL, 29.0% of animals 380-480 mm TL and 24.2% of animals greater than 480 mm TL. Analysis of

movement in Ozark hellbenders (*C. a. bishopi*) by remote sensing suggests these upstream movements involve gradual wandering of individuals throughout their home range.

Hotelling, D. R. and C. A. Taber, Department of Biology, Missouri State University, Springfield, MO 65804. LIFE HISTORY OF THE STIPPLED DARTER *ETHEOSTOMA PUNCTULATUM*. The stippled darter was studied in the Spring River, MO, where a total of 481 specimens was collected from 3 March 1983 to 19 April 1984. Females attained a maximum standard length of 85 mm and males 83 mm. Both sexes had a longevity of slightly over 4 years. Spawning began in early February and continued through late May. All males and larger females (49+ mm) were sexually mature at 1 year of age. Females matured 2 or more clutches of eggs (\bar{x} no. = 447) per season. Fertilized eggs were 1.6 mm in diameter and hatched in 16°C water in 11 days. Diet was made up primarily of isopods and aquatic insect larvae.

Taber, C. A. and B. A. Taber, Department of Biology, Missouri State University, Springfield, MO 65804. REPRODUCTION AND POPULATION FEATURES OF THE ARKANSAS DARTER, *ETHEOSTOMA CRAGINI*. Arkansas darters in the Spring River of southwest Missouri were periodically sampled in 1983 and 1984. Spawning occurred from early February to mid-July during which time females contained up to 2631 maturing ova. The number of maturing ova (0.55+ mm) remained high through the spawning period, indicating continual recruitment of oocytes from oogonia during the spawning season. Distinct size groups (clutches) were present in some females but absent in others. Males developed and maintained very large testes (to 8% of total weight) through the spawning period. The population was dominated by yearling fish in the spring of both years, but an exceptionally strong year class was produced in 1983. Maximum longevity was 3 years for both sexes but very few (5.7%) 2 and 3 year-old fish were taken. Sex ratio of the breeding population was 0.83:1 (140 males and 169 females).

Economics

Topping, E. E. and M. S. Topping, Department of Economics and Biology, Southwest Missouri State University, Springfield, MO 65804. ANALYSIS OF PATTERNS IN COMPENSATION. Patterns of compensation at Southwest Missouri State University during 1984-85 were analyzed by multiple regression analysis using quantitative (age and years experience) and qualitative or dummy variables (6 areas of specialization, 4 ranks, 2 levels of education, sex and their interactions). Significant differences could be attributed to 1 college, each of the ranks, sex, years experience, and interactions between sex and one college and MS degrees and 2 colleges. These explanatory variables accounted for 88% of the variation in compensation. This technique is widely used to deduce the significance and relative importance of variables when that information is not known *a priori*.

Topping, E. E. and M. S. Topping, Departments of Economics and Biology, Southwest Missouri State University, Springfield, MO 65804. DEMAND FOR A STATE ACADEMY OF SCIENCE JOURNAL. Origin of papers and abstracts published in the *Transactions* of the Missouri Academy of Science for 1967-1983 were analyzed. Shares of publications devoted to Academy business, public and private universities and colleges and other sources were determined. The distribution between "free" pages (i.e., financed by general membership) versus contributor "paid" pages also was calculated. As expected, demand was more influenced by exogenous factors (e.g., whether publication is expected by the contributor's employer) than the cost of publishing.

Engineering

Wu, W. Z., Department of Engineering Mechanics, University of Missouri, Rolla, MO 65401. MODAL ANALYSIS OF A MOVING BAND UNDER CUTTING LOADS. Rising raw material cost of recent years compels the industry to improve wood sawing practices and efficiency. Excessive band vibration directly contributes to poor cutting accuracy and surface quality, raw material waste, gullet cracking and increased downtime of band mills. The vibration and stability of a moving band is analyzed in the research. The study has developed an accurate, comprehensive, fast and inexpensive numerical method for efficient analyses of the natural frequencies and mode shapes of the cutting blade. Cutting loads induce coupled vibration modes, decrease the resonant frequency of the fundamental mode and yield the divergence buckling. For a normal operation, more than 100% over-estimate of the buckling load can be induced by neglecting bending moments and tangential cutting forces. Back-up rollers are recommended for stabilizing the saw blade.

Prelas, M., J. Kunze, J. Freeman, D. Brinegar, S. McGhee, Nuclear Engineering Department, University of Missouri, Columbia, MO 65211, and **T. Dolan**, University of Missouri, Rolla, MO 65401. A MAGNETIC CUSP END CELL FOR A MIRROR PLASMA MACHINE. After acquiring several large bore (50 cm) superconducting magnets capable of generating 4 Tesla fields, researchers at University of Missouri, assisted by McDonnell Douglas Fusion Energy Project personnel have: 1) set up a preliminary experiment with normal magnets, in both the cusp and mirror mode, with a plasma chamber volume of approximately 100 L and 2) completed the preliminary design of a cost-effective similar experimental device to employ the superconducting magnets in the cusp configuration. The magnetic cusp is 2 magnets with opposed fields. Our experimental program calls for modifying electron densities in the plasma to prevent escape of the charged particles that find their way to the center of the cusp. Our device at UMC has established a population of hot electrons, as a first step in modifying the plasma and magnetic fields in order to achieve better containment. The challenge of the superconducting

magnetic cusp (compared to an ordinary mirror) is constraining the 125-ton repulsive force of the magnets, while maximizing volume. A complimentary tandem mirror experiment exists at Nagoya, Japan.

Wu, W. Z., Department of Engineering Mechanics, University of Missouri, Rolla, MO 65401. MICROCOMPUTER APPLICATION IN EVALUATING EFFICIENCY OF PERCUSSIVE DRILLING. Percussive drilling is an ancient art, which still remains the most universal rock-cutting technique. The investigation provides a method of efficiency evaluation among several types of tools employed to cut different types of rocks. A ballistic test stand incorporated with the Hopkinson Bar is used to simulate a percussive drilling tool. An Apple IIe microcomputer has been used for high-speed data acquisition and analysis. The research presents a newly developed method to monitor the rock-tool interaction and shows the application of a microcomputer in the analysis. Theoretical and experimental results appear in a fairly good agreement. The computer-aided evaluation in the percussive drilling will lead to a more rapid and efficient methodology of tunneling, excavating and mining. The research is supported by the University of Missouri Weldon Springs Research Award.

Bills, G. A. and K. P. Zimmermann, University of Missouri, Columbia, MO 65211. SPECTRAL BANDWIDTH OF HUMAN HANDWRITING. Transmission of signals requires knowledge of the frequency bandwidth of the signal to design adequate filters and amplifiers. Of particular interest in our research is the bandwidth necessary for transmission of human graphic and handwriting signals over telephone lines. Two methods, Fourier analysis and auto-regressive modeling, are used in determination of the bandwidth. In general, handwriting is represented as a complex signal created by letting the horizontal deflection be the real component and the vertical deflection be the imaginary component. Such complex signals typically have asymmetric power spectra. Our research shows that the majority of the energy in human handwriting lies in the frequency range of -10 to +15 Hertz.

Mueller, G. E. and R. L. Boyer, Nuclear Engineering, University of Missouri, Rolla, MO 65401. NATURAL CIRCULATION START-UP TEST PREDICTION FOR A SNUPPS. A RETRAN-01 model of the Union Electric (UE) Callaway Westinghouse Standardized Nuclear Unit Power Plant System (SNUPPS) was used to investigate the Nuclear Regulatory Commission's requirement that each Nuclear Steam Supply System prove its ability to achieve natural circulation during start-up testing. Before performing the actual plant test, a procedure must be written by the utility which describes the plant's initial conditions, test objectives, test scenario, limits and precautions, data requirements and test acceptance criteria. This test procedure was written by UE with the aid of several other utilities. Therefore, the RETRAN-01 results provided useful information in establishing particular setpoints for the actual start-up test.

Wang, J., C. Hwang, J. Kunze and D. Alger, Nuclear Engineering Department, University of Missouri, Columbia, MO 65211. PERFORMANCE OF THE MURR AT 30 MW FOLLOWING PUMP SHUTDOWN. The University of Missouri Research Reactor has operated at 10 MW for the last 10 years, and the University is now proposing to license it for a power level approaching 30 MW. The pump shutdown condition has been analyzed, using the most recent data and codes for calculating decay heat, and the sophisticated RELAP code for determining whether the hot spot on the fuel plates will exceed the condition of departure from nucleate boiling. The latter condition might be anticipated when the core flow reverses and begins to flow by natural convection. Results show that power levels of nearly 25 MW can tolerate this type of shutdown even with the present fuel elements. The paper will discuss some of the issues encountered in using package computer codes for a situation different from the specific model that the code developers had used for the design of the code.

Wu, W. Z., Department of Engineering Mechanics, University of Missouri, Rolla, MO 65401. STABILITY ANALYSIS OF A PARAMETRICALLY EXCITED MOVING THIN BEAM. Periodic variation of in-plane forces, including the band tension, surface friction and cutting forces can excite a parametric instability in the transverse vibration of high speed thread-lines, chains, belts, transport cables, magnetic tapes and band saws. The investigation reveals critical conditions for the transverse instability of a moving thin beam subjected to periodic loadings. The equations of motion are formulated by the extended Hamilton's principle. The Ritz method is used to discretize the stationary principle. A perturbation method, called the method of multiple scales, is then applied to predict the simple and combination parametric instabilities. Increasing band velocity and/or axial tension stabilizes the moving band. Through combination resonances, a small-amplitude, high-frequency periodic edge load can induce a large-amplitude, low-frequency torsional vibration, which is thought to determine band instability during cutting.

Environmental Science

Belshe, J. F., Biology Department, Central Missouri State University, Warrensburg, MO 64093. THE DISTRIBUTION OF *TRIBOLIUM CASTANEUM* (COLEOPTERA, TENEBRIONIDAE) IN LARGE CULTURES. Large numbers of *Tribolium* were placed in large fingerbowls with 1.5 cm of standard culture medium and distribution of the adults determined at various times after introduction. The culture containers were divided into 25 equal areas using a stiff divider constructed so there was 1 central area, 8 intermediate areas and 16 marginal areas concentrically arranged. The contents of each area were removed to museum jars by suction within a very short time. The animals were allowed to distribute for a period of a few to 60 days before census. The *Tribolium* were found to be heterogeneously distributed within the container for all periods of time evaluated. Differences in distribution related to time and other factors will be presented and discussed.

Jones, S., Biology Department, Drury College, Springfield, MO 65802. NOTES ON THE AMBLYOPSIDS OF SOUTHWEST MISSOURI. Two cavefishes (Amblyopsidae) inhabit the groundwater systems of southwest

Missouri: the southern cavefish (*Typhlichthys subterraneus*) and the Ozark cavefish (*Amblyopsis rosae*). Recent information indicates that the range of *T. subterraneus* is much less extensive than formerly thought. Specimens representing the western limits are apparently *A. rosae*. There is now no evidence that these 2 species are sympatric. *A. rosae* has recently been determined "threatened" by the U.S. Fish and Wildlife Service. Currently, confirmed sightings of *A. rosae* are documented for only 5 caves in southwest Missouri. Groundwater contamination appears contributory to the fish's declining status in Missouri.

Freeman, J., Biology Department, Central Missouri State University, Warrensburg, MO 64093. MORPHOLOGY AS A PREDICTOR OF ECOLOGY IN CHIROPTERA. Multivariate analyses of morphological and ecological data were used to define niches of 11 species of bats from an assemblage in northwestern Colorado. The assumption that morphological characteristics can predict ecological interactions was tested with the following null hypotheses: 1) intraspecific morphological variability is not correlated to dietary diversity, 2) morphology of a species is unrelated to the composition of its diet, 3) morphology of a species is unrelated to its foraging pattern, 4) morphological resemblance among species is unrelated to dietary resemblance among species and 5) morphological resemblance among species is unrelated to foraging resemblance among species. All hypotheses were rejected. The strong relationship between morphology and ecology in Chiroptera implies that slight differences in form connote slight differences in function. It has been suggested that, since bats develop and become independent rapidly, the role of experience and learning in structuring ecological behavior is minimized. Inherited factors controlling morphology and ecological behavior are likely to be dominant.

Ward, D. W. and J. A. Randall. Department of Biology, Central Missouri State University, Warrensburg, MO 64093. FOOTDRUMMING RESPONSES TO 3 STIMULI IN THE BANNERTAIL KANGAROO-RAT, *DIPODOMYS SPECTABILIS*. The hypothesis exists that adult bannertail kangaroo-rats have different footdrumming responses when exposed to stimuli of varying degrees of threat. Adult bannertail kangaroo-rats were studied in the field near Portal, AZ. They were exposed to 3 treatments: audio (footdrumming playback), visual (stuffed and mounted kangaroo-rat), audio-visual (a combination of the 2) and a control. Significant differences existed between the control and each treatment. In addition, a significant difference existed between the audio and audio-visual treatments. This difference is perhaps due to the greater potential threat expressed in the audio-visual treatment. Results are consistent with behavioral theory which predicts that greater stimuli should elicit a greater response.

McGinnes, E. A., Jr., R. P. Guyette, School of Forestry, Fisheries and Wildlife, and **O. R. Overby,** Department of Art History and Archaeology, University of Missouri, Columbia, MO 65211. USE OF TREE RINGS OF WOODEN STRUCTURAL MEMBERS TO DATE TIME OF BUILDING OF BEQUETTE-RIBAULT HOME IN STE. GENEVIEVE, MISSOURI. Oak timbers and joists, redcedar wall logs and pine boards used for flooring were sampled to obtain estimates of time of tree growth (calendar years formed). From these data, time of tree harvest was established for all samples between 1807 and 1808, A.D. The oak and redcedar trees apparently came from quite dry, southwest facing sites with either thin soil or fragipan. The pine boards sampled could have been obtained from the same tree. Data indicate that the house could not have been built prior to 1808 A.D.

McGinnes, E. A., Jr., B. E. Cutter, J. E. Phelps, School of Forestry, Fisheries and Wildlife, University of Missouri, Columbia, MO 65211 and **G. B. Reeves,** College of Agriculture and Forestry, University of Liberia, Monrovia, Liberia. DEVELOPMENT OF TENSION WOOD IN SELF-STRAIGHTENING BLACK WALNUT TREES. Wood of 4 plantation-grown black walnut (*Juglans nigra* L.) trees, 10-12 years old, were studied to evaluate the effect of self-straightening on wood properties. One tree had a normal straight stem (control) while the others were crooked at varying degrees from the vertical. Samples were obtained from below the crook, at the midpoint of the crook and above the crook where the bole seemed to be straightened. Tension wood formed in the self-straightening plane of the leaning black walnut trees. This wood had a faster growth rate, higher specific gravity, higher extractives content, longer fiber and vessel elements, higher holocellulose and lower lignin contents compared with normal wood from the non-leaning side of the same trees as well as the wood from comparable planes of the control tree.

Henson, M. F., Southeast Missouri State University, Cape Girardeau, MO 63701. THE EFFECTS OF LOWERED pH AND TEMPERATURE ON THE EARLY LIFE STAGES OF THE BLEEDING SHINER (*NOTROPIS ZONATUS*). One-day-old embryos of bleeding shiner were exposed to pH levels of 8.4 (control), 7.0, 6.0 and 4.5 and incubated at temperatures of 22 and 18°C. Solutions were renewed daily (H_2SO_4 = acid source) and embryos were examined for mortality, stage of development and hatching. Exposure was continued on the surviving fry for a period of 30 days post-fertilization to determine long-term effects of pH and temperature on growth, survival and viability. Embryos exposed to 4.5 pH and 18°C had the lowest hatching success of all groups tested (60% hatching success). Of the total initially exposed embryos at this pH and temperature, only 48% survived for the duration of the test, and only 40% were considered viable. The $P > F = 0.006$ for hatching, and for both survival and viability $P > F = 0.0001$. Length/depth ratios were also recorded, and a significant decrease in these were noted as pH dropped. Lowered pH may stress the organism in such a way that yolk energy is directed to maintenance rather than to growth.

Doubet, D. K. Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. EMBRYOTOXICITY OF MERCURY (MERCURIC CHLORIDE) IN *CAMPOSTOMA OLIGOLEPIS*. Twelve-hour old and 48-hour old *Campostoma oligolepis* embryos were exposed to Hg^{++} (as mercuric chloride) concentrations which ranged from 0 to 200 $\mu g\ l^{-1}$ (ppb). Five replicates of 10 embryos each were subjected to a static renewal bioassay for all treatments. Exposure media was replaced daily with well aerated, 0.45 μm filtered field water (Little Whitewater River). All embryos were incubated at 18°C with a 14-hour light, 10-hour dark

photoperiod. Embryonic parameters measured included 96-hour survival, hatching success and percent viable hatch. The 96-hour LC50 was increased approximately 30% for the 48-hour old embryos in comparison to the 12-hour old embryos from a value of 102.723 ppb to 136.135 ppb Hg^{++} . The SH50 value (median hatching success) was increased from 64.863 ppb for the 12-hour old embryos to 176.224 ppb Hg^{++} for the 48-hour old embryos. The VH50 was slightly increased from 52.552 ppb for the 12-hour old embryos to 59.711 ppb Hg^{++} for the 48-hour old embryos. Of the measured parameters, the VH50 value obtained for the 12-hour old embryos was the best estimate of the lower limits of toxicity of $HgCl_2$ to *C. oligolepis*.

Sharp, J. R., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. EMBRYOTOXICITY IN FISHES: PREDICTIVE CONSEQUENCES OF ENVIRONMENTAL STRESSORS. Over the past 10 years several different species of fish embryos have been exposed to a variety of potential stressors. In general embryonic responses are predictable, regardless of the specific stressor tested. Early cleavage stage embryos are typically more sensitive than older embryonic stages. When these embryos are exposed to moderate levels of a stressor, mortality occurs prior to neurulation and with the onset of hatching, between which times little mortality occurs. Specific abnormalities are likewise predictable. Adverse changes in normal growth are the most frequently encountered anomaly, followed by cardiac malformation, reduced circulatory pigmentation, hemorrhaging, reduced embryonic pigmentation, pericardial cavity enlargement and blistering. Increased mortality with the onset of hatching is correlated with a decrease in embryonic motor activity, a necessary process for distributing the hatching enzyme and rupturing the chorion. Fry typically exhibit a high frequency of spinal curvature. These predictive consequences support the concept of the generalized stress-stressor syndrome.

Henson, G. P., Southeast Missouri State University, Cape Girardeau, MO 63701. THE INTERACTIVE EFFECTS OF pH, COPPER SULFATE AND COPPER CHELATE ON THE GROWTH OF *CHLORELLA VULGARIS*. *Chlorella vulgaris* Beij. was acutely exposed to different concentrations of Cu^{++} (as $CuSO_4$) and copper chelate (Cu-EDTA complex) at 7.2, 6.0 and 5.0 pH, in order to determine the 96 and 168-hour LC50's and long-term effects of both toxicants upon population growth. Both forms of copper were found to increase in toxicity as pH decreased. Cu^{++} was found to be 4-10 times more toxic than Cu-EDTA at both 96 and 168-hour exposures at all pH levels. The effects of Cu-EDTA seemed to persist in the system longer than the effects of Cu^{++} at all pH levels for both 96 and 168-hour examinations. All 7.2 pH algal cultures were allowed to grow through day 25. At all concentrations of Cu^{++} and Cu-EDTA, algae showed reduced growth when compared to controls (Oppb). Lower growth of the exposed algae began on day 9 and persisted throughout the experiment. Cu^{++} exposed algae population size stabilized after 15 days. As the Cu^{++} concentration increased, population size decreased. In the Cu-EDTA groups, stabilization of population size was not obtained and the growth curves were nearly identical (although approximately 1/2 of the control curve) until day 25.

Anglen, D. M., Department of Industrial Safety and Hygiene, Central Missouri State University, Warrensburg, MO 64093, and **R. G. Smith**, University of Michigan, Ann Arbor, MI. SENSORY RESPONSE OF HUMANS TO CHLORINE. The effects of exposure to high levels of chlorine (Cl₂) are well known, but there are conflicting opinions concerning the effects of concentrations of 3 ppm or less. The purpose of this research was to study the response of humans to Cl₂ with particular attention to how the data could be used in setting occupational exposure standards. Human subjects were exposed to Cl₂ concentrations of 0, 0.5 or 1.0 ppm for periods of 4 hours. Some subjects were exposed to 0.5 or 1.0 ppm for 8 hours or to 2.0 ppm for up to 4 hours. In a second phase of the study, subjects were exposed to 0, 0.5 and 1.0 ppm in 3 separate 8-hour sessions. During each session the subjects were asked to fill out questionnaires which evaluated their subjective responses. Statistically significant differences in subjective irritation were found between exposures to Cl₂ and exposure to a control atmosphere. Sensations of throat irritation and urge to cough exhibited the highest level of response.

Yourtee, D., Toxicology Research Program, School of Pharmacy, University of Missouri, Kansas City, MO 64108. THE ROLE OF DETOXIFICATION IN THE ETIOLOGY OF DISEASE FROM THE ENVIRONMENTAL TOXICANT AFLATOXIN B₁: RECENT LABORATORY STUDIES AND EPIDEMIOLOGY. Toxicity to the liver including hepatocellular carcinoma is thought to develop from the ingestion of the mycotoxin aflatoxin B₁ via contaminated grains and other food products. Metabolism by the injured host leading to reactive intermediates has been postulated as the mechanism for injury. Our *in vitro* metabolism experiments have shown that postmitochondrial fraction (p.m.f.) of human liver converts this toxicant, also, to the detoxified derivative Aflatoxin Q₁. Furthermore, rat, rabbit and mouse liver p.m.f. produces the water soluble glucuronide conjugate of this metabolite. These observations have prompted a search of Q₁ and its glucuronide in the urine of Nigerians, which population has a high incidence of liver cancer. Evaluation of samples from patients at the Lagos University Teaching Hospital has revealed a pattern of urinary metabolites that could be useful toward diagnosis of impending liver damage from aflatoxins. Work supported by a Fulbright Grant and the Weldon Spring Endowment, University of Missouri.

Chiou, K. Y. and O. K. Manuel, Department of Chemistry, University of Missouri, Rolla, MO 65401. CHALCOGEN ELEMENTS IN ATMOSPHERIC PARTICLES. The atmospheric burden of sulphur oxides are of interest because of the environmental effects of these acidic products. The heavier chalcogen elements, Se and Te, occur in association with S in nature, and the study of these 3 elements may provide more information on their environmental pathways than is possible from separate studies of each. Measurements of S, Se, Te and 15 other elements in atmospheric aerosol samples collected in Rolla, MO in 1983 show a general enrichment of chalcogen and other volatile elements with S, Se and Te displaying enrichment factors relative to crustal abundances of about 600, 2,000 and 12,000, respectively. The distribution of chalcogen elements in aerodynamically-sized fractions of aerosols show that a large fraction of the lithophilic elements, like Al and Ca, are contained in the coarse aerosols (>2 μ m) from mechanical processes, e.g., soil-laden winds, pollen from plants, volcanic eruptions, etc., but that most

of the Te, Se, S and other heavy volatile metals are contained in the fine aerosols ($<2\mu\text{m}$) from vapor condensation and coagulation in air, e.g., exhaust emissions and photochemical reactions.

Mills, S. H., A. W. Brush and G. A. Reinhart, Department of Biology, Central Missouri State University, Warrensburg, MO 64093. THERMAL RESPONSES IN NEUROPATHIC RATS. Rats intoxicated with a metabolite of methyl butyl ketone (acetonylacetone) in their drinking water exhibited peripheral neuropathy characterized by generalized weakness and "foot drop." An analytical technique for detection of this neurotoxic chemical was developed and used to show its presence in blood of intoxicated rats. Although the body temperatures of these rats were not altered by cold exposure, the metabolic rates were more variable and apparently higher at temperatures below the lower critical temperature. The greater slope of metabolic rate as a function of ambient temperature in intoxicated rats suggests a greater rate of heat loss in these rats at low temperature. This apparent reduction in insulation in intoxicated rats is correlated with hair loss, poor fur maintenance and passive rise of tail temperature during transient heating.

Geography

Cheek, W. H., Department of Geosciences - Geography, Southwest Missouri State University, Springfield, MO 65804. TOURISM IN MISSOURI: PATTERN AND POTENTIAL. Tourism has become a major economic force in Missouri. It's importance, however, varies considerably within the state. The purpose of the research was to describe and interpret the spatial variation of tourism and to formulate policy recommendations concerning tourism as a tool for economic development. Data were derived from state and federal publications. The importance of tourism to the state cannot be disputed, but problems are present in certain communities dependent upon tourism.

Driever, S., Department of Geosciences, University of Missouri, Kansas City, MO 64108. THE DEVELOPMENT OF OUTLYING REGIONS IN GUATEMALA. Guatemala can be divided into 4 major physiographic regions: the Highlands, the Pacific Lowlands, the Northeast Ridge and Valley System and the Peten. With the exception of a few places, the latter 2 regions have not been exploited intensively for centuries. This paper discusses why the Peten and the Northeast have been largely bypassed in the drive to modernization and what patterns of land use, where they exist, are found there. Also discussed is how Guatemala has tried recently to use government programs and private investment to spur settlement and economic development in the 2 regions. Finally, the varying consequences of these public and private development efforts is assessed at both the regional and national scales.

Johnson, E., Department of Geosciences - Geography, Southwest Missouri State University, Springfield, MO 65804. AN INVESTIGATION REGARDING LAND COVER MAPPING OF GREENE COUNTY, MISSOURI. BY USE OF REMOTE SENSING. The purpose of this investigation is to evaluate the utility of Landsat Thematic Mapper (TM) data in an attempt to discriminate between land cover types for Greene County, MO. Five bands of TM data, collected on April 27, 1984, were used to develop spectral signatures for training field statistics. Along with other imagery and ground truth, early results indicate that a number of land cover types were readily separated. For example, poorer quality pastureland, primarily fescue and native grasses, grouped together. But, a notable amount of fescue which was fertilized during the winter season for its hay crop, surprisingly, classified with alfalfa and winter wheat. Greater land cover detail over the rural landscape may surface with TM data collected later in the year.

Robertson, A. C., Southeast Missouri State University, Cape Girardeau, MO 63701. RECENT CLIMATE VARIATIONS IN MISSOURI. Recent winters in Missouri seem to be colder than usual. Temperature data were evaluated to determine past means for comparison with the most recent 10 years. The implication of cooler winters could mean the redrawing of the Humid Subtropical (Cfa)/Humid Continental (Dfa) climatic boundaries according to the Trewartha modification of the Koppen Classification system. Maps illustrate the general equatorward migration of the above mentioned climatic boundary in Missouri.

Schroeder, W. A., Department of Geography, University of Missouri, Columbia, MO 65211. REGIONAL DISCRIMINATION IN THE STUDY OF MISSOURI. A quantitative analysis of a comprehensive 1976 compilation of 1550 written items on the state of Missouri shows that some places in Missouri have been studied much more than other places. Major urban areas, the southeastern lowlands, the eastern Ozarks and central Missouri rank high in number of studies, while the Osage Plains, south-central Ozarks and most of rural northern Missouri appear to be neglected regions of study. Reasons for this geographical imbalance include distribution of population, historical significance, mining and recreation activities and the perception of social and economic problem areas needing study.

Ferguson, M., Department of Geosciences, University of Missouri, Kansas City, MO 64110. BARBADOS: AN ECONOMIC REJUVENATION PLAN. This paper discusses a possible 10-year plan for development of the flagging Barbadian economy. The present situation in agriculture, industry and tourism are reviewed. Although tourism is increasing steadily, it cannot be relied on as is to revive the entire economy; therefore, structural changes are proposed for tourism as well as agriculture and industry. Specifically, it is proposed that agriculture should be mechanized and export-oriented, foreign investments in industry should be welcomed in order to employ Barbadians displaced from agriculture and tourism could be stimulated further via legalized gambling.

Geology - Geophysics

Nold, J. L., Geology Department, Central Missouri State University, Warrensburg, MO 64093. THE JACK RANCH FOLD NEAR SOUTH PASS WYOMING—ITS GEOMETRY, ORIENTATION AND RELATION TO THE CONTACT OF THE SWEETWATER GRANITE. In this area, which is mapped during the University of Missouri geology field course, metasediments and metavolcanics of the South Pass greenstone belt have undergone multiple folding and have been intruded by Precambrian granitoid plutons. A fold with particularly interesting geometry and contact relations occurs just northeast of the Jack Ranch. Even though this area has been metamorphosed up to middle amphibolite facies, bedding is still visible on many outcrops. On the western limb the bedding has an average attitude of N75E, 70N, and the eastern limb trends average N35W, 75SW. These trends define a fold with an axis that plunges steeply northwest (N65W, 60°) and an axial surface trace that trends northeasterly. The schistosity lies parallel to the axial plane of the fold. Sweetwater granite intrudes the eastern limb of the fold and the contact is generally parallel to the schistosity. Locally, however, large offshoots of Sweetwater granite invade the schists parallel to their bedding direction.

Emerson, J. W., Geology Department, Central Missouri State University, Warrensburg, MO 64093. SOIL SURVEYS: AN AID IN GEOLOGIC MAPPING. Detailed geologic mapping in Missouri is difficult and time consuming due to plant cover. USDA County Soil Surveys have proven to be most useful in delimiting areas in which to search for the outcrop of some rock units. While most sedimentary deposits do not form a unique soil type, there are 2 soil series which, in the area mentioned, are specific to a particular deposit. The Bolivar Series, fine sandy loam, is developed only on thick channel sandstones which are linear, persistent in outcrop and are unconformable on all the other exposed rocks. The "Warrensburg type" channel sandstone outcrop was traced north-south across Henry County by using soils maps. This new information is displayed on the 1979 Geologic Map of Missouri. Haig silt loam is found on broad ridgetops and formed from Kansan proglacial lake deposits which blanket the uplands for miles across central Missouri. Using the Johnson County soil map, the known outcrop of these Kansan sediments has been greatly extended. To the south, in Henry and Benton counties, the Hartwell Series is used to describe similar parent material.

Easson, G. L. and R. C. Laudon, Department of Geology and Geophysics, University of Missouri, Rolla, MO 65401. THE GRAYDON SPRINGS CHANNEL, PENNSYLVANIAN OF SOUTHWESTERN MISSOURI. The Graydon Springs Member, here assigned to the Warner Formation of Pennsylvanian age, is composed of an upper sandstone unit and a lower conglomerate unit. The conglomerate is composed of very poorly sorted, very well rounded chert clasts, with rare carbonate clasts in a fine to coarse sand matrix cemented with either iron oxide or silica. Quartz grains in the sandstone are well sorted and well rounded suggesting multiple cycles of erosion, transportation and deposition. Paleocurrent data in the form of cross beds and pebble imbrication suggest a southerly current flow. This, coupled with cumulative frequency distribution curves, the overall geologic framework and member geometry, suggests that the Graydon Springs Member represents a point bar sequence deposited by a meandering stream that flowed generally southward across western Missouri.

Marikos, M. A. and R. C. Laudon, Department of Geology and Geophysics, University of Missouri, Rolla, MO 65401. RELATION OF BITUMEN TO ORE IN THE MAGMONT WEST OREBODY, SOUTHEAST MISSOURI. Bitumen in the form of hardened oil blebs from the Magmont West orebody of the Viburnum Trend was examined and analyzed in an attempt to relate hydrocarbon distribution and origin to ore genesis. In open cavities many of the blebs line up preferentially with organic rich layers in the dolostone suggesting that the blebs are derived from an oil that was frozen in the act of primary migration from the Bonnetterre Formation. Textural data indicate that the oil was generated primarily *after* lead-zinc mineralization. Elemental analyses indicate that the H/C ratio is 1.41 and NSO components make up $2.60 \pm 0.20\%$ of the bitumen. Normal alkanes released during pyrolysis-gas chromatography have from 11 to 20 carbons with no odd or even carbon preference in their molecular structure. These data suggest that the bitumen is derived from a normal crude oil that has had its lighter alkanes removed by biodegradation and water washing.

Brandom, R. T. and R. D. Hagni, University of Missouri, Rolla, MO 65401. ORE MICROSCOPY OF THE BOSS-BIXBY, MO, COPPER-IRON DEPOSIT, AND A COMPARISON TO OLYMPIC DAM (ROXBY DOWNS), AUSTRALIA. Ore microscopic study of the Boss-Bixby, MO, copper-iron deposit has shown that it contains an ore mineral assemblage that is comparable to that present in the economically important Olympic Dam (Roxby Downs) copper-uranium-gold deposit in south Australia. The minerals present in both deposits include: magnetite, hematite, pyrite, chalcopyrite, bornite, carrollite and covellite. Both deposits are dominated by the iron oxides, magnetite, hematite and pyrite. The deposits are similar in that the sulfide mineralization followed that of the iron oxide deposition and oxidation. Both deposits are Middle Proterozoic in age, but they differ in their structural settings: the Olympic Dam deposit occurs in a sedimentary trough, whereas the Boss-Bixby deposit occurs in breccia zones associated with a basic dike. Similarities brought out by this ore microscopic investigation could possibly generate interest in exploration for ore deposits of the Roxby Downs-type in Missouri.

Dudley, M. and J. L. Nold, Geology Department, Central Missouri State University, Warrensburg, MO 64093. MINERALOGY OF THE PRECAMBRIAN GREISEN VEINS AT SILVER MINE, ST. FRANCOIS MOUNTAINS, MO. The mineralogy of the Silver Mine greisen occurrence is being studied in thin sections and polished sections. The greisen occurs as narrow alteration envelopes around the veins and is characterized by topaz, sericite, fluorite, apatite and cassiterite. Topaz is the dominant mineral in many specimens. Following development of the greisen, a quartz-vein assemblage was deposited with the main minerals as follows: quartz, zinnwaldite, chlorite, pyrite, arsenopyrite, sphalerite, chalcopyrite, galena, wolframite, apatite and fluorite. The sphalerites are of particular

interest. Most of the sphalerite is yellow-brown in color; however, most of the crystals show a prominent, sharply-bounded zone of blackjack sphalerite on their exterior portions. Exsolution blebs of chalcocopyrite are quite abundant within the sphalerite.

Freund, M. J., University of Missouri, Rolla, MO 65401. ANALYSIS OF COMPUTER CONTOURING METHODS. A study of geostatistical methods used in computer contouring and analysis of spatial phenomena has shown that a greater understanding of the purpose of these techniques is needed. Geologists study a 3-dimensional world, but their view of it is strongly 2-dimensional. Maps are used as an efficient and compact means of expressing relationships and details of 3-dimensional data. The geologist has at his disposal numerous techniques for interpreting geologic data from 1 of the first methods of contouring and point estimation—triangulation—through more mathematically exact and complex techniques, such as: trend surface analysis, inverse distance weighing and kriging. The computer has greatly eased this process through its speed and ability to manipulate immense amounts of information. Each of these methods has its limitations, however, that geologists should be aware of in order to use the techniques to their fullest. Through various comparisons of estimation methods and in actual field practice kriging has been found to give the best estimates of spatial relationships.

Herpetology

Scheibe, J. S., Southeast Missouri State University, Cape Girardeau, MO 63701. THE EVOLUTION OF LIFE HISTORY STRATEGIES IN AGE-STRUCTURED LIZARD POPULATIONS. Lizard population growth was modeled using a renewal equation which incorporated age-specific fecundity, age-specific survival and a physiological time scale. Computer simulation results show that in variable environments lizard populations do not achieve a stable age distribution. The renewal equation model was used to determine the life history parameters which had the greatest influence on fitness in the age-structured population. These parameters included mean and variance of the optimal development rate and timing of the final clutch in a season.

Trautwein, S. N., Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. RELATIONSHIPS BETWEEN BEHAVIOR, BODY TEMPERATURE AND HABITAT UTILIZATION IN THE NORTHERN FENCE LIZARD *SCOLOPORUS UNDULATUS HYACINTHINUS*. Observations were made of *S. u. hyacinthinus*, 2 at a time, in a 4 x 8 foot enclosure behind a 1-way mirror. Behavior, body temperature and location of the animals within the enclosure were recorded at 10-sec intervals. By far the most significant predictor of body temperature was found to be location of the lizard with respect to heat source. Other significant, but moderate, predictors of body temperature are identity and sex of the lizard, time since dawn and behavior. The importance of location is discussed within the context of the social structure of this species and its impact on habitat utilization by individuals of different social status. These results are related to the dual set-point model of lizard thermoregulation (Heath, 1965, Univ. Calif. Publ. Zool. 64:97-136).

Clark, D. W. and J. S. Scheibe, Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. A MODEL OF DINOSAUR THERMOREGULATION IN VARIABLE ENVIRONMENTS. A dinosaur thermoregulation model was constructed which treated the reptiles as large ectothermic cylinders composed of various layers of tissue. Daily and seasonal environmental temperature and radiation regimes were established. The thermodynamics of the cylinder was modeled via computer simulation. The results are consistent with previous studies in that large size results in relatively stable core body temperatures. However, growth and development of the dinosaurs in variable environments imposed significant constraints on the life history parameters.

Oncology

LeGrand, R., R. Reynolds, J. McEntire, A. Khojasteh, E. Mitchell, B. Papermaster, A. Garcia, N. Anson, M. Doyle, M. Karrer-Dugan and J. Walter, Ellis Fischel State Cancer Center and Cancer Research Center, Columbia, MO 65201. THE PHAGOCYtic INDEX AS A MEASURE OF MACROPHAGE ACTIVATION FACTOR (MAF) FROM THE RPMI-1788 LYMPHOBLASTOID CELL LINE. Fourteen patients with advanced cancer were treated with Human B-cell RPMI-1788 derived lymphoblastoid MAF using low (3-4.5 ml) or high (120-250 ml) doses given by 4-hour intravenous infusions, every other day, 5-11 days. Age of patients ranged from 35 to 83 yrs. Diagnoses included carcinoma of lung and breast; malignant melanoma; lymphoma; colon, ovary and soft tissue sarcoma. Measurements of macrophage phagocytic activity were made according to the method of Dunn et al. (J. Immunol. Meth. 64:71, 1981) at baseline, following completion of treatment, 1 month and 2 or more months later. Human monocytes used in the assay were tested for phagocytic activity using both a buffered saline control and lymphokine/MAF stimulation. The high-dose group showed increases in phagocytic MAF activity. Measurements at 1 and 2 months following treatment showed return to pretreatment values. This 2-stage assay will be a useful measurement of MAF activity in future clinical trials.

Kapoor, A., W. Kraybill, B. Allen and R. Reynolds, University of Missouri and Ellis Fischel State Cancer Center, Columbia, MO 65201. INCIDENCE OF CORONARY ATHEROSCLEROTIC HEART DISEASE IN LUNG CANCER AND OTHER CANCERS. This retrospective study of autopsied patients with lung cancer, breast, ovarian, prostatic and colon cancer was undertaken to estimate the incidence of coronary atherosclerotic heart disease (CAHD) in these various cancer groups. Detailed scrutiny of records was made for pertinent risk factors.

clinical evidence of CAHD and necropsy data for pericardial involvement, luminal cross sectional diameter of coronary arteries, myocardial fibrosis and heart weight. The results are depicted in the following table:

Ca Type	Lung	Prostatic	Breast	Ovarian	Colonic
No. of patients	120	32	95	30	60
W/CAHD	(62.5%)	(25%)	(1.1%)	0	(11.7%)
P values	0.001	p 0.05	NS	NS	NS

There is also a significant association between lung cancer, CAHD and smoking. High incidence of significant obstruction CAHD not detected antemortem.

Khojasteh, A., J. Walter, W. Kraybill, R. Reynolds, M. Lopez, A. Highbarger and P. Walker, Ellis Fischel State Cancer Center, Columbia, MO 65201. THE SAFETY OF EARLY USE OF HICKMAN CATHETERS IN CANCER PATIENTS. While indwelling Hickman catheters facilitate venous access in cancer patients with poor peripheral venous systems, a common complication associated with their use is the occurrence of infections. To determine the overall incidence of catheter-related infections and the safety of early use of this line for chemotherapy, 37 patients, aged 17 to 89, were randomly selected to receive chemotherapy using a Hickman catheter. Eighteen received chemotherapy immediately after insertion. Nineteen received chemotherapy at 5 days or later following placement. Not 1 episode of infection occurred in either group within the first 4 weeks. A followup of longer duration (60-520 days) documented 8 episodes of infections associated with the catheters; 3 were local skin infections and 5 were bloodborne. Two exit site infections were due to *Candida albicans* and one due to *Pseudomonas aeruginosa*. Septicemia was due to *Pseudomonas aeruginosa* in 2 patients, *Klebsiella* in 2 patients and *Citrobacter* in 1. Our study demonstrates the safety of early usage of Hickman catheters for chemotherapy administration.

Reynolds, R., M. Lopez, H. Lankford, D. Pearson, P. Robinson, A. Khojasteh, E. Mitchell, A. Garcia, N. Anson and M. Dugan, Ellis Fischel State Cancer Center and Cancer Research Center, Columbia, MO 65201. DIETARY FACTORS IN BREAST CANCER. We have been selected by the NIH to participate in the design and conduct of a dietary intervention study which will evaluate the value of lowering daily dietary fat in women at high risk for developing breast cancer. The study is designed to reduce the daily dietary fat (normally 60-80 g) to 20 g in a prospectively randomized trial. All participants will also receive annual physical examinations and bilateral mammography studies. Dietary fat content will be measured by log sheets prepared by the participants. Rationale for the study is based on epidemiological evidence that some populations have relatively higher incidence of breast cancer. The selection of women at high risk for the development of breast cancer has been made so that the effect of diet modification can be detected within a population study. The study will require entry of approximately 10,000 participants and a followup evaluation of at least 5 years.

Mitchell, E., R. Reynolds, A. Khojasteh, N. Anson, M. Karrer-Dugan, Ellis Fischel State Cancer Center, **J. McEntire, B. Papermaster and J. Wibbenmeyer**, Cancer Research Center, Columbia, MO 65201. URINARY EXCRETION OF INTERFERON, ALBUMIN AND β 2-MICROGLOBULIN DURING LYMPHOKINE TREATMENT. Serum and urinary levels of albumin, β 2-microglobulin and interferon were determined in 6 patients undergoing therapy with lymphokine from the cultured human lymphoblastoid cell line RPMI-1788. Intravenous infusions of lymphokine were administered on 3 alternate days in a Phase I trial. No increase in serum or urinary interferon activity was observed. Serum β 2-microglobulin increased after lymphokine treatment. Urinary excretion of β 2-microglobulin increased. Measurement of the urinary albumin and β 2-microglobulin ratio revealed no glomerular or tubular lesion. We conclude that lymphokine therapy using the doses and schedule in this Phase I trial does not result in significant interferon production or clinically significant nephrotoxicity.

Physics

Thomas, W., Southwest Missouri State University, Springfield, MO 65804. MICROCOMPUTER SIMULATION OF TRAJECTORY MOTION. While most intermediate and advanced physics texts examine projectile motion using linear air resistance, for many applications quadratic air resistance is more appropriate. If quadratic air resistance is used to study the motion of a projectile in 2 dimensions, however, the equations of motion become coupled, requiring computer solutions using numerical analysis techniques. The technique used for this simulation is a predictor-corrector type called the self-starting modified Euler method, implemented on an Apple computer using the BASIC language. Unlike other simulations where the value of k , the drag coefficient, must be found from wind tunnel experiments or from knowledge of the terminal velocity of a falling body, this simulation uses a value of k that is calculated as a function of the shape of the projectile, eliminating any need for *a priori* knowledge of the behavior of a body. Simulation results have been compared to the observed behavior of several types of objects dropped from rest, to Olympic shot put records, and to a variety of thrown or fired projectiles. Excellent agreement has been found in all cases.

Adawi, I., University of Missouri, Rolla, MO 65401. COMMENTS ON THE RAINDROP PROBLEM. The motion of a raindrop with mass accretion has been considered by many authors to illustrate a motion with changing mass. Recently Krane (1981 Am. J. Phys. 49:113) considered several interesting cases which led to the solution of nonlinear differential equations, some of which he left unsolved. We give here solutions to some of these equations and discuss the nature of the solutions.

Banks, L., Southwest Missouri State University, Springfield, MO 65804. DESKTOP COMPUTERS FOR PHYSICS AND ASTRONOMY INSTRUCTION. This presentation will discuss the small computer facilities

available to students and faculty in the Department of Physics and Astronomy at Southwest Missouri State University. General uses by all the faculty for course instruction and administration will be reviewed. Specific examples will be discussed showing how students are expected to use microcomputers for solving physics problems that involve Newton's second law of motion, Laplace's equation and Schrodinger's equation.

Gerson, R., University of Missouri, Rolla, MO 65401. ACOUSTICS AND THE PHYSICS CURRICULUM. A course labeled "Acoustics" is not usually a requirement for a BS in Physics, probably because most Physics faculty do not see a need for a study of the technical aspects of sound generation and propagation. A typical Acoustics course is, however, concerned mainly with wave mechanics in solids and fluids, in more detail than these topics are allowed in the undergraduate mechanics requirement. Acoustics offers an introduction to complex notation applied to waves, Fourier analysis of vibrating systems, the normal modes of extended bodies, practice with the wave equation using various boundary conditions and Bessel functions. These topics are studied in the context of simple mechanical waves, which are more easily visualized than electromagnetic waves or quantum wave functions. Acoustics, taken at about the same time as undergraduate mechanics, is therefore a great help to the student in understanding wave theory.

Phillips, R. A. and Whittle, P. R., Missouri Southern State College, Joplin, MO 64801. GEOTHERMAL HEAT PUMP. A geothermal heat pump system has been developed at MSSC with a COP ranging from 3 to 5. A full-scale system, based upon the prototype, is now heating the home of 1 of the researchers and recent results of this will be presented at the meeting. The system achieves its high COP by circulating Freon through copper tubes placed in the ground. Further studies and modifications now in progress should result in even higher COP's.

Gosselin, C. M., Penn Valley Community College, Kansas City, MO 64111. APPLICATION OF AN APPLE MICROCOMPUTER TO THE TESTING OF PHYSICS AND ENGINEERING COURSES. In 1973, I began to develop a program of competency based tests for our Engineering Physics I course. The course requirements were modified such that a student, to obtain a passing grade in the course, was required to perform above a minimum level in each of 11 study modules. This requirement demanded that some method of re-testing be established. It has been determined that the original competency test for a given unit is also an effective re-test if the test is designed with decision points. The decision mechanism within the test can be manipulated by means of input data and can easily be handled by a microcomputer. General characteristics of the competency test and a demonstration of how a unit test is developed from a seed program will be presented.

Psychology

McClellan, J. E., Park College, Parkville, MO 64152. HOMICIDE AS A PSYCHOSOCIAL PHENOMENON: AN ANALYSIS OF CERTAIN VERBAL MODELS. Previous research efforts regarding the causes of homicide have rarely been examined for their propositional statements and analysis of circumstance which generate murderous responses. The current study provides for a constructive view of certain verbal models and proposes the development of mathematical models describing the phenomenon of murder. The verbal models provide the contextual variables, relative significance and construct of a schematic diagram to be used in predicting the probability of homicide in urban environments. The schematic diagram "model of murder" provides for measurable variables which could be used to estimate the degree of murderous potential in a community. A significant number of these variables are within social control contexts of a community thereby indicating that a community could affect the degree of murderous potential and hopefully reduce the instance of homicides.

Bargar, J., Missouri Western State College, St. Joseph, MO 64507. DUAL-CAREER RELATIONSHIPS: A LITERATURE REVIEW. The investigator reviewed literature pertaining to couples where both partners in the relationship are committed to careers. Areas presented were nature of the relationship, implications for counseling and critical comments regarding studies reviewed. It was concluded that the numerous problems and advantages associated with dual-career couples make it unlikely that this form of relationship will work unless couples invest heavily in the relationship. Counselors may find themselves in roles ranging from problem-solving facilitators to growth/change stimulators when working with these couples.

Vertin, S. and P. D. Wann, Missouri Western State College, St. Joseph, MO 64507. WHAT PRICE LOBOTOMY? THE PIONEERING STUDIES OF MARY FRANCES ROBINSON. As a volunteer psychologist at the St. Joseph (MO) State Hospital in the early 1940's, Mary Frances Robinson (1890-1964) conducted pioneering studies of the intellectual and personality changes which follow prefrontal lobotomy. In two papers in 1946, she described the "intellectually mutilating" effects of lobotomy, concluding that the operation, then widely used to treat psychotic disorders, should be performed only as a "measure of last resort." The next year Robinson was invited by Dr. Walter Freeman, the surgeon who popularized prefrontal lobotomy in the U.S., to evaluate his patients. Using a battery of personality tests, Robinson compared Freeman's lobotomy patients with a control group of other psychotics. Her major finding was that the operation disrupted self-continuity, or concern for the past and the future. As a result of this study, Freeman changed his surgical procedure from standard lobotomy to a less radical transorbital approach. Later, Robinson's book (*Psychosurgery and the Self*, 1954) describing her study contributed to the demise of all forms of lobotomy, thus helping to end the era of psychosurgery.

Science Education

Delaware, D. L. and D. L. Hanks, Division of Science, Northeast Missouri State University, Kirksville, MO 63501. SCREENING PROGRAM FOR ENTERING FRESHMAN SCIENCE MAJORS AT N.M.S.U. A testing

program was developed to screen incoming freshman science majors in mathematics and chemistry and to give academic advisement regarding freshman courses. The program was initiated because of concern about performance levels of entering freshman science majors in required mathematics and chemistry courses. The program is an ongoing one. Second year results of the testing will be discussed, as will implications for future study.

Stanley, C. M. and A. R. P. Journet, Department of Biology, Southeast Missouri State University, Cape Girardeau, MO 63701. DOES THE SCIENCE LABORATORY CONTRIBUTE TO THE COGNITIVE DEVELOPMENT OF STUDENTS? The General Biology Laboratory course at Southeast Missouri State University is a non-majors course which satisfies the General Education laboratory requirement. For several years the course has been developing toward a greater emphasis on the science in biology, on the process of science as opposed to simply memorizing. Through the course, students first learn and then gain experience at generating their own hypotheses, devising experiments, analyzing their data and drawing their own conclusions. The goal of this course design is not only to develop in students an understanding of science as a process, but also to promote in them the improvement of problem-solving skills. To assess our success in this second goal, a study has been conducted on student cognitive development as a consequence of taking the course, using primarily a pencil and paper test that correlates with Piagetian cognitive levels. This paper presents data on the improvement of the problem-solving skills of students in relation to the course.

Gordon, A. R., Department of Biomedical Sciences, Southwest Missouri State University, Springfield, MO 65804. TEACHING CONCEPTS OF CELLULAR RESPIRATION USING A TALLY METHOD. The usual teaching approach to cellular respiration in classrooms and textbooks involves a reaction-by-reaction analysis of the major respiratory pathways reinforced by memorization. The author's approach teaches students to determine the molecular and energy input and output for each food substrate. The author's "valence electron difference method" is used to calculate reducing power potential in this short method. Energy transfer and conversion principles and restrictions are presented. All equations are balanced, a common deficiency in published materials. Students construct probable respiratory sequences using different food molecules. Molecular and energy input and output are tallied. Students validate sequences by comparing tallies with totals obtained using the short method. With minimum guidance, students are able to recreate the major respiratory sequences with considerable understanding and accuracy.

Hoggard, F., Southwest Missouri State University, Springfield, MO 65804. THE SEMANTIC AND LINGUISTIC STRUCTURE OF VERBAL PROBLEMS. Verbal problem statements are highly structured, yet many students cannot work them with any degree of confidence. The difficulty seems for the most part to lie in students' lack of ability to decode the deep structure of the language. Examples of this will be given along with a method of remediating the problem.

Mantei, E., Geosciences Department, Southwest Missouri State University, and **F. Lojko**, Springfield Public Schools, Springfield, MO 65804. DEPARTMENTAL GENERATED MICRO-COMPUTER SOFTWARE FOR THE UNIVERSITY UNDERGRADUATE AND SECONDARY GEOSCIENCE CURRICULUM. Apple computer software developed by faculty and faculty-guided student research at SMSU for courses such as mineralogy, petrology, geochemistry and well logging procedures has been introduced into the geoscience curriculum. "Number crunching" as well as teaching aid programs are included. This self-produced software has 4 important attributes: 1) it is inexpensive, 2) it gives the student experience in the application to his/her field of interest, 3) contents of each program can be easily accessed and changed if desired and 4) course content need not be changed to accommodate the software. The secondary earth science teacher can develop with his/her students software which will enhance the learning environment, course content and the overall earth science curriculum.

Klingel, E. J. and J. Davis, Department of Geosciences, Southwest Missouri State University, Springfield, MO 65804. A COMPUTER ASSISTED INSTRUCTION (CAI) COURSE INTERFACED WITH A RANDOM ACCESS PROJECTOR IN THE FIELD OF METAMORPHIC PETROGRAPHY. The project entails the programming of a CAI course in IBM BASIC using a combination of linear and branching programmed instruction. The interface correlates metamorphic texture information on the CRT with photomicrographs of metamorphic textures projected by a random access projector onto an 8 x 12" screen mounted next to the CRT. The metamorphic texture categories covered in the program are relict, dynamic and crystalloblastic. It is hoped that the use of this CAI program will allow for more efficient student learning in petrography, better use of instructor time during petrography lab, a review tool for self-paced individualized instruction in petrography and if used before the petrographic scope the program may reduce the initial misinterpretation problems when using the scope to identify textures. Also, the system will be adaptable to other learning areas that require non-verbal visual material correlated with verbal text.

Cocke, J. M., R. K. Becker and M. J. Rogers, Geology Department, Central Missouri State University, Warrensburg, MO 64093. PRELIMINARY INVESTIGATION OF ELEMENTARY GEOLOGY LABORATORY PROCEDURE FOR THE VISUALLY IMPAIRED. This study indicates that visually impaired students can successfully execute many traditional laboratory techniques in the physical geology laboratory. A typical suite of minerals were studied; however, some of the minerals were selected with certain clearly developed physical properties. The following physical properties were studied: hardness, elasticity, crystal form, cleavage, specific gravity, magnetism, taste, effervescence, texture, feel, striations and odor. In addition, topographic maps, geologic maps and geologic structure were studied. At present, procedures are being formulated for the visually impaired to study sedimentary rocks, fossils and geologic structures.

COLLEGIATE DIVISION

Biological Sciences

Schulz, S. and D. F. Millikan, Department of Plant Pathology, University of Missouri, Columbia, MO 65211. *IN VITRO* PROPAGATION OF *PRUNUS BESSEYI* BAILEY. *Prunus besseyi* is a useful dwarfing rootstock for peaches and nectarines. Clones selected for their superior horticultural qualities by Dr. J. Cummins of New York, have been found to be infected with the green ring mottle virus (GRMV). Since there are no other satisfactory dwarfing rootstocks for nectarines, we are investigating the use of shoot tip meristem culture to produce GRMV-free clones of *B. besseyi*. These studies show that explants containing the dome and 4-6 leaf primordia will start proliferating (Stage II) after 2 months in culture on the Murashige-Skoog medium. A variety of basal media, growth regulators and environmental factors are being evaluated for their effect on growing explants.

Mock, A. and G. D. Sells, Northeast Missouri State University, and **O. B. Mock**, Kirksville College of Osteopathic Medicine, Kirksville, MO 63501. AGE-RELATED CHANGES IN THE MORPHOLOGY, PHYSIOLOGY AND ELECTRICAL AXIS DEVIATION IN THE HEART OF THE LEAST SHREW (*CRYPTOTIS PARVA*). Age-related changes were studied by determining variations in heart size, hypertrophy of the ventricular walls and electrical axis deviations (EAD). Changes in the morphology of the heart were determined by measuring left and right ventricular widths using a cross section of the ventricles at the widest point. As animals aged, there was distinct hypertrophy of the myocardium of the left ventricle. In old animals there was also subsequent hypertrophy of the right ventricle. Average heart rate of the animals was 777 beats/min, with an average respiration rate of 406 breaths/min. Shrews used in the EAD study ranged in age from 27 to 563 days. The mean EAD for the 27-200 day age group was 55.6 degrees as determined for 16 animals. The mean EAD for the 211-563 day age group was 28 degrees as determined for 11 animals. The trend observed was a decrease in the EAD after the age of 200 days. The shift of the EAD to the left as correlated with the hypertrophy of the ventricular walls may possibly be due to the obesity observed in older animals.

Chemistry and Geology

Johnson, T. R., Southwest Missouri State University, Springfield, MO 65804. PRELIMINARY INVESTIGATION OF SOIL SEDIMENTS IN VALLEY GEOMORPHIC POSITIONS IN SOUTHWEST MISSOURI. The possibility of loessal material existing in low lying geomorphic positions is examined. Selected chemical and physical properties of the soil at 2 sites is analyzed and compared. One site is located in northern Greene County on the Dry Sac River, and the other is located in northern Christian County on the James River. Textural data show a high percentage of silt indicative of loessal material. The change in abundance of clay minerals throughout the soil profile displays interruptions of the illuviation process. Interpretation of these soils suggests that the loess present may be reworked from toe slope and foot slope deposits. What are thought of as flood plains may be the result of reworked loess deposition by hillslope processes.

Henderson, O., K. Fountain and D. Delaware, Science Division, Northeast Missouri State University, Kirksville, MO 63501. COMPETITION REACTIONS WITH DIPHENYLKETENES. Diphenylketenes were generated by a Friedel-Crafts reaction. Competition reactions with substituted aromatic compounds were run with the diphenylketenes. The competition reactions were used to study the mechanisms of ketene reactions.

Social and Behavioral Sciences

Crane, W. and F. Haemmerlie, University of Missouri, Rolla, MO 65401. EVALUATIONS OF THE WORK OF MEN AND WOMEN IN VARIOUS PROFESSIONS BY MALE AND FEMALE ENGINEERING UNDERGRADUATES. Conditions under which male and female college students majoring in engineering are prejudiced against women in various professions were investigated. Undergraduates evaluated professional articles in 2 feminine (nursing and education) and 2 masculine (law and engineering) fields. The author's sex and title were manipulated such that each article was authored in 4 ways—by a male with a title, by a female with a title, by a male with no title and by a female with no title. Subjects also completed the Bem Sex Role Inventory and the Attitudes Towards Women Scale. Results showed sex bias against the female nurse by female technical majors and for the females in both masculine professions by all of the technical majors. Although there were no significant differences on the Bem Inventory, significant differences did occur on the Attitudes Towards Women Scale—with males showing the more liberal scores. Results showed the presence of positive and negative bias and the importance of subjects' attitudes about women's roles in society.

Bowles, M. and F. Haemmerlie, University of Missouri, Rolla, MO 65401. PERSONALITY MEASURES AS A FUNCTION OF STAGE OF THE MENSTRUAL CYCLE IN A GROUP OF YOUNG VS OLDER FEMALES. Previous research on personality changes during the premenstrual phase of women's cycles has suffered from problems with poor measures and use of non-normal subjects. The present study involved 2 groups of subjects, a

young group (ages 18-24) and an older group (ages 30-36) taking the Guilford Zimmerman Temperament Survey and the Minnesota Multiphasic Personality Inventory during either the early (day 5-9) or the premenstrual (day 20-25) phase of their menstrual cycles. Results showed females tested during the premenstrual phase had lower energy and a greater degree of hostility. Also, the young-premenstrual group showed a greater degree of hostility and sensitivity than did the older-premenstrual, older-early or young-early phase groups, while the older-premenstrual phase group showed greater hypochondriacal tendencies. These results suggest that the premenstrual syndrome does occur in both age groups and that similarities as well as differences may exist in specific personality changes that occur in younger vs older females.

Smith, S. and F. Haemmerlie, University of Missouri, Rolla, MO 65401. THE EFFECT OF STRESS ON DAILY BLOOD GLUCOSE READINGS IN DIABETES MELLITUS. Although it is generally assumed that increased stress produces an exacerbation of symptoms of diabetes, previous research has been limited by consideration of this relationship in artificial laboratory situations or by use of a retrospective case study approach where subjects remembered past symptoms. The present research employed a nonretrospective case study approach to examine this relationship in subjects with Type II Diabetes Mellitus. Three subjects—a 16 year old female, a 24 year old female, and a 22 year old male—kept daily records of blood glucose, biological events commonly associated with glucose levels (i.e., insulin dosage, food intake, exercise and weight), and personal and interpersonal events occurring in their lives over a 4-week time period. Results showed instances of changes in blood glucose occurred in all 3 subjects that were uncorrelated with the biological factors but which were associated with stressful personal and/or interpersonal events.

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