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Grasshopper Populations Inhabiting the B-C Cribs and Redox Pond Sites, 200 Area Plateau, United States Energy Research and Development Administration's Hanford Reservation

February 1976

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Grasshopper Populations Inhabiting the B-C Cribs and Redox Pond Sites, 200 Area Plateau, United States Energy Research and Development Administration's Hanford Reservation

by
J. K. Sheldon
L. E. Rogers

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EXECUTIVE SUMMARY

The purpose of this study was to determine the taxonomic composition, abundance, and food habits of grasshopper populations inhabiting the 200 Area plateau. Two sites were selected for detailed study, one near the B-C Cribs control zone and the other near the former REDOX Pond.

A total of 14 grasshopper species were collected from the B-C Cribs study area and 16 species from the REDOX Pond area. Thirteen of these species occurred at both locations. Population density was low throughout most of the spring, increased in late May, and reached a peak of about 4 grasshoppers per square meter in early July.

A dietary analysis showed that 7 of the 28 species of vascular plants recorded from the area were major components in grasshopper diets. These included needle-and-thread grass (Stipa comata), turpentine cymopterus (Cymopterus terebinthinus), Carey's balsamroot (Balsamorhiza careyana), western tansymustard (Descurainia pinnata), Jim Hill mustard (Sisymbrium altissimum), big sagebrush (Artemisia tridentata) and green rabbitbrush (Chrysothamnus viscidiflorus).

The plant most heavily utilized was big sagebrush, followed by turpentine cymopterus, green rabbitbrush, and Carey's balsamroot. Other species were less frequently eaten. Several plants were present in the diet at a much higher frequency than they occurred in the environment, indicating that they were preferred food items. These included turpentine cymopterus, Carey's balsamroot, Jim Hill mustard, and green rabbitbrush. Some plants were apparently avoided by the grasshoppers since they were encountered at a much lower diet frequency (or were not eaten at all) than one would expect based on their natural abundance. Included in this group of plants were cheatgrass (Bromus tectorum), six-week fescue (Festuca octoflora), Sandberg's bluegrass (Poa sandbergii), western tansymustard (Descurainia pinnata), matted cryptantha (Cryptantha circumscissa), winged cryptantha (Cryptantha pterocarya), and microsteris (Microsteris gracilis).

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INTRODUCTION

To aid in the formulation of an ecologically sound, long-term waste management program at Hanford, a biological characterization of the 200 Area plateau was undertaken to provide information concerning species present, their relative abundance, and the position they occupy in the ecosystem. Grasshoppers are a major herbivore group of this region. Because of their high reproductive potential and use as a food resource by predators, they serve as an important link in energy and nutrient flow pathways through the ecosystem.

The objective of the present study was to evaluate the ecological role of grasshopper populations inhabiting the 200 Area plateau of the ERDA Hanford Reservation. Two representative study sites were selected, one near the B-C Cribs control zone and the other near the former REDOX Pond. Grasshopper collections and identifications were conducted; population density estimates made; and a dietary analysis of abundant species conducted.

STUDY AREA

This study was conducted in noncontaminated regions near the B-C Crib Controlled Zone (200 East Area) and REDOX Pond (200 West Area). See Figure 1.

B-C CRIBS

The B-C Cribs study site (Figure 2) is located on the 200 Area plateau approximately 400 m south of the main gate of the 200 East Area. Soils are primarily Rupert sands and Burbank loamy sands (Hajek 1966). Average elevation is approximately 223 m with surface contours seldom exceeding 15 m. A brief history of radionuclide depositions and subsequent management of the B-C Crib site is given by O'Farrell and Gilbert (1975).

The vegetation of the B-C Cribs area varies from a relatively undisturbed plant association consisting of the dominant big sagebrush/Sandberg's bluegrass to highly disturbed regions where big sagebrush has been largely replaced by two rabbitbrush species, Chrysothamnus nauseosus and C. viscidiflorus. The ground cover in such areas is dominated by cheatgrass (Bromus tectorum). Russian thistle, Salsola kali, is also present.

The grasshopper study at the B-C Crib site was conducted in a relatively undisturbed portion of the region. A vegetation analysis of this site was conducted by Cline et al. (1975). The plant taxa that were present are listed in Table 1. All plant citations follow Hitchcock and Cronquist (1973). Big sagebrush dominated the shrub stratum with a density of 3720 plants per ha, relative frequency of occurrence 8%, and cover 26%. The understory consisted of a mixture of grasses and forbs. Five species of grass were recorded. Cheatgrass, six-weeks fescue, and Sandberg's bluegrass were the most abundant. Most of the species were present at a low frequency; however, western tansymustard, matted cryptantha, winged cryptantha, and microsteris were abundant. Because of the variation in the topography, microhabitat differences were present. This resulted in a clumped distribution of some species; e.g., Carey's balsamroot and turpentine cymopterus, which were thus locally abundant, although recorded at a low environmental frequency.

REDOX POND

The REDOX Pond study site (Figure 3) lies outside and approximately 1 km south of the 200 West fenced exclusion area. It is 8.5 km west of the B-C Crib study area. The pond was created in September 1956 and utilized until June 1972 as a holding area for condensor coolant water bearing low-level radionuclides. In 1972 the water source was diverted, all major vegetation was removed, the bottom was allowed to dry and then covered with soil. Prior to deactivation, the pond occupied an area of approximately 12-1/2 ha and was about 1/2 m deep.

The work reported here was conducted approximately 100 m south of the original pond site in a relatively undisturbed area. The elevation is similar to that at the B-C Cribs; however, the topography is more uniform.

Vegetation analysis indicates a flora similar to that found at the B-C Cribs (compare Tables 1 and 2). The density of big sagebrush was lower (840/ha vs. 3720/ha at the B-C Cribs) and that of rabbitbrush

higher in the REDOX area. Two more grass species were present; however, cheatgrass and six-week fescue remained the most common species. The forb population was also similar except for an increase in the density of Jim Hill mustard and a pronounced reduction in the abundance of microsteris. Twenty-two herbaceous plant species were encountered compared to 23 species found in the B-C Cribs survey. The herbaceous plant cover was also similar, 38% for the REDOX Pond site vs. 37% for the B-C Crib site (Cline et al. 1975).

CLIMATE

Climatic conditions for the two areas are also similar. Most of the precipitation ($\bar{X}$ annual = 17.1 cm) falls during the months of October through May, the period which also corresponds with the majority of plant growth. From June through September there is little rain and significant dehydration occurs in most plants. Temperature extremes ranging from over 100°F in the summer to below 0°F in the winter are not uncommon (Stone et al.1972).

MATERIALS AND METHODS

Periodic general collecting was conducted in both the B-C Cribs and REDOX Pond areas from June 6 to August 13, 1974 to obtain representative specimens of all grasshopper species present. Collected specimens were pinned and sent to specialists for species confirmation.

Relative population densities were determined by sweep samples taken at approximately 2-week intervals at both sites from June 2 until October 15, 1974. Big sagebrush and green rabbitbrush were swept at the B-C Cribs site and big sagebrush alone at the former REDOX Pond site. Two replicates of 50 sweeps each were taken on each plant species.

Absolute density for ground-dwelling species was taken at the B-C Cribs area at approximately 2-week intervals from May 2 until October 8, 1974, using an ocular estimate method (Bhatnagar and Pfadt 1973). While walking through the area to be sampled, one fixes his sight on approximately a 1-ft^2 area of ground surface several feet in advance and records the number of grasshoppers present on the plot as it is approached. This process is repeated until 100 sample points are tallied. Density is recorded as the number of grasshoppers per ft^2 and then converted to grasshoppers/m^2.

A diet analysis was conducted only at the B-C Cribs site. Grasshoppers were collected at 2-week intervals between June 27 and August 8, 1974. Specimens were obtained by walking through the area with a standard aerial net and catching individuals as they jumped or flew. They were immediately preserved in 95% ETOH. Crops of preserved grasshoppers were

later removed in the laboratory, a microscope slide mount was prepared from the contents of each, and crop contents identified as described by Rogers and Uresk (1974). Plant tissue determinations were based on the structural characteristics of the epidermal cells. Comparison was made to a reference collection containing all plant taxa present in the study area. Twenty microscope fields were read per slide and posted to a keypunch form (Appendix A). Following keypunching the data cards were processed using a computer program designed to calculate relative frequency for each grasshopper species and food item. The computer program is documented in Appendix B.

RESULTS

B-C CRIB AREA

The grasshopper species collected at the B-C Crib site are listed in Table 3. With the exception of two species of Tettigoniidae, Apote notabilis and Steiroxys sp., all specimens collected were acridid grasshoppers. Two of the species were quite restricted in their distribution--Melanoplus cinereus was usually encountered on big sagebrush, and Hesperotettix viridis was collected almost exclusively on green rabbitbrush.

The density of the grasshopper population remained low throughout the spring and did not begin to increase significantly until the end of May at which time numerous early instar nymphs were present (Figures 4-6). Adults of many species began to appear in late June and a peak population density of 4.0 grasshoppers/m^2 was recorded in early July (Figure 4). Sweep samples of green rabbitbrush (Figure 5) and big sagebrush (Figure 6), both taken on June 21, indicate that the greatest population was present on the shrubs a few weeks earlier. At this time 165 grasshoppers were obtained from 100 sweeps of rabbitbrush and 59 from a sagebrush sample. Most of the grasshoppers encountered on green rabbitbrush were Hesperotettix viridis. Other less abundant species collected on this plant included Melanoplus yarrowii, Melanoplus cinereus, and Ageneotettix deorum. On July 18, for example, 17 Hesperotettix viridis were swept compared to 2 Melanoplus yarrowii and 3 Melanoplus cinereus. Grasshoppers swept from big sagebrush were almost entirely Melanoplus cinereus and Oedaleonotus enigma.

The combined results of the diet analysis of the 8 species from the B-C Cribs area are presented in Table 1. The raw data from the computer printout appears in Appendix C. A total of 576 crops were removed in the study and 15 species of plants were identified from crop contents. Eight of these were recorded at a frequency of less than 1%. Of the other seven, big sagebrush was the most abundant (41%), followed by green rabbitbrush and turpentine cymopterus (15%), Carey's balsamroot (13%), Jim Hill mustard (7%), western tansymustard (4%), and needle-and-thread grass (1%).

The relative frequency of plant specimens in grasshopper diets (all sample dates combined) is presented in Table 4. The only food item utilized by all species was cryptogams. Its relative frequency in the crop contents varied from 15% in Conozoa wallula to 81% in Ageneotettix deorum. In all cases the unknown category was encountered at a frequency of ≤ 3%.

Diet of *Apote notabilis* Scudder (Figures 7a,b)

Nine food plants were identified (Table 4). Shrub fragments from both big sagebrush (18%) and green rabbitbrush (15%) were present. Cryptogams were recorded at 15%, grass less than 1%, and forbs constituted the remainder. Of these, turpentine cymopterus was most abundant (34%). Other forbs present were Jim Hill mustard (13%), western tansymustard (3%), and Carey's balsamroot and matted cryptantha (≤ 1%).

Specimens for diet analysis were obtained on three dates (Table 5), July 11, July 25, and August 8. Little variation was found in the diet between the three dates. Jim Hill mustard decreased in frequency from 22% to 1% and green rabbitbrush increased; other changes were less pronounced.

Diet of *Trimerotropis caeruleipennis* Bruner (Figure 8)

Six food plants were identified (Table 4). Cryptogams constituted the most frequently encountered food item (41%). The only grass utilized was needle-and-thread grass (8%). Big sagebrush was encountered in 6% of the observed fields while the annual forbs tarweed fiddleneck (6%), Carey's balsamroot (25%), and western tansymustard (12%) comprised the remainder of the identifiable diet. A sufficient number of specimens of this species was obtained for analysis only on August 8, 1974 and is shown in Table 4.

Diet of *Conozoa wallula* (Scudder) (Figure 9)

This species primarily selected annual forbs. Carey's balsamroot was present at a frequency of 73% and western tansymustard at 3% (Table 4). Shrubs were encountered at a frequency of less than 3%. The only grass species found was needle-and-thread grass (4%). Cryptogam fragments occurred at a frequency of 16%.

Samples were obtained on July 25 and August 8 (Table 6). A total of four diet items were consumed on each date. Of these, only Carey's balsamroot and cryptogams were eaten on both dates.

Diet of *Melanoplus cinereus* Scudder (Figure 10)

Ten food items were identified (Table 4). Big sagebrush was found to be most abundant (61%). Cryptogams were also present (18%), green rabbitbrush and turpentine cymopterus, both at 6%, Jim Hill mustard (5%), common yarrow (2%), and common rabbitbrush, spiny hopsage, Carey's balsamroot, and western tansymustard, all with relative frequencies $\leq$ 1%.

Samples were obtained on the dates listed in Table 7. The June 27 sample revealed that 4 plant species were consumed with green rabbitbrush and cryptogams constituting the bulk of the diet. On subsequent dates more diversity was present in the diet. Eight species were identified from the July 11 sample, six from July 26, and nine from August 8. In each case, big sagebrush was the dominant species consumed, the relative frequency ranging from 58-68%, and cryptogams next (13-34%).

Diet of *Melanoplus yarrowii* (Thomas) (Figures 11-12)

Thirteen species were identified (Table 4). Cryptogam fragments were most abundant (27%). The shrubs identified were big sagebrush (12%), green rabbitbrush (6%) and common rabbitbrush (1%). One species of grass, Sandberg's bluegrass (2%) was also encountered. The remainder of the diet consisted of herbaceous plants including Carey's balsamroot (22%), turpentine cymopterus (15%), western tansymustard (7%), Jim Hill mustard (3%), and tarweed fiddleneck, common yarrow, matted cryptantha, and Russian thistle all with frequencies of 1% or less.

Sample dates and food items consumed are presented in Table 8. The number of species consumed was quite constant between the samples, ranging from nine on August 11 to a high of twelve on July 26. On no date was the relative frequency for any food item higher than 37%.

Diet of *Oedaleonotus enigma* (Scudder) (Figure 13)

Eleven species of plants were recorded. Table 4 shows that the two most common plants consumed were big sagebrush (47%) and cryptogams (36%). The frequency of the other nine species did not exceed 4%. These included the three shrubs, green rabbitbrush, spiny hopsage, and common rabbitbrush; and the six forbs, tarweed fiddleneck, Carey's balsamroot, western tansymustard, Jim Hill mustard, turpentine cymopterus, and matted cryptantha.

Samples were obtained on four consecutive dates from June 27 to August 8 (Table 9). Diversity in consumption varied from a high of 11 species on June 27 to 5 species on both July 25 and August 8. On each date, relative frequency of big sagebrush was greatest, ranging from 43% to 54%, with cryptogams consistently comprising the second highest food item (10% to 41%).

Diet of *Ageneotettix deorum* (Scudder) (Figure 14)

Nine species of plants were found (Table 4). Of these, only cryptogams were frequently encountered. All other plants were present at a frequency of ≤ 4%. These include three species of shrubs, big sagebrush, green rabbitbrush, and common rabbitbrush; two species of grass, needle-and-thread grass, and cheatgrass; and three forbs, western tansymustard, turpentine cymopterus, and Russian thistle.

Specimens were obtained in sufficient number for analysis only on July 26 and August 8 (Table 10). An obvious difference in diet diversity is present for the two dates. Nine specimens were identified in the crop contents on July 26 but only three in the sample 2 weeks later. In both cases cryptogams were the only item exceeding a frequency of 6%. It was present in the July 26 sample at a frequency of 76% and in the August 8 sample at 91%.

Diet of *Hesperotettix viridis* (Thomas) (Figure 15)

Only three species of plants were recorded from this stenophagous species (Table 4). It was collected almost exclusively on green rabbitbrush and this plant was also the most abundant species in the diet (76%). Cryptogam fragments were also fairly common (21%). Russian thistle was the only other plant found (< 1%).

Sample dates for Hesperotettix viridis were June 27, July 11, and July 25 (Table 11). Variability in the relative frequency of green rabbitbrush ranged from 22% on June 27 to 87% on July 25. As the frequency of rabbitbrush consumption increased, the frequency of cryptogams consumed decreased, dropping from 78% on June 27 to 12% on July 25. By August 8 the population density had decreased to the point that the procurement of an adequate sample for diet analysis was not possible.

REDOX POND AREA

Grasshoppers collected at the REDOX Pond site are listed in Table 3. Species present here but not found at the B-C Crib site include Arphia pseudonietana, Paropomala pallida, and Amphitornus coloradus. Trimerotropis bilobata was collected at the B-C Cribs but not at REDOX Pond.

The population density based on sweep samples of sagebrush is shown in Figure 16. The peak juvenile population (23/100 sweeps) appeared near the middle of June and adults were present in the July 5 sample. Grasshopper abundance decreased throughout the remainder of the season with the last specimen taken in the October 15 sample. As was the case in the big sagebrush sweep samples from the B-C Cribs, most individuals belonged to two species - Melanoplus cinereus and Oedaleonotus enigma.

DISCUSSION

Distribution and Abundance of Grasshopper Species

The similarity of species composition of the grasshopper population at the B-C Crib and REDOX Pond sites is not surprising since only minor differences were encountered in the vegetation analysis and both the elevation and climatic conditions of the two areas are similar. The presence of Paropomala pallida at the REDOX Pond apparently is due to an abundance of needle-and-thread grass which is present but at a much lower density at the B-C Cribs site. Paropomala was collected almost exclusively on this grass. The reasons for the restricted distribution of the other four grasshopper species which were encountered at only one of the two sites is not clear. Perhaps they were present in low numbers and not sampled.

Two different sampling procedures, an ocular estimate and sweep sample, were necessary to adequately study grasshopper density because of microhabitat preferences. Certain grasshoppers were encountered primarily on vegetation, while others are exclusively soil surface dwellers and are rarely encountered on vegetation. Hesperotettix viridis falls into the former category, and to a lesser extent Melanoplus cinereus and Oedaleonotus enigma. The Trimerotropis spp., Xanthippus lateritus, Conozoa wallula, and Arphia pseudonietana are found predominately on exposed bare areas.

Sweep samples of green rabbitbrush and big sagebrush provided qualitative information on population densities of shrub inhabiting species. Large numbers of nymphs were collected, but as the population ecdysed to the adult stage the number collected decreased rapidly. This may in part have been due to an increase in mortality. Flying adults are exposed to a new guild of aerial predators including a large robber fly population. Of the species commonly encountered on shrubs, Melanoplus cinereus is probably affected most by aerial predators since it readily takes flight. Hesperotettix viridis is reluctant to fly and Oedaleonotus enigma is brachypterus and thus incapable of flight, although it is an excellent jumper. In addition to aerial predators, parasites and parasitoids may take a high toll in the late juvenile stages. Adults may also be more evasive than nymphs, thus reducing their capture rate.

Diet Analysis

A pronounced dietary selectivity was encountered in all grasshopper species. Of the 28 vascular plants from the B-C Cribs area (Table 1), 15 were encountered in the diet analysis. The food niche breadth of individual species ranged from a maximum of 13 species of plants consumed by Melanoplus yarrowii to a minimum of three species by the stenophagous Hesperotettix viridis. Three of the 13 plant species not consumed were

major components of the flora indicating a relative avoidance by grasshoppers. These include the annual grass six-weeks fescue, microsteris, and winged cryptantha. Three other plants with high habitat frequency, cheatgrass, Sandberg's bluegrass and matted cryptantha, were eaten but only at low levels, indicating that they, too, were being avoided. Four herbaceous species had habitat frequencies of $\leq$ 1% but were heavily utilized. These included needle-and-thread grass, turpentine cymopterus, Carey's balsamroot, and Jim Hill mustard. The two rabbitbrush species were also consumed at disproportionately high levels for their low environmental frequency. Russian thistle (Salsola kali) was not found in the diets of any grasshopper species. This plant species occurred infrequently in the study area (<1%). It is possible that grasshoppers may consume some Russian thistle in areas where it is more abundant.

A large amount of overlap was present in the partitioning of available food resources. Only seven of the 15 species of vascular plants were eaten at a high frequency. Grasses, with the exception of needle-and-thread grass, were not found to constitute a major portion of the diet. Needle-and-thread grass, however, was consumed by Trimerotropis caeruleipennis and Conozoa wallula at a higher level than its habitat frequency. It was also present in the diet of Apote notabilis and Ageneotettix deorum. These results are very similar to those reported by Ueckert and Hanson (1971), for a different group of grasshopper species where needle-and-thread grass was found to support a high level of herbivory while cheatgrass was virtually untouched. The small amount of grass consumed by Ageneotettix deorum indicates a somewhat atypical food base for this normally gramnivorous species (Banfill and Brusven 1973; Mulkern et al. 1969, Ueckert et al. 1972). It also contained the highest cryptogam frequency which correlates well with observations reporting a significant level of detritus feeding (Mulkern et al. 1969, Lavigne and Pfadt 1964, Banfill and Brusven 1973).

Two species of perennial forbs were widely utilized although in both cases their habitat frequency was less than 1%. Turpentine cymopterus was found in the diets of 5 of the 8 species while Carey's balsamroot was utilized by all but two species. Two annual forbs appear to be important. Western tansymustard was consumed by 6 of the 8 grasshoppers, although the diet frequency was far below its habitat frequency, and Jim Hill mustard was utilized by four grasshopper species.

Two shrubs were found to be important food sources. Both big sagebrush and green rabbitbrush were consumed by 7 of the 8 species. Both also served as a major food source for one grasshopper species. Melanoplus cinereus was frequently collected on the foliage of big sagebrush and had a diet frequency of 61% for that species. Hesperotettix viridis, on the other hand, was found almost exclusively on green rabbitbrush which had a diet frequency of 76%. Its only other major food source was lichen. Other studies have shown that Hesperotettix viridis is selective in its feeding behavior. At North Platte, Nebraska, it was reported to feed primarily on Gutierrezia sarothrae and Aster oblongifolius (Mulkern et al. 1969). Brooks (1958) reported that in the Canadian prairie province Gutierrezia sp. was the major food source, but consumption of Solidago sp.,

Helianthus sp., Grindelia sp., and Aster sp. also occurred. In a Montana study (Anderson and Wright 1952), Hesperotettix viridis was closely associated with Gutierrezia sp., but also ingested Solidago rigida, Chrysothamnus nauseousus, and Grindelia squarrosa.

Scavenging was observed for only one species, the tettigoniid Apote notabilis. This species, which is largely nocturnal in contrast to the diurnal grasshoppers, was often observed feeding on dead insects (including members of its own species) as well as on other detritus. This habit was particularly noticeable on roads where the kill rate was high.

The combined results for all grasshopper species (Table 1) shows that the diet frequency of 41% for big sagebrush is more than twice that of any other vascular plant. These results contradict a recent statement by Daubenmire (1975) that the foliage of Artemisia is not eaten by grasshoppers. He does not, however, name the grasshopper species in his study or provide information on his diet assay technique. He does state that grasshoppers congregate in big sagebrush at night, roosting in the canopy. We confirm this and also found that during the heat of the day many species of grasshoppers sit on big sagebrush thereby avoiding high temperatures associated with exposed soil surface areas.

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TABLE 1. Plant Taxa; Common Names, Relative Habitat, Frequency of Occurrence (% FO); Canopy Cover (% C) on 400, 20 x 50 cm Plots (Data from Cline et al. 1975 and Uresk et al. 1975); and Frequency of Diet Composition (% FC) (All Grasshopper Species Combined) in the B-C Crib Site, 200 Area Plateau, Hanford Reservation, 1974

Taxa	Common Name	% FO	% C	% FC
Annual Grasses				
Bromus tectorum L.	Cheatgrass	20	15	<1
Festuca octoflora Walt.	Six-Weeks Fescue	16	4	--
Perennial Grasses				
Poa sandbergii Vasey	Sandberg's Bluegrass	5	2	<1
Stipa comata Trin. & Rupr.	Needle-and-Thread Grass	<1	<1	<1
Agropyron spicatum (Pursh) Scribn. & Smith	Bluebunch Wheatgrass	<1	<1	--
Perennial Forbs				
Oenothera pallida Lindl.	White-stemmed Evening Primrose	<1	<1	--
Cymopterus terebinthinus (Hook.) T&G	Turpentine cymopterus	<1	<1	15
Erigeron filifolius Nutt.	Thread-leaved Fleabane	<1	<1	--
Calochortus macrocarpus Dougl.	Green-banded Star Tulip	<1	<1	--
Mentzelia albicaulis Dougl.	White-stemmed Mentzelia	<1	<1	--
Phlox longifolia Nutt.	Long-leaved Phlox	<1	<1	--
Brodiaea douglassii Wats.	Brodiaea	<1	<1	--
Commandra umbellata (L.) Nutt. (var. pallida)	Bastard-toad-flax	<1	<1	--
Balsamorhiza careyana Gray	Carey's Balsamroot	<1	<1	13
**Achillea millefolium* L.	Common yarrow	--	--	<1

TABLE 1 (Continued)

Taxa	Common Name	% FO	% C	% FC
Annual Forbs				
Descurainia pinnata (Walt.) Britt.	Western Tansymustard	18	8	5
Cryptantha circumscissa (H&A) Johnst.	Matted Cryptantha	10	2	<1
Sisymbrium altissimum L.	Jim Hill Mustard	<1	<1	7
Salsola kali L.	Russian Thistle	<1	<1	<1
Cryptantha pterocarya (Torr.) Greene	Winged Cryptantha	3	<1	--
Microsteris gracilis (Hook.) Greene	Microsteris	14	3	--
Phacelia linearis (Pursh) Holz.	Narrow-leaved Phacelia	<1	<1	--
Amsinckia lycopsoides Lehm.	Tarweed Fiddleneck	<1	<1	1
Erodium circutarium (L.) L'Her.	Filaree	<1	<1	--
Shrubs				
Artemisia tridentata Nutt.	Big Sagebrush	8	26	41
Chrysothamnus viscidiflorus (Hook.) Nutt	Green Rabbitbrush	<1	<1	16
Chrysothamnus nauseousus (Pall.) Britt.	Common Rabbitbrush	<1	<1	<1
**Atriplex spinosa* (Hook.) Collotzi	Spiny Hopsage	--	--	<1
TOTAL TAXA		28	--	15

**Plant species identified in diet study but not found in vegetation analysis.

TABLE 2. Plant Taxa, Relative Frequency of Occurrence (% FO), (Herbaceous Species), Density per ha (Shrubs), and Canopy Cover (% C) on 400, 20 x 50 cm Plots in the REDOX Pond Area Plateau, Hanford Reservation, 1974

Taxa	Common Name	% FO	% C
Annual Grasses			
Bromus tectorum L.	Cheatgrass	28	22
Festuca octoflora Walt.	Six-Weeks Fescue	17	2
Perennial Grasses			
Poa sandbergii Vasey	Sandberg's Bluegrass	<1	<1
Stipa comata Trin & Rupr.	Needle-and-Thread Grass	3	2
Sitanion hystrix (Nutt.) Smith	Bottlebrush Squirreltail	<1	<1
Agropyron dasystachyum (Hook) Scribn.	Downy Wheatgrass	<1	<1
Poa scabrella (Thurb.) Benth.	Pine Bluegrass	<1	<1
Perennial Forbs			
Oenothera pallida Lindl.	White-stemmed Evening Primrose	<1	<1
Aster sp.	Aster	3	<1
Cymopterus terebinthinus (Hook). T&G	Turpentine Cymopterus	2	2
Erigeron filifolius Nutt.	Thread-leaved Fleabane	3	<1
Calochortus macrocarpus Dougl.	Green-banded Star-tulip	<1	<1
Mentzelia albicaulis Dougl.	White-stemmed Mentzelia	<1	<1
Lupinus sp.	Lupine	<1	<1
Phlox longifolia Nutt.	Long-leaved Phlox	<1	<1
Astragalus sp.	Locoweed	<1	<1

TABLE 2. (Continued)

Taxa	Common Name	% FO	% C
Annual Forbs			
Descurainia pinnata (Walt.) Britt.	Western Tansymustard	15	3
Cryptantha circumscissa (H&A) Johnst.	Matted cryptantha	16	3
Sisymbrium altissimum L.	Jim Hill Mustard	6	1
Salsola kali L.	Russian Thistle	2	<1
Cryptantha pterocarya (Torr.) Greene	Winged Cryptantha	3	<1
Microsteris gracilis (Hook.) Greene	Microsteris	<1	<1
Shrubs		Density/ha	% C
Artemisia tridentata Nutt.	Big Sagebrush	840	18
Chrysothamnus sp.	Rabbitbrush	260	2
TOTAL TAXA		22	

TABLE 3. Grasshopper Species Collected at B-C Crib and REDOX Pond Areas

B-C Crib	REDOX Pond
Species:	
Ageneotettix deorum (Scudder)	Ageneotettix deorum (Scudder)
----------	*Amphitornus coloradus (Thomas)
Apote notabilis Scudder	Apote notabilis Scudder
----------	Arphia pseudonietana (Thomas)
Aulocara elliotti Thomas	Aulocara elliotti (Thomas)
Conozoa wallula (Scudder)	Conozoa wallula (Scudder)
Hesperotettix viridis (Thomas)	Hesperotettix viridis (Thomas)
Melanoplus cinereus Scudder	Melanoplus cinereus Scudder
Melanoplus sanguinipes (F.)	Melanoplus sanguinipes (F.)
Melanoplus yarrowii (Thomas)	Melanoplus yarrowii (Thomas)
Oedaleonotus enigma (Scudder)	Oedaleonotus enigma (Scudder)
----------	Paropomala pallida Bruner
Steiroxys sp.	Steiroxys sp.
Trimerotropis bilobata Rehn and Bebard	----------
Trimerotropis caeruleipennis Brunner	Trimerotropis caeruleipennis Brunner
Trimerotropis pallidipennis (Burmeister)	Trimerotropis pallidipennis (Burm.)
Xanthippus lateritus Saussure	Xanthippus lateritus Saussure
TOTAL: 14	TOTAL: 16

*Collected during the summer of 1975.

TABLE 4. Relative Frequency of Plant Species in Grasshopper Diets

Plant Species	Grasshopper Species							
	APNO	TRCA	COWA	MECI	MEYA	OEEN	AGDE	HEVI
Annual Grasses								
Bromus tectorum							3	
Perennial Grasses								
Poa sandbergii					2			
Stipa comata	<1	8	4				3	
Perennial Forbs								
Cymopterus terebinthinus	34			6	15	2	<1	
Balsamorhiza careyana	<1	25	73	<1	22	3		
Achillea millefolium				2	<1			
Annual Forbs								
Descurainia pinnata	3	12	3	1	7	4	<1	
Cryptantha circumscissa	<1				<1	<1		
Sisymbrium altissimum	13			5	3	2		
Salsola kali					<1		<1	<1
Amsinckia lycopsoides		6			<1	<1		
Shrubs								
Artemisia tridentata	18	6	<1	61	12	47	4	
Chrysothamnus viscidiflorus	15		3	6	6	2	1	76
Chrysothamnus nauseousus				<1	<1	<1	3	
Atriplex spinosa				<1		<1		
Other								
Cryptogams	15	42	16	18	27	36	81	21
Unknown	2	<1		<1	<1	<1	3	<1
Number of crops examined	61	17	38	124	137	111	36	52
Number of food types utilized (excluding unknown category)	9	6	6	10	13	11	9	3

Orthoptera species are: APNO = *Apote notabilis* Scudder; TRCA = *Trimerotropis caeruleipennis* Brunner; COWA = *Conozoa wallula* (Scudder); MECI = *Melanoplus cinereus* Scudder; MEYA = *Melanoplus yarrowii* (Thomas); OEEN = *Oedaleonotus enigma* (Scudder); AGDE = *Ageneotettix deorum* (Scudder); HEVI = *Hesperotettix viridis* (Thomas).

TABLE 5. Frequency (%) of Plant Species in Diet of *Apote notabilis* by Date of Capture

Plant Species	Date		
	July 11	July 25	August 8
Stipa comata		<1	
Cymopterus terebinthinus	33	38	23
Balsamorhiza careyana			4
Descurainia pinnata	4	<1	6
Cryptantha circumscissa	<1		
Sisymbrium altissimum	22	10	<1
Artemisia tridentata	21	10	32
Chrysothamnus viscidiflorus	3	25	13
Cryptogams	14	14	20
Unknown	2	2	<1
Number of slides examined:	22	28	11

TABLE 6. Frequency (%) of Plant Species in Diet of *Conozoa wallula* by Date of Capture

Plant Species	Date	
	July 25	August 8
Stipa comata		7
Balsamorhiza careyana	78	70
Descurainia pinnata		5
Artemisia tridentata	1	
Chrysothamnus viscidiflorus	8	
Cryptogams	13	17
Number of slides examined:	17	21

TABLE 7. Frequency (%) of Plant Species in Diets of *Melanoplus cinereus* by Date of Capture

Plant Species	Date			
	June 27	July 11	July 26	August 8
Cymopterus terebinthinus	4	1	9	5
Balsamorhiza careyana				2
Achillea millefolium		2	3	3
Descurainia pinnata		2		<1
Sisymbrium altissimum		9	2	7
Artemisia tridentata	11	66	58	68
Chrysothamnus viscidiflorus	52		7	
Chrysothamnus nauseosus		<1		
Atriplex spinosa				<1
Cryptogams	34	17	20	13
Unknown		<1		<1
Number of slides examined:	7	41	46	30

TABLE 8. Frequency (%) of Plant Species in Diet of *Melanoplus yarrowii* by Date of Capture

Plant Species	Date			
	June 27	July 11	July 26	August 11
Poa sandbergii	2	9	2	
Cymopterus terebinthinus	9	5	32	7
Balsamorhiza careyana	18	37	12	30
Achillea millefolium			<1	<1
Descurainia pinnata	7	5	3	11
Cryptantha circumscissa			2	
Sisymbrium altissimum	9	<1	<1	2
Salsola kali	3	2		
Amsinckia lycopsoides	<1		<1	
Artemisia tridentata	5	6	23	9
Chrysothamnus viscidiflorus	12		2	7
Chrysothamnus nauseosus		5	2	
Cryptogams	33	29	18	32
Unknown	1	2		2
Number of slides examined:	34	20	45	38

TABLE 9. Frequency (%) of Plant Species in Diet of *Oedaleonotus enigma* by Date of Capture

Plant Species	Date			
	June 27	July 11	July 25	August 8
Cymopterus terebinthinus	1			5
Balsamorhiza careyana	3	10	3	
Descurainia pinnata	6		3	
Cryptantha circumscissa	1	8		
Sisymbrium altissimum	4			2
Amsinckia lycopsoides	1			
Artemisia tridentata	43	54	53	49
Chrysothamnus viscidiflorus		10	3	2
Chrysothamnus nauseosus	<1	10		
Atriplex spinosa	1			
Cryptogams	37	10	37	41
Unknown	<1			
Number of slides examined:	52	10	25	24

TABLE 10. Frequency (%) of Plant Species in Diets of *Ageneotettix deorum* by Date of Capture

Plant Species	Date	
	July 26	August 8
Bromus tectorum	2	6
Stipa comata	4	
Cymopterus terebinthinus	1	
Descurainia pinnata	1	
Salsola kali		2
Artemisia tridentata	6	
Chrysothamnus viscidiflorus	2	
Chrysothamnus nauseosus	4	
Cryptogams	76	91
Unknown	4	
Number of slides examined:	25	11

TABLE 11. Frequency (%) of Plant Species in Diets of *Hesperotettix viridis* by Date of Capture

Plant Species	Date		
	June 27	July 11	July 25
Salsola kali		2	
Chrysothamnus viscidiflorus	22	77	87
Cryptogams	78	19	12
Unknown		2	1
Number of slides examined:	5	30	17

FIGURE 1. Location of Study Areas on 200 Area Plateau

FIGURE 2. B-C Crib Study Site

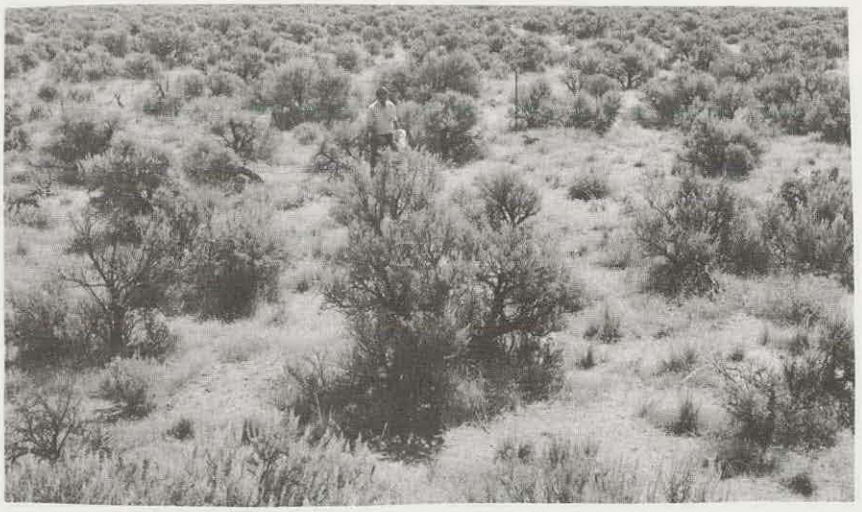


FIGURE 3. REDOX Pond Study Site. Note the Lower Density of Big Sagebrush at REDOX Compared to B-C Crib.

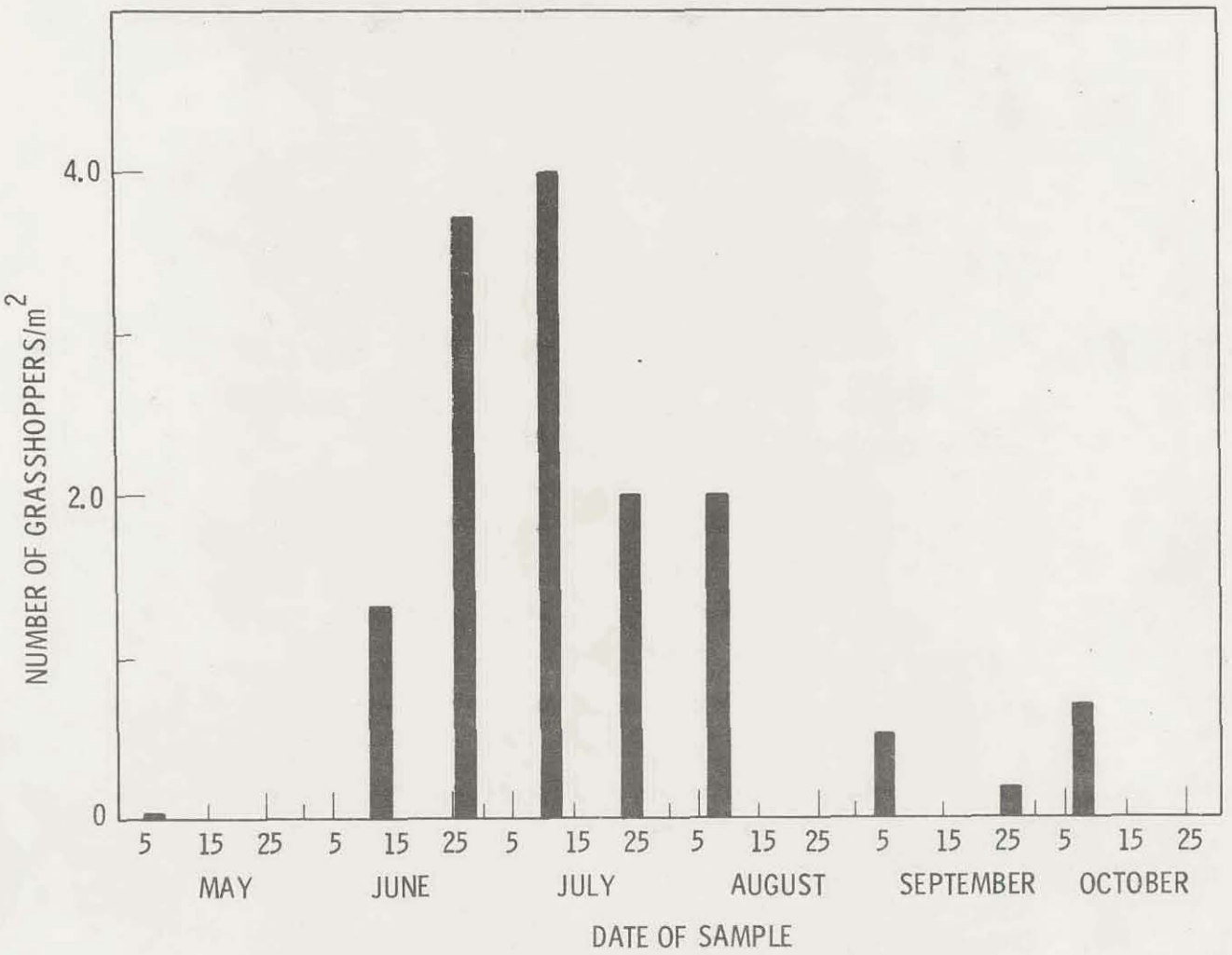


FIGURE 4. Grasshopper Density per m^2 Based on Ocular Estimate

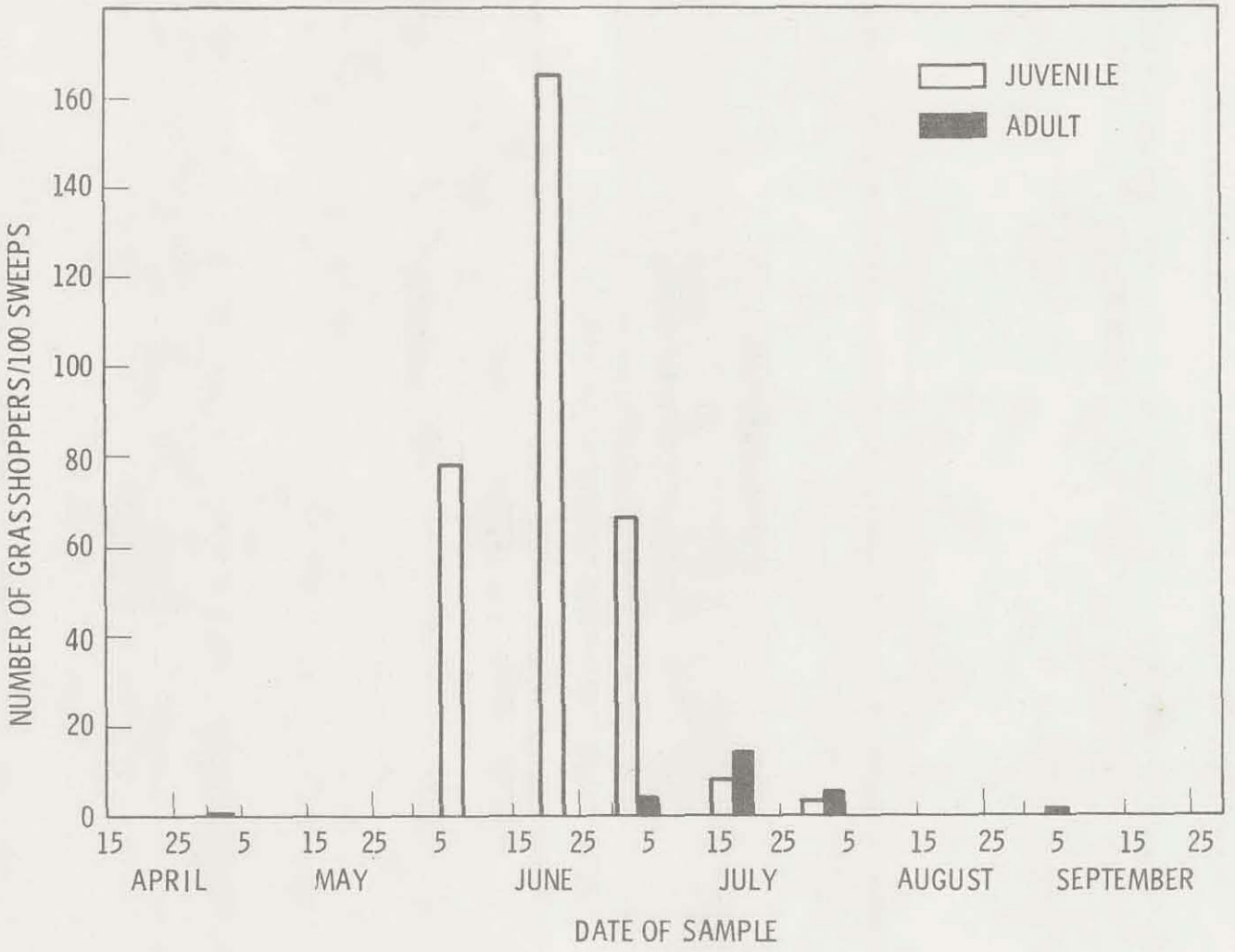


FIGURE 5. Sweep Sample of Green Rabbitbrush, Chrysothamnus viscidiflorus, at B-C Crib Site

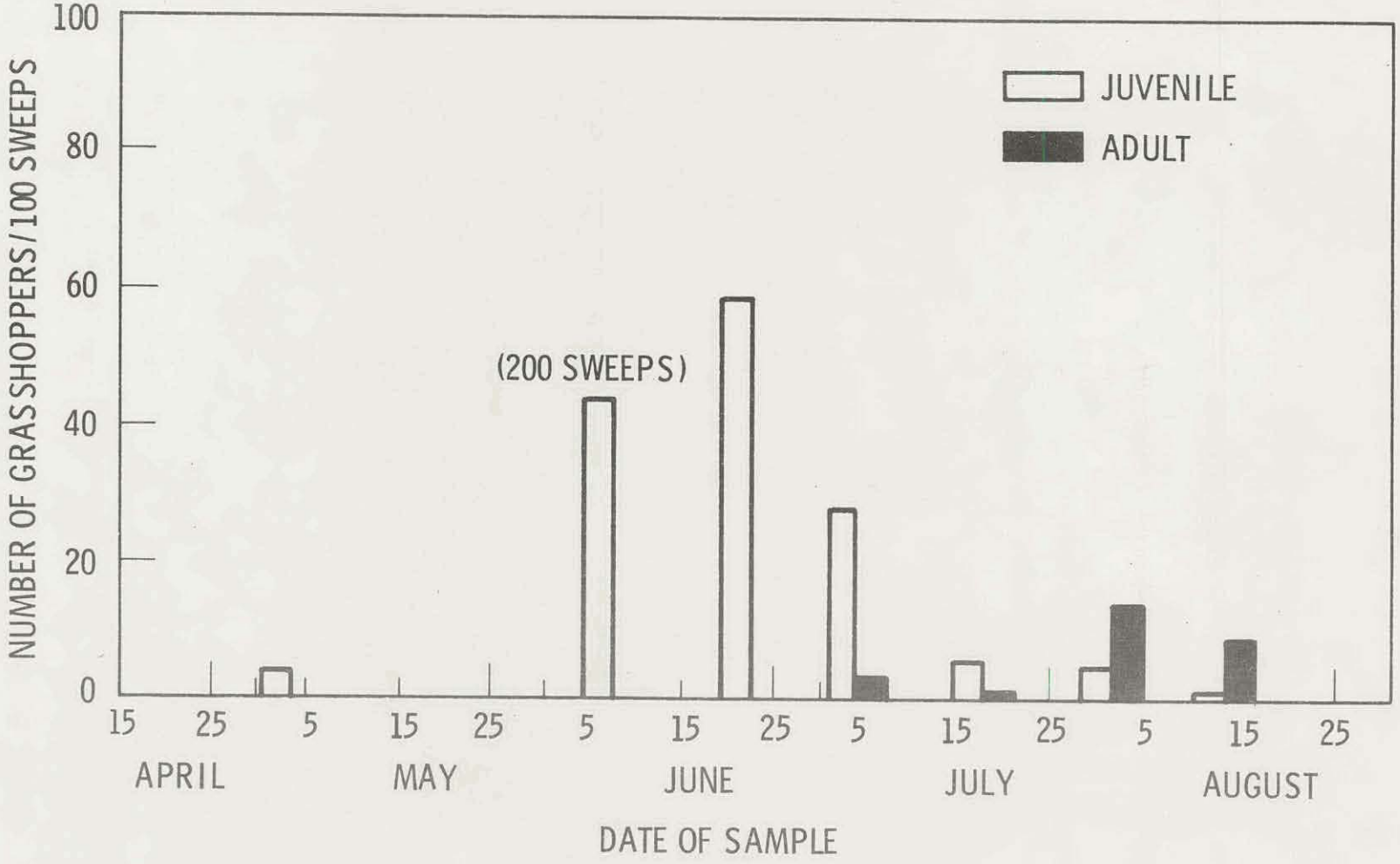


FIGURE 6. Sweep Sample of Big Sagebrush, Artemisia tridentata, at B-C Crib Site

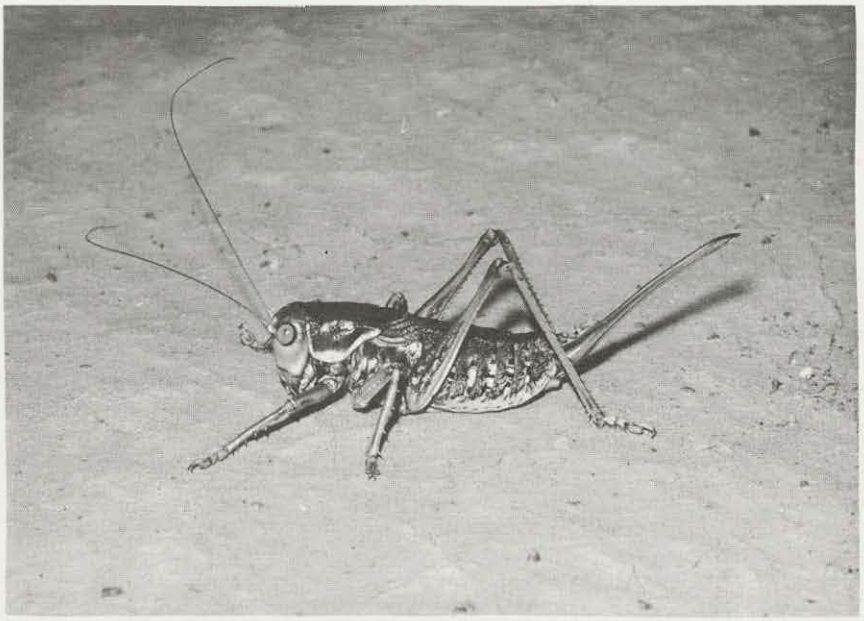


FIGURE 7a. Apote notabilis, Side View

FIGURE 7b. A. notabilis, Front View

FIGURE 8. Trimerotropis caeruleipennis

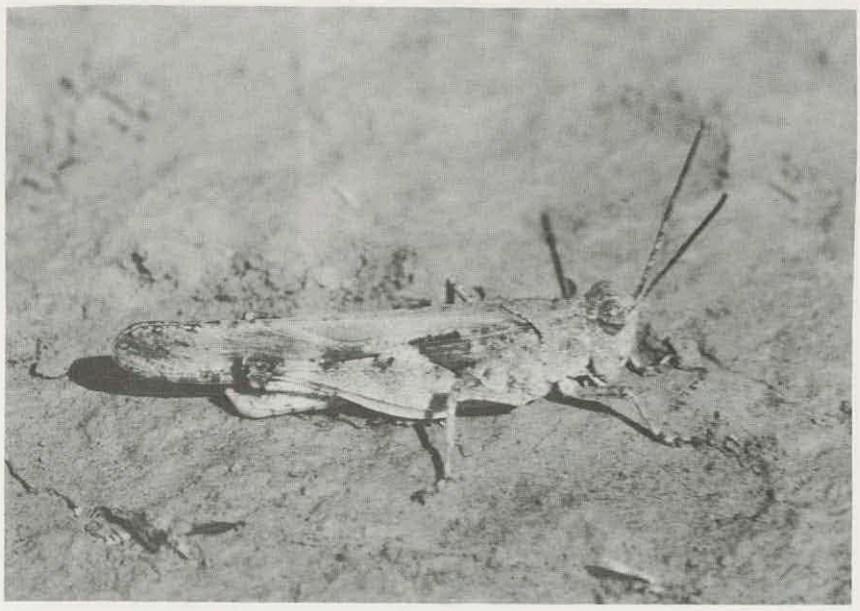


FIGURE 9. Conozoa wallula

FIGURE 10. Melanoplus cinereus

FIGURE 11. Melanoplus yarrowii, Light Form

FIGURE 12. Melanoplus yarrowii, Dark Form

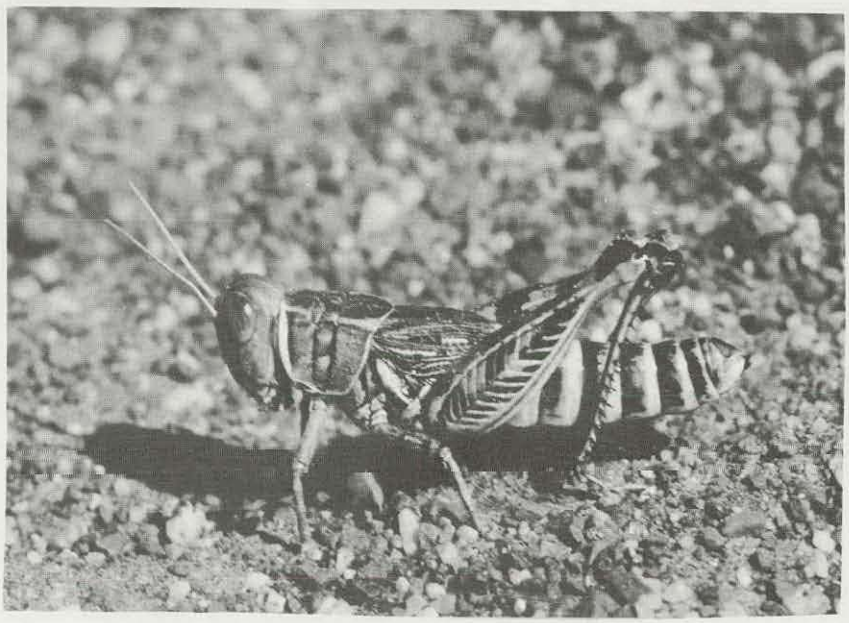


FIGURE 13. Oedaleonotus enigma

FIGURE 14. Ageneotettix deorum

FIGURE 15. Hesperotettix viridis

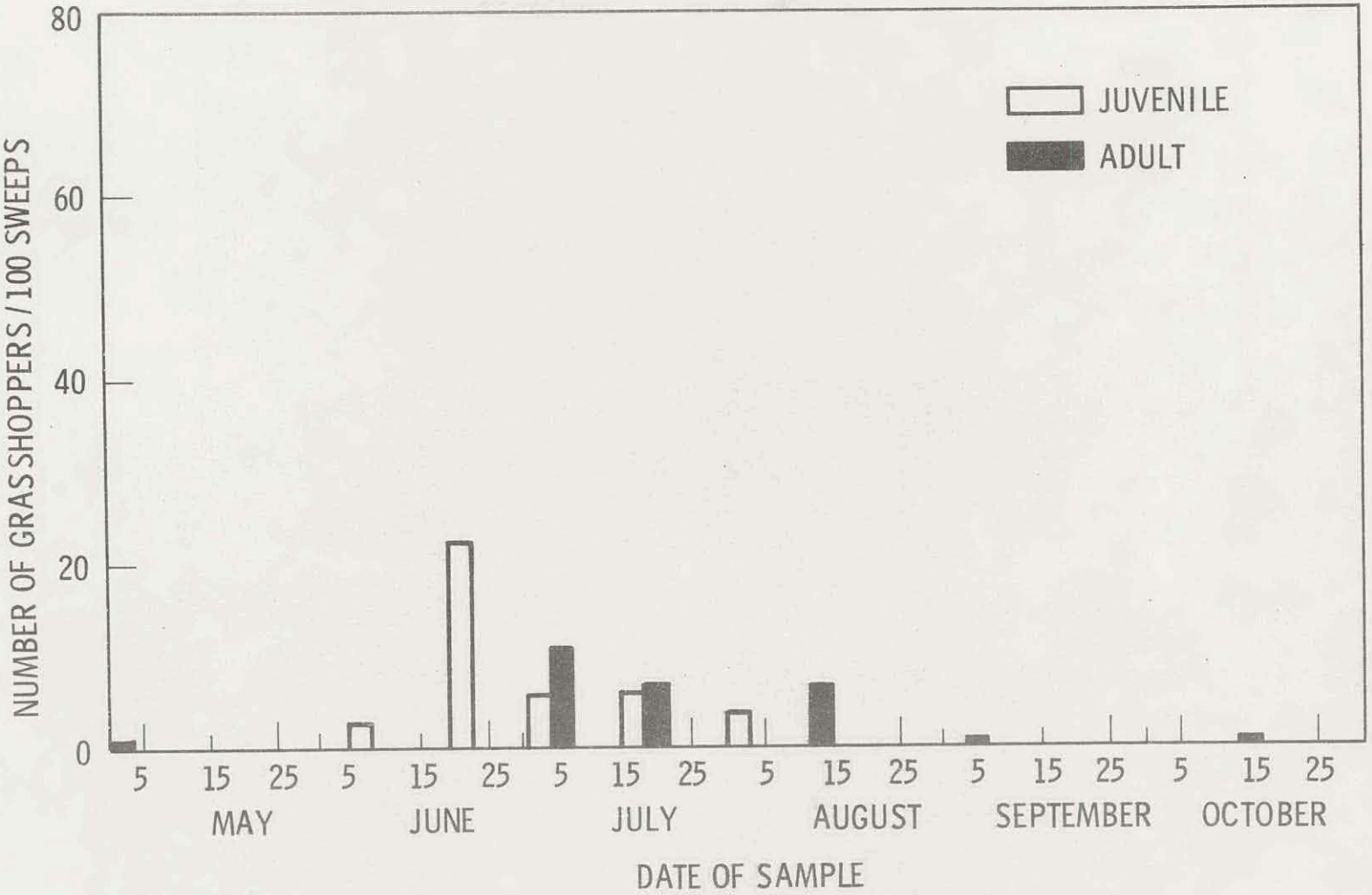
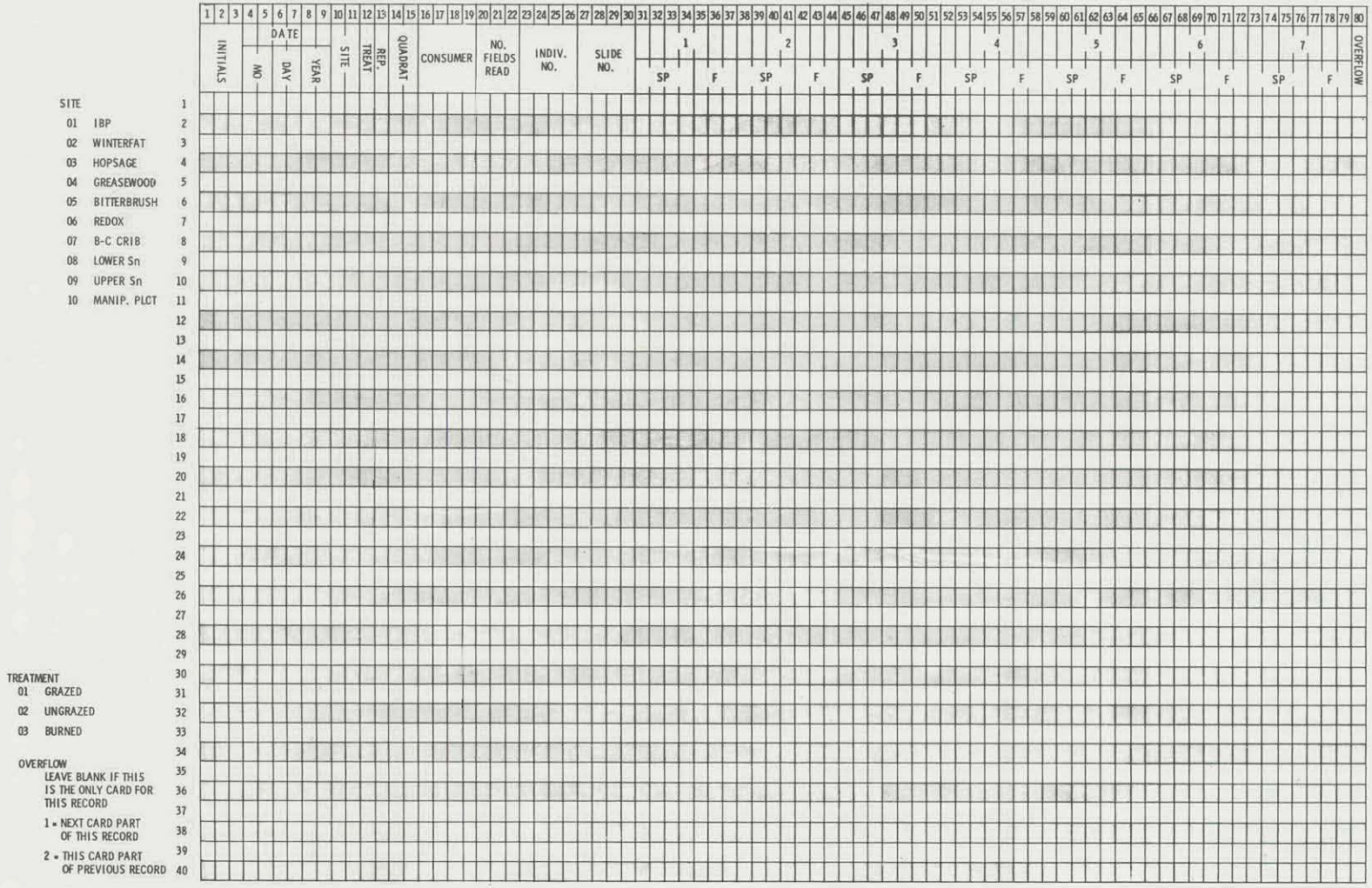


FIGURE 16. Sweep Sample of Big Sagebrush, Artemisia tridentata, at REDOX Pond Site

APPENDIX A

Key Punch Form for Data Analysis

APPENDIX A. Key Punch Form for Data Analysis



SITE

01	IBP	1
02	WINTERFAT	2
03	HOPSAGE	3
04	GREASEWOOD	4
05	BITTERBRUSH	5
06	REDOX	6
07	B-C CRIB	7
08	LOWER Sn	8
09	UPPER Sn	9
10	MANIP. PLOT	10

TREATMENT

01	GRAZED	30
02	UNGRAZED	31
03	BURNED	32

OVERFLOW

LEAVE BLANK IF THIS IS THE ONLY CARD FOR THIS RECORD — 33

1 = NEXT CARD PART OF THIS RECORD — 34

2 = THIS CARD PART OF PREVIOUS RECORD — 35

APPENDIX B

Computer Program to Calculate Frequency Percentages

for Each Grasshopper Species and Food Item

APPENDIX B. Computer Program to Calculate Frequency Percentages for Each Grasshopper Species and Food Item

```
DDIET,T10,CM50000,IO100.                    R SAUER 26828      331/300 AREA
ACCOUNT(UN=BCC363,PW=BCC363)
FTN(R=2,OPT=0)
MAP(OFF)
LGO.
REWIND(INPUT)
COPYSBF(INPUT,OUTPUT)
      PROGRAM DIET(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      DIMENSION FREQ(30),DENS(30),NAME(30),ISPS(7),IDATA(7),DATA(7)
C,,, PLACE A BLANK CARD AT THE END OF EACH GROUP (CONSUMER SPECIES,
C,,, DATE OR WHATEVER) TO BE ANALYZED.
C,,, INITIALIZE COUNTERS AND VARIABLES
85    TOTFQ=TOTDENS=0.
      NSLIDS=NNAME=0
      TFLDS=0.
      DO 10 J=1,30
      FREQ(J)=0.
      DENS(J)=1000000000.
C,,, DENS IS INITIALIZED TO A VALUE THAT WILL BLOW THE OUTPUT FORMAT TO
C,,, INDICATE WHEN FREQUENCY WAS 100 PERCENT AND DENSITY WAS INDETERMINATE.
      NAME(J)=10H
10    CONTINUE
30    READ(5,100)MDATE,MCONS,IFLDS,(ISPS(J),IDATA(J),J=1,7)
100   FORMAT(3X,A6,6X,A4,I3,8X,7(A4,I3))
      IF(EOF(5).NE.0) GO TO 90
      IF(MCONS.EQ.4H     ) GO TO 35
      NCONS=MCONS
      NDATE=MDATE
      DO 15 K=1,7
15    DATA(K)=IDATA(K)
      TFLDS=TFLDS+IFLDS
C,,, COUNT SLIDES
      NSLIDS=NSLIDS+1
C,,, NNAME IS THE NUMBER OF OBSERVED FOOD SPECIES, WHICH ARE STORED IN NAME
C,,, LOG IN THE FOOD SPECIES NAMES IF NECESSARY, AND ACCUMULATE OBSERVATIONS,
      DO 20 J=1,7
      IF(ISPS(J).EQ.4H     ) GO TO 25
      DO 40 JK=1,NNAME
      KEEP=JK
      IF(ISPS(J).EQ.NAME(JK)) GO TO 50
40    CONTINUE
      NNAME=NNAME+1
      NAME(NNAME)=ISPS(J)
      FREQ(NNAME)=DATA(J)
      GO TO 20
50    FREQ(KEEP)=FREQ(KEEP)+DATA(J)
20    CONTINUE
25    CONTINUE
      GO TO 30
C,,, SUMMARIZE THE DATA FOR THE CONSUMER SPECIES
35    CONTINUE
      DO 70 J=1,NNAME
      FREQ(J)=FREQ(J)/TFLDS*100.
      IF(FREQ(J).GE.100.) GO TO 70
      DENS(J)=ALOG(-1./(FREQ(J)/100.-1.))
      TOTFQ=TOTFQ+FREQ(J)
      TOTDENS=TOTDENS+DENS(J)
70    CONTINUE
      WRITE(6,220)NCONS,NDATE,TFLDS,NSLIDS,NNAME
220   FORMAT(1H1,* DIET ANALYSIS FOR CONSUMER *,A4,*  ON DATE *,A6,1X,
     1*WITH*,F8.0,* OBSERVED FIELDS,*,I4,* SLIDES AND*,I3,* FOOD SPECIES
     2*)
      WRITE(6,200)
200   FORMAT(///,* FOOD SPECIES       FREQUENCY   DENSITY*)
      DO 80 K=1,NNAME
80    WRITE(6,210)NAME(K),FREQ(K),DENS(K)
210   FORMAT(1H ,3X,A4,9X,F10.4,2X,F7.4)
      DO 75 K=1,NNAME
      FREQ(K)=FREQ(K)/TOTFQ*100.
      DENS(K)=DENS(K)/TOTDENS*100.
75    CONTINUE
      WRITE(6,230)
230   FORMAT(///,* FOOD SPECIES       REL FREQ  REL DENS*)
      DO 76 J=1,NNAME
      WRITE(6,210) NAME(J),FREQ(J),DENS(J)
76    CONTINUE
      GO TO 85
90    CONTINUE
      END
```

APPENDIX C

Computer Print-Out Listing Plant Species and Their Frequency of Encounter in the Crop Contents for Each Grasshopper Dissected

Key To Computer Print-Out

Consumer Species are Abbreviated As Follows: AGDE = Agenestettix deorum; HEVI = Hesperotettix viridis; TRCA = Trimerotropis caeruleipennis; COWA = Conoza Wallula; TETT = Apote notabilis; MECI = Melanoplus cinereus; MEPA = Melanoplus yarrowii; OEEN = Oedaleonotus enigma. Plant Species Are Abbreviated As Follows: LICH = lichen; STCO = Stipa comata; CHVI = Chrysothamnus viscidiflorus; UNKA = unknown; BRTE = Bromus tectorum; ARTR = Artemisia tridentata; DEPI = Descurainia pinnata; CYTE = Cymopterus terebinthinus; CHNA = Chrysothamnus nauseosus; SAKA = Salsola kali; BACA = Balsamorhiza careyana; AMLY = Amsinckia lycopsoides; SIAL = Sisymbrium altissimum; CRCI = Cryptantha circumscissa; POSE = Poa sandbergii; ACLA = Achillea millifolium; GRSP = Atriplex spinosa; CHUI = Chrysothamnus viscidiflorus; BACH = Balsamorhiza careyana. The last two are typed incorrectly on the cards and must be added to CHVI and BACA, respectively, where the errors were made.

APPENDIX C. Computer Print-Out Listing Plant Species and Their Frequency of Encounter in the Crop Contents for Each Grasshopper Dissected

Initials	Date (Month Day Year)	Site	Consumer	No. Fields Read	Slide No.	1 Sp	1 F	2 Sp	2 F	3 Sp	3 F
LER	7267407		AGDE	20	453LICH	20					
LER	7267407		AGDE	20	454LICH	20					
LER	7267407		AGDE	20	455STCO	8LICH	10				
LER	7267407		AGDE	20	456LICH	20					
LER	7267407		AGDE	20	458LICH	20					
LER	7267407		AGDE	20	459CHUI	8LICH	13				
LER	7267407		AGDE	20	460LICH	20					
LER	7267407		AGDE	20	461LICH	8UNKA	10				
LER	7267407		AGDE	20	466LICH	18					
LER	7267407		AGDE	20	467UNKA	4					
LER	7267407		AGDE	20	469LICH	14					
LER	7267407		AGDE	20	471LICH	20					
LER	7267407		AGDE	20	472LICH	20					
LER	7267407		AGDE	20	474BRTE	3					
LER	7267407		AGDE	20	475ARTR	20					
LER	7267407		AGDE	20	476LICH	20					
LER	7267407		AGDE	20	477LICH	20					
LER	7267407		AGDE	20	478BRTE	3DEPI	5ARTR	4			
LER	7267407		AGDE	20	479LICH	20					
LER	7267407		AGDE	20	480LICH	20					
LER	7267407		AGDE	20	481CYTE	5					
LER	7267407		AGDE	20	482LICH	12					
LER	7267407		AGDE	20	485CHNA	15					
LER	7267407		AGDE	20	486STCO	8					
LER	7267407		AGDE	20	487LICH	4					
LER	8 87407		AGDE	20	489LICH	6					
LER	8 87407		AGDE	20	490LICH	4					
LER	8 87407		AGDE	20	491LICH	10					
LER	8 87407		AGDE	20	492SAKA	4LICH	10				
LER	8 87407		AGDE	20	493LICH	20					
LER	8 87407		AGDE	20	495LICH	20					
LER	8 87407		AGDE	20	496LICH	20					
LER	8 87407		AGDE	20	497LICH	12					
LER	8 87407		AGDE	20	498LICH	7					
LER	8 87407		AGDE	20	500LICH	20					
LER	8 87407		AGDE	20	501BRTE	9LICH	10				
LER	6277407		HEVI	20	597LICH	9					
LER	6277407		HEVI	20	598CHUI	20					
LER	6277407		HEVI	20	599LICH	20					
LER	6277407		HEVI	20	602LICH	20					
LER	6277407		HEVI	20	603LICH	20					
LER	7117407		HEVI	20	531LICH	18SAKA	10CHUI	14			
LER	7117407		HEVI	20	533CHUI	14LICH	10				
LER	7117407		HEVI	20	534CHUI	20					
LER	7117407		HEVI	20	535CHUI	14LICH	3				
LER	7117407		HEVI	20	537CHUI	20					
LER	7117407		HEVI	20	538CHUI	20					
LER	7117407		HEVI	20	539LICH	5					
LER	7117407		HEVI	20	540CHUI	9					
LER	7117407		HEVI	20	541CHUI	10LICH	4				
LER	7117407		HEVI	20	542LICH	16					
LER	7117407		HEVI	20	545CHUI	20					
LER	7117407		HEVI	20	546CHUI	16LICH	12				
LER	7117407		HEVI	20	549CHUI	11UNKA	2				
LER	7117407		HEVI	20	550CHUI	8LICH	3				
LER	7117407		HEVI	20	551CHUI	20					
LER	7117407		HEVI	20	552CHUI	20LICH	13				

Initials	Date (Month Day Year)	Site	Consumer	No. Fields Read	Slide No.	1 Sp	1 F	2 Sp	2 F
LER	7117407		HEVI	20	554CHUI	9LICH	4		
LER	7117407		HEVI	20	556CHUI	20UNKA	5		
LER	7117407		HEVI	20	557CHUI	20			
LER	7117407		HEVI	20	558UNKA	4			
LER	7117407		HEVI	20	559CHUI	20			
LER	7117407		HEVI	20	560CHUI	20LICH	9		
LER	7117407		HEVI	20	562LICH	8			
LER	7117407		HEVI	20	563CHUI	20			
LER	7117407		HEVI	20	565CHUI	20			
LER	7117407		HEVI	20	566CHUI	20			
LER	7117407		HEVI	20	569CHUI	20			
LER	7117407		HEVI	20	570CHUI	20			
LER	7117407		HEVI	20	571CHUI	20			
LER	7117407		HEVI	20	572CHUI	8			
LER	7257407		HEVI	20	573CHUI	20LICH	9		
LER	7257407		HEVI	20	575CHUI	20			
LER	7257407		HEVI	20	577CHUI	20			
LER	7257407		HEVI	20	578CHUI	20			
LER	7257407		HEVI	20	579CHUI	20			
LER	7257407		HEVI	20	582CHUI	20LICH	19		
LER	7257407		HEVI	20	583CHUI	20			
LER	7257407		HEVI	20	584CHUI	20UNKA	3		
LER	7257407		HEVI	20	586CHUI	20			
LER	7257407		HEVI	20	587CHUI	20LICH	17		
LER	7257407		HEVI	20	588CHUI	20			
LER	7257407		HEVI	20	589CHUI	20			
LER	7257407		HEVI	20	590CHUI	20			
LER	7257407		HEVI	20	591CHUI	20UNKA	1		
LER	7257407		HEVI	20	592CHUI	20			
LER	7257407		HEVI	20	595CHUI	20			
LER	7257407		HEVI	20	596CHUI	20			
LER	8 87407		TRCA	20	504BACA	10			
LER	8 87407		TRCA	20	506STCO	8LICH	9		
LER	8 87407		TRCA	20	507DEPI	20LICH	12		
LER	8 87407		TRCA	20	508BACA	20LICH	20		
LER	8 87407		TRCA	20	509BACA	18			
LER	8 87407		TRCA	20	510BACA	20			
LER	8 87407		TRCA	20	511ARTR	20			
LER	8 87407		TRCA	20	512RACA	14			
LER	8 87407		TRCA	20	514LICH	20			
LER	8 87407		TRCA	20	515AMLY	20LICH	18		
LER	8 87407		TRCA	20	517DEPI	20			
LER	8 87407		TRCA	20	518UNKA	3			
LER	8 87407		TRCA	20	519STCO	6			
LER	8 87407		TRCA	20	520LICH	20			
LER	8 87407		TRCA	20	523LICH	20			
LER	8 87407		TRCA	20	524LICH	20			
LER	8 87407		TRCA	20	525STCO	12			
LER	7257407		COWA	20	428BACA	12			
LER	7257407		COWA	20	429BACA	5			
LER	7257407		COWA	20	430BACA	14			
LER	7257407		COWA	20	431BACA	20			
LER	7257407		COWA	20	432LICH	10			
LER	7257407		COWA	20	434CHUI	18			
LER	7257407		COWA	20	436BACA	3			
LER	7257407		COWA	20	438BACA	6			
LER	7257407		COWA	20	439BACA	4			

APPENDIX C. (Continued 2)

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LER 7257407    COWA 20     440BACA  1LICH  2ARTR  3
LER 7257407    COWA 20     442BACA 20
LER 7257407    COWA 20     443BACA 20
LER 7257407    COWA 20     444BACA 20
LER 7257407    COWA 20     447BACA 20
LER 7257407    COWA 20     450BACA 20
LER 7257407    COWA 20     451BACA 20
LER 7257407    COWA 20     452LICH 20

LER 8 87407    COWA 20     427BACA  5
LER 8 87407    COWA 20     677BACA 20
LER 8 87407    COWA 20     679BACA  8
LER 8 87407    COWA 20     680BACA 20
LER 8 87407    COWA 20     681BACA  5
LER 8 87407    COWA 20     683BACA  6
LER 8 87407    COWA 20     684LICH 20
LER 8 87407    COWA 20     685BACA 20
LER 8 87407    COWA 20     686STCO 18LICH 14
LER 8 87407    COWA 20     687BACA 10
LER 8 87407    COWA 20     688BACA 20
LER 8 87407    COWA 20     691LICH 20STCO  9
LER 8 87407    COWA 20     693BACA  2
LER 8 87407    COWA 20     694BACA 20
LER 8 87407    COWA 20     695BACA 20LICH  8
LER 8 87407    COWA 20     696BACA 20
LER 8 87407    COWA 20     697BACA 20
LER 8 87407    COWA 20     698BACA 20
LER 8 87407    COWA 20     699BACA 20
LER 8 87407    COWA 20     701DEPI 20
LER 8 87407    COWA 20     702BACA 20

LER 7117407    TETT 20     608LICH 20CHUI 20ARTR 13SIAL  9
LER 7117407    TETT 20     609SIAL 20LICH 10ARTR  4
LER 7117407    TETT 20     610CYTE 20SIAL 16LICH 15ARTR 10
LER 7117407    TETT 20     611ARTR 10
LER 7117407    TETT 20     612CYTE 20SIAL 13LICH 10UNKA  4
LER 7117407    TETT 20     613CYTE 20SIAL 18ARTR  9
LER 7117407    TETT 20     614CYTE 20ARTR 20LICH  8
LER 7117407    TETT 20     615CYTE 20LICH 12DEPI 10ARTR  6
LER 7117407    TETT 20     616CYTE 20LICH 20ARTR 11SIAL  9
LER 7117407    TETT 20     617CYTE 20SIAL 12ARTR 14
LER 7117407    TETT 20     618CYTE 20SIAL 18ARTR  7LICH 13
LER 7117407    TETT 20     619CYTE 16SIAL 16DEPI  9ARTR  5
LER 7117407    TETT 20     620CYTE 18SIAL 16DEPI 12ARTR  8
LER 7117407    TETT 20     621CYTE 14ARTR 11LICH 10CRCI  9
LER 7117407    TETT 20     623CYTE 20SIAL 20ARTR 13UNKA  9
LER 7117407    TETT 20     624CYTE 20SIAL 19ARTR 16
LER 7117407    TETT 20     625ARTR 20LICH 14
LER 7117407    TETT 20     626CYTE 20SIAL 12LICH  9ARTR 10
LER 7117407    TETT 20     627CHUI 15ARTR  9SIAL  6CYTE 13
LER 7117407    TETT 20     628ARTR  9CYTE 18
LER 7117407    TETT 20     629CYTE 20DEPI  9ARTR  8SIAL 12
LER 7117407    TETT 20     630CYTE 12SIAL  7UNKA  6

LER 7257407    TETT 20     631LICH  4CYTE  2
LER 7257407    TETT 20     632CYTE 20SIAL 18LICH  9
LER 7257407    TETT 20     633CYTE 20LICH 10SIAL 20
LER 7257407    TETT 20     635CHUI 13CYTE 17UNKA  6
LER 7257407    TETT 20     637CYTE 20CHUI 16
LER 7257407    TETT 20     638CYTE 20CHUI 20UNKA  4

LER 7257407    TETT 20     640CYTE 20CHUI 20SIAL 13LICH  8
LER 7257407    TETT 20     642CYTE 14LICH 16SIAL 19ARTR  9
LER 7257407    TETT 20     644CYTE 14CHUI 18UNKA  6
LER 7257407    TETT 20     645CYTE 20CHUI 18ARTR  8
LER 7257407    TETT 20     646ARTR 20CHUI 14LICH  9UNKA  2
LER 7257407    TETT 20     647CYTE 20CHUI 20LICH  8
LER 7257407    TETT 20     648CYTE 20SIAL 20
LER 7257407    TETT 20     649CYTE 20CHUI 14
LER 7257407    TETT 20     650ARTR 20LICH 20UNKA  5
LER 7257407    TETT 20     651CYTE 14ARTR 18STCO  3
LER 7257407    TETT 20     652CYTE 20ARTR 19LICH 13
LER 7257407    TETT 20     653CYTE 20CHUI 20LICH 15SIAL 10
LER 7257407    TETT 20     654CYTE 20CHUI 20STCO  6
LER 7257407    TETT 20     655CYTE 20CHUI 20LICH 11
LER 7257407    TETT 20     657CYTE 17CHUI 13ARTR  8LICH  9
LER 7257407    TETT 20     658CYTE 20CHUI 18DEPI 10
LER 7257407    TETT 20     659CYTE 20CHUI 20
LER 7257407    TETT 20     660ARTR 14CYTE 12CHUI  9
LER 7257407    TETT 20     661ARTR  8LICH 20SIAL 13
LER 7257407    TETT 20     662CYTE 18LICH 10
LER 7257407    TETT 20     634CYTE 20
LER 7257407    TETT 20     636CYTE 20CHUI 20

LER 6 87407    TETT 20     663ARTR 20LICH 20
LER 6 87407    TETT 20     664ARTR 20CYTE 20
LER 6 87407    TETT 20     665ARTR 12CYTE  9CHUI 11
LER 6 87407    TETT 20     666DEPI 20LICH 20
LER 8 87407    TETT 20     667ARTR 10CHUI 20BACA 14
LER 8 87407    TETT 20     668CYTE 20
LER 6 87407    TETT 20     670CYTE  9UNKA  2
LER 6 87407    TETT 20     671CYTE  8ARTR 20
LER 8 87407    TETT 20     672ARTR 18LICH  8
LER 8 87407    TETT 20     673CYTE 13CHUI 15ARTR  8SIAL  4
LER 8 87407    TETT 20     675LICH 20

LER 6277407    MECI 20      72CHUI 20
LER 6277407    MECI 20      73CHUI 14LICH 20CYTE  7
LER 6277407    MECI 20      74CHUI 20LICH  6
LER 6277407    MECI 20      75CHUI 20LICH 12
LER 6277407    MECI  7    • 76CHUI  3LICH  4
LER 6277407    MECI 20      77CHUI 18LICH 11
LER 6277407    MECI 20      78ARTR 20LICH  9

LER 7117407    MECI 20     164ARTR 20LICH 14
LER 7117407    MECI 20     165ARTR 20LICH 10
LER 7117407    MECI 20     168ARTR 20LICH 20
LER 7117407    MECI 20     170ARTR 20
LER 7117407    MECI 20     172ARTR 20LICH 18
LER 7117407    MECI  9    •173ARTR  9
LER 7117407    MECI 20     175ARTR 20
LER 7117407    MECI 20     176ARTR 20
LER 7117407    MECI 12    •177ARTR 12
LER 7117407    MECI 20     178ARTR 20
LER 7117407    MECI 20     179ARTR 20
LER 7117407    MECI 20     180ARTR 20
LER 7117407    MECI 20     181ARTR 20
LER 7117407    MECI  7    •182ARTR  7
LER 7117407    MECI 20     183ARTR 20
LER 7117407    MECI 20       1CYTE 13LICH 16DEPI 19ACLA 15SIAL  7
LER 7117407    MECI 20       2CHNA 10ARTR  9DEPI  8LICH  4SIAL 16
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APPENDIX C. (Continued 3)

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LER 7117407    MECI 20      3ARTR 20LICH 15ACLA  3
LER 7117407    MECI 20      4ARTR 19SIAL  4LICH  3
LER 7117407    MECI 20      5ARTR 19SIAL  4ACLA  4CYTE  3
LER 7117407    MECI 20      6ARTR 20
LER 7117407    MECI 20      7ARTR 19LICH  9SIAL  6
LER 7117407    MECI 20      8ARTR 20SIAL  6
LER 7117407    MECI 20      9ARTR 20LICH 11SIAL  6
LER 7117407    MECI 20     10ARTR 20LICH  6
LER 7117407    MECI 20     11ARTR 20
LER 7117407    MECI 20     12ARTR 20LICH 12
LER 7117407    MECI 20     13ARTR 20LICH  8SIAL 10
LER 7117407    MECI  8   * 15ARTR  8
LER 7117407    MECI 20     27ARTR 20SIAL 14LICH  9
LER 7117407    MECI  4     28ARTR  4
LER 7117407    MECI 20     29ARTR 20
LER 7117407    MECI 20     30ARTR 20SIAL  9
LER 7117407    MECI 20     31ARTR 19SIAL 11LICH  8
LER 7117407    MECI 20     32ARTR 19SIAL  5LICH  9
LER 7117407    MECI 20     34ARTR 20
LER 7117407    MECI 20     38ARTR 20UNKA  3
LER 7117407    MECI 20     39ARTR 20SIAL  4LICH  6
LER 7117407    MECI 20     41ARTR 20
LER 7117407    MECI 20     42ARTR 20LICH 12
LER 7117407    MECI 20     43ARTR 20

LER 7257407    MECI 20     47ARTR 20LICH  9
LER 7257407    MECI 20     48ARTR 20LICH 13
LER 7257407    MECI 20     49ARTR 20LICH 16
LER 7257407    MECI 20     50ARTR 20LICH 11
LER 7257407    MECI 20     51ARTR 20SIAL  7LICH  4
LER 7257407    MECI 20     52ARTR 20
LER 7257407    MECI 20     53ARTR 20LICH 14
LER 7257407    MECI 20     54ARTR 20
LER 7257407    MECI 20     55ARTR 20SIAL  9LICH  8
LER 7257407    MECI 20     56ARTR 20SIAL 10
LER 7257407    MECI 20     57ARTR 20CYTE  3
LER 7257407    MECI 20     58ARTR 20
LER 7257407    MECI 20     59ARTR 20
LER 7257407    MECI 20     60ARTR 20SIAL  5LICH  3
LER 7257407    MECI 20     61ARTR 20
LER 7257407    MECI 20     62ARTR 14CHUI 20
LER 7257407    MECI 20     63ACLA  6CYTE 20CHVI  5
LER 7257407    MECI 20     64ARTR 20CYTE 13
LER 7257407    MECI 20     65ARTR 20LICH 20CYTE  7
LER 7257407    MECI 20     66ARTR 20
LER 7257407    MECI 20     67CHUI 20LICH  9
LER 7257407    MECI 20     68ARTR 20LICH  4CYTE  6
LER 7257407    MECI 20     69CHUI 20CYTE 15ACLA 10
LER 7257407    MECI 20     70CHUI 20CYTE 14ACLA  6
LER 7257407    MECI 20     71ARTR 19CHUI  6
LER 7267407    MECI 20    166ARTR 20LICH 13
LER 7267407    MECI 20    167ARTR 20
LER 7267407    MECI 20    174ARTR 20
LER 7267407    MECI 20     79ARTR 20CYTE  9
LER 7267407    MECI 20     80ARTR 20
LER 7267407    MECI 12   * 81ARTR 12
LER 7267407    MECI 20     82ARTR 20LICH 20
LER 7267407    MECI 20     83ARTR 20LICH 13
LER 7267407    MECI 20     84ARTR 20LICH 10
LER 7267407    MECI 10   * 85ARTR 10CYTE  5

LER 7267407    MECI 20   * 86ARTR 20
LER 7267407    MECI  5   * 87CHUI  5
LER 7267407    MECI 20     88ARTR 20LICH  7
LER 7267407    MECI 20     90ARTR 20CYTE  9LICH 14
LER 7267407    MECI 20     91ARTR 20LICH 10CYTE  8
LER 7267407    MECI 20     93ARTR 20ACLA  8LICH 15CYTE  4
LER 7267407    MECI  5   * 94ARTR  5
LER 7267407    MECI 20     95ARTR 20LICH 10CYTE 12ACLA  9
LER 7267407    MECI 20     97ARTR 20LICH 20
LER 7267407    MECI 20     98ARTR 20LICH 20
LER 7267407    MECI 20     99APTR 20

LER 6 67407    MECI 20    116CYTE 20
LER 8 67407    MECI 20    184ARTR 20
LER 8 87407    MECI 20    185BACA 16ACLA 20
LER 8 87407    MECI 20    186ARTR 20
LER 6 67407    MECI 20    187ARTR 20
LER 8 87407    MECI 20    188ARTR 20
LER 6 87407    MECI 20    189ARTR 20DEPI  7
LER 6 67407    MECI 20    190ARTR 20
LER 5 67407    MECI 20    191ARTR 20
LER 8 67407    MECI 20    192ARTR 20
LER 6 87407    MECI 20    193ARTR 20
LER 8 87407    MECI 20    194CYTE 20
LER 8 87407    MECI 20    195ARTR 20
LER 8 87407    MECI 20    196ARTR 20
LER 8 87407    MECI 20     17ARTR 20SIAL  6LICH  9
LER 8 87407    MECI 20     18ARTR 20
LER 8 87407    MECI 20     19ARTR 20LICH  7
LER 6 87407    MECI 20     20ARTR 18LICH  8SIAL 10UNKA  3
LER 8 87407    MECI 20     21ARTR 17GRSP  5SIAL  6
LER 8 87407    MECI 20     22ARTR 20
LER 8 87407    MECI 20     23ARTR 20LICH 10
LER 6 87407    MECI 20     24ARTR 20LICH  6SIAL  8
LER 6 87407    MECI 20     25ARTR 18LICH  9SIAL 12
LER 8 87407    MECI 20     26ARTR 20
LER 6 87407    MECI 20     35ARTR 20SIAL  8
LER 6 87407    MECI 20     36ARTR 20SIAL  3LICH  6
LER 8 87407    MECI 20     40ARTR 20LICH 10
LER 8 87407    MECI 20     45ARTR 20LICH 20
LER 8 87407    MECI 20     46ARTR 20LICH 19
LER 8 87407    MECI 20     44ARTR 20

LER 6277407    MEPA 20    607CHUI 20
LER 6277407    MEPA 20    214CHUI 20
LER 6277407    MEPA 20    215LICH 20SAKA 20
LER 6277407    MEPA 20    216CYTE 20UNKA  8
LER 6277407    MEPA 20    218LICH 20
LER 6277407    MEPA 20    219LICH 20
LER 6277407    MEPA 10   *224CHUI 10
LER 6277407    MEPA 20    225SIAL 13CYTE  8
LER 6277407    MEPA 20    248BACA 20ARTR 18
LER 6277407    MEPA 20    274DEPI 20LICH 20
LER 6277407    MEPA  8   *275POSE  8CYTE  4
LER 6277407    MEPA 20    276BACA 20
LER 6277407    MEPA 20    277LICH 20
LER 6277407    MEPA 20    278BACA 20
LER 6277407    MEPA 20    280LICH 16CYTE  9SIAL  6
LER 6277407    MEPA 20    292CHUI 20
LER 6277407    MEPA 20    293DEPI 20
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APPENDIX C. (Continued 4)

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LER 6277407   MEPA 20     294CYTE 13SIAL 11
LER 6277407   MEPA 20     296LICH 20
LER 6277407   MEPA 20     297BACA 20
LER 6277407   MEPA 20     298CYTE 12CHUI 10
LER 6277407   MEPA 20     300CHUI 14LICH 10
LER 6277407   MEPA 20     302LICH 16
LER 6277407   MEPA 20     303LICH 20
LER 6277407   MEPA 20     304ARTR 20
LER 6277407   MEPA 20     305LICH 20SIAL 15
LER 6277407   MEPA 20     308LICH 20
LER 6277407   MEPA 20     145SIAL 20
LER 6277407   MEPA 20     155LICH 20AMLY  4
LER 6277407   MEPA 20     156DEPI 14UNKA  3LICH 10
LER 6277407   MEPA 20     157BACA 20
LER 6277407   MEPA 20     158BACA 20
LER 6277407   MEPA 20     159BACA 20
LER 6277407   MEPA 10    *160POSE 10

LER 7117407   MEPA 14    *261LICH 14
LER 7117407   MEPA  4    *262BACA  4LICH  4
LER 7117407   MEPA 20     263BACA 20LICH 14
LER 7117407   MEPA 20     264POSE 20
LER 7117407   MEPA 20     266CHNA 20LICH 10
LER 7117407   MEPA 20     268LICH 20UNKA  9
LER 7117407   MEPA 20     269ARTR 20LICH 20
LER 7117407   MEPA 20     270BACA 20
LER 7117407   MEPA 10    *273LICH 10ARTR  7
LER 7117407   MEPA 20     132BACA 20LICH 12
LER 7117407   MEPA 16    *133BACA 12SIAL  4
LER 7117407   MEPA 20     134BACA 20POSE  8
LER 7117407   MEPA 10    *135SAKA 10
LER 7117407   MEPA 20     136DEPI 20
LER 7117407   MEPA 20     139BACA 20
LER 7117407   MEPA 17    *140BACA 17
LER 7117407   MEPA 20     142BACA 20
LER 7117407   MEPA  6    *143BACA  6
LER 7117407   MEPA 20     151CYTE 20LICH 20
LER 7117407   MEPA 10    *153POSE 10

LER 7257407   MEPA 20     199BACA 20
LER 7257407   MEPA 20     200CRCI 20
LER 7257407   MEPA 20     201BACA 20
LER 7257407   MEPA 20     202BACA 20DEPI 10
LER 7257407   MEPA 20     203ARTR 14POSE 20
LER 7257407   MEPA 20     204APTR 10LICH 12
LER 7257407   MEPA 20     206ARTR 20
LER 7257407   MEPA 20     207ARTR 20
LER 7257407   MEPA 20     211ARTR 20ACLA  9
LER 7257407   MEPA 20     213BACA 20
LER 7257407   MEPA 20    *281BACA  5
LER 7257407   MEPA 20     282APTR 20
LER 7257407   MEPA  4    *283DEPI  4
LER 7257407   MEPA 20     285LICH 20
LER 7257407   MEPA 20     286ARTR 20LICH 16
LER 7257407   MEPA 20     287ARTR 20
LER 7257407   MEPA 20     288APTR 20LICH 20
LER 7257407   MEPA 20     290ARTR 20LICH 18
LER 7257407   MEPA 20     291LICH 20
LER 7257407   MEPA 20     147CHNA 20
LER 7257407   MEPA 20     148ARTR 20

LER 7257407   MEPA 20     149ARTR 20
LER 7257407   MEPA 20     154CYTE 20
LER 7267407   MEPA 20     240CYTE 20
LER 7267407   MEPA 20     241CYTE 20
LER 7267407   MEPA 20     242CYTE 14LICH  9
LER 7267407   MEPA 20     243CYTE 20
LER 7267407   MEPA 10    *246CHUI 10
LER 7267407   MEPA 20     247DEPI 20LICH 20
LER 7267407   MEPA 13    *249CHUI 13
LER 7267407   MEPA 20     100CYTE 20
LER 7267407   MEPA  9    *101SIAL  9CYTE  4
LER 7267407   MEPA 20     102CYTE 20
LER 7267407   MEPA 20     103CYTE 20AMLY  2
LER 7267407   MEPA 20     104CYTE 20LICH 13
LER 7267407   MEPA 20     105CYTE 19LICH 10
LER 7267407   MEPA 20     106CYTE 20
LER 7267407   MEPA 20     107BACA 20
LER 7267407   MEPA 20     109CYTE 20
LER 7267407   MEPA 20     110CYTE 18LICH  3
LER 7267407   MEPA 12    *111CYTE 12
LER 7267407   MEPA 20     112ARTR  8CYTE 14BACA  3
LER 7267407   MEPA 20     113CYTE 20LICH 19
LER 7267407   MEPA 15    *114BACA 15
LER 7267407   MEPA 20     115CYTE 20

LER 6 67407   MEPA 20     250DEPI 20LICH 20
LER 6 67407   MEPA 20     251LICH 20
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LER 8 67407   MEPA 20     253LICH 20SIAL  9
LER 6 87407   MEPA 15    *254BACA 15
LER 6 87407   MEPA 20     255BACA 10LICH 14
LER 5 67407   MEPA 20     256LICH 14CYTE  8
LER 6 87407   MEPA 20     257LICH 16CHUI  4
LER 6 87407   MEPA 20     258APTR 20LICH 20
LER 6 87407   MEPA 13    *259DEPI 13
LER 8 67407   MEPA 20     265APTR 10LICH 16
LER 8 67407   MEPA  8    *117LICH  8
LER 8 67407   MEPA 20     118LICH 20SIAL  4
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LER 8 87407   MEPA 15    *120CYTE 15
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LER 6 87407   MEPA 14    *127BACA 14
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LER 6 87407   MEPA 20     131BACA 20DEPI  6
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LER 8117407   MEPA 20     228BACA 20
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LER 8117407   MEPA 20     233LICH 20ARTR 10
LER 8117407   MEPA 20     234LICH 20
LER 8117407   MEPA 20     235CHUI 20
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APPENDIX C. (Continued 5)

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LER 8117407    MEPA 20     237CHUI 20CYTE  4
LER 8117407    MEPA 20     239BACA 20ARTR 14

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LER 8 87407    OEEN 20     331ARTR 20LICH 19
LER 8 87407    OEEN 20     332LICH 20
LER 8 87407    OEEN 20     333ARTR 20
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