Technical Report No. 14

# DIETARY AND ENERGY RELATIONSHIPS OF JACKRABBITS AT THE PAWNEE SITE

Prepared by R. M. Hansen, J. T. Flinders and B. R. Cavender

GRASSLANDS BIOME

U. S. International Biological Program

Investigators:[1]

| | |
|---|---|
| R. M. Hansen | Project Leader |
| J. T. Flinders | NDEA Project Assistant[2] |
| B. R. Cavender | Diet Technician |
| S. R. Woodmansee | Diet Technician |
| L. D. Reed | GRA Field Investigator[2] |
| R. L. Olson | Lab Technician[2] |
| J. C. Ellmann | Lab Technician[2] |
| N. E. Green | GRA Field Investigator[2] |
| C. Baker | Computer Programmer |
| T. E. Lines | Lab and Field Technician[2] |
| M. Taylor | Computer Programmer |
| J. E. Gross | Cooperator and Leader of Allied Project |

December, 1969

---

[1] Present address of the above: Range Science Department, Colorado State University, Fort Collins, Colorado 80521

[2] These persons helped collect data and process samples but their stipends came from Range Science Department funds.

## INTRODUCTION

Jackrabbits as herbivorous consumers may play a large role in the utilization of vegetation within the shortgrass ecosystem. The purpose of studying black-tailed (*Lepus californicus*) and white-tailed (*Lepus townsendii*) jackrabbits on the Pawnee National Grasslands is to determine the year-round partitioning of herbage and energy by jackrabbits and the ecological ramifications of such partitioning.

The objectives of this study are as follows: 1) To determine the year-round dietary habits of each species of jackrabbit; 2) to delimit habitats of occurrence for both species of jackrabbits, based on measurements taken at kill sites; 3) to investigate interspecific competition between the two species of jackrabbits and with other herbivores; 4) to relate the dietary habits of these jackrabbits to the disturbing effects of man on the native vegetation of the shortgrass ecosystem.

Pursuant to these objectives, a program of research was designed and started in August of 1968. Allotments of time for each phase of the program are given in Table 1.

## METHODS AND MATERIALS

### Reference Collection of Plants

Before beginning a dietary study of wild herbivores, a researcher must become familiar with the species of plants in the herbivore's habitat. With this in mind, a thorough collection of plants of the Pawnee National Grasslands was begun the first week in August, 1968. A botanical reference collection was compiled, and by the end of September, 1968 it contained some 150 species of plants. These botanical specimens were mounted within paper "file folders" and housed in a file cabinet. This collection is fully portable and is taken to the field for aid in botanical identifications.

Small samples of the various parts of the plants in the reference collection were removed for preparation of a reference collection of microscope slides of tissues of plants from the study area. This reference collection and the numerous drawings made from it aid in the identification of dietary material under the microscope. The collection of plants for both these reference collections is a continuing field operation, an integral part of every trip to the study area.

## Review of Literature

It was felt that researchers on this project should have a thorough knowledge of the work that had been done on the dietary habits of jackrabbits. An exhaustive review of literature was undertaken and resulted in the publication *Food Habits of North American Hares* (Hansen and Flinders, 1969).

## Sampling Jackrabbit Populations

An area of the Pawnee National Grasslands was delimited for the collection of jackrabbits of both species for dietary analysis. This area includes roughly 208 sq miles and encompasses both private and federal lands as well as the Pawnee Site of the Grasslands Biome. The entire area is classified as being within the shortgrass ecosystem. Jackrabbits have been collected within this area on a year-round schedule of monthly collections in the summers and bimonthly collections during the winters. Collecting was started in September, 1968. Nine collections are made each year, and 12 collections have been completed to date. One collection consists of the stomachs from at least 25 individuals of each of the two species of jackrabbits. At least 50 stomachs were collected each period.

The jackrabbit stomachs are removed and chilled in the field soon after each animal is killed to insure against in vivo changes in nutrient levels of the stomach contents. Future studies will deal with the energy budgets and nutrient compliments of the stomach contents. Quick removal of stomachs helps insure reliable results. To date, 615 stomachs of jackrabbits have been removed and processed for dietary, nutrient, and energy analysis.

Sampling Vegetation

As each jackrabbit is killed, the collection site is marked. Measurements are taken of the vegetation at each kill site by estimating the green biomass of each plant species in ten 450 $cm^2$ (15 x 30 cm) quadrats. This is a double-sampling technique, and actual weight correction factors are obtained from clipped samples of vegetation for every 10 quadrats. The findings for the 500-plus quadrats read each collection period will be used as measurements of the vegetational habitat of each species of jackrabbit.

Analyzing Dietary Material

Stomachs removed from jackrabbits in the field are frozen until processed in the laboratory. Processing begins with thawing the stomachs and removal of the contents. Care is taken not to include the mucosal lining of the stomach or blood contamination in the sample of the stomach contents saved for future analysis. The samples are then dried at less than 70°C and then ground in a "Wiley Mill" over a 15- to 20-mesh screen.

Two subsamples are taken from each of the thoroughly-mixed dietary samples and mounted on two microscope slides. This amounts to two slides per jackrabbit, or 100-plus slides per collection period. The procedure followed for mounting the dietary material has been outlined by Cavender and Hansen (Appendix I). The "microtechniques" method is used to analyze the dietary samples mounted on the microscope slides. This technique was first described by Baumgartner and Martin (1939) and later defined and modified by many others (Hansen and Flinders, 1969). The identification of each plant species, by the microscopic technique, is based on characteristics of epidermal tissues (Davis, 1959; Croker, 1959; Brusven and Mulkern, 1960; Storr, 1961). The percent frequency of each plant species as it is found in 20 fields of the microscope (10 fields on each of the two slides made from one jackrabbit's stomach contents) is read from the slides under 100 power magnification. The percent frequency for each plant species in dietary samples has been recorded for 564 jackrabbits to date. This necessitated the making of 1128 microscope slides of dietary samples and evaluating 11,280 fields under the microscope.

Data processing of the percent frequencies for each plant species in the diet of each jackrabbit is to be done by the Grasslands Biome Data Processing Center at Colorado State University. The procedure uses techniques developed by Sparks and Malechek (1968) for converting the percent frequency of plant species in the diets of jackrabbits to the relative percent of dry weight of each plant species in the diets. These data are being processed to determine the relative amount (percent of dry weight) of each plant species in the diets of the jackrabbits from the Pawnee Site. Fig. 1 and 2 show the importance of two plant species in the diets of both species of jackrabbits through 11 periods of collection. Data in these figures are not conclusive at this writing for they still contain approximately 8.5 percent keypunching errors and omissions of data. Forty-six species of plants have been identified in the diets of black-tailed jackrabbits and 55 species of plants have been identified in the diets of white-tailed jackrabbits. Eighteen species of plants occurred in amounts of four percent or more in the diets of black-tailed jackrabbits while 26 species of plants occurred in amounts of four percent or more in the diets of white-tailed jackrabbits.

The clipped samples of vegetation compiled from the kill-site sampling of vegetation are taken to the laboratory for drying. Each plant species that occurred in amounts of 1 g or more per quadrat are clipped, estimated by weight, weighed, and then dried in an oven at slightly less than 70°C. These samples yield estimated-to-actual weight correction factors and wet weight to dry weight correction factors. All plant material from all periods of collection has been saved for possible chemical or energy analysis.

All plant species that occurred in the herbage sampling at the kill sites of both species of jackrabbits are summarized. The green or wet weight and the oven-dry weight is listed for each of these plant species. The ratio of these weights is used to calculate the kg/ha for each plant species in the habitats of each species of jackrabbit.

Fig. 3 and 4 show the percent frequency of occurrence of two plant species (*Agropyron smithii* and *Chrysothamnus nauseosus*) at the kill-sites of both species of jackrabbits. These plants are important items of food for both species of jackrabbits (Fig. 1 and 2). Fig. 5 and 6 show the percent frequency of occurrence of *Bouteloua gracilis* and *Buchloe dactyloides* at kill-sites of both species of jackrabbits. Note that neither of these abundant grasses exceeds 72 percent frequency, and this is from readings taken from a 15 x 30 cm quadrat (refer to Sampling Vegetation). These grasses are not important foods of jackrabbits; *B. gracilis* accounted for 3.9 percent of the diets of black-tailed jackrabbits in September (1968) and occurred in lesser amounts or not at all throughout the rest of the periods of collections.

Fig. 7 shows the total aboveground biomass of herbage at the kill-sites of both black-tailed and white-tailed jackrabbits. Fig. 8, 9, and 10 show the same information for grasses, forbs, and *B. dactyloides*, respectively. Preliminary reviews of processed data have dramatically reduced the distance between the $P \geq .95$ confidence limits and the means of the biomass of vegetation. When these corrections are completed we are expectant that most of the confidence intervals will be significantly reduced from those shown.

## SEX RATIOS

Six hundred and eight jackrabbits were sexed during the 12 completed collection periods. Out of the 303 black-tailed jackrabbits, there were 152 males and 151 females for a sex ratio of 100 to 99.34. There were 305 white-tailed jackrabbits, 152 males and 153 females, for a sex ratio of 100 to 100.66. These sex ratios are very close to a 1:1 relationship and both are closer than was reported by Tiemeier (1965) for live and prenatal Kansas black-tailed jackrabbits. Fig. 11 and 12 show the graphs of these sex ratios for both species of jackrabbits for each period of collection. There are several factors that might be said to account for the varying sex ratios from one period to the next, and random occurrence is not the least of these factors. Future study may reveal other reasons for the oscillations.

## AGE STRUCTURE

Bear and Hansen (1966) noted that body weights were useful for establishing general age relationships in very young white-tailed jackrabbits. Haskell and Reynolds (1947) reported similar findings for black-tailed jackrabbits. Tables 2 and 3 show the age structure of the black-tailed and white-tailed jackrabbits taken from the study area throughout the 12 periods of collection. Weights are based on tables constructed by the afore-mentioned researchers. Our method of sampling the jackrabbit populations and the time of sampling may not give a completely random indication of the relative numbers of animals in each age class, especially the youngest classes. The tables do show that by our data the two species are somewhat similar in their periods of reproduction.

## SUCKLING PERIOD OF JACKRABBITS

Table 4 gives the vitae for nine young jackrabbits whose stomachs contained milk when they were collected. By comparisons with Tables 2 and 3, note that of the 18 white-tailed jackrabbits less than 18 weeks old, collected in both Septembers, five (27.8%) had milk in their stomachs. The one whitetail collected in October 1968, 10 to 12 weeks old, had milk in its stomach. One of the three whitetails four to six weeks old, taken in August, 1969, had milk in its stomach. In May, 1969 all black-tailed jackrabbits taken would be judged near adult by their weights (Haskell and Reynolds 1947), but one of these had milk in its stomach. One of the two blacktails six to eight weeks old taken in July, 1969 had milk in its stomach.

Tiemeier (1965) indicated that a female black-tailed jackrabbit suckled her young for 17 to 20 days. Others have reported finding milk in the stomachs of both black-tailed and white-tailed jackrabbits up to 12 or 13 weeks of age and four weeks of age, respectively (Sparks, 1968). The results reported here conclusively prove that the precocial young of black-tailed and white-tailed jackrabbits suckle much longer than was previously reported.

## COMPUTER PROGRAMS FOR HERBIVORES

Computer programs (Appendix II) have been developed to summarize the aboveground biomass of plants for individual jackrabbits (or any other herbivore) and for each species of jackrabbit (or herbivore) by collection period, by season, and by the annual mean biomass at collection sites. The tabulations include frequency of occurrence, human estimate errors, percentage moisture, percentage botanical composition based on kg/ha, standing aboveground biomass in kg/ha, 95% confidence intervals, and standard errors. Another program has been developed (Appendix III) to convert frequency of plant species on microscope slides to percentage dry weight in the diets of herbivores and to determine preference indices and standard errors of preference. The program computes an ecological similarity index for diets between species, between collections, between seasons, between sexes and ages, between different vegetational patterns for diets and habitat preferences, between habitats among species of herbivores. Whenever appropriate the confidence limits are printed out.

## LITERATURE CITED

Baumgartner, L. L. and A. C. Martin. 1939. Plant histology as an aid in squirrel food-habit studies. J. Wildlife Manage. 3:266-268.

Bear, G. D. and R. M. Hansen. 1966. Food habits, growth and reproduction of white-tailed jackrabbits in southern Colorado. Colo. State Univ. Agr. Exp. Sta. Bull. No. 90. 59 p.

Brusven, M. A. and G. M. Mulkern. 1960. The use of epidermal characteristics for the identification of plants recovered in fragmentary condition from crops of grasshoppers. North Dakota Agr. Exp. Sta. Res. Rep. No. 3. 11 p.

Croker, B. H. 1959. A method of estimating the botanical composition of the diet of sheep. New Zealand J. Agr. Res. 2:72-85.

Davis, I. 1959. The use of epidermal characteristics for the identification of grasses in the leafy stage. Brit. Grassland Soc. J. 14:7-16.

Hansen, R. M. and J. T. Flinders. 1969. Food habits of North American hares. Range Sci. Dep., Sci. Series No. 1, Colorado State Univ. 17 p.

Haskell, H. S. and H. G. Reynolds. 1947. Growth, developmental food requirements and breeding activity of the California jack rabbit. J. Mammal. 28:129-136.

Sparks, D. R. 1968. Occurrence of milk in stomachs of young jackrabbits. J. Mammal. 49:324-325.

Sparks, D. R. and J. C. Malechek. 1969. Estimating percentage dry weight in diets using a microscopic technique. J. Range Manage. 21:264-265.

Storr, G. M. 1961. Microscopic analysis of faeces, a technique for ascertaining the diet of herbivorous mammals. Australian J. Biol. Sci. 14:157-164.

Tiemeier, O. W. 1965. Bionomics, p. 5-37. *In* The black-tailed jack-rabbit in Kansas. Kan. State Univ. of Agr. Appl. Sci., Agr. Exp. Sta. Tech. Bull. No. 140. 75 p.

Table 1. Allotments of time in research schedule of dietary study of jackrabbits.

| Outline of Research | Man Hrs. Collect. Period | Man Hrs. Year | No. People Involved |
|---|---|---|---|
| Reference collection of plants | | | |
| 1. field collections | | 120 | 1 |
| 2. microscope slides | | 120 | 1 |
| 3. drawings | | 40 | 2 |
| Review of literature | | 120 | 2 |
| Sampling jackrabbit populations | | | |
| 1. collecting animals | 48 | 432 | 3 |
| 2. removal of stomachs | 6 | 54 | 3 |
| Sampling vegetation | | | |
| 1. total standing crop for jackrabbits | 48 | 432 | 2 |
| Analyzing dietary material | | | |
| 1. removing, drying, and grinding stomach contents | 6 | 54 | 1 |
| 2. mounting dietary material on microscope slides | 12 | 108 | 2 |
| 3. microscopic identification of plant material | 40 | 360 | 3 |
| Analyzing procedure for herbage data and material | | | |
| 1. drying and weighing | 2 | 18 | 1 |
| 2. summary listing of wet and dry weights | 2 | 18 | 1 |
| Data processing and analysis | 48 | 432 | 2 |
| IBP requirements | | | |
| 1. written reports | | 160 | 4 |
| 2. seminars and meetings | | (22 days) | 4 |

Table 2. Age structure of black-tailed jackrabbits.

| AGE IN WEEKS | SEPT | OCT | DEC | FEB | APRIL | MAY | JUNE | JULY | AUG | SEPT | OCT | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 - 2 | | | | | | | 2 | | | | | |
| 2 - 4 | | | | | | | | | | | | |
| 4 - 6 | | | | | | | 2 | | | | | |
| 6 - 8 | | | | | | | | 2 | | | | |
| 8 - 10 | 1 | | | | | | 2 | 3 | 2 | | | |
| 10 - 12 | 1 | | | | | | | | 2 | 1 | | |
| 12 - 14 | 5 | 1 | | | | | 1 | 3 | 2 | 1 | | |
| 14 - 16 | 1 | | | | | | | 3 | 2 | 2 | 1 | |
| 16 - 18 | | 1 | | | | | | | 2 | 3 | | |
| 18 - 20 | 1 | | | | | | | 2 | 2 | 1 | | |
| 20 - 22 | 2 | 1 | 1 | | | | | 1 | | 1 | | |
| 22 - 24 | 2 | 1 | | | | | 2 | | 2 | 1 | 2 | 1 |
| 24 - + | 12 | 19 | 24 | 26 | 27 | 26 | 17 | 12 | 11 | 15 | 24 | 25 |

PERIODS OF COLLECTION

Table 3. Age structure of white-tailed jackrabbits.

| AGE IN WEEKS | SEPT | OCT | DEC | FEB | APRIL | MAY | JUNE | JULY | AUG | SEPT | OCT | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 – 2 | | | | | | | | | | | | |
| 2 – 4 | | | | | | | 4 | | | | | |
| 4 – 6 | | | | | | | 4 | | 3 | | | |
| 6 – 8 | 2 | | | | | | 1 | 2 | 2 | 1 | | |
| 8 – 10 | | | | | | | | 6 | 2 | 2 | | |
| 10 – 12 | 1 | 1 | | | | | | 4 | 3 | 4 | | |
| 12 – 14 | 1 | 2 | | | | | | 2 | 2 | 2 | | |
| 14 – 16 | 2 | | 1 | | | | | | 2 | 1 | 1 | |
| 16 – 18 | 1 | | | | | | 1 | | | 1 | | |
| 18 – 20 | 1 | 2 | | | 1 | | | 1 | 1 | | 1 | 1 |
| 20 – 22 | | 2 | | | 2 | | 1 | 2 | 1 | 2 | 4 | |
| 22 – 24 | 2 | 2 | | | 4 | 2 | 1 | | | | 1 | |
| 24 – + | 18 | 18 | 25 | 26 | 18 | 24 | 13 | 10 | 9 | 12 | 18 | 24 |

PERIODS OF COLLECTION

Table 4. Jackrabbits collected on the Pawnee National Grasslands in 1968-69 whose stomachs contained milk.

| Species[1/] and sex | Date collected | Time PM of collection | Body wt. oz. | % of adult wt.[2/] | Estimated age in weeks[3/] | % milk of stomach contents by weight |
|---|---|---|---|---|---|---|
| WT ♀ | Sept. 4 | 9:15 | 78 | 72 | 16-18 | 13.5 |
| WT ♂ | Sept. 6 | 8:15 | 51 | 50 | 6- 8 | trace |
| WT ♂ | Sept. 6 | 8:40 | 50 | 46 | 6- 8 | 43.2 |
| WT ♀ | Sept. 6 | 10:30 | 71 | 65 | 12-14 | 8.6 |
| WT ♀ | Oct. 3 | 9:00 | 68 | 62 | 10-12 | 8.3 |
| BT ♂ | May 4 | 9:36 | 85 | 84 | 24+ | trace |
| BT ♀ | July 5 | 10:15 | 35 | 34 | 6- 8 | 34.3 |
| WT ♀ | Aug. 3 | 11:55 | 35 | 32 | 4- 6 | 32.2 |
| WT ♀ | Sept. 6 | 10:30 | 51 | 47 | 6- 8 | 46.9 |

1/ Symbols WT and BT stand for white-tailed and black-tailed jackrabbits, respectively.

2/ The mean ± one standard deviation for body weights of adults in December and February on the study area was: 109 ± 8 for female and 102 ± 8 for male whitetails, and 102 ± 11 for female and 101 ± 8 for male blacktails.

3/ Estimated ages of white-tailed jackrabbits after Bear and Hansen (Colorado State Univ. Agr. Exp. Sta. Tech. Bull. 90:1-59, 1966) and estimated ages of black-tailed jackrabbits after Haskell and Reynolds (J. Mammal. 28: 129-136, 1947).

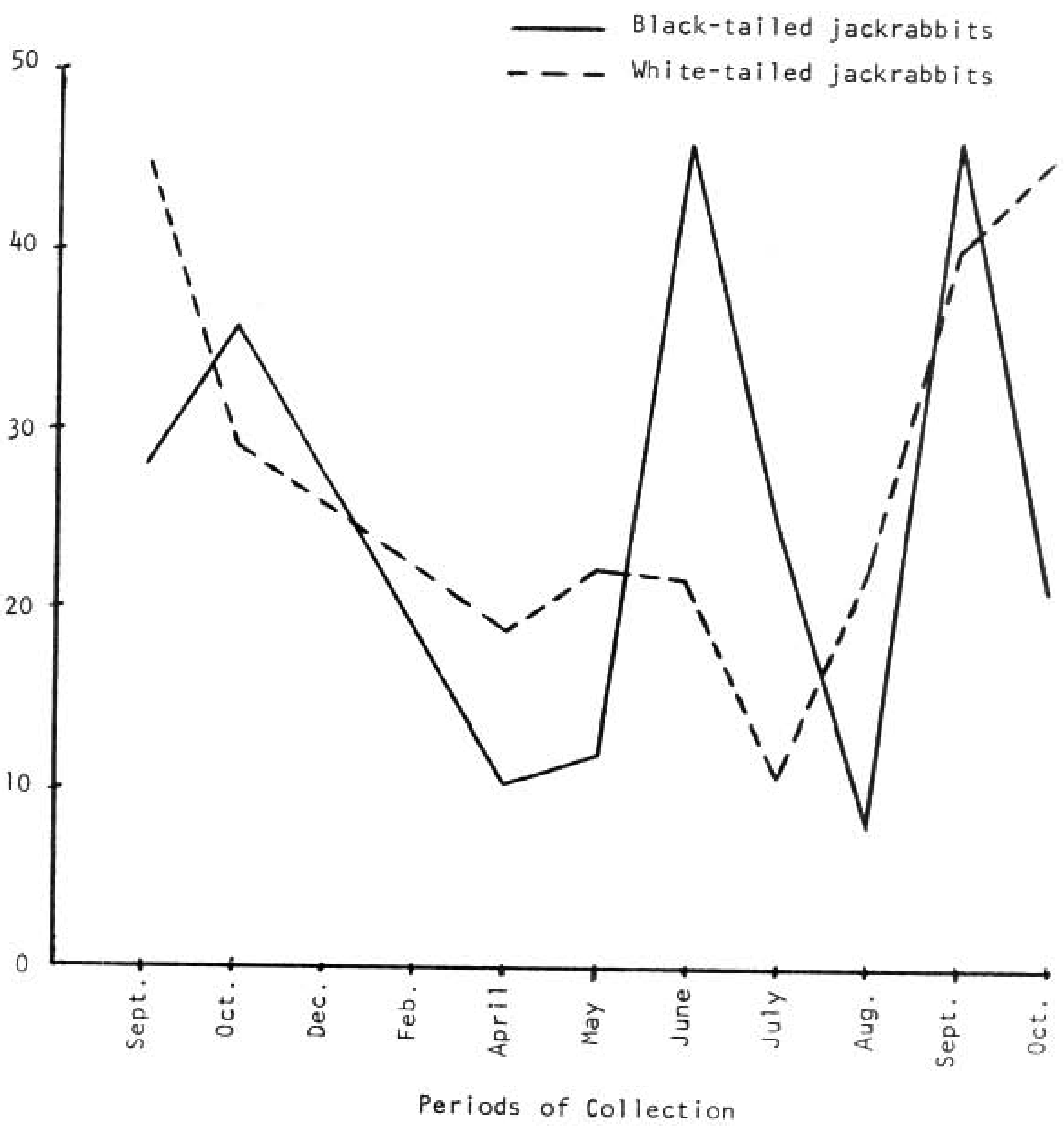


Fig. 1. The percent of *Agropyron smithii*, on a dry-weight basis, in the diets of black-tailed and white-tailed jackrabbits.

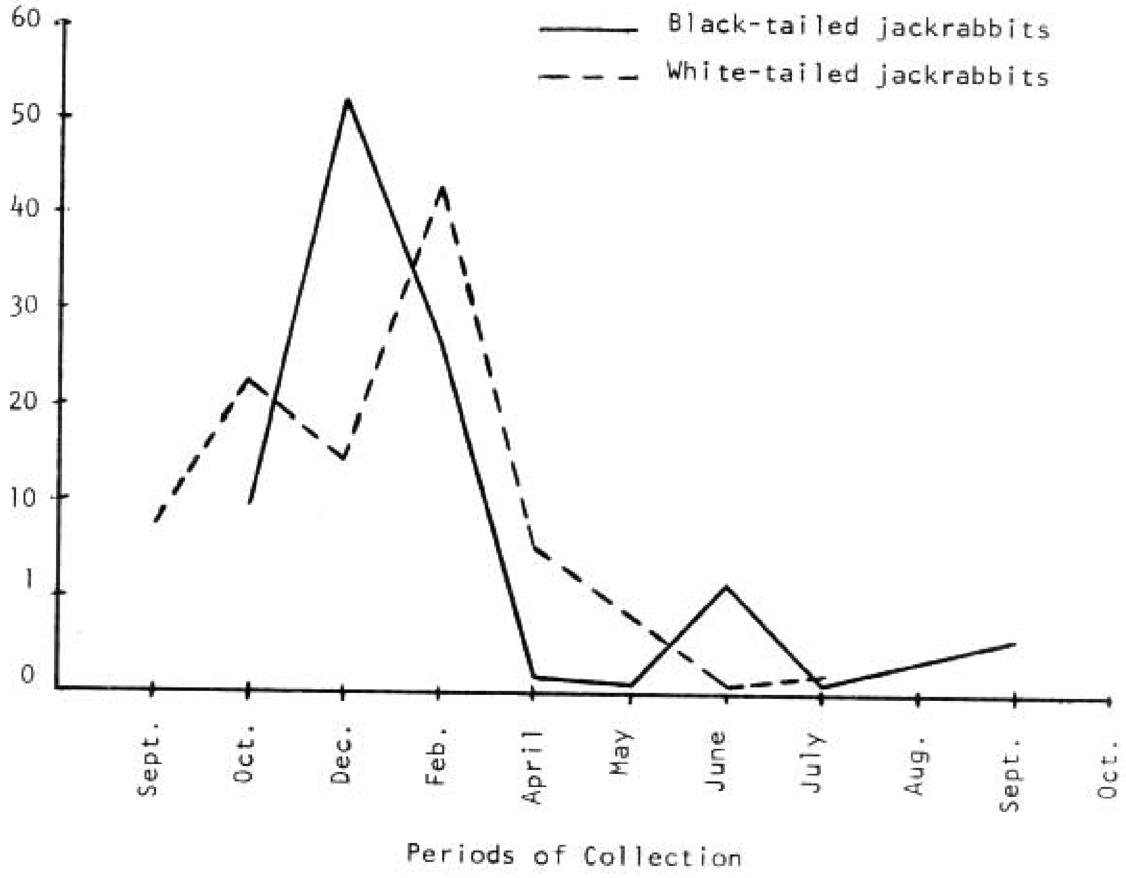


Fig. 2. The percent of *Chrysothamnus nauseosus*, on a dry-weight basis, in the diets of black-tailed and white-tailed jackrabbits.

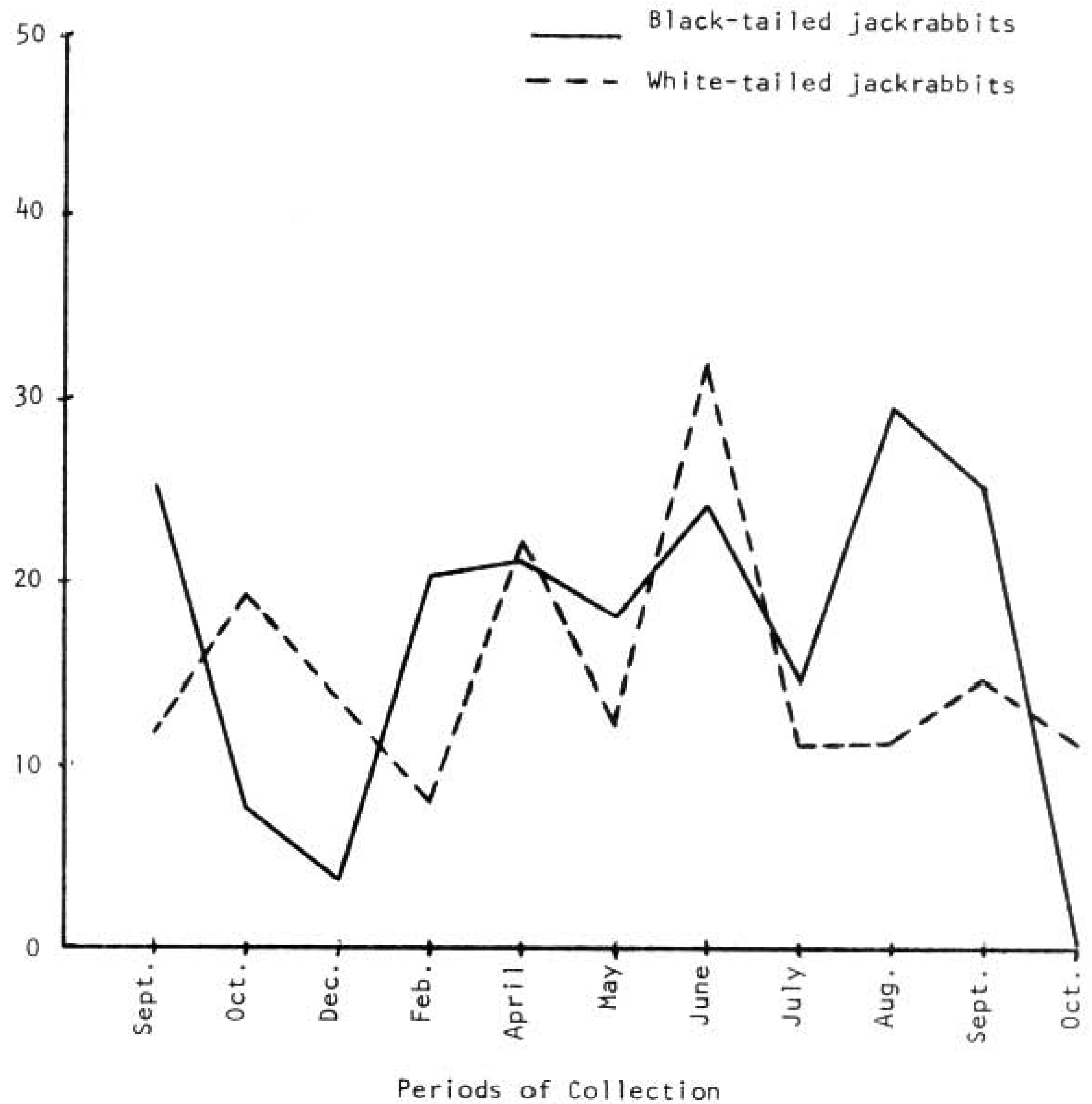


Fig. 3. Percent frequency of *Agropyron smithii* in quadrats read at kill-sites of black-tailed and white-tailed jackrabbits.

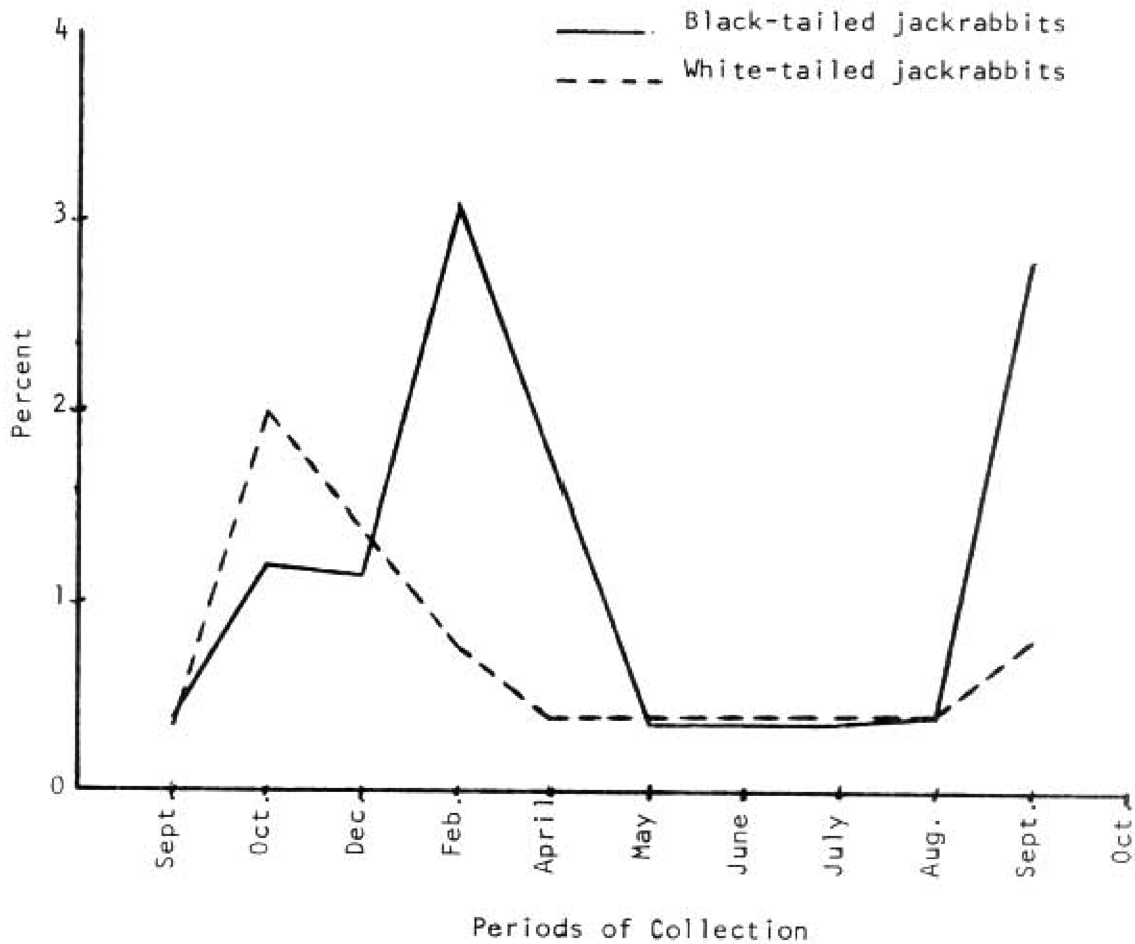


Fig. 4. Percent frequency of *Chrysothamnus nauseosus* in quadrats read at kill-sites of black-tailed and white-tailed jackrabbits.

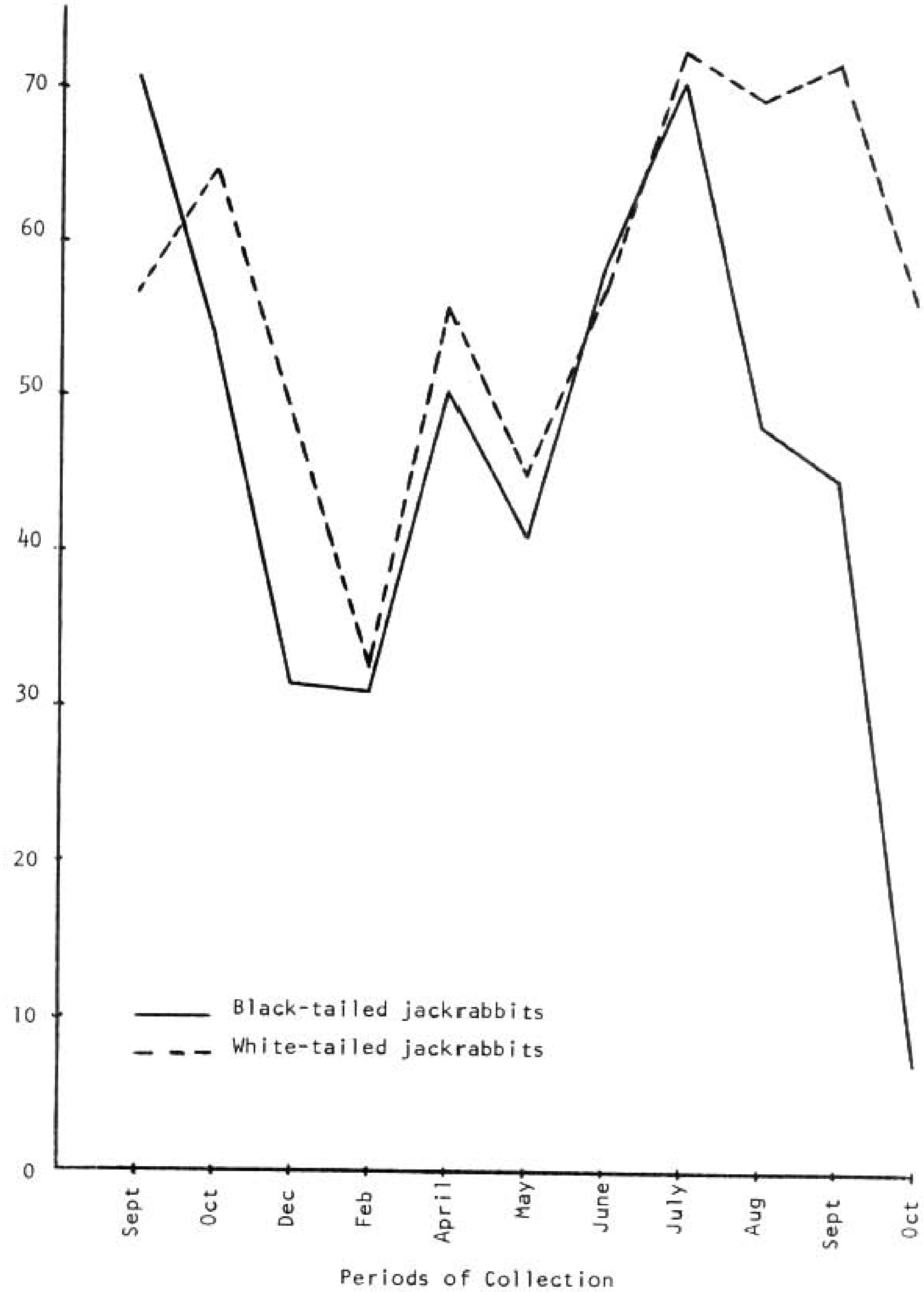


Fig. 5. Percent frequency of *Bouteloua gracilis* in quadrats read at kill-sites of black-tailed and white-tailed jackrabbits.

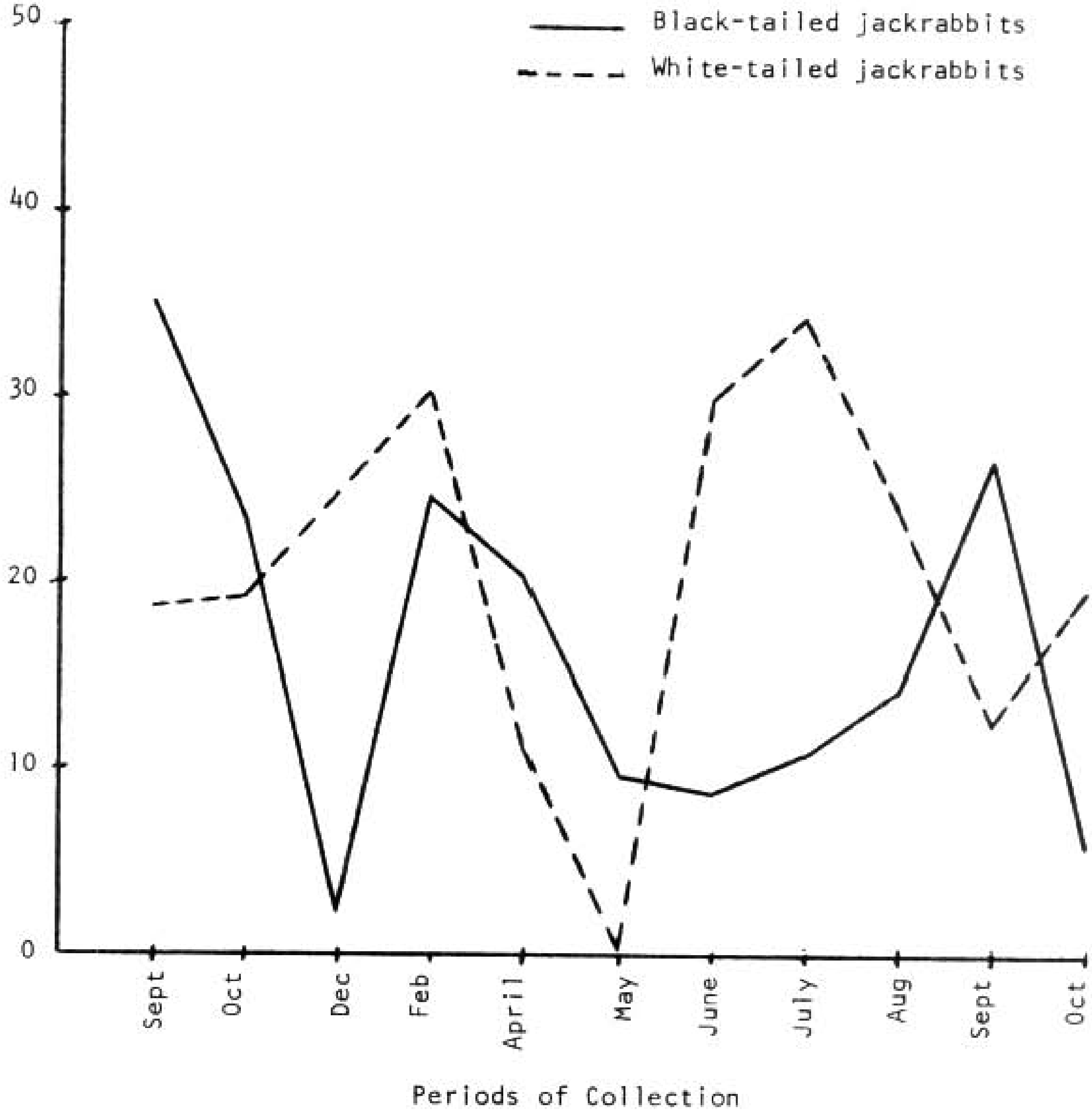


Fig. 6. Percent frequency of *Buchloe dactyloides* in quadrats read at kill-sites of black-tailed and white-tailed jackrabbits.

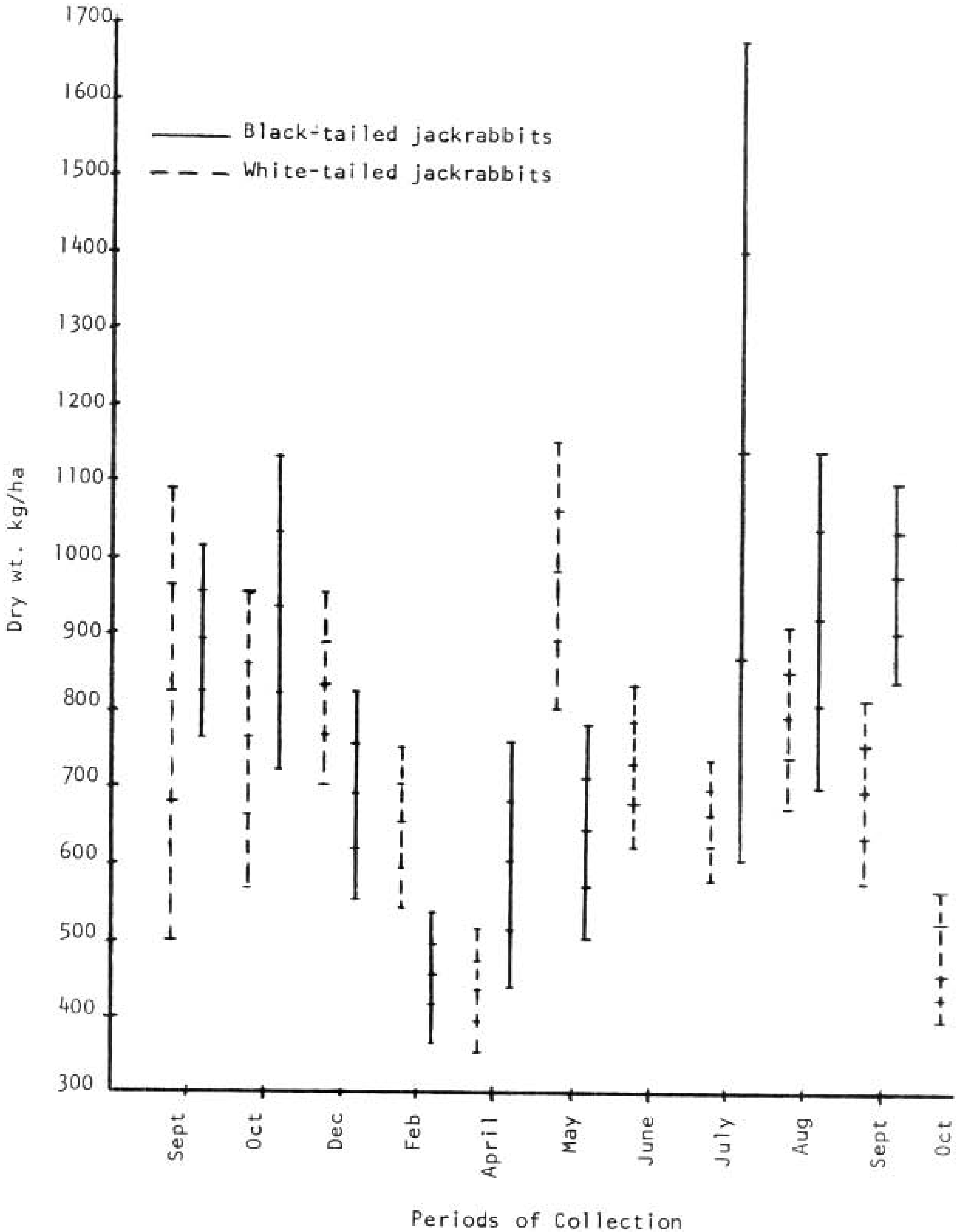


Fig. 7. Total dry-weight of aboveground herbage, derived from readings of quadrats at kill-sites of black-tailed and white-tailed jackrabbits. Means, standard errors, and confidence intervals (at the P.95 level) are shown.

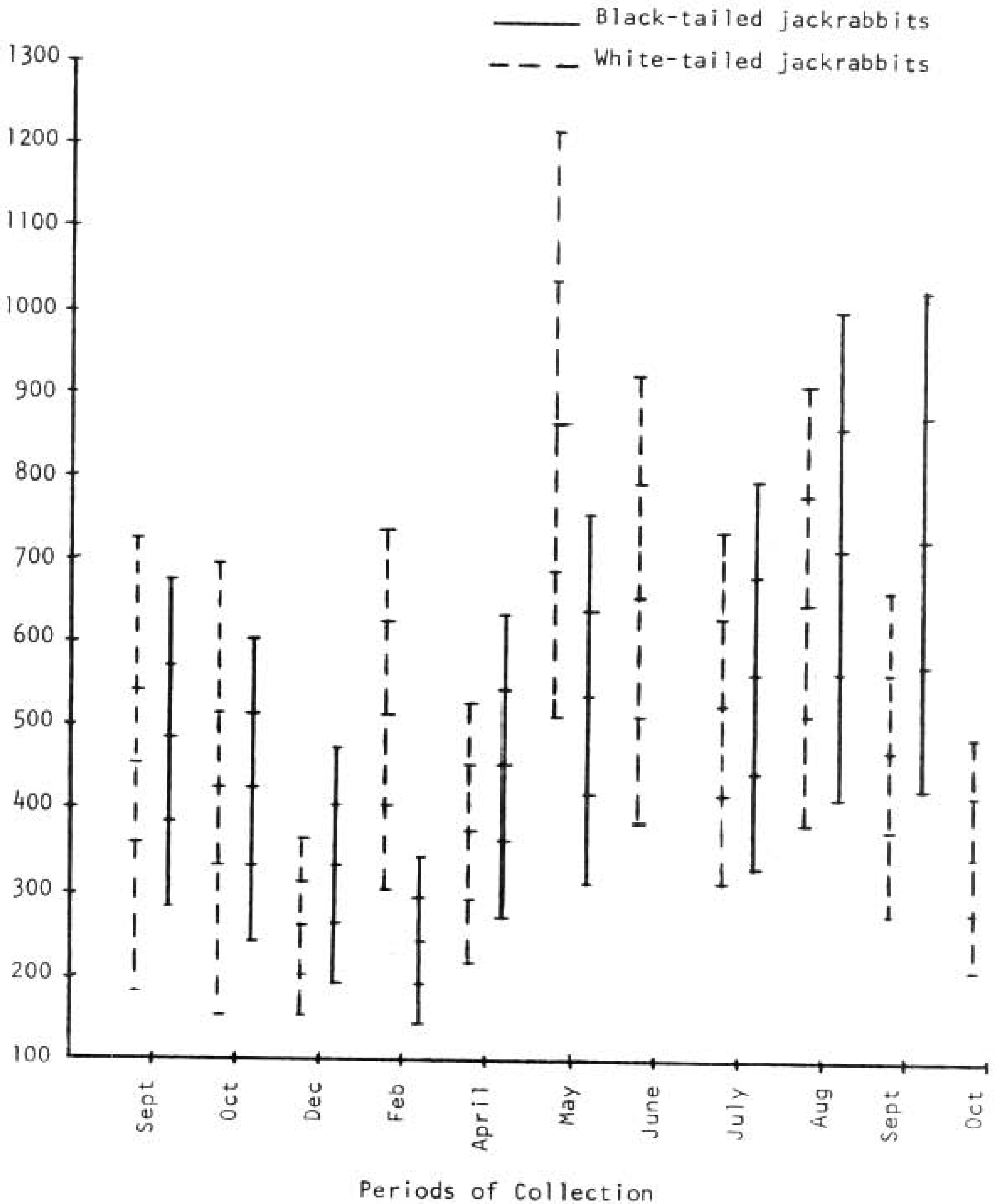


Fig. 8. Dry-weight of aboveground herbage of grasses, derived from readings of quadrats at kill-sites of black-tailed and white-tailed jackrabbits. Means, standard errors, and confidence intervals (at the P.95 level) are shown.

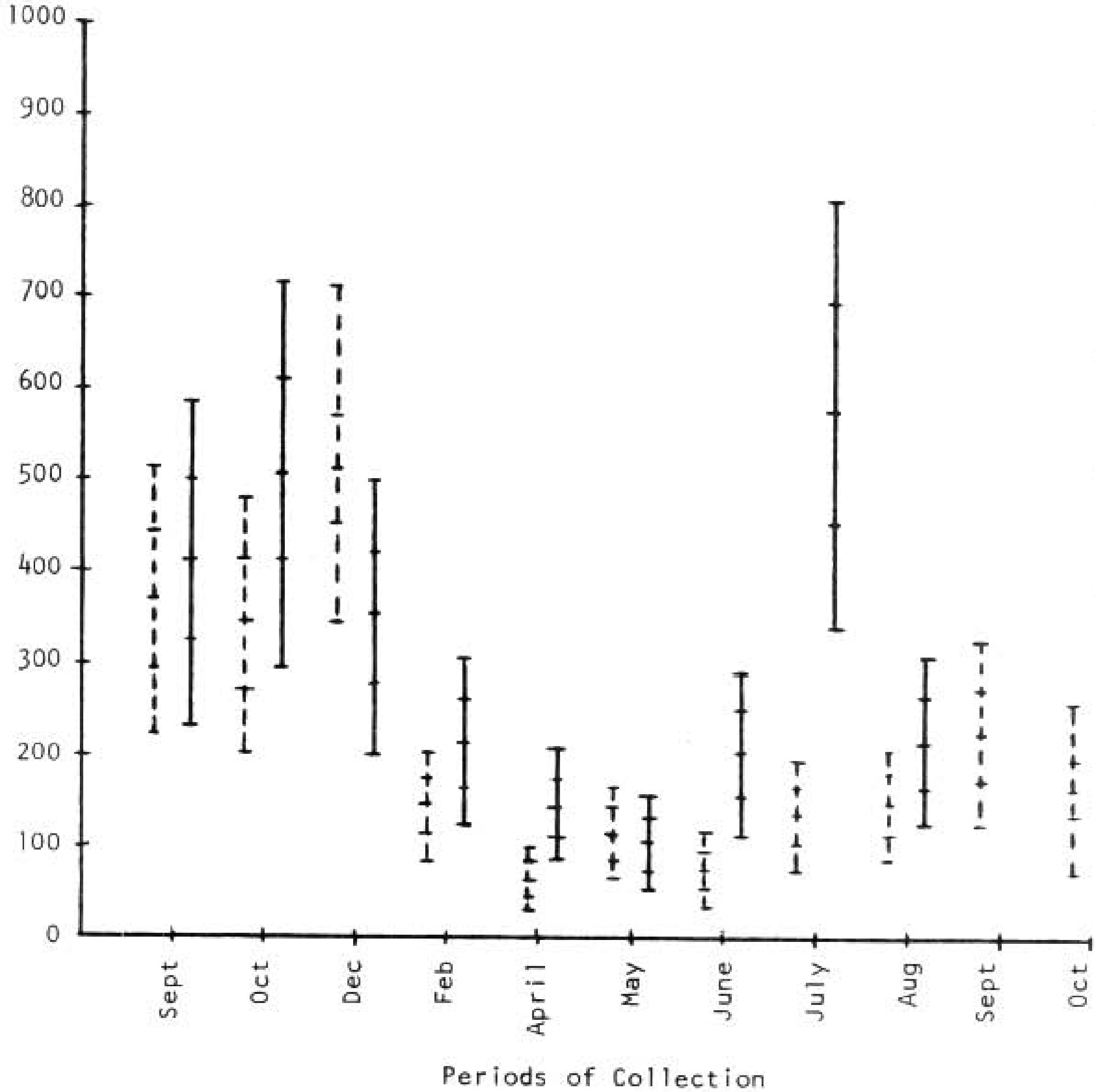


Fig. 9. Dry-weight of aboveground herbage of forbs, derived from readings of quadrats at kill-sites of black-tailed and white-tailed jackrabbits. Means, standard errors, and confidence intervals (at the P.95 level) are shown.

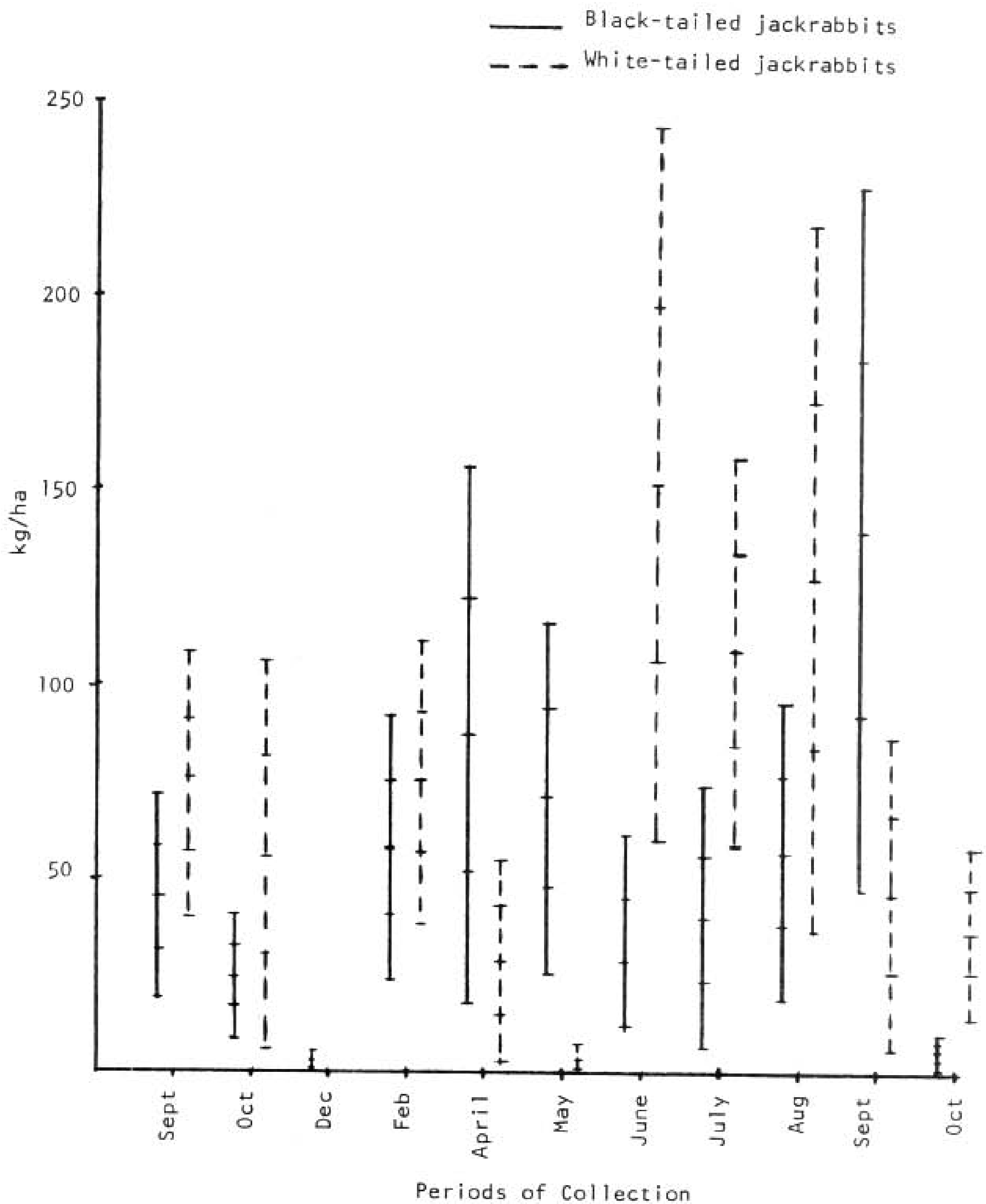


Fig. 10. Dry-weight of aboveground herbage of *Buchloe dactyloides*, derived from readings of quadrats at kill-sites of black-tailed and white-tailed jackrabbits. Means, standard errors, and confidence intervals (at the P.95 level) are shown.

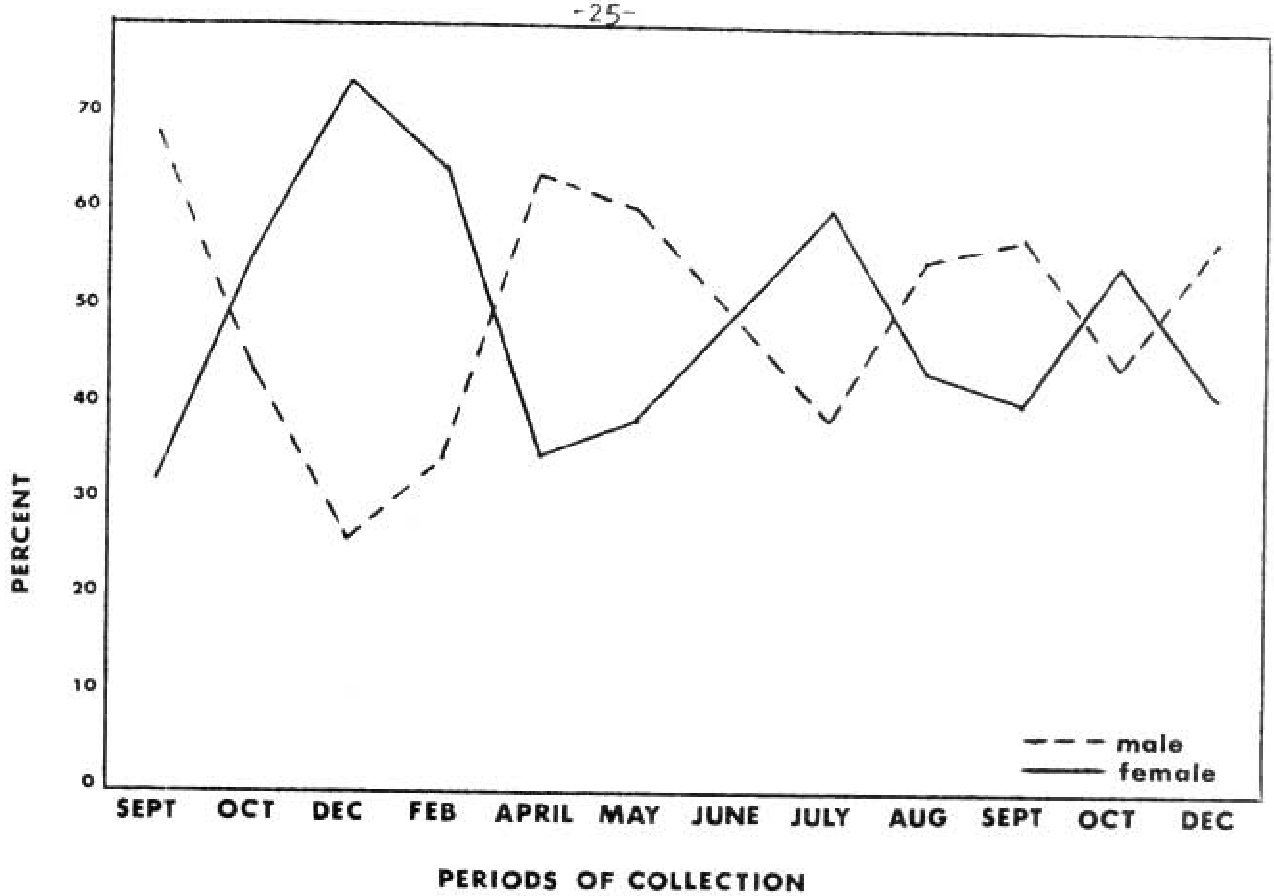


Fig. 11. Percent male and percent female black-tailed jackrabbits.

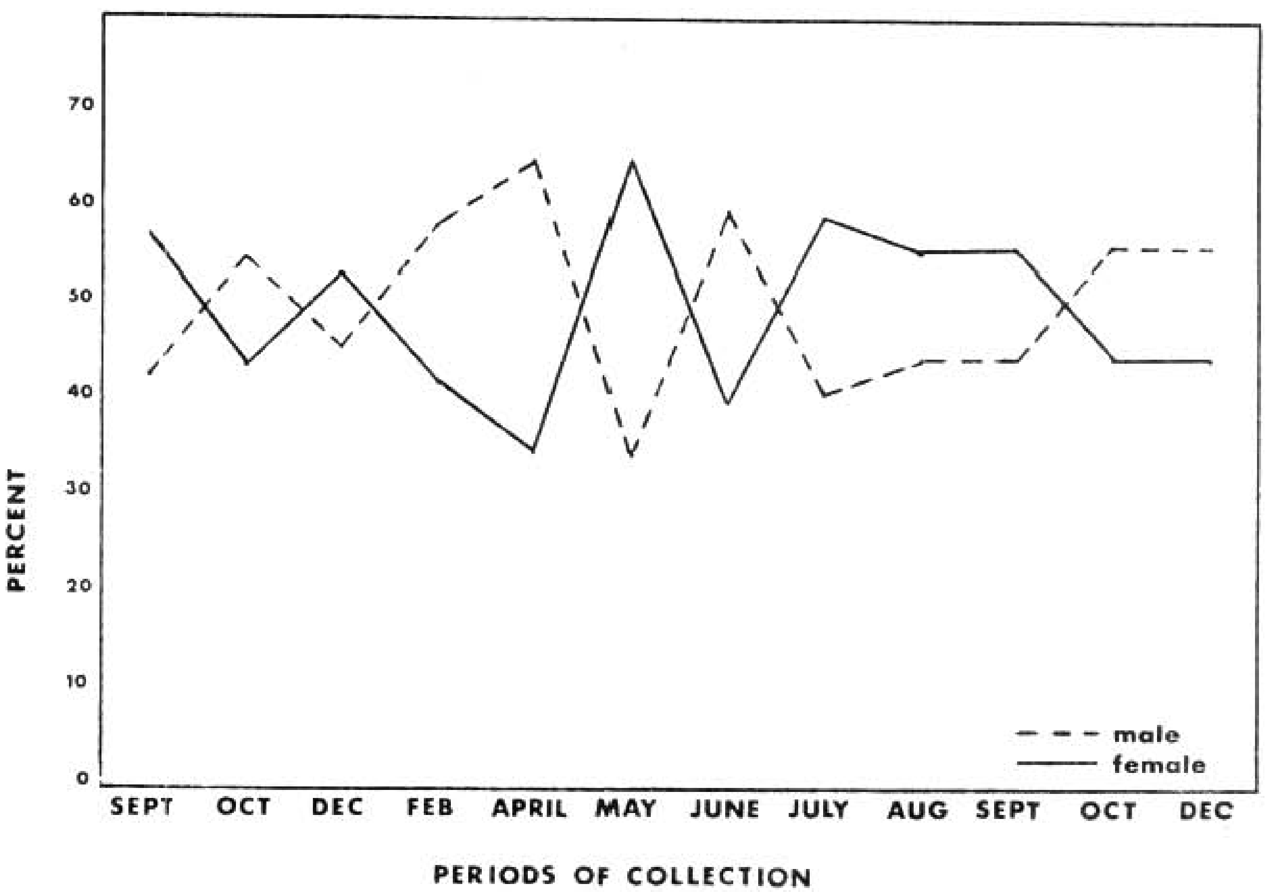


Fig. 12. Percent male and percent female white-tailed jackrabbits.

# APPENDIX I



```
      PROGRAM VEGTAT3 (INPUT=202B,OUTPUT=202B,PUNCH=202B,TAPE5=INPUT,
     1TAPE6=OUTPUT,TAPE7=PUNCH,TAPE1)
C        THIS PROGRAM IS DESIGNED FOR HANSENS STANDING CROP DATA.  IT IS SET UP IN
C A BATCH PROSSING FASHION TO HANDLE EACH DATA SET INDIVIDUALLY - AS MANY SETS
C AS DESIRED MAY BE INCLUDED PER RUN.  FOR EACH DATA SET A SUMMARY IS GIVEN FOR
C EACH SPECIES OF HARE BY BOTANICAL SPECIES IN THE STANDING CROP, INCLUDING:
C FREQUENCY OF OCCURRENCE, WET WEIGHT IN KG/HA CORRECTED FOR HUMAN ESTIMATION
C ERROR, DRY WEIGHT AND PERCENT DRY WEIGHT, STANDARD ERRORS AND 95 PERCENT
C CONFIDENCE LIMITS ABOUT THE DRY WEIGHT, AND THE RELATIVE PERCENT DRY WEIGHT OF
C EACH CATEGORY IN THE STANDING CROP.  OPTIONAL OUTPUT INCLUDES SIMILAR INFORMA-
C TION FOR EACH LOCATION SAMPLED INDIVIDUALLY (WITHOUT STD. ERRORS AND CONF.
C LIMITS) AND THE HUMAN ESTIMATION ERROR FACTORS COMPUTED FOR THE WET WEIGHTS.
C        VEGTAT3 CONSTITUTES AN EXTENSIVE REVISION AND CORRECTION OF
C  VEGTAT2 AS PREPARED BY MEL TAYLOR.
C  VAN BAKER  NATURAL RESOURCE ECOLOGY LAB - CSU - FALL, 1969.
C
C   REQUIRED INPUT:
C    I.  FOR EACH RUN:
C        A.  CONTROL CARD     COL.                  INFORMATION
C                              1-3     NUMBER OF GRASSES IN CATEGORY LIST - NG
C                              4-6     NUMBER OF FORBS IN CATEGORY LIST - NF
C                              7-9     TOTAL NUMBER OF CATEGORIES = NG + NF
C                             10-14    SIZE - FOR CORRECTION OF PLOTS TO KG/HA -
C                                      222.2 FOR 450 SQ. CM PLOTS.
C                               15     PUNCH CONTROL - 1 GIVES PERCENT DRY WEIGHT,
C                                      RELATIVE PERCENT DRY WEIGHT OF EACH STANDING
C                                      CROP CATEGORY AS PUNCHED OUTPUT FOR EACH DATA
C                                      SET.
C                              16      1 TO ACTIVATE NEW PRINT CONTROL.
C                              17      OPTIONAL PRINT CONTROL - 1 GIVES PRINTOUT FOR
C                                      EACH LOCATION (HARE) INDIVIDUALLY IN ADDITION
C                                      TO THE SUMMARY.
C        B.  CATEGORY LIST - AS MANY CARDS AS REQUIRED (FOR UP TO 150 CATEGOR-
C            IES:   FOUR LETTER SPECIES CODES (AS THEY APPEAR ON DATA CARDS)
C            PACKED 20 PER CARD, WITH GRASSES FIRST FOLLOWED BY FORBS (AND
C            SHRUBS).  THE LAST CODE IN EACH GROUP MUST BE FOR THE TOTAL OF THAT
C            GROUP - EG  TOTG AND TOTF.  THE ORDER OF THE CODES IN THIS LIST
C            CONTROLS THE ORDER OF CATEGORIES FOR PRINTED AND PUNCHED OUTPUT.
C   II.  FOR EACH DATA SET:
C        A.  CONTROL CARD:  COL.                    INFORMATION
C                            1-3        SAMPLE NUMBER
C                            4-5        NUMBER OF LOCATIONS (HARES) WITHIN THAT
C                                       SAMPLE (UP TO 53).
C                            9-10       NUMBER OF PLOTS PER LOCATION (USUALLY 10).
C                           11-80       SAMPLE IDENTIFICATION - WILL BE PRINTED AT
C                              *        THE TOP OF SAMPLE SUMMARY TABLES.
C        B.  FOR EACH LOCATION (HARE) WITHIN THAT DATA SET:
C            (DATA FOR ALL HARES OF ONE SPECIES MUST BE GROUPED TOGETHER BUT THE
C            ORDER OF THE GROUPS AND WITHIN GROUPS IS UNIMPORTANT).
C              IDENTIFICATION CARD:
C                            1-3        HARES NUMBER.
C                            4-5        MONTH (NUMBER).
C                            6-7        DAY STANDING CROP WAS TAKEN.
C                            8-9        NUMBER OF READERS - 1 THRU 5 ALLOWABLE.
```

```
C                           10-13     ALPHAMERIC SPECIES CODE - EG   WT.
C                           14-15     SPECIES NUMBER CODE - 1 OR 2 ALLOWABLE.
C               STANDING CROP DATA CARD(S) - AS MANY AS NEEDED, ONE CARD PER
C               SPECIES IN THE STANDING CROP.  (ALL NUMBERS RIGHT ADJUSTED WITH D
C               DECIMAL (IF ANY) PUNCHED).
C                            1-4      ALPHAMERIC CODE (MUST MATCH ONE ON THE CAT
C                                     CATEGORY LISTABOVE).
C                            5-9      ESTIMATED WEIGHT OF THAT SPECIES ON PLOT 1
C                           10-14     ESTIMATED WEIGHT OF THAT SPECIES ON PLOT 2
C                           ...       ...
C                           50-54     ESTIMATED WEIGHT OF THAT SPECIES ON PLOT 10
C                           55-59     ESTIMATED WEIGHT ON CLIPPED PLOT
C                           60-64     ACTUAL WEIGHT (GREEN) ON CLIPPED PLOT
C               TRAILER CARD -  COL. 1-3 - 111
C   ***         REPEAT B. ABOVE FOR EACH HARE IN DATA SET (COL. 4-6 OF CONTROL
C               CARD II. A.)
C          C.  DRY WEIGHT CORRECTIONS FOR DATA SET (FROM CLIPPED PLOTS):  ONE CARD
C              FOR EACH CATEGORY (SPECIES) FOUND IN ANY LOCATION FOR THAT DATA SET
C                            1-4      SPECIES CODE (AS ON LIST)
C                            5-9      WET WEIGHT (CLIPPED)
C                           10-14     DRY WEIGHT
C               TRAILER CARD -  COL. 1-3 - 111
C   ***        . REPEAT II. ABOVE FOR EACH DATA SET TO BE INCLUDED IN THIS RUN.
C III.  AFTER LAST DATA SET - TRAILER CARD TO SIGNAL END OF RUN:
C                     COL.  1-3  - 999
C
C     **************************************************************
C

      COMMON IDENT(7),IDT(53),MAN(53),ISPCD(2),ISPNO(53),
     1EST(10),ESTW(53,130),DWT2(130),LIST(130),TOTACT(53),ESTW2(53,130),
     2LPC( 6,130),RELDEN(130),LTLPC(130),NUM(2),CORF(5,130)
      DIMENSION TOTEST(130),TOTDWT(130),VARE(130),TOTREL(130),TOT(130),
     1TOTD(53), TOTE(53), CTMP(5,130),CI(130)
      DIMENSION AGC(5),AFC(5)
      EQUIVALENCE (DWT2,TOTDWT),(RELDEN,TOTEST)
      EQUIVALENCE (CORF(1),VARE),(CORF(131),TOTREL),(CORF(261),TOT),
     1(CORF(391),CI),  (CORF(521),TOTD),(CORF(574),TOTE)

C     READ LIST OF DIET CATEGORIES AND THE NUMBER IN SUB-CATEGORIES
      READ 99, NG,NF,NCAT,SIZE,IPN,IZ,INC,(LIST(I),I=1,NCAT)
   99 FORMAT (3I3,F5.0,3I1/10(20A4/))

C  RETURN TO HERE FOR BATCH PROCESSING
    1 CONTINUE
C     READ CONTROL AND IDENTIFICATION CARD
      IF (IZ.EQ.1) GO TO 1000
      READ 100,NSAM,NST,INC,NP,IDENT
  100 FORMAT(2I3,I2,I2,7A10)
      IF (NSAM.NE.999) GO TO 14
 1000 PRINT 110
  110 FORMAT(1H1)
      STOP

C   ERROR MESSAGES
 1005 PRINT 501, NSITE,ISPP,IDENT
```

```
  501 FORMAT (' WRONG SPECIES NUMBER CODE - HARE'I4', SPECIES 'A5' ID= '
     17A10)
      IF (M.EQ.1) ISPNO(M)=1
      IF (M.GT.1) ISPNO(M)=ISPNO(M-1)
      GO TO 1006
 1002 PRINT 502, NSITE,ISPP,IDENT
  502 FORMAT (' TOO MANY SPECIES ENCOUNTERED - HARE NUMBER'I4', SPECIES
     1'A5,' ID= '7A10)
      MX=2
      GO TO 5

 1000 READ 500,NSAM,NST,NP,IDENT
  500 FORMAT (2I3,2X,I2,7A10)
      IF (NSAM.EQ.999) GO TO 1001
   14 CONTINUE
C     INITIALIZE ARRAYS TO ZERO
      DO 4 J=1,NCAT
      DO 21 I=1,NST
      ESTW(I,J)=0.
      ESTW2(I,J)=0.0
      TOTACT(I)=0.0
   21 CONTINUE
      LTLPC(J)=0
      DO 41 I=1,6
   41 LPC(I,J)=0
      DO 19 I=1,5
      CTMP(I,J)=0.
   19 CORF(I,J)=0.
    4 DWT2(J)=0.
      DO 25 I=1,5
      AGC(I)=0.
   25 AFC(I)=0.
      NUM(1)=0
      NUM(2)=0
      MX=1
      KXT=0
      N=0

      DO 10 M=1,NST
C   M=SITE (HARE) NUMBER WITHIN PROGRAM - A COUNTER.
C     READ IDENTIFICATION FOR EACH SITE
      READ 101, NSITE,ID,IDT(M),MAN(M),ISPP,ISPNO(M)
  101 FORMAT (I3,3I2,A4,I2)
C   STORE SITE NO. IN LEFT HALF OF IDT(M).
      CALL SBYTE (IDT(M),NSITE,0,30)
      CALL SBYTE (IDT(M),ID,30,18)
C     COUNT NUMBER OF ANIMALS IN EACH SPECIES AND NO. OF SPECIES
      INO=ISPNO(M)
      IF (INO.LT.1.OR.INO.GT.2) GO TO 1005
 1006 NUM(INO)=NUM(INO)+1
      IF (M.EQ.1) ISPCD(INO)=ISPP
      IF(M.EQ.1)GO TO 5
      IF (ISPNO(M).NE.ISPNO(M-1)) ISPCD(INO)=ISPP
      IF(ISPNO(M).NE.ISPNO(M-1))MX=MX+1
      IF (MX.GT.2) GO TO 1002
    5 CONTINUE
```

```
C     READ VEGETATION DATA FOR EACH PLANT ON EACH SITE FOR EACH READER
    2 CONTINUE
      READ 102, NAMET,(ESTI(J),J=1,NP),ESTWT,ACTT
  102 FORMAT (A4,1X,12F5.0)
      IF (NAMET.EQ.4HIIII ) GO TO 10
C     TRANSFER DATA TO LARGE ARRAY FOR MANIPULATION
      DO 15 I=1,NCAT
      IF(NAMET   .NE.LIST(I))GO TO 15
C     CALCULATE TOTAL ESTIMATED AND TOTAL ACTUAL WEIGHT FOR CLIPPED PLOTS
C     FOR EACH SPECIES, EACH MAN, OVER ALL SITES
      IMN=MAN(M)
      CORF(IMN,I)=CORF(IMN,I)+ESTWT
      CTMP(IMN,I)=CTMP(IMN,I)+ACTT
      DO 27 J=1,NP
C     COUNT FREQUENCY OF EACH SPECIES ON EACH SITE
      IF (ESTI(J).LE.0.) GO TO 27
C  PACK THE FREQUENCY DATA IN LPC WITH 10 NUMBERS ALLOWED PER WORD
      IW=(M-1)/10+1
      IB=6*MOD(M-1,10)
      CALL GBYTE (LPC(IW,I),JTMP,IB,6)
      JTMP=JTMP+1
      CALL SBYTE (LPC(IW,I),JTMP,IB,6)
C     TOTAL THE TEN PLOTS FOR EACH SPECIES ON EACH SITE
      ESTW(M,I)=ESTW(M,I)+ESTI(J)
   27 CONTINUE
      IF (ISPNO(M).EQ.1) IK=0
      IF (ISPNO(M).EQ.2) IK=30
C   FREQUENCIES FOR SPP. 1 ARE STORED IN LEFT HALF OF LTLPC, SPP. 2 IN RIGHT.
      IW=(M-1)/10+1
      IB=6*MOD(M-1,10)
      CALL GBYTE (LPC(IW,I),JTMP,IB,6)
      CALL GBYTE (LTLPC(I),ITMP,IK,30)
      ITMP=ITMP+JTMP
      CALL SBYTE (LTLPC(I),ITMP,IK,30)
   -  GO TO 2
   15 CONTINUE
      CALL GBYTE (IDT(M),NSITE,0,30)
      PRINT 299, NAMET,NSITE,IDENT
  299 FORMAT (' SPECIES ',A4,' NOT ON LIST - FROM MARE',I4,', ID = ',
     1 7A10)
      GO TO 2
   10 CONTINUE

C     READ DRY WEIGHT DATA FOR EACH SAMPLE, EACH SPECIES
    9 CONTINUE
      READ 104, NAMET,WET,DWT
  104 FORMAT(A4,2F5.0)
      IF (NAMET.EQ.4HIIII ) GO TO 8
C   COMPUTE PERCENT DRY WEIGHT
      DO 16 N=1,NCAT
      IF (NAMET.NE.LIST(N)) GO TO 16
      IF (WET.LE.0.) GO TO 9
      DWT2(N)=DWT/WET
      GO TO 9
   16 CONTINUE
      PRINT 298, NAMET,IDENT
```

```
  298 FORMAT (' SPECIES ',A4,' NOT ON LIST - FROM CLIPPED PLOTS,  ID = '
     1,7A10)
      GO TO 9
    8 CONTINUE
C     COMPUTE HUMAN CORRECTION FACTOR
C  COMPUTE AVERAGE CORRECTION FACTOR FOR EACH MAN FOR GRASSES AND FORBS
      DO 24 K=1,5
      S=0.
      DO 22 I=1,NG
      S=S+CTMP(K,I)
   22 AGC(K)=AGC(K)+CORF(K,I)
      IF (S.EQ.0.) GO TO 26
      AGC(K)=AGC(K)/S
   26 J=NG+1
      S=0.
      DO 25 I=J,NCAT
      S=S+CTMP(K,I)
   25 AFC(K)=AFC(K)+CORF(K,I)
      IF (S.EQ.0.) GO TO 24
      AFC(K)=AFC(K)/S
   24 CONTINUE
C  CORRECTION FACTOR FOR EACH MAN, SPECIES = SUM EST. WTS. / SUM ACT. WTS.
      DO 17 I=1,NCAT
      DO 17 K=1,5
      IF (CTMP(K,I).EQ.0.) GO TO 18
      IF (CORF(K,I).EQ.0.) GO TO 18
      CORF(K,I)=CORF(K,I)/CTMP(K,I)
      GO TO 17
   18 IF (I.LE.NG) CORF(K,I)=AGC(K)
      IF (I.GT.NG) CORF(K,I)=AFC(K)
   17 CONTINUE
   33 M=KXT+1
      DO 29 N=1,NCAT
      RELDEN(N)=0.
      IF (ESTW(M,N).EQ.0.) GO TO 29
      K=MAN(M)
C     COMPUTE THE ESTIMATED CORRECTED DRY WEIGHT FOR EACH SPECIES ON EACH SITE
C     CONVERT TO KG/HEC
      ESTW(M,N)=(ESTW(M,N)/CORF(K,N))*(SIZE/FLOAT(NP))
      ESTW2(M,N)=ESTW(M,N)*DWT2(N)
C     FIND TOTAL DRY WEIGHT OF ALL SPECIES ON EACH SITE
      TOTACT(M)=TOTACT(M)+ESTW2(M,N)
   29 CONTINUE
   34 K=MAN(M)
C     PRINT RESULTS OF CALCULATIONS FOR EACH SITE(OPTIONAL)
      IF(INC.EQ.0)GO TO 49
      IF(M.EQ.1)PRINT 110
      IND=ISPNO(M)
      CALL GBYTE (IDT(M),NSITE,0,30)
      CALL GBYTE (IDT(M),ID,30,18)
      CALL GBYTE (IDT(M),IE,48,12)
      PRINT 120,IDENT,NSAM,ID,IE, MAN(M),NSITE,   ISPC(IND)
  120 FORMAT(1H0,130(*-*)/1H ,7A10/1H ,*SAMPLE*I4,*   DATE*I5*/*I2*   RE
     1ADER*I3*   HARE*I4*   SPECIES*A5)
      PRINT 121
  121 FORMAT(1H ,130(*-*)/1H *SPECIES    OCCURRENCE    WET WEIGHT   DRY
```

```
     1WEIGHT   PERCENT DWT   RELATIVE PC DWT    HUMAN CORRECTION"/1H ,13
     10("*"))
C     CALCULATE RELATIVE PERCENT DRY WEIGHT FOR EACH SPECIES ON EACH SITE
C     AND FOR GRASSES AND FORBS SEPARATELY AS A TOTAL
      DO 30 N=1,NCAT
      IF(N.EQ.NG.OR.N.EQ.(NF+NG))GO TO 40
      IF (TOTACT(M).EQ.0.) GO TO 31
      RELDEN(N)=ESTW2(M,N)/TOTACT(M)
      IF (N.LT.NG) RELDEN(NG)=RELDEN(NG)+RELDEN(N)
      IF (N.GT.NG) RELDEN(NG+NF)=RELDEN(NG+NF)+RELDEN(N)
   31 CONTINUE
      IW=(M-1)/10+1
      IB=6*MOD(M-1,10)
      CALL GBYTE (LPC(IW,N),JTMP,IB,6)
      IF (JTMP.EQ.0) GO TO 30
   40 PRINT 122,LIST(N),JTMP,    ESTW(M,N),ESTW2(M,N),DWT2(N), RELDEN(N)
     1,CORF(K,N)
  122 FORMAT(1H ,A4,I12,F18.4,F12.4,F13.4,F16.4,F20.4)
   30 CONTINUE
   49 KXT=KXT+1
      IF (KXT.LT.NST) GO TO 33
C***************************************************************************
C     BEGIN SUMMARY ROUTINE
   50 ND=1
      DO 65 I=1,MX
C     PRINT HEADER
      INO=ISPNO(ND)
      PRINT 131,IDENT,ISPCD(INO)
  131 FORMAT(1H1,7A10/1H "SUMMARY FOR SPECIES"A4/1H 130("*")/1H "SPECIES
     1    PC OCCURNC    WET WEIGHT    DRY WEIGHT    STD ERROR    CONF INT
     1T   REL PC DWT"/1H ,130("*"))
      IF(I.NE.1)GO TO 70
      IK=0
      NC=NUM(INO)
      GO TO 71
   70 NC=NUM(1)+NUM(2)
      IK=30
   71 TOTWT=TOTWET=0.0
C     FIND TOTAL WET AND DRY WEIGHT FOR EACH SITE, ALL SPECIES INCLUDED
      DO 59 M=ND,NC
      TOTE(M)=TOTD(M)=0.0
      DO 59 N=1,NCAT
      TOTE(M)=TOTE(M)+ESTW(M,N)
      TOTD(M)=TOTD(M)+ESTW2(M,N)
   59 CONTINUE
C     FIND TOTALS FOR FREQUENCY, ESTIMATED WEIGHTS, AND DRY WEIGHT
      NN=NC-ND+1
      DO 60 N=1,NCAT
      TOTEST(N)=0.0
      TOTDWT(N)=0.0
      VARE(N)=0.0
      DO 51 M=ND,NC
      TOTEST(N)=TOTEST(N)+ESTW(M,N)
      TOTDWT(N)=TOTDWT(N)+ESTW2(M,N)
   51 CONTINUE
C     FIND TOTAL DRY WEIGHT FOR ALL SPECIES, ALL PLOTS, ALL MEN
```

```
      IF (TOTDWT(N).LE.0.) GO TO 60
   67 TOTWT=TOTWT+TOTDWT(N)
      TOTWET=TOTWET+TOTEST(N)
C     CALCULATE MEAN OF DRY WEIGHTS
      TOTEST(N)=TOTEST(N)/FLOAT(NN)
      TOTDWT(N)=TOTDWT(N)/FLOAT(NN)
   60 CONTINUE
      TOTWET=TOTWET/FLOAT(NN)
      TOTWT=TOTWT/FLOAT(NN)
      TOTEST(NG)=TOTDWT(NG)=TOT(NG)=0.0
      TOTEST(NG+NF)=TOTDWT(NG+NF)=TOT(NG+NF)=0.0
      TOTREL(NG)=TOTREL(NG+NF)=0.0
      DO 61 N=1,NCAT
      DO 62 M=ND,NC
C     CALCULATE STANDARD ERROR AND CONFIDENCE LIMITS FOR MEAN OF DRY WEIGHTS
      ESTW2(M,N)=ESTW2(M,N)-TOTDWT(N)
   62 VARE(N)=VARE(N)+(ESTW2(M,N))**2
      VARE(N)=SQRT(VARE(N)/(FLOAT(NN)-1.0)/FLOAT(NN))
      NT=10*NN
      CI(N)=VARE(N)*T(NT)
C     FIND TOTAL DRY WEIGHT, WET WEIGHT, RELATIVE DENSITY, AND PERCENT
C     OCCURRENCE OF GRASSES AND FORBS FOR EACH SPECIES OF ANIMAL
      IF(N.EQ.NG.OR.N.EQ.(NG+NF))GO TO 72
      CALL GBYTE (LTLPC(N),ITMP,IK,30)
      TOT(N)=(FLOAT(ITMP))/(FLOAT(NN)*FLOAT(NP))
      TOTREL(N)=TOTDWT(N)/TOTWT
      IF(N.LE.NG-1)73,74
   73 TOTREL(NG)=TOTREL(NG)+TOTREL(N)
      TOTEST(NG)=TOTEST(NG)+TOTEST(N)
      TOTDWT(NG)=TOTDWT(NG)+TOTDWT(N)
      GO TO 78
   74 TOTREL(NG+NF)=TOTREL(NG+NF)+TOTREL(N)
      TOTEST(NG+NF)=TOTEST(NG+NF)+TOTEST(N)
      TOTDWT(NG+NF)=TOTDWT(NG+NF)+TOTDWT(N)

C     PRINT SUMMARY TABLE
   78 IF(TOT(N).EQ.0.0)GO TO 77
   72 PRINT 130,LIST(N),TOT(N),TOTEST(N),TOTDWT(N),VARE(N),CI(N),
     1TOTREL(N)
  130 FORMAT(1H ,A4,F14.4,F16.4,F14.4,2F13.4,F11.4)
   77 TOTREL(N)=TOTREL(N)*100.
   61 CONTINUE
C     CALCULATE 95 PERCENT CONFIDENCE LIMITS FOR THE MEAN DRY WEIGHT
C     PER HECTARE, AND FOR WET WEIGHT PER HECTARE
      VARWT=VARDY=0.0
      DO 65 M=ND,NC
      TOTE(M)=TOTE(M)-TOTWET
      TOTD(M)=TOTD(M)-TOTWT
      VARWT=VARWT+TOTE(M)**2
      VARDY=VARDY+TOTD(M)**2
   65 CONTINUE
      VARWT=SQRT(VARWT/(FLOAT(NN)-1.0)/FLOAT(NC))
      VARDY=SQRT(VARDY/(FLOAT(NN)-1.0)/FLOAT(NC))
      CW=VARWT*T(NT)
      CD=VARDY*T(NT)
C     PRINT OVERALL TOTALS WITH CONFIDENCE LIMITS
```

```
      PRINT 202, TOTWET,VARWT,CW,TOTWT,VARDY,CD
  202 FORMAT(1H0,130("*")/1H0"TOTAL MEAN WET WEIGHT IN KG/HA IS"F15.4" +
     1/- SE "F11.4," +/- CI "F11.4/"0TOTAL MEAN DRY WEIGHT IN KG/HA IS"
     2F15.4" +/- SE "F11.4" +/- CI "F11.4/1H0,130("*"))
      PRINT 250, NN
  250 FORMAT ("0THIS SUMMARY IS BASED ON"I3" LOCATIONS")
C     PUNCH RELATIVE PERCENT DRY WEIGHT CARDS FOR USE IN PROGRAM DIETS
      IF(IPN.EQ.0)GO TO 95
      ID=ISPNO(ND)
      PUNCH 205,NSAM,ISPCD(ID),(TOTREL(L),L=1,NCAT)
      PUNCH 204,NSAM,ISPCD(ID),(TOTDWT(L),L=1,NCAT)
  204 FORMAT("DRY WT"I3,A4/10(16F5.1/))
  205 FORMAT("REL PC DWT"I3,A4/10(16F5.1/))
   95 ND=NUM(IND)+1
   65 CONTINUE
      GO TO 1
      END
```

```
      FUNCTION T(KT)
C     THIS FUNCTION RETURNS A T-VALUE AT THE .05 LEVEL FOR ANY
C     NUMBER OF SAMPLES UP TO 50, AND 2.0 FOR KT GREATER THAN 50.
      DIMENSION X(50)
      DATA (X(I),I=1,50)/12.706,4.303,3.182,2.776,2.571,2.447,2.365,
     12.306,2.262,2.228,2.201,2.179,2.160,2.145,2.131,2.12,2.11,2.101,
     12.093,2.086,2.080,2.074,2.069,2.064,2.060,2.056,2.052,2.048,
     12.045,2.042,2.040,2.038,2.036,2.035,2.030,2.028,2.026,2.024,
     12.022,2.021,2.019,2.017,2.016,2.105,2.014,2.012,2.011,2.010,
     12.009,2.008/
      IF(KT.GT.50)1,2
    1 T=2.0
      RETURN
    2 T=X(KT)
      RETURN
      END
```

APPENDIX II



```
      PROGRAM SIMDIET
     1 (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C      THIS PROGRAM IS DESIGNED FOR HANSENS AND FLINDERS HARE DIET DATA.  IT IS
C SET UP IN A BATCH PROCESSING FASHION TO HANDLE EACH DATA SET INDIVIDUALLY -
C AS MANY DATA SETS AS DESIRED MAY BE INCLUDED PER RUN.  FOR ANY ONE DATA SET,
C OUTPUT MAY BE OF 3 OPTIONAL TYPES, OR ANY COMBINATION OF THESE THREE:
C     1)  RELATIVE DENSITY SUMMARY - MEANS AND STANDARD ERRORS ARE GIVEN FOR EACH
C         CATEGORY IN THE DIETS FOR SEVEN SUBSETS OF THE HARES INCLUDED IN THAT
C         DATA SET - NAMELY: ALL HARES, ALL BT HARES, BT MALES, BT FEMALES, ALL -
C         WT HARES, ALL WT MALES, AND ALL WT FEMALES.  THE NUMBER OF HARES IN
C         EACH SUBSET IS TABULATED.
C     2)  PREFERENCE INDEX SUMMARY - AS ABOVE BUT PREFERENCE INDICIES ARE GIVEN.
C         FOR THIS OPTION, DRY WEIGHT OF AVAILABLE STANDING CROP FOR EACH SPECIES
C         IN THE DIETS MUST BE INCLUDED WITH EACH DATA SET (SEE INPUT SECTION
C         BELOW).  THE FORMAT MAY BE VARIABLE BETWEEN DATA SETS, BUT THE ORDER
C         OF DIET CATEGORIES MUST BE AS IN THE CATEGORY LIST INCLUDED AT THE
C         FIRST OF EACH RUN.
C     3)  SIMILARITY INDICIES - THE DIETS OF ALL POSSIBLE PAIRS OF THE ABOVE
C         SUBSETS OF HARES ARE COMPAREDVIA A COEFFICIENT OF COMMUNITY TYPE INDEX.
C   VAN BAKER   NATURAL RESOURCES ECOLOGY LAB - CSU - WINTER, 1969
C   EXPECTED INPUT:
C   I.   FOR EACH RUN:
C        A.  CONTROL CARD    COL.               INFORMATION
C                             3     1 IF OPTION 1 (ABOVE) IS DESIRED
C                             6     1 IF OPTION 2 IS DESIRED
C                             9     1 IF OPTION 3 IS DESIRED
C                           10-12   NUMBER OF ENTRIES IN THE CATEGORY LIST  NG+NF
C                           13-15   NUMBER OF GRASSES IN THE CATEGORY LIST  NG
C                           16-18   NUMBER OF FORBS IN THE CATEGORY LIST    NF
C                                     THE LIST SHOULD NOT INCLUDE CATEGORIES FOR
C                                   TOTAL GRASSES OR TOTAL FORBS - THESE ARE
C                                   COMPUTED WITHIN THE PROGRAM.
C        B.  CATEGORY LIST - AS MANY CARDS AS REQUIRED (FOR UP TO 70 ENTRIES):
C                FOUR LETTER SPECIES CODES (AS THEY APPEAR ON DATA CARDS)
C                PACKED 20 PER CARD WITH GRASSES FIRST FOLLOWED BY FORBS (AND
C                SHRUBS).  THE ORDER OF THE CODES IN THIS LIST CONTROLS THE
C                ORDER OF PRINTED OUTPUT FOR OPTIONS 1 AND 2.
C   II.  FOR EACH DATA SET:
C        A.  HEADER CARD     COL.               INFORMATION
C                            1-3    HARE NUMBER
C                            4-5    ALPHAMERIC SPECIES CODE
C                            6-11   DATE - MONTH,DAY,YEAR  (NUMERIC)
C                            12     SEX - M OR F
C                           13-14   READERS INITIALS
C                           15-16   WEIGHT - POUNDS
C                           18-19            OUNCES
C                           21-22   TIME OF KILL - HOURS AFTER MIDNIGHT
C                           24-25            MINUTES
C                            26     LOCATION - 10 THS OF MILE E OF SW CORNER OF
C                                             SECTION
C                            29          10 THS OF MILE N OF SW CORNER OF SECTION
C                           32-33        SECTION NUMBER
C                           35-36        TOWNSHIP NUMBER
C                           38-39        RANGE NUMBER
C                           41-42        NUMBER OF SPECIES IN DIET OF HARE - NSP
```

```
C                    SKIPPED COLUMNS MAY BE FILLED WITH PUNCTUATION OR ETCETERA
C                    FOR EASIER READING OF CARDS.
C          B.  DIET CARD(S) AS NEEDED (USUALLY ONE)
C                UP TO 15 GROUPS OF 6 COLUMNS EACH PACKED PER CARD, WHERE A
C                GROUP CONSISTS OF A 4 COLUMN SPECIES CODE AND 2 COLUMNS FOR THE
C                FREQUENCY OF THAT SPECIES.
C   ***        REPEAT  A. AND B. ABOVE FOR EACH HARE IN THAT DATA SET.
C          C.  TRAILER CARD  -  $$$ IN COLUMNS 1-5 AFTER EACH DATA SET EXCEPT THE
C                LAST.  $$$$$ IN COLUMNS 1-5 AFTER LAST DATA SET TO SIGNAL END
C                OF RUN.
C
C     ****************************************************************
C
      COMMON  LIST(70),KEY(70),ISEX(53),ISPP(53)
      COMMON/L2/NS,NF
      DIMENSION LBUF(15),KUF(15),DWT(70),ID(54),LOC(5),DEN(53,70),
     1PREF(53,70),IFMT(8),IDT(3),IWT(2),ITM(2),SIM(70,6),TOT(53)
      DIMENSION DENFCN(20),IDENT(7)
      DATA DENFCN/.05,.10,.16,.22,.29,.35,.43,.51,.60,.69,.80,.91,1.05,
     1 1.20,1.39,1.61,1.89,2.30,2.99,6.91/
C  READ CONTROL CARDS
      READ 100, IRD,IPI,ISI,NCAT,NS,NF
  100 FORMAT (6I5)
      READ 101, (LIST(I),I=1,NCAT)
  101 FORMAT (20A4)
    5 CONTINUE
C  RETURN TO HERE FOR EACH BATCH OF DATA
C  IF REQUIRED, READ DRYWEIGHT FORMAT AND CARDS
      READ 110, NSAM,IDENT
  110 FORMAT (I5,5X,7A10)
      PRINT 210, NSAM,IDENT
  210 FORMAT ('1  SAMPLE'I5,8X,7A10//)
      IF (IPI.NE.1) GO TO 1
      READ 102, IFMT
  102 FORMAT (8A10)
      READ IFMT, (DWT(I),I=1,NCAT)
    1 CONTINUE
C  INITIALIZE COUNTERS AND ARRAYS
      DO 10 I=1,NCAT
      DO 9 J=1,53
      PREF(J,I)=0.
    9 DEN(J,I)=0.
      KEY(I)=0
   10 CONTINUE
      [illegible]=0
      DO 8 I=1,53
    8 TOT(I)=0.
C  READ DATA FOR ONE HARE
    2 [illegible]=[illegible]+1
      READ 105, ID([illegible]),ISPP([illegible]),IDT,ISEX([illegible]),IREAD,IWT,ITM,LOC,NSP
  105 FORMAT (A5,A2,5[illegible]2,A1,A2,5[illegible]2,[illegible],I2,2[illegible],2A1,2[illegible]2,[illegible],2I2)
      IF (NSP.GT.15) PRINT 800
  800 FORMAT ('[illegible]*****  MORE THAN 15 SPP. IN DIET - CHANGE INPUT')
      IF (ID([illegible]).EQ.5H$$$$$) GO TO 20
      READ 10[illegible], (LBUF(I),KUF(I),I=1,NSP)
```

```
  107 FORMAT (I3,A4,I2)
C  DECIDE WHETHER TO INCLUDE HARE IN THIS RUN

C  STORE DATA IN KEYED ARRAYS
      DO 12 I=1,NSP
      DO 11 J=1,NCAT
      IF (LBUF(I).EQ.LIST(J)) GO TO 13
   11 CONTINUE
      PRINT 250, LBUF(I),ID(JNO),IDT
  250 FORMAT (" WRONG SPECIES CODE  ",A5" FROM "A5"ON"2(I2"/"),I2)
   13 IF (KUF(I).LE.0) GO TO 14
      JJ=KUF(I)
      DEN(JNO,J)=DENFCN(JJ)
   14 KEY(J)=1
      TOT(JNO)=TOT(JNO)+DEN(JNO,J)
   12 CONTINUE
      GO TO 2

   20 CONTINUE
      JNO=JNO-1
      IF (JNO.GT.55) PRINT 801, JNO
  801 FORMAT ("0TOO MANY HARES - "I3" COUNTED")
      IF (JNO.GT.55) JNO=55
C  CONVERT DENSITIES TO RELATIVE DENSITIES
      DO 22 I=1,NCAT
      IF (KEY(I).EQ.0) GO TO 22
      DO 21 J=1,JNO
      IF (DEN(J,I).LT.0.) DEN(J,I)=0.
   21 DEN(J,I)=DEN(J,I)/TOT(J)
   22 CONTINUE
      IF (IRD.NE.1) GO TO 30

C  COMPUTE MEANS,STANDARD ERRORS OF RELATIVE DENSITIES (APPROX. PERCENT DWT)
C  AND OUTPUT
      PRINT 205
  205 FORMAT ("0RELATIVE DENSITY SUMMARY"/130("*")/)
      CALL SEPOUT (DEN,JNO,NCAT)
   30 IF (IPI.NE.1) GO TO 40

C  COMPUTE PREFERENCE INDICIES, MEANS AND STANDARD ERRORS AND OUTPUT
      DO 32 I=1,NCAT
      IF (KEY(I).EQ.0) GO TO 32
      IF (DWT(I).LE.0.) GO TO 32
      DO 31 J=1,JNO
      PREF(J,I)=DEN(J,I)/DWT(I)
   31 CONTINUE
   32 CONTINUE
      PRINT 206
  206 FORMAT ("0PREFERENCE INDEX SUMMARY"/130("*")/)
      CALL SEPOUT (PREF,JNO,NCAT)
   40 CONTINUE

      IF (ISI.NE.1) GO TO 50
C  COMPUTE SIMILARITY INDICES AND OUTPUT
C  SEPARATE RELATIVE DENSITIES INTO SIM  AS SUMS FOR ALL DIET CATEGORIES FOR
C  ALL BT, BT MALES, BT FEMALES, ALL WT, WT MALES, AND WT FEMALES, RESPECTIVELY
```

```
      DO 41 I=1,NCAT
      DO 41 J=1,6
   41 SIM(I,J)=0.
      DO 46 J=1,NCAT
      IF (KEY(J).EQ.0) GO TO 46
      DO 45 I=1,JNO
      IF (ISPP(I).EQ.2HAT) GO TO 43
      SIM(J,1)=SIM(J,1)+DEN(I,J)
      IF (ISEX(I).EQ.1HF) GO TO 42
      SIM(J,2)=SIM(J,2)+DEN(I,J)
      GO TO 45
   42 SIM(J,3)=SIM(J,3)+DEN(I,J)
      GO TO 45
   43 SIM(J,4)=SIM(J,4)+DEN(I,J)
      IF (ISEX(I).EQ.1HF) GO TO 44
      SIM(J,5)=SIM(J,5)+DEN(I,J)
      GO TO 45
   44 SIM(J,6)=SIM(J,6)+DEN(I,J)
   45 CONTINUE
   46 CONTINUE
      PRINT 207
  207 FORMAT ('1SIMILARITY INDICIES'/130('*')/)
      CALL SOREN (SIM,6,NCAT)
   50 IF (ISPP(JNO+1).NE.2H$$) GO TO 5
      STOP
      END
```

```
      SUBROUTINE SEPOUT (A,UND,NCAT)
C     TO SEPARATE AND SUMMARIZE THE ARRAY  A  TO GIVE MEANS AND STANDARD ERRORS
C  BY SPECIES IN THE DIETS FOR ALL HARES COMBINED, FOR WT AND BT HARES, AND
C  BY SEX WITHIN SPECIES, AND TO OUTPUT THE RESULTS
      COMMON  LIST(70),KEY(70),ISEX(53),ISPP(53)
      COMMON/L1/SUM(7,70),SS(7,70),ANUM(7),SUMG(7),SSG(7),SUMF(7),SSF(7)
      COMMON/L2/NG,NF
      COMMON/L3/KK(7),S,TSUMG(7),TSUMF(7),KG(7),KF(7)
      DIMENSION A(53,70)
      TOTG=4HTOTG
      TOTF=4HTOTF
      DO 11 I=1,7
      DO 10 J=1,NCAT
      SUM(I,J)=0.
   10 SS(I,J)=0.
      TSUMG(I)=TSUMF(I)=0.
      SUMG(I)=SSG(I)=SUMF(I)=SSF(I)=0.
   11 ANUM(I)=0.
      ANUM(1)=UND
C  COMPUTE APPROPRIATE SUM, SUM OF SQUARES, AND SAMPLE SIZES
      DO 26 I=1,UND
      DO 9 K=1,7
      KG(K)=KF(K)=0
    9 KK(K)=0
      DO 25 J=1,NCAT
      IF (KEY(J).EQ.0) GO TO 25
      SUM(1,J)=SUM(1,J)+A(I,J)
      S=A(I,J)*A(I,J)
      SS(1,J)=SS(1,J)+S
      IF (J.LE.NG) GO TO 12
      SUMF(1)=SUMF(1)+A(I,J)
      IF (KF(1).EQ.1) GO TO 4
      KF(1)=1
      SSF(1)=SSF(1)+TSUMF(1)*TSUMF(1)
      TSUMF(1)=A(I,J)
      GO TO 13
    4 TSUMF(1)=TSUMF(1)+A(I,J)
      GO TO 13
   12 SUMG(1)=SUMG(1)+A(I,J)
      IF (KG(1).EQ.1) GO TO 6
      KG(1)=1
      SSG(1)=SSG(1)+TSUMG(1)*TSUMG(1)
      TSUMG(1)=A(I,J)
      GO TO 13
    6 TSUMG(1)=TSUMG(1)+A(I,J)
   13 CONTINUE
      IF (ISPP(I).EQ.2HWT) GO TO 23
      CALL STAT (A,2,I,J)
      KK(2)=1
      IF (ISEX(I).EQ.1HF) GO TO 22
      CALL STAT (A,3,I,J)
      KK(3)=1
      GO TO 25
   22 CALL STAT (A,4,I,J)
      KK(4)=1
      GO TO 25
```

```
   23 CALL STAT (A,5,I,J)
      KK(5)=1
      IF (ISEX(I).EQ.1HF) GO TO 24
      CALL STAT (A,6,I,J)
      KK(6)=1
      GO TO 25
   24 CALL STAT (A,7,I,J)
      KK(7)=1
   25 CONTINUE
   26 CONTINUE
C  COMPUTE STANDARD ERRORS, MEANS
      DO 33 I=1,7
      IF (ANUM(I).EQ.0.) GO TO 33
      DO 30 J=1,NCAT
      IF (ANUM(I).EQ.1.) GO TO 31
      SS(I,J)=SQRT((SS(I,J)-SUM(I,J)*SUM(I,J)/ANUM(I))/(ANUM(I)*(ANUM(I)
     1-1.)))
      SUM(I,J)=SUM(I,J)/ANUM(I)
      GO TO 30
   31 SS(I,J)=0.
   30 CONTINUE
   33 CONTINUE
      DO 32 I=1,7
      IF (ANUM(I).LT.1.) GO TO 32
      IF (ANUM(I).EQ.1.) GO TO 35
      SSG(I)=SSG(I)+TSUMG(I)*TSUMG(I)
      SSF(I)=SSF(I)+TSUMF(I)*TSUMF(I)
      G=ANUM(I)
      SSG(I)=SQRT((SSG(I)-SUMG(I)*SUMG(I)/G)/(G*(G-1.)))
      SUMG(I)=SUMG(I)/G
      SSF(I)=SQRT((SSF(I)-SUMF(I)*SUMF(I)/G)/(G*(G-1.)))
      SUMF(I)=SUMF(I)/G
      GO TO 32
   35 SSG(I)=SSF(I)=0.
   32 CONTINUE
C  OUTPUT RESULTS
      PRINT 200, (ANUM(I),I=1,7)
  200 FORMAT ('0GROUP:    BOTH SPECIES'18X'BLACK-TAILED JACKRABBITS'29X,
     1'WHITE-TAILED JACKRABBITS'/' SEX:'10X'BOTH'2(14X'BOTH'13X'MALES',
     211X'FEMALES')/' NUMBER:'8X,F3.0,5X,3(13X,F3.0),1X,3(13X,F3.0))
      PRINT 201
  201 FORMAT (' '7X,14('-'),6X,50('-'),4X,50('-')/' CODE'5X'MEAN'5X'SE',
     15X,3(5X'MEAN'5X'SE'),7X,3(5X'MEAN'5X'SE')/)
      DO 40 I=1,NG
      IF (KEY(I).EQ.0) GO TO 40
      PRINT 202, LIST(I),((SUM(J,I),SS(J,I)),J=1,7)
  202 FORMAT (' 'A4,2F8.3,6X,6F8.3,6X,6F8.3)
   40 CONTINUE
      PRINT 202, TOTG,((SUMG(J),SSG(J)),J=1,7)
      PRINT 203
  203 FORMAT (' ')
      NN=NG+1
      DO 41 I=NN,NCAT
      IF (KEY(I).EQ.0) GO TO 41
      PRINT 202, LIST(I),((SUM(J,I),SS(J,I)),J=1,7)
   41 CONTINUE
```

```
      PRINT 202, TOTF,((SUMF(J),SSF(J)),J=1,7)
      RETURN
      END
```

```
      SUBROUTINE STAT (A,N,I,J)
C   TO ACCUMULATE SUMS, SUMS OF SQUARES, AND SAMPLE SIZES
      COMMON/L1/SUM(7,70),SS(7,70),ANUM(7),SUMG(7),SSG(7),SUMF(7),SSF(7)
      COMMON/L2/NG,NF
      COMMON/L3/KK(7),S,TSUMG(7),TSUMF(7),KG(7),KF(7)
      DIMENSION A(55,70)
      IF (KK(N).EQ.0) ANUM(N)=ANUM(N)+1.
      SUM(N,J)=SUM(N,J)+A(I,J)
      SS(N,J)=SS(N,J)+S
      IF (J.LE.NG) GO TO 5
      SUMF(N)=SUMF(N)+A(I,J)
      IF (KF(N).EQ.1) GO TO 4
      KF(N)=1
      SSF(N)=SSF(N)+TSUMF(N)*TSUMF(N)
      TSUMF(N)=A(I,J)
      RETURN
    4 TSUMF(N)=TSUMF(N)+A(I,J)
      RETURN
    5 SUMG(N)=SUMG(N)+A(I,J)
      IF (KG(N).EQ.1) GO TO 6
      KG(N)=1
      SSG(N)=SSG(N)+TSUMG(N)*TSUMG(N)
      TSUMG(N)=A(I,J)
      RETURN
    6 TSUMG(N)=TSUMG(N)+A(I,J)
      RETURN
      END
```

```
      SUBROUTINE SOREN (A,M,NC)
C SUBROUTINE TO COMPUTE SORENSONS COEFFICIENT OF COMMUNITY INDEX  K=2C/(A+B)
C WHERE C IS THE SUM OF THE NUMBER OF CHARACTERISTICS COMMON TO THE INDIVIDUALS
C BEING COMPARED, A IS THE SUM OF THE CHARACTERISTICS OF ONE INDIVIDUAL, AND
C B IS THE SUM OF THE CHARACTERISTICS OF THE SECOND INDIVIDUAL.
C **********
C  M = NUMBER OF GROUPS TO COMPARE
C  NC = NUMBER OF CHARACTERS PER GROUP
      DIMENSION A(70,6),V(6),C(15)
C CHANGING THE DIMENSION CARD IS ALL THAT IS NECESSARY TO CHANGE PROGRAM SIZE.
C  A(NC,M),V(M),C(M*(M-1)/2)
      DIMENSION IGRP(6)
      INTEGER VARFMT(3)
      DATA IGRP/8H  ALL BT,9H BT MALES,10HBT FEMALES,8H  ALL WT,9H WT MALES
     1ES,10HWT FEMALES/
      KK(I,J)=M*(I-1)-I*(I-1)/2+J-I
C **********
C COMPUTE VECTOR OF COLUMN SUMS.
      DO 21 I=1,M
      V(I)=0.
      DO 21 J=1,NC
   21 V(I)=V(I)+A(J,I)
C **********
C COMPUTE INDEX MATRIX C - AN UPPER TRIANGULAR MATRIX STORED AS A VECTOR.
      N=M-1
      MM=0
      DO 23 L=1,N
      II=L+1
      DO 23 I=II,M
      MM=MM+1
      C(MM)=S=0.
      DO 24 J=1,NC
      SM=A(J,L)
      IF(A(J,I).LT.SM)SM=A(J,I)
      S=S+SM
   24 CONTINUE
   23 C(MM)=2.*S/(V(L)+V(I))
C **********
C OUTPUT THE RESULTS.
      NSEG=(M+9)/10
      KSEG=0
   51 KSEG=KSEG+1
      IF(KSEG.GT.NSEG) GO TO 52
      NLINE=10*KSEG-1
      NNUM=10
      IF(KSEG.EQ.NSEG) 53,54
   53 NLINE=M-1
      NNUM=MOD(M-1,10)+1
   54 KLN=0
      IFRST=KSEG*10-9
      ILST=IFRST+NNUM-1
      IF (KSEG.EQ.1) GO TO 7[illegible]
      PRINT 900, (IGRP(K),K=IFRST,ILST)
  900 FORMAT [illegible]
   7[illegible] DO 60 I=1,NLINE
      KF=KK(I,IFRST)
```

```
      KL=KK(I,ILST)
      IF(I.LT.(10*KSEQ-9))55,56
   55 PRINT 901, IGRP(I),(C(J),J=KF,KL)
  901 FORMAT (1H ,A10,10F10.5)
      GO TO 60
   70 KX=IFRST+1
      PRINT 903, (IGRP(K),K=KX,ILST)
  903 FORMAT (1H0,22X,6A10//)
      GO TO 71
   56 KLN=KLN+1
      KLNI=10-KLN
      NSPACE=10*KLN
      ENCODE (21,902,VARFMT) NSPACE,KLNI
  902 FORMAT ("(1H ,A10,",I2,"X,",I2,"F10.5)")
      KF=KK(I,IFRST+KLN)
      KL=KK(I,ILST)
      PRINT VARFMT, IGRP(I),(C(J),J=KF,KL)
   60 CONTINUE
      GO TO 51
   52 RETURN
      END
```