FEEDING HABITS OF THE RING-NECKED PHEASANT CHICK, PHASIANUS COLCHIUS, AND THE EVALUATION OF AVAILABLE FOODS

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ABSTRACT

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By

Harry Hill

The feeding behavior of the ring-neck pheasant chick, Phasianus colchius, has been studied by placing them with foster hens in three structurally different plant communities. After the young pheasants were allowed to forage about the fields for several days, the chick crops were examined and compared with available foods. No apparent feeding preferences were detected. It appeared that young pheasants eat the available invertebrates, primarily leafhoppers and slugs.

Slugs can provide the chick with large quantities of food during cool, wet periods. Yet, another implication regarding the land slug is the high concentration of calcium in its body tissue which could provide an excellent source of this mineral.

Sweep netting was used to capture more mobile plant inhabiting arthropoda while baited boards were used to sample ground dwelling invertebrates. Using these techniques biomass estimates were determined for 11 fields.

The relationship between the quantity of available foods and the weight changes of pheasants in different field types was studied. Weight changes in the young pheasants were different for the three plant communities.

Three major types of vegetative communities were examined as potential pheasant producing areas. More mature communities appeared to offer more available foods. Clover fields studied exhibited lower biomass levels and their stem structure does not allow the young pheasant good mobility.

The results of this study have provided an understanding of invertebrate foods upon which pheasant chicks subsist. Several management techniques have been proposed based upon this study.

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INTRODUCTION

The ring-necked pheasant, *Phasianus colchius*, is an imported game bird which has experienced extreme population fluctuations. Although much research has been done on the pheasant's life cycle, the reasons for these fluctuations remain poorly understood. Since the young of the year comprise approximately three-fourths of the fall population, the brooding period has been considered a crucial stage in the success of the species. Weather, habitat changes, and brood food have long been suspected as critical factors in brood success (Ginn 1962, MacMullen 1957, and Shick 1952).

The major objective of this investigation was to evaluate food habits of young pheasants. In order to accomplish this goal, three prerequisite requirements were necessary. Representative community types had to be chosen from an area known to produce pheasants and the foods available in these communities had to be quantatively and qualitatively evaluated. The next objective was to obtain enough young pheasant crops to make statements about feeding preferences.

Two major problems exist which make any field study of brooding pheasants very difficult. Brooding pheasants are not easily observed in the field because of their secretive behavior and the dense cover they inhabit during the brooding period.

The role of changing agricultural practices and its influence on pheasant habitat has been recognized for many years. Although sound data is lacking regarding the productivity of selected retired agricultural land, my empirical data suggests that such areas contribute substantially as pheasant producing areas. What qualities do these inactive agricultural lands possess that encourage brood production? Obviously these areas provide adequate nesting sites and cover. Preliminary studies for this project indicate that agricultural monocultures discourage vegetative cover often used by pheasants for brooding areas. Lack of vegetative cover affects insect populations and invertebrate biomass upon which pheasants subsist during their first 4 weeks of life. The dependency of gallinaceous chicks on invertebrate fauna is well documented by Buss (1946), Dalke (1935), Erickson (1951), Ford et al. (1938), Fried (1940), Leffingwell (1928), Loughery (1951), Martin (1972), Shick (1952), Southwood and Cross (1969), and Stiven (1961). The insect food provides the young pheasants with a high protein diet required for their rapid growth.

Although numerous qualitative studies have been conducted on "feeding preferences" of pheasant chicks in the wild, none have been quantitatively evaluated in the field. To establish feeding preferences, it is first necessary to quantify available foods and secondly to evaluate the foods eaten. The quality and quantity of insect foods available in the various field types has been largely unknown. Which field types provide adequate food for pheasant productivity?

A study of brood success cannot neglect the importance of weather. Meteorological conditions dictate the phenology of plant communities. The insects upon which young pheasants feed are also affected by weather. Weather throughout the season affects insect activity as well as that of the chick. Not only does weather affect the activity patterns of both insects and chicks, but it also influences the interface upon which insects and chicks interact.

A major focal point of this project was the evaluation of potential relationship between arthropod fauna and the survival of pheasant chicks. Some of the questions have been answered, other questions have not. It is hoped that this study stimulates a renewed interest in important factors effecting pheasant brood production.

STUDY AREAS

Throughout much of the pheasant range, a few basic plant communities produce a majority of the pheasant crop each year (Wagner 1965). For this study, three plant communities were considered. Preliminary work eliminated row crops as brooding areas as these fields were devoid of most vegetative cover and provided almost no inserts on which the chicks could feed.

Oldfields, clover fields, and bromegrass fields are considered to be good pheasant producing areas throughout much of the pheasant's range (Ginn 1962 and Wagner et al. 1965). Not only are these plant communities common but they offer an opportunity to evaluate the effect of plant structure on brood usage. Oldfield communities are composed of both forbes and grasses and therefore are structurally heterogeneous. Clover fields are characterized by their homogeneous plant structure and dense canopies. Bromegrass fields are generally homogeneous and represent a structurally different community type.

The history of these three important community types requires some consideration. Clover fields usually originiate from seed sown in conjunction with winter wheat planting. In mid-July the wheat is harvested and frequently the plant stalks bailed for straw. At this time the larger varieties of clover grow rapidly. The biennial clover matures rapidly in the following season providing a dense plant canopy. The clover fields are often in a short term government land retirement program. In contrast, most old-field and bromegrass communities may have been developed from long term land retirement programs. Many bromegrass fields may also originate from alfalfa-brome hayfields. As the biennial alfalfa dies off, the bromegrass spreads and frequently takes over an entire field. Bromegrass communities can exist for many years as they continually reseed themselves. Oldfields find their origin from fields that are allowed to grow wild.

This study was conducted in northeast Barry County during the summers of 1972 and 1973. Study plots were situated in a one square mile area located at T4N, R7W, W1/2 Section 34. This portion of Barry County is considered good agricultural land and has produced moderate pheasant populations in recent years. A reasonable pheasant population was a prerequisite for the study area.

Conover silt loam is the dominant soil type of this area (USDA 1957). Conover silt loam is considered a fertile, heavy soil. The topography of the area exhibits gentle slopes interspersed with small woodlots. Low, poorly drained sections can occassionly be found throughout the study area. Moisture tolerant plants such as smartweed, Polgonum pennsylvanicum, nightshade, Solanum nigrum, and teasel, Dipsacus sylvestris, are commonly found in these lower areas.

METHODS

Selection of Fields

Fifteen fields were chosen; five fields for each of three major community types mentioned. Where possible, a set of three fields (oldfield, clover, and bromegrass) were located within 100 yards of each other. This arrangement was utilized in an effort to eliminate variance other than that attributable to community effects. The study fields were all within a one square mile area to minimize differences associated with regional effects and soils.

Sampling of Vegetation

The vegetative composition of each field was qualitatively and quantatively evaluated. A wooden frame measuring one meter square was divided into quandrants used to estimate the percent of cover of each species. To locate each sampling point an initial point representative of the field was chosen on the edge of the field. Twenty samples were taken at 30 foot intervals along a line perpendicular to the edge of the field.

Available Biomass: Insects Sampled By Sweep Netting

Sweep Net Samples

In each experimental field, sweep net samples were taken with a 1.25 foot diameter net to collect the insect fauna present. Five samples comprised of 10 sweeps each were collected from each field. Since an average sweep covers a length of 5 feet, 10 sweeps with a 1.25 diameter net covers an area of 62.5 square feet. The total area covered for all 5 samples in each field was 312.5 square feet.

The collection sites for each sample were systematically within those areas considered representative for that field in much the same manner as the vegetative samples. Each sample was comprised of ten sweeps which were spaced 30 feet apart. Four clover fields, four oldfields, and three bromegrass fields, were sampled in this manner.

The arthropoda collected were immediately placed in a labeled plastic bag and anesthisized with pyrethrium. The insects were then sorted to the ordinal level. Where functional or behavioral differences were thought to be important, as with large and small dipterans, size groupings were established.

Although insects are known to move up and down vegetation in response to temperature, moisture and diurnal behavior, it was hoped that subjective selection of an evening sample would minimize this source of variance.

Sampling emphasis was directed at the total community and not at specific insect populations.

Accuracy of Sweeping

It was desirable to know what portion of the insect fauna was captured by sweep netting. A technique utilizing a complete count was used to establish effectiveness of sweep net sampling for each important insect group (Ruesink and Haynes 1973).

A representative field was selected for each of the three major vegetative community types studied. A nylon bottomless screen tent measuring 6 feet on a side was used to obtain the absolute count. With each of the three fields, five randomly selected 6 foot square areas were evaluated. The tents were positioned in a manner that would minimize disturbance of the insects within. Three sweeps, 1.25 feet in width, were then taken in the tent commencing at one side of the tent and terminating on the opposite side.

A hedge trimmer powered by a portable generator was used to cut down all vegetation within the confines of the tent. Insects inhabiting the vegetation generally sought the sides of the tent to escape capture and for resting. The insects were then collected by a small one amp vacuum cleaner. Most insect types were readily caught; however, a few arthropod groups such as daddy longlegs, (Opiliones), and other ground surface dwellers were difficult to collect.

From these fifteen samples the number of each group captured by sweep netting could be compared with the absolute number found within the tent and the percent captured by sweeping could be established. To equate the sweep samples to the absolute counts, multiplication factors were used. Multiplication factors were established by obtaining the reciprical of the proportion of an insect group caught by sweeping. This procedure was used to calculate the multiplication factors for each of the 16 major groups. The effectiveness of sweeping varies with the plant structure and thus a different set of multiplication factors was required for each community type.

In some instances no insects were found in the sweep samples for a specified community type while in other instances the sweeps caught a disproportionately large number of an insect group. To handle these sampling problems it was necessary to establish replacement values. In an effort to obtain the best possible replacement values, the combined data for all samples were used. The total number of insects collected by sweeping was compared to the total absolute count for each insect group. The need for adjustment, in this case, replacement values, was necessary because of the limited number of samples.

Insect Weights

One of the major objectives of this study was to estimate the invertebrate biomass in a number of different plant communities. The diversity of the insect fauna and the size ranges encountered within each insect taxa complicated biomass estimates. If the total biomass for a selected field was desired, the task would have been easier. However, the real objective was to develop techniques that provide a more general application. To accomplish this end, insects were grouped into functional taxa. A functional taxon included insects possessing similar size, appearance, mode of locomotion and other behavioral features. Twenty-four taxa were originally selected. For other purposes of analysis the 24 taxa were later combined into sixteen groups.

For each of the 24 taxa, a mean dry weight was calculated. Where possible, an attempt was made to collect enough insects from each taxa to provide a representative sample. For several taxonomic groups inadequate numbers were available and therefore the resulting mean weights may have been somewhat inaccurate. Several of the taxa were not available at the time of collection so values for these groups were taken from the literature (Cross 1966).

The insects collected were taken to the laboratory, the dry weight determined, and the weight per insect for each taxa calculated. The dry weights obtained were very comparable with those calculated by Cross (1966).

Biomass Per Unit Area

The biomass of an area sampled can be calculated by multiplying the number of individuals for each taxa times the mean dry weight established for that taxa. This product was then multiplied by the reciprocal of that portion collected by sweep netting, the multiplication factor (Ruesink and Haynes 1973). A summation of the biomass of each component group was then used as an estimate of the total biomass. This procedure was used for each of the study fields.

Available Biomass: Ground Dwelling Invertebrates

Examination of pheasant chick crops revealed that sweep net samples did not adequately survey all of the available foods. For example, slugs were found in over 50 percent of the crops and in several fields, slugs exceeded 50 percent of the chick's diet. To a lesser extent, sowbugs, millipeds, and other ground surface dwelling invertebrates were found in the crop contents.

In response to this condition an additional sampling technique was required to estimate the numbers and biomass of peri-soil dwelling invertebrates. Several sampling techniques were tried and eliminated. A sampling system using baited boards was used with good results. Boards measuring 6 in. x 12 in. were soaked in water for eight hours, baited and then placed in the study fields in a grid pattern. Areas 6 in. x 12 in. were cleared of vegetation and boards were placed on the bare soil surface and their location marked with florescent colored stakes. Dog food was used as the bait as it was found superior to lettuce and other baits tried. The rationale of using baited boards as traps was based on behavior patterns. Slugs are attracted to the boards as they search out moist cover and having found suitable food and cover remain beneath the boards.

The ideal time to sample slugs was during a rainy period. Nine fields (three from each of the major community types) were sampled. The number of slugs in these samples was accepted as an underestimate but it was felt that a large portion of the population was collected in the samples. Boards were removed from the fields after a couple of days to prevent the inclusion of slugs attracted from areas beyond the 40 foot square sampling area. The distribution and behavioral pattern of these groups of arthropoda make adequate sampling extremely difficult.

Pheasant Chicks

A total of over 700 pheasant eggs were obtained for this study; 500 eggs were procured from the Department of Natural Resources' Mason Hatchery, and 200 eggs were obtained from Michigan State University's Poultry Science Department. The genetic composition of the eggs is open to question, but for the most part the genetic sources were similar i.e., Mason stock birds originated from M.S.U. stock. It should also be noted that no discernable differences were observed in feeding behavior from any of the genetic sources.

The young chicks were held in an incubator for a period of from one to three days before introduction to their foster hens. Experience demonstrated that this short period allowed the young pheasants to gain strength enough to avoid trampling by the hen and yet respond to the heat source beneath the hen. No negative behavioral characteristics were observed using this procedure. Evidently, the critical period of imprinting in the pheasant chick occurs after the third day.

Introduction of the brood to their foster mother was the most crucial point for the experimental chicks. The foster hens were "barnyard banties" for the most part while a few pure strains of chickens, such as the New Hampshire Reds and Japanese Silkies were sparingly used. Banties possessed desirable qualities such as their foraging skills, frequency of broodiness, and a body size comparable to that of a hen pheasant. Niney "banty" hens were maintained in anticipation of the fact that some of the hens would never set, some would set only once and some would probably set several times.

The procedure for introducing chicks to the foster hens evolved through trial and error. The first step was to select a suitable broody hen. Broody hens were recognized by behavioral patterns such as clucking and brooding posture. Once the hens were chosen, they were placed in a closed brooding coop with about 12 pheasant chicks (Figure 1a). It was found that the hens were easier to handle after dark and were less anxious. On most occasions the hens would be found brooding the chicks by the following morning. Once the hen adopted her brood, the slated doors were opened allowing the chicks to feed, water, and move about in the small, screened runway (Figure 1b). The hen and her brood were fed identical diets which consisted of a game bird starter diet. They also ate additional insects which strayed into the confined area.

The entire coop and its attached runway were kept on a mowed section of grass and moved daily to minimize disease. When the chicks became adequately acclimated to their mother and environment, they were transferred to a 10 foot square pen. These pens were made of 1 in. chicken netting nailed onto a wooden frame measuring 3 feet in height. Their construction made the pens extremely portable. Although the chicks were allowed to range the enclosed grass area, the hens were still restrained within the coops. It was found essential that the young pheasants adjust to vegetation and become acquainted with insect food that may stray into the pens. In the previous years work, pheasant chicks raised indoors with no exposure to natural sunlight, vegetation, nor a mother to brood them did not respond as desired.

When placed in outdoor pens, the pheasant chicks reared with a foster hen in outdoor pens, behaved in manner

Figure 1a. Brooding coop used to house pheasants in the field.

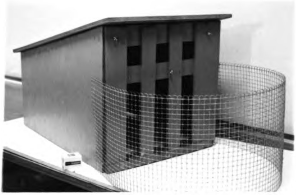


Figure 1b. Brooding coop with attached pen used to acclimate the chicks to the foster hens.

similar to that observed for wild pheasants. This normal behavior was assumed in the treatment of the data and the inferences based upon the data.

Again, through experience, it was found that chicks should be two weeks old before field release. Chicks one week of age and younger were field released but high losses were incurred. The two week old birds developed stronger behavioral bonds towards their mother and the rest of the brood. The chicks communicated between themselves and hunted in social groups in a fashion similar to resident wild pheasant chicks.

At two weeks of age, the young pheasants were wing banded, weighed, and had their right primary feathers clipped to prevent flight. In the evening the broods along with their coops were moved into the fields. At daybreak the chicks were allowed to roam at will in the field and were observed feeding upon arthropods throughout the day. A container of fresh, clean water was placed at the entrance of the coop. At night, when the chicks had returned to the coop the door was closed. Not all chicks returned at night; some returned a day or two later while many were never seen again.

Crop Contents of Pheasant Chicks

The young chicks and their foster mother were randomly assigned to selected fields and given one day to acclimate to their new surroundings. Most chicks were observed foraging for and eating insect material throughout the first day, but not enough food was eaten to allow any accumulation within the crop during the day. This event caused some concern initially, but it was discovered that a substantial amount of food begins to accumulate in the crop towards evening. For this reason, chicks to be sacrificed were collected soon after they returned to the brooding coop at sunset.

The sacrificed chicks were individually placed in a labeled plastic bag and returned to the field laboratory. The crops and gizzards were put in labeled vials containing 95 percent ethyl alcohol and stored for analysis. The remainder of the chick's body was placed in plastic bags for future examination.

The sorting of crop contents into the various insect groups followed the same methodology as that used for sweep net samples. This procedure was required for comparison of crop contents to insect biomass collected in the field. The number of insects and other invertebrates were tabulated for each of the pre-established groups. A total of 148 pheasant chick crops were examined.

Comparison of the raw number of insects does not provide an adequate basis for comparative purposes. The percent biomass contributed by each insect group was calculated by multiplying the mean weight for each insect group times the number of insects in that category. The total biomass was also calculated. The proportion of crop content comprised by each of the component groups was established.

Feeding Preferences

Feeding Preferences Based Upon Physical Characteristics of Insect Foods

Five characteristics were selected which could influence how the pheasant predators preceived available food and thus selected their insect prey. Physical characteristics considered were size, shape and color. Two additional features that could have also influenced the pheasant's feeding behavior were the prey's mode of locomotion and the vertical strata occupied by the prey.

Prey species were grouped into 5 size categories; <2 mm, 2-4 mm, 4-6 mm, 6-10 mm, and >10 mm. Insect shapes were classified as oval, wormlike, oblique, long appendaged and minute. Insects were also grouped according to whether they were green, light brown or grey, dark brown or black and dark green. The mode of locomotion of insect prey were walking, flying, jumping, crawling and resting.

Insects found in three strata were evaluated. The strata under consideration were the ground surface, from the ground to 12 inches and 12-36 inches. Ground beetles and ants typify ground dwellers, leafhoppers are considered representative of the 0-12 inch strata while most flying insects were categorized as inhabitants of the 12-36 inch strata.

Only those insects regularly caught by sweeping were considered. Each insect was placed in one classification for each of the characteristics evaluated. The number in each category was multiplied by their respective estimated weights and then by their multiplication factor. The total weights for each category were then tallied. The proportion of the biomass of each category in a pheasants crop was compared with its respective biomass available in the field.

Physical Characteristics of Pheasant Chick Foods Eaten in Three Structurally Different Plant Communities

Ninety-nine pheasant chicks were placed in three major community types to evaluate and contrast foods eaten. The data represent the combined information gathered from 4 clover fields, 4 oldfields, and 3 bromegrass fields. Only those insect categories which were thought to be meaningful and provided adequate data were analyzed.

Age Contrasts

Three ages of young pheasants were selected to demonstrate differences in feeding behavior attributable to age. The age groups studied were 1 week, 2 weeks and 3 weeks. Each age group was randomly assigned adjacent sites in a representative area of an oldfield community. The young birds were allowed to feed throughout the day and were captured when they returned to their coops in the evening. The techniques used to handle the crop material has been explained in an earilier section.

Weight Gains of Chicks in Various Fields

Each pheasant chick was weighed every other morning. The weight changes were recorded to an accuracy of one-tenth of a gram. Predicted foul weather occassionally altered this study because the young birds used in this section were critical to other studies and therefore could not be risked to bad weather.

Nutritional Value of Invertebrate Material

The nutritional aspects of insect materials have been thoroughly explored by several authors (Beck and Beck 1955, Cross 1966, and Korschgen 1964). Since the values in these references are in agreement, the decision to bypass nutritional analysis of the invertebrate material was made with one major exception. The land slug, *Limax* spp., an invertebrate found in numerous pheasant crops was not analyzed in any of these previous studies. A sample of 15 grams live weight of slugs was collected in the field and taken to the biochemistry laboratory at Michigan State University for an approximate analysis.

Laboratory Studies on Growth and Passage of Food Through the Digestive System

The genetic composition of the experimental chicks was uncertain and therefore it was not known if the growth performances of these chicks would be comparible with that of native birds. Eight randomly selected experimental birds were reared in captivity for 30 days to detect any differences in growth patterns. The chicks were weighed every morning for 10 days and then weighed every other day thereafter. The pheasants were weighed in the morning prior to feeding. For the remainder of the day they were allowed to feed ad lib.

These same chicks were also used to determine the rate of food passage through the digestive tract. Chromium oxide, an inert material often used for studying digestive rates, was mixed with the starter ration. The chicks were placed in individual cages with a white paper drop cloth. A greenish stool indicated the length of time required for the chromium oxide to pass through the digestive system.

RESULTS

Vegetative Analysis

Since the major soil type of the entire study area is a Conover loam, the vegetative communities would be expected to show analogous characteristics. Also, all fields assigned to each set of community types possessed identical histories. Furthermore, the proximity of all fields to each other also contributed to their expected likeness.

Table 1 presents the vegetative composition for nine of the major fields studied. The percent values represent the average obtained from 20 one meter square vegetative samples in each of the study fields. One clover field was not included in this table because it was mowed before the vegetative analysis was completed. Twenty-five of the more abundant plants of the area are listed in Appendix A.

Similarity indices were calculated for the nine fields. The analogue used to compute these similarity indices is that presented by Murdock et al. (1972) and is:

Table 1.--Percent of vegetative cover contributed by selected plant groups for nine study fields in Northeast Barry County (July 13-24, 1973).

	Clover		Bromegrass			Oldfield			
Plant groups	12	15	6	13	14	4	5	11	16
Clover	94	89					17	4	1
Bromegrass			98	100	98	55		7	10
Daisy Fleabain		1					27	2	2
Wild lettuce		5				3			
Quackgrass	3						16	5	1
Timothy grass			2			1		28	25
Dandelion						6		5	3
Goldenrod						2		23	38
Queen Anne's lace								16	
Yellow rocket							36	1	1
Regal's plantain								8	6
Bluegrass						7		1	6
Wild strawberry						13			
Miscellaneous	3	5			2	13	4		7

The percents listed are the mean values calculated from 20 vegetative samples obtained from each of nine fields. Scientific names are listed in Appendix A.

$$I = 1 - 0.5 \left(\sum_{i}^{s} a_i - b_i \right)$$

where:

a_i is the proportion of the total individuals in Sample A that belongs to species i

b_i is the proportion in Sample B belonging to species i, and there are s species.

This is an elementary method of demonstrating the degree of likeness or dissimilarity. Complete similarity produces I = 1 while complete dissimilarity gives I = 0. Similarity indices are presented in Table 2.

The results show that bromegrass and clover fields are extremely similar in plant composition. Oldfield communities vary widely in their similarity to each other due to their heterogeneous composition.

Available Biomass: Insects Captured by Sweep Netting

Fifteen fields were sampled utilizing a sweep net. The data presented in Appendix B are the totals of five samples taken in each field. Each total presented in this table represents the number of insects collected for each category in an area covering 312.5 square feet. The data showing the numbers of insects for each sample that contributed to these totals has been omitted for the sake of brevity.

Clearly, not all insects in any area were captured. A comparison of insects caught in the sweep net samples were

Table 2.--Similarity indices* demonstrating the degree of likeness of plant communities in study fields.

	Clover		Bromegrass			Oldfield			
	12	15	6	13	14	4	5	11	16
Clover 12		.894	.008	.002	.001	.026	.212	.080	.040
Clover 15			.005	.002	.002	.053	.178	.059	.935
Bromegrass 6				.975	.976	.566	.009	.093	.129
Bromegrass 13					.981	.548	.002	.075	.105
Bromegrass 14						.567	.002	.084	.123
Oldfield 4							.037	.176	.254
Oldfield 5								.130	.074
Oldfield 11									.695
Oldfield 16									

*An index of 1 indicates complete likeness while an index of 0 shows complete dissimilarity. Bromegrass field 6 is .976 as similar as bromegrass field 14.

compared to those captured in the nylon screen tents in a field considered to be representative of that major habitat type (Table 3). The insects caught in each of the five samples were totaled along with their respective tent counts. Since the area sampled by the sweep net was 52 percent of the area sampled by the cage, it was necessary to multiply the sweep sample numbers by 1.92 to obtain the results.

The number of insects caught in the sweep samples were divided by the total captured within the tent area. The reciprocal of these proportions, multiplication factors, are presented (Table 4) and when multiplied times the sweep net numbers provides an estimate of the total insects present. The data also demonstrates that sweeping efficiency varies with the structure of the vegetation.

As previously mentioned in the methods section, replacement values were required for completeness in analysis. Replacement values are also presented in Table 4. Rather than arbitrarily assigning some value, the use of replacement values provided the direction and relative order of magnitude for those parameters not measurable.

By knowing the relative efficiency of the sweeping, estimates of insect numbers per unit area were determined. Calculation of the biomass per square foot for each group was done be multiplying the mean dry weight per insect group (Table 5) times the estimated number of insects per

Table 3.--Number of insects caught by sweeping compared with absolute counts.

	Field type							
	Clover		Bromegrass		Oldfield		Total*	
	Sweeps	Absolute	Sweeps	Absolute	Sweeps	Absolute	Sweeps	Absolute
Coleoptera (<4mm)	20	3	6	1	1	6	36	40
Coleoptera (4-6mm)	9	21		3		5		
Coleoptera (>6mm)						1		
Diptera (>4mm)	4	104		20		22	2	146
Diptera (<4mm)	6	60	22	16	5	145	33	221
Hemiptera (>4mm)	51	188	1	12	8	69	76	292
Hemiptera (<4mm)	11	22			5	1		
Hymenoptera (<4mm)	1	9		7	1	8	2	24
Hymenoptera (>4mm)	9	13	12	5	5	57	26	75
Ants			1		1	1	1	2
Leafhoppers (>4mm)	32	180	66	334	41	472	174	1167
Leafhoppers (<4mm)	15	113	9	13	11	55		
Aphids					1		1	
Collembola					1		1	
Grasshoppers		1	1	1		6	1	8
Crickets				1		16		17
Lepidoptera (>1cm)		2		1		3	1	19
Lepidoptera (<1cm)		2		1	1	10		
Spider (>4mm)		1		1	1	2	4	19
Spider (<4mm)		2		1	3	12		
Daddy longlegs						2		2
Thysanoptera					16		16	

*The totals for coleoptera, hemiptera, leafhoppers, lepidoptera, and spiders were the combined totals for all size groups for those orders. Combining size groups was done to establish the best estimates of the proportion of insects caught by sweep netting. These numbers were the basis for the establishment of replacement values which were used when the true values were unknown.

Table 4.--Multiplication factors used to convert sweep net insect numbers to obtain a more accurate estimate of the absolute number.

Insect group	Community type			Replacement value*
	Clover	Bromegrass	Oldfield	
Coleoptera	--	--	6.77	1.10
Diptera (>4mm)	27.77	--	--	38.46
Diptera (<4mm)	5.74	--	15.62	4.02
Hemiptera	2.28	6.80	3.32	2.52
Hymenoptera (>4mm)	5.20	--	4.69	6.80
Hymenoptera (<4mm)	1.27	--	6.49	2.02
Leafhopper	3.77	2.93	5.81	4.02
Grasshopper	--	1.04	--	4.69
Lepidoptera	--	--	7.29	5.46
Spiders	--	1.56	2.35	2.99

*Replacement values were required where inadequate data was available for a specific field type. Replacement values were calculated from the totals for all field types combined.

square foot for each group times the multiplication factor for that group. The resultant values are presented in Table 6.

The similarities of the insect groups comprising the biomass of 11 fields is presented in Table 7. Generally, fields of the same major community types demonstrated high similarity indices in biomass composition. As would have been expected, the mean value calculated for similarity indices amongst all fields in the general vicinity of the one square mile study area were more similar than would have been expected if the fields had been chosen randomly from various regions.

Table 5.--Mean dry weight for 26 invertebrate groups.

INSECT Order	Common groups	WEIGHTS IN MILLIGRAMS Ave. dry wts.	Est. live wt.	NUMBER IN SAMPLE
Coleoptera (<4mm)	Snout beetles & mixed spp.	.30	.86	50
Coleoptera (4-6mm)	Mixed species	3.90	11.14	109
Coleoptera (>4mm)	Ground beetles & mixed spp.	37.36	106.74	7
Diptera (>4mm)	Mixed species	2.50	9.26	137
Diptera (<4mm)	Mixed species	.10	.37	33
Hemiptera	Miridae & mixed spp.	2.20	8.15	301
Hymenoptera (>4mm)	Mixed species	1.50	5.00	62
Hymenoptera (<4mm)	Mixed species	.10	.33	50
Hymenoptera	Ants	1.50	5.00	est.
Homoptera (>4mm)	Mainly <u>Otiocerus</u> sp. and other leafhoppers	4.20	10.77	171
Homoptera (<4mm)	Leafhoppers and spittle-bugs	.60	1.54	34
Homoptera	Aphids	.10	.40	est.
Lepidoptera & Hymenoptera (symphyta) larva	Mixed species	10.20	51.00	147
Coleoptera larva	Coccinellidae	1.30	5.20	est.
Collembola		.10	.33	est.
Orthoptera	Grasshopper & cricket	10.00	33.00	35
Lepidoptera	Microlepidoptera	2.50	10.00	3
Lepidoptera	Macrolepidoptera	19.10	76.40	8
Araneida	Spider	5.30	17.67	11
Phalangida	Daddy-Longlegs	15.30	50.99	5
Acarina	Mites	.10	.30	est.
Thysanoptera	Thrips	.10	.30	est.
Neuroptera	Lacewings	4.80	14.40	57
Millipedes	Thousandleggers	46.90	117.25	73
Isopoda	Sowbugs	3.70	9.25	1000
Stylommatophora	Slugs	18.40	110.84	1100

Table 6.--Estimated biomass for each insect group expressed in mg/ft^2 for eleven study fields.

	Fields										
	Clover				Bromegrass			Oldfield			
Insect group	7	9	12	15	6	13	14	4	5	11	16
Coleoptera (<4mm)	.06	.37	.01	.02	.02	.01	.01	.16	.26	.17	.08
Coleoptera (>4mm)	.31	.62	.45	.28	.02	.04	.15	1.41	1.57	.74	.99
Diptera (>4mm)	2.00	8.20	14.00	6.80	1.06	2.66	.53	3.72	8.79	2.66	1.86
Diptera (<4mm)	.27	.43	.18	.48	1.17	.38	.20	2.42	.67	.29	.33
Hemiptera	2.39	3.27	.20	.12	1.54	.65	.70	5.81	15.66	2.99	7.04
Hymenoptera (>4mm)	.05	.20	.12	.02	.06	.06	.02	.02	.02	.04	
Hymenoptera (<4mm)	.01	.03	.03	.03	.10	.11	.02	.36	.13	.08	.07
Ants			.05		.06			.32		.02	.31
Leafhopper	16.80	11.64	3.77	9.69	94.87	13.51	20.54	84.32	43.62	10.51	8.61
Grasshopper	.06	.19	.03	.09	.38	.19	.22	.25		.61	.06
Lepidoptera larvae (>1cm)	.32							.43	.87		.43
Lepiodoptera larvae (<1cm)	.12	.21	.16	.08	.75	.16	.08	.08	.28	.05	.05
Spider	.07	.24	.07	.11	.18	.23	.11	.35	.08	.19	.71
Total biomass	22.46	25.40	20.77	20.78	100.19	18.00	22.58	99.65	71.95	18.35	20.54

Table 7.--Similarity indices for insect communities inhabiting the experimental fields.

	Clover				Bromegrass			Oldfield			
	7	9	12	15	6	13	14	4	5	11	16
Clover 7		.696	.398	.699	.796	.902	.819	.590	.699	.808	.666
Clover 9			.646	.957	.510	.692	.540	.618	.750	.804	.699
Clover 12				.634	.228	.394	.241	.354	.433	.461	.406
Clover 15					.514	.690	.540	.644	.772	.809	.705
Bromegrass 6						.802	.956	.443	.647	.620	.465
Bromegrass 13							.833	.516	.784	.803	.586
Bromegrass 14								.467	.671	.656	.498
Oldfield 4									.699	.655	.842
Oldfield 5										.898	.780
Oldfield 11											.753
Oldfield 16											

Available Biomass: Ground Dwelling Invertebrates

Virtually no reference has been made in the literature concerning the role of soil invertebrates as a food source for pheasant chicks. The distribution of soil dwelling organisms is poorly understood as is the methodology of sampling slugs and associated arthropoda.

The results of the slug and sowbug samples collected in 9 experimental fields are presented (Table 8). For the entire area sampled, an averaged of 11.52 slugs per sample (.18 slugs/ft^2) was calculated. If the slugs were evenly distributed throughout the study area, a minimum of 3.3 mg of additional biomass per square foot would have been available.

Table 8.--Number of slugs and sowbugs collected from 6 in. x 12 in. sample boards for selected study fields (Sept. 19 - Oct. 7, 1973).

Field	N	Slugs $\bar{X} \pm SD$	Sowbugs $\bar{X} \pm SD$
Clover 7	20	3.55 ± 3.29	.30 ± --
Clover 12	20	24.50 ± 9.72	6.30 ± 3.85
Clover 15	20	20.70 ± 6.64	4.60 ± 2.48
Bromegrass 6	20	19.80 ± 10.27	2.20 ± --
Bromegrass 13	20	8.55 ± 2.74	5.40 ± 4.33
Bromegrass 14	20	16.75 ± 5.06	11.65 ± 5.87
Oldfield 4	20	2.95 ± 3.74	6.20 ± 3.69
Oldfield 11	20	.45 ± .99	19.40 ± 13.05
Oldfield 16	20	5.85 ± 4.60	16.15 ± 9.36

Predicted Insect Weights Versus Actual Insect Weights

It was necessary to use estimates of insect weights in this study as it would have been impossible to record the weight of each individual insect and selected insect groups. Even if the measurement of each insect had been possible, the values and conclusions drawn from such data would have been specific to this experiment. The establishment of estimated mean values, application of the values with real data, and the accuracy of results based upon these estimates is the measure of their value. If, after testing, these estimates remain relatively reliable, wider application makes the estimates more valuable.

Figure 2 is a scatter plot demonstrating the correlation between actual and predicted weights of total field biomass. A correlation coefficient of .96 was found using the data from one sample from each of 11 fields.

Predicted and Actual Crop Biomass

The crop contents of 63 chicks were weighed. These measurements were compared with estimates derived by multiplying each insect group by estimated dry weights. A correlation coefficient of .813 was calculated with explained 66 percent of the association between the two variables (Figure 3).

Insects (including arachnida) and ground dwelling invertebrates were evaluated separately. Ground dwelling invertebrates presented problems in the determination of

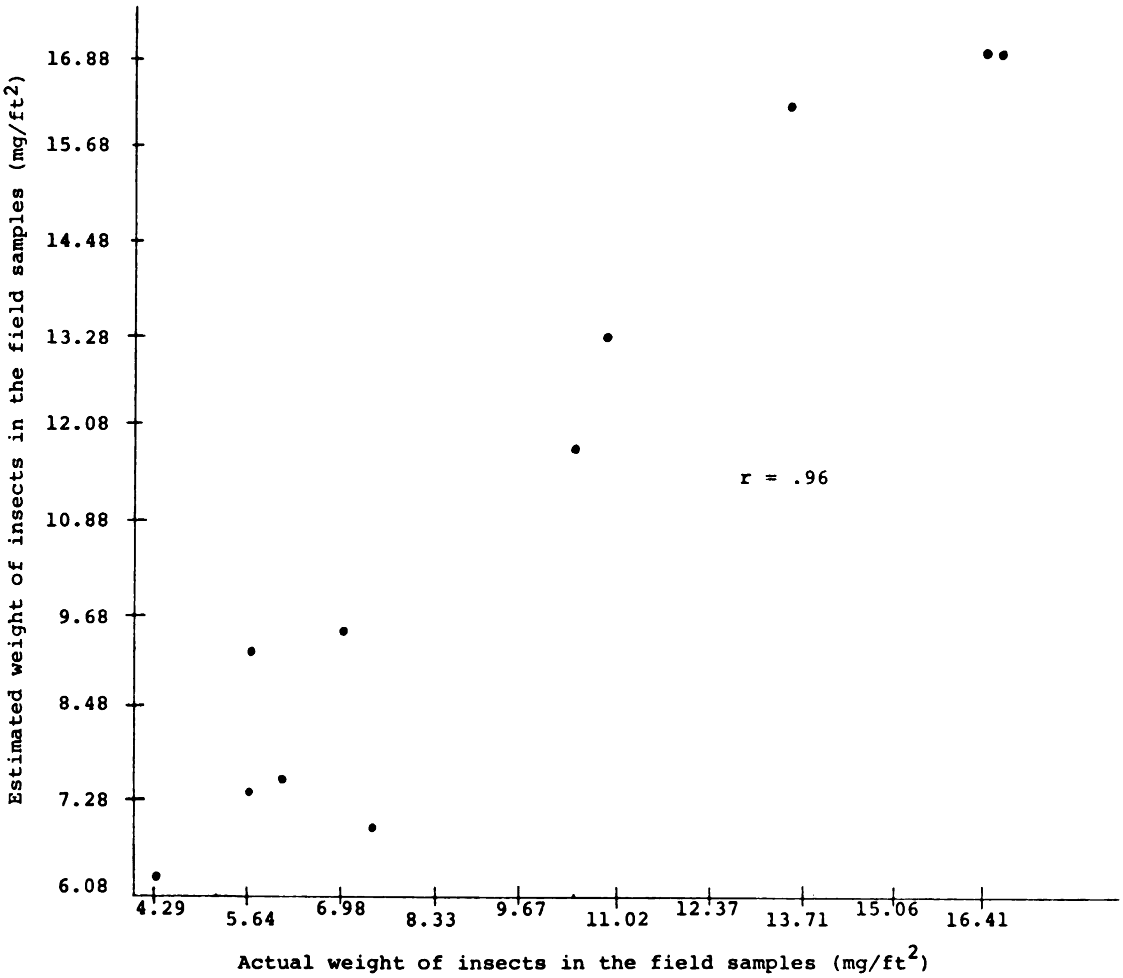


Figure 2. Relationship between estimated and actual weight of insects in the field samples.

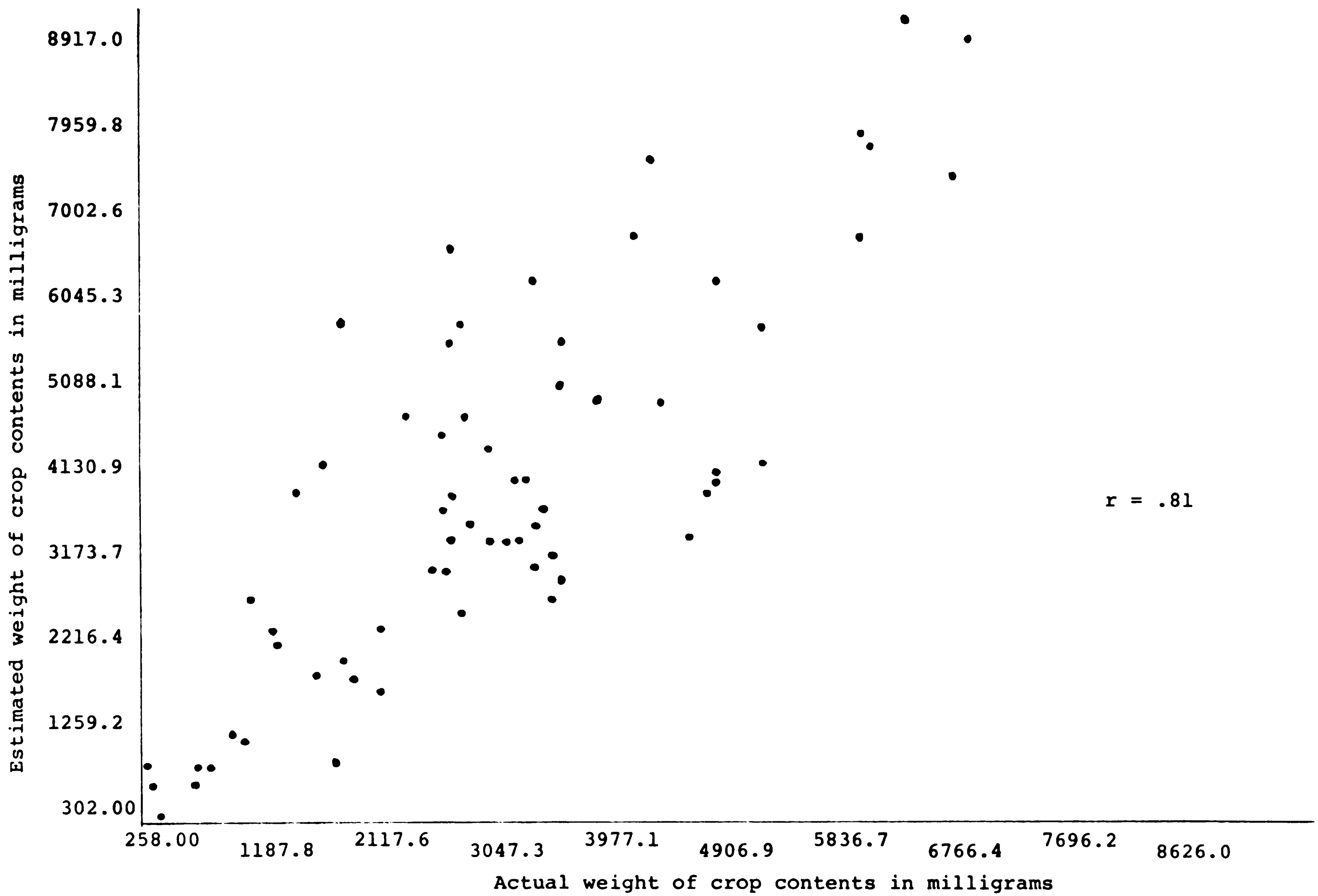


Figure 3. Relationship between estimated and actual biomass of pheasant chick crop contents.

feeding preferences since their population numbers were difficult to ascertain. The portion of the total insect biomass was calculated for each insect group for 148 young pheasants. This procedure was necessary because it was felt that reliable estimates of invertebrate groups was restricted only to those captured in the sweep net samples.

Weight Changes of Chicks in Various Fields

Pheasant chicks were weighed daily for three days. On the first day in the field large weight losses were observed. After the initial adjustment of foraging for their food, most chicks began to gain weight. Over a three day period the weight gains often did not compensate for large losses of weight during their first day in the field. One field from each of the three major plant communities are represented for each of the three time periods used. The time interval between each set of study fields was approximately one week.

The weight changes were recorded as a proportion of the body weight. This method of comparison was necessitated because of large variations in body weights.

A one way analysis of variance was used to evaluate the weight changes between each set of fields. No comparison was made between fields evaluated on different dates because of the compounding problems of weather, plant phenology and between field variation. The analysis of variance statistics for each set of fields are presented in

Table 9. Significant differences were observed between the chick weight gains for the three field types on each of the sampling dates.

Feeding Preferences

Feeding preferences were calculated by a comparison of a selected food to its availability. The analytical techniques used evaluate feeding preferences utilized 90 pheasants taken from 11 fields. The biomass composition varied with each field as was demonstrated in Table 6.

A table of correlation coefficients (Table 10) was used to show the association between diets and availability of 11 insect groups. Only those cases where both the diet and food availability were known were used to calculate the correlation coefficients. The number of valid cases used are found in parenthesis beneath the correlation coefficients. Correlations based on few observations should be viewed with caution.

Feeding Preferences Based Upon Physical Characteristics of Insect Foods

Characteristics of insect prey were evaluated to establish which features influence feeding preferences of the young pheasants. Of the 19 characteristics examined, 10 were significantly correlated with their respective availability (Table 11). The correlation coefficients that were significant range from .3033 to .7677. Three of the

Table 9.--Analyses of variance of body weight changes of pheasants feeding in three field types on three different dates.

Date		Field type: Clover	Field type: Bromegrass	Field type: Oldfield	Significance level
July 3-5	n	16	18	18	
	(g ± SD)	0.002 ± 0.048	-0.025 ± 0.035	-0.061 ± 0.051	.01
July 12-14	n	6	7	8	
	(g ± SD)	-0.031 ± 0.063	0.020 ± 0.035	-0.157 ± 0.069	.01
July 19-21	n	10	8	3	
	(g ± SD)	-0.228 ± 0.040	-0221 ± 0.035	-0.150 ± 0.020	.05

Table 10.--Correlation coefficients showing the relationship between the available foods and the pheasant chick's diet.

AVAILABLE INSECT BIOMASS IN THE STUDY FIELDS	INSECT BIOMASS IN PHEASANT DIETS										
	Coleoptera (<4mm)	Coleoptera (>4mm)	Diptera (<4mm)	Diptera (>4mm)	Hemiptera	Hymenoptera (>4mm)	Ants	Homoptera (Leafhoppers)	Orthoptera	Lepidoptera larva(<10mm)	Arachnida (Spiders)
Coleoptera (<4mm)	.3119 (43)	-.0483 (44)	.2469 (44)	-.0459 (44)	-.0445 (44)	-.2677 (44)	.1238 (26)	-.1534 (44)	-.1753 (41)	.3568* (44)	-.0429 (44)
Coleoptera (>4mm)	.1420 (62)	.1358 (67)	.5132** (67)	-.3687** (67)	.1734 (67)	-.3122* (67)	-.0107 (46)	-.4383** (67)	-.1594 (62)	.3385** (67)	-.0486 (67)
Diptera (<4mm)	-.5687 (11)	-.4357 (13)	.2288 (13)	.1733 (13)	-.3707 (13)	.3904 (13)	.4767 (9)	-.0364 (13)	-.3137 (12)	.4591 (13)	.2418 (13)
Diptera (>4mm)	-.2486 (4)	-.3684 (4)	-.4058 (4)	.8545 (4)	-.8248 (4)	.9931** (4)		.4703 (4)	.8845 (4)	-.8142 (4)	-.1806 (4)
Hemiptera	-.0323 (58)	-.0491 (64)	.1342 (64)	-.1265 (64)	.0930 (64)	-.4032** (64)	.3409* (39)	-.1117 (64)	-.3039* (60)	.1127 (64)	-.0921 (64)
Hymenoptera (>4mm)	-.0397 (14)	.0798 (14)	.3939 (14)	-.3006 (14)	.1269 (14)	-.4749 (14)	.2690 (7)	-.4455 (14)	-.5165 (14)	.1168 (14)	-.0103 (14)
Ants	-.2133 (34	-.1556 (35)	-.1961 (35)	.3614* (35)	-.1961 (35)	.0697 (35)	.1108 (28)	.2530 (35)	.0007 (35)	-.3466 (35)	-.2055 (35)
Homoptera (Leafhoppers)	-.5325** (81)	-.4852** (90)	-.5721** (90)	.1033 (90)	-.4303 (90)	.1357 (90)	-.2408 (59)	.6441** (90)	-.0341 (85)	-.1108 (90)	-.2441** (90)
Orthoptera	-.5525* (14)	-.6103* (14)	-.4377 (14)	-.4424 (14)	-.3479 (14)	-.8378 (14)	.4773 (11)	.4792 (14)	-.5889* (14)	.6935* (14)	-.2094 (14)
Lepidoptera larva (<10mm)	-.3478 (9)	-.3069 (11)	.0208 (11)	-.2552 (11)	-.2154 (11)	-.2385 (11)	.2611 (6)	.0765 (11)	-.4227 (11)	.2886 (11)	-.2201 (11)
Arachnida (Spiders)	.0370 (16)	-.1944 (16)	-.0891 (16)	.2152 (16)	-.2050 (16)	-.2820 (16)	.2240 (8)	.2037 (16)	0.2208 (13)	-.1687 (16)	-.2790 (16)

[1]Values in parenthesis are the sample sizes

*Significance at the p<.05.

**Significance at the p<.01.

Table 11.--Correlation coefficients between the percent biomass in the pheasant chick crops and the percent biomass present in the field for 19 characteristics of insect prey.

	Characteristics	Number of crops (N)	Correlation coefficient	Significance level
Mode of locomotion	Walking	123	.4425	.01
	Flying	60	-.1000	n.s.
	Jumping	119	.5145	.01
	Crawling	51	.7035	.01
	Resting	17	.2657	n.s.
Size	Minute (<2mm)	78	.0703	n.s.
	Small (2-4mm)	120	.0856	n.s.
	Medium (4-6mm)	126	.3033	.01
	Large (6-10mm)	79	.0094	n.s.
	Very Large (>10mm)	40	.0628	n.s.
Color	Light brown/grey	117	.4284	.01
	Brown/black	126	.4562	.01
	Green (dark)	81	.3484	.01
Shape	Oval	103	.1860	n.s.
	Wormlike	32	.7677	.01
	Oblique	120	.4431	.01
	Long appendages	73	-.0037	n.s.
Vertical strata	Ground to 12 in.	125	.4485	.01
	12-36 in.	69	-.0811	n.s.

correlation coefficients were negative which reflects the inability of the sampling methods to estimate these groups.

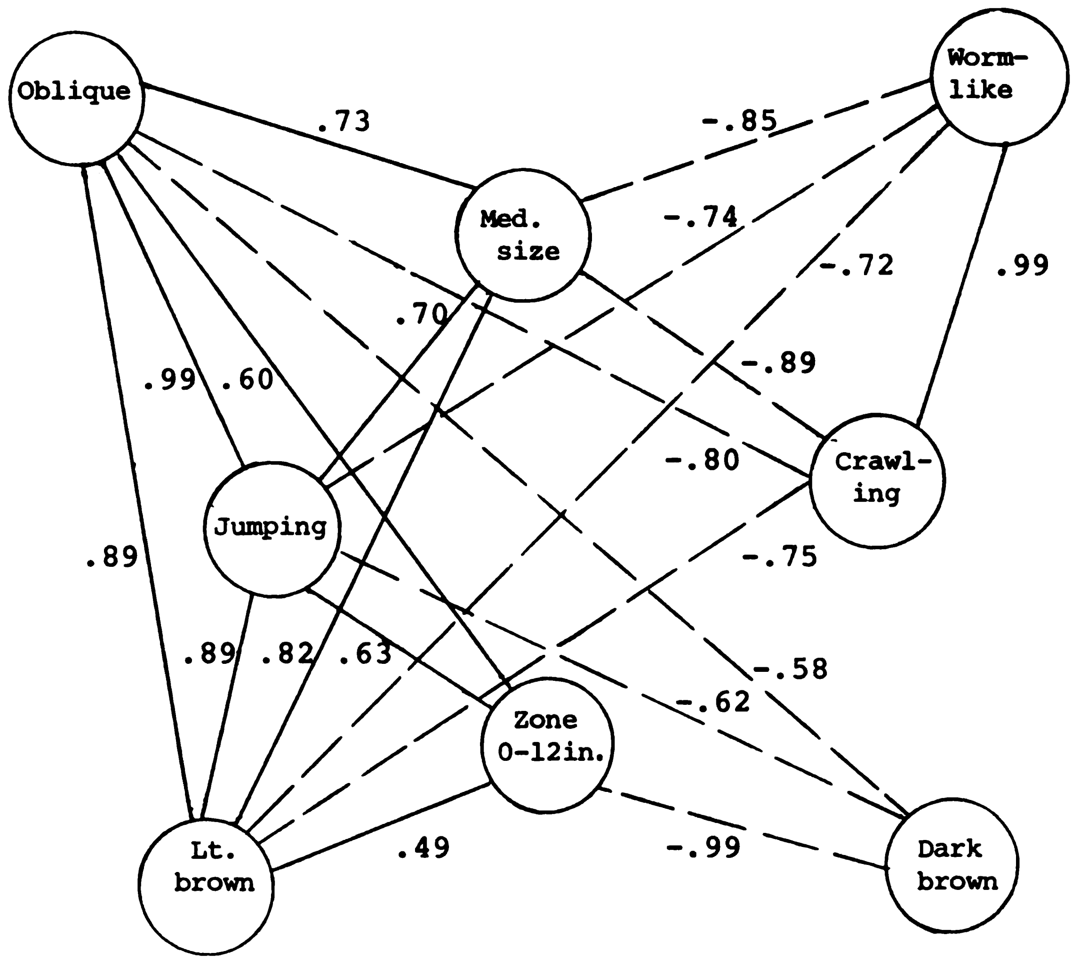
The significant correlation coefficients associated with color were of the same order of magnitude with a range of .3484 to .4284. This minor difference would not suggest any food preference based upon color.

Three methods of locomotion, one size category, three of the four colors, two shape categories and the middle strata were highly significant. Since each insect was assigned to one characteristic for each of the major categories, could the jumping insects be related to the oblique shaped insects? To answer this question the significant correlations are presented in Figure 4.

Many of the criteria used to classify insects into categories were correlated. Jumping and oblique shaped insects were highly correlated ($r = .987$, $p<.01$) as were crawling and wormlike insects ($r = .987$, $p<.01$). The insect common to jumping and oblique shape categories was the leafhopper while crawling and wromlike insects consisted of numerous insect larvae. These high correlations suggest that wormlike or crawling insects were a measure of the same group.

A Comparison of Physical Characteristics of Pheasant Chick Foods Eaten in Three Structurally Different Plant Communities

The proportion of an insect category found in each crop was subtracted from its respective proportion available



These correlation coeficients are all significant (p<.01) with a sample size ranging from 72 to 120.

Figure 4. Correlations between selected characteristics of insect prey found in the pheasant chick crops.

in the field. This methodology allowed the data to be analyzed with a one way analysis of variance test. Only seven characteristics possessed sufficient sample sizes for analysis (Table 12). Some of the means were negative values indicating that chicks ate a higher proportion of a group than was available.

Five of the seven insect groups evaluated were significant ($p<.05$). Two groups, crawling and vertical strata were highly significant ($p<.01$). From these results, it would appear that vegetative structure alters feeding patterns of pheasant chicks.

Age Contrasts in Feeding Behavior

The proportion of crop biomass consisting of selected insect categories was used to contrast the feeding behavior of three age groups of pheasant chicks. Only those categories with adequate sample sizes were compared (Table 13).

Only two groups, crawling and brown/black, were significantly different ($p<.05$). These two groups have been shown to be highly correlated ($r = .987$) and therefore should be considered as two measurements of the same insect group.

Growth and Digestion in the Laboratory

Pheasant chicks were confined to rearing pens in the laboratory and weighed. Mean weights for five day intervals are listed in Table 14. The growth recorded was much like

Table 12.--Analyses of variance of relative feeding preferences by field type for selected insect groups.

Insect group	% Available - % in crop ($\bar{x} \pm$ SD)			Significance level
	Clover(n=25)	Bromegrass(n=19)	Oldfield(n=55)	
Crawling	-26.14 ± 26.52	-2.35 ± 6.54	-16.35 ± 16.91	.01
Jumping	6.18 ± 43.61	0.28 ± 21.10	9.67 ± 23.23	n.s.
Walking	-12.86 ± 22.47	0.34 ± 2.33	- 2.46 ± 18.30	.05
Small (2-4mm)	3.23 ± 5.81	-2.86 ± 6.28	- 0.58 ± 7.40	.05
Med. size (4-6mm)	12.97 ± 26.67	3.07 ± 23.01	0.36 ± 25.29	n.s.
Large (6-10mm)	- 7.33 ± 20.23	-0.46 ± 18.33	6.51 ± 20.25	.05
Vertical strata (ground to 12 in.)	32.36 ± 20.36	1.17 ± 21.06	8.73 ± 3.36	.01

Table 13.--Analyses of variance of relative feeding preferences by age group for selected insect groups.

Insect group	Percent in crop ($\bar{x} \pm$ SD) 1 week (n=8)	2 weeks (n=9)	3 weeks (n=7)	Significance level
Walking	10.70 ± 25.60	2.03 ± 2.70	19.41 ± 17.91	n.s.
Jumping	25.06 ± 28.05	11.24 ± 15.87	16.65 ± 22.59	n.s.
Crawling	22.70 ± 14.66	21.41 ± 16.65	5.42 ± 5.79	.05
Med. size (4-6mm)	18.25 ± 18.43	14.13 ± 25.64	5.47 ± 13.58	n.s.
Lt brown/grey	22.95 ± 20.20	9.82 ± 25.04	7.14 ± 20.95	n.s.
Dark green	2.92 ± 2.85	3.94 ± 1.20	4.10 ± 1.43	n.s.
Brown/black	3.57 ± 16.71	5.30 ± 2.75	15.67 ± 16.99	.05
Wormlike	17.92 ± 11.36	21.00 ± 17.09	5.37 ± 5.76	n.s.
Oblique	28.08 ± 25.49	15.28 ± 15.79	20.85 ± 22.48	n.s.
Ground to 12 in.	5.41 ± 23.49	6.21 ± 2.97	15.38 ± 18.25	n.s.

Table 14.--Weight of pen reared pheasant chicks through 30 days.

Age	N=8	Weight in gms. ($\bar{x} \pm$ SE)
Hatch		21.27 ± 0.39
5 days		34.56 ± 1.27
10		55.23 ± 2.52
15		90.32 ± 5.68
20		115.27 ± 7.23
25		157.77 ± 10.07
30		198.17 ± 13.54

that described for young pheasants in other studies and provides a basis of comparison for growth rates in the field (Loughrey 1951 and Suomalainen 1965). In addition, these results demonstrated that these chicks had a growth pattern similar to other strains of pheasants.

The results of the digestive rate studies show that it took 132 ± 14 S.D. minutes for the chromium oxide to pass the entire length of the digestive tract. Assimilation rates were not monitored in these experiments.

DISCUSIONS AND CONCLUSIONS

Available Foods in the Study Fields

The insect samples collected from the study fields reveal several conditions which may play an important role in determining the suitability of a specific field for pheasant production. Data from this study suggests that a crucial requirement for brood production would be the quantity of available invertebrate biomass. The minimum level of invertebrate biomass required by brooding pheasants can usually be found in only densely vegetated fields. As was previously pointed out, sparsely vegetated areas would probably lack an adequate supply of insect biomass to sustain growing pheasants. Support of this statement is demonstrated by extremely low insect biomass found in the row crops and the first year fallow fields mentioned in the methods section. The weeds associated with newly established fallow fields i.e., velvet leaf, lambs quarter, smartweed, and ragweed do not host a large variety nor quantity of invertebrate foods. Uncultiviated fields left alone for several years soon become inhabited by biennials and perennials and thus attract and perpetuate a multitude of insect species and also sustain a greater standing crop of insects upon which pheasant chicks feed.

General insect feeders such as pheasant chicks appear to find a vegetatively diverse field more suitable because the absence of one insect food can be readily substituted for another. As was found throughout the 1973 season, certain insect species became abundant for a period of time and then declined. Other species remained in the field for the entire brooding season. The length of time that a high biomass level of an insect population remained in the field was dependent on the developmental time of that species and the total time during which that species is an available food source (Southwood 1966). Insect species with a rapidly peaking and declining population that can not readily replenish itself may have limited value to foraging predators. In contrast, an invertebrate species possessing a short developmental time coupled with a longer reproductive period can continually replenish the available biomass even though the peak population may not be as high. The biomass level of each insect population followed through time can be expressed with a curve. The composite of all biomass curves for insect populations reflects the total available biomass at any point in time. A sudden rise or fall in a single important insect population may have important survival implications to the brooding pheasants.

The success of brooding pheasants in Bromegrass Field 6 may have been due to the ability of leafhoppers to continually replace that portion of their biomass removed by the foraging chicks. Other invertebrate species such as the land slug may provide a large biomass for an instant in time but may not be able to replace that biomass removed by the pheasants.

The topic of biomass levels through time should receive careful consideration in any future feeding studies of gallinaceous gamebird chicks. A single sampling window has limited value and can be likened to a snapshot picture while periodic sampling throughout the brooding period best expresses the dynamic features encountered in field situations. The young pheasant's survival depends on an adequate food supply through time and therefore food studies should periodically monitor insect biomass throughout the entire brooding season. Fulton and Haynes (1976) present the methodology of periodic sampling.

The problem of varying biomass levels would not appear to be as critical in heteorgeneous communities since numerous species can substitute and replace other species. This condition may account for the brood success often observed in oldfield communities. The ability of generalized insect predators to switch from one food source to another is important for survival. Wide variation of pheasant chick food is well documented. Chick crops from this study provide further evidence of this. Several crops contained only slugs, other crops were filled with leafhoppers, while most crops contained assorted combinations of invertebrate groups.

Full crops were most often encountered for those chicks taken from heterogenious plant communities. In addition, most of these crops contained a variety of insect species. The evidence gathered in this study lends further support to the theory that pheasant chicks as well as adults are, indeed, opportunists.

The field that provided the highest biomass of invertebrate foods was Bromegrass Field 6 with 100.19 milligrams/ft^2 (9.6 lbs/acre). Following Field 6, were Oldfields 4 and 5 with an estimated 99.65 and 71.95 mg/ft^2 respectively. The remaining 8 fields possessed biomass estimates ranging from 18.00 to 25.40 mg/ft^2. It is interesting to note that in 1973 at least one wild brood inhabited Oldfield 4 and Bromegrass Field 6, the fields with the highest biomass levels. Subjectively speaking, Oldfield 4 and Bromegrass Field 6 were good pheasant producing areas. Wild broods were also observed at the edge of field 6 in both 1974 and 1975.

One bromegrass field possessed the highest invertebrate biomass while the other two bromegrass fields possessed extremely low biomass levels. An explanation for this discrepency is lacking. One possible explanation for such a wide difference could be the relationship between the bromegrass fields and the adjacent fields which might have been effected differentially by agricultural practices such as weed and insect control. A monoculture such as bromegrass field is much more sensitive to change.

Clover fields were more predictable in terms of biomass quantity as well as species composition. In the clover fields evaluated, most insect groups were represented and when compared with other field types, lower biomass quantities were found. The sampling efficiency of sweeping in clover fields was evaluated and found to be quite comparable to other field types (Table 3). However, underestimates of biomass in clover fields could exist.

Another feature unique to clover fields was the apparent difficulty of chicks to move through the tangled network of stems below the vegetative canopy. Although no detailed experimentation was made regarding vertical stratification of available insect foods, it appeared that most motile insects remained in the canopy and thus were more difficult for the small pheasants to reach. The ground dwelling, moisture sensitive invertebrates were more available in the feeding zones of foraging chicks. Ground dwelling invertebrates were frequently found in chick crops collected from clover fields. As a result of certain structural features, clover communities probably retain moisture better than other community types evaluated. This factor could explain why more slugs were found in the crops of birds taken from clover fields. Another factor that might have contributed to the high portion of slugs in crops is the fact that slugs constituted a large portion of available biomass in clover fields.

Validity and Usage of Estimated Biomass

A correlation coefficient of .96 was found between the estimated insect biomass and actual biomass collected from the sweep net samples. This correlation was based upon one sample from each of eleven fields. A high correlation was expected since the dependent variable was an estimation of the independent variable. Such estimates possess inherent sources of error. The mean dry weights per insect group cannot be expected to explain all situations. For example, the size of beetles may vary with the field types, conditions of collection or season of the year.

Comments Concerning the Chick's Diets

The insect groups that constituted a majority of the pheasant's diet were generally larger, more common invertebrates such as leafhoppers, caterpillars, larger beetles, true bugs, and slugs. Occasionally, large less common invertebrates comprised a large portion of a few chick crops. Collectively however, invertebrate groups such as earthworms, snails, mites, millipeds and centipeds contribute little to the pheasant chick's diet under normal conditions. Therefore, these invertebrate groups do not warrant any special attention in establishment of estimated biomass levels.

Small invertebrate groups such as collembola, small flies, small hymenoptera, and small bettles also provide little food accounting for only 0.3 percent of the pheasant's diet. In fact, nutritional value contributed by these small insects may not equal the energy expended to capture them. A notable exception to this statement was a single chick which had its crop completely filled with 948 aphids, which would suggest that this bird encountered a cluster of aphids and took advantage of a food source.

Food Preferences

Establishment of feeding preferences are usually calculated by a comparison of an animals' diet to available foods. A table of correlation coefficients is provided to show how the various available foods were selected by young pheasants (Table 10). A notable positive correlation exists between the percent of leafhoppers in the crops and leafhopper availability. A correlation coefficient of .644 demonstrates a highly significant relationship ($p<.0000$). This correlation would have been higher if several extreme values had been eliminated. One explanation of these deviate values is the fact that several chicks were observed foraging in neighboring plant communities in which the insect biomass was not known. Total restriction of chick movement was impossible.

A second possible explanation could be the insect distribution within each study field. Non-uniform and clumped distributions are expected in oldfield communities. Even homogeneous plant communities such as bromegrass and clover may experience uneven insect distributions and thus effect the calculation of feeding preferences.

A third factor that might influence the calculated relationship between food availability and diets is the fact that both values are estimates. This is an accepted source of error.

Leafhoppers, according to this study, provide an excellent means of evaluating feeding preferences. Generally, large numbers of leafhoppers were present in the fields and lent themselves to sweep net sampling. According to the absolute numbers from the tent samples 17 percent were caught by sweeping in oldfields while 34 percent were collected in bromegrass demonstrating the effectiveness of sweeping. Since one species of leafhopper comprised the majority of those captured, the uniformity of size provided an excellent basis on which to estimate available biomass.

The negative correlations reflect the fact that the presence of one insect group in diets is negatively related to the presence of other groups in the field. Leafhoppers in the field were negatively correlated with the presence of large and small coleopterans, large dipterans, hemipterans, large hymenopterans, and spiders in the crops. Collectively, these groups comprise 85 percent of the biomass excluding leafhoppers. This pattern of negative correlations can be observed to a lesser extent with other insect groups. The negative correlations between spiders and grasshoppers in crops and their availability in the field reflects the difficulties of the sampling techniques. These two groups were not properly sampled by sweeping. Sweeping does not adequately sample areas commonly occupied by spiders and crickets nor does sweeping truly represent elusive grasshoppers.

Feeding Preferences Based Upon Physical Characteristics of Insect Foods

Examination of the relationships between the characteristics of insect prey and their presence in crops provides many interesting insights into the feeding responses of young pheasants. Of the five size classes evaluated, only the medium sized insects correlate significantly ($p<.01$). One explanation for this high correlation is the fact that leafhoppers comprise most of the biomass for this size class.

Three of the four colors examined (light brown/grey, brown/black, and dark green) yielded highly significant correlations ($p<.01$). The three correlation coefficients were not only highly significant but also very similar which would indicate a lack of color preference.

Insect shapes were extremely difficult to evaluate. Although two correlation coefficients were significant ($p<.05$), the meaning of these findings was not clear. Worm-like insects were eaten in proportion to their availability.

Oblique shaped insects were also highly significant but this could have been attributable to the large biomass of leafhoppers.

Three vertical strata were examined with only the ground surface of 12 inch strata showing significance. A major problem with contrasting vertical strata was the fact that many of the insects and invertebrate fauna may have occupied all three strata at some time. Meteorological conditions and diurnal movement dictate where most insects will be found at a given time.

Examination of significant correlation coefficients for physical characteristics of insect foods reveal that they range from .3033 to .7677. Removal of the 2 correlation coefficient associated with the characteristics of worms limits the range to .3033 to .5145. The fact that most of these correlations are of the same order of magnitude strengthens the postulate that young pheasants eat what is available. Extreme values would have reflected differential selection of foods.

A Comparison of Physical Characteristics of Pheasant Chick Foods Eaten in Three Structurally Different Plant Communities

Five of the seven insect categories tested were significant. However, the two groups that were not significant comprised a majority of the biomass for their respective groups.

Walking insects were significantly different at the .05 level. Examination of the mean values for the three field types provides some insight as to why these field types were different. A positive mean would indicate a lack of preference because the scores were obtained by subtracting the proportion of the insect in the crop from the proportion found in the field. A negative mean would indicate a preference. Walking insects were least preferred in bromegrass and most preferred in clover with oldfields intermediate. It appeared that vegetative structure was somehow related to these apparent preferences. In four out of the five significant tests the order of the means was either bromegrass, oldfield and clover or the reverse. Walking insects, crawling insects and large insects were most preferred in clover while small insects and insects occupying the 0-12 inch strata were least preferred. Difference in the foods eaten in the three field types did exist. It appeared that the feeding preferences shown here reflect effects of plant structure. In spite of the adjustments made to the insect numbers to account for the differences due to vegetative structure, some error still remained. Insect density could have also effected the results.

Age Contrasts

Of the eleven physical characteristics of insect prey evaluated, two were significantly different. One week old chicks fed especially heavy on caterpillars. The reason for this behavior is not fully understood although it is suspected that the slow moving caterpillars experienced an uneven distribution and were encountered more frequently by the younger pheasants. This situation demonstrated the ability of a small chick to feed upon very large invertebrates.

The second characteristic of statistical significance was the brown/black colored insects. This group was comprised principally of beetles and ants, both of which were difficult to capture by sweeping.

In spite of the 2 categories that were significantly different, it is doubtful if various aged chicks fed differently.

Weight Changes

Examination of the 3 day weight change for chicks feeding in the experimental fields shows a significant difference between each set of fields ($p < .05$) (Table 9). The mean weight changes observed for each of the three fields compared on July 3 are in the same order as that observed for their respective biomass levels. The fields with more available foods showed the most favorable weight changes for those chicks feeding in these fields.

The fields evaluated on July 12 show that the chicks in Oldfield 11 had the best growth of all the fields studied in spite of the fact that the estimated biomass for that field is quite low. Oldfield 11 was difficult to adequately sample by sweeping because of the high timothy grass and for this reason the biomass estimate appears to be low.

The third set of fields compared is difficult to explain because of the unknown influence of strong winds which may have been responsible for the loss of 9 of the 12 chicks in the clover field. This condition casts serious doubt on any conclusions concerning the value of field 15. Why were so many chicks lost in this field? Did these young birds have to travel further to procure food and at this point lose vocal communication with their foster hen because of the noise created by the wind?

It is apparent that pheasant chicks do not fare well for the first few days in the field. Had these broods been measured over a longer period of time, better weight gains would probably have been observed. It was necessary to terminate this section of the study since these birds were needed in the feeding preference work. However, five pheasant chicks in field 5 were periodically weighed and after an initial weight loss approached normal size at the end of thirty days.

Nutritional Considerations of Available Foods

The nutritional analysis of insect material was ommited from this study as other studies have thoroughly evaluated the nutritional values for numerous insect taxa.

The results of these studies are in good agreement (Beck and Beck 1955, Cross 1966, Korschgen 1964). These data reveal that the high protein levels and M.E. are available in insect material.

As the study progressed, it became evident that slugs frequently comprised a large portion of a chick's diet. The significant findings of this analysis was the extremely high level of ash content of slugs as compared with insects, almost 11 percent of the dry weight as compared to 3.3 percent for insects (Cross 1966). Analysis of the ash content left from the approximate analysis revealed a calcium content of 19.2 percent, which amounts to 2 percent of the total dry weight of slugs. Beck and Beck (1955) claim that beetles, grasshoppers and lepidoptera larva contain 1.208, 1.279 and 1.050 percent calcium by body weight respectively.

It is apparent that slugs can provide a abundant source of calcium. If evidence becomes available pointing to calcium as a limited factor in pheasant distribution, slugs could provide a source of the needed calcium. Korschgen (1964) investigated several sources of calcium and concluded that pheasants can probably differentiate calcium rich food sources such as the common land snail.

Another ramification of the role of slugs as chick food was observed. During wet and cold days insect activity declines while the activity level of slugs drastically increases. Most insects seek cover and/or become quiescent under these meteorological conditions which would minimize their exposure to foraging pheasant chicks and thus effectively reduce available foods. Under these conditions slugs may provide a readily available food source.

When it was first discovered that slugs constituted a large portion of the pheasant chick's diet in several experimental fields, the feeding behavior of the artificially reared chicks was questioned. However, 3 of the 6 native pheasant chicks collected from several locations in Michigan had also fed on slugs. Examination of weather data for these areas revealed that these chicks had been collected following rain. Why have slugs been overlooked as pheasant food in the past? Were the collection sites in southern and central Michigan unique? The presence of slugs in the crops of young pheasants truly suggest opportunistic feeding behavior.

Vegetation: Comments and Suggestions

The biomass collected from the study fields suggests that oldfield communities offer adequate biomass to fulfill the food requirements of young pheasants. Oldfields also provide more community stability than do either bromegrass or clover. Two apparent reasons for this stability are species diversity and lack of periodic disturbances. Oldfields may remain in land retirement programs for a decade thus providing nesting cover in the spring, brooding cover in the summer and escape cover for the duration of the year. However, the future of land retirement programs looks dim as government subsidies dwindle. Agricultural economics are not compatable with productive areas left idle.

These conditions reflect the importance of maximizing pheasant productivity of the residual lands available. Several considerations may enhance productivity of these areas. Pheasant broods are often observed feeding along paths and mowed road shoulders. Examination of these cut areas reveal high insect populations which attract foraging chicks. Several reasons could account for this interaction of predator chicks and their prey. Available insects have only one strata to occupy in cutover areas and are therefore, easy prey. Insects may also seek the succulent shoots of young plants becoming established in these areas. Roadsides may also provide the flora which insect prey find attractive.

A possible cultural recommendation suggested by this observation is the mowing of strips through oldfields. These strips would provide the same function as roadsides without the additional hazard of traffic. The mowed strips could be the width of a farm lane and possibly spaced 100 yards apart. Too many mowed strips would increase the chance of nest destruction. Experimentation of this technique is suggested.

The roadside flora frequently includes bromegrass. As has been previously shown, bromegrass can sustain extremely high insect biomass. The evidence found in this study suggest that bromegrass can be an important plant in pheasant producing areas. Bromegrass interspersed with forbes provides food and cover for general insectivorous feeders such as pheasant chicks.

The value of clover or alfalfa fields for foraging broods is questionable. The mobility of young pheasants is somewhat hampered by the dense horizontal stem structure of these plants. Furthermore, the evidence presented suggests a marginal level of available foods and a large portion of that food may remain in the plant canopy beyond the reach of the small chicks. Under certain conditions clover fields may provide abundant foods. In early June high population levels of spittlebugs and green cloverworm are common and appear to be very accessable to young pheasants.

Another problem of clover and alfalfa fields is the conflict between cutting and pheasant broods. Early mowing has been shown to destroy pheasant nests. Even if the young escape, the cutover field offers little food and cover.

The values of legume fields as pheasant producing areas is questionable. However, these fields do provide excellent cover throughout much of the growing season.

SUMMARY

Three major types of plant communities were examined and the invertebrate fauna that inhabit them was evaluated. Several sampling techniques were used. The efficiency of sweep netting which was evaluated varies with the plant community and insect species. The use of baited boards provided a means of sampling a large portion of the slug population. Some fields revealed high slug populations while others did not.

Leafhoppers of the genus *Otiocerus* constituted a large portion of available arthropoda biomass. This leafhopper was extremely abundant in bromegrass communities. The young pheasants exhibited no difficulty in capturing the fast moving leafhoppers. The diet of young pheasants appears to be a function of food availability. It should be cautioned that this statement is based upon data which minimizes the effects of insect density. Possibly a laboratory study utilizing varying insect densities could provide the answer to this question.

Insect populations associated with three structurally different plant communities have been studied. However, it

appears at this time that a vegetatively diverse community offers more stability in the amount of insect foods than the homogeneous communities studied.

No behavioral problems were detected with the experimental pheasant chicks. The crop contents of both native and experimental chicks were similar. The experimental pheasants, if allowed sufficient time to adjust to their new environment, demonstrated growth comparable to native chicks.

Empirical data suggests that usage of roadsides by brooding pheasants seems to be related to insect food found in these cutover areas. Cutting strips in fields used as brooding areas could provide advantages offered by roadsides without the danger of traffic.

Oldfields have demonstrated their role as important pheasant producing areas. This study has, in part, brought forth some of the possible reasons why oldfields produce pheasants.

The vegetative composition of plant communities and the knowledge of the insect communities inhabiting them provides another useful management tool. This information provides a basis upon which communities can be evaluated for available pheasant foods and possibly indicates how the food sources in these communities can be monitored.

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APPENDICES

APPENDIX A

APPENDIX A

SOME COMMON PLANTS OF NORTHEAST BARRY COUNTY OLDFIELDS

Common name	Scientific name
Bluegrass	*Poa* sp.
Bromegrass	*Bromus inernis*
Burdock	*Arctium minus*
Clover (Red Mammoth)	*Trifolium pratense*
Curled dock	*Rumex crispus*
Daisy fleabane	*Erigeron strigosus*
Dandelion	*Taraxacum officinale*
Goldenrod	*Soidago nemoralis*
Ground cherry	*Physalis heterophylla*
Horseweed	*Erigeron canadensis*
Milkweed	*Asclepias syriaca*
Plantain (Regal's)	*Plantago rugelii*
Plantain (Staghorn)	*Plantago lanceolata*
Quackgrass	*Agropyron repens*
Queen Ann's Lace	*Daucus carata*
Ragweed	*Ambrosia artemisiifolia*
Smartweed	*Polgonum pennsylvanicum*
Sweet clover	*Melitotus officinalis*
Teasel	*Dipsacus sylvestris*
Thistle	*Cirsium sp.*
Timothy	*Phleum pratense*
Wild flax	*Coreopsis tinctoria*
Wild lettuce	*Lactuca canadensis*
Wild rose	*Rosa* sp.
Yellow rocket	*Barbarea vulgaris*

APPENDIX B

APPENDIX B

INSECT NUMBERS COLLECTED BY SWEEPING 312.5 ft^2 AREAS FROM FIFTEEN STUDY FIELDS (July 3-18, 1973)

FIELD TYPE

Invertebrate group	Clover					Bromegrass			Oldfield				Fallow	Wheat	Brush
	3	7	9	12	15	6	13	14	4	5	11	16	1	2	10
Coleoptera (<4mm)	4	58	351	15	27	6	7	10	26	42	27	14	4	4	7
Coleoptera (>4mm)	10	23	45	33	21	2	3	11	17	19	9	12	4	2	10
Diptera (>4mm)	5	10	41	70	34	4	10	2	14	33	10	7	1	7	5
Diptera (<4mm)	746	248	385	163	433	184	496	266	758	211	93	105	90	73	139
Hemiptera (>4mm)	4	92	174	79	76	31	14	12	59	155	26	27	27	8	26
Hemiptera (<4mm)	9	58	31	40	123	2		3	7	23	8	53	28		49
Hymenoptera (>4mm)	3	2	8	5	1	2	2	2	1	1	2		2	2	1
Hymenoptera (<4mm)	40	45	81	90	82	50	186	42	171	63	38	35	64	4	27
Ants				2		2			12		1	14			15
Leafhoppers (>4mm)	153	243	155	54	72	2356	329	588	979	532	124	76	77	1	71
Leafhoppers (<4mm)	65	95	79	22	123	45	13	33	88	20	9	33	20	8	65
Aphids	137	10	7	3	3				44	3		2	19	38	112
Lepidoptera larvae(1>cm)		1	4	1	3				1			2			
Lepidoptera larvae(<1cm)	18	4	24	1	4	1	2	1	3	4		3	3		
Coleoptera larvae(>6mm)	5														
Coleoptera larvae(<6mm)	1		3			1			1				11	8	1
Collembola		1			59		1	3	2			1	3		
Grasshopper		2	6	1	3	12	6	7	8		19	2	2	1	1
Lepidoptera adult(>1cm)		1							1	2		1			
Lepidoptera adult(<1cm)		3	5	4	2	18	4	2	2	5	1	1	2		7
Spider (>4mm)	1	1	1			5	4	5	2	1	3	2	1		1
Spider (<4mm)	1	1	5	2	3	2	5	9	7	1	2	16	1		18
Daddy long-legs						1							1		
Mites		3	1		1	14	23	12	3	5	2	1			4
Thrips		2	3	1	2	3	2		7	1	2		1	1	20
Pscoptera			3		2		1				3	1			
Total	1197	894	1410	584	1070	2723	1082	996	2203	1115	372	406	358	156	556