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Author(s): Jennifer A. Smith and Ty W. MatthewsElizabeth Doxon
Holcomb, Lucas P. Negus, and Craig A. DavisMary Bomberger
Brown and Larkin A. PowellJ. Scott Taylor

Source: The American Midland Naturalist, 173(2):318-325.

Published By: University of Notre Dame

URL: [http://www.bioone.org/doi/full/10.1674/
amid-173-02-318-325.1](http://www.bioone.org/doi/full/10.1674/amid-173-02-318-325.1)

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Invertebrate Prey Selection by Ring-necked Pheasant (*Phasianus colchicus*) Broods in Nebraska

JENNIFER A. SMITH AND TY W. MATTHEWS¹

School of Natural Resources, 3310 Holdrege Street, University of Nebraska-Lincoln, Lincoln, 68583

ELIZABETH DOXON HOLCOMB,² LUCAS P. NEGUS³ AND CRAIG A. DAVIS

*Department of Natural Resource Ecology and Management, Agricultural Hall, Oklahoma State University,
Stillwater 74078*

MARY BOMBERGER BROWN AND LARKIN A. POWELL⁴

School of Natural Resources, 3310 Holdrege Street, University of Nebraska-Lincoln, Lincoln 68583

AND

J. SCOTT TAYLOR

Nebraska Game & Parks Commission, 2200 N. 33rd Street, Lincoln, Nebraska 68503

ABSTRACT.—Biologists often manage grassland habitat for ring-necked pheasants (*Phasianus colchicus*) through provision of the grasses and forbs that support the invertebrates on which they forage. However, specific information pertaining to invertebrate prey selection by ring-necked pheasant broods is lacking. To address this, we used radio-telemetry to locate pheasant roost sites where we collected pheasant chick droppings. We then identified characteristic fragments of invertebrates in each dropping sample to family and order to calculate percent composition of each. Next, we sampled invertebrate abundance near to sites where droppings had been collected using a standard sweep netting protocol. Invertebrates found in chick droppings were compared with the diversity of invertebrates available on the landscape. Curculionidae [weevils (Order Coleoptera)] were present in all droppings sampled, and they were the most frequently consumed invertebrate taxa by seven of the nine broods sampled. The remaining two broods consumed Formicidae [ants (Order Hymenoptera)] most frequently. All broods significantly selected Coleoptera more than expected by their availability, and two broods significantly selected Hymenoptera more than expected by their availability. Habitat management practices that result in greater abundance of these species on the landscape should be beneficial to pheasants.

INTRODUCTION

Pheasant (*Phasianus colchicus*) populations across the Great Plains, including Nebraska, have experienced long term declines since the 1950s (Taylor *et al.*, 1978; Vandel and Linder, 1981; Rodgers, 1999). Deterioration of pheasant winter habitat due to broad scale changes in agricultural practices may be the cause of these long term declines (Rodgers, 1999; Rodgers, 2002), in combination with the loss of brood rearing grassland habitat which has resulted in reduced brood survival (Warner *et al.*, 1984). However, the mechanisms

¹Present address: Fish and Wildlife Service Eastern Idaho Field Office, 4425 Burley Drive Suite A, Chubbuck, Idaho 83202

²Present address: Department of Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville 37996

³Present address: Nebraska Game & Parks Commission, Royal, Nebraska 68773

⁴Corresponding author: Telephone: (402) 472 6825; Fax: (402) 472 2946; e-mail: lpowell3@unl.edu

underlying the effect of grassland habitat loss on brood survival have largely been neglected since the work of Warner *et al.* (1984).

The loss of grassland habitat results largely from a shift in land use from small acreages of interspersed grains, legumes, and grass to large homogeneous agro-ecosystems dominated by corn and soybeans (Taylor *et al.*, 1978; Warner *et al.*, 1984; Hiller *et al.*, 2009). Changes to agricultural practices in the Great Plains have decreased habitat heterogeneity and have led to an increase in the use of pesticides and herbicides, both of which reduce the availability of the invertebrates that are primary food sources for pheasant broods (Wilson *et al.*, 1999). Because invertebrates are an important source of protein that is essential for chick development and growth (O'Connor, 1984), any decline in their abundance due to changes in agricultural practices could underlie the observed decreases in brood survival that have contributed to declines in pheasant populations across the Great Plains (Warner *et al.*, 1999).

The Conservation Reserve Program (CRP) was created in 1985 primarily to reduce soil erosion and improve water quality, but also to re-establish native grass cover, reduce further loss of wildlife habitat, enhance the quality of wildlife habitat, and promote biodiversity. Recently, Matthews *et al.* (2012a) showed CRP that had been recently (0–3 y prior to data collection) inter-seeded with legumes had a positive effect on pheasant brood survival compared to other habitat types; brood survival increased with time spent in the managed CRP, and decreased as broods spent more time in cropland. Matthews *et al.* (2012a) suggested invertebrate prey availability was higher in managed CRP compared to croplands that were routinely sprayed with insecticides, and the higher abundance of invertebrates in CRP explained much of the variation in brood survival.

To assess the role of invertebrate availability on brood survival, it is important we better understand the dietary requirements and preferred prey of pheasant broods. Previous studies have shown invertebrates form a large part of the diet of pheasant chicks (Dalke, 1935; Hill, 1985), but an understanding of the relationship between the composition of pheasant chick diet and prey abundance and availability is limited. Doxon and Carroll (2010), examined differences in prey preferences between pheasant and northern bobwhite (*Colinus virginianus*) chicks using compositional analysis. Compared to bobwhite chicks, pheasant chicks showed preference towards the insect orders Homoptera, Hemiptera, and Coleoptera, but similar to the previous studies, they did not determine prey availability and, therefore, did not assess prey selection. To our knowledge, only Hill (1985) has examined the relationship between dietary composition and prey selection of wild pheasant broods, and this study compared invertebrate composition of droppings collected from chicks with invertebrate diversity within brood rearing home ranges of hen pheasants. Hill (1985) found chicks preferentially consumed sawfly (Order Hymenoptera) and Lepidoptera larvae, adult and larval carabid beetles, rove beetle larvae, and elaterid beetles (all Order Coleoptera) in the United Kingdom. Hill (1985) also found chicks preferentially selected winter barley, rough grass, and weedy areas in which to forage. Although structurally similar habitats may be available to pheasant broods in some regions of the Great Plains, they are very different from our study area in Nebraska where corn and soybean based agriculture dominate the landscape. Therefore, because invertebrate availability differs between habitat types, and varies geographically, it is unlikely the results of Hill (1985) provide an accurate account of prey selection of free-living pheasant broods in the Great Plains.

Here, we assess the diet and prey selection of free-living pheasant broods in northeastern Nebraska by comparing the relative abundance of different invertebrate taxa collected from droppings compared to those available on the broader landscape. We hypothesized ground

dwelling invertebrates [*e.g.*, beetles (Order Coleoptera)] would be more easily captured by pheasant chicks than more mobile invertebrates [*e.g.*, leafhoppers (Order Hemiptera)]. Therefore, we predicted pheasant broods would preferentially select Coleoptera but would select Hemiptera less than expected by availability. Results of this study can inform management strategies that are focused on supporting invertebrate prey communities for pheasant and other upland gamebird broods.

METHODS

STUDY AREA

We conducted our study in Stanton County, Nebraska from 2005–2006 (centered on 42°0'41"N, 97°14'19"W). The landscape consisted of a matrix of agricultural cropland that included corn, soybean and alfalfa, and CRP lands enrolled for more than 10 y prior to initiating the study (Matthews *et al.*, 2012a, b). CRP fields were initially planted with a mixture of native grasses (*e.g.*, switchgrass – *Panicum virgatum*), nonnative grasses (*e.g.*, smooth brome – *Bromus inermis*), or forb mixes. From 2002–2005 large sections of the CRP fields were inter-seeded with an alfalfa (*Medicago sativa*), red clover (*Trifolium pratense*), and yellow sweet clover (*Melilotus officinalis*) seed mix using a no-till drill (Matthews, 2009).

RADIO TELEMETRY AND BROOD MONITORING

We captured hen pheasants using baited funnel entrance box traps and night lighting techniques (Labisky, 1959) from Jan.–Mar. of each year of the study. We fitted each hen with a necklace style radio transmitter weighing <20 g (Model #A3960, Advanced Telemetry Systems, Inc., Isanti, MN., U.S.A.). We tracked hens using vehicles mounted with a null peak antenna receiver and an electronic compass (C100, KVH Industries, Inc., Middletown, R.I., U.S.A.). We estimated hen locations using triangulation 5 to 10 times per wk from 15 Mar. to 1 Aug., 2005–2006. All tracking occurred between 0700 and 2000 Central Daylight Time.

We located the roost site of each hen at night 10 d post hatch and flagged the area using survey flags. On the following day, once the hen had moved away from the area, we looked for any chick droppings that were present at the roost sites. Pheasant droppings are easily recognizable because of their shape and size; adult droppings are approximately 20 mm long, 4–5 mm in diameter, and are often found in large concentrations surrounded by the smaller droppings produced by the chicks (Brown *et al.*, 1987). Droppings from each roost site identified were combined and collectively considered an individual sample.

DROPPING ANALYSIS

Droppings were thoroughly dried and weighed individually to determine their dry mass. Droppings from each brood were then soaked in water and teased apart using forceps. We then identified characteristic fragments of invertebrates that were not destroyed by digestion (*e.g.*, mandibles, elytra) to family and order and calculated the minimum number of invertebrates based on numbers of diagnostic parts following Moreby (1988) and then estimated the percentage composition of each sample for each family and order identified.

INVERTEBRATE SAMPLING

Invertebrates available to pheasant broods were sampled in Jun. 2005 and again in Jul. 2005 at 20 randomly selected fields across the study area by using a standard sweep netting technique (Triplehorn and Johnson, 2005). The fields were chosen as sites by Negus *et al.* (2010) for a concurrent bird study and were selected to be representative of CRP grasslands

TABLE 1.—Average availability of invertebrates across 20 sites in northeastern Nebraska, 2005 as determined by sweep netting

Order	Available invertebrates	
	Average counts across sites	Average % across sites
Araneae	13.2	3.0
Coleoptera	87.7	19.6
Diptera	29.7	6.6
Hemiptera	207.0	46.3
Hymenoptera	66.7	14.9
Lepidoptera	3.1	0.7
Neuroptera	0.1	<0.1
Odonata	0.1	<0.1
Orthoptera	32.2	7.2
immature*	7.7	1.7

* immature are unidentified larval invertebrates

in the study area. All sampling sites were in the general area where droppings were collected (*e.g.*, within the same field). However, in one case droppings were collected approximately 4000 m away from the nearest invertebrate sampling site. However, because both insects and droppings were collected in CRP with similar structure, we suggest the insects available to pheasant broods were likely to be equivalent between sites.

At each site invertebrates were sampled by sweeping the vegetation at ground level with a standard insect sweep net along three separate transects of equal length. Invertebrates collected along the three transects at each site were then combined to form a single sample for each site and stored in 75% ethanol pending analysis. For analysis we identified individuals to order and dried them to constant mass in an oven at 60 C for approximately 3 d. We classified larval invertebrates that could not be identified to order as immature.

STATISTICAL ANALYSIS

We used chi-square tests to assess if pheasant broods selected the invertebrate orders identified in the droppings more or less than would be expected by their availability on the landscape. To calculate availability, we calculated the average abundance of invertebrates across all sites and across the two sampling periods as a representation of the landscape (*i.e.*, availability was the same for each brood). We calculated standardized residuals to determine which invertebrate orders were selected significantly more or less than expected by their availability when a chi-square statistic was significant ($P < 0.05$). Standardized residuals ≥ 1.96 were considered significant at $P = 0.05$ (Sheskin, 2003).

RESULTS

We identified nine orders of invertebrates that were available to pheasant broods across the 20 sites (Table 1). On average Hemiptera were the most abundant invertebrates identified in sweep net samples (46.3% of all invertebrates sampled), followed by Coleoptera (19.6% of all invertebrates sampled), and Hymenoptera (14.9% of all invertebrates sampled). In contrast Odonata were the least abundant invertebrates identified in the sweep net samples (0.02% of all invertebrates sampled).

During 2005 and 2006 we collected droppings from nine broods. We identified invertebrates from 18 families that belonged to seven orders from droppings (Table 2).

TABLE 2.—Composition (given as % of total number of invertebrates) of the diet of 10 d old ring-necked pheasant chicks feeding in northeastern Nebraska, 2005 and 2006

Family	Order	Sample ID								
		D1	D2	D3	D4	D5	D6	D7	D8	D9
Acrididae	Orthoptera	1.5	0	0.9	0	0.6	0.4	0.3	0.7	0.4
Aphididae	Hemiptera	0.7	0	0.9	0	0	0.4	0	0	0
Araneae	Araneae	0.7	0.9	1.3	0.6	0.6	0	0.6	0	0
Carabidae (adult)	Coleoptera	2.9	22.3	0.9	0.6	1.3	10.2	37.2	1.3	0
Carabidae (larvae)	Coleoptera	0	0.5	0	0	0	0	0	0	0
Cercopidae	Hemiptera	0	0	0	0	0.6	0	0	0	0
Chrysomelidae	Coleoptera	1.5	1.9	3.0	2.8	1.3	1.2	1.5	1.0	0
Cicadellidae	Hemiptera	0	0.9	1.3	4.4	3.1	0.8	0.6	1.3	1.7
Curculionidae	Coleoptera	89.9	29.3	37.4	87.3	85.6	73.6	56.5	90.7	94.1
Diptera	Diptera	0	0	1.3	0	0	0	0	0	0
Elateridae	Coleoptera	0	0.5	0	0	0	0	0	0	0
Formicidae	Hymenoptera	2.2	40.5	45.7	1.1	0	12.6	0.6	2.3	2.1
Gryllidae	Orthoptera	0	0	0	0	0.6	0.4	0	0.3	0
Lepidoptera (larvae)	Lepidoptera	0	0	3.0	0	0	0	0	0	0
Lygaeidae	Hemiptera	0	0	0	0	3.1	0	0.9	1.3	0.8
Miridae	Hemiptera	0	1.9	0.4	0.6	0.6	0	0.3	0.3	0.4
Nabidae	Hemiptera	0.7	0.9	2.6	2.2	1.3	0.4	0.6	0.7	0.4
Scarabaeidae	Coleoptera	0	0.5	0.9	0.6	0.6	0	0.6	0	0
Tenebrionidae	Coleoptera	0	0	0.4	0	0.6	0	0.3	0	0

We found Curculionidae (Order Coleoptera) in every sample and they were the most frequently consumed invertebrate taxa by seven of the nine broods sampled. The remaining two broods consumed Formicidae (Order Hymenoptera) most frequently. We also found Nabidae (Order Hemiptera) in every sample but they only formed a small proportion (average 1%) of the total number of invertebrates consumed by each brood. Other frequently consumed taxa were Carabidae (Order Coleoptera), Chrysomelidae (Order Coleoptera), Cicadellidae (Order Hemiptera), and Formicidae (Order Hymenoptera), all of which were identified in eight of the nine samples. In contrast larvae of Carabidae (Order Coleoptera) and Lepidoptera, Elateridae (Order Coleoptera), and Cercopidae (Order Hemiptera) were each only identified in a single sample.

All broods demonstrated significant prey selection patterns (χ^2 test: $P < 0.0001$) with all broods significantly selecting Coleoptera more than expected by their availability, and two broods significantly selecting Hymenoptera more than expected by their availability (Table 3). In contrast Diptera and Hemiptera were consumed less than expected by their availability by all broods, Orthoptera consumed less than expected by eight broods, and Hymenoptera consumed less than expected by six broods.

DISCUSSION

Our results demonstrate 10 d old pheasant broods in northeastern Nebraska preferentially selected and consumed Coleoptera over other available invertebrate taxa. Our results are similar to those of Hill (1985) who showed pheasant broods in the United Kingdom preferentially consumed Coleoptera over other invertebrate taxa. However, whereas the Coleopteran family primarily selected by broods in our study was Curculionidae (weevils), the families selected by pheasant broods in Hill (1985) were primarily Elatridae (click beetles)

TABLE 3.—Standardized residuals from chi-square tests (χ^2) used to test for significant differences between observed and expected prey selection by 10 d old ring-necked pheasant chicks. Standardized residuals in bold indicate where invertebrate prey were selected more (+) or less (–) than expected by their availability

Order	Sample ID								
	D1	D2	D3	D4	D5	D6	D7	D8	D9
Araneae	–1.50	–1.72	–1.45	–1.88	–1.71	–2.74	–2.49	–2.98	–2.65
Coleoptera	19.79	11.53	7.88	21.74	19.93	23.55	31.52	28.76	25.96
Diptera	–3.02	–3.78	–3.14	–3.46	–3.26	–4.10	–4.70	–4.47	–3.97
Hemiptera	–7.74	–9.17	–9.15	–7.73	–6.98	–10.47	–11.77	–10.87	–9.73
Hymenoptera	–3.87	9.71	12.08	–4.81	–4.88	–0.95	–6.76	–5.65	–5.12
Lepidoptera	–0.98	–1.22	–1.26	–1.12	–1.05	–1.33	–1.52	–1.44	–1.28
Neuroptera	–0.20	–0.25	–0.25	–0.22	–0.21	–0.27	–0.31	–0.29	–0.26
Odonata	–0.15	–0.19	–0.20	–0.17	–0.16	–0.21	–0.24	–0.22	–0.20
Orthoptera	–2.51	–3.93	–3.57	–3.61	–2.80	–3.80	–4.69	–4.01	–3.89
immature*	–1.53	–1.39	1.55	–1.76	–1.65	–2.08	–2.38	–2.27	–2.01

* immature are unidentified larval invertebrates

and Carabidae (ground beetles). In addition Hill (1985) demonstrated pheasant broods in the United Kingdom selected larvae of sawfly (Order Hymenoptera) and Lepidoptera. The differences between our results and those of Hill (1985) are likely due to significant habitat, climatic and geographic differences, between the study areas. For example hen pheasants in our study population selected inter-seeded CRP for brood rearing (Matthews *et al.*, 2012b) whereas pheasant broods in Hill (1985) preferred to forage in weedy areas, rough grass, and winter barley; it is likely these two habitats supported substantially different invertebrate communities. The differences in these results may also be due in lesser part to differences in the methods used to estimate invertebrate availability. We used sweep netting, whereas Hill (1985) used Dietrick vacuum sampling and pitfall traps, which target smaller invertebrates, (Doxon *et al.*, 2011) as well as sweep nets. Using different sampling methods can bias the types of invertebrates collected. For example the most abundant invertebrate taxa in our study as determined by sweep netting were Hemiptera, followed by Coleoptera, and Hymenoptera. Hill (1985) found the most abundant invertebrate taxa, as determined by using a combination of Dietrick vacuum, sweep net and pitfall trap sampling to be Tipulidae (crane flies) and Elatridae (click beetles). In addition, when estimating percentage composition of invertebrate foods in each chick dropping, Hill (1985) used correction factors to account for differential digestion of various invertebrate taxa consumed by pheasant chicks; we did not account for differential digestion among the invertebrate taxa consumed. Using different techniques to estimate dietary composition may bias results of dropping analyses and, therefore, the results of the statistical analyses.

We were unable to simultaneously collect droppings and invertebrate samples, and we were unable to determine brood foraging locations, but we assume they were close to the locations of the droppings. Because invertebrate abundance may vary by year, season and microhabitat (Triplehorn and Johnson, 2005), it is possible the invertebrates we sampled in this study do not accurately represent those available to the broods. However, because both dropping and invertebrate samples were collected in Jun. and Jul. in the same area across the same habitat types and broods move across the area, we suggest the invertebrate samples collected broadly represent those that were available to the broods and, therefore, useful inferences can be made from our results.

It is also possible, because invertebrates vary by year and season (Triplehorn and Johnson, 2005), selection may vary on an annual basis and, therefore, the results of this study may be 'year specific'. However, average temperatures and precipitation during Jun. and Jul. 2005 were similar to those in the same months between 1980–2010 [temperature: 22.78 C (2005) vs. 24.10 C (1980–2010); precipitation: 0.23 cm (2005) vs. 0.30 cm (1980–2010) – Applied Climate Information System, <<http://www.rcc-acis.org/>>]. Therefore, we suggest invertebrate availability and, therefore, prey selection of pheasant broods in 2005 is likely to be representative of that in other years.

Invertebrate abundance and diversity across the range of pheasants in the Great Plains is influenced by habitat type, with native prairie likely supporting a larger, more diverse invertebrate community compared to CRP lands (McIntyre and Thompson, 2003), and CRP supporting a higher abundance of invertebrates compared to crop fields (Doxon and Carroll, 2007). CRP acres are important to grassland birds (Negus *et al.*, 2010) and may be the only grassland habitat in row-crop dominated landscapes. The abundance of invertebrates including Coleoptera, the preferred prey of pheasant broods that foraged in both managed and unmanaged CRP fields in this study, is greater in managed CRP fields (inter-seeded) compared to in unmanaged CRP fields (L. Negus, pers. obs.). Our results suggest grasslands can be managed to provide the preferred prey items of pheasant broods, which will likely help support pheasant populations.

Acknowledgments.—Funding for this study was provided through the Federal Aid in Wildlife Restoration program and the State Wildlife Grant program. We thank Jeff Lusk for providing information that helped us develop the manuscript. Animal capture and handling protocols were approved by the University of Nebraska-Lincoln Institutional Animal Care and Use Committee (Protocol #05-02-007).

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