South Dakota State University

Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange

Electronic Theses and Dissertations

1972

Bionomics of Mallophaga of Sharp-Tailed Grouse in South Dakota

Major L. Boddicker

Follow this and additional works at: https://openprairie.sdstate.edu/etd

Part of the Entomology Commons

Recommended Citation

Boddicker, Major L., "Bionomics of Mallophaga of Sharp-Tailed Grouse in South Dakota" (1972). *Electronic Theses and Dissertations*. 5437.
https://openprairie.sdstate.edu/etd/5437

This Dissertation - Open Access is brought to you for free and open access by Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange. It has been accepted for inclusion in Electronic Theses and Dissertations by an authorized administrator of Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange. For more information, please contact michael.biondo@sdstate.edu.

BIONOMICS OF MALLOPHAGA OF SHARP-TAILED

GROUSE IN SOUTH DAKOTA

BY

MAJOR L. BODDICKER

A thesis submitted
in partial fulfillment of the requirements for the
degree Doctor of Philosophy, Major in
Entomology, South Dakota
State University

1972

SOUTH DAKOTA STATE UNIVERSITY LIBRARY

BIONOMICS OF MALLOPHAGA OF SHARP-TAILED

GROUSE IN SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Doctor of Philosophy, and is acceptable as meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser　　　　Date

Head, Entomology-Zoology Department　　　　Date

BIONOMICS OF MALLOPHAGA OF SHARP-TAILED
GROUSE IN SOUTH DAKOTA
Abstract

MAJOR L. BODDICKER

Under the supervision of Dr. Burruss McDaniel

The ecologies of chewing lice (Insecta:Mallophaga) which parasitize sharp-tailed grouse, Pedioecetes phasianellus, were studied in southwestern South Dakota from 1964 to 1967. Five hundred twenty-eight hens, cocks and chicks were collected and examined for louse damage. Louse populations were monitored each month from December, 1964, to September, 1967.

Five louse species which infested grouse in the study area were Goniodes nebraskensis Carriker, Amyrsidea megalosoma Overgaard, Lagopoecus perplexus Kellogg and Chapman, Goniocotes chrysocephalus and Lipeurus maculosis Clay.

Goniodes nebraskensis fed on feather parts and skin debris and was found to have seasonally fluctuating populations. Cocks carried peak populations of 250 lice/host during June. Hens and chicks carried peak populations in July, averaging 169 and 32 lice/host, respectively. It was concluded that G. nebraskensis had little effect on its host.

Amyrsidea megalosoma was found on 21% of the cocks, 15% of the hens and 19% of the chicks examined. The intensities of infestations of this species were the highest of the five species observed. Infestations of over 1,000 lice/host were found frequently on breeding cocks from April to June. Populations of this species during the remainder

of the year were very small. These lice fed on blood and epidermal cells as well as feather parts.

Athlete's foot fungi, Trichophyton mentagrophytes, were isolated from skin lesions which were common on the throats and heads of breeding cocks which were infested with Amyrsidea megalosoma. A definite association was evident between the A. megalosoma and T. mentagrophytes. Cocks heavily infested with A. megalosoma weighed less than lightly and uninfested cocks. This species caused its host serious irritations and was observed gnawing the skin and eating blood. Because hens were infested to a far lesser degree, A. megalosoma was concluded to have no important effect on egg production and reproductive success.

Lagopoecus perplexus infested 19% of the cocks, 5% of the hens and 6% of the chicks. This species was an occasional parasite of dancing cocks during April, May and June. It was not recovered during five months of the year. It had little effect on the hosts examined. Feather parts were found in the crops of this louse. The species inhabited the head, neck and wings of sharptails.

Goniocotes chrysocephalus and Lipeurus maculosis, normally parasites of the ring-necked pheasant, were found on less than 1% of the grouse. Goniocotes chrysocephalus was found on four dancing cocks. All stages of this louse were present, indicating an ability to reproduce and complete its life cycle on this host. Lipeurus maculosis was found on four grouse (a cock, a hen and two chicks). All stages of this species also were present, indicating an ability to complete the life cycle on sharptails.

During the months of peak infestations by the five louse species, submean host weights were recorded. Weights of cocks declined at a rate of 30 grams/month from a peak mean of 938.1 grams in April to 835.2 grams in July and August. Louse infestations began to climb in April and reached a peak in June. Louse populations on cocks dropped sharply during July from a mean of 825 to 40 lice/bird.

The overriding conclusion drawn from this research was that natural infestations of lice have a very minor effect on wild sharptail populations and detrimentally affect only a few individual birds.

ACKNOWLEDGMENTS

The author extends his sincere appreciation and thanks to the following staff of the Entomology-Zoology Department who assisted with this research endeavor: Dr. Burruss McDaniel, the author's major adviser, who supervised and encouraged this research and provided technical advice during this research project. Many thanks are extended to him for his valuable assistance with the preparation of this manuscript. Dr. Robert J. Walstrom, Head of the Entomology-Zoology Department, who served as major adviser during the first months of this project and has continued to give generously of his technical advice and encouragement throughout the course of this project. Dr. Walstrom was also instrumental in obtaining funds for this project. Dr. Ernest J. Hugghins, who served as minor field adviser and gave generously of his time and advice during this research program. My sincere appreciation is extended to him for his assistance in the preparation of this manuscript and for his aid in obtaining funds for this research. Dr. Benjamin Kantack, Dr. Gary Thibodeau, Nelle Hartwig, Dr. Edward U. Balsbaugh, Jr. and Dr. Algirdas Greichus for their advice and encouragement.

Dr. K. C. Emerson, Arlington, Virginia, assisted in the identification of the lice found during this study.

I also thank the following persons who helped with field collections or with field data: F. Robert Henderson, formerly of the Department of Game, Fish and Parks, Kadoka, South Dakota (presently at Kansas State University, Manhattan, Kansas) provided valuable

technical advice and assisted the author with field collections and research. He made many of the collections upon which this research depended and assisted in obtaining funds for the project. Further, it was he who brought this project to the attention of the author and encouraged the continuance of the research. Conrad H. Hillman, Department of Game, Fish and Parks, Rapid City, South Dakota, provided assistance in collecting grouse and advice on grouse habits, population trends and management. Warren Jackson and Ronald Hoffman, Department of Game, Fish and Parks, collected many specimens used in this research and assisted the author in obtaining information at hunter bag checks. Carl Trautman, Robert Dahlgren, Douglas West, Arthur Richardson, Charles Keeler, Bruce Harris and John Popowski of the Department of Game, Fish and Parks assisted the author at grouse bag checks. Robert Powell, Badlands National Monument, Cedar Pass, South Dakota, assisted with collections. Bruce Renhowe, formerly of the Department of Wildlife Management (presently with the North Dakota Game and Fish Department of Parshall, North Dakota), helped with collections of grouse and information on food habits. Keith Evans, United States Forest Service, Rapid City, South Dakota, aided with collections and technical advice on grouse habitat and food habits.

Special thanks are extended to Mr. and Mrs. Floyd Vogelgesang, Wanblee, South Dakota. They generously housed and boarded the author during many research trips, provided valuable information on grouse habitat and behavior and permitted the author to conduct research on their property. Also, thanks are extended to Mr. and Mrs. Charles

Vogelgesang and Manuel Maldonado of Wanblee, South Dakota, and Blaine and Celia Young, Mr. and Mrs. C. D. Uhlir and Walter Dennis of Kadoka, South Dakota, for permission to conduct research on their properties.

Dr. L. P. Swisher and members of the Badlands Natural History Association, Cedar Pass, South Dakota, provided $1,800 for this research. The National Science Foundation financed the project during its last year through a graduate fellowship granted to the author. Dr. Edward Kozicky and the Conservation Division of Olin-Mathieson Corporation provided five cases of shotgun shells. The National Wildlife Federation awarded the author three conservation awards ($3,000) on the basis of this research.

To my wife, Janice, I extend my gratitude for her encouragement and patience during this long, tedious venture.

To these major contributors and to many others who contributed their time and energies, the author extends his sincere thanks.

MLB

TABLE OF CONTENTS

	Page
INTRODUCTION	1
METHODS AND MATERIALS	16
RESULTS AND DISCUSSION	26
Life History of the Sharp-tailed Grouse in South Dakota	26
Sharptail Weight and Age Characteristics	32
Mallophaga of Sharptails	42
Bionomics of Goniodes nebraskensis	44
Bionomics of Amyrsidea megalosoma	65
Bionomics of Lagopoecus perplexus	81
Bionomics of Goniocotes chrysocephalus	91
Bionomics of Lipeurus maculosis	98
Total Louse Infestations	98
SUMMARY AND CONCLUSIONS	114
LITERATURE CITED	122
APPENDIX A	128
APPENDIX B	130
APPENDIX C	131

LIST OF TABLES

Table		Page
1.	Age Distribution of Grouse Chicks in Week Classes Collected During Summers, 1966-67	21
2.	Distribution of Cock and Hen Samples by Months and Years (1965-67)	21
3.	Sharptail Weights Per Month Pooled During Years 1965-1967	25
4.	Louse Infestations of Sharp-tailed Grouse, November, 1964 - May, 1965	33
5.	Sex and Age Ratios of Lice on Adult Grouse	50
6.	Measurements of <u>Goniodes nebraskensis</u> Life Stages	51
7.	Louse Data Pooled Per Month on Adult Grouse, September, 1965 - October, 1967	55
8.	Measurements of Life Stages of <u>Amyrsidea megalosoma</u> . . .	69
9.	Measurements of Life Stages of <u>Lagopoecus perplexus</u> . . .	86
10.	Measurements of Life Stages of <u>Goniocotes chrysocephalus</u> .	95
11.	Measurements of Life Stages of <u>Lipeurus maculosis</u>	102

LIST OF FIGURES

Figure		Page
1.	Distribution of sharp-tailed grouse samples collected between 1965-1967	17
2.	Average monthly sharptail weights pooled during 1965-1967 with inclusion of weight data collected during bag checks	36
3.	Sharptail weight distributions according to sex	38
4.	Age-weight data for chicks fitted to a Gompertz growth curve	41
5.	*Goniodes nebraskensis* female - dorsal	45
6.	*Goniodes nebraskensis* female - ventral	45
7.	*Goniodes nebraskensis* male genitalia	46
8.	*Goniodes nebraskensis* female vulva	46
9.	*Goniodes nebraskensis* male - dorsal	47
10.	*Goniodes nebraskensis* male - ventral	47
11.	*Goniodes nebraskensis* 3rd stage nymph	48
12.	*Goniodes nebraskensis* 2nd stage nymph	48
13.	*Goniodes nebraskensis* 1st stage nymph	48
14.	*Goniodes nebraskensis* ova	48
15.	*Goniodes nebraskensis* infestations per month on adult grouse	56
16.	Monthly infestation rates in percentages of *Goniodes nebraskensis* and *Lagopoecus perplexus*	59
17.	Average louse infestation intensities on chicks per month - 1966-67	60
18.	*Amyrsidea megalosoma* female - dorsal	66
19.	*Amyrsidea megalosoma* female - ventral	66

Figure Page

20. Amyrsidea megalosoma male - dorsal 67

21. Amyrsidea megalosoma male genitalia 67

22. Amyrsidea megalosoma male - ventral 67

23. Amyrsidea megalosoma 3rd stage nymph 68

24. Amyrsidea megalosoma 2nd stage nymph 68

25. Amyrsidea megalosoma 1st stage nymph 68

26. Amyrsidea megalosoma ova 68

27. Average Amyrsidea megalosoma infestations per month on adult grouse 74

28. Monthly infestation rates of Amyrsidea megalosoma on adult sharptails 75

29. Lagopoecus perplexus female - dorsal 82

30. Lagopoecus perplexus female - ventral 82

31. Lagopoecus perplexus male - dorsal 83

32. Lagopoecus perplexus male genitalia 83

33. Lagopoecus perplexus male - ventral 83

34. Lagopoecus perplexus 3rd stage nymph 84

35. Lagopoecus perplexus 2nd stage nymph 84

36. Lagopoecus perplexus 1st stage nymph 84

37. Lagopoecus perplexus ova 84

38. Average Lagopoecus perplexus infestations per month on adult grouse 89

39. Goniocotes chrysocephalus female - dorsal 92

40. Goniocotes chrysocephalus female - ventral 92

41. Goniocotes chrysocephalus male - dorsal 93

42. Goniocotes chrysocephalus male genitalia 93

Figure | Page

43. Goniocotes chrysocephalus male - ventral 93
44. Goniocotes chrysocephalus 3rd stage nymph 94
45. Goniocotes chrysocephalus 2nd stage nymph 94
46. Goniocotes chrysocephalus 1st stage nymph 94
47. Goniocotes chrysocephalus ova 94
48. Lipeurus maculosis female - dorsal 99
49. Lipeurus maculosis female - ventral 99
50. Lipeurus maculosis male - dorsal 100
51. Lipeurus maculosis male genitalia 100
52. Lipeurus maculosis male - ventral 100
53. Lipeurus maculosis 3rd stage nymph 101
54. Lipeurus maculosis 2nd stage nymph 101
55. Lipeurus maculosis ova 101
56. Average monthly distribution of lice on adult sharptails . 104
57. Distribution of louse infestations on chick age classes . 106
58. Monthly weight fluctuations of cocks compared with mean louse infestations 108
59. Monthly weight fluctuations of hens compared with mean louse infestations 109
60. Field examination laboratory 77
61. Examination of lice removed from freshly killed grouse . . 77
62. Lesions and denuded areas on cock infested with Amyrsidea megalosoma compared with cock heavily infested with Goniodes nebraskensis 78

INTRODUCTION

The population fluctuations of species of grouse have been the subject of much research and comment since the 19th century. Halloran (1955) listed 234 references dealing with diseases and parasites of grouse. Several important works have been published since then implicating parasitic organisms as contributors to grouse population limitations. Herman (1963) compiled an excellent commentary with regard to the value and limitations of past research dealing with grouse diseases. Briefly, he stated that little substantial evidence exists to implicate disease organisms and parasites as regular, definitive causes for grouse population declines or as population regulators. Bendell (1955) provided a convincing report that Dispharynx nasuta, a nematode, was a major factor in the population control of blue grouse on Vancouver Island. Janson (1955) discussed limiting factors operating on sharptail populations in South Dakota. He concluded that ordinarily parasites did not seem to harm the host, but with extremely heavy infestations a loss of weight and vigor occurred. In various studies viruses, bacteria, protozoa, flukes and nematodes have been implicated in causing grouse die-offs. No references were found which showed that lice play a role in population fluctuations of grouse.

Much of the difficulty in assessing the importance of grouse parasites is a lack of techniques needed to successfully pen-rear grouse and maintain parasite life cycles in captive birds. Judgments of parasite disease effects have been based on observations of a few diseased birds found in nature or at bag checks. Few adequate

measurements of effects of an individual parasite on its host have been published. When it has been demonstrated that an organism is pathogenic in a penned situation, it has been difficult to extrapolate its effects on wild birds. Potentially pathogenic parasites have been found frequently in apparently healthy birds. Diseased sharp-tailed grouse, Pedioecetes phasianellus (Linn.), which outwardly appear to be affected by nematode infections were observed only seven times during this research. No grouse were found to be mortally injured by lice, even though large numbers of birds with serious louse damage were found.

Population declines in upland game have been attributed to changes in land use, weather and predators as well as disease organisms. Many population declines have been the result of poor reproductive success, through either poor nesting habitat, poor hatching success or from poor brood survival. The relationship between diseases, parasites and reproductive success in domestic poultry has not been well established. Neither has the effect of lice on reproductive success in wild birds been thoroughly studied. Consequently, it was necessary to review what was known of lice effects on the health of domestic poultry, i.e., egg production, chick survival and growth. This does not necessarily mean that lice on grouse cause the same effects but it indicates that this is a possibility.

Roberts and Smith (1956) stated that poultry heavily infested with lice appeared unthrifty and showed damaged plumage. Heavily infested chicks may fail to gain weight as a result of restlessness caused by lice.

LaPage (1956) expressed the principal effects of Mallophaga as "irritation and its consequences." According to him, young hosts become restless, peck or scratch the irritated parts of the body and in this process loosen feathers or pull them out. Further, he stated that louse irritations result in loss of sleep, reduction of feeding and possible reduction in egg production.

Metcalf et al. (1962) stated, "The irritation from the mouth parts, together with that of the sharp claws on their feet in running about over the skin results in a nervous condition of the infested birds that prevents sleep, causes loss of appetite and diarrhea, and renders the weakened fowls easy prey for various poultry diseases. Young chickens and turkeys that are brooded by lousy hens are often killed in great numbers by the swarming of lice from the hen to them almost as soon as they hatch from the eggs. The most serious effect upon older fowls is a reduction in the number of eggs laid. Infested fowls are in a mopey, drowsy condition with droopy wings and ruffled feathers, refuse to eat, and gradually become emaciated." When speaking of Cuclotogaster (=Lipeurus) heterographus (Nitzsch), they stated that this species passed very early from the brooding hens to chicks and that chicks were often killed by the lice.

Benbrook (1965) stated, "It might be concluded that lice are not highly pathogenic to mature birds. However, there appears to be clinical evidence that lice irritate nerve endings, thus interfering with the rest and sleep so necessary to immature animals. Louse infested chicks

may die. Also, lousiness frequently accompanies manifestations of poor husbandry such as internal parasitisms, infectious diseases, malnutrition, and insanitation."

The vent or body louse, *Menacanthus stramineus* (Nitzsch), was shown by Wilson (1933) to actively obtain blood from the host. He observed a louse with mandibles sunk into the quill of an immature feather with a blood-rich dermal papillae present. Upon removal of the louse, blood flowed from the wound and blood was evident in the alimentary tract of the louse. Crutchfield and Hixson (1943) examined the crop contents of *Menacanthus stramineus, Goniodes gigas, Menopon gallinae* and a *Menacanthus* sp. They found that blood made up a considerable portion of the diet of *M. stramineus.* Red blood cells were found in every louse crop examined. Blood was obtained by gnawing away the epidermis and tiny blood clots and scabs that followed. This condition was found on relatively heavily infested individuals. Also, they observed that quill ruptures were common on birds infested with *M. stramineus.* An unidentified *Menacanthus* sp. they studied contained blood. They considered it similar in feeding habits to *M. stramineus.* All the other louse species listed above fed on feather parts and skin debris.

Investigators have disagreed on the effects of *Menacanthus stramineus* infestations on egg production, weight characteristics and survival of chickens. Warren et al. (1948) and Tower and Floyd (1961) found no differences between laying records of infested and uninfested birds. However, Edgar and King (1950) and Gless and Raun (1959) found

that infestations with this species resulted in egg production losses of 11 to 84%.

Ash (1960) stated that lice of the suborder Amblycera are dependent on some blood as food. He found that some species of Ricinus and Trochileocetes have mandibles modified for piercing and that blood may be sucked up by the hypopharynx.

It can be concluded that lice may seriously affect the health of chicks. They can reduce egg production. Some species which suck blood serve as transmitters of viral and bacterial diseases as well as induce anemia. Howitt et al. (1948) isolated equine encephalomyelitis from Menacanthus stramineus. Ornithosis virus was isolated from Menopon gallinae by Meyer and Eddie (1960). Unfortunately, there have been no such studies of the effects of lice on wild hosts.

In attempting to study the mallophagan parasites of a wild host, the investigator was immediately confronted with many very basic problems. The taxonomy of the group is not completely stable. Identifying lice is difficult and affinities with other genera and families are uncertain. Hopkins and Clay (1955) proposed that some species of Menacanthus from gallinaceous birds are more closely related to species of Amyrsidea than to other species of Menacanthus. These are separable only by the presence of a postpalpal process. Clay (1969) included the genus Amyrsidea in a Menacanthus complex which included Mencanthus, Amyrsidea, Argimenopon, Cracimenopon and Desumenopon. It can be assumed then that since both genera are found on Galliformes and are closely related morphologically that they are closely related

phylogenetically. Amyrsidea megalosoma (Overgaard) was a common louse found on sharptails during this study.

Previous investigators have neglected the life history and ecology studies of Mallophaga except for some lice parasitic on domestic poultry and livestock. There have been three extensive studies conducted on wild birds. Martin (1934) studied the life history and habits of Columbicola columbae but did not investigate prevalence on the host, seasonal distribution or effects of lice on the host. Boyd (1951) studied the seasonal distribution of Bruelia (=Deguriella) nebulosa and Menacanthus spinosum which parasitize the starling, Sturnus vulgaris. She found an infestation rate of 93.4% and that the percentage of infested birds and number of lice/bird dropped in the winter. Lice were absent on birds collected in January, and only nymphs of these species were present in February. There were differences in the population fluctuations between the two species. Peak populations in B. nebulosa, an ischnoceran, came in September, that of M. spinosum, an amblyceran, in November. Birds were not collected during the months of May and June. She noted blood in the intestines of the nymphs of M. spinosum. She made no attempt to determine the effects that these species had on the starling host.

Boyd (1956) in a review paper mentioned that Mallophaga may produce a run-down condition in hosts, lowering their resistance to disease. Skin damage caused by them may act as portals of entry for bacteria. She stated that ectoparasites may cause reduced egg

production in wild birds. She mentioned that Mallophaga could cause serious anemia in birds. Greichus (verbal communication, July, 1970, South Dakota State University, Brookings, South Dakota) found that nestling pelicans heavily infested with Piagetella sp. attached to the roof of the mouth suffered from an anemic condition.

Ash (1960), working primarily with passerine birds, produced probably the most extensive study of ecology of lice on wild birds. His work on a variety of species included studies on seasonal distribution, frequency, numbers per host, fluctuations on a host during a year, food and temperature requirements, effects of lice on the hosts, parasite-host relationships, seasonal changes in parasite prevalence and distribution on the hosts. His data were not complete for the months of May to July because he collected birds by live trapping. Birds could not successfully be trapped during the breeding season. He concluded that normal louse populations have little effect on their hosts. He stated that birds kept numbers of lice in check by preening and dust baths. He believed that heavy infestations on sick birds were the result of the birds' inability to care for themselves rather than a result of the action of lice. He found more louse eggs than adult lice on healthy birds. Ash further was of the opinion that lice had no effect on the average weight. Three species of infested birds examined for weight differences did show slightly lower weights than uninfested birds. Ash found that infestation intensities varied per species of bird and that wading birds were the most heavily parasitized.

He reported that birds may go for periods with no lice, become infested and later be found uninfested again.

Rearing lice on artificial media and its difficulty has been studied by several authors. Martin (1934) unsuccessfully attempted to rear Columbicola columbae. Wilson (1934) succeeded in rearing Cuclutogaster heterographus and Matthysse (1946) reared Bovicola bovis. Lice of the domestic pigeon have been reared successfully in vitro (Wiseman, 1959).

Successful methods of pen-rearing native gallinaceous birds have been rare. McEwen et al. (1969) published a method for rearing sharp-tails in captivity, but it was expensive and time consuming. Shoemaker (1961, 1964) discussed the difficulty of rearing captive prairie chickens. In both studies lice became a serious problem and captive birds required treatment for control of lice (McEwen et al., 1969; Shoemaker, verbal communication at Prairie Grouse Technical Council, Effingham, Illinois, 1967). Because of the expense and difficulties involved in captive studies of sharptails, no penned studies were attempted by the author.

According to Crutchfield and Hixson (1943), Boyd (1951) and Ash (1960) different species of lice have very different feeding and life habits. One species could therefore be a serious pest when present in relatively small numbers, while another species on the same bird at the same time may cause little or no harm. This complicated the study of louse effects on sharptails.

No attempt was made to artificially rear any of the species found during this study.

Mallophagan lice are obligate parasites. Normally, a given species of chewing louse will be found on only one host or a closely related group of hosts. Chewing lice will not survive for extended periods of time when not in intimate contact with a living host. Therefore, the distribution of the host dictates the distribution of the louse species. The health and frequency of the host dictates the health and total numbers of lice existing at any one time. Factors adversely affecting the reproduction and viability of the host ultimately adversely affect the parasite. Because of this dependency it is necessary to review the life history of the plains sharp-tailed grouse, _Pedioecetes phasianellus jamesi,_ to gain an insight into the factors which ultimately affect the louse populations infesting them.

Aldrich (1963) has shown the geographical distribution of the subspecies of sharp-tailed grouse. States included in its range are New Mexico, Colorado, Nebraska, Wyoming, South Dakota, North Dakota and Montana.

Janson (1955) included a distribution map of sharptails in South Dakota. All counties west of the Missouri River are included. The Black Hills have scattered populations occurring in areas once burned by fires. Sharptails are also found in the tier of counties bordering the Missouri River on the east, and scattered populations are occasionally reported still further east. The original range of the sharptail in South Dakota and its present range coincide closely,

indicating an ability to survive encroachment of agriculture or to resist further dispersal.

Hunting seasons for sharptails have been long and liberal, with a three bird/day bag limit for 60 to 90 days being an average season. Hillman (written communication in files of author, June, 1970) stated that in 1969, 20,400 hunters bagged 96,300 birds. He reported that in 1967, when the preliminary part of this study was in progress, 94,500 grouse (both greater prairie chicken, Tympanuchus cupido (Linneaus, 1758), and sharptails) were harvested by 19,400 hunters. Janson (1955) and Hillman (verbal communication at the South Dakota Chapter of the Wildlife Society, Huron, South Dakota, March, 1970) have stated that sharptails made up 95% of the total grouse kill since 1948. The biggest harvest reported by Henderson (1965) was in 1954 when 27,000 hunters bagged 151,000 birds. Janson (1955), Henderson (1965, 1969) and Hillman (1969a, 1969b, 1970a) reported on the hunting success and management data of the sharptail in South Dakota. The sharptail has been an important game bird in South Dakota. It provides a delicious meat for the table and a challenging hunt. Because of the importance of this bird as an upland game species and the accompanying economic values, this study was considered justified.

The aesthetic value of the sharptail is difficult to assess, but, for those who have had the opportunity to observe the mating antics of cocks in the spring or the brooding hen with chicks, it is indeed a valuable experience. Forbush (1936) has described breeding antics of the cock vividly and is quoted as follows:

"With the first promise of spring on the Great Plains, the remarkable mating antics of the sharptail begin ... The birds have a meeting place where they gather at the booming calls of the male at early dawn and again at sunset. At first, they appear to be standing quietly, then one begins to dance by portly spreading its wings in a horizontal direction, lowering its head, raising and spreading its tail, distending and spreading its tail, distending the air sacs and then bristling up, runs across the floor of the meeting place, stamping its feet so hard and fast as to produce a drumming sound, uttering ... a sort of bubbling crow, beating the air with its wings and vibrating its tail with a low rustling sound. Immediately all join the dance. Some circle to the right, others to the left, passing each other stiffly charging back and forth, bowing, squatting and posturing. Faster and faster goes the dance, more and more madly swings the giddy whirl until the excited birds jump over the backs of their companions, strut, swell and even fight. The dance goes on day after day until the mating season is over and often begins again in autumn."

Forbush also noted that about the middle of autumn sharptails begin to light in trees and gather in flocks.

Lumsden (1965) reported on the behavior of sharptails in Ontario. He stated that on a dancing ground a cock held the same territory and defended it each day and that a hierarchy restricted matings to relatively few cocks. He postulated that the quality of chicks produced under this system was less variable than if many cocks took part in mating. He also stated that, "if chick quality and survival

can be regulated through the selection of certain cocks for mating, it is possible that populations of lek grouse may be internally regulated." Lunsden discussed at length the territorial activity and breeding behavior of sharptails.

Ammann (1957, 1963) reported on the ecology and management of the sharptails in Michigan. Hammerstrom (1963) reviewed the status of the sharptail in Wisconsin. Bremer (1965) discussed banding, trapping and the movement of sharptails in Minnesota. Bernholf (1967) reported on the habitat preferences of sharp-tailed grouse in North Dakota. Kobriger (1965) reported on the status, movements, habitat and food preferences of sharptails in Nebraska.

A great deal of published and unpublished research has been completed in South Dakota on sharptails. Janson (1955) reported on the life history and management of the sharptail in South Dakota. Henderson and Jackson (1967) reported the history of selected dancing grounds in South Dakota. They stated that some of the grounds had been used continuously for at least 21 years. Henderson (1965) reported on the population surveys and management of prairie grouse in South Dakota. This report contains a wealth of information on banding returns, hunter success and population trends of sharptails. Henderson and Jackson (1965, 1969), Henderson (1967), Hillman and Betts (1969), and Hillman (1970b) reported on winter trapping and banding, winter weights, age and sex ratios and movements of sharptails. Robel et al. (1972) reported on results of band returns over a six year period and the dispersal of grouse in South Dakota. Jackson (1963, 1964, 1967)

and Jackson and Henderson (1965) reported the seasonal movements of sharptails. Jackson (1967) found 93% of adult cocks were recovered within three miles of the banding site and that young cocks traveled further than old cocks. Hens were found to move the greatest distances, and 35% of young hens were recovered over three miles from the banding sites. Henderson (1965) reported that, since the 1940's, sharptail populations have undergone population cycles which have peaked about every fourth year. He also stated (verbal communication to Prairie Grouse Technical Council, Warroad, Minnesota, September, 1965) that a general decline in sharptail numbers over the state has occurred over those years. He attributed this general decline to changing land use and intensified grazing on the prairie grasslands which are so vital to sharptails. Cyclic declines have not been satisfactorily explained. Evans (1965) reported on habitat requirements of the sharptail and is continuing that research.

Renhowe (1968) in conjunction with this research and using grouse and data collected during this study determined the food habits and preferences of sharptails in the study area.

After reviewing the literature concerning the effects of lice on hosts, it was concluded that chewing lice had the potential of affecting the sharptail in the following ways, since they have been found producing the same effects on domestic and wild avian hosts:

1. Sucking blood and serum, thus producing anemia.

2. Chewing of living flesh and emerging feathers, thus reducing health and viability of grouse.

279538

SOUTH DAKOTA STATE UNIVERSITY LIBRARY

3. Transmission of disease and rendering the host susceptible to secondary infections by lowering resistance.

4. Transmission of parasites.

5. Reducing the reproductive output by causing a reduction of egg production or mortality in the chicks.

6. Irritation and resulting nervousness and lack of sleep. This could affect several important behavioral characteristics of grouse which could reduce reproductive success in the following ways:

a. Adversely affect broodiness on the nest and with chicks and discourage renesting.

b. Depress mating behavior of cocks and hens and contribute to a shorter mating season and lower renesting success.

c. Affect wariness and susceptibility to predators.

d. Play a role in determining peck order dominance in dancing cocks as described by Lumsden (1965).

7. Reduction of insulating capacity of feathers in cold weather and reduction of flying efficiency.

It was the author's purpose to attempt to determine the seriousness and extent that lice affected the sharptails.

The major thesis of this research was that louse populations played an important role in the health and reproduction of sharptails. To prove this thesis, the following objectives were established to be accomplished during the general survey:

1. Determine the species of lice parasitic on sharp-tailed grouse.

2. Determine the frequencies, seasonal distribution and population characteristics of each louse species.

3. Determine the effects of each louse species on sharptail weights, general condition, reproductive potential and direct pathological damage.

4. Determine the effects of combination louse infestations on sharptails.

5. Determine what role lice play in disease transmission.

6. Investigate the behavior of the lice species.

7. Determine if precipitation, land use, soil associations and air temperatures had an effect on louse populations and distributions independent of the host.

8. Investigate the intraspecific and interspecific relationships of the lice.

METHODS AND MATERIALS

The distribution of sharptails and their louse parasites is shown in Fig. 1. Collections were made in southwestern South Dakota for the following reasons:

Since chewing lice are obligate parasites, the host must be collected to collect the parasites. Distribution of the host can be assumed to be that of the parasite. Since one of the objectives of this research was to determine if this were true, it was necessary to set up collections of the hosts to facilitate comparisons between the hosts and the parasites on them. To determine if soil associations, mean annual precipitation and mean air temperatures affected louse populations independent of the host, it was necessary to collect hosts from regions with diverse weather and soil characteristics. The collection area provided four distinct regions of prime sharptail habitat with a history of moderate to high grouse populations. These areas were separated for purposes of comparison into north, south, east and west regions. The counties north of the White River constituted the northern area. This area was characterized generally by more intensive land use, less nesting cover and lower grouse populations than the counties lying south of the White River. The eastern region included the counties east of the western Lyman and Tripp County borders. The western region was characterized by drier climate, less intensive land use and higher sharptail populations than the eastern counties.

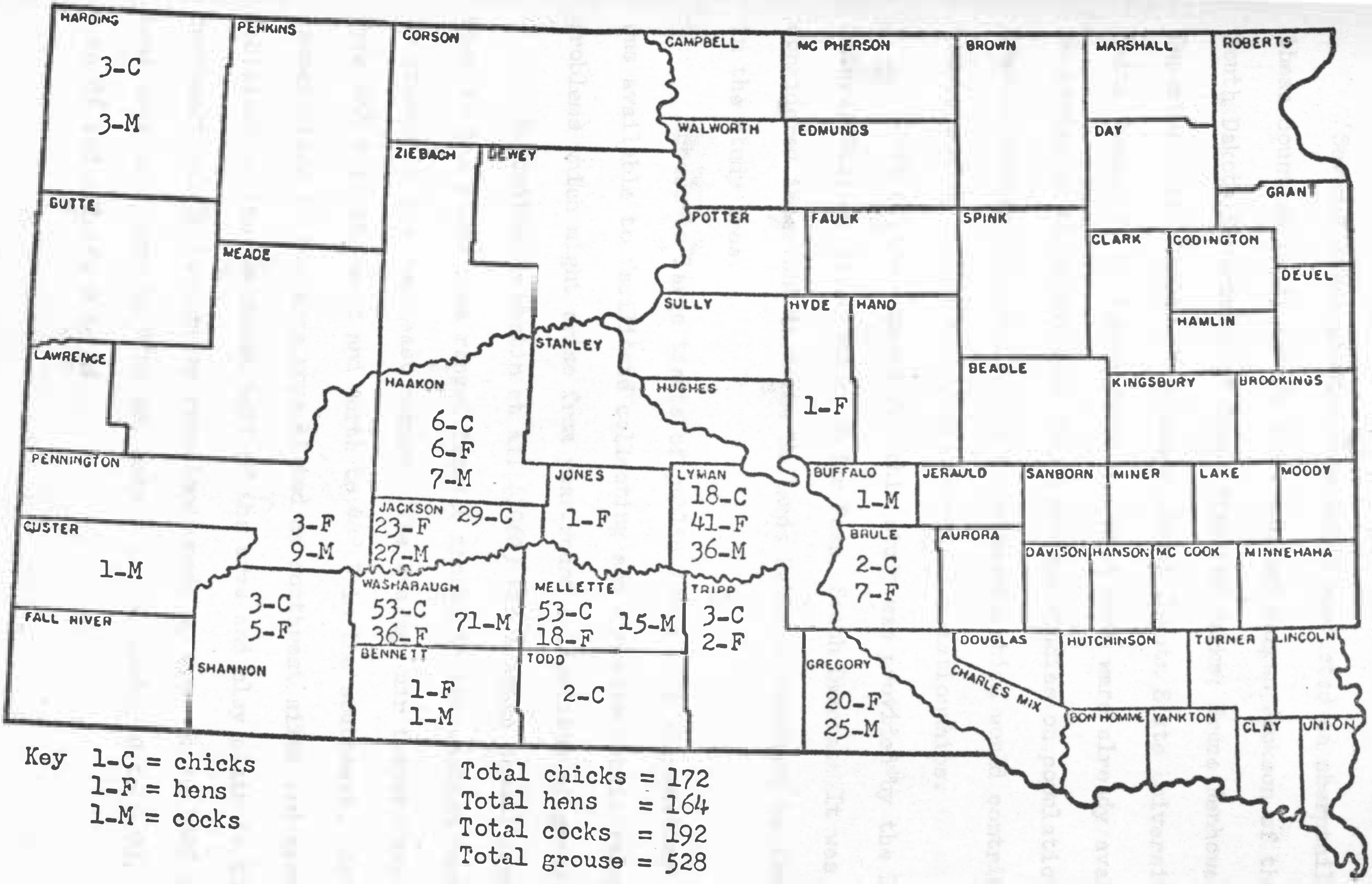


Fig. 1. Distribution of sharp-tailed grouse samples collected between 1965-1967.

Several other studies were being conducted on sharptails in these counties by F. Robert Henderson and Warren Jackson of the South Dakota Department of Game, Fish and Parks; Bruce Renhowe, Department of Wildlife Management, South Dakota State University and Keith Evans, U. S. Forest Service. Much data were already available on grouse in the study area from previous studies on population trends, dispersion and habitat requirements which would contribute to understanding of the mallophaga-sharptail relationships.

Much of the support for this study was provided by the Badlands Natural History Association, Cedar Pass, South Dakota. It was considered important that the Badlands National Monument be included in the study area.

Access to large tracts of public lands with all-weather roads was available to facilitate collecting and minimize public relations problems which might arise from year-round collections of grouse.

According to Westin et al. (1967) the average annual precipitation in the study area ranged from 16 inches in the western portion to 24 inches in the southeast corner. The average air temperature ranged from 46° F in the west and north to 48° F in the southeast. Soil associations in the area were listed as southwest silty and sandy tableland in the southwest half of the area and clay plain in the northeast half. Pasture or rangelands made up from 61 to 100% of the land area with corn in 0 to 9%, oats 0 to 9%, barley 0 to 0.9%, wheat 0 to 6% and alfalfa 0 to 8%.

Habitat and cover types as well as species composition of the plant communities in the study area were discussed by Renhowe (1968). Generally, the heaviest grouse populations were encountered in central Washabaugh County and in the northwestern fourth of Mellette County. These counties were generally less heavily grazed, and cultivated cropland was available within the movement range of broods and wintering birds. Grouse in these counties had relatively light hunting pressure, even though hunting for grouse was practiced year-round by Indians and ranchers.

A collection schedule was established among cooperators, and collecting was begun in September of 1965 and continued until September, 1967. The schedule allowed for monitoring louse populations through two complete reproductive seasons. It was decided that 20 adult grouse per month, 10 from the east and 10 from the west areas, in equal sex ratios would suffice for statistical purposes. This number was the limit that could be examined in the time available. In addition to adults, it was decided to attempt to collect all grouse chicks younger than 18 weeks which were encountered. At 18 weeks the young are nearly the same weight as adults and their plumage is complete. This stage of maturity occurred for the majority of young from the middle of September to October 1.

Each month the two cooperators were to collect 10 adult grouse at random in their game management districts. In addition, the author assisted cooperators in both areas. Data cards and collection instructions were distributed to collectors (Appendixes A and B).

Collecting was accomplished by shooting with 22 caliber rifles and 20 and 12 gauge shotguns or by selecting birds at random from traps during banding activities. Most samples were shot from vehicles during travels to and from game management projects. Roads which were arbitrarily selected were traveled at 20 to 30 miles per hour. Every grouse seen was to be taken until 20 birds/month had been collected. Chicks and brooding hens were collected at a higher rate for comparative purposes. The samples with complete data were placed immediately in air-tight plastic bags, frozen as soon as possible and stored for future examination.

Collecting 20 grouse/month was difficult. Cooperators were unable to get samples because of inclement weather and more pressing heavy work loads. A total of 532 usable grouse were collected for the parasite survey (Fig. 1). An average of eight cocks and seven hens were collected per month throughout this study. Chicks were collected at a higher rate (22 chicks/month) through the summer months (Tables 1 and 2). Chicks below 18 weeks of age were not separated by sex with regard to louse data, since no statistically significant difference was found in louse infestations between chick sexes. Numbers of sexes and chicks collected were 192 adult cocks, 164 adult hens and 172 chicks. Collections were started in September, 1965, and continued through October, 1967. Supplementary collections of grouse were made in April and May, 1968; August, 1969; and June and August, 1970.

The examination procedure for lice was as follows: Samples were thawed and carefully removed from the plastic bags, weighed to the

Table 1. Age Distribution of Grouse Chicks in Week Classes Collected During Summers, 1966-67

Week classes	1966	1967	Total
1 week	0	4	4
2 weeks	0	0	0
3 weeks	0	3	3
4 weeks	0	3	3
5 weeks	11	10	21
6 weeks	4	9	13
7 weeks	0	8	8
8 weeks	0	9	9
9 weeks	12	10	22
10 weeks	0	13	13
11 weeks	8	11	19
12 weeks	2	1	3
13 weeks	5	0	5
14 weeks	3	6	9
15 weeks	16	1	17
16 weeks	5	2	7
17 weeks	13	0	13
18 weeks	2	1	3
	81	91	172

Table 2. Distribution of Cock and Hen Samples by Months and Years (1965-67)

Month	Cocks 1965	Cocks 1966	Cocks 1967	Hens 1965	Hens 1966	Hens 1967
January	--	7	6	--	6	5
February	--	4	12	--	5	2
March	--	2	4	--	11	8
April	--	4	11	--	1	8
May	--	12	35	--	4	5
June	--	0	31	--	2	2
July	--	7	8	--	11	18
August	--	2	9	--	6	11
September	3	4	2	3	5	4
October	2	1	--	1	2	1
November	2	2	--	13	11	--
December	14	8	--	9	10	--
Total	21	53	118	26	74	64

nearest tenth of a gram on an Ohaus triple beam balance, sexed by four methods [head feather characteristics (Henderson et al., 1967), brow-patch, tail feathers (Tabor, 1963) and gonads] and aged by primary feather measurements (Ammann, 1957; Rous, 1967). The aging technique of separating adult and young adult cocks (Tabor, 1963) was abandoned because of collection damage and conflicting evidence.

The general appearance and condition of the bird was ascertained and a cursory examination was made for ectoparasites. The birds were then placed in a gallon plastic container with approximately 1/2 teaspoon of liquid soap added and the container filled with hot water. The container was sealed and agitated strongly for approximately 1 1/2 minutes. The soapy liquid was poured into a 25 mesh screen placed over a 100 mesh screen. Feathers and other debris were retained in the upper screen; lice and other ectoparasites were caught in the 100 mesh screen. Birds were then flushed vigorously with a strong stream of water and the feathers were ruffled by hand and flushed again. This liquid which contained ectoparasites was then poured through screens as above. The material in the 100 mesh screen was rinsed with cold water, collected and stored in 70% alcohol in 20 dram vials. Debris remaining in the 25 mesh screen was examined and the ectoparasites found were collected and placed in the 20 dram vial. Birds were then examined by manually manipulating feathers and viewing feathers and skin under a .7-30x dissecting microscope.

An attempt was made to evaluate the efficiency of this procedure. The first 25 birds subjected to this procedure were plucked and each

feather examined. Less than 5% of the lice remained in the feathers. It was considered impractical to obtain a better yield and the individual plucking and counting was terminated. Methods of Hopkins (1949), Buxton (1934), Dunn (1932) and Williamson (1954) were considered but were not adopted for various reasons. Ash (1960) reviewed those methods. The lice encountered during this study did not fasten firmly to the feathers at death and were easily removed by washing. It is possible that freezing killed the lice without having stimulated them to fasten to the feather.

Feathers over the entire body were examined for louse feeding and eggs. The skin was also examined for louse damage. Damaged areas as seen in Fig. 62 were in some cases excised and sent to the Veterinary Diagnostic Laboratory, South Dakota State University, Brookings, South Dakota, for determination of the causes.

Estimates of numbers of Amyrsidea megalosoma eggs were made in several heavy infestations by plucking all of the feathers from one-half of the head and neck and separating these into size groups. The number of feathers of each group was recorded. Eggs were then counted on single feathers, chosen at random, from each group. The number of eggs on each feather was then multiplied by the number of feathers in its size group. These numbers were summed and multiplied by two to give an approximation of the louse eggs present on both sides of the bird. Egg counts were made only for A. megalosoma.

The ectoparasites were emptied into petri dishes which were marked in half. In these dishes the lice were identified, counted,

sexed and aged in only one-half of the dish under a .7-30x dissecting microscope. This number was multiplied by two. When the number of lice was near 100 or less, exact counts were taken. Each time the entire sample was scanned for unusual lice or other parasites. Several complete counts were made to check the accuracy of this procedure which gave sufficiently accurate counts (±5%). Results were recorded on data cards as shown in Appendix C.

Representative samples of lice were cleared and mounted in Turtox CMC-10. Identifications were made by the author and confirmed by K. C. Emerson. Since all species parasitizing the sharptail were distinctly different in shape and size, they were relatively easy to differentiate.

Observations on the activity of lice were made. Grouse behavior as it may possibly be related to louse infestations was observed. Broods (hens and chicks), solitary birds, birds in winter flocks and groups of dancing cocks were observed with 8x50 binoculars and a 40 power spotting scope. Preening, dusting, scratching and pecking behavior were observed.

Living and freshly killed birds occasionally were examined under a dissecting scope to observe louse behavior. Live adult grouse were examined during trapping and banding operations in the winters of 1966 and 1967.

A system of determining the effects of lice on grouse was not successfully developed. Weights of birds were recorded and are used as a measure of general condition. Monthly average weights of cocks

and hens are listed in Table 3. The weights shown in Table 3 were assumed to be representative of bird weights in the general population. These monthly weights were used as a basis for later comparisons between infested and uninfested grouse.

Data collected during this study were analyzed using the least square analysis of variance. The program was set up and run by Dr. Lee Tucker, Experiment Station Statistician, South Dakota State University, Brookings, South Dakota.

Table 3. Sharptail Weights Per Month Pooled During Years 1965-1967

Month	Mean cock weights	Mean hen weights
January	914.0 (13)[a]	762.3[b] (11)
February	915.0 (16)	762.3 (7)
March	920.5 (6)	768.2 (19)
April	938.1 (15)	861.1 (9)
May	864.9 (47)	750.0 (9)
June	851.9 (31)	832.9 (4)
July	835.2 (15)	712.3 (29)
August	858.2 (11)	706.4 (17)
September	902.3 (9)	744.2 (12)
October	875.8 (3)	712.3 (4)
November	877.4 (4)	815.5 (18)
December	908.6 (22)	798.0 (24)

[a] Number of samples pooled.
[b] Weight units in grams.

RESULTS AND DISCUSSION

Life History of the Sharp-tailed Grouse in South Dakota

The following is an account of observations made by the author on the life history of South Dakota sharptails during the years of 1965 to 1970. It is necessary to include this information so that a better understanding of the host-parasite relationships can be reached. There are many facets of the life history of sharptails which have an important impact on the lice populations they carry.

Nesting began during the third week in April and occurred as late as early July. In 1966 and 1967 the peak hatch occurred during the last two weeks of May and the first week of June. Forbush (1936) stated that sharptails lay from 10 to 16 eggs. Two nests found during this study contained 12 and 13 eggs. Broods with more than 16 chicks were found on three occasions. In 1966 chicks were collected from 20 broods; average brood size was ten. In 1967 chicks were collected from 37 broods; average brood size was nine. Two active and two abandoned nests were found within one-half mile of active dancing grounds. Bernhoft (1968) found radio-tracked hens nested within 1.5 miles of the dancing ground on which they were captured. Nests were located under or very near a large forb such as lead plant or buck brush.

Hens with chicks under five weeks old were exceedingly difficult to find. Only seven chicks from three broods under three weeks of age were collected (Table 2). A hen which was flushed from a brood less than one week old feigned a broken wing and returned to the immediate

vicinity of the chicks when she did not succeed in drawing the author away. The hen, with 18 chicks, remained within five feet during an encounter in which the author collected three chicks. The chicks remained motionless and were very difficult to find in the vegetation. Three-week-old chicks were able to fly short distances. Hens observed with this age group remained very protective and remained near the brood after being flushed. Broods of this age group were as difficult to find and observe as the younger chicks.

At five weeks of age, chicks were capable of sustained flight and were found much more easily. Broods began to appear at roadsides and frequented small brushy ditches and haystacks. Chicks were observed dusting in the gravel on roadsides at five weeks of age. Broods returned frequently to the same area for shade in the heat of the day and for feeding in the early morning. Hens did not feign broken wings with five-week-old chicks and above. As chicks grew older, they became increasingly easier to find. Hens and chicks remained together as a distinct brooding unit until 16 to 18 weeks. Then, several broods often would be found together and a general flocking behavior was evident. Young birds completed their plumage growth in about 18 weeks, primaries nine and ten matured; and it became difficult to separate adults from young. Brooding behavior ceased and birds were considered adults at 18 weeks.

During the heat of the day, broods were found in the shade of buck brush, lead plant, cedar thickets, weedy fence rows, plum thickets and other places with tall dense vegetation. Chicks and hens sat

quietly and preened themselves and occasionally pecked at the ground near them. When approached, the group would sometimes squat until the author reached within 50 feet. The hen would then flush followed by the chicks.

Dancing activity as described earlier by Forbush (1936) was terminated generally during the first two weeks of June, occasionally lasting into the first week in July. Cocks during the summer were solitary and secretive. They were usually collected during early morning hours picking up gravel or dusting in roadways. Cocks, old and young, began frequenting dancing grounds during September and early October. Intensity of fall dancing activity was not great. The intensity of dancing activity in cocks built gradually through fall and winter into March. With the onset of warm weather and longer days in late March and April, the dancing activity became intense and activity like that described by Forbush (1936) occurred each day, from before sunrise until 8:00 to 9:00 a.m. and began again at 4:00 p.m. and continued to darkness. Weather affected the dancing activity to some extent, particularly during the later part of the breeding season in June and early July. During strong winds, cocks sat with heads raised or squatted on their territories with very little dancing activity. During the peak breeding season in late March to early May, cocks became relatively oblivious to weather and human activity. Dancing grounds could be approached and five to ten 22 rifle shots fired before birds would fly off. Birds would then return within 15 minutes and resume dancing around the car. During the breeding season,

cocks often remained in a flock, feeding together away from the ground between dancing hours.

Generally, dancing groups were located on bare, closely grazed ridge tops, usually on a small flat area which was heavily grazed and had much of the sod broken by cattle use, pocket gophers and harvester ants. These flat areas were usually from 30 square yards to an acre in size and were placed on the south facing slope of a ridge. Many of these areas have been used for many years. Henderson and Jackson (1967) reported continuous use of a dancing ground for 21 years. Movement of dancing grounds was observed when the sod was plowed or the area was not grazed and vegetation grew too high to be attractive to the birds. Two dancing grounds which were surveyed during this study were abandoned. New dancing sites were established within one-fourth mile of the old site. In both instances, vegetation on the dancing grounds became tall and dense as a result of no grazing and above normal moisture. These sites were abandoned in favor of heavily grazed, bare ridge tops.

Hens came to the dancing ground and were mated either on the dancing ground or in the immediate area around the dancing ground, while other dancing cocks continued to display. Through the months of March to September, cocks and hens were relatively separated in their activities except for occasional contacts during mating. Nesting hens were solitary. Occasionally hens which were not nesting were found together during the brooding season.

Sharptails spent most of their time on a very few selected areas. During the study, breeding cocks spent up to ten hours a day within an area of ten square yards for up to six and one-half months and one to eight hours per day for four months. Only during July, August and early September were dancing grounds inactive, yet cocks were occasionally observed on the grounds even during those months. Brooding hens and chicks were observed as many as eight times loafing in the shade of the same tree and were flushed on four occasions within 50 yards of the tree. It appeared to this observer that nesting and brooding occurred within one square mile or less for the first eight weeks. Sharptails spent a majority of time in a very restricted group of attractive habitat sites. It was concluded that this habit could facilitate external and internal parasite life cycles. The close social habits of sharptails could result in an easy and continuous transmission vehicle for lice.

Janson (1955) stated that grouse were frequently found infested with parasites. He stated that tapeworms were found in both young and old birds but did not identify the species. He also reported an eyeworm, an intestinal worm and a larval nematode that encysted in the breast muscle of grouse. He mentioned that lice were commonly encountered. He did not mention the species names of any of these parasites.

Seriously diseased live sharptails were found on only four occasions. Diseased and dead grouse were quickly disposed of by predators, scavengers or carrion insects in the study area. This made

examination of adequate numbers of naturally, mortally infected birds difficult to achieve and complicated the determinations of causative organisms. Indeed, population declines have not been substantiated or evident until brood counts, hunter bag checks and breeding ground surveys have revealed reduced numbers of birds, sometimes months after die-offs have occurred.

Henderson and Jackson (verbal communication, Warroad, Minnesota, September, 1965) stated that during their grouse research they had frequently been temporary hosts for grouse lice. They also stated that the very lousy birds were often birds which appeared sick in the grouse traps. Both researchers requested that a study be initiated to study the effect of parasites on the health and viability of sharptails. This study deals only with the Mallophaga parasitic on sharptails.

Between December, 1964, and May, 1965, Henderson collected 44 cock and 18 hen sharptails. These birds were examined for external and internal parasites. The findings were reported in three abstracts, Boddicker and Hugghins (1965a, 1965b) and Boddicker (1965).

Three species of lice were found during the preliminary survey, Goniodes nebraskensis Carriker (1946), Amyrsidea megalosoma Overgaard (1943) and Lagopoecus perplexus Kellogg and Chapman (1899). Lice were not found on birds collected in November through January, possibly as a result of poor efficiency of the recovery procedure. On both cocks and hens, louse infestation rates and intensities increased beginning in March and continued upward until collections were terminated in May. The increase of lice appeared to parallel increased breeding activity

and the onset of warmer weather. Approximate infestation rates are shown in Table 4. The percentage of birds infested increased from 0% in November through January to 100% in April and May. Goniodes nebraskensis occurred on 68% of all birds examined and 86% of the birds infested with lice. The highest infestation found was estimated at about 100. Amyrsidea megalosoma was found on 23% of all birds and 33% of the infested birds. Lagopoecus perplexus was found in small numbers on only two birds. It was noted that heaviest louse infestations were found on dancing cocks. Hens carried very light louse populations.

Dancing cocks heavily infested with A. megalosoma had an unthrifty appearance and large denuded, scabeous skin patches on the chin and air sacs. No lesions of this type were observed on hens infested with A. megalosoma.

Microspores and hyphae of microfungi were observed attached to body setae of A. megalosoma during identification procedures. These microspores and hyphae appeared to be of dermaphytic origin but were not identified further during this preliminary study.

It was decided on the basis of the results of the preliminary survey that a continued research program was warranted. It was initiated as described in the Methods section.

Sharptail Weight and Age Characteristics

Weight characteristics of the host were considered to be the most reliable index of general health. It was assumed that the most evident louse effect on the sharptails would be expressed in weight

Table 4. Louse Infestations of Sharp-tailed Grouse, November, 1964 - May, 1965

Month	No. of samples	No. infested	% infested	% with *G. nebraskensis*	% with *A. megalosoma*	% with *L. perplexus*	Mean total lice/month
November	1	0	0	0	0	0	0
December	2	0	0	0	0	0	0
January	7	0	0	0	0	0	0
February	10	4	40	40	10	0	16.4
March	12	8	67	67	25	0	24.9
April	15	15	100	67	47	12	48.6
May	15	15	100	93	20	0	53.6
	62	42	68	50	23	3	

differences between hosts. It was therefore imperative that the weight characteristics of the sharptails be studied in detail for indications of louse parasite effects. It was assumed that heavy louse burdens would be expressed in lower weights of the host. It was postulated that, if louse infestation intensities varied through the months of the year on wild birds as was shown by Boyd (1951) and Ash (1960), then low grouse weights could be expected during months of highest louse infestations. It was also postulated that heavily infested birds should weigh less than uninfested or lightly infested birds during all months.

The weights of sharptails have been recorded often in the literature. On examination of these records, it was apparent that these weights were taken at hunter bag checks and during winter trapping studies and do not express the weight characteristics of birds over the year. It was necessary to determine spring and summer weights for use in this study. It was also imperative that individual bird weights be recorded in order that a relationship could be established between louse infestations and host condition.

Weight data has been collected on sharptails in South Dakota at hunter bag checks and during grouse banding operations since September, 1960. Henderson (1965) listed the weights of adult cocks and hens and young cocks and hens weighted at bag check stations between 1960 and 1963.

Jackson and Henderson (1965) included a table which listed weights of winter-trapped grouse through the months of December, 1963,

and January to March of 1964. No data on late spring and summer weights were available.

In this study old and young grouse were not separated by weights after the September collections because of difficulties in determining ages. Table 3 shows the average monthly weights of adult cocks and hens. During the months of October and November, young grouse of subadult weights were included with breeding adults. It was noted that adult and young weights overlapped consistently after the young reached 18 weeks (Fig. 2).

Since weights were assumed to be an indication of the general condition of the birds, the monthly weight variations of adult birds were of particular interest, since it was noted in the preliminary study that louse populations varied between months.

The heaviest cock collected weighed 1043 grams; it was collected in December, 1966, 12 miles west of Interior, South Dakota. Only three grouse were collected during the study which weighed over 1000 grams; all were old cocks. Only two cocks were collected which weighed under 700 grams. Both grouse were diseased. One was collected in August, 1966, in Mellette County. It weighed 516.5 grams and was afflicted with a large carcinoma and Sarcophagid maggots. A cock heavily infested with a nematode, Seurocynea colini, collected in January, 1966, from Lyman County weighed 699.0 grams. The statistically adjusted mean weight of all cock samples collected during the study was 874.3 grams. Mean cock weights varied considerably between months as illustrated in Fig. 2. Mean weights through the months of December,

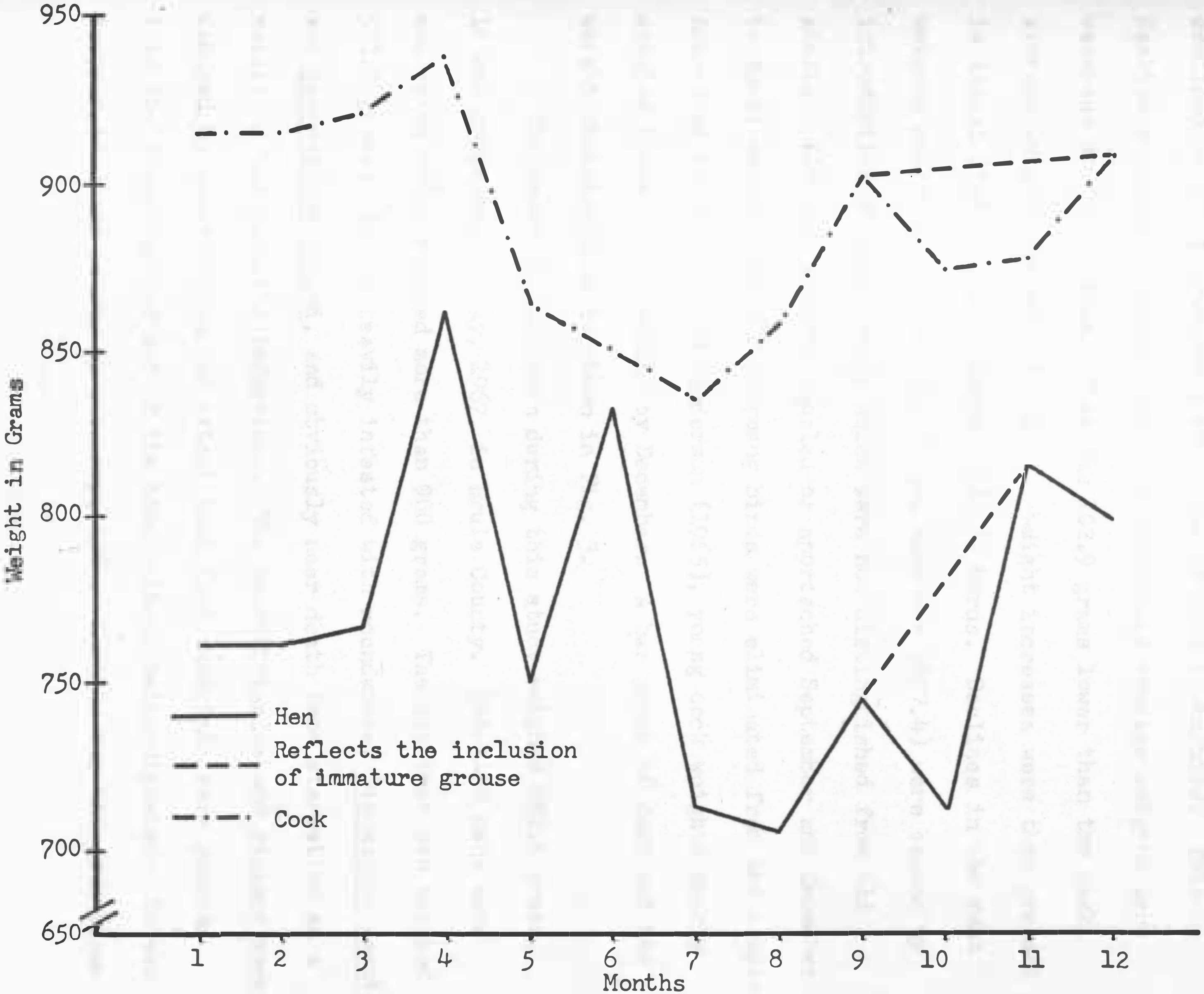


Fig. 2. Average monthly sharptail weights pooled during 1965-1967 with inclusion of weight data collected during bag checks.

January, February and March remained steady between 908 and 920 grams. A slight average increase occurred during April to an average weight level of 938.1 grams/cock. Then during May, average cock weights declined to 861.1 grams or a reduction of 77.0 grams/bird. This decline continued through July when the lowest average weights were recorded at 835.2 grams. This was 102.9 grams lower than the peak average weights recorded in April. Weight increases were then present in August (858.2) and September (862.3) birds. Declines in the mean weights noted in October (875.8) and November (877.4) were caused by introduction of young cocks which were not distinguished from old adults. Old cock weights equaled or approached September and December to April weight levels when young birds were eliminated from the sample. According to Jackson and Henderson (1965), young cock weights nearly equaled those of old adults by December. A bar graph of cock and hen weight distributions is shown in Fig. 3.

The heaviest hen taken during this study weighed 981.0 grams. It was collected in May, 1967, in Brule County. Thirteen hens were collected which weighed more than 900 grams. The lightest hen weighed 571.0 grams. It was heavily infested with roundworms, Dispharynx nasuta and Seurocyrnea colini, and obviously near death from starvation as a result of the parasite infections. The proventriculus and gizzard were damaged by nematodes to the extent that food materials were passing into the intestine and out of the bird without being digested. It was trapped in Jones County in February, 1967. Hens in the 600 gram class

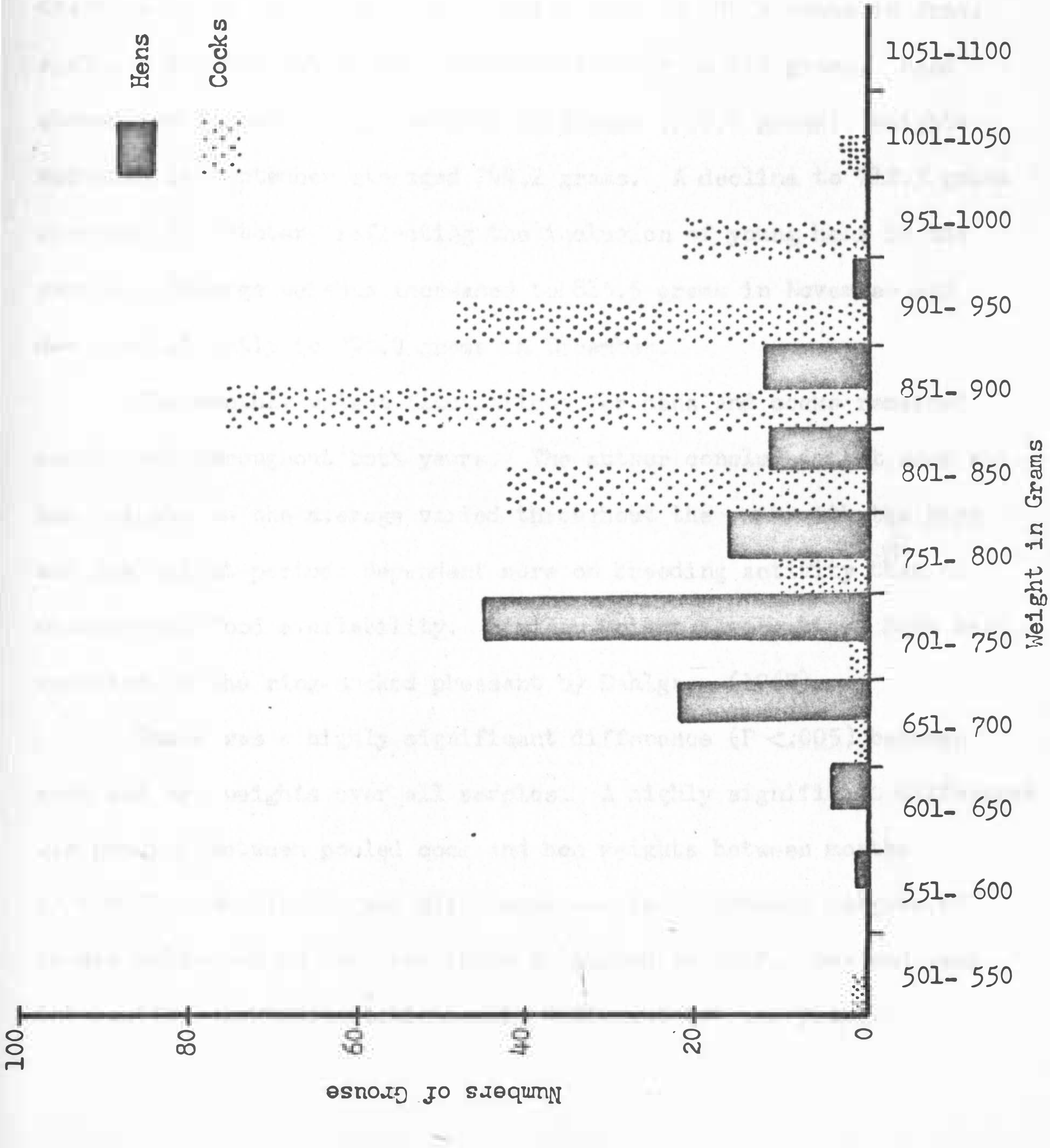


Fig. 3. Sharptail weight distributions according to sex.

were common (Fig. 3). Mean hen weights also varied considerably per month (Fig. 2).

The statistically adjusted mean weight of all hens collected during the study was 755.1 grams. Hen weights from January to March were similar, ranging from 762 to 768 grams. Average weights then increased in April to 861.1 grams. Weights in May dropped rather drastically to 750 grams only to climb back to 832.9 grams in June. Again, a drastic weight drop occurred in July to 712 grams. Hens showed the lowest average weights in August (706.4 grams); weights recorded in September averaged 744.2 grams. A decline to 712.3 grams occurred in October, reflecting the inclusion of young hens in the sample. Average weights increased to 815.5 grams in November and declined slightly to 798.0 grams in December.

The monthly weight fluctuations for hens and cocks remained consistent throughout both years. The author concluded that cock and hen weights on the average varied throughout the year with the high and low weight periods dependent more on breeding activity than on weather and food availability. Similar weight fluctuations have been reported in the ring-necked pheasant by Dahlgren (1967).

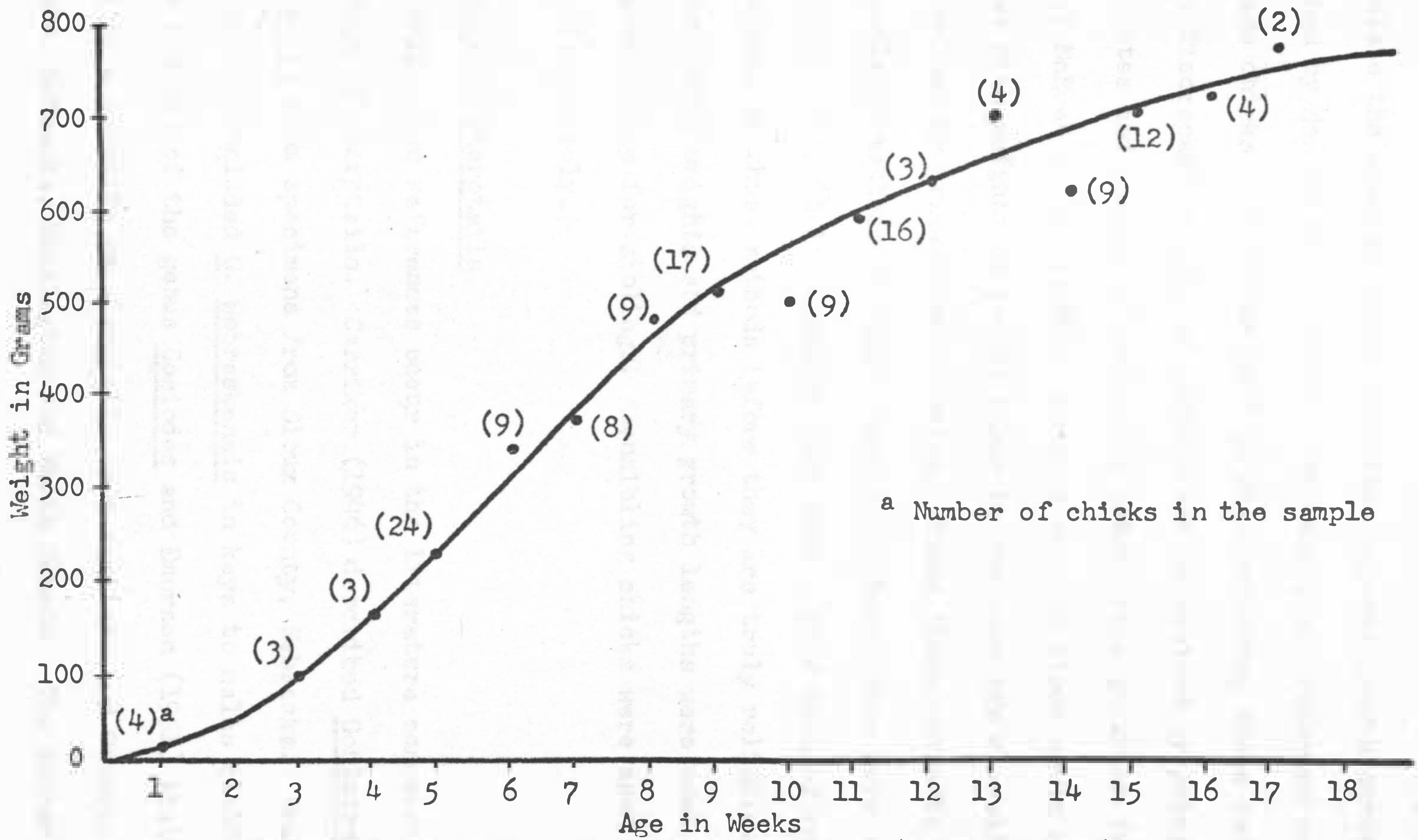
There was a highly significant difference ($P < .005$) between cock and hen weights over all samples. A highly significant difference was present between pooled cock and hen weights between months ($P < .005$). No significant difference was found between weights of grouse collected in 1966 and those collected in 1967. Sex and year interactions were not statistically different between years.

Comparisons were made of adult weights collected in the east half of the study area with weights from the western half. Similar comparisons were made between north and south halves of the study area. No statistically significant differences were present in adult weights between those areas.

It was postulated from these comparisons that the differences in soil types, mean annual precipitation and land use in the study area had no significant effect on adult sharptail weights.

Average weights of week classes of chicks are shown in Fig. 4. McEwen et al. (1969) published a weight-age growth curve for pen-reared sharptail chicks. Wild chicks collected during this study appeared to have been heavier at the same ages than those of McEwen et al. (1969). However, the birds in that study reached peak weights in 15 or 16 weeks. The same weights were not found in wild birds until 17 weeks of age. There were no statistically significant differences in weights between chicks of opposite sexes collected during this study.

Comparisons of weights were made between chicks collected from the north and south and the east and west regions of the study area. No statistically significant difference was present between chick weights of east and west areas. However, a significant difference did exist ($P < .025$) between chicks from the north and south areas. The reason chicks collected in the southern half of the study area averaged higher weights was not determined. There was no significant weight difference between chicks collected in 1966 and those in 1967.



Det. by Prim. Measurement After Rous (1967) and Janson (1955)

Fig. 4. Age-weight data for chicks fitted to a Gompertz growth curve.

As stated earlier, chicks were aged according to primary growth rate measurements as described by Rous (1967) and Ammann (1957). Weights were recorded with the age data. The author attempted to interpolate the ages of chicks from the Gompertz growth curve published by McEwen et al. (1969). McEwen et al. recorded weights of known age chicks. It became obvious when reviewing these data that serious discrepancies existed between age determined by primary growth rates and age as determined by weight interpolation from the chart of McEwen et al. (1969). Weights of wild birds could not be compared with weights of penned birds in the same age classification as determined by primary growth rates. Since these criteria were the only available methods of aging sharptail chicks, they were used during this study. But, it is suggested here that a good deal of refinement must be made on those methods before they are truly reliable. During this study both weights and primary growth lengths were used to arrive at an average age for siblings. Nonsibling chicks were aged using primary length only.

Mallophaga of Sharptails

Only a few references occur in the literature concerning Mallophaga of sharptails. Carriker (1946) described *Goniodes nebraskensis* from specimens from Sioux County, Nebraska. Emerson (1948, 1950a) included *G. nebraskensis* in keys to males (1948) and females (1950a) of the genus *Goniodes* and Emerson (1951) listed this species as a parasite on sharptails from Manitoba and Ontario, Canada, Wisconsin, Nebraska, Washington and North Dakota. The author was

unable to find references to its life history or ecology in the literature.

Amyrsidea megalosoma was described by Overgaard (1943) from the Hungarian partridge, Perdix perdix, and the ring-necked pheasant, Phasianus colchicus, in Denmark. Emerson (1951) recorded P. colchicus as a host in Illinois, Rhode Island, New Hampshire and New Jersey; sharptails in Wisconsin and ruffed grouse in New York. In South Dakota, three specimens of P. perdix and 27 of P. colchicus were examined, but no A. megalosoma were found. The author has collected A. megalosoma from greater prairie chickens, Tympanuchus cupido (Rudow), in Lyman County, South Dakota. According to Emerson (unpublished letter in files of the author, June, 1965), this species was probably introduced into the United States with the ring-necked pheasant and secondarily infested native birds. Pen-reared adult sharptail cocks developed heavy infestations of A. megalosoma and several died, presumably as a result of louse infestations (McEwen et al., 1969). In the pen-rearing studies, large populations of lice occurred during the spring and early summer of 1963 but were controlled by dust boxes containing a mixture of sand, 5% rotenone powder and two to three cups of Cellite. Shoemaker (verbal communication at Prairie Grouse Technical Council, Effingham, Illinois, 1967) experienced the same problem with lice when developing a pen-rearing technique for prairie chickens in Illinois. Although the louse species was not identified, his description of it left little doubt that it was A. megalosoma. No mention of the life history or ecology of this species was found in the literature.

The only other louse mentioned in the literature as a parasite on sharptails is Lagopoecus perplexus (Kellogg and Chapman, 1899) which was described from specimens collected from the Columbian sharptail in Washington (Kellogg and Chapman, 1899). Emerson (1950b) also listed this species from grouse collected in Washington and Ontario. No mention of this species could be found in the literature with regard to its life history or ecology.

Bionomics of Goniodes nebraskensis Carriker, 1946 (Fig. 5-14). Eggs of this species are laid on the inner side of the hyporhachis between the afterfeather and main contour feather. One to five eggs are laid in single file in the first two centimeters from the base of the hyporhachis distal. The distal operculated end of the egg is pointed upward and the proximate end and one side of the egg is cemented to the hyporhachis (Fig. 14). Contour feathers in the ventral, cervical and pectoral tracts appear to be the major oviposition sites. Contour feathers of the femoral, sternal, dorsal and pelvic tracts are used to a lesser extent. On heavily infested birds every contour feather examined contained eggs. Eggs were firmly fastened to the afterfeather. Goniodes nebraskensis feed on the empty egg shells, fragments of which were found in the crops of adult lice. Eggs were not counted or estimated during this study nor was the length of time in the egg stage determined.

During copulation the male is positioned below the female with his head beneath the thorax of the female. Modified antennae of the male are used to grip the female. Male genitalia are extended

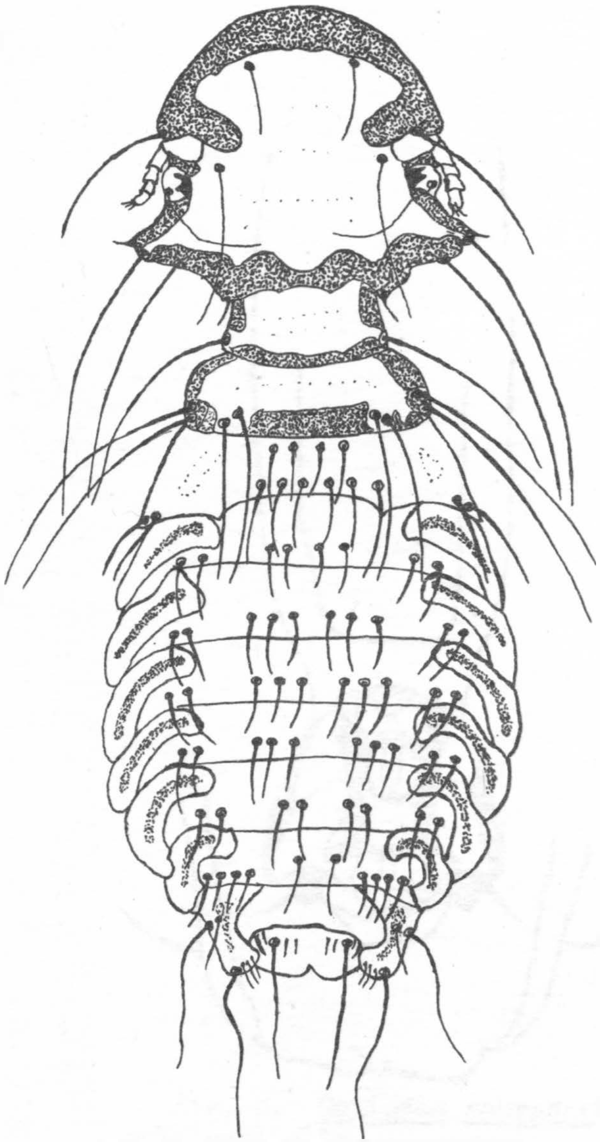


Fig. 5. Goniodes nebraskensis
female - dorsal.

Scale: 5 cm = 1 mm

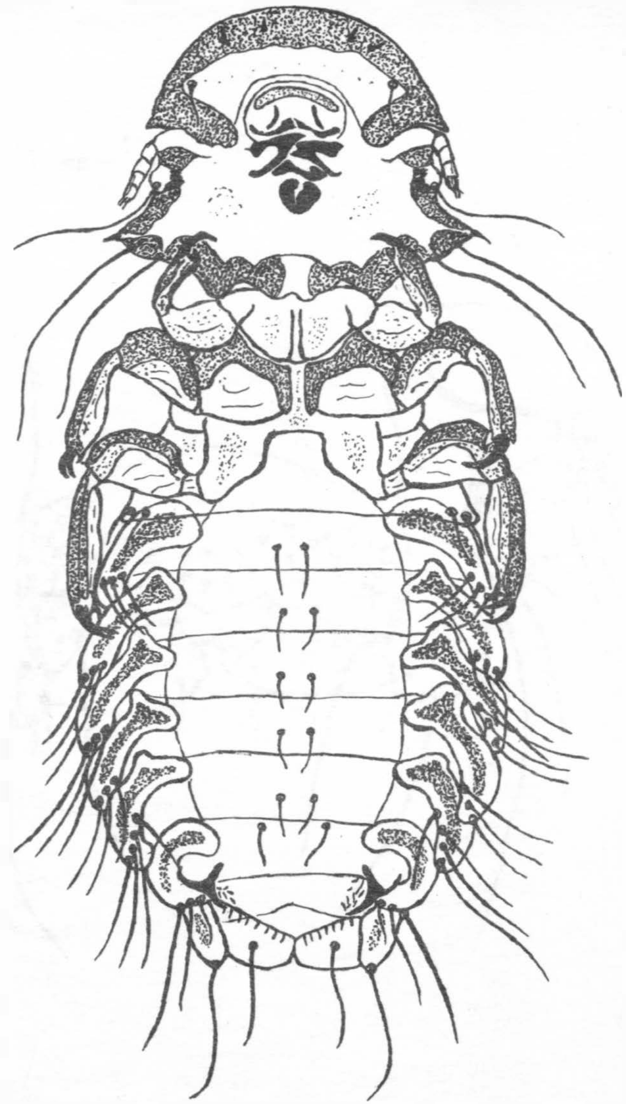


Fig. 6. Goniodes nebraskensis
female - ventral.

Scale: 14.5 cm = 1 mm

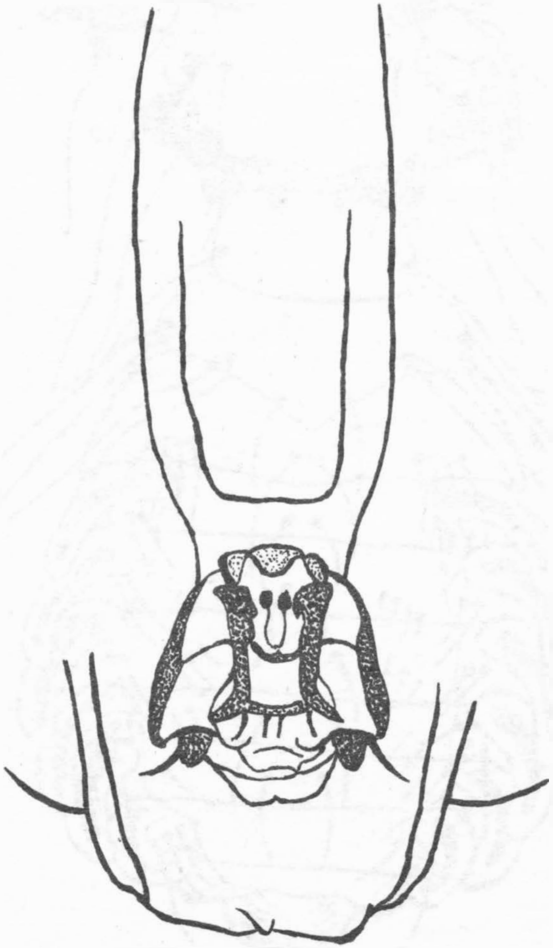


Fig. 7. Goniodes nebraskensis male genitalia.

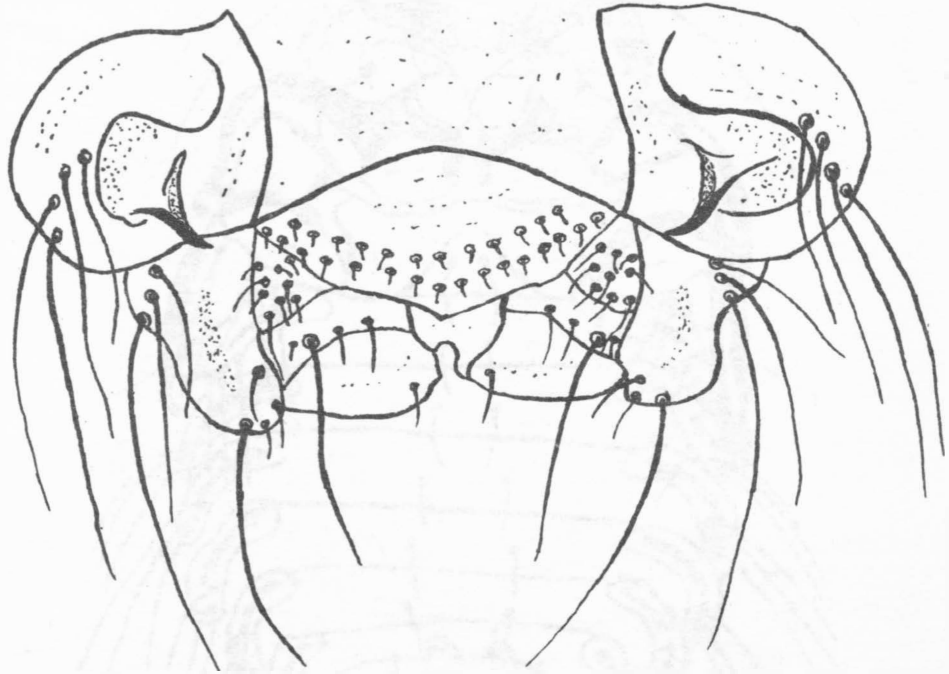


Fig. 8. Goniodes nebraskensis female vulva.

Scale: 7 cm = 1 mm

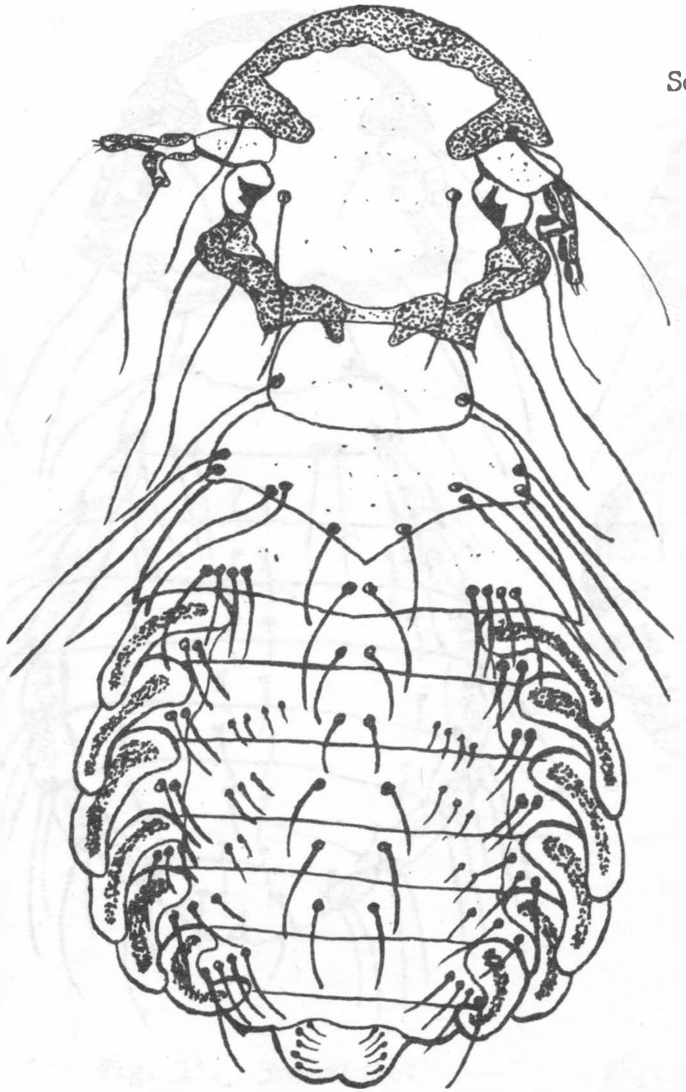


Fig. 9. Goniodes nebraskensis male - dorsal.

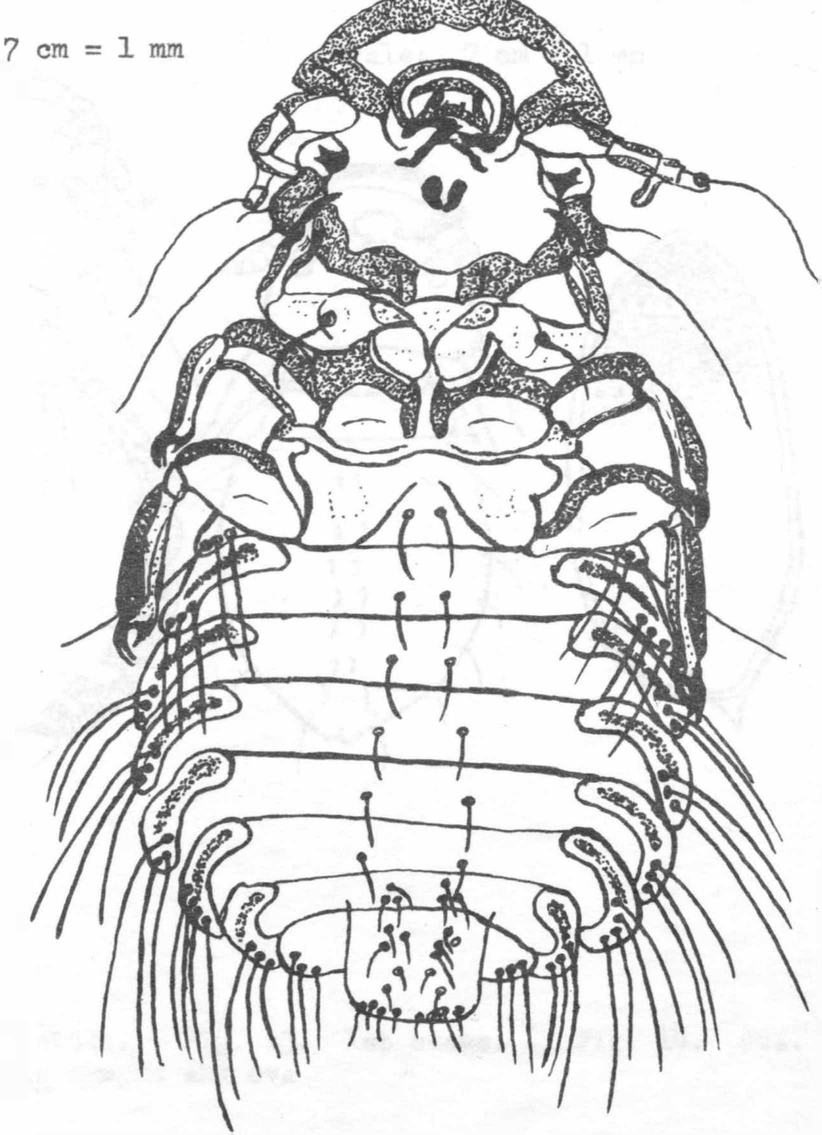


Fig. 10. Goniodes nebraskensis male - ventral.

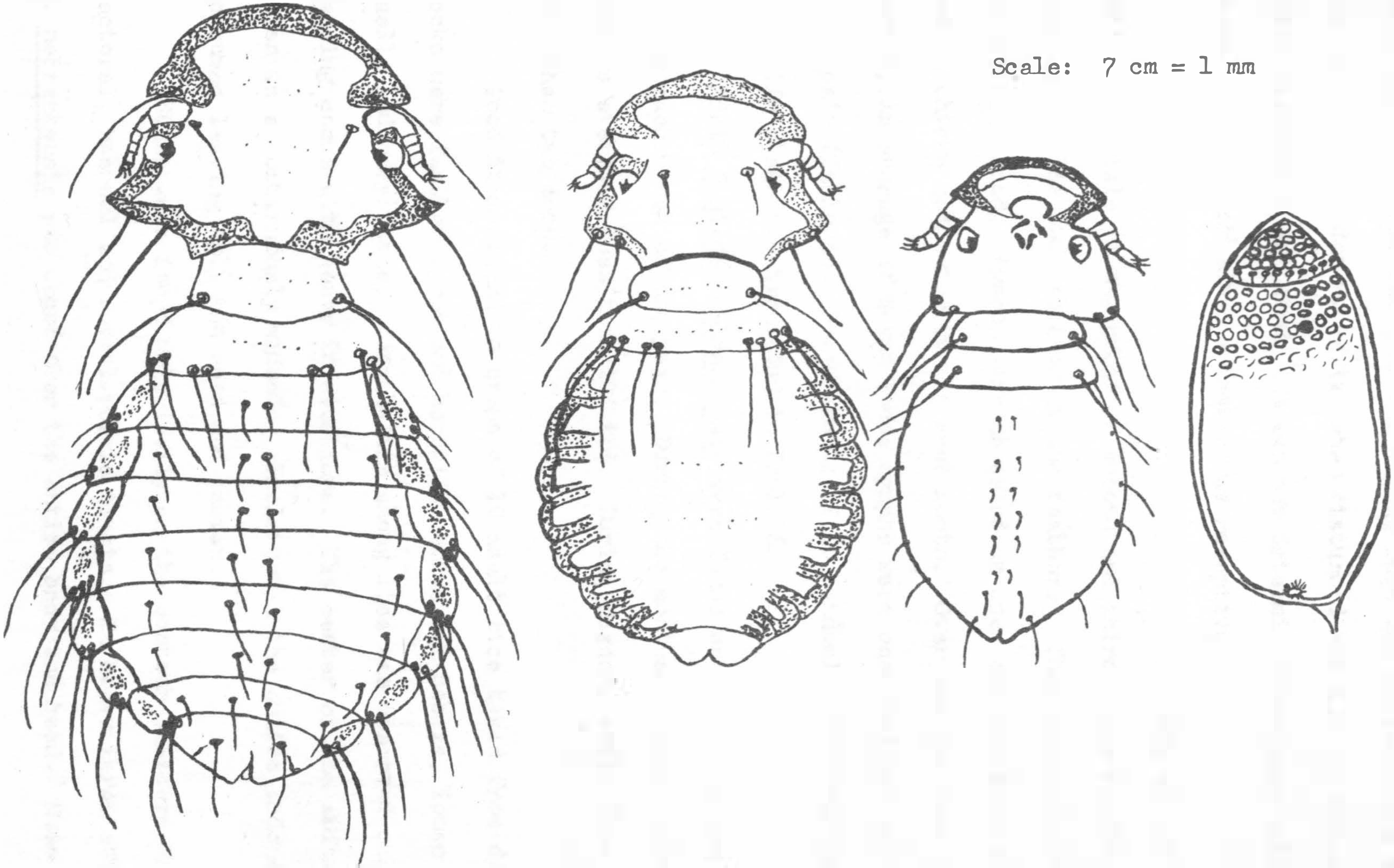


Fig. 11. 3rd stage. Fig. 12. 2nd stage. Fig. 13. 1st stage. Fig. 14. Ova.

Goniodes nebraskensis nymphs and ova

posteriorly, dorsad and then anteriorly into the vulva. Both the male and female moved during coitus when disturbed but did not disconnect until vigorously agitated. It was not determined how long coitus lasted or how many times a female was receptive.

Immature lice preferred feather parts which were closer to the skin. Materials in the crops of second and third stage nymphs were epidermal cells and barbules of the feathers. They were not observed to feed on blood. Nymphs were observed on one- and two-day-old chicks and on chicks collected during each month. Over the two year study period, an average of seven louse nymphs were observed per each adult louse pair (Table 5). Measurements of 10 randomly selected lice from each life stage are tabulated in Table 6.

Adult _Goniodes nebraskensis_ were found on grouse collected during each month of the year. During the months of July to February, numbers averaged less than 10/bird. During August, adult lice averaged less than two/cock.

Food items found in crops of 10 adult lice taken from dancing cocks were feather barbs and barbules, epidermal debris, louse egg shells and body parts. Cannibalism among lice was observed only on dancing cocks with heavy infestations. The center of the abdomen was eaten in a continuously widening circle until the entire abdomen was consumed leaving only the head and thorax.

Adults were found principally on the contour feathers of the pectoral, sternal and dorsal-pelvic tracts. In heavy infestations _G. nebraskensis_ was found over the entire body and head. When

Table 5. Sex and Age Ratios of Lice on Adult Grouse

Month	Goniodes nebraskensis			Amysidea megalosoma		Lagopoecus perplexus		
	Male	Female	Nymph	Adult	Nymph	Male	Female	Nymph
				Cocks				
1	5.5	5.0	24.0	2.5	12.0	2.0	1.0	3.0
2	4.2	5.5	25.4	6.5	1.5	0	1.0	0
3	9.5	10.5	79.0	1.3	0	0	.5	0
4	18.4	28.5	103.5	83.3	116.0	1.0	.5	3.5
5	25.6	34.5	162.0	292.7	342.0	1.7	5.4	30.0
6	52.6	86.1	276.5	244.5	492.5	2.6	4.8	4.5
7	4.0	4.6	16.0	14.7	11.7	0	1.0	0
8	.3	.3	3.5	1.0	0	0	0	0
9	3.0	5.5	36.5	0	0	0	0	0
10	3.5	3.0	9.5	12.0	30.0	0	0	0
11	5.7	5.7	54.5	1.0	1.0	0	0	0
12	3.1	4.5	17.6	14.5	30.5	0	0	0
				Hens				
1	1.7	3.2	24.7	0	0	0	0	0
2	2.3	2.7	7.9	2.0	7.0	0	0	0
3	4.2	6.2	28.5	1.7	2.3	0	0	0
4	3.7	4.4	35.1	1.0	0	.5	4.0	4.5
5	4.2	2.2	17.7	2.0	0	0	0	0
6	3.7	3.9	9.9	55.0	75.0	0	0	0
7	2.0	14.4	158.2	7.8	5.4	2.5	3.5	4.2
8	1.5	2.4	5.4	5.0	1.0	0	0	0
9	8.9	2.0	.3	2.5	0	0	0	0
10	1.5	2.0	9.0	0	0	0	0	0
11	2.7	2.3	11.0	2.6	5.6	0	2.0	4.0
12	1.7	3.9	16.6	2.5	7.0	0	0	0

Table 6. Measurements of *Goniodes nebraskensis* Life Stages

	Total length	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length
Male								
1	2.24	.68	.71	.69	1.06	.99	1.26	.45
2	2.15	.65	.72	.60	1.06	1.01	1.24	.49
3	2.30	.68	.73	.60	1.05	1.29	1.31	.47
4	2.42	.65	.75	.74	1.06	1.06	1.27	.42
5	2.33	.69	.74	.74	1.10	1.01	1.27	.44
6	2.35	.72	.71	.71	1.04	1.06	1.29	.46
7	1.98	.65	.70	.65	.92	.97	1.10	.37
8	2.04	.65	.70	.62	.92	.92	1.08	.37
9	2.02	.64	.67	.60	.90	.92	1.10	.39
10	2.15	.67	.71	.60	.92	.97	1.13	.39
Mean	2.20	.67	.71	.66	1.00	1.02	1.21	.43
$S_{\bar{x}}$	±.143	±.025	±.025	±.046	±.065	±.120	±.075	±.034
Female								
1	2.42	.74	.90	.65	.92	1.20	1.09	.24
2	2.49	.74	.90	.65	.95	1.25	1.20	.25
3	2.42	.74	.86	.65	.97	1.24	1.15	.25
4	2.53	.79	.92	.69	.92	1.26	1.14	.25
5	2.48	.74	.92	.69	.92	1.20	1.10	.28
6	2.86	.79	1.10	.74	1.12	1.47	1.26	.29
7	2.42	.74	.92	.65	.97	1.23	1.25	.30
8	2.58	.75	.97	.69	1.10	1.34	1.29	.28
9	2.46	.69	.90	.65	.92	1.24	1.10	.25
10	2.48	.74	.87	.65	.94	1.29	1.13	.28
Mean	2.51	.75	.93	.67	.97	1.27	1.18	.27
$S_{\bar{x}}$	±.143	±.032	±.078	±.029	±.065	±.088	±.065	±.020

Table 6 Continued

	Total length	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length
3rd Stage Nymph								
1	1.76	.60	.74	.49	.75	.76	.90	.23
2	1.56	.51	.68	.42	.70	.70	.90	.23
3	1.76	.54	.72	.46	.79	.87	1.04	.23
4	1.49	.54	.69	.46	.65	.65	.68	.19
5	1.58	.55	.70	.46	.69	.66	.85	.23
6	1.60	.55	.71	.48	.69	.69	.79	.19
7	1.60	.55	.71	.48	.69	.68	.80	.21
8	1.87	.57	.74	.46	.80	.92	1.06	.18
9	1.76	.59	.74	.48	.74	.83	.97	.18
10	1.73	.59	.74	.46	.74	.79	.92	.23
Mean	1.67	.56	.72	.47	.72	.76	.89	.21
$S\bar{x}$	±.124	±.029	±.019	±.022	±.049	±.084	±.124	±.002
2nd Stage Nymph								
1	1.32	.44	.54	.32	.60	.64	.76	.16
2	1.15	.44	.54	.34	.55	.51	.68	.17
3	1.18	.46	.55	.33	.54	.47	.62	.18
4	1.24	.46	.54	.34	.55	.65	.68	.17
5	1.15	.42	.52	.32	.55	.47	.58	.15
6	1.15	.46	.54	.37	.59	.60	.69	.18
7	1.32	.46	.54	.38	.60	.57	.70	.16
8	1.34	.43	.60	.37	.60	.52	.78	.15
9	1.16	.42	.52	.32	.55	.48	.64	.19
10	1.23	.42	.53	.32	.55	.51	.62	.17
Mean	1.22	.44	.54	.34	.57	.54	.68	.17
$S\bar{x}$	±.052	±.013	±.026	±.019	±.019	±.059	±.065	±.001

Table 6 Continued

	Total length	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length
1st Stage Nymph								
1	.99	.40	.39	.34	.32	.49	.50	.14
2	.93	.37	.39	.25	.37	.44	.38	.15
3	.97	.31	.38	.23	.32	.51	.51	.13
4	1.01	.34	.37	.23	.37	.51	.51	.13
5	.83	.32	.37	.18	.28	.34	.29	.14
6	1.01	.34	.41	.23	.42	.46	.51	.14
7	1.04	.33	.38	.28	.37	.50	.51	.14
8	.96	.33	.39	.23	.37	.46	.46	.14
9	.91	.32	.37	.23	.42	.40	.40	.13
10	1.01	.36	.40	.28	.37	.33	.46	.14
Mean	.97	.34	.39	.25	.36	.44	.45	.14
$S\bar{x}$	±.068	±.029	±.018	±.052	±.045	±.059	±.072	±.006

		Total width
Ova		
1	.84	.42
2	.83	.37
3	.88	.46
4	.83	.42
5	.91	.51
6	.87	.51
7	.92	.51
8	.86	.48
9	.94	.37
10	.91	.50
Mean	.88	.46
$S\bar{x}$	±.036	±.133

disturbed, adults crawled from the pennaceous part of the feathers down toward the calamus or hid between the afterfeather and plumulaceous portion of the vane. They would hide in this fluffy portion of the feather until touched directly. When touched, they simply readjusted their position. Immatures had the same movement habits as adults.

Goniodes nebraskensis remained on its host after its death. No attempt was made by this species to crawl onto the hand of the investigator, either from living or dead grouse. When removed from the host and placed on a foreign substrate, these lice appeared confused. Forward motion was slow and usually required initiation by disturbing the insect. When prodded, the male assumed the position taken during mating with antennae raised and waving and the abdomen extended posterio-dorsally. On a dead and cooling host, this species assumed the position in the feathers as when disturbed on a living host. They appeared to spend most of their lives on the feathers and appeared confused and disoriented when removed from the feathers. Both adults and immature insects were observed on the skin.

During this study, G. nebraskensis was the most common louse occurring on the sharptail. It infested 66% of the chicks, 73% of the cocks and 74% of the hens. Seventy-three percent of all the grouse examined were infested. The percentage of infested hosts varied between months (Table 7, Fig. 15).

The lowest average infestation occurred on cocks during August, 1.4 lice/cock (Fig. 15). Lice populations increased in September to 10 and then leveled off to remain fairly stable until March when a

Table 7. Louse Data Pooled Per Month on Adult Grouse, September, 1965 - October, 1967

Month	No. of samples Total infested	Mean total lice	Mean total *G. nebraskensis*	Mean total *A. megalosoma*	Mean total *L. perplexus*	No. unin-fested	Mean weight
			Cocks				
1	13	32.0	29.0	2.0	.5	2	914.0
2	16	31.0	29.0	1.0	.1	2	915.0
3	6	98.0	97.0	.6	.1	0	920.5
4	15	196.7	116.7	79.7	.5	1	938.1
5	47	516.1	191.6	310.3	14.0	0	864.9
6	31	825.5	250.1	570.8	4.6	0	851.9
7	15	35.0	23.0	12.0	.1	0	835.2
8	11	1.7	1.4	.1	0	6	858.2
9	9	10.0	10.0	0	0	7	902.3
10	3	17.6	4.0	14.0	0	1	875.8
11	4	39.0	38.5	.5	0	0	877.4
12	22	24.0	19.8	4.0	0	4	908.6
			Hens				
1	11	25.0	25.0	0	0	2	762.3
2	7	7.5	7.5	0	0	1	762.3
3	19	29.0	28.6	.6	0	3	768.2
4	9	36.0	33.8	.1	2.0	1	861.1
5	9	22.4	22.0	.5	0	0	750.0
6	4	105.0	14.5	90.2	0	0	832.9
7	29	173.5	169.0	2.2	2.2	0	712.3
8	17	6.4	5.3	1.0	.1	4	706.4
9	12	1.3	.9	.4	0	7	744.2
10	4	6.2	6.2	0	0	2	712.3
11	18	14.4	12.7	1.4	.3	5	815.5
12	24	15.6	14.8	.8	0	7	798.0

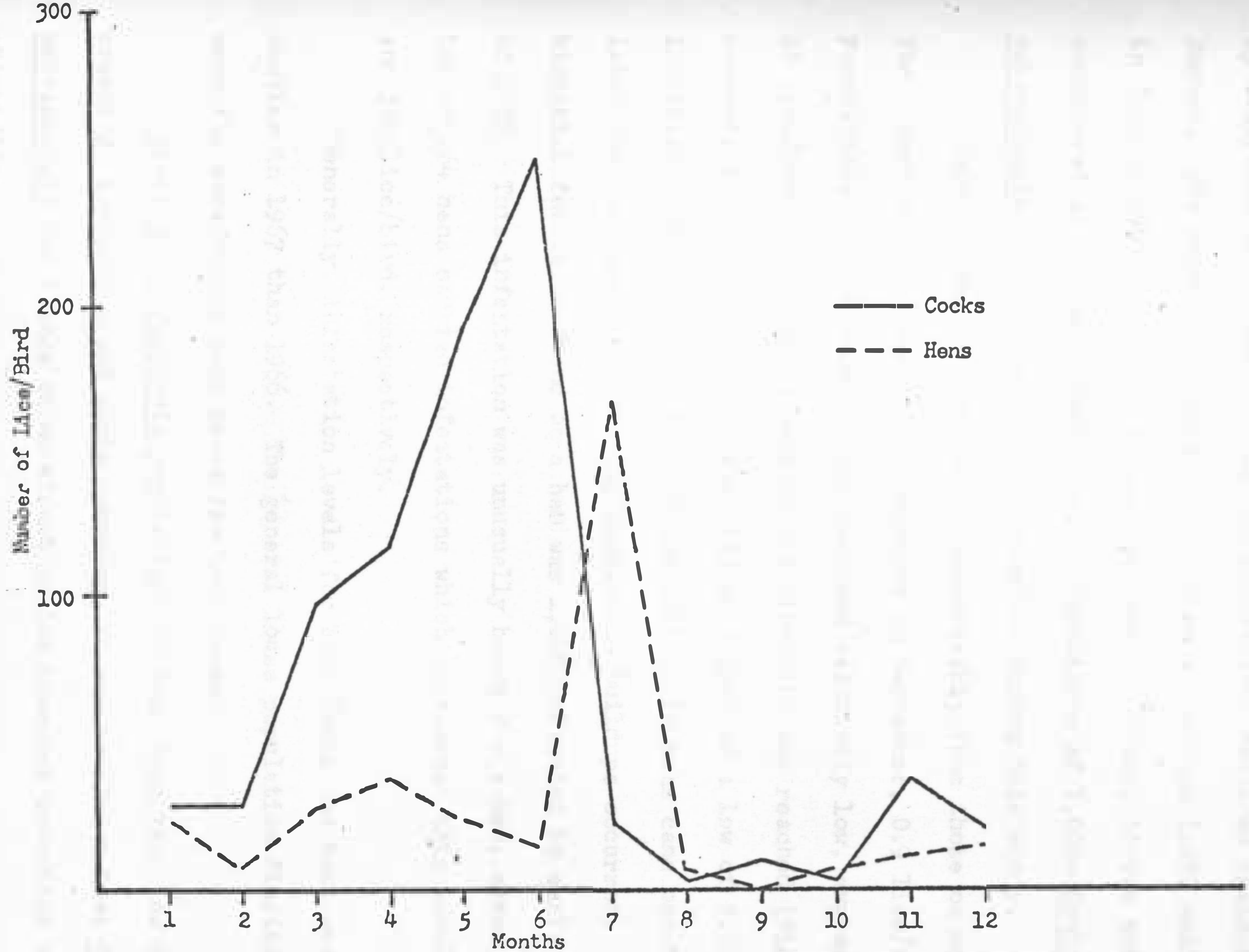


Fig. 15. Goniodes nebraskensis infestations per month on adult grouse.

threefold increase took place. This increase reached a peak average of 250.1 lice/cock in June followed by a marked decline. Averages of 23 lice/cock were found in July and populations declined again in August. The heaviest infestation found on a cock was 1,202 collected in June of 1967. Although it was the heaviest found, it was not considered an unusual infestation. Infestations of 1,000+ Goniodes nebraskensis occurred on 27 cocks examined during this study.

Infestations on hens varied considerably from those on cocks. The lowest average populations occurred in September, 0.9 lice/bird. Populations from October to June remained relatively low, averaging 18 lice/bird. In July, a peak of 169 lice/bird was reached (Fig. 5). However, a decline occurred (Fig. 15) in August to a low of 5.3 lice/bird. This rise and fall of populations in hens came one month later than on cocks. No gradual population buildups occurred. The highest infestation found on a hen was 1,098 collected in early July of 1967. This infestation was unusually heavy for a hen, since only two of 164 hens carried infestations which approached this level, 866 and 502 lice/bird, respectively.

Generally, infestation levels for both cocks and hens were heavier in 1967 than 1966. The general louse population fluctuations were the same during both years for both sexes.

Since G. nebraskensis populations on hens were very low during breeding, incubation and early brooding, it was concluded that G. nebraskensis had little or no effect on the breeding potential of sharptails.

The percentages of birds infested with Goniodes nebraskensis per month are shown in Fig. 16. The percentage of cocks and hens infested with this species varied between months and was fairly consistent. The percentages of birds infested in a given month did not consistently reflect the infestation intensities (Fig. 15 and 16). Cocks collected in June were infested at a 61% rate, yet these cocks averaged the heaviest infestations (250 lice/bird, including uninfested cocks). Ninety-three percent of the hens were infested in June with an average of 15 lice/bird.

Immature lice were found on freshly hatched chicks from a hen with a pure infestation of G. nebraskensis. Adult lice were first found on three-week-old chicks and chicks of all week classes thereafter. The most intense infestations (33 lice/bird) were found on chicks five and six weeks of age. These age classes were collected in July when G. nebraskensis infestations peaked on the hens (169 lice/bird). Louse infestations on chicks declined into August and September, corresponding to louse population declines on the hens (Fig. 15 and 17). Chicks in the age classes 12 to 18 weeks carried 4.8 lice/bird. This is roughly the same infestation rate found on adults during August to September. Distribution of adjusted mean louse infestations on chicks per month are shown in Fig. 17.

Goniodes nebraskensis populations typically consisted of an average ratio of 1 adult male to 1.5 adult females to 7 nymphs. This ratio varied per month between sex and age groups of the hosts with the highest ratio of 1 male·1.6 females·17.7 nymphs occurring on hens

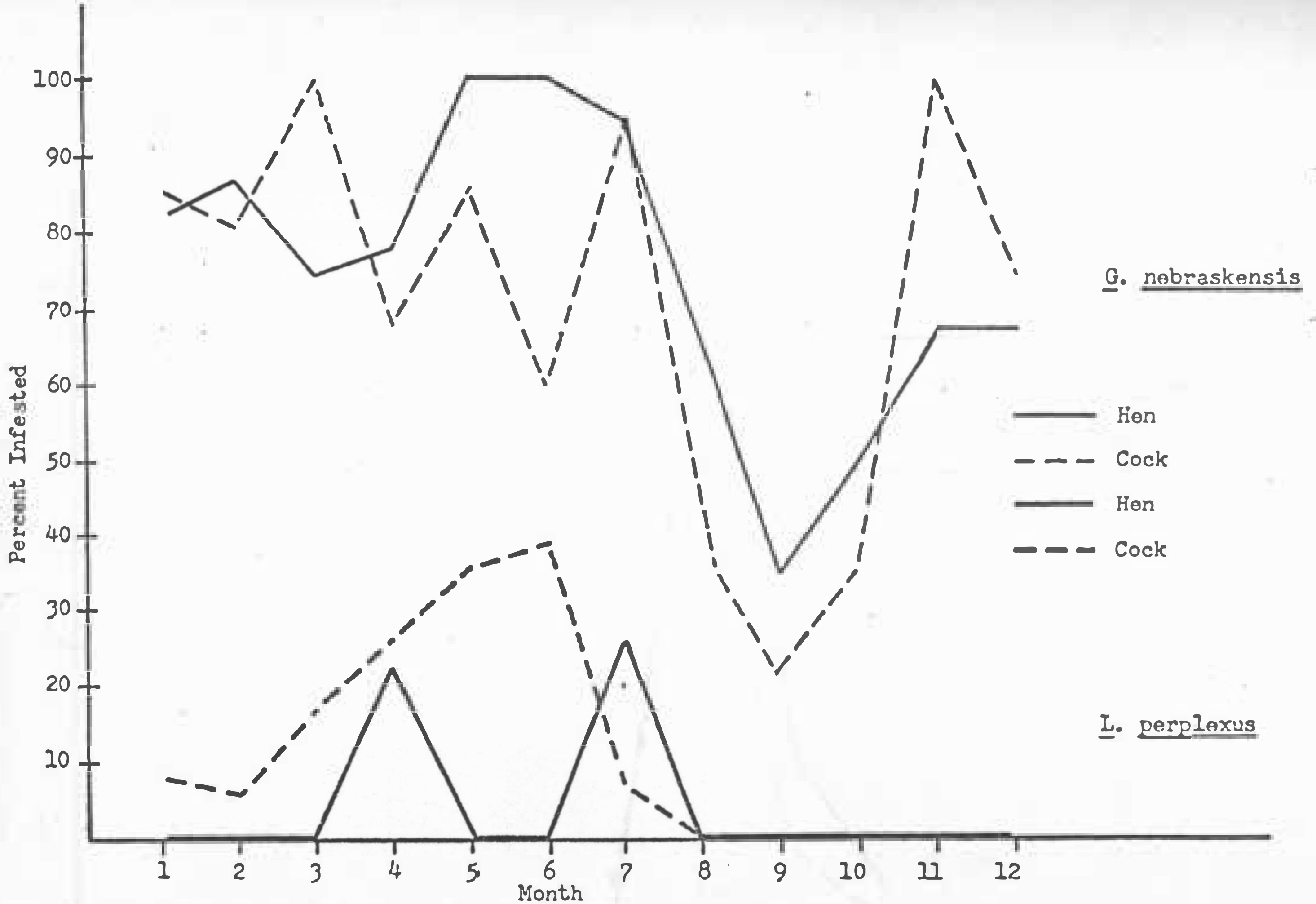


Fig. 16. Monthly infestation rates in percentages of Goniodes nebraskensis and Lagopoecus perplexus.

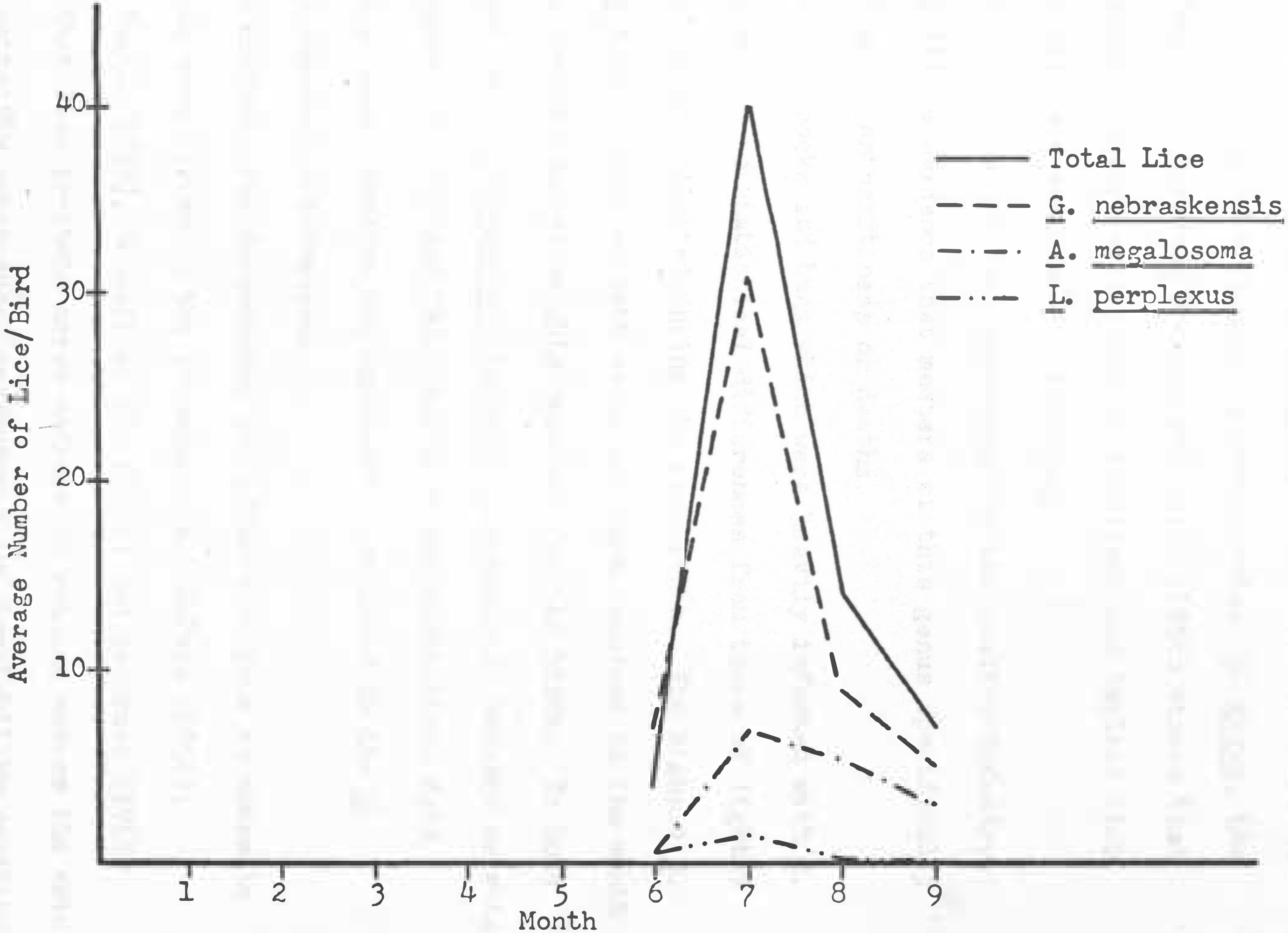


Fig. 17. Average louse infestation intensities on chicks per month - 1966-67.

collected in July (Table 7). During the months of July to September, 13 adult grouse were found with no adult lice but with small infestations of nymphs.

The effect of Goniodes nebraskensis on the host was difficult to assess. In looking at a closely related species, G. gigas, the large body louse of chickens, Roberts and Smith (1956) stated that only a few specimens were ever found on a chicken and implied that they were of little consequence to the bird.

Control of lice has been encouraged by the poultry industry, but there is little evidence that members of this genus specifically cause irritations, unthriftiness or deaths.

Weights of cocks and hens which were heavily infested with G. nebraskensis showed no statistical differences from those of lightly or uninfested birds collected during the same month. The highest G. nebraskensis infestations on both cocks and hens occurred in the month prior to the lowest average weights recorded for the birds. In both cocks and hens as G. nebraskensis infestations climbed, average weights of birds dropped (Fig. 58 and 59). Based on the statistical data presented, the weight decline was apparently unrelated to the G. nebraskensis population increases.

Other criteria for determining the effects of lice on domestic and wild birds were listed in the introduction. LaPage (1956), Roberts and Smith (1956), Metcalf et al. (1962) and Benbrook (1965) have stated that lice irritate nerve endings by running across the skin and that an unthrifty appearance, nervousness and irritability resulted

from heavy louse infestations. Therefore, host weight fluctuations are not the sole criteria for judging the effects of lice on the host. Direct observations were made of cocks, hens and chicks infested with Goniodes nebraskensis during this study. These birds did show behavior which was indicative of louse irritations. Birds carrying heavy infestations pecked, scratched and dusted themselves more vigorously than birds observed during months of low louse populations. Birds found later to be carrying only G. nebraskensis were more vigorous in this behavior than birds which were found uninfested or very lightly infested with other species.

Goniodes nebraskensis was found on grouse collected in each county sampled except Harding and Todd. It undoubtedly is found on sharptails throughout the South Dakota range. Comparisons were made on intensities of infestations among the four study areas. There were no significant differences in infestations between the areas on adults.

Differences in soil types, mean annual precipitation and temperatures between regions in the study area apparently showed no effect on G. nebraskensis populations on adult grouse.

Chicks collected from the eastern half of the study area carried a significantly higher burden of G. nebraskensis ($P < .025$) than the chicks from the western half. Comparisons between chicks collected in the north and south zones did not show a statistical difference.

There was no significant difference in G. nebraskensis infestations between years in chicks; however, there was in adults ($P < .025$). Adults in 1967 carried an average of 47.3 lice/bird more than birds in

1966. Adjusted mean infestations including all grouse regardless of sex and month collected were 33.6 lice/bird in 1966 and 80.9 lice/bird in 1967. This large difference was caused by increased numbers of heavily infested cocks collected in the 1967 sample. However, a general increase in lice was evident when these heavily infested cocks were removed from the 1967 sample.

There was too much variability in the numbers of this species on individual grouse to determine statistical differences between infestation rates on cocks and hens and infestation rates between months by least squares analysis. However, these differences were substantial and were indicated by a significant difference ($P < .05$) in the interaction between sex and months. These very obvious differences in cock and hen infestation levels and monthly fluctuations are shown in Fig. 15.

Statistical correlations were made between chick and adult weights and populations of this species. A very small negative correlation was present (-.32) between Goniodes nebraskensis numbers and chick weights. This would indicate that even the rather small infestations of this species on chicks had a negative effect on growth and weight gain. On adult grouse there were no correlations between total G. nebraskensis numbers and weights over the year. This showed that, when using weight as an indicator over the year, there was no negative effect on adults caused by the relatively low levels of this species. Infestations of 100 were considered moderate, and average

infestations topped this level in cocks during three months and in hens during only one month.

The following conclusions were made as a result of the data and observations collected regarding Goniodes nebraskensis and sharptail interactions. This species was found on more sharptails than any of the other lice. Cocks carried much heavier burdens of this species than hens (adjusted mean infestations, 94.5 in cocks vs. 59.6 in hens). Very distinct seasonal population fluctuations occurred in this species on both cocks and hens. This species fed on feather parts, skin debris and louse casts and egg shells. It usually was found on the feathers and was not often observed on the skin. This species was not associated with specific skin pathology but was associated with host behavior suggesting irritations caused by lice (dusting, scratching and preening). This species was not shown to directly cause weight losses in adult grouse. A slight negative correlation (-.32) was present between chick weights and G. nebraskensis infestations.

It was concluded that this species and its host have evolved a host-parasite relationship which has approached the ideal. Goniodes nebraskensis takes enough from the host to maintain its life cycle and yet does not seriously affect the health or reproductive ability of the host. Populations of this species on hens were low during breeding, egg laying, incubation and during the first critical weeks of brooding, which would minimize the effects of this species on reproductive success. Populations remained very low on grouse during the winter months when a loss of insulating capacity of feathers and

irritability of grouse could be expected to reach critical levels. Even though the incidence of this species was highest of the lice found, populations per bird remained relatively low compared with infestations of Amyrsidea megalosoma. There was no evidence to indicate increased predation on grouse infested with this louse species.

Bionomics of Amyrsidea megalosoma (Overgaard, 1943) (Fig. 18-26). The genus Amyrsidea was erected by Ewing (1927). Emerson (1964) listed seven species parasitic on North American hosts. Overgaard (1943) described Amyrsidea megalosoma as Menopon megalosomum from Perdix perdix and Phasianus colchicus collected in Denmark. Emerson (1961) designated a lectotype for A. megalosoma and reported conspecific specimens collected from various species of gallinaceous birds from North America. Measurements of 10 randomly selected specimens of each sex and stage are found in Table 8.

The eggs of this species were found around the base of the feathers in the upper ventral cervical tract and in very heavy infestations on the interramal tract, all in the head and throat region. Ova were cemented completely around the shaft from the superior umbilicus upward to one-half the length of the feather. Up to 137 ova were counted on one feather. The highest number of ova estimated on a heavily infested bird reached 22,800. This bird hosted 2,540 adult and immature A. megalosoma. Every feather in the throat area of heavily infested birds was used for oviposition. Empty egg shells and developing eggs were present on the feathers. These were commonly

Scale: 5.5 cm = 1 mm

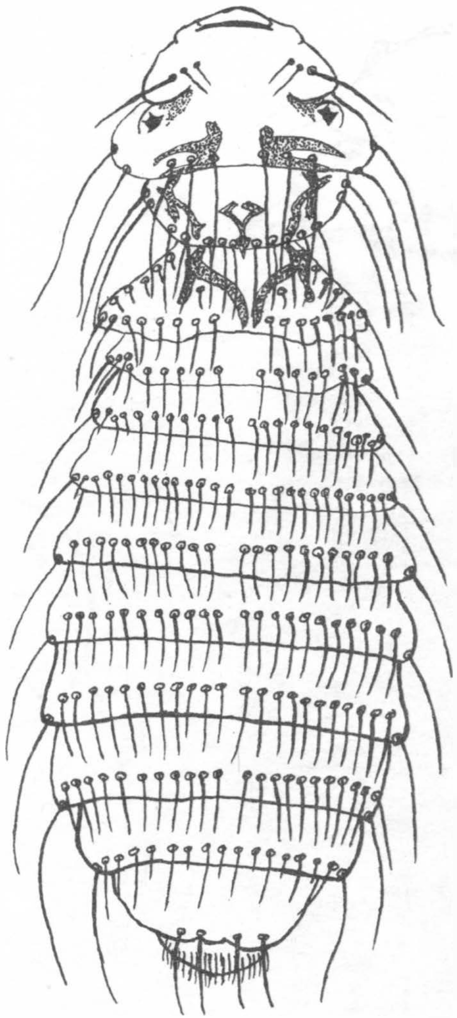


Fig. 18. Amyrsidea megalosoma female - dorsal.

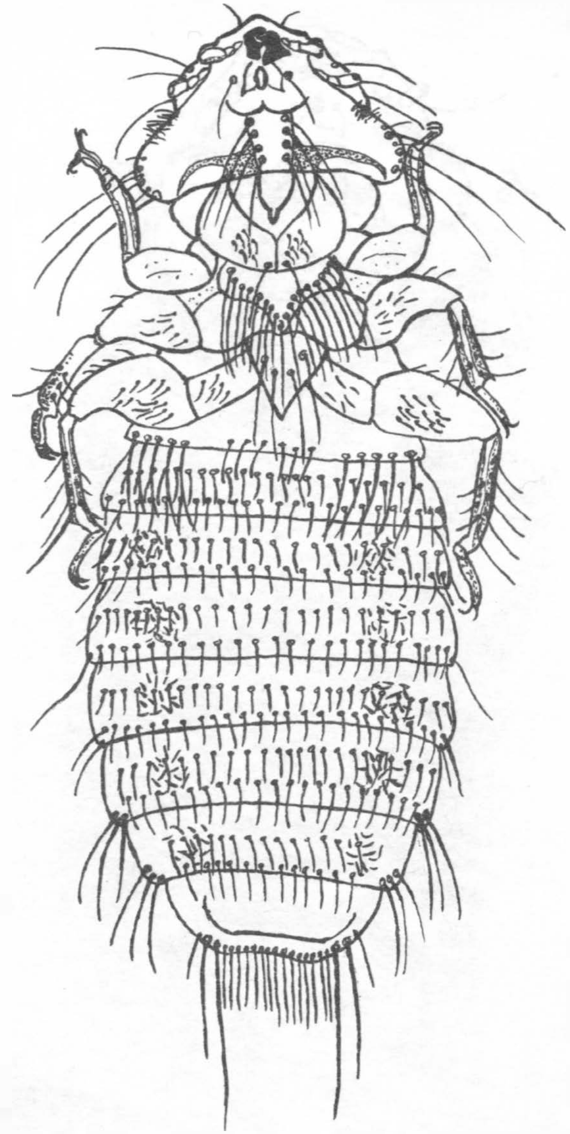


Fig. 19. Amyrsidea megalosoma female - ventral.

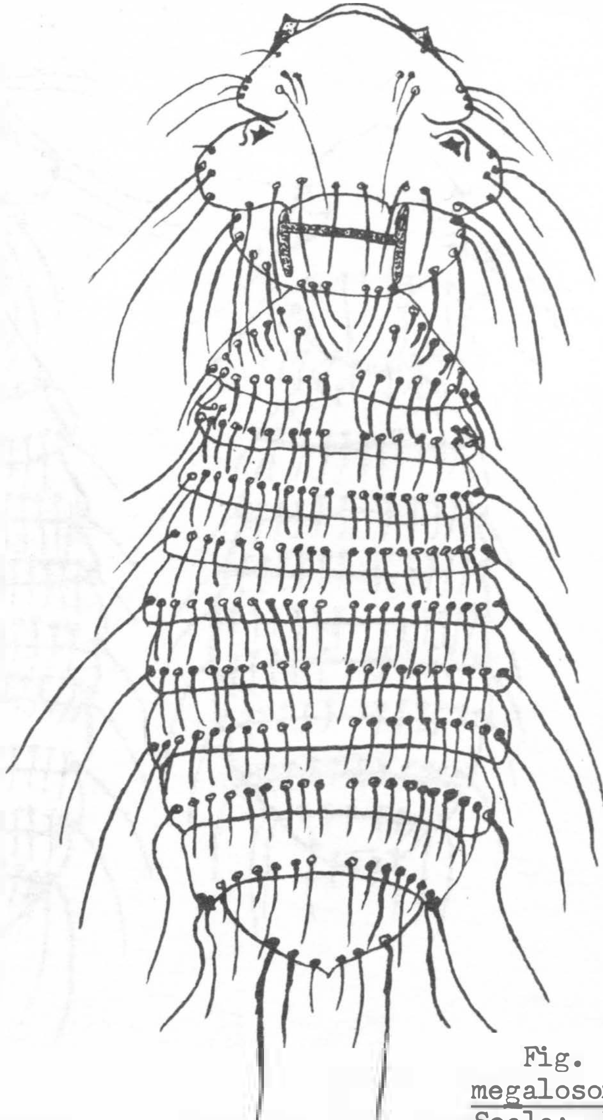


Fig. 20. *Amyrsidea megalosoma* male - dorsal.
Scale: 6.25 cm = 1 mm

Fig. 21. *Amyrsidea megalosoma* male genitalia.
Scale: 12 cm = 1 mm

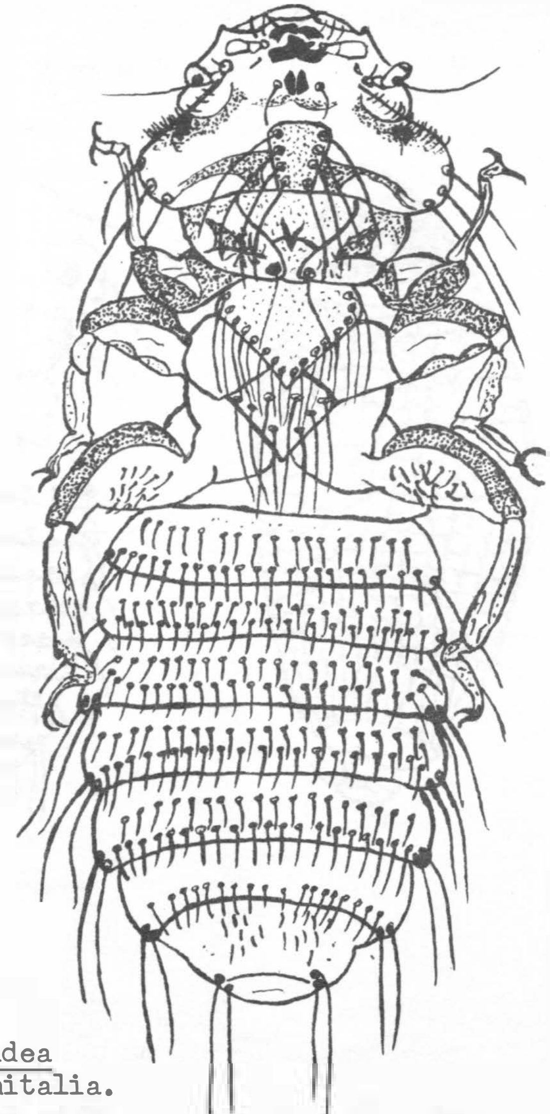


Fig. 22. *Amyrsidea megalosoma* male - ventral.
Scale: 6.25 cm = 1 mm

Scale: 7 cm = 1 mm

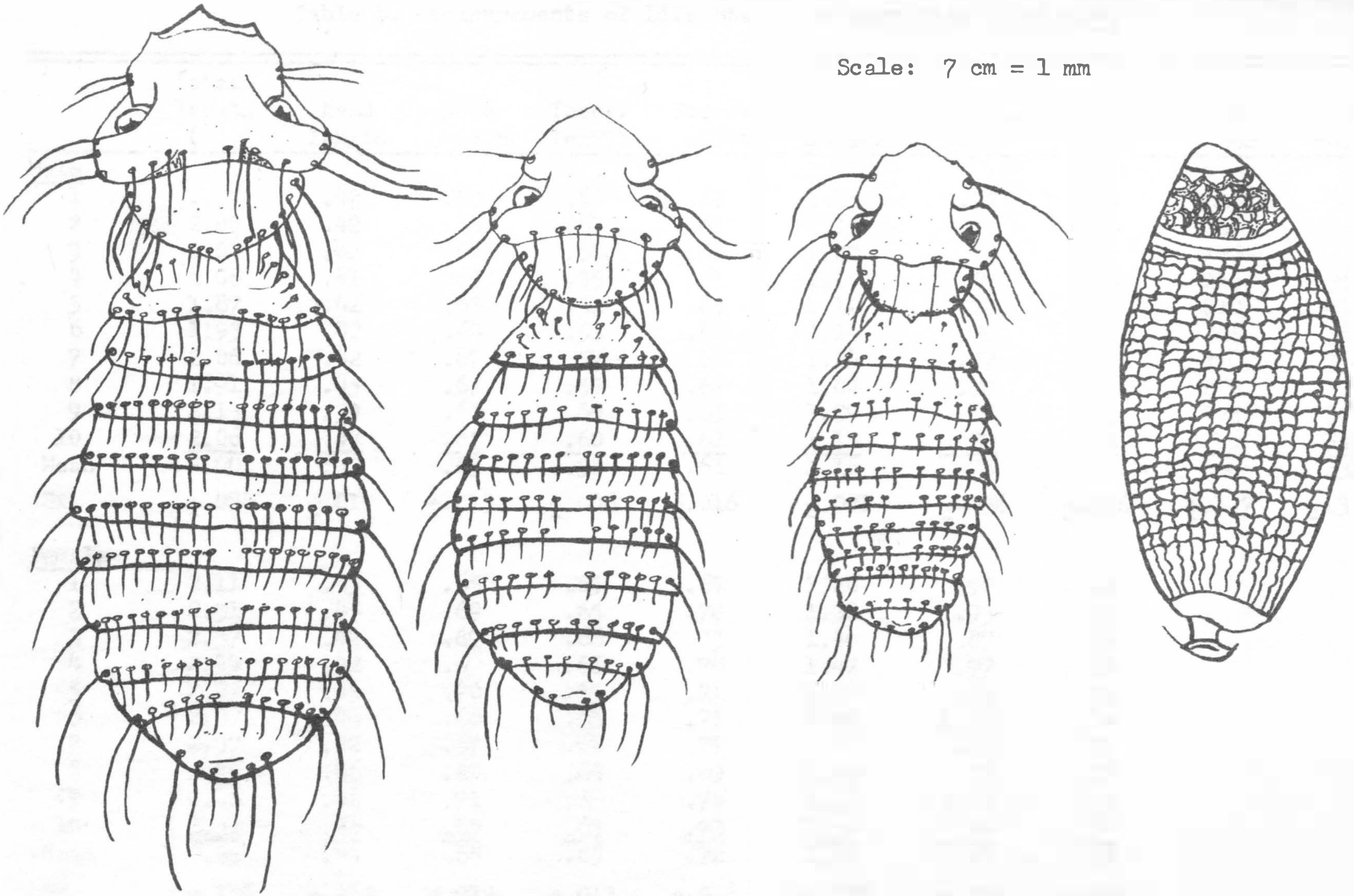


Fig. 23. 3rd stage. Fig. 24. 2nd stage. Fig. 25. 1st stage. Fig. 26. Ova.

Amyrsidea megalosoma nymphs and ova

Table 8. Measurements of Life Stages of *Amyrsidea megalosoma*

	Total length (mm)	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length	Para-meres	Endo-meres
Male										
1	1.98	.42	.63	.60	.60	1.15	.77	.14	225	348
2	2.00	.42	.65	.62	.60	1.10	.79	.14	281	322
3	2.04	.42	.64	.60	.60	1.20	.74	.14	236	332
4	2.06	.41	.65	.55	.61	1.15	.69	.14	242	360
5	1.87	.42	.63	.51	.62	1.10	.74	.12	270	349
6	1.93	.42	.64	.51	.60	1.14	.70	.11	225	342
7	2.06	.42	.67	.57	.62	1.24	.77	.16	270	320
8	1.91	.45	.67	.59	.62	1.04	.79	.15	270	337
9	2.13	.39	.65	.60	.65	1.29	.80	.15	292	360
10	2.06	.44	.65	.60	.62	1.15	.79	.12	290	349
Mean	2.00	.42	.65	.58	.61	1.16	.76	.14	260	332
S$\bar{x}$	±.084	±.019	±.013	±.006	±.016	±.081	±.036	±.016	±21.7	±13.0
Female										
1	2.11	.45	.65	.65	.69	1.20	.92	.12		
2	2.31	.45	.69	.65	.70	1.38	.93	.15		
3	2.37	.42	.69	.66	.73	1.44	.87	.14		
4	2.44	.42	.69	.65	.74	1.47	.97	.12		
5	2.27	.45	.70	.65	.71	1.28	.92	.15		
6	2.37	.46	.68	.65	.71	1.43	1.01	.14		
7	2.37	.42	.67	.61	.71	1.47	.97	.14		
8	2.46	.46	.67	.65	.69	1.52	.93	.14		
9	2.46	.42	.71	.65	.74	1.56	1.04	.15		
10	2.31	.46	.69	.65	.73	1.34	.94	.14		
Mean	2.35	.44	.68	.65	.72	1.41	.95	.14		
S$\bar{x}$	±.114	±.013	±.019	±.013	±.016	±.117	±.055	±.009		

Table 8 Continued

	Total length (mm)	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length	Para-meres	Endo-meres
3rd Stage Nymph										
1	1.70	.39	.55	.51	.54	.85	.65	.10		
2	1.76	.37	.54	.53	.54	.91	.65	.11		
3	1.77	.37	.59	.53	.52	.92	.60	.12		
4	1.62	.37	.53	.48	.47	.87	.56	.10		
5	1.75	.39	.59	.52	.53	.97	.60	.12		
6	1.66	.38	.54	.53	.51	.90	.57	.11		
7	1.77	.39	.58	.52	.55	.97	.63	.10		
8	1.59	.37	.54	.46	.51	.83	.60	.09		
9	1.75	.37	.55	.54	.51	.92	.67	.11		
10	1.93	.39	.56	.54	.55	1.10	.79	.13		
Mean	1.73	.38	.56	.52	.52	.92	.63	.11		
$S\bar{x}$	±.111	±.006	±.019	±.026	±.026	±.088	±.074	±.013		
2nd Stage Nymph										
1	1.20	.30	.48	.39	.42	.55	.49	.11		
2	1.20	.28	.41	.37	.42	.60	.47	.10		
3	1.39	.32	.48	.42	.42	.69	.42	.11		
4	1.38	.32	.49	.42	.42	.66	.44	.11		
5	1.34	.32	.46	.42	.42	.65	.47	.10		
6	1.44	.32	.48	.46	.44	.73	.47	.10		
7	1.43	.37	.46	.46	.48	.74	.54	.11		
8	1.31	.31	.46	.39	.47	.65	.51	.11		
9	1.42	.31	.46	.42	.42	.71	.54	.11		
10	1.24	.27	.39	.37	.35	.55	.42	.09		
Mean	1.34	.31	.46	.41	.43	.65	.48	.11		
$S\bar{x}$	±.078	±.032	±.032	±.029	±.042	±.062	±.039	±.006		

Table 8 Continued

	Total length (mm)	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length	Para-meres	Endo-meres
1st Stage Nymph										
1	1.15	.28	.38	.32	.32	.55	.37	.11		
2	1.01	.28	.38	.32	.31	.46	.32	.10		
3	1.06	.28	.43	.33	.32	.52	.42	.11		
4	1.10	.28	.40	.29	.32	.53	.35	.10		
5	1.10	.25	.36	.34	.32	.53	.44	.08		
6	1.06	.27	.37	.28	.31	.51	.44	.09		
7	1.04	.27	.37	.31	.32	.51	.33	.09		
8	1.02	.28	.41	.28	.33	.44	.33	.11		
9	1.01	.28	.39	.28	.37	.46	.37	.10		
10	1.02	.27	.39	.28	.37	.51	.31	.10		
Mean	1.06	.27	.39	.30	.33	.50	.37	.10		
$S\bar{x}$	±.046	±.009	±.019	±.019	±.019	±.036	±.042	±.009		
Ova		Total width								
1	1.01	.40								
2	1.00	.37								
3	.99	.45								
4	1.10	.51								
5	1.10	.51								
6	1.06	.49								
7	.97	.38								
8	.94	.34								
9	1.10	.52								
10	1.10	.51								
Mean	1.04	.45								
$S\bar{x}$	±.052	±.059								

found in external washes of infested birds. Amyrsidea megalosoma was not observed to use egg shells as food. Eggs of this species were found on hens four times during August to October when no lice were found. Amyrsidea megalosoma was found laying eggs on nine-week-old grouse.

Oviposition activity was observed on three occasions. Females crawled over eggs previously laid on a feather searching for an oviposition site. The egg was extruded by contractions of the abdomen, the nonoperculated end of the egg being covered with a sticky cement. This allowed the egg to stick in the crevass or to the shaft of the feather. The female appeared to hesitate a few seconds and then began to move upward away from the egg. Many females were observed with two maturing eggs in the abdomen.

Nymphs of this species were counted but not separated into stages. As with Goniodes nebraskensis, nymphs were found in the same body areas of the host as the adult lice. This species was found primarily on the skin. Materials found in the crops of adult and immature lice included skin debris, feather parts, blood and epidermal cells of the host. It was common to find light-colored immatures showing a bright red-colored gastrointestinal tract indicating blood had been consumed. Both adult and immature lice were observed feeding on blood.

Immature lice were first found on three-week-old birds. One adult louse was present for each 1.5 immatures on the average over the year (Table 5).

Adult and immature lice were found on adult grouse collected during each month of 1966-67. There was a very pronounced difference between infestation levels on cocks and hens. Cock infestations during the months of July to March averaged 4.3 lice, with 0.1/bird in August. No lice were collected in September. The dramatic increase in louse populations occurred in *Amyrsidea megalosoma* in April (Table 7). Peak populations occurred in June and averaged 570.8 lice/bird. The population declined sharply from 570.8 in June to 12.0 lice/bird in July. Since only 77% of cocks were infested during June, infested cocks carried average densities of 737 lice/cock (Fig. 27 and 28).

Infestations on hens were much lower than those of cocks. Hens collected in October, January and February were not infested with adult or immature lice. During all other months, except June, average infestations on hens were less than 1 louse/hen. During June, infestations averaged 90.2 lice/bird.

Adults were observed on the skin and in the feathers over the entire body. They preferred the skin of the breast and legs and were observed commonly on the apterous areas of the body. When disturbed, the adults and immatures crawled off quickly into the adjoining feather-covered areas. This species was much more active than any other found on the sharptail. When under observation, they moved continuously on the skin.

This species commonly crawled on the hands of handlers of live and dead grouse. It was also active and moved continuously when off the host. Lice migrated from dead, cooling hosts by moving to the

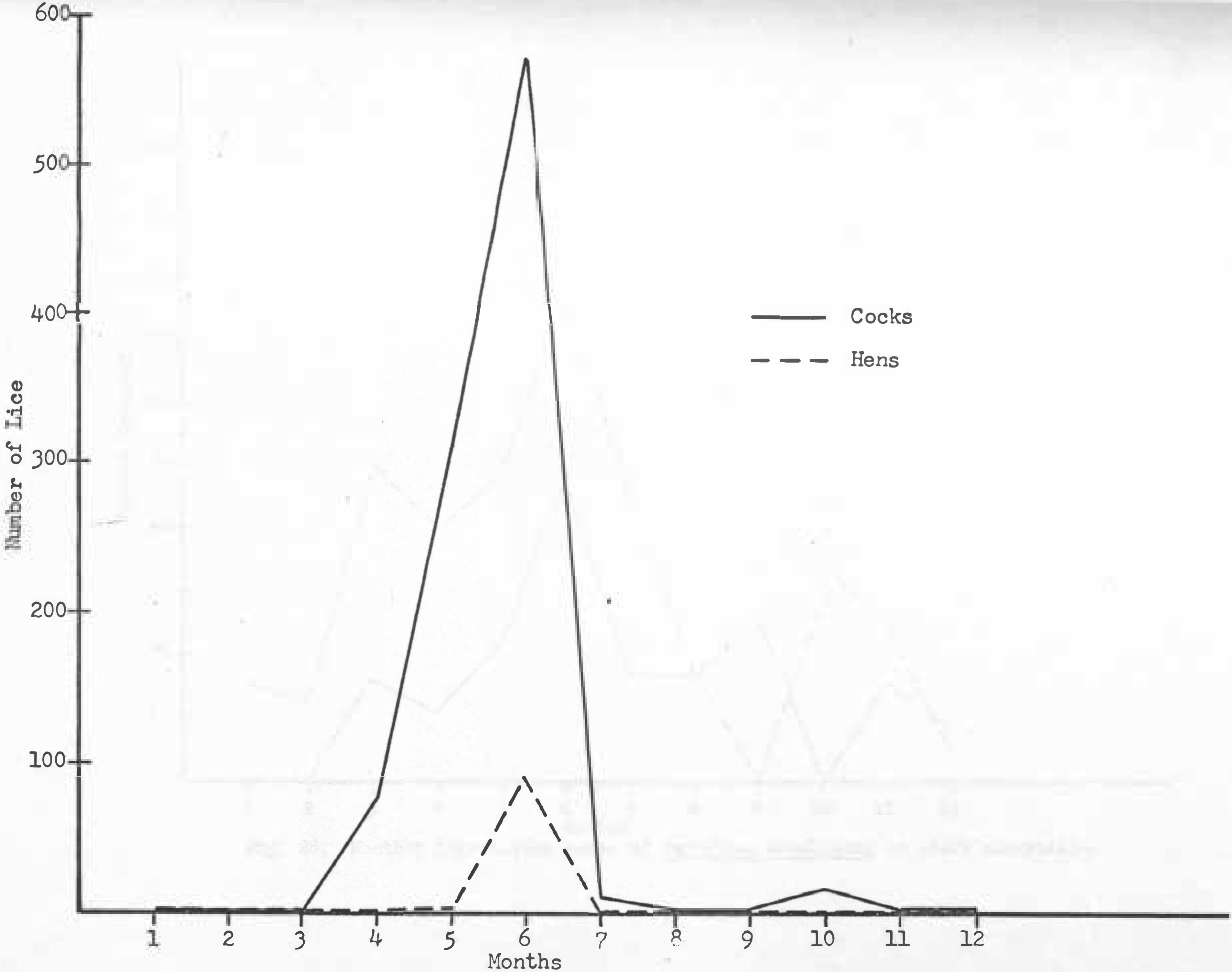


Fig. 27. Average *Amyrsidea megalosoma* infestations per month on adult grouse.

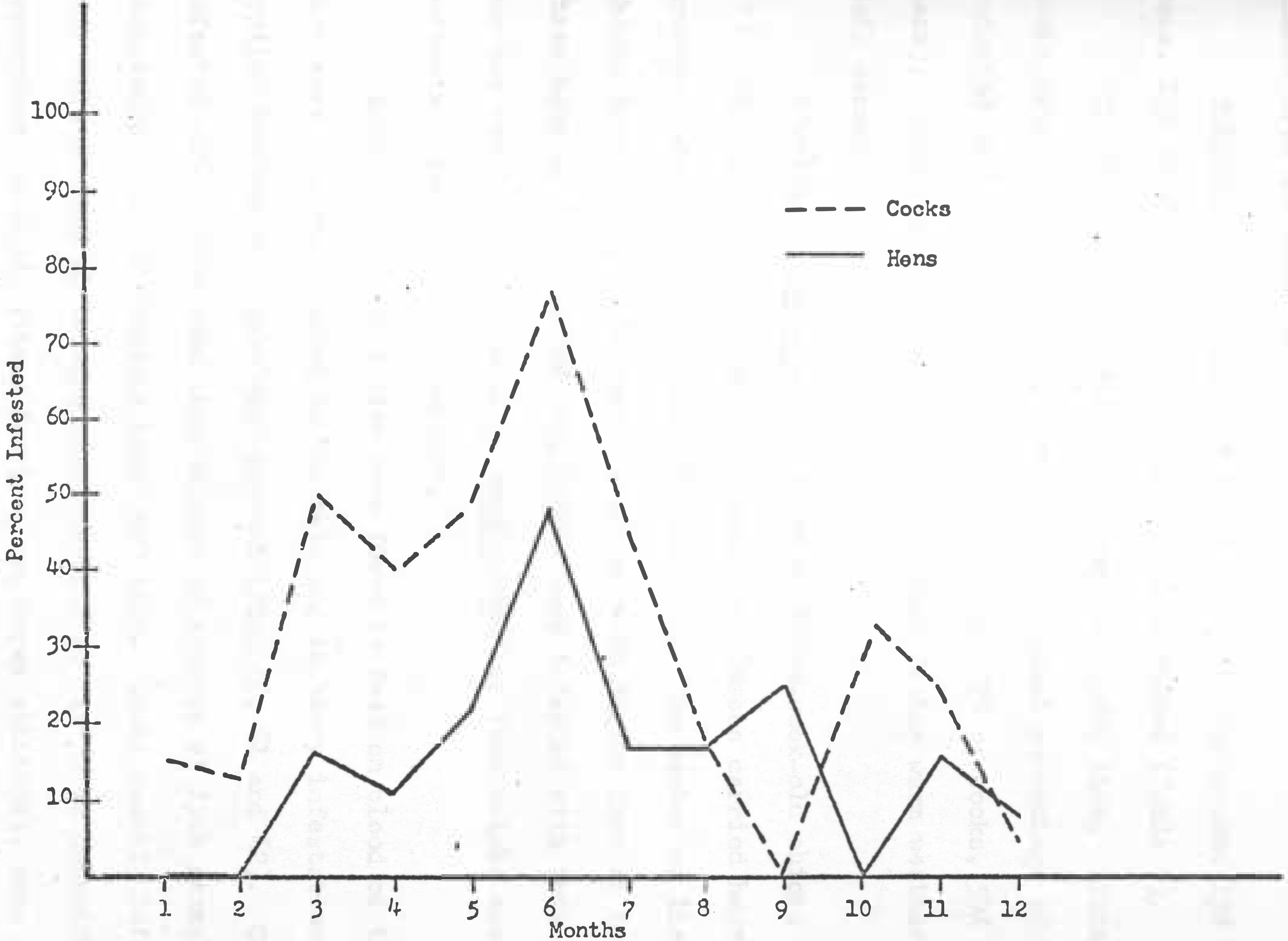


Fig. 28. Monthly infestation rates of Amyrsidea megalosoma on adult sharptails.

head of the bird and dropping off into the vegetation. On one occasion they crawled to the hand of the author which was placed about six inches from the dead birds.

Amyrsidea megalosoma was found on 21% of the cocks, 15% of hens, 19% of chicks and 19% of all grouse surveyed (Table 7).

The highest infestation on a cock was 3,072 lice. Sixteen cocks carried over 1,000 specimens. The highest percentage of grouse infested with this species occurred in June (77% of cocks, 50% of hens). Infestation percentages were higher during warm weather on both sexes.

Amyrsidea megalosoma was found on three-week-old chicks (Fig. 17). Chicks in the five and nine week age classes carried heaviest average infestations of 66 and 76 lice/bird. The number of lice on chicks during July to September averaged much higher than on hens. Three hens of 13 collected with broods were infested with this species. One hen was infested with 12 A. megalosoma; her four chicks each hosted an average of 21 lice/bird.

Adult and immature lice were found to feed on blood of the host. They were observed gnawing on the skin and in heavy infestations typical lesions and scabs were present (Fig. 60, 61 and 62). Cocks infested with 500 or more lice weighed an average of 15.4 grams less than cocks with infestations below 500 lice. Cocks heavily infested with this species alone were characterized as having an unthrifty appearance (stained, frizzy feathers and mopey attitude), were seen pecking themselves, scratching themselves frequently and vigorously

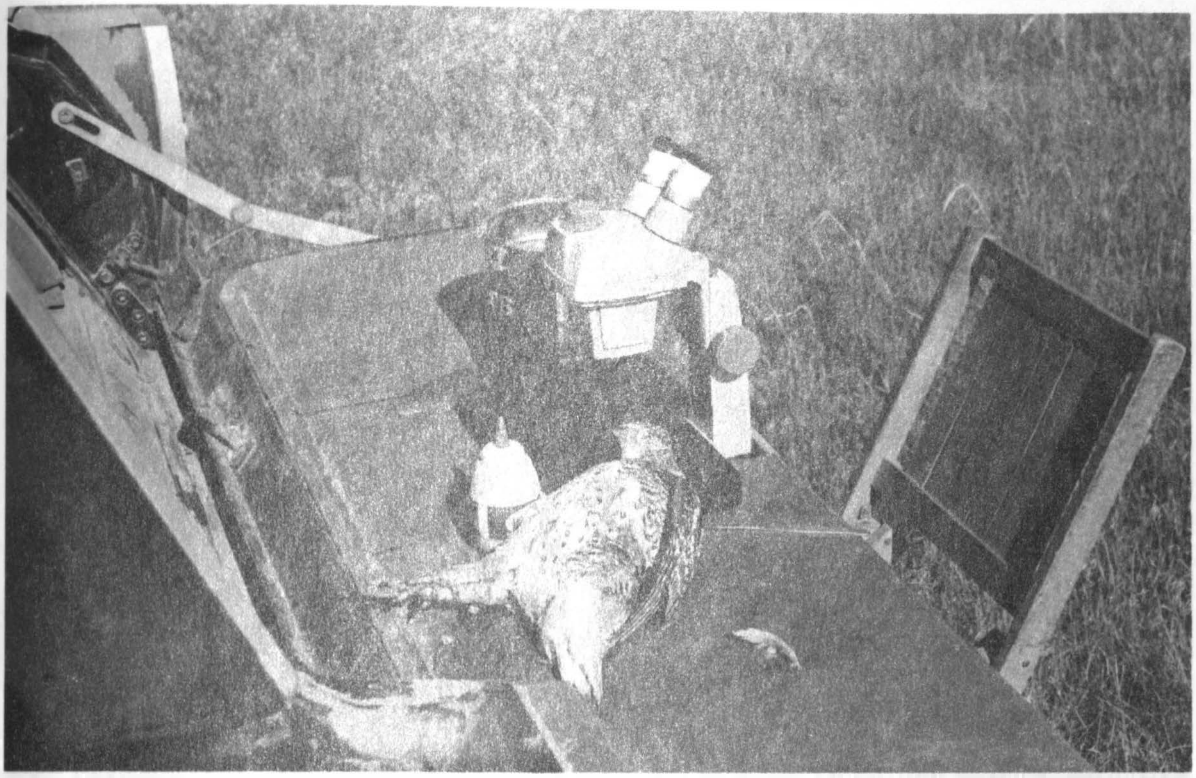


Figure 60. Field examination laboratory.

Figure 61. Examination of lice removed from freshly killed grouse.

Figure 62. Lesions and denuded areas on cock infested with Amyrsidea megalosoma (left) compared with cock heavily infested with Goniodes nebraskensis (right). Bird on the left shows three large denuded areas. Note large crusty lesion at the base of the bill. The cock on the right bears no featherless areas or skin lesions.

and were observed dusting vigorously. This intense behavior was generally in contrast to cocks with infestations of other lice or very light infestations.

Damage as described by Crutchfield and Hixson (1943) to chickens by Menocanthus stramineus was found in heavy Amyrsidea megalosoma infestations of cocks. Because of the very low levels of infestation and small percentage of hens infested with this species, it was concluded that it had little effect on the reproductive potential of sharptails.

Many cocks infested with this louse carried yellow and reddish, crusted lesions on the brow patch, chin, throat, apterous body regions and areas denuded of feathers by louse feeding. Lesions were observed on approximately one-third of the dancing cocks infested with A. megalosoma. Hyphae and microspores from these lesions were found to be Trichophyton mentagrophytes, which causes athlete's foot in humans (Knudtson et al., 1969). This was the first record of this fungus on a wild or domestic fowl. Typical lesions were again seen on dancing cocks in May and June of 1968 and 1970, all of which were infested with A. megalosoma. Trichophyton mentagrophytes was again isolated from these lesions, confirming the earlier findings. These lesions were not observed on birds which were infested with any of the other louse species alone. Microspores and hyphae were observed entangled in the setae of A. megalosoma.

This louse was collected from grouse in all parts of the study area, including Harding County. Least squares analysis of variance was completed on data on this species. There was no significant difference between infestations among the different areas in either adults or chicks. There was too much individual variation in infestations of this species to obtain valid inferences with the least squares analysis with regard to differences between cocks and hens and months and years. However, very distinct differences occurred between months and sexes (Table 7). A statistical difference was present in chick infestations ($P > .05$) between 1966 and 1967.

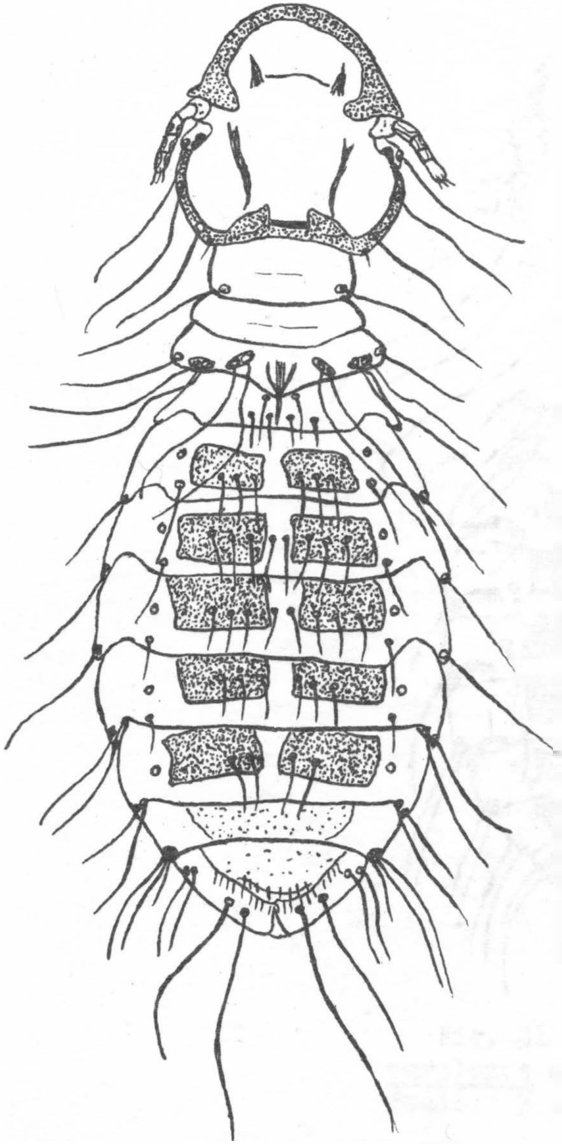
Correlations were calculated between total weights of adults and total Amyrsidea megalosoma numbers. No correlation was present, indicating that A. megalosoma had little effect on adult weights. A slight negative correlation was present between chick weights and A. megalosoma numbers (-.11), indicating a slight negative effect on growth and weight gain.

The following are conclusions regarding Amyrsidea megalosoma and sharptail interactions. This species was the second most prevalent louse on sharptails. Populations reached higher numbers than any of the other lice found on sharptails. Cocks were much more heavily infested than hens (570.8 vs. 90.2 lice/bird during June, the month of heaviest infestations). Very distinct seasonal population fluctuations occurred in this louse with high populations occurring during spring and early summer.

This louse ate blood, epidermal cells and feather parts of grouse. Adults and immatures were found primarily on the skin. It was associated with *Trichophyton mentagrophytes* infections. Adults and immatures were observed gnawing on skin and feathers. Heavily infested birds expressed a very unthrifty general appearance as a result of the feeding of this species. Cocks infested with only this ectoparasite were very seriously irritated by this louse as expressed by scratching, dusting and nervous behavior.

Infestations on hens were so low and percentage of incidence so small that the species was concluded to have little effect on egg production or health of the hens. A slight negative correlation (-.11) was present between chick weights and *Amyrsidea megalosoma* infestations. This would indicate its blood eating habits and constant movements on the skin of chicks are irritating even in light infestations. Heavily infested cocks weighed an average of 15.4 grams less than lightly or uninfested cocks.

Bionomics of Lagopoecus perplexus (Kellogg and Chapman, 1899) (Fig. 29-37). Kellogg and Chapman (1899) described this species from female specimens collected on the Columbian sharptail, *Pediocetes phasianellus columbianus.* Emerson (1950b) examined specimens from the Columbian sharp-tailed grouse from Pullman, Washington, and the northern sharp-tailed grouse from Kirkland, Ontario. Emerson (1962) listed nine species of *Lagopoecus* on North American hosts. Three other species, *L. gibsoni, L. colchicus* and a new species, have been collected from other gallinaceous hosts in South Dakota.



Scale: 6 cm = 1 mm

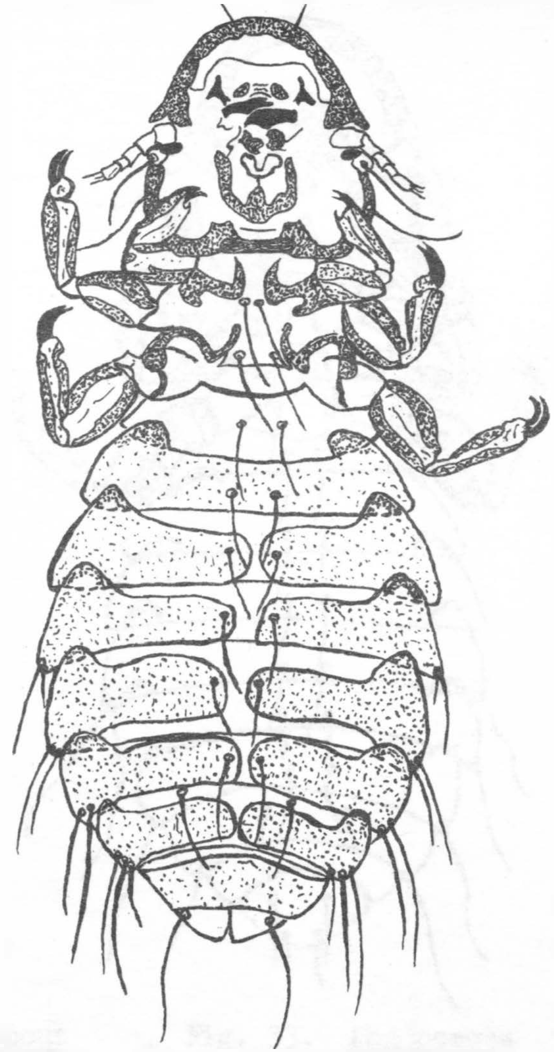


Fig. 29. Lagopoecus perplexus female - dorsal.

Fig. 30. Lagopoecus perplexus female - ventral.

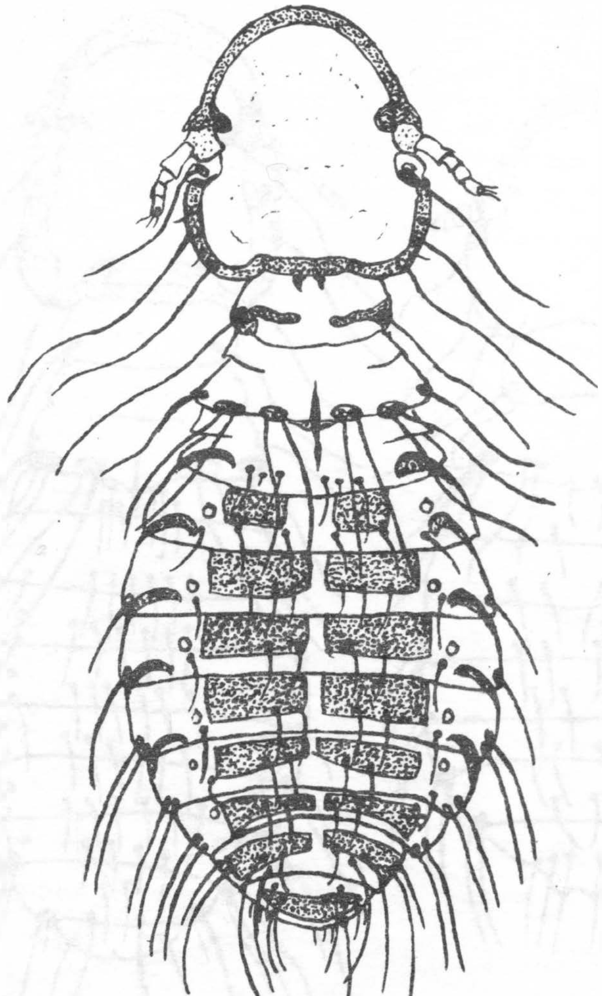


Fig. 31. Lagopoecus perplexus male - dorsal. Scale: 7 cm = 1 mm

Fig. 32. Lagopoecus perplexus male genitalia. Scale: 16 cm = 1 mm

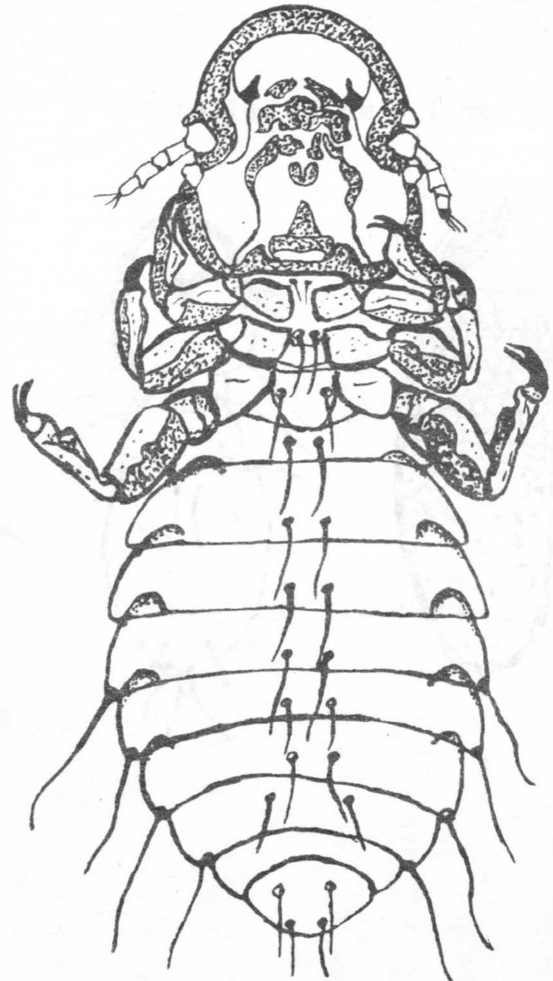


Fig. 33. Lagopoecus perplexus male - ventral. Scale: 7 cm = 1 mm

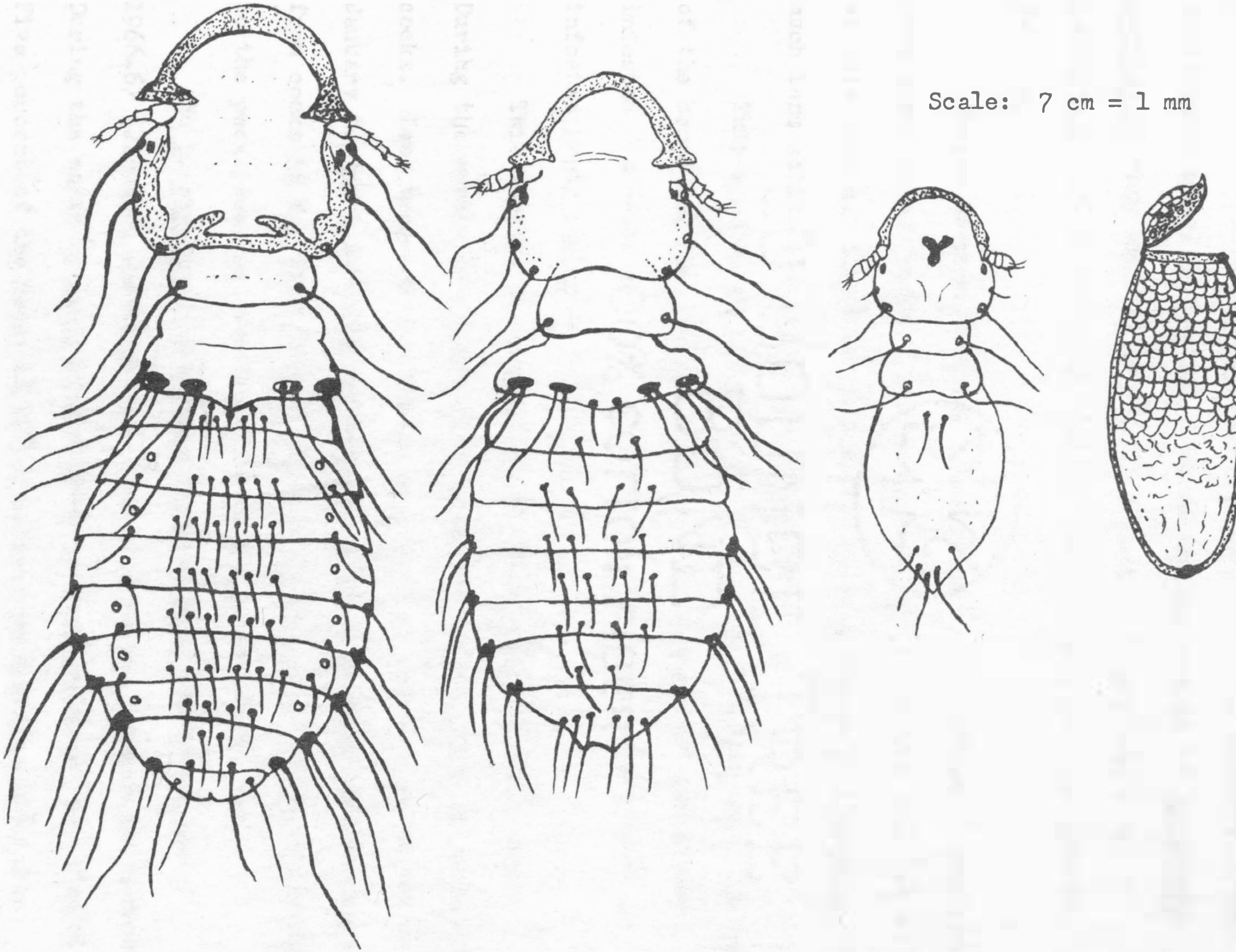


Fig. 34. 3rd stage. Fig. 35. 2nd stage. Fig. 36. 1st stage. Fig. 37. Ova.

Lagopoecus perplexus nymphs and ova

Since neither Kellogg and Chapman (1899) nor Emerson (1950b) included drawings of the male, ova or nymphal stages of *Lagopoecus perplexus*, they are included in this paper. Measurements of 10 individuals of the adult and immature life stages are included in Table 9.

Nymphs were counted but not separated into instars. Immatures were observed on feathers of the capital and dorsal cervical tracts as were adults. They were more active than *Goniodes nebraskensis* but much less active than *Amyrsidea megalosoma*.

This species was first found on four-week-old grouse. The hen of the brood was free of this species. Six percent of chicks were infested. A ratio of 1 male to 2 females to 6 nymphs was found on infested hosts (Table 5, Fig. 17).

This species had a very spotty distribution on both sexes. During the months of September to December, no lice were collected from cocks. Less than one louse/bird was found on cocks collected during January to April and July and August. Highest numbers were collected from cocks in May (14.0/bird) and June (4.6/bird). This corresponded to the peak breeding activity of cocks (Fig. 16 and 38, Table 7).

No *L. perplexus* were found on hens during seven months of 1966-67 (January, February, May, June, September, October and December). During the month of July, infestations on hens peaked at 2.2 lice/bird. Five percent of the hens and 19% of cocks were infested with this species. Forty-one lice was the heaviest infestation observed on a hen.

Table 9. Measurements of Life Stages of *Lagopoecus perplexus*

	Total length	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length	Paramere length	Endomere length
Male										
1	1.62	.49	.44	.37	.42	.90	.67	.21	.08	.30
2	1.60	.48	.44	.35	.42	.92	.67	.23	.07	.27
3	1.69	.51	.46	.37	.42	.97	.69	.23	.07	.33
4	1.76	.52	.47	.36	.46	.99	.70	.23	.07	.28
5	1.65	.51	.44	.33	.43	.99	.69	.23	.06	.25
6	1.78	.53	.48	.39	.48	1.10	.75	.23	.07	.28
7	1.71	.51	.47	.35	.42	.95	.65	.25	.06	.32
8	1.80	.52	.47	.37	.44	1.04	.70	.23	.06	.33
9	1.81	.51	.48	.37	.42	1.05	.65	.25	.06	.29
10	1.71	.51	.48	.37	.42	.99	.69	.24	.07	.31
Mean	1.71	.51	.46	.36	.43	.99	.69	.23	.067	.296
$S\bar{x}$	±.068	±.016	±.013	±.019	±.019	±.065	±.032	±.013	±.006	±.019
Female										
1	2.13	.57	.53	.46	.51	1.27	.83	.23		
2	2.04	.55	.51	.40	.51	1.22	.83	.23		
3	2.13	.58	.52	.42	.51	1.26	.90	.21		
4	2.09	.57	.51	.42	.51	1.28	.87	.24		
5	2.11	.56	.53	.42	.51	1.26	.81	.23		
6	2.00	.55	.49	.42	.48	1.21	.79	.21		
7	2.02	.55	.51	.42	.48	1.20	.81	.22		
8	1.98	.55	.51	.39	.47	1.22	.71	.24		
9	2.14	.59	.53	.42	.50	1.26	.82	.28		
10	2.04	.55	.52	.46	.51	1.15	.75	.28		
Mean	2.07	.56	.52	.42	.50	1.23	.81	.24		
$S\bar{x}$	±.052	±.013	±.013	±.022	±.013	±.042	±.062	±.022		

Table 9 Continued

	Total length	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length	Para-mere length	Endo-mere length
3rd Stage Nymph										
1	1.65	.49	.46	.34	.42	.93	.73	.19		
2	1.60	.47	.46	.36	.46	.97	.73	.18		
3	1.54	.46	.44	.32	.42	.91	.63	.20		
4	1.65	.47	.46	.34	.44	.97	.74	.18		
5	1.56	.48	.46	.33	.44	.92	.68	.19		
6	1.54	.46	.46	.33	.42	.92	.68	.18		
7	1.76	.55	.51	.42	.50	.94	.67	--		
8	1.65	.51	.51	.34	.42	.92	.73	.20		
9	1.78	.59	.51	.42	.46	1.06	.64	.23		
10	1.59	.46	.45	.33	.42	.92	.65	.18		
Mean	1.63	.49	.47	.35	.44	.95	.69	.19		
$S\bar{x}$	±.078	±.042	±.023	±.013	±.026	±.049	±.035	±.016		
2nd Stage Nymph										
1	1.62	.49	.42	.32	.38	.79	.41	.16		
2	1.37	.46	.42	.32	.38	.76	.49	.19		
3	1.25	.47	.42	.37	.40	.55	.49	.18		
4	1.25	.38	.45	.28	.32	.74	.44	.16		
5	1.21	.37	.36	.23	.32	.67	.53	.16		
6	1.29	.46	.42	.32	.38	.60	.48	.18		
7	1.21	.37	.36	.25	.31	.65	.46	.16		
8	1.10	.35	.34	.28	.32	.60	.46	.15		
9	1.11	.37	.34	.23	.29	.60	.41	.14		
10	1.38	.46	.42	.31	.34	.74	.37	.18		
Mean	1.27	.42	.40	.29	.34	.67	.45	.17		
$S\bar{x}$	±.019	±.045	±.035	±.045	±.035	±.078	±.052	±.016		

Table 9 Continued

	Total length	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length	Paramere length	Endomere length
1st Stage Nymph										
1	.87	.29	.28	.21	.23	.42	.29	.12		
2	.88	.30	.28	.18	.25	.46	.28	.12		
3	.81	.30	.29	.18	.21	.38	.28	.12		
4	.82	.29	.28	.22	.23	.37	.28	.09		
5	.81	.29	.28	.18	.23	.40	.31	.12		
6	.78	.29	.28	.21	.23	.34	.31	.09		
7	1.06	.37	.33	.20	.29	.57	.32	.14		
8	.99	.37	.34	.23	.29	.46	.37	.14		
9	.83	.29	.29	.16	.23	.42	.28	.09		
10	1.01	.29	.28	.18	.24	.52	.34	.14		
Mean	.89	.31	.29	.20	.24	.43	.31	.12		
$S\bar{x}$	±.091	±.026	±.019	±.023	±.026	±.075	±.029	±.016		
Ova		Total width								
1	.82	.29								
2	.70	.29								
3	.65	.25								
4	.87	.35								
5	.73	.28								
6	.83	.29								
7	.79	.32								
8	.77	.24								
Mean	.77	.29								
$S\bar{x}$	±.071	±.036								

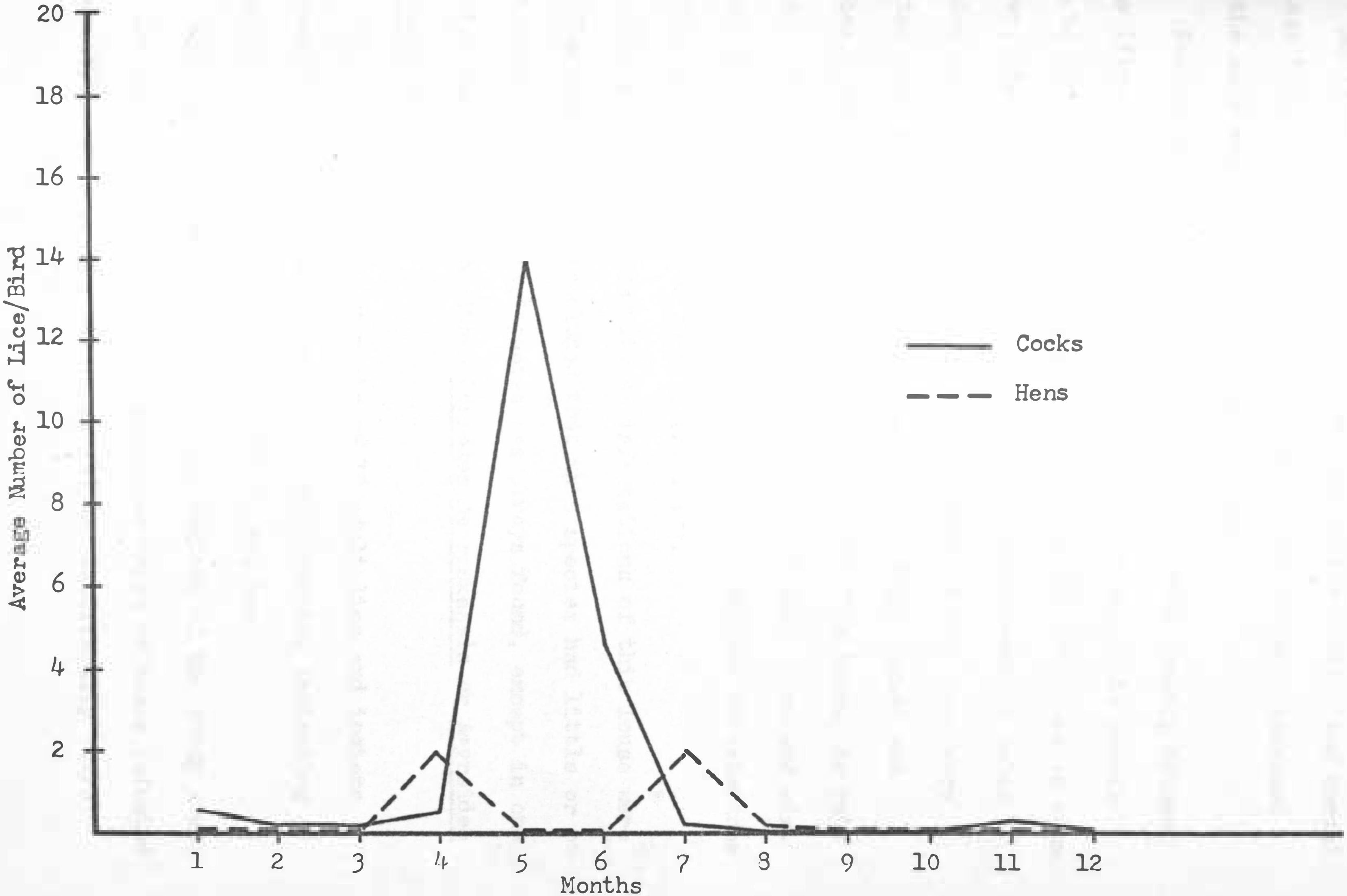


Fig. 38. Average *Lagopoecus perplexus* infestations per month on adult grouse.

Adult lice occurred on the feathers of the capital and dorsal cervical tracts. The lice moved from the crown feathers backward onto the skin and feathers of the upper neck.

Percentage of infested cocks and hens varied greatly between months (Fig. 16). The number of cocks infested with this species began to increase in March, reaching a peak of 39% incidence in June. However, the number of lice on the infested birds remained below one/bird until June when it rose to an average of 14. Hens were infested with lice during four months, April, July, August and November. Cocks were infested at approximately five times the rate of hens. This species occurred on 6% of the chicks. Five and six-week-old chicks carried heaviest infestations. Highest infestations on chicks and hens occurred in July (Fig. 17).

The percent and intensity of infestations of this louse were low. Therefore, it was concluded that this species had little or no effect on the grouse. This species was always found, except in one case, in combination with either *Goniodes nebraskensis* or *Amyrsidea megalosoma* or both.

The contents of the stomachs of 10 adult lice and instars contained feather barbs and barbules and skin debris, indicating feeding did not cause serious irritation to the host.

This species was found in all four regions of the study area. Since the numbers of lice were low and percentages of hosts infested were small, least squares analysis showed no statistically valid

differences in all comparisons except in infestations on chicks between years ($P < .05$).

Correlations were made between weights of chicks and adults with Lagopoecus perplexus. They were zero. There was no indication of negative effects on weights or health of either chicks or adults.

Bionomics of Goniocotes chrysocephalus (Fig. 39-47). This species was found on four cocks collected during May of 1966 and 1967 in Lyman County, South Dakota. These infestations were 308, 246, 33 and 3. On three cocks reproduction of the louse was evident. Oviposition sites were not found, but ova were recovered from external washes and all stages of nymphs were present. No observations were made on live lice. This species is closely related to Goniocotes gallinae, a cosmopolitan parasite of chickens.

No specific damage was associated with this species. Crops of 10 adult lice contained feather barbules and skin debris. It was obviously not important to any more than a few individual birds, since it was recovered from less than 1.0% of the cocks examined. Table 10 lists the measurements of 10 randomly selected lice of each life stage. This species was also collected from the greater prairie chicken from Lyman County and three ring-necked pheasants in Brookings County, South Dakota, during this study.

Scale: 7 cm = 1 mm

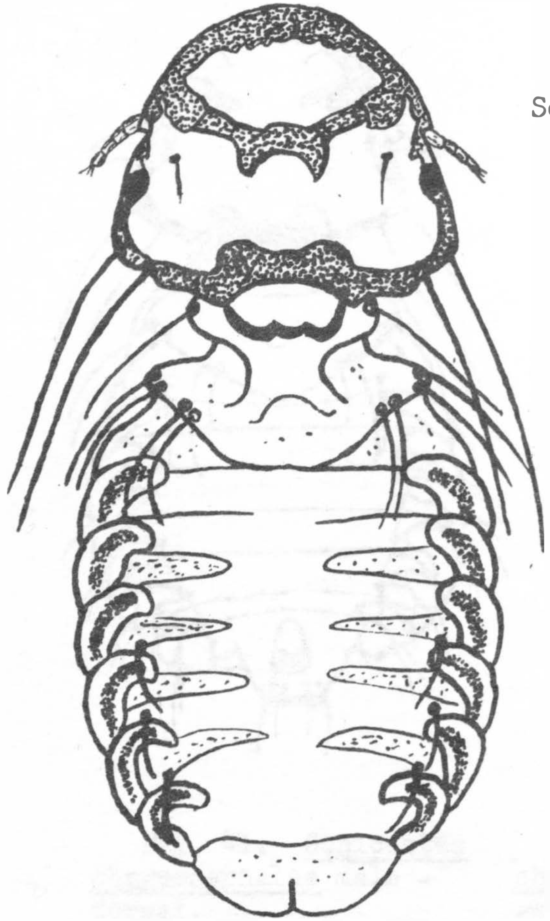


Fig. 39. Goniocotes chrysocephalus female - dorsal.

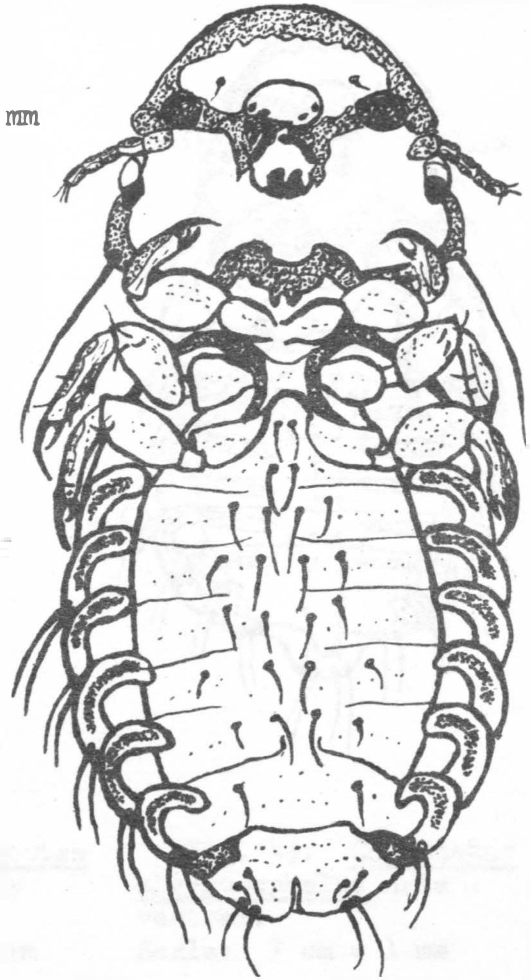


Fig. 40. Goniocotes chrysocephalus female - ventral.

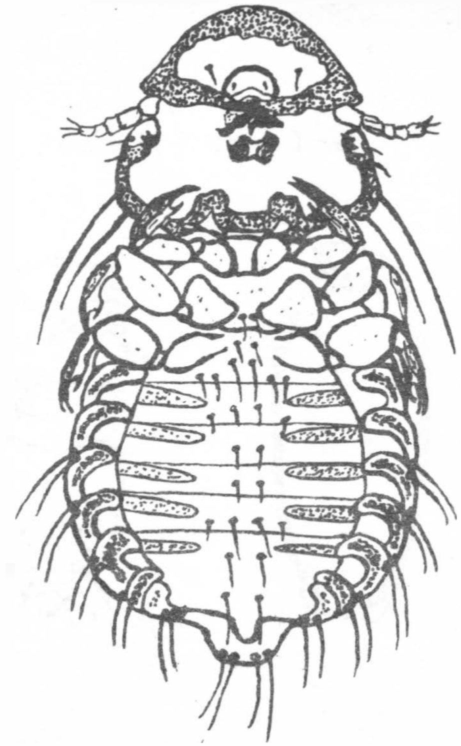


Fig. 41. *Goniocotes chrysocephalus* male - dorsal.
Scale: 7 cm = 1 mm

Fig. 42. *Goniocotes chrysocephalus* male genitalia.
Scale: 16 cm = 1 mm

Fig. 43. *Goniocotes chrysocephalus* male - ventral.
Scale: 7 cm = 1 mm

Scale: 7 cm = 1 mm

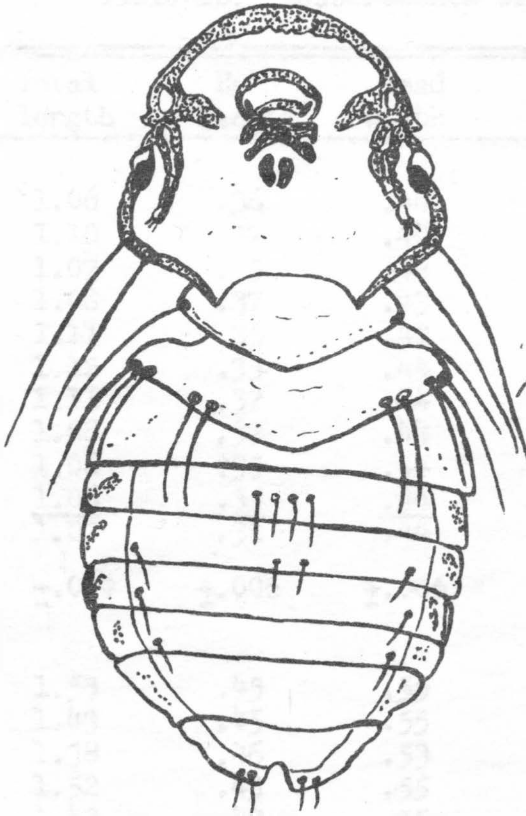
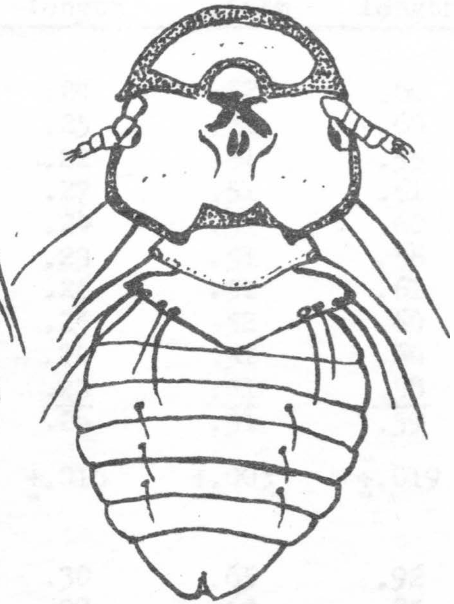
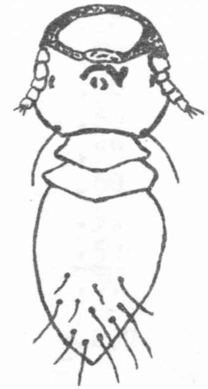
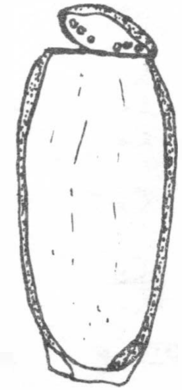





Fig. 44. 3rd stage. Fig. 45. 2nd stage. Fig. 46. 1st stage. Fig. 47. Ova.

Goniocotes chrysocephalus nymphs and ova

Table 10. Measurements of Life Stages of *Goniocotes chrysocephalus*

	Total length	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length	Aedeagus length
Male									
1	1.06	.36	.44	.24	.52	.60	.60	.16	.34
2	1.10	.37	.44	.25	.51	.60	.61	.16	.34
3	1.07	.35	.42	.22	.51	.55	.58	.17	.32
4	1.08	.37	.43	.27	.51	.61	.58	.16	.32
5	1.11	.35	.42	.24	.51	.60	.60	.16	.33
6	1.12	.35	.44	.23	.51	.56	.60	.16	.38
7	1.11	.37	.44	.26	.52	.61	.58	.17	.35
8	1.08	.37	.44	.25	.52	.60	.60	.15	.34
9	1.06	.35	.44	.24	.51	.60	.59	.16	.35
10	1.06	.35	.44	.23	.51	.58	.59	.16	.36
Mean	1.09	.36	.44	.24	.51	.59	.59	.16	.34
$S\bar{x}$	±.019	±.006	±.006	±.016	±.003	±.019	±.097	±.006	±.019
Female									
1	1.53	.45	.55	.30	.65	.92	.84	.18	
2	1.43	.45	.55	.28	.60	.85	.72	.18	
3	1.38	.46	.53	.30	.60	.83	.71	.18	
4	1.52	.43	.55	.25	.62	.89	.74	.18	
5	1.43	.47	.55	.29	.60	.85	.71	.16	
6	1.47	.47	.56	.32	.60	.90	.74	.21	
7	1.43	.46	.55	.28	.61	.92	.72	.18	
8	1.38	.46	.53	.28	.57	.84	.68	.19	
9	1.45	.47	.55	.26	.60	.92	.73	.19	
10	1.43	.47	.56	.32	.63	.92	.73	.18	
Mean	1.44	.46	.55	.29	.61	.88	.73	.18	
$S\bar{x}$	±.045	±.013	±.009	±.023	±.026	±.029	±.052	±.016	

Table 10 Continued

	Total length	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length	Aedeagus length
3rd Stage Nymph									
1	1.06	.37	.42	.23	.37	.60	.53	.18	
2	1.08	.39	.42	.30	.44	.60	.51	.18	
3	1.12	.37	.52	.28	.51	.66	.60	.15	
4	1.21	.42	.53	.28	.55	.61	.64	.17	
5	1.18	.46	.52	.28	.57	.65	.60	.18	
6	1.03	.51	.41	.22	.42	.55	.54	.17	
7	1.18	.37	.52	.28	.55	.65	.63	.18	
8	1.23	.42	.53	.30	.60	.62	.62	.18	
9	1.21	.46	.53	.32	.55	.65	.62	.18	
Mean	1.14	.42	.49	.28	.51	.62	.59	.17	
$S\bar{x}$	±.065	±.046	±.039	±.029	±.042	±.032	±.042	±.009	
2nd Stage Nymph									
1	.91	.30	.32	.18	.32	.40	.37	.14	
2	.99	.37	.42	.23	.42	.51	.49	.16	
3	.99	.37	.42	.29	.46	.43	.55	.15	
4	.91	.35	.38	.23	.37	.37	.38	.15	
5	.91	.30	.39	.21	.37	.46	.42	.14	
6	.88	.30	.37	.19	.40	.60	.43	.15	
7	.87	.34	.40	.22	.39	.46	.42	.15	
8	.92	.34	.35	.20	.41	.51	.44	.16	
9	.99	.37	.42	.23	.42	.47	.46	.16	
Mean	.93	.34	.39	.22	.40	.47	.44	.15	
$S\bar{x}$	±.039	±.022	±.032	±.035	±.046	±.075	±.059	±.006	

Table 10 Continued

	Total length	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length	Aedeagus length
1st Stage Nymph									
1	.72	.28	.28	.14	.23	.42	.30	.12	
2	.78	.29	.30	.18	.39	.39	.35	.14	
3	.81	.29	.31	.18	.28	.42	.36	.14	
4	.79	.30	.29	.19	.31	.39	.35	.12	
5	.85	.35	.40	.23	.40	.44	.42	.14	
6	.74	.29	.30	.18	.32	.25	.31	.13	
7	.76	.28	.28	.18	.28	.32	.27	.12	
8	.78	.30	.31	.23	.32	.34	.32	.14	
9	.76	.28	.32	.18	.23	.37	.32	.12	
Mean	.78	.30	.31	.19	.32	.37	.33	.27	
Sx̄	±.042	±.023	±.039	±.029	±.055	±.061	±.049	±.006	
		Total width							
Ova									
1	.51	.21							
2	.51	.21							
3	.58	.23							
4	.55	.23							
5	.56	.25							
6	.55	.21							
7	.56	.21							
8	.58	.23							
Mean	.55	.22							
Sx̄	±.023	±.013							

Bionomics of Lipeurus maculosis (Clay, 1938) (Fig. 48-55). This species was collected from the ring-necked pheasant, Phasianus colchicus, in Hungary and England (Clay, 1938). Emerson (1951) listed it as occurring on pheasants in Connecticut, New Jersey, Oregon, Wisconsin and British Columbia. The author could find no records of this species for any other gallinaceous birds. This louse was found on one cock, one hen and two chicks from Brule, Lyman and Washabaugh Counties. The highest number found was nine on a chick. Little is known of its habits or importance. It is undoubtedly a rare straggler on grouse but may be able to reproduce on young sharptails, since two immature stages and ova as well as gravid adults were present on the two chicks. Examination of crop contents showed feather parts and skin debris. It is apparently of little consequence to grouse.

Oviposition sites were not found and observations of this species were not made on live birds. Table 11 contains the measurements of ova, nymphs and adults of Lipeurus maculosis collected from sharptails during this study.

Total Louse Infestations. The total distribution of adult lice infestations by month is shown in Fig. 56. There is a significant difference in infestation intensities between cocks and hens during each month but July.

An analysis of variance test revealed a highly significant difference ($P < .005$) was present between average total louse infestations of hens and cocks. A highly significant difference ($P < .005$)

Scale: 5.5 cm = 1 mm

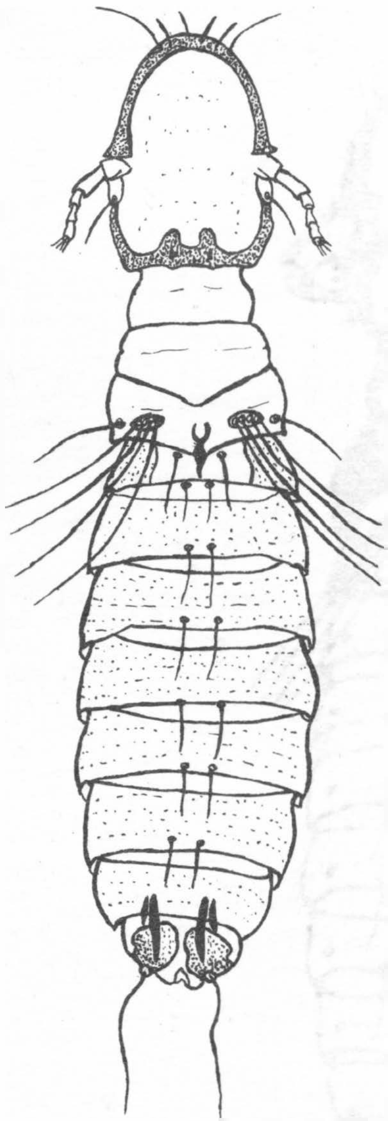


Fig. 48. Lipeurus maculosis female - dorsal.

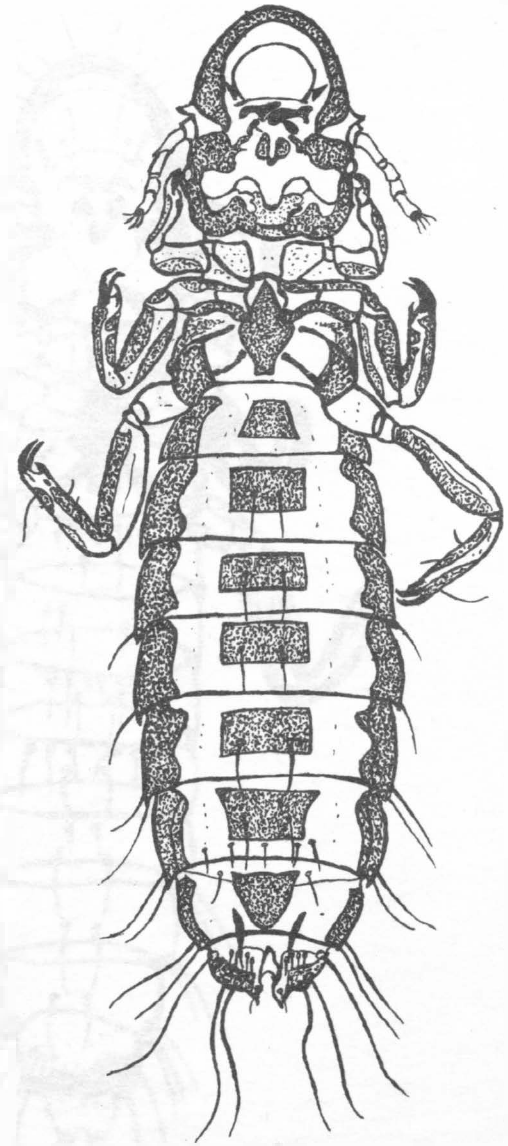


Fig. 49. Lipeurus maculosis female - ventral.

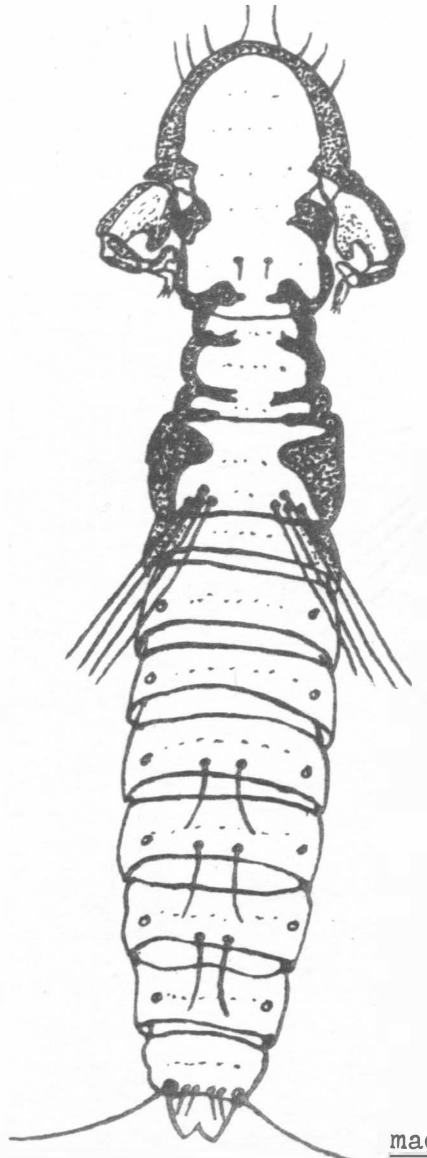


Fig. 50. Lipeurus maculosis male - dorsal.
Scale: 7 cm = 1 mm

Fig. 51. Lipeurus maculosis male genitalia.
Scale: 16 cm = 1 mm

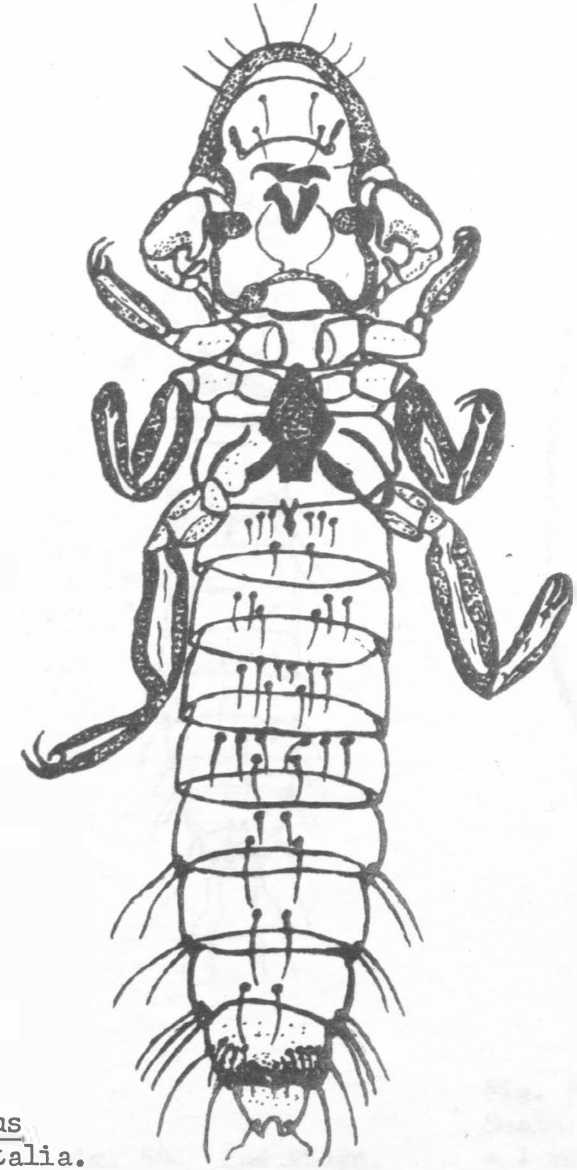


Fig. 52. Lipeurus maculosis male - ventral.
Scale: 7 cm = 1 mm

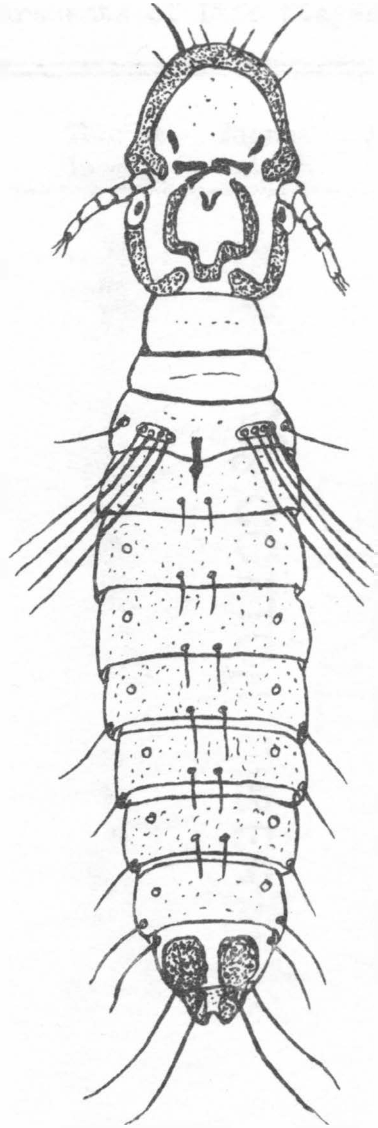


Fig. 53. 3rd stage.
Scale: 6.5 cm = 1 mm

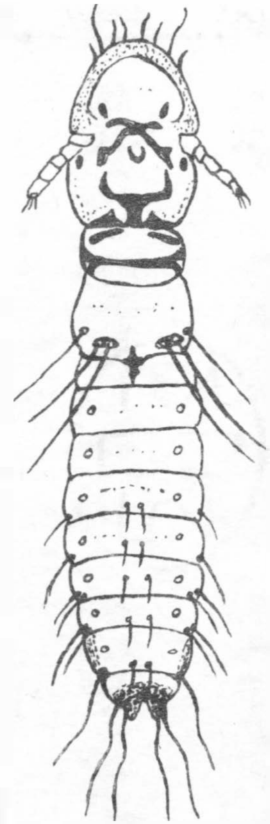


Fig. 54. 2nd stage.
Scale: 6 cm = 1 mm

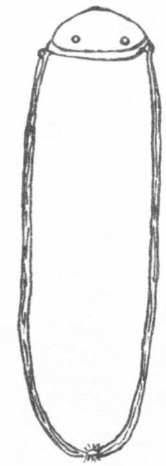


Fig. 55. Ova.
Scale: 6.5 cm = 1 mm

Lipeurus maculosis nymphs and ova

Table 11. Measurements of Life Stages of *Lipeurus maculosis*

	Total length (mm)	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length	Paramere length	Endomere length
Male										
1	2.00	.51	.36	.39	.48	1.20	.41	.35	.24	.13
2	2.04	.51	.37	.46	.37	1.28	.40	.39	.24	.15
Mean	2.02	.51	.37	.43	.43	1.24	.41	.37	.24	.14
Female										
1	2.37	.58	.42	.46	.47	1.51	.64	.29		
2	2.42	.56	.42	.42	.47	1.75	.66	.30		
3	2.26	.55	.42	.47	.47	1.41	.58	.28		
4	2.37	.58	.42	.51	.46	1.42	.61	.28		
5	2.33	.61	.44	.51	.48	1.43	.65	.28		
6	2.34	.60	.44	.46	.46	1.45	.60	.32		
Mean	2.35	.58	.43	.47	.47	1.49	.62	.29		
$S_{\bar{x}}$	±.043	±.016	±.006	±.029	±.006	±.110	±.026	±.013		
3rd Stage Nymph										
1	2.03	.53	.37	.42	.40	1.18	.44	.28		
2	1.96	.52	.36	.42	.42	1.18	.42	.24		
3	1.71	.48	.33	.37	.29	.83	.37	.23		
4	1.78	.45	.32	.32	.32	.99	.35	.21		
5	1.78	.47	.35	.37	.35	1.05	.37	.24		
Mean	1.85	.49	.35	.38	.36	1.05	.39	.24		
$S_{\bar{x}}$	±.104	±.023	±.016	±.016	±.035	±.114	±.029	±.022		

Table 11 Continued

	Total length (mm)	Head length	Head width	Thorax length	Thorax width	Abdomen length	Abdomen width	Antennae length	Para-mere length	Endo-mere length
2nd Stage Nymph										
1	1.59	.46	.33	.37	.28	.83	.27	.22		
2	1.45	.41	.28	.31	.28	.83	.31	.18		
3	1.49	.42	.28	.31	.29	.84	.35	.18		
4	1.37	.41	.26	.36	.25	.74	.29	.18		
5	1.27	.38	.25	.30	.24	.65	.24	.16		
6	1.43	.41	.35	.30	.28	.78	.28	.18		
Mean	1.43	.41	.29	.32	.27	.78	.29	.18		
$S\bar{x}$	±.104	±.026	±.026	±.023	±.016	±.058	±.035	±.019		
		Total width								
Ova										
1	.88	.28								
2	.83	.28								
3	.87	.28								
Mean	.86	.28								
$S\bar{x}$	±.016	±.000								

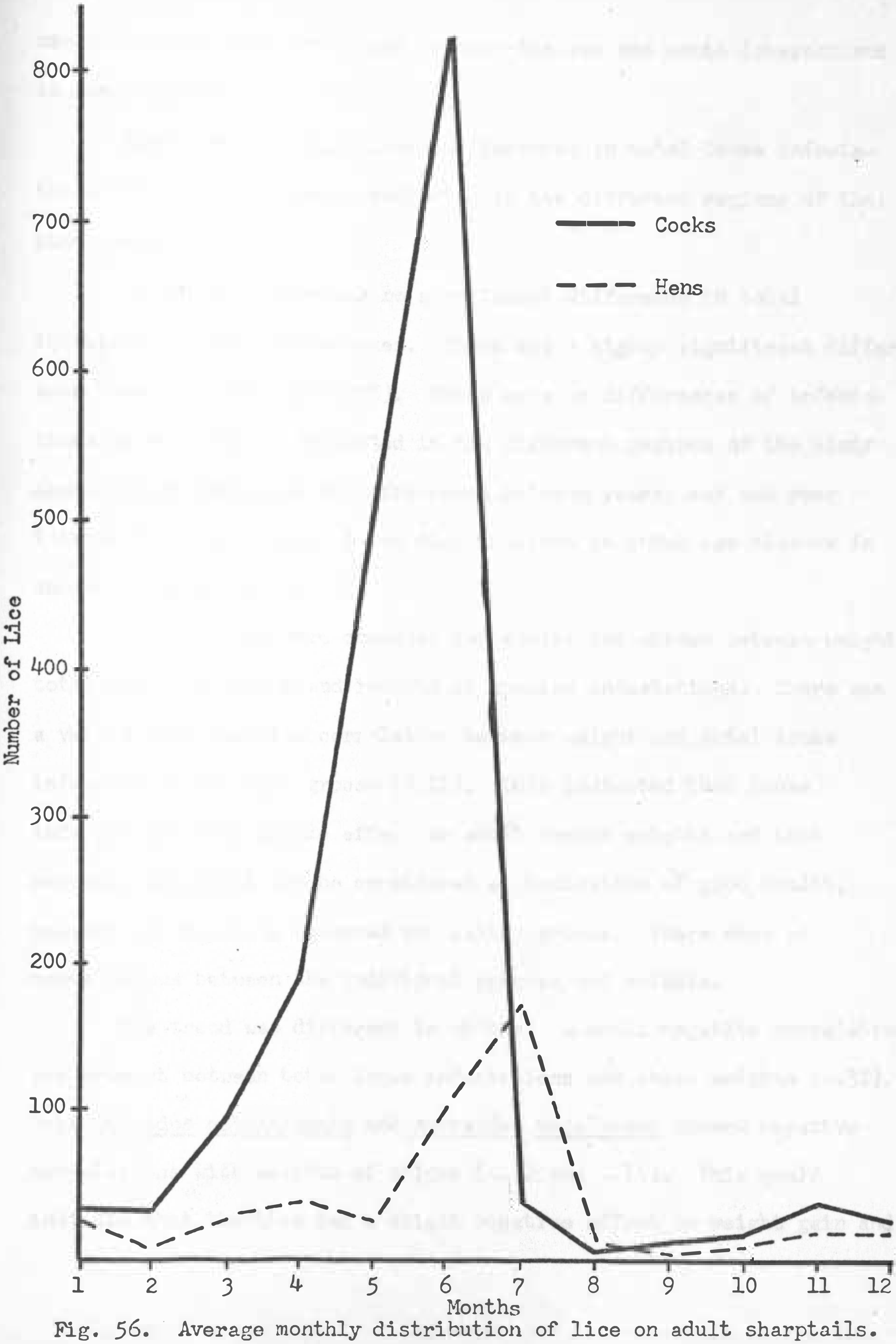


Fig. 56. Average monthly distribution of lice on adult sharptails.

was present between months and between the sex and month interactions in adult grouse.

There were no significant differences in total louse infestations between adult grouse collected in the different regions of the study area.

In chicks, there was no significant difference in total infestations between the sexes. There was a highly significant difference between months ($P < .005$). There were no differences of infestations between chicks collected in the different regions of the study area. There were also no differences between years, sex and year interactions in chicks. Louse distributions on chick age classes in weeks are shown in Fig. 57.

Correlations were computed for adults and chicks between weight, total lice and weight and individual species infestations. There was a very slight positive correlation between weight and total louse infestations in adult grouse (0.11). This indicated that louse infestations have little effect on adult grouse weights and that perhaps, if weight can be considered an indication of good health, heavier infestations occurred on healthy grouse. There were no correlations between the individual species and weights.

The trend was different in chicks. A small negative correlation was present between total louse infestations and chick weights (-.32). Both <u>Goniodes nebraskensis</u> and <u>Amyrsidea megalosoma</u> showed negative correlations with weights of chicks (-.32 and -.11). This would indicate that the lice had a slight negative effect on weight gain and

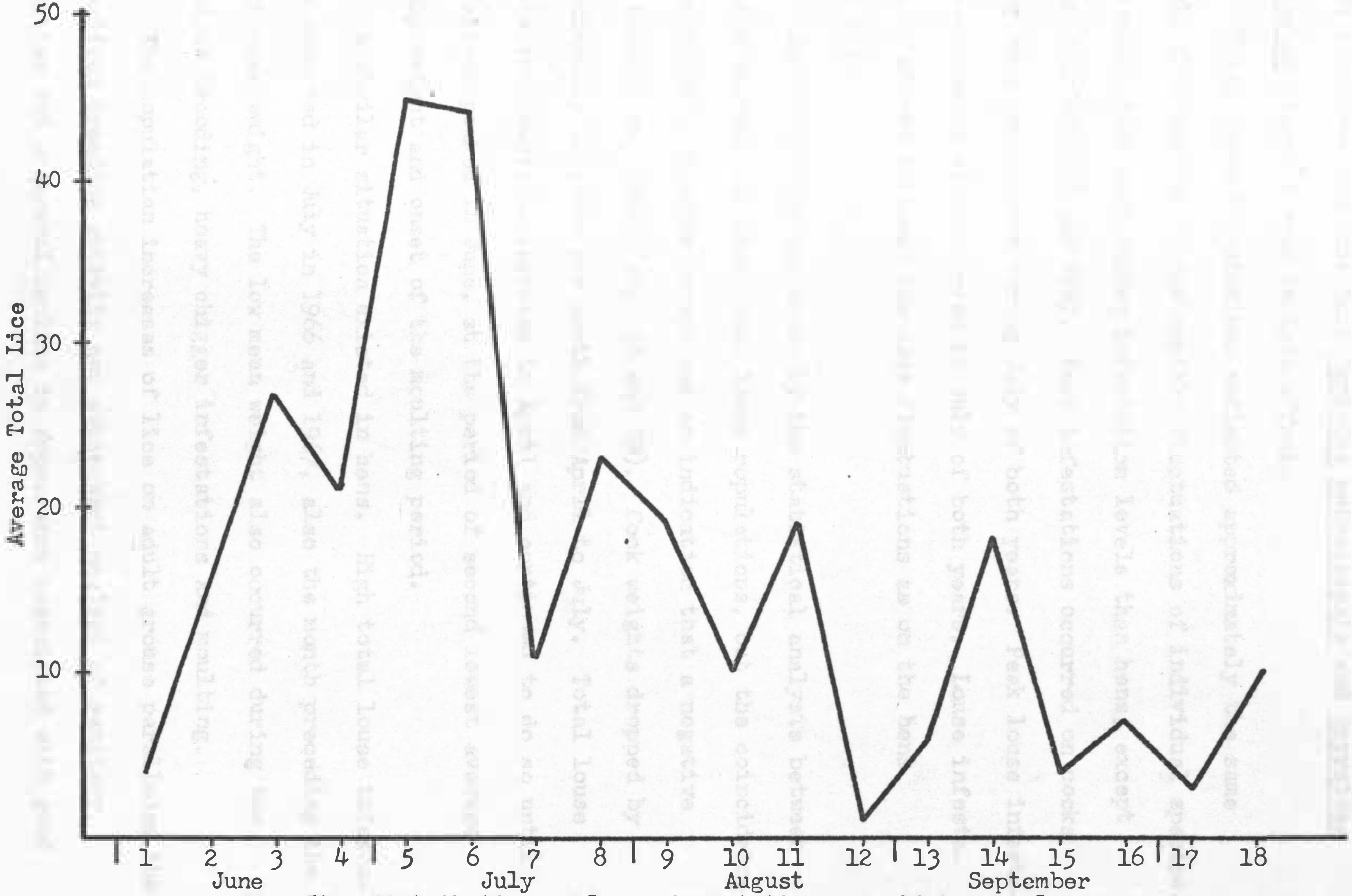


Fig. 57. Distribution of louse infestations on chick age classes.

growth in chicks and that both Goniodes nebraskensis and Amyrsidea megalosoma played a role in this effect.

Total louse infestations reflected approximately the same monthly fluctuations as the monthly fluctuations of individual species. Cocks maintained much higher infestation levels than hens, except during July of 1966 and 1967. Peak infestations occurred on cocks during June and on hens during July of both years. Peak louse infestations on chicks also occurred in July of both years. Louse infestations on chicks followed the same fluctuations as on the hens (Fig. 57).

No correlation was shown by the statistical analysis between low bird weights and high total louse populations, but the coincidence of the directly inverse curves was an indication that a negative relationship may exist (Fig. 58 and 59). Cock weights dropped by approximately 30 grams per month from April to July. Total louse infestations began to increase in April and continued to do so until populations peaked in June, at the period of second lowest average monthly weight and onset of the moulting period.

A similar situation existed in hens. High total louse infestations occurred in July in 1966 and 1967, also the month preceding the lowest mean weight. The low mean weight also occurred during the period of brooding, heavy chigger infestations and moulting.

The population increases of lice on adult grouse paralleled the intensified breeding activity and subsequent neglect of sanitary activities and a general decline in appearance associated with good

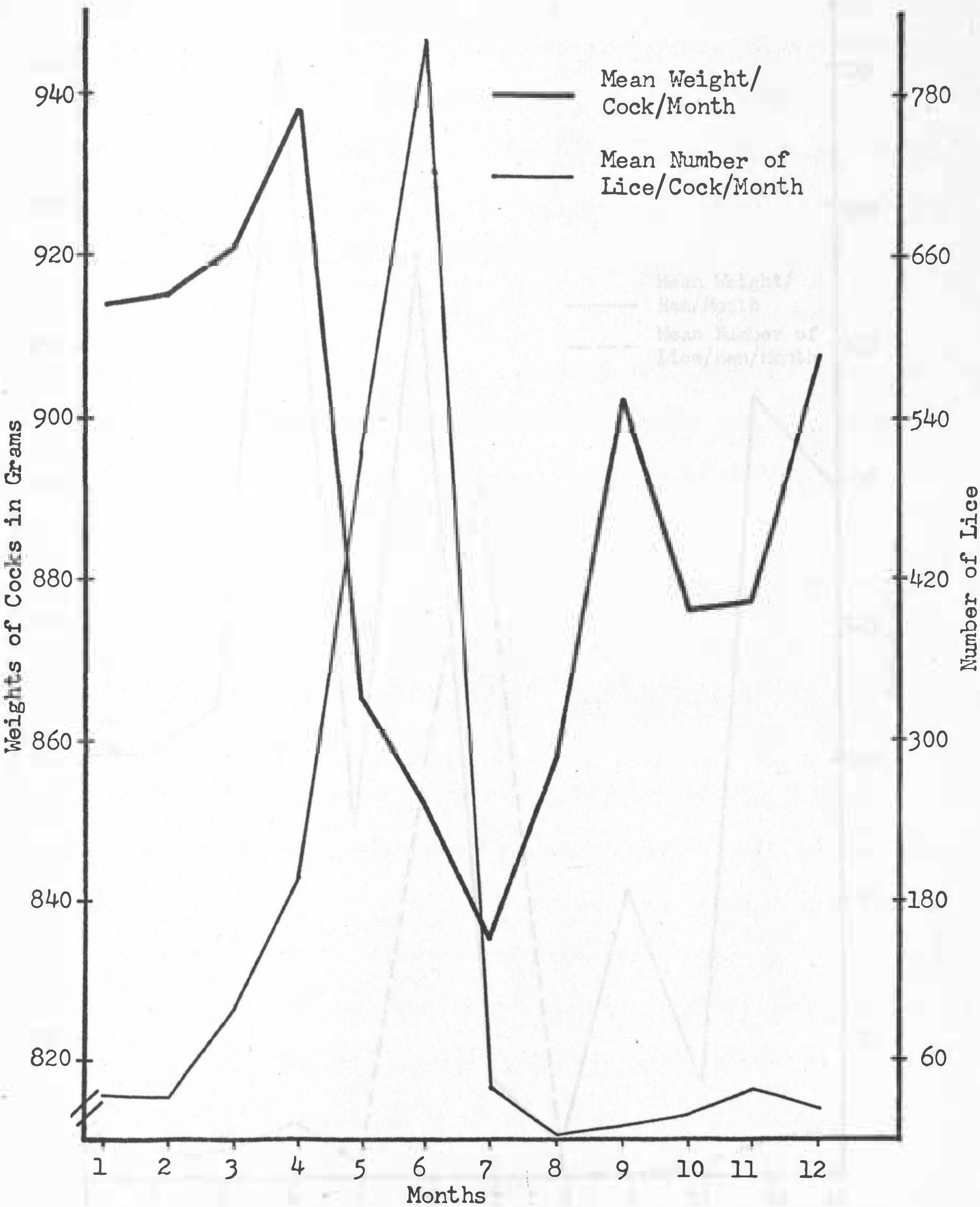


Fig. 58. Monthly weight fluctuations of cocks compared with mean louse infestations.

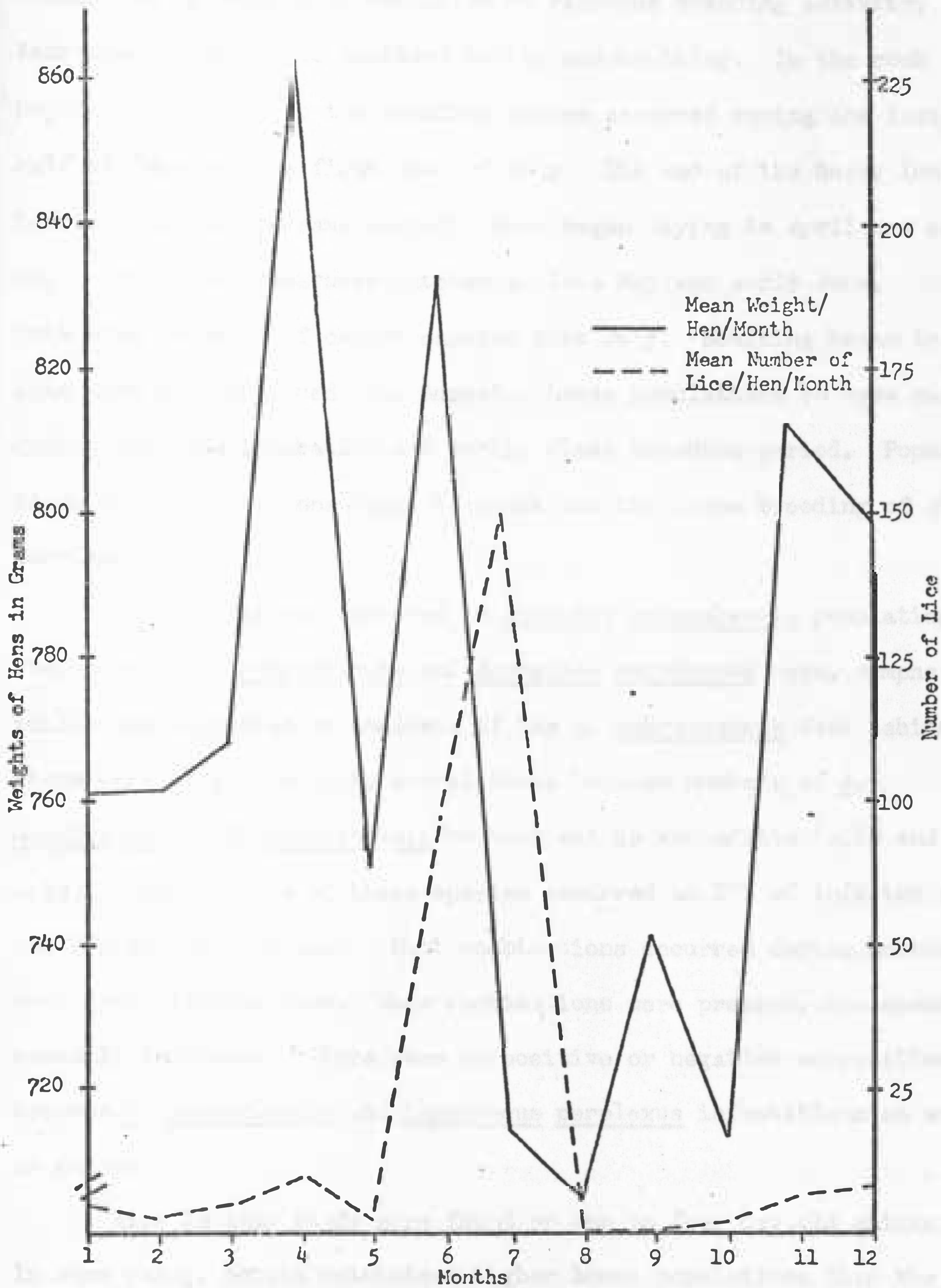


Fig. 59. Monthly weight fluctuations of hens compared with mean louse infestations.

health. Reasons for the sharp population declines in lice were thought to be related to cessation of rigorous breeding activity, increased attention to sanitary habits and moulting. In the cock population, an end to the breeding season occurred during the last half of June and the first week of July. The end of the heavy louse burdens came at the same period. Hens began laying in April and early May. Grouse clutches were hatched in late May and early June. Intensive brooding of chicks carried into July. Moulting began in late June and continued into August. Louse populations on hens rose during the late incubation and early, close brooding period. Populations dropped when hens began to moult and the close brooding of chicks terminated.

Cannibalism was observed in Goniodes nebraskensis populations. Predation of G. nebraskensis and Amyrsidea megalosoma eggs, nymphs and adults was suggested by analysis of the G. nebraskensis food habits. There were slight negative correlations between numbers of A. megalosoma and G. nebraskensis on both chicks and adults (-.12 and -.13). Combinations of these species occurred on 17% of infested cocks and 10% of infested hens. Most combinations occurred during months of peak louse infestations. When combinations were present, one species normally dominated. There were no positive or negative correlations between G. nebraskensis and Lagopoecus perplexus infestations on adults or chicks.

Lice in this study were found on one to four day old chicks. In some cases, chicks maintained higher louse populations than the

hens. Some chicks carried more and different species than their mothers. Louse numbers on chicks were consistently low, yet the percentage of chicks infested was high at 66%.

Combinations of species were most common on cocks during May and June during peak total louse infestations. Thirty-three cocks carried combinations of Goniodes nebraskensis and Amyrsidea megalosoma. Seventeen cocks carried combinations of G. nebraskensis and Lagopoecus perplexus. All three species were found on thirteen cocks. Combinations of A. megalosoma and L. perplexus were found on five cocks. Combinations on hens were less frequent with G. nebraskensis and A. megalosoma found on fourteen. Goniodes nebraskensis and L. perplexus were found on nine hens. As the percentage of cocks infested with A. megalosoma increased from 50% in May to 78% in June, the percent infested with G. nebraskensis decreased from 86% in May to 61% in June, and yet the populations of both lice species climbed substantially on infested birds. Generally, infestations of L. perplexus were so light that little could be concluded about their interactions with other species.

Goniodes nebraskensis and A. megalosoma were found together on 29 breeding cocks. Fourteen of these populations were dominated by A. megalosoma and fifteen were dominated by G. nebraskensis. These combinations were characterized by large populations of the dominant species and very few of the submissive one on a particular bird, i.e., roughly an average ratio of 23 to 1 in A. megalosoma dominated birds and 22 to 1 in G. nebraskensis dominated birds.

In the Goniodes nebraskensis infestations and in combinations where G. nebraskensis dominated, the only visible effect on the host was damage to feather barbules and observed irritability expressed by bird activity (dusting, pecking, scratching and preening). In Amyrsidea megalosoma infestations, including combinations where A. megalosoma was dominant, the typical lesions and skin damage was present. Infestations of this species could be determined immediately by eggs on chin feathers. Lagopoecus perplexus was dominant on only one bird where significant numbers were present, and no damage was observed.

Movement of lice between sharptails has been mentioned earlier with regard to G. nebraskensis and A. megalosoma movement between the hen and its chicks. Cocks when active on the dancing grounds have a great deal of physical contact usually during brief displays and attacks. During the weeks of the breeding activity, cocks spend up to 12 hours per day in close proximity. This close proximity and these concentrated louse sources would give lice a maximum opportunity to find a new host either by direct host contact and transfer, phoretical transfer by hippoboscid flies or by crawling from a dead host to a live one.

Coitus occurs both on the dancing ground and in the immediate vicinity by cocks partaking in the ceremony. The time period of coitus is very short, one to several seconds. It is probable that some louse transfers take place during these brief encounters. The brief encounter in coitus is the only time when cocks and hens are in

close contact after the brooding period. It is likely that the major louse transfers and new infestations occur between the hen and chicks, hens and cocks in coitus and between adult cocks on the dancing grounds. Young cocks and hens carry nearly the same infestation rates and louse intensities at the beginning of the breeding season in March. The percent of infested hens and the intensity of the infestations rise during May through July but reach only 21% that of the cocks. The louse increases on hens are more likely a reflection of population growth of lice already present on the hens than of transfer between cocks and hens during coitus.

SUMMARY AND CONCLUSIONS

In summary, the objectives as set forth in the introduction of this paper will be listed along with data discovered to support the conclusions drawn previously or discussed here. The first objective of this research was to determine the species of lice parasitic on sharp-tailed grouse. Five species of mallophagous lice were found infesting sharptails in South Dakota, Goniodes nebraskensis, Amyrsidea megalosoma, Lagopoecus perplexus, Goniocotes chrysocephalus and Lipeurus maculosis.

The frequencies, seasonal distributions and population characteristics of each louse species were investigated. Goniodes nebraskensis was the most common louse. It was found on 73% of all sharptails examined. It was most abundant during the spring and early summer months on breeding cocks. Infestations on individual birds varied considerably. Adults were more heavily infested than chicks. Cocks carried heavier infestations than hens. Infestations of G. nebraskensis were heaviest on all birds during the spring and early summer months. Peak populations on cocks occurred in June and on hens in July. The range of infestation intensities ranged from 1,202 lice on one cock to zero on many sharptails.

The age ratio of G. nebraskensis was typically 1 male·1.5 females·7 nymphs. This ratio varied considerably between months, the lowest ratio being 1 male·1 female·3 nymphs in October and the highest ratio 1 male·1.6 females·17.7 nymphs on hens collected in July.

Amyrsidea megalosoma was the second most prevalent louse. It infested 19% of all sharptails surveyed. It was most abundant on breeding cocks during the spring and early summer. Peak populations on cocks and hens occurred in June. More cocks and chicks were infested with this species than hens. Cocks carried much heavier infestations than hens or chicks. The numbers this species attained on individual birds was much higher than attained by any other lice. The range of infestation intensities ranged from 3,072 lice to zero. The highest percentage of birds infested with this species was found in June. During that month 77% of cocks and 50% of the hens carried this species.

The population structure of this species generally consisted of 1 male·1 female·2 nymphs. This ratio remained fairly consistent even during months of very low populations.

Lagopoecus perplexus ranked third in frequency on sharptails. It occurred on 14% of all grouse examined. This species was most frequent on breeding cocks in May. Only 5% of the hens and 6% of the chicks carried it. The seasonal distribution of this species was most marked of the lice. It was rarely found except during the months of April to August. The range of infestation intensities was from zero to 309. The species was most abundant in June when it infested 39% of the cocks.

The population structure during the months of highest populations was 1 male·2 females·6 nymphs. This species was not found on sharptails during the months of August to October and December.

Goniocotes chrysocephalus is normally a parasite of the ring-necked pheasant. It was found only on 4 breeding cocks during May from Lyman County, South Dakota. It can be considered a rare straggler on the sharptail. This species established breeding populations on the new host. Lipeurus maculosis is also normally a parasite of the pheasant. It was found on four sharptails from several counties during the summer months. It is apparently a rare straggler on the sharptail. There was evidence that breeding on the sharptail was taking place.

The effects each louse species had on sharptail weights, general condition, breeding potential and direct pathological damage were investigated. Goniodes nebraskensis was considered to have little independent effect on the weight, general condition and breeding potential of sharptails. There was no evidence of direct pathological damage caused by this species.

Amyrsidea megalosoma was shown to affect sharptails in several negative ways. Cocks heavily infested with A. megalosoma averaged 15.4 grams less than birds with none of this species or light infestations. The general condition of heavily infested birds was observed to be much lower quality than uninfested or lightly infested birds. Heavily infested birds carried less fat, dirty, stained feathers and were much more irritable. This species was considered to have little effect on hens and chicks because of its relative scarcity on these birds. Since cocks were unequally infested with this species, there were always active breeders available to hens, even though heavily infested cocks appeared to be discouraged by the louse loads they

carried. Direct pathological damage was observed in Amyrsidea megalosoma infestations. This species chewed holes in the skin and ate blood and scabs that formed as a result of the chewing. Its activities also resulted in large areas of denuded skin.

Lagopoecus perplexus, Goniocotes chrysocephalus and Lipeurus maculosis were not present in sufficient numbers to determine what effects they had. It was concluded that these species were not important to the health and well-being of sharptails.

The effects of combination louse infestations on sharptails were studied. Lice were found in large numbers and on a high percentage of grouse only during the months of March to July. On birds collected during these months, combinations of two to three louse species were the rule rather than the exception. Direct pathological damage to the host was present only when A. megalosoma made up the majority of lice present. Weights of cocks and hens began to fall in April and continued to do so until July and August. Cocks went from an average of 938 to 835 grams and hens from 861 to 706 grams. During this period of weight loss, louse populations went from less than 100 lice/infested bird to 825/infested bird on cocks and 30 lice/bird to 174/bird on hens. Curves of weights and louse populations were inverse. A direct cause and effect relationship was not established, but it is an interesting coincidence.

There was not sufficient data collected to substantiate firm conclusions on the effects of heavy louse populations on the length and intensity of cock dancing activity. However, based on three years

of observations of cock behavior on ten selected dancing grounds, the following statements held true. On dancing grounds with a history of cocks heavily infested with Amyrsidea megalosoma, dancing activity was less intense and terminated up to 30 days sooner. Birds were more irritable and spent less time per day on the ground. Louse populations varied a great deal between cocks on the same dancing ground and between cocks of different dancing grounds. Louse intensity on individual cocks did not have any relationship to the number of cocks on a dancing ground.

Data indicated that lice had no effect on brood size, as hens carried consistently low infestations of all species. Louse infestations during critical periods of the reproductive season were low, and damage associated with heavy louse infestations on cocks was not observed on hens. Birds infested almost exclusively with lice were observed to scratch themselves, dust, preen and peck, all indicating that lice caused irritations to the birds.

No data were collected to show that there was any direct or induced mortality caused by lice in wild grouse populations. However, louse populations on wild birds equaled those on penned sharptails of McEwen et al. (1969), where mortality was attributed to louse burdens of the same species.

The role lice play in disease transmission to sharptails was investigated. A very definite relationship between A. megalosoma and the dermaphytic fungi Trichophyton mentagrophytes was shown. Hyphae and microspores were found in the setae of A. megalosoma. Trichophyton

mentagrophytes was isolated from lesions on cocks which were heavily infested with Amyrsidea megalosoma during the years 1965 to 1970. These lesions were not found on grouse infested with other louse species.

The behavior of the lice species was studied. Only Goniodes nebraskensis, A. megalosoma and Lagopoecus perplexus were found in sufficient numbers to investigate the behavior patterns. Goniodes nebraskensis was found to be a very slow moving, strongly host dependent parasite. It inhabited mainly the contour feathers and died on the host without making an effort to escape. Eggs were laid on the afterfeather of the large contour feathers of the breast and legs. Food items identified were skin debris, feather barbules and barbs, egg shells and parts of other lice.

Amyrsidea megalosoma was a very active louse which spent most of its time on the skin. It was not a strongly host dependent louse and would crawl onto the hands of handlers and immigrate from a dead host. Eggs were laid on the feathers of the neck and head. Food items identified were feather parts, skin debris and blood.

Lagopoecus perplexus was intermediate in activity between Goniodes nebraskensis and A. megalosoma. It died on the host without making any effort to crawl from the host. This species inhabited the head and neck region. The oviposition site was not found. Food items identified were feather parts and skin debris.

The effects of precipitation, land use, soil association and air temperatures on louse populations and distributions independent of the host were studied.

There were several statistical differences in comparisons between louse infestations on birds from areas of different levels of precipitation, land use, soil associations and mean annual air temperatures of the study. Chicks from the eastern one-half of the study area carried significantly higher numbers of Goniodes nebraskensis than chicks in the west one-half. Infestations of G. nebraskensis were significantly higher in 1967 than 1966. There were no important differences in the species present or infestation intensities on adults between the various regions of the study areas. It was concluded that to determine if precipitation, land use, soil associations and air temperatures had a measurable effect on louse distribution or intensity a much more extensive study would be necessary.

It was concluded on the basis of the data collected that the distribution of lice was a function of the distribution of the host. It was also concluded that the intensity of louse infestations was a function of the habits and condition of the host rather than a function of external environmental factors. The only heavy infestations of lice found outside the months of March through July were on diseased and debilitated birds.

The intraspecific and interspecific relationships of the lice were studied. Evidence gathered during this study indicated that G. nebraskensis adults and nymphs competed for the same food sources and that they cannibalized each other. It was also found that, when lice were in combination infestations, about one-half the hosts

carried heavy infestations of Goniodes nebraskensis and one-half carried heavy infestations of Amyrsidea megalosoma. On these birds the dominant species maintained a ratio of 22 to 1. Lagopoecus perplexus was found in abundance only twice; both times it was without competition from any other louse species.

LITERATURE CITED

Aldrich, J. W. 1963. Geographic orientation of American tetraonidae. J. Wildl. Mgmt. 27(4):528-545.

Ammann, G. A. 1957. The prairie grouse of Michigan. Game Div., Dept. of Cons., Lansing, Michigan. 200 p.

Ammann, G. A. 1963. Status and management of sharp-tailed grouse in Michigan. J. Wildl. Mgmt. 27(4):802-809.

Ash, J. S. 1960. Study of the Mallophaga of birds with particular reference to their biology and ecology. Ibid. 102(1):93-110.

Benbrook, E. A. 1965. External parasites of poultry, p. 925-931. In Diseases of Poultry. Iowa State University Press, Ames, Iowa.

Bendell, J. F. 1955. Disease as a control of a population of blue grouse, Dendragapus obscurus fuliginosus (Ridgeway). Can. J. Zool. 33(3):195-223.

Bernhoft, L. S. 1967. Habitat preferences of the sharp-tailed grouse. North Dakota. Pittman-Robertson Project W-67-R-8, Rep. No. A-329. 9 p.

Bernhoft, L. S. 1968. Habitat preferences of the sharp-tailed grouse. North Dakota. Pittman-Robertson Project W-67-R-8, Rep. No. A-346. 18 p.

Boddicker, M. L. 1965. Some parasites of sharp-tailed grouse in South Dakota. Proc. 6th Conf. Prairie Grouse Tech. Council, Warroad, Minn., Sept., 1965. p. 31.

Boddicker, M. L. and E. J. Hugghins. 1965a. Some parasites of sharp-tailed grouse in South Dakota. 10th Trans. Ann. Summer Conf. Central Mts. and Plains Sec. of Wildl. Soc., Centennial, Wyoming, Aug., 1965. p. 19.

Boddicker, M. L. and E. J. Hugghins. 1965b. Parasites of sharp-tailed grouse in South Dakota. S. D. Acad. Sci. 44:244. (Abstr.).

Boyd, Elizabeth M. 1951. A survey of parasitism of the starling Sturnus vulgaris in North America. J. Parasitol. 37:56-84.

Boyd, Elizabeth M. 1956. The external parasites of birds: a review. The Wilson Bull. 63(4):363-369.

Bremer, P. E. 1965. Summary of the results of four years of sharp-tailed grouse live-trapping and banding in northwestern Minnesota. Manuscript presented to Prairie Grouse Tech. Council, Effingham, Ill., Sept., 1967. 13 p.

Buxton, P. A. 1934. The separation of lice from hair, wool or feathers. Proc. Roy. Ent. Soc. (London) 9:5-6.

Carriker, M. A. 1946. Goniodes nebraskensis. Revista Acad. Colombiana Sci. 6:357-359. Fig. 6-8.

Clay, T. 1938. Revision of the genera and species of Mallophaga occurring on gallinaceous hosts. Part I. Lipeurus and related genera. Proc. Zool. Soc. (London) (B) 108:109-204. Fig. 5a, 6a and pl. 1, fig. e.

Clay, T. 1969. A key to the genera of the Menoponidae (Amblycera: Mallophaga:Insecta). Bull. Brit. Mus. Nat. Hist. (Ent.) 24(1):17-19.

Crutchfield, C. M. and H. Hixson. 1943. Food habits of several species of poultry lice with special reference to blood consumption. Fla. Entomol. 26:63.

Dahlgren, R. 1967. The pheasant decline. S. D. Dept. Game, Fish and Parks. 44 p.

Dunn, L. H. 1932. An effective method for collecting ectoparasites from live animals and birds. Psyche 39:26-29.

Edgar, S. A. and D. F. King. 1950. Effect of the body louse, Eomenacanthus stramineus, on mature chickens. Poultry Sci. 29:214.

Emerson, K. C. 1948. A new Mallophaga from a ruffed grouse. J. Kansas Entomol. Soc. 21(3):92-95.

Emerson, K. C. 1950a. New species of Goniodes. Ibid. 23(4):120-126.

Emerson, K. C. 1950b. The genus Lagopoecus (Philopteriadae:Mallophaga) in North America. Ibid. 23(3):97-101.

Emerson, K. C. 1951. A list of Mallophaga from gallinaceous birds of North America. J. Wildl. Mgmt. 15(2):193-195.

Emerson, K. C. 1961. Designation of a lectotype for Amyrsidea megalosoma (Overgaard, 1943). Proc. Entomol. Soc. Wash. 63(1):66-67.

Emerson, K. C. 1962. A tentative list of Mallophaga for North American birds (North of Mexico). Dugway Proving Ground, Dugway, Utah. 217 p.

Emerson, K. C. 1964. Checklist of the Mallophaga of North America (North of Mexico). Part II. Suborder Amblycera. Dugway Proving Ground, Dugway, Utah. 104.

Evans, K. E. 1965. Sharp-tailed grouse habitat requirements in western South Dakota, a preliminary report. Manuscript presented to Prairie Grouse Tech. Council, Warroad, Minn., Sept., 1965. 11 p.

Ewing, H. E. 1927. Descriptions of new genera and species of Mallophaga, together with keys to some related genera of Menoponidae and Philopteridae. J. Wash. Acad. Sci. 17(4):86-96.

Forbush, E. H. 1936. Sharp-tailed grouse, Part II, p. 27-29. In Birds of America. Garden City Publishing Co., Inc., Garden City, N. Y.

Gless, E. E. and E. S. Raun. 1959. Effects of chicken body louse infestations on egg production. J. Econ. Entomol. 52:358.

Halloran, P. O. 1955. A bibliography of references to diseases of wild mammals and birds. Amer. J. Vet. Res. 16(61):1-465.

Hammerstrom, F. N., Jr. 1963. Sharptail brood habitat in Wisconsin's northern pine barrens. J. Wildl. Mgmt. 27(4):792-802.

Henderson, F. R. 1965. Surveys and management of prairie grouse in South Dakota. Manuscript presented to Prairie Grouse Tech. Council, Warroad, Minn. 32 p.

Henderson, F. R. 1967. Winter trapping and banding of prairie grouse, 1967, South Dakota. Pittman-Robertson Project Rep. W-95-R-1, December, 1967. 6 p.

Henderson, F. R. 1969. Prairie grouse bag check, 1959-1967, South Dakota. Pittman-Robertson Project Rep. W-95-R-2, May, 1969. p. 1-16.

Henderson, F. R. and W. Jackson. 1965. Winter trapping and banding of sharp-tailed grouse in South Dakota, March, 1963, through March, 1965. S. D. Dept. of Game, Fish and Parks. 14 p.

Henderson, F. R. and W. Jackson. 1967. History of selected dancing grounds in South Dakota. S. D. Dept. of Game, Fish and Parks. 5 p.

Henderson, F. R. and W. Jackson. 1969. Winter trapping and banding of prairie grouse, 1967-68, South Dakota. Pittman-Robertson Project Rep. W-95-R-2, February 6, 1969. 6 p.

Henderson, F. R., F. W. Brooks, R. E. Wood and R. B. Dahlgren. 1967. Sexing of prairie grouse by crown feather patterns. J. Wildl. Mgmt. 31(4):764-769.

Herman, C. M. 1963. Disease and infection in the Tetraonidae. Ibid. 27(4):850-855.

Hillman, C. N. 1969a. Prairie grouse brood survey, 1968, South Dakota. Pittman-Robertson Project Rep. W-95-R-3, Jan., 1969. 3 p.

Hillman, C. N. 1969b. Prairie grouse bag check, 1968, South Dakota. Pittman-Robertson Project Rep. W-95-R-3, July, 1969. p. 1-5.

Hillman, C. N. 1970a. Prairie grouse bag check, 1969, South Dakota. Pittman-Robertson Project Rep. W-95-R-4, March, 1970. p. 1-5.

Hillman, C. N. 1970b. Winter trapping and banding of prairie grouse, 1969-1970, South Dakota. Pittman-Robertson Project Rep. W-95-R-4, April, 1970. 4 p.

Hillman, C. N. and B. Betts. 1969. Winter trapping and banding of prairie grouse, 1968-69, South Dakota. Pittman-Robertson Project Rep. W-95-R-3, December, 1969. 5 p.

Hopkins, G. N. E. 1949. The host-associations of the lice of mammals. Proc. Zool. Soc. 119:387-604.

Hopkins, G. N. E. and T. Clay. 1955. Additions and corrections to the check list of Mallophaga. Ann. Mag. Nat. Hist. 8:177-190.

Howitt, G. F., H. R. Dodge, L. K. Bishop and R. H. Gorie. 1948. Virus of eastern equine encephalomyelitis isolated from chicken mites (Dermanyssus gallinae) and chicken lice (Eomenacanthus stramineus). Proc. Soc. Exp. Biol. Med. 68:622.

Jackson, W. W. 1963. Prairie grouse movement study, 1962, South Dakota. Pittman-Robertson Project Rep. W-75-R-4, January, 1963. 18 p.

Jackson, W. W. 1964. Prairie grouse movement study, 1963, South Dakota. Pittman-Robertson Project Rep. W-75-R-5, March, 1964. 14 p.

Jackson, W. W. 1967. Seasonal movements of prairie grouse in South Dakota. Manuscript presented to Prairie Grouse Tech. Council, Effingham, Ill., Sept., 1967. 7 p.

Jackson, W. W. and F. R. Henderson. 1965. Prairie grouse movement study, 1964, South Dakota. Pittman-Robertson Project Rep. W-75-R-6, March, 1965. 11 p.

Janson, R. 1955. The sharp-tailed and pinnated grouse in South Dakota. S. D. Dept. Game, Fish and Parks, Pierre, S. D. 30 p.

Kellogg, V. L. and B. L. Chapman. 1899. Mallophaga from birds of California. Proc. Calif. Acad. Sci. 2nd Ser. 6:53-143, pl. 7, fig. 3.

Knudtson, W. U., M. L. Boddicker and G. Robertstad. 1969. Isolation of Trichophyton mentagrophytes from favus in a grouse. Bull. Wildl. Dis. Assoc. 5:141.

Kobriger, G. D. 1965. Status, movements, habits and foods of prairie grouse on a sandhills refuge. J. Wildl. Mgmt. 29(4):788-800.

LaPage, G. 1956. Veterinary Parasitology. Oliver and Boyd, Pub., London. p. 548-571.

Lumsden, H. G. 1965. Displays of the sharp-tailed grouse. Res. Rep. No. 66, Dept. Lands and Forests, Ottawa, Ontario, Can. p. 1-68.

McEwen, L. C., D. B. Knapp and E. A. Hilliard. 1969. Propagation of prairie grouse in captivity. J. Wildl. Mgmt. 33(2):276-283.

Martin, Margaret. 1934. Life history and habits of the pigeon louse (Columbicola columbae Linnaeus). Can. Entomol. 66(1):6-16.

Matthysse, J. F. 1946. Cattle lice, their biology and control. N. Y. Agr. Exp. Sta. Bull. 832. 67 p.

Metcalf, C. L., W. P. Flint and R. Metcalf. 1962. Destructive and Useful Insects. McGraw-Hill Book Co., New York. p. 984-989.

Meyer, K. F. and B. Eddie. 1960. Feather mites and ornithosis. Science 132:300.

Overgaard, H. 1943. Menopon megalosum. Entomol. Medd. 23:1-17, fig. 5-6.

Renhowe, B. A. 1968. Food habits of the sharp-tailed grouse (Pedioecetes phasianellus jamesi) and the greater prairie chicken (Tympanuchus cupido pinnatus) in western South Dakota. M.S. Thesis. South Dakota State University, Brookings, South Dakota. 80 p.

Robel, R. J., F. R. Henderson and W. Jackson. 1972. Some sharp-tailed grouse population statistics from South Dakota. J. Wildl. Mgmt. 36(1):87-98.

Roberts, I. H. and C. L. Smith. 1956. Poultry lice, p. 490-493. In Animal Diseases, U.S.D.A. Yearbook, 1956. U.S. Gov. Print. Off. House Doc. No. 344.

Rous, J. L. 1967. Age determination of juvenile hand-reared prairie sharp-tailed grouse. Manuscript presented to Prairie Grouse Tech. Council, Effingham, Ill., Sept., 1967.

Shoemaker, H. H. 1961. Rearing of young prairie chickens in captivity. Ill. Wildl. 16(4):Sept., 1961.

Shoemaker, H. H. 1964. Report on studies of captive prairie chickens. Ibid. 19(3):6-8.

Tabor, R. D. 1963. Criteria of sex and age, p. 119-149. In Wildlife Investigational Techniques, The Wildlife Soc., Washington, C. C.

Tower, B. A. and E. H. Floyd. 1961. The effect of the chicken body louse, Eomencanthus stramineus, on egg production in New Hampshire pullets. Poultry Sci. 40:395.

Warren, D. C., R. Eaton and H. Smith. 1948. Influence of infestations of body lice on egg production in the hen. Poultry Sci. 27:641.

Westin, F. C., L. F. Puhr and G. J. Buntley. 1967. Soils of South Dakota. S. D. Agr. Exp. Sta. Soil Survey Ser. No. 3, Brookings, South Dakota. 32 p.

Wilson, F. H. 1933. A louse feeding on the blood of its host. Science 77:490.

Wilson, F. H. 1934. The life cycle and bionomics of Lipeurus heterographus Nitzsch (Mallophaga). J. Parasitol. 20(5):304-311.

Williamson, K. 1954. The Fair Isle apparatus for collecting bird ectoparasites. Brit. Birds 47:235-236.

Wiseman, B. R. 1959. Genera of Mallophaga of North America north of Mexico. Ph.D. Thesis. Texas A & M University, College Station, Texas. 339 p.

APPENDIX A

Instruction Sheet

Explanation of Data Card

Date: The date the grouse was collected: if possible include the exact time it was taken.

Locality: Both studies require exact locality data to the nearest landmark in the quarter section.

Area Number: Bruce Renhowe wants to set up 5 representative areas in different vegetation or topographical types. When grouse are taken in these areas, give the number.

Collector: The person actually collecting the grouse so we can pump them for additional information if necessary.

Age: Estimate the age of the grouse by your usual technique. We can then compare the results with the aging technique studies.

Sex: Estimate the sex of the grouse by your usual methods. We will then compare your estimate with gonad examination and other methods.

Condition of the Grouse When Collected: This is a relative estimate on the bird's health. Was it healthy and vigorous, sick, thin, mopey, fair, average, etc.

Method of Dispatch: How was the grouse killed, shot, trapped, neck rung, killed by predator, road kill, etc. This is important in evaluating the bird as a sample for ectoparasite study.

Reliability of Ectoparasite No.'s: How long did the grouse lay before it was bagged and frozen. Did collector notice lice on hands, flies flying away, etc.

Number and Species of Other Gallinaceous Birds in the Area: How many pheasants, prairie chickens, domestic poultry and sharptails are in the area the grouse was collected.

Topography of the Area: What topographical type was the grouse taken from? Badlands, table top, creek or river bottom, prairie, etc.

Dominant Vegetation Type in Area: What is the dominant vegetation type in the locality? Cropland (corn, wheat, maize), bluestem, western wheatgrass, etc.

Remarks: Only information which would help us evaluate the sample. Like known age from banding data, known movement data on the grouse. Was it on dancing ground, nest, with brood, in roost, etc. Number of chicks in the brood with it, etc.

Well, that's a big order. Thanks.

APPENDIX B

Data Cards Used During the Louse Population and Ecology Study

Date: Collector:

Time:

Locality: Area No.:

Condition of bird: Age of bird:

Method of killing: Sex:

Number and species of gallinaceous birds in area:

Topography of locality:

Dominant vegetation type:

Reliability of ectoparasite no.'s:

Remarks:

APPENDIX C

Data Record Card for Each Bird Collected and Examined During This Study

No.	Species	Sex	Age	Weight	Collector	Locality	Collection Type	Date

Provent dia.	Pro. Cond.	Condition	Remarks	Related Sample No.

Parasites Recovered	No.	M	F	I	Vol.	Organ	Food Items Crop and Provent Items Pres.	No.	Vol.	Gizzard Items Pres.	No.	Vol.