Biological Survey of Canada
Terrestrial Arthropods

Briefs

ARTHROPOD ECTOPARASITES OF VERTEBRATES IN CANADA

A brief prepared by the Biological Survey of Canada
(Terrestrial Arthropods) 1990

Abstract

Arthropod ectoparasites are a diverse element of the Canadian fauna, and frequently impinge upon the performance and well-being of man, domestic animals, and wildlife. The fauna is not well known, with only about 17% of the expected species recorded. The mites and chewing lice in particular need study. There is considerable potential for investigation of the ecological, physiological and systematic relationships of the ectoparasites and their hosts. Unfortunately, there has been no coordinated research effort, and much of the research has been directed only to economically important species or disease vectors. Consequently we are presented with a rather biased view of faunal relationships.

The Biological Survey of Canada (Terrestrial Arthropods) therefore recommends ways to improve the state of knowledge of Canadian arthropod ectoparasites: additional resources aimed at long-term objectives, increased awareness among a variety of biological disciplines, and fruitful avenues for future research.

LES ARTHROPODES ECTOPARASITES DE VERTÉBRÉS AU CANADA

Résumé

Les arthropodes ectoparasites sont des éléments divers de la faune canadienne et affectent fréquemment la performance et le bien-être de l'homme, des animaux domestiques et des animaux sauvages. La faune n'est pas bien connue, avec 17% seulement des espèces anticipées, décrites. Les acariens et les poux broyeurs en particulier, demandent plus d'étude. Le potentiel d'enquête scientifique des relations écologiques, physiologiques et systématiques des ectoparasites et de leurs hôtes est considérable. Malheureusement, il n'y a eu aucune recherche coordinée, et une grande partie de la recherche a été dirigée vers des espèces économiquement importantes ou vers des porteurs de maladies. Par conséquent, une vue relativement préjugée des relations de la faune nous est présentée.

La Commission biologique du Canada (Arthropodes terrestres) recommande donc des méthodes pour améliorer l'état de connaissances des arthropodes ectoparasites canadiens: ressources supplémentaires visées à des objectifs long-terme, une augmentation de conscience parmis une variété de disciplines biologiques, et des possibilités fructeuses pour des recherches futures.

Introduction

Arthropod ectoparasites are a diverse and highly adapted group of animals that inhabit the external body surfaces of vertebrates. They may live permanently on their host, or they may occupy the host's nest and immediate environment, and visit the body of the host periodically. In either case, there is a close dependency on the host for various life-sustaining resources. The relationship between parasite and host is an ancient one, and the mechanisms by which parasites seek, identify and maintain contact with their host are sophisticated and complex.

The potential and need for study of ectoparasites in Canada are as diverse as the fauna itself. There is a rich vertebrate host fauna which is reasonably well known, inhabiting a range of widely different habitats and geographic regions. Some of these host species are threatened or endangered where they are currently found in Canada, and if they disappear, there is a good chance that many species of parasites will suffer the same fate. Some ectoparasites are vectors of important human and wildlife diseases (e.g. Plague, Rocky Mountain Spotted Fever, Lyme Borreliosis), or create undesirable dermal immune responses (e.g. chigger mites, scabies). Ectoparasites have the potential to affect the health and general well being of wildlife and domestic animal populations, and they may seriously restrict habitat and land resource use

because of stress and reduced performance of animals living in a particular habitat. Development and use of land designated for recreational activities may also be affected by the threat of infestation of people and their companion animals by undesirable ectoparasites.

Therefore, the potential economic impact of ectoparasites is substantial. Despite this economic focus for study, research on most groups of ectoparasites has been fragmentary. This brief describes the relationships between arthropods and vertebrates, comments on the nature of the ectoparasite fauna of Canada as a whole, and indicates potential for study. Recommendations show how integrated, long-term studies on the ectoparasites in Canada can be supported.

Associations Between Vertebrates and External Arthropod Parasites

Vertebrates offer a variety of potential resources, and the nature and availability of these resources may influence the success of any ectoparasite species. The body itself is a cistern of renewable, nutrient-rich fluids. Some of the best known ectoparasites, the ticks, fleas and sucking lice among them, have modified mouthparts by which they can penetrate the skin and obtain these fluids. Specificity of the association with a vertebrate may, in part, be influenced by host behavior, the chemical nature of the body fluids, and the microhabitat created by skin and pelage.

The external surface of the body, too, is rich in potential food resources. Abraded and sloughed skin, sebaceous secretions, and microbial growth are consumed by some arthropods, for example the Mallophaga. The vertebrate body is a myriad of microhabitats in which scavenging species can be found. There are folds, pockets, and invaginations of the skin, and outgrowths of feathers or hair. All, in combination with variations over different regions of the body, allow for a high degree of specificity and relative isolation. Consequently, a single animal may harbour several ectoparasite species, some of which appear to compete actively with one another for available resources.

Typically, vertebrates select specific habitats in which to live, and may variously modify those habitats to suit their needs. Survival of some arthropods may be affected by biotic and abiotic factors quite independent of the host and its activity. Ixodid ticks, in particular, rely on host movement in specific areas to enhance the probability of encounter, but because they spend most of their life off the host, environmental conditions are as important to their survival as the presence of the host.

Most birds and many mammals construct a nest, either as a place to rest and hide, or to rear their young. Nests may be built in trees, shrubs, or other platforms, they may lie concealed on the ground, and are found in excavated or pre-existing cavities. Two nest conditions, other than the vertebrate species occupying the nest, are critical for ectoparasites found there. The microclimate within the nest is affected by the placement of the nest and the way it is made. For example, conditions inside a stick or leaf nest high in a tree will be substantially different from those inside the grass nest of a burrowing rodent. Ectoparasites which spend the majority of their time off the host, in the nest, or for which the nest is the only place in which certain life cycle stages occur (e.g. Siphonaptera), depend on the favourable environment which exists there. Ectoparasites which occur in nests used by their host for only one breeding season, or in one of several nests maintained by their host, must have effective dispersal mechanisms to locate a new host, or they may fail to develop a narrow dependency on that host. On the other hand, vertebrates which assume permanent residence in the nest, or which return predictably to a particular nest site may be host to a variety of highly specific parasites. In Canada, amphibians, reptiles, birds and mammals are partially or entirely terrestrial, and are hosts for arthropod ectoparasites relevant to the current discussion. There are approximately 856 species in these four groups, with considerable potential for colonization by arthropod ectoparasites.

The Canadian Arthropod Ectoparasite Fauna

It is not the intent here to provide extensive analysis of the relationships among ectoparasites and their hosts. There is evidence of a long association with a particular host species or group of species, and hence there is a varying degree of host specificity. There are several excellent reviews on the subject, the references for which are provided in Appendix 1. Nevertheless, it is useful to examine the breadth of the fauna, and treat each major group in general terms to show the extent of our knowledge on the group in Canada. Relevant data have been extracted from Danks (1979) to compile Appendix 2.

Among the major groups of the Acari, only the ticks (Metastigmata) are reasonably well known. The ticks are a relatively small group of medical and veterinary importance, with a larger body size than most acarines, and they have been studied by some Canadian specialists over the years (e.g. J.D. Gregson, P.R. Wilkinson). Concerns about their vector potential for Rocky Mountain Spotted Fever, tularemia and more recently, Lyme Borreliosis, and the ability of some species to induce tick paralysis have provided impetus for study. The Mesostigmata, on the other hand, are poorly known, with less than 30% of the Canadian fauna described or recorded. The very small families (e.g. Spinturicidae, Ixodorhynchidae), or those with economically important species (e.g. Dermanyssidae) are the better known, while others have been neglected. Among the Laelapidae and Haemogamasidae, only some species are ectoparasites, but relationships with hosts or with the nest environment are poorly known.

The prostigmatid mites (Acariformes) are enormously diverse in their life histories and degree of association with vertebrate hosts. Unfortunately, no one in Canada has ever directed their attention to this group of ectoparasites, and less than 2% of the total fauna is recorded or described. There is tremendous potential for study, particularly on the species associated with the skin and feathers of birds.

The pentastomids are a small, curious group of species in Canada. They can only loosely be defined as ectoparasites, since the adults are found in the air sacs of birds, or the respiratory passages of reptiles and mammals. They have been rarely encountered in Canada, and warrant further investigation.

Among the six orders of insects containing ectoparasites, most have received sufficient attention that the Canadian species have been described. The Siphonaptera are perhaps the best known because of over 40 years of work invested by G.P. Holland. The Anoplura includes many species associated with humans and domestic animals, which have received some attention. The ectoparasitic flies, beetles and bugs comprise few species. They are so striking in appearance, and are such a surprise when encountered, that they are usually preserved and retained when seen. The Mallophaga, however, are desperately in need of study with less than 50% of the Canadian species known.

Potential for Study

Arthropod ectoparasites and their hosts offer unique opportunities for research. These are divided into three broad, but of course interdependent, categories below.

1. ***Faunal Relationships***
   Because only about 17% of the ectoparasites expected to occur are known for Canada, fundamental work on species present and host relationships is needed. Even where species have been recorded for Canada, the number of records is often small, or localities are widely separated. Additional records for all ectoparasites are required, with the information integrated systematically with that available for the remainder of North America and the Palaearctic Regions.
   The basis and history of the relationship to a specific host or group of hosts offers a particular challenge. The fossil record for ectoparasites is very limited and hypotheses regarding phylogenetic relationships rely largely upon the extant fauna. However, the coevolutionary relationships among parasites and their hosts (e.g.Timm 1983; Kim 1985) may offer insight to past history (e.g. Traub 1972) and lead to the development of new avenues of investigation. Closer working relationships among vertebrate palaeontologists, systematists, and ecologists are important here.

2. ***Ecological Relationships***
   We lack basic understanding of fundamental life history relationships for most ectoparasites. Information on life cycles, reproductive strategies, developmental rates, temperature tolerances, diapause initiation and termination, and so on is needed for most species.
   There is also a need to test various ecological hypotheses using ectoparasites and their hosts, both at the community and population levels. Species of closely related or divergent taxa may compete for resources on the host or in the nest environment. Very little is known about dispersal patterns among ectoparasites. These arthropods must possess mechanisms for maintaining their position on the host, despite physical disturbance by the host during maintenance or grooming activities. Yet these same parasites must be able to transfer to new suitable hosts at the appropriate times. In some ways, a host can be viewed as a mobile island, and by dispersing or moving from that island, an element of risk is added to the parasites' existence. The proportion of individuals successfully colonizing a new habitat may be small, and the effects on the gene pool within the developing population are significant. We need to know more about the timing of such events, and the subsequent impact on the population.
   Once a parasite has reached a suitable host, numerous factors influence subsequent development and stability of the population. The microenvironment of the parasite is a major consideration, and the impact of these factors on parasite development is largely unknown. Host-related events, including growth, moulting, nest construction, reproduction, grooming, and humoral responses are important, but largely unstudied. Conversely, ectoparasites may have an impact on individual host behaviour and fitness, and perhaps ultimately the population structure of the host. This may be particularly evident when a pathogenic organism is transmitted by the ectoparasite.

3. ***Physiological Relationships***
   Many ectoparasites possess highly specialized physiological and biochemical mechanisms for survival on a host. The food they eat, i.e. body fluids and tissues, are complex materials and specific means for ingestion and digestion may be necessary. Metabolism of the food resources, and subsequent growth and development may be similar in many ways to the free-living arthropods, but insufficient data have been collected on most ectoparasite

species for valid comparisons to be made.
Reproduction in ectoparasites has attracted considerable attention, notably directed towards ticks and insects. Researchers are undoubtedly struck by some rather spectacular examples among ectoparasites (e.g. hypodermic insemination in cimicids, pupipary in flies, neosomy in fleas). Although a great deal of work has been conducted, it is restricted to a limited number of species and much of it is fragmentary.

Resources for Study

The study of arthropod ectoparasites has been driven in the past in Canada principally by the need for answers to specific problems affecting man, domestic animals or wild game species. Our knowledge of the fleas arose from initial concerns about plague in Western Canada. Where ticks caused paralysis and death in livestock in British Columbia, a specialist in the field was appropriated to conduct the needed research. Lice, keds, and mites are frequent pests on confined livestock and poultry and several studies have been conducted to measure impact on performance and for pest control.

The number of researchers available in Canada to respond to new problems is relatively small, and many of these researchers study other pests of vertebrates as well. Consequently, there is little flexibility in the system. A good example is in the need for information on the recently derived problem of Lyme Borreliosis in Canada. Lyme Borreliosis is a tick-borne disease that can be debilitating in clinical human cases. The bacterial pathogen responsible and the tick vector, *Ixodes dammini* Spielman *et al*., might be widespread in Canada. However, it has been difficult to mobilize the available resources to obtain answers to questions being raised by health officials and the public. We would be naive to believe that Lyme Borreliosis is a unique example where relevant basic information on ectoparasites is deficient, and where new problems cannot be addressed.

Therefore, it is necessary to maintain a basic core of expertise in Canada. This expertise should not be vitally linked to economically important problems. Typically, vector-borne diseases and problems with ectoparasites in Canada have been sporadic and generally isolated in their focus. Although we must continue to address these problems, we cannot support a research program that lives or dies on the basis of the number of clinical cases per year. Such programs do not survive over the long term in this country.

Rather, we should turn to the natural heritage of Canada to form the basic structure and support for continued research. While the amphibian, reptile, bird, and mammal faunas are reasonably well known in Canada, their ectoparasites are not. In any particular region of Canada, a great deal remains to be learned about the nature of the ectoparasite fauna, the ecological relationships with the available hosts, and the physiological mechanisms related to successful growth and development. Research on ectoparasites might very profitably be linked to that being carried out by vertebrate ecologists and physiologists, as well as parasitologists studying different classes of organisms in the same hosts. Opportunities for interdisciplinary research are available and should be pursued. Such collaboration would certainly enhance the vitality of a research program, and may eventually provide essential information for successful management and survival of threatened or endangered species. In the end, all will profit by a better understanding of the fauna of Canada, and our ability to respond to critical problems in vector-borne disease epidemiology and livestock or wildlife management will be greatly increased.

Recommendations

The arthropod ectoparasites of vertebrates are not well known in Canada, despite the significance of these organisms to man, domestic animals, and wildlife. The Biological Survey of Canada (Terrestrial Arthropods) therefore seeks to coordinate activities that will enhance research and encourage awareness. To this end, the Survey recommends:

1. ***Need for Resources***
   That additional personnel to study arthropod ectoparasites be hired.
   - These positions should be established to acquire a base of knowledge for a variety of long-term needs, and not be linked to particular disease epidemics/enzootics, or other short-term goals.
   - Additional positions should be established in universities, where opportunities for graduate projects will expand the current resource base.
2. ***Need for Awareness***
   That researchers in different biological disciplines be made aware of the interest and potential of arthropod ectoparasites.
   - Interdisciplinary research projects that include mammalogists, ornithologists, herpetologists, and parasitologists as well as researchers interested in ectoparasites should be initiated.
   - Ecologists and physiologists should be made aware of the potential for study of arthropod ectoparasites.
   - Meetings of entomological societies should be integrated with meetings of the societies dealing with the various host groups (especially birds and mammals), to encourage contact among researchers in different disciplines.
   - The interest of ectoparasites in a wide context (host biology, medical-veterinary entomology, parasitology, ecology, comparative morphology) should also be incorporated into university teaching materials.
3. ***Need for Research***
   That basic studies of ectoparasites should be carried out to discover what species occur in Canada, where they are found, and with what hosts they are associated.
   - In most groups, new species remain to be collected and described, coevolutionary and phylogenetic relationships have not been constructed, and biogeographic analysis is incomplete.
   - Information on parasitic acarines and lice (notably Mallophaga) is especially deficient.
   - Integrated work that involves entomologists and other zoologists should be emphasized.
   - New and existing knowledge, therefore, should be focused in a series of monographs, treating the various groups of ectoparasites, that assemble the available taxonomic, distributional, and biological information in one place.

APPENDIX 1 - SELECTED REFERENCES

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APPENDIX 2 - SYNOPSIS OF ARTHROPOD ECTOPARASITES OF VERTEBRATES IN CANADA

	No. spp. known	Est. no. spp. unknown	Percent of est. total spp. known	Known host associations
A. ACARI*				
Parasitiformes				
Mesostigmata				
Dermanyssoidea				
1. Laelapidae (in part)	38	80	32	birds, mammals
2. Haemogamasidae (in part)	9	10	47	birds, mammals
3. Dermanyssidae	4	4	50	birds
4. Macronyssidae	7	10	41	birds, mammals, snakes
5. Rhinonyssidae	3	50	6	birds
6. Halarachnidae	4	10	29	rodents, dogs, seals
7. Spinturnicidae	2	2	50	bats
8. Ixodorhynchidae	5	3	63	snakes
9. Entonyssidae	0	3	0	cattle
10. Raillietidae	0	1	0	cattle
	72	173	29	
Ixodides (Metastigmata)				
Argasoidea				
11. Argasidae	7	2	78	birds, mammals
Ixodoidea				
12. Ixodidae	20	2	91	mammals, birds
13. Amblyommidae	6	1	86	mammals
	33	5	87	
Acariformes				
Prostigmata				
Tydeoidea				
14. Ereynetidae (in part)	7	30	10	amphibians, birds, mammals

Cheletoidea				
15. Cheyletiellidae	3	20	13	birds, mammals
16. Cloacaridae	0	2	0	turtles
17. Myobiidae	7	20	26	rodents, bats, insectivores
18. Harphynchidae	2	20	9	birds
19. Syringophilidae	0	700	0	birds
20. Psorergatidae	4	50	7	mammals
21. Demodicidae	1	50	2	mammals
Trombidioidea				
22. Trombiculidae	7	70	9	birds, mammals
	31	962	3	

	No. spp. known	Est. no. spp. unknown	Percent of est. total spp. known	Known host association
Astigmata				
Freyanoidea				
23. Freyaniidae	0			
Pterolichoidea				
24. Pterolichidae	2			
25. Eustathiidae	0			
26. Faculiferidae	0			
27. Gabuciniidae	0			
28. Kramerellidae	0			
29. Rectijanuidae	0			
30. Syringobiidae	0			
Analgoidea				
31. Alloptidae	3	~2000	<1	birds
32. Analgidae	1			
33. Avenzoariidae	3			
34. Epidermoptidae	2			
35. Proctophyllodidae	3			
36. Xolaligidae	1			
37. Dermoglyphidae	0			
38. Apionacaridae	0			
39. Dermationidae	0			
40. Trouessartiidae	0			
Turbinoptoidea				
41. Turbinophidae	1	4	20	
Listrophoroidea				
42. Listrophoridae	7	10	41	mammals
43. Myocoptidae	5	3	63	mammals
44. Chirodiscidae	1	10	9	mammals
45. Atopomelidae	0	1	0	mammals
Psoroptoidea				
46. Psoroptidae	3	1	75	mammals
47. Audycoptidae	0	1	0	mammals
48. Yunkeracaridae	0	1	0	mammals
Sarcoptoidea				
49. Sarcoptidae	2	10	17	mammals
50. Knemidocoptidae	0	10	0	birds
Cytiditoidea				

51. Cytoditidae	0	10	0	birds
52. Laminosioptidae	0	25	0	birds
53. Pneumocoptidae	0	10	0	rodents
	34	~2096	2	

* The assistance of E. Lindquist (Biosystematics Research Centre, Agriculture Canada) on classification of the ectoparasitic Acari is gratefully acknowledged.

	No. spp. known	Est. no. spp. unknown	Percent of est. total spp. known	Known host associations
B. PENTASTOMIDA				
Cephalobaenida				
54. Reighardiidae	1	0	100	birds
55. Railletiellidae	0	1	0	reptiles
Porocephalida				
56. Porocephalidae	0	1	0	reptiles
57. Linguatulidae	1	0	100	mammals
	2	2	50	

	No. spp. known	Est. no. spp. unknown	Percent of est. total spp. known	Known host associations
C. INSECTA				
Mallophaga				
Ischnocera				
58. Philopteridae	200	250	44	birds
59. Trichodectidae	20	30	40	mammals
Amblycera				
60. Menoponidae	100	100	50	birds
61. Ricinidae	3	25	11	birds
62. Laemobothriidae	2	5	29	birds
63. Gyropidae	2	1	67	rodents
64. Boopidae	1	0	100	carnivores
65. Trimenoponidae	1	0	100	rodents, marsupials
Anoplura*				
66. Echinopthiriidae	4	2	67	marine mammals
67. Linognathidae	6	1	86	mammals
68. Pediculidae	1	0	100	humans
69. Haematopinidae	4	0	100	mammals
70. Hoplopleuridae	2	5	29	rodents, rabbits, hares
71. Enderleinellidae	2	3	40	
72. Polyplacidae	11	1	92	
73. Phthiridae	1	0	100	humans
Hemiptera				
74. Cimicidae	4	0	100	birds, mammals
Coleoptera				
75. Leptinidae	3	1	75	mammals
Diptera				

76. Hippoboscidae	11	4	73	birds, mammals
77. Nycteribiidae	1	1	50	bats
78. Streblidae	1	0	100	bats
Siphonaptera				
79. Pulicidae	10	0	100	mammals
80. Vermipsyllidae	5	0	100	carnivores
81. Hystrichopsyllidae	62	4	94	rodents, insectivores
82. Ischnopsyllidae	4	0	100	bats
83. Leptopsyllidae	19	1	95	rodents, lagomorphs, birds
84. Ceratophyllidae	80	5	94	mammals, birds
	560	439	56	
TOTALS	**732**	**3677**	**17**	

*Adopted from Kim et al. (1986)

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