ARTHROPODS OF SPRINGS: INTRODUCTION

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In the early days of civilization, springs were regarded as sacred places. The Roman philosopher Lucretius tells of the woodland retreats of nymphs "where waters issued with copious overflow, washing the wet and slippery stones and dripping on the green moss, and in places gushing forth upon the level plain". Although springs in general were hallowed, special sanctity was attached to those that served as the immediate sources of large streams and important rivers (Geikie 1912).

In 1982, the Scientific Committee of the Biological Survey of Canada (Terrestrial Arthropods) recognized that coldwater and warmwater springs contained animal communities worthy of special study. A project on springs stemmed from this recognition and aimed, in the long term, to further knowledge of the systematics, distribution, and general ecology of invertebrates, particularly insects, from these widespread but little known aquatic habitats (Williams 1983).

In parallel with its other initiatives, the Biological Survey attempted to develop new attention and coordinate existing interest in this topic among Canadian researchers. It soon became clear that scattered across the country were many individuals with some interest in springs. For some researchers, interest was, like that of the ancient Romans, somewhat eclectic, whereas others had more concrete aims or actual studies in progress. The Biological Survey's project on springs was particularly interested in intensive studies of regionally characteristic spring types which might lead to an understanding of variation in life cycles, community dynamics, trophic bases, dispersal mechanisms, effects of past environmental changes, and other primary scientific features perhaps unique to the faunas of these habitats. Springs represent the point of issue of groundwater, an important storage element, which, as was pointed out in the recent Report of the Inquiry on Federal Water Policy (Pearse et al. 1985) "is less well explored and documented in Canada than in many countries".

Initially, it proved difficult to pinpoint the exact location of springs in different parts of the country. Of course, famous hot springs in the west and some larger mineral springs in Ontario and Quebec were recorded in the literature (e.g. Elworthy 1918; van Everdingen 1970; Souther and Halstead 1973) but because most of these have been capped for controlled, commercially managed discharge and now have no naturally existing stream channel or associated biota, they are of little use for biological study. Some provincial agencies were able to supply information on spring locations and, occasionally, on water chemistry but such data were totally lacking in many regions — particularly in the Maritimes. Correspondence with federal agencies confirmed that no Canadian agency maintains a national inventory of groundwater data nor a record of springs. Even estimates as to the approximate numbers of springs in different regions of Canada and a consensus on their definition do not exist. From a management point of view, springs are key features in many national and regional developments through their use as sources of drinking water, commercial bottled water operations, fishing, therapeutic properties, appreciation of nature, and tourism.

Some random collections of specific taxa from springs form part of the general holdings of national or regional museums. However, these collections seldom have sufficient accompanying habitat descriptions to make them useful except in an introductory capacity.

Despite these shortcomings, some interesting findings were possible about the Trichoptera, for example (Williams and Williams 1987).

Compared with most other aquatic habitats, the biological characteristics of Canadian springs still are relatively unknown. Despite their academic and more applied interest, we are far from a detailed understanding of the animal communities of springs and consequently there is much research still to do.

Academically, spring faunas may hold the answers to unique questions of endemism and zoogeography because the habitats are discrete. Moreover, specifically for Canada, post-Pleistocene colonization patterns may be visible because spring faunas may recover only slowly after having been damaged or removed by glaciation. Springs hold a position of importance as study areas that is far out of proportion to their size and number compared with other types of environments. They are, as Odum (1971) has stated, "the aquatic ecologist's natural constant temperature laboratory because of the relative constancy of the chemical composition, velocity of water and temperature". However, apart from a few earlier, classic papers on spring faunas in Europe (e.g. Nielsen 1950; Iversen 1976) and the United States (e.g. Odum 1957; Teal 1957; Tilly 1968) relatively few thorough ecological studies have been forthcoming (see Williams and Smith 1990).

In a more applied, and as yet largely unappreciated, sense spring faunas may provide useful and relatively inexpensive indicators for monitoring groundwater quality using the very simplest of sampling methodologies as, for example, when contamination from various point or non-point sources is suspected. Further, because the faunas of springs live there permanently, integrating the effects of geology, vegetation, and climate in space and time, they would provide an additional and especially accurate index of groundwater quality and history. In this sense, biological study of springs could provide an effective tool for the management of groundwater resources (Williams et al. 1990; Williams 1991).

Because each spring is a discrete entity that can be relatively easily assessed, springs are amenable to meaningful inventory. This feature, alone, makes springs and their faunas of considerable value in assaying the condition of groundwater resources. Quite apart from this, the fact that springs are unique habitats makes them valuable resources in themselves and many may prove to be habitats worth preserving.

The Survey's project on springs led to a symposium on the "Arthropods of Springs, with Particular Reference to Canada", which was held in St. John's, Newfoundland, on 3 October 1989 as part of the joint Annual Meetings of the Entomological Society of Canada and the Acadian Entomological Society.

Papers presented at the Symposium summarized current information on the ecology and systematics of faunas of a variety of Canadian spring types. These proceedings are published here. The first paper presents an overview of the physical, chemical, and distributional aspects of spring habitats in Canada and sets the scene for other, largely faunistic papers. The first of these papers attempts an analysis of the environmental factors that control the structure of arthropod communities in springs. A second paper summarizes what is known of saline springs in British Columbia. Two papers then consider how insects cope with the particular conditions in springs, one examining the life history traits of aquatic insects and the other the insects in thermal springs. Subsequent papers present features of specific arthropod groups important in these habitats: Trichoptera, Coleoptera, Acari, Chironomidae, and Ostracoda, the latter pointing out applications in paleohydrology. A concluding paper synthesizes relevant knowledge about Canadian spring faunas, seeks appropriate ways to define spring habitats, and identifies research needs for the future.

In editing these papers, we have deliberately permitted a reasonable degree of latitude in style and approach to the subject material in order to allow a certain diversity of orientation and opinion to surface. We hope that this set of papers outlining our current

knowledge of these discrete and fascinating habitats will serve as a useful springboard for more intensive study.

References

Elworthy, R.T. 1918. Mineral springs of Canada, Part II. The chemical character of some Canadian mineral springs. *Can. Dep. Mines, Mines Brch Bull.* **20**: 1–173.

Geikie, A. 1912. The Love of Nature among the Romans, John Murray, London. 349 pp.

Iversen, T.M. 1976. Life cycles and growth of Trichoptera in a Danish spring. *Arch. Hydrobiol.* **78**: 482–493.

Nielsen, A. 1950. On the zoogeography of springs. *Hydrobiologia* **2**: 313–321.

Odum, E.P. 1971. Fundamentals of Ecology, 3rd ed. W.B. Saunders, Toronto, Ont. 574 pp.

Odum, H.T. 1957. Trophic structure and productivity of Silver Springs, Florida. *Ecol. Monogr.* **27**: 55–112.

Pearse, P.H., F. Bertrand, and J.W. MacLaren. 1985. Currents of change. Final Report. Inquiry on Federal Water Policy, Ottawa, Canada. 222 pp.

Souther, J.G., and E.C. Halstead. 1973. Mineral and thermal waters of Canada. *Geol. Surv. Can. Pap.* **73-18**: 225–256.

Teal, J.M. 1957. Community metabolism in a temperate cold spring. *Ecol. Monogr.* **27**: 283–302.

Tilly, L.J. 1968. The structure and dynamics of Cone Spring. *Ecol. Monogr.* **38**: 169–197.

van Everdingen, R.O. 1970. Seasonal variations, Sulphur Mountain Hot Springs, Banff, Alberta. *Inland Waters Brch, Dep. Energy Mines Resources Can., Tech. Bull.* 33. 11 pp.

Williams, D.D. 1983. National survey of freshwater springs. *Bull. ent. Soc. Can.* **15**(1): 30–34.

——— 1991. The spring as an interface between groundwater and lotic faunas and as a tool in assessing groundwater quality. *Verh. int. Verein. theor. angew. Limnol.* **24**. In press.

Williams, D.D., H.V. Danks, I.M. Smith, R.A. Ring, and R.A. Cannings. 1990. Freshwater springs: A national heritage. A brief prepared by the Biological Survey of Canada (Terrestrial Arthropods). *Bull. ent. Soc. Can.* **22**(1), *Suppl.* 8 pp.

Williams, D.D., and I.M. Smith. 1990. Spring habitats and their faunas: An introductory bibliography. Biological Survey of Canada (Terrestrial Arthropods), Ottawa. (Biol. Survey of Canada Document Series No. 4.) 156 pp.

Williams, D.D., and N.E. Williams. 1987. Trichoptera from cold freshwater springs in Canada: Records and comments. *Proc. ent. Soc. Ont.* **118**: 13–23.

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