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Three detailed, radiocarbon-dated, Holocene tufa and alluvial fan mollusc successions from southern Ontario: The first in northeastern North America

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Abstract

Fossil mollusc remains, particularly those of land snails, provide a wealth of detailed information concerning local Quaternary paleoenvironments and regional paleoclimatic conditions. However, this important resource is generally overlooked in North America and consequently quantitative, well-dated terrestrial mollusc successions are extremely rare here. In an attempt to redress this imbalance, a project examining the Holocene molluscan faunal history of northeastern North America has been initiated. Thus far, detailed mollusc successions and associated radiocarbon age determinations have been obtained from three sites in southern Ontario; two alluvial fans (Chine Drive Fan and Cudia Park Fan, both from the Scarborough Bluffs east of Toronto) and a tufa (West River Road, near Cambridge). The observed land snail successions to provide an initial view of the molluscan faunal history of this region during the period from the late glacial to the mid Holocene, between approximately 10,500 and 5000 radiocarbon years BP (yr BP). The molluscan data have also been used to reconstruct the paleoenvironmental history of southern Ontario during this time, documenting the progression from exposed, open habitats characterised by species such as *Vertigo modesta*, *Vallonia albula*, *Columella columella* and *Vitrina angelicae limpida*, to closed woodland biotopes indicated by the presence of taxa including *Carychium nannodes*, *Nesovitrea binneyana*, *Paravitrea multidenta* and *Helicodiscus parallelus*. This study has already demonstrated the potential of this technique in the study of Quaternary climatic and environmental change in eastern North America and represents a strong foundation for extending the analysis of fossil land snail successions to other sites throughout this region. It has also provided new and important insights into the establishment of the modern molluscan fauna, which are essential to the understanding of present day distributional patterns and environmental associations.

Keywords: Land snails; Biostratigraphy; Radiocarbon; Ontario; Holocene

1. Introduction

The majority of Quaternary paleoecological investigations are based on palynology. Pollen, released into the atmosphere by flowering plants, becomes trapped in accumulating sediments, thereby preserving a record of vegetational, and inferred environmental, conditions at the time of deposition. As most pollen disperses over large

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areas, such records usually reflect regional conditions. While clearly exceptionally useful, it must also be acknowledged that fossil pollen sequences do have their limitations. The nature of the record preserved can vary greatly, being influenced by factors such as topographical position (e.g. local relief, proximity to large waterbodies), the character of the sediments being examined and, not least of all, the nature of the pollen and source vegetation themselves (Simmons, 1996). Consequently, study sites must be chosen carefully to reflect the goals of a particular palynological investigation. Fortunately, pollen is by no means the only type of fossil available to the Quaternary paleontologist. Other floral and faunal groups regularly employed include plant macrofossils (e.g. seeds, fruits, phytoliths, wood and leaf impressions), diatoms, molluscs, ostracodes, insects and vertebrates.

The value of fossil mollusc assemblages, particularly those containing land snails, as paleoecological indicators has long been recognised. They can furnish a wealth of detailed paleoenvironmental information and possess a number of advantages over pollen (Simmons, 1996):

- Mollusc shells survive well in a wide range of sediments, including oxidized deposits that rarely preserve other fossil groups, particularly pollen.
- In addition to conveying a *regional* paleoclimatic overview, fossil land snail assemblages provide detailed information relating to *local* paleoenvironments, such as whether a site was open or shaded, wet or dry, at the time of deposition (e.g. Sparks, 1961, 1964).
- The ability to identify most snails to species level, as opposed to generic or family level as is the case with many pollen grains, further improves the accuracy and detail of the paleoecological information obtainable.
- Since snails frequently reflect very local conditions, fossil mollusc faunas are particularly useful at detecting small-scale disturbance resulting from anthropogenic activity (Preece et al., 1986) and are, therefore, frequently utilised during archaeological investigations (Evans, 1972).

Until now, North American paleoenvironmental reconstructions have tended to focus on bogs and lakes, chiefly because of the predominance of pollen studies, which emphasize those types of depositional sites. Other types of sedimentary records have been largely neglected. Consequently, only a limited range of nominally terrestrial environments has been subjected to detailed paleontological study.

The recentness of glaciation over the northern half of North America set a late lower boundary for the commencement of non-glacial sedimentary sequences and as a result alluvial records are typically short. There has been little interest in Canada in documenting and analyzing the history of stream valley development, although this could provide valuable contributions to broadening our knowledge of landscape evolution. These would, in turn, be of great significance in, for example, our understanding of human history. An important facet of fluvial processes and sedimentation is the alluvial fan. Fans are dominant landforms in the desert southwest, but actually occur widely as smaller features in all landscapes. Although given significant attention in the southwestern and southeastern (unglaciated) USA, they have been generally ignored in the north. The information provided by their geomorphic processes, stratigraphy and paleontology is rarely utilised. Recent exceptions that may signal a new trend are the works of Campbell (1998) in southern Alberta and Jennings et al. (2003) in Vermont. However, neither of these studies dealt with fossil molluscs.

1.1. History

In Europe, while nowhere near as ubiquitous as palynological investigations, molluscan analysis is a technique commonly employed, often in conjunction with other disciplines, such as sedimentology, vertebrate paleontology, archaeology and palynology. The significance of non-marine molluscan successions has long been recognised by North American Quaternary scientists (e.g. Bell, 1861; Cheatum and Allen, 1965; Taylor, 1965) and Miller and Bajc (1990) extol the particular virtues of fossil land snails as paleoecological tools. Nevertheless, these important repositories of detailed information on the paleoenvironmental and faunal history of this continent remain a largely untapped resource. Of those studies conducted in North America thus far, most have concentrated on aquatic assemblages (e.g. Warner, 1968; Miller et al., 1985; Kerr-Lawson et al., 1992; Karrow et al., 1995; Warren and Harington, 1998), although admittedly this often has not been simply a matter of choice. The Great Lakes region, for example, is located on glaciated terrain dissected by innumerable rivers and lakes and thus the majority of Quaternary sediments encountered are aquatic in origin. Of those terrestrial studies that do exist, many are restricted to bed-by-bed examinations or simple lists of the species encountered (e.g. Hubricht, 1962, 1964a,b; Miller and Eshelman, 1985), although sometimes this is clearly a result of low shell abundances (e.g. Miller et al., 1994a). While the scarcity of such information in North America means these investigations are undoubtedly valuable, modern scientific principles now call for a more detailed approach.