marginal only on one or both sides of the test or complete. The septal flap may extend into a umbilical plate, a foramenal plate, a bipartitor, a cover plate, or a toothplate. [Paries proximus, pars auct.]

Supplementary apperture(s).—Primarily formed openings either in apertural face ("apertural pores") or (slit-like) in sutural position, always in addition to a main cameral aperture. Sutural supplementary apertures are not converted into intercameral foramina because of their position and thus do not serve for passage of functional endoplasm between chambers. The same seems to be true of multiple supplementary apertures, which, although situated in the septum, may be absent in earlier chambers and may be plugged in part at a subsequent instar. [Secondary aperture(s), pars. auct.]

Toothplate.—A contorted plate running from an intercameral foramen to an aperture, attached to both. Folded in a single, double, or spiral fold. Folds (or tongues) with free, often serrated distal ends and distally protruding into the aperture. A toothplate separates partly or entirely the main chamber lumen from an axial space (adapertural depression) in post-embryonic stages. Interconnected toothplates produce a primary canal. In contrast to an umbilical plate, the toothplate is never associated with a foliar or stellar chamberlet and it does protrude with a free edge distally and adaxially to the aperture. [Sipho-central pillar, pars auct.]

Umbilical bowl.—A deep, wide or narrow conical space in axial position formed between inner umbilical chamber walls, wherever the latter are separated from the outer umbilical walls by a distinct edge or shoulder; may communicate with a true open umbilicus or may be closed by an umbilical plug. [Pseudoumbilicus, pars auct.]

Umbilical plate.—A more or less contorted plate-like test element, extending between distal and proximal chamber walls and joined to both, attached to the intercameral foramen and to the main aperture, but not protruding into the latter. Separates the main chamber lumen from a primary spiral umbilical canal, produced between plate and adjacent coil or by foliar chamberlets, or from stellar chamberlets. Between plate and adjacent coil or within the plate itself an opening provides connection between chamber and foliar or stellar chamberlet, wherever present. This opening may remain open in all chambers or it may be "plugged" in all but the ultimate chamber by a sealing plate. An umbilical plate may be single or composed of two symmetrical branches in some planispiral genera, thereby producing one or two spiral umbilical canals between plate and adjacent coil. [Foramenal plate; umbilical flap; murus reflectus; toothplate; paries proximus; pars auct.]

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DISTRIBUTION AND POSSIBLE PALEOECOLOGICAL SIGNIFICANCE OF *ANNECTINA VIRIOSA*, A NEW SPECIES OF AGGLUTINATED FORAMINIFERA FROM NONMARINE SALT PONDS IN MANITOBA

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ABSTRACT—*Annectina viriosa,* a new species of Ammodiscidae (Foraminiferida), is described from Recent brackish ponds on a salt flat adjacent to Lake Winnipegosis, Manitoba. Colonization of the ponds was probably by avian transport. The distinct morphotype is either the result of an allopatric speciation event within the last 5,000 years or it is a previously undescribed species of shallow-water *Annectina* from nearby Hudson Bay. It is also possible that recovered specimens are previously unrecognized ecophenotypic variants of some known species produced by unknown hostile environmental factors within the pond ecosystem. The latter hypothesis is difficult to test without extensive biological culturing. The large number of phenotypically stable specimens living in these ponds warrants recognition of these populations as a distinct taxon.

INTRODUCTION

During a distributional analysis of nonmarine foraminifera from salt ponds of the Lake Winnipegosis region of Manitoba, a species of *Annectina* Suleymanov, 1963, was observed that was not referable to any previously described species (Patterson et al., in press). The foraminiferal fauna at most sampled Lake Winnipegosis localities was dominated by *Jadammina macrescens* with lesser numbers of *Polysaccammina ipohalina.* This fauna is very similar to those found in marshes that border Hudson Bay and James Bay (Patterson et al., 1990; Scott and Martini, 1982). Numerous previous reports attribute the establishment of foraminiferal faunas in the Lake Winnipegosis region to avian transport (Resig, 1974; Cann and De Deckker, 1981; Patterson, 1987; Patterson et al., 1990).

Difficult to explain, however, is the enigmatic occurrence of an *Annectina* sp. dominated fauna in brackish ponds just west of Lake Winnipegosis (Figures 1, 2; Patterson et al., 1990). *Annectina* is a comparatively rare genus—it has previously only been observed in Paleocene sediments from central Asiatic USSR and from Holocene deposits in Australia—and has never been reported from marsh environments, although the closely related genus *Glomospira* Rzehak, 1885, has occasionally been reported from estuarine environments (Scott et al., 1980). The tolerance of this latter genus to low-salinity estuarine environments may explain the tolerance of *Annectina* specimens for the brackish water (17.00–20.72‰) characterizing the ponds at the Lake Winnipegosis locality.

METHODS AND MATERIALS

Foraminifera were examined from a brackish pond on a salt flat 4 km north of the intersection of Manitoba Provincial Highways No. 20 and No. 271 (Figure 1). This locality consists of a

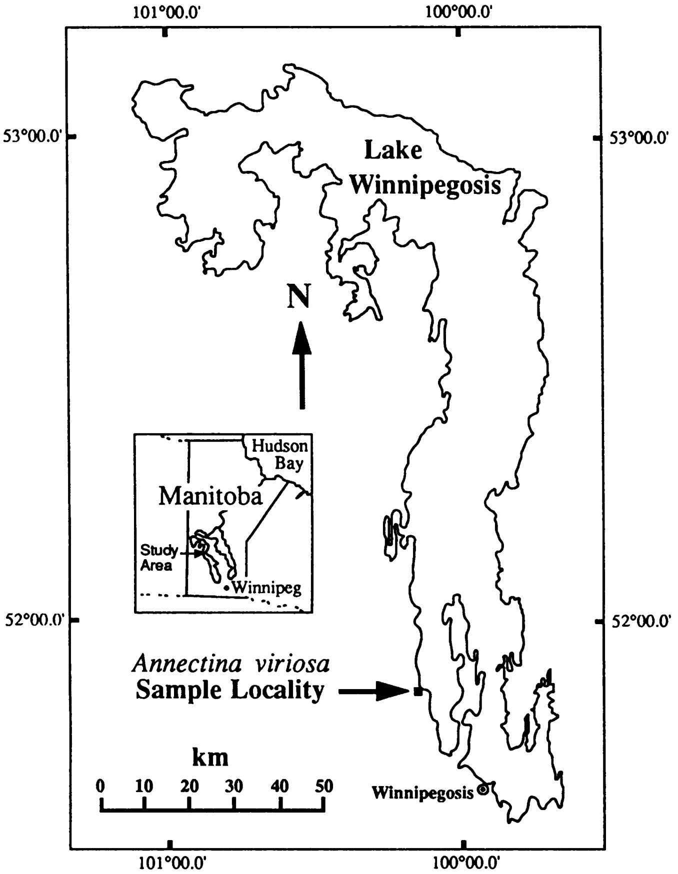

FIGURE 1—Location map of Lake Winnipegosis, Manitoba, showing *Annectina viriosa* type locality.

TABLE 1—Percent abundance of foraminifera and arcellaceans from a brackish pond near Lake Winnipegosis, Manitoba; L = living, T = total population; SF = salt flat environment.

Sample		May 88	Sep 88	Jul 89
Salinity		17.00	20.72	—
pH		8.2	8.0	—
Water temperature (°C)		23.0	16.0	—
Environment		SF	SF	SF
No. of species		4	3	1
Number of individuals/10 cc	L	0	11	0
	T	27	120	24
Arcellaceans				
D. protaeiformis	L			
	T	4.0		
Foraminifera				
A. viriosa	L		8.3	
	T	74.0	47.5	100.0
P. ipohalina	L			
	T		1.7	
J. macrescens	L			
	T	18.0	41.7	
J. macrescens (polystoma phenotype)	L			
	T	4.0		

series of interconnected shallow ponds (3–7.5 cm deep) partially separated by a number of low hummocks (Figure 2). The entire area covered by ponds is about 20,000 m². One of the larger ponds at this locality, where all samples were collected, is about 20 m long by 6 m wide (120 m²). This locality coincides with Sample Station 6 of Patterson et al. (1990). Samples analyzed for this report were collected from this sample station three times: 27 May 1988; 27 September 1988; and 11 July 1989 (Table 1). Physicochemical parameters, such as water temperature and pH, were measured at the time of collection. Water salinity was calculated from chlorinity measurements using the equation (Strickland and Parsons, 1968):

$$\text{salinity (‰)} = 0.030 + 1.8050 \times \text{chlorinity (‰)}.$$

FIGURE 2—*Annectina viriosa* n. sp. type locality, *with* numerous interconnected small ponds.

Buffered formalin (7.5 percent with borax added to buffer the solution) was initially added to the biological samples to prevent decay. In the laboratory, rose Bengal stain (a few grains) was added to the samples to detect specimens of foraminifera living at the time of collection. After several hours the samples were rinsed to remove excess stain. Samples were then sieved using a 35-mesh Tyler (500 μm) screen to retain coarse organic material and a 230-mesh Tyler (63 μm) screen to retain the arcellaceans and foraminifera. Scanning electron micrographs were taken using the Cambridge Stero-Scan 90 scanning electron microscope located at the Geological Survey of Canada, Vancouver, British Columbia, using Polaroid NP 55 film.

DISCUSSION

Three hypotheses possibly explain the presence of this distinct phenotype of *Annectina* in the Lake Winnipegosis region:

1) An allopatric speciation event occurred in these ponds following the establishment of a small founder population. A good argument can be made for recognition of this population as a separate species. This phenotype is so distinct that it is not obviously referable to any known species, and a large population (101 specimens) was recovered. This population is characterized by a very stable phenotype (displaying little morphologic variation) and many living specimens, indicating that the species has probably been at this locality for many generations. This also suggests that the species is very hardy and capable of withstanding salinity shifts and the desiccation events that occasionally occur in most salt pond environments. The ponds from which *Annectina* specimens were recovered, however, shrink slightly during drought conditions but have never been observed to dry completely. In winter these ponds do not freeze completely but become slushy. Cann and De Deckker (1981) identified species of trochamminid and elphidid foraminifera from ephemeral lakes in southwest Australia that could withstand both salinity shifts and seasonal desiccation events.

It is not known whether the *Annectina* specimens from Lake Winnipegosis have been at this location long enough to speciate. Rates of speciation vary greatly depending on the type of organism and its population structure (Futuyma, 1986). For example, some plant populations that have been isolated for at least 20 million years, such as the American and Mediterranean plaintains, form viable hybirds (Stebbins and Day, 1967). In contrast, Fryer and Iles (1972) reported that several distinct species of cichlid fishes are endemic to Lake Nabugabo, which is separated from Lake Victoria in Africa by a strip of low-lying land that has been dated by radiocarbon analysis to have developed only 4,000 years before present (B.P.). Under the right conditions speciation can therefore be an almost instantaneous event (Eldredge and Gould, 1972).

Following a warm phase, approximately 5,000 years B.P., climatic conditions rapidly deteriorated in northern North America. Conditions similar to those presently found in the Lake Winnipegosis region have existed for at least 4,000 years (Scott et al., 1987). Patterson et al. (1990) observed that the present distribution of foraminifera in the Lake Winnipegosis area is significantly different from that of the foraminiferal fauna inhabiting the region 5,000 years before present (Nielsen et al., 1987). Unfortunately, no cores were taken to determine the duration of *Annectina* at this locality. However, based on the above caveat on speciation rates, it is entirely feasible that this population of *Annectina* may have existed in this area for over 4,000 years and has evolved to represent a distinct species.

2) The *Annectina* specimens found on the salt flat are ecophenotypic variants of populations living in marine environments. The distinct morphology displayed by individuals found at this locality is the result of a phenotypic response to environmental factors.

Ecophenotypic variation is well documented in many species of foraminifera, such as the shallow-water species *Cribroelphidium excavatum* (Miller et al., 1982), the marsh species *Jadammina macrescens* (Scott and Medioli, 1980; Patterson, 1990), and the planktonic foraminifer *Neogloboquadrina pachyderma* (Reynolds and Thunell, 1986; Yeh et al., 1989). Miller et al. (1982) observed that the greatest morphological variability in *Cribroelphidium excavatum* is found in nearshore temperate estuaries that are subject to extremes in climate and environmental conditions. Similarly, *Jadammina macrescens* has a tendency toward subareal supplementary apertures in higher salinity environments, whereas phenotypes from lower salinity environments typically have none (Scott and Medioli, 1980; Patterson, 1990). Finally, northeastern Pacific populations of *Neogloboquadrina pachyderma* tend to reverse coiling directions depending on the water temperature. In addition, the amount of nutrients in the water column determines the shape and level of encrustation of the test (Reynolds and Thunell, 1986). The environmental conditions existing in the ponds may be stressing the metabolism of *Annectina*. Although the observed phenotype is dissimilar to any phenotype displayed by *Annectina* elsewhere, it is possible that the recovered specimens are ecophenotypic variants of an existing species.

3) These specimens are phenotypically similar to an undescribed species living in the Hudson–James Bay area, since the foraminifera of this region are not well known.

The presence of a large, morphologically stable population of living and dead specimens at this locality supports the hypothesis that this species is the result of an allopatric speciation event, or is an unknown species from Hudson or James Bay. If later studies should prove this species to be a radically different ecophenotypic variant of some well-known species, it can easily be placed in synonymy. The taxonomic relationships and ecological significance of this and other Ammodiscidae could only be obscured by misidentification of these specimens with respect to species.

SYSTEMATIC PALEONTOLOGY

Family Ammodiscidae Reuss, 1862
Subfamily Ammovertellininae
Saidova, 1981
Genus *Annectina* Suleymanov, 1963
Annectina viriosa n. sp.
Figure 3.1–3.6

Diagnosis.—Ovate species of *Annectina* with axis of coiling more or less in same plane.

Description.—Test free, compressed in plane of coiling of outer whorl, proloculus followed by undivided second chamber tightly appressed against outer walls of earlier whorls that serve as floor for chamber; enrollment about elongate axis for 2–4 whorls; specimens with two whorls elongate, specimens with more than two whorls more circular; width of second chamber rapidly increasing as added, second chamber coiled in various planes, although by third or fourth whorl coiling more or less planispiral, apparent planispiral coiling arrangement somewhat illusory due to large size of third and fourth whorls relative to earlier whorls, occasional sigmoidally coiled specimens observed; wall agglutinated, imperforate, of medium- to fine-grained detrital sand, with pennate diatoms incorporated into walls of some specimens, approximately 8.5 μm thick in outer whorl; simple aperture at end of tube, of same width as chamber, surrounded by slightly produced lip.

Etymology.—From the Latin *viriosus*, robust, strong, with reference to the survival of this species in this brackish nonmarine environment.

Types and occurrence.—Recent. Figured holotype (GSC 96786), figured paratypes (GSC 96787–GSC 96790) and unfigured paratypes (GSC 96791) from a brackish pond on a salt flat 4 km north of the intersection of Highways No. 20 and No. 271, near Lake Winnipegosis, Manitoba. Deposited in the collections of the Geological Survey of Canada, Ottawa, Ontario.

Dimensions.—Maximum length, 350 μm; maximum width, 325 μm; maximum thickness, 125 μm.

Remarks.—Comparison of type illustrations shows *Annectina viriosa* to be very similar in appearance to *Trochammina milioloides* Jones, Parker, and Kirkby (1869) from the Permian of England. Due to the tremendous temporal difference it is unlikely that these forms are conspecific, although it is difficult to assess similarities and differences due to a lack of detail in the type description of *Trochammina milioloides*. It is also impossible to compare type material as the respository of this latter species is unknown (Ellis and Messina, 1940). *Annectina viriosa* is also similar in outline to *Ammodiscus peruvianus* Berry (1928). However, Berry's species has 4–5 whorls and is entirely planispiral, as opposed to the 2–4 whorls and more variable coiling characterizing the *Annectina viriosa* test. It was initially thought that *Annectina viriosa* might be an ecophenotypic variant of *Trochammina squamata gordialis* Jones and Parker (1860), the type species of *Glomospira* Rzehak, 1885 (now known as *Glomospira gordialis*). This was based on the probable original colonization of the Lake Winnipegosis area by foraminifera transported from shallow-marine environments elsewhere (Patterson et al., in press). *Glomospira gordialis* has been reported from relatively shallow, brackish estuarine environments in Nova Scotia (Scott et al., 1980) with salinities similar to the brackish values recorded at the Lake Winnipegosis area locality. However, *Glomospira gordialis* has numerous streptospirally coiled whorls and very distinct sutures between whorls. In contrast, *Annectina viriosa* has a maximum of only four whorls, despite

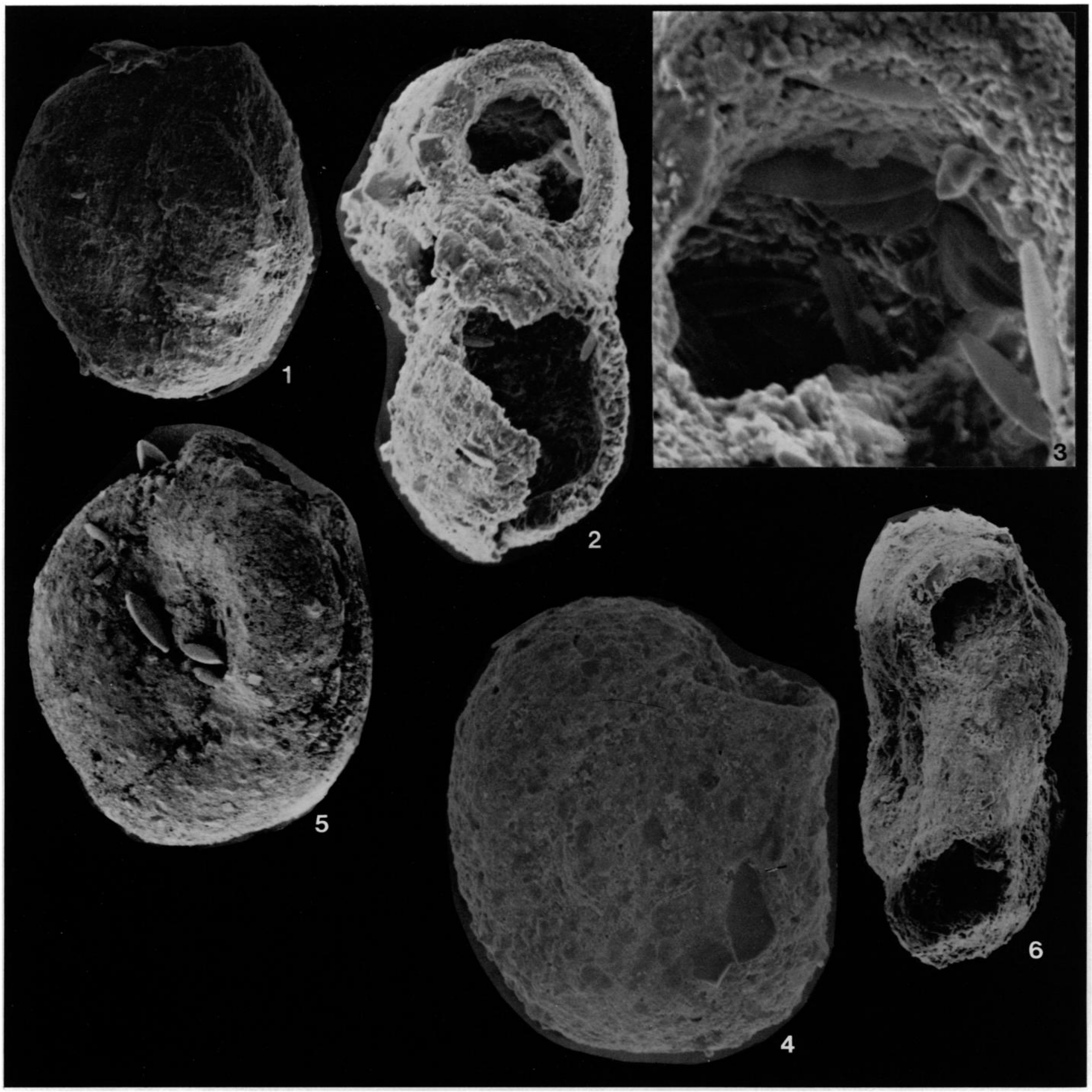

FIGURE *3*—*1–7*, *Annectina viriosa* n. sp., brackish pond near Lake Winnipegosis, Manitoba, Recent. *1*, side view of holotype (GSC 96786) showing somewhat elongated test, ×302; *2*, apertural view of damaged paratype (GSC 96787) showing large aperture, which is just an opening at the end of the enrolled second chamber; damage to test (while reorienting) in lower part of very delicate test shows relative thickness of wall to test size, ×489; *3*, enlargement of aperture of same specimen showing large numbers of pennate diatoms on inner surface of test, ×1,720; *4*, side view of same paratype showing slightly flared apertural opening, ×379; *5*, side view of paratype (GSC 96788) showing change in orientation of coiling of final whorl, ×200; *6*, edge view of paratype (GSC 96790) showing compressed test and apertural region where wall of previous chamber can be seen serving as the floor of final whorl; opening at bottom of illustration is damage to the test, ×261.

being about the same size as *Glomospira gordialis*, and is elongate and compressed with the axis of coiling of later whorls more or less in a single plane. *Annectina viriosa* also has much less distinct sutural contacts between whorls and the relative breadth of the whorls is much greater than in *Glomospira gordialis*. Based on such radical morphologic differences, it is not possible to refer the present species to *Glomospira gordialis*.

Numerous unicorporated pennate diatom frustules were found on the interior of many tests of *A. viriosa* (Figure 3.3), indicating a probable food source.

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