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Distribution of Hydrilla in Northern China: Implications on Future Spread in North America

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ABSTRACT

Hydrilla (*Hydrilla verticillata* L.f. Royle) has greatly expanded its range in the USA since it "escaped" cultivation in Florida streams in the early 1950s. It now occurs in all the southern border states, as well as along the eastern seaboard as far north as Delaware, but further northward expansion by hydrilla in the U.S. appears controversial. We have recently been collecting potential biological control agents for hydrilla in China, and present our observations on the density and distribution of hydrilla in northern China. These are supplemented by data from hydrilla specimens in the herbaria of various Chinese scientific institutions, as well as literature records from northern Asia. These collections, along with comparisons of climatic data, indicate that hydrilla has the potential to grow in aquatic habitats almost anywhere in North America, including Canada and parts of Alaska.

Key words: *Hydrilla verticillata*, range expansion, Harbin, Sino-American Biological Control Laboratory, Manchuria.

INTRODUCTION

Hydrilla is a submersed Hydrocharitaceae, native to Australia (Swarbrick *et al.* 1981) and to Asia and Central Africa (Cook and Luond 1982). Hydrilla was introduced into the United States in 1951 or 1952 by an aquarium fish and plant dealer who released six bundles of hydrilla from Sri Lanka

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(then Ceylon) into a canal near his business in Tampa, FL (Schmitz *et al.* 1991). Hydrilla's spread in Florida was rapid, but it was incorrectly identified as *Elodea canadensis* Rich., or sometimes as *Egeria densa* Planch., until 1965 (Blackburn *et al.* 1969). The hydrilla in Florida is dioecious, with only the pistillate (female) form being present. Despite the lack of sexual reproduction (and therefore seeds), by the early 1980s, pistillate hydrilla had spread westward across the southern states into California, while simultaneously moving northward into Georgia, Alabama and North Carolina (Steward *et al.* 1984). Around this time, hydrilla was discovered in Washington, D.C. (Haller 1982). This infestation, along with those in Delaware, Maryland, North Carolina and Virginia, consisted of the monecious (both male and female flowers on the same plant) form, and was apparently the result of a new introduction from an unknown foreign source (Steward *et al.* 1984).

Forty years after its introduction, hydrilla infestations in the U.S. continue to expand. In Florida during 1991, hydrilla infested over 26,000 Ha, the most ever recorded (Schardt 1992) in state-sponsored surveys, and appears to be becoming more troublesome in some of the other states where it was introduced more recently. Several scientists (Balciunas 1985, Steward and Van 1987) have noted that, based on its distribution in northern Europe, the potential range of hydrilla in North America could include all of the U.S. as well as southern Canada. However, in the past decade few new states have been added to the list of those infested by hydrilla, encouraging some people to hope that hydrilla's geographical expansion in the U.S. has ceased.

We believe that our recent investigations into hydrilla's distribution in the Peoples Republic of China have relevance to this weed's future spread in the U.S. In 1989, the U.S. Dept. of Agriculture, in cooperation with the Chinese Academy of Agricultural Sciences, jointly established the Sino-American Biological Control Laboratory (SABCL). One of the initial (and still major) projects at the SABCL was the search for biological control agents for hydrilla and Eurasian watermilfoil, *Myriophyllum spicatum* L. (Balciunas 1990). While the SABCL is physically based in Beijing, with proper permits and contacts, we had access to sites throughout China. We also gained access to aquatic plant specimens in the herbaria of various Chinese scientific institutions. This paper presents some of our observations, based on our own collecting and collections by other SABCL staff and cooperators, as well as data from hydrilla specimens at various Chinese scientific institutions.

METHODS AND MATERIALS

Between August 1989 and the end of 1991 we collected hydrilla and other aquatic plants at numerous sites throughout China. Our collections were supplemented by those made by other SABCL staff and cooperating scientists. In addition, we examined hydrilla specimens deposited in Academica Sinica's herbarium at Fragrant Hills, in Beijing's northwest suburbs. Dr. Diao Zhengsu, Yuzhou University in Chongqing, provided a listing of the hydrilla specimens which he had collected. We also examined aquatic plant specimens in the herbaria at Inner Mongolia University and at Xinjiang August 1st Agricultural College. A report by the Fisheries Institute of Jilin Province provided us with a few hydrilla records for that province.

RESULTS AND DISCUSSION

Hydrilla is widespread throughout China and a complete listing of our hydrilla collections, as well as those from the herbaria, is being prepared for later publication. The map in Figure 1 shows the provinces in China at which we collected hydrilla and/or from where hydrilla specimens in various herbaria were collected. This map also shows the three northernmost cities (Harbin, Shenyang and Beijing) near which we personally collected hydrilla. Hydrilla was not uncommon at these three locations, and we found hydrilla in at least several sites within and near each of these three cities.

Harbin, the capital of Heilongjiang Province (previously part of Manchuria) is the northernmost of our collecting sites. It lies near the 46th parallel which in North America passes through Portland, OR, north of Minneapolis, MN, and Montreal, Canada, and above Bangor, ME, on the east coast. Thus, based only on latitude of Harbin China, hydrilla could easily occur in most of the continental USA.

Even more troubling is that hydrilla is known from numerous locations in the former U.S.S.R. (Cook and Luond 1982). Dr. C.D.K. Cook supplied the senior author with a partial listing (unpublished) of the specimens used in preparing the maps shown in the above publication. A specimen from the Angara River, north of Irkutsk, in the Kraysnoyarskiy Kray region of Siberia, at a latitude of 58°30′N, appears to be the northernmost specimen on Cook's list. This is only 9° below the Arctic Circle, and the corresponding latitude in North America would include all of Canada below the Yukon and Northwest Territories, as well as the southeastern peninsula of Alaska.

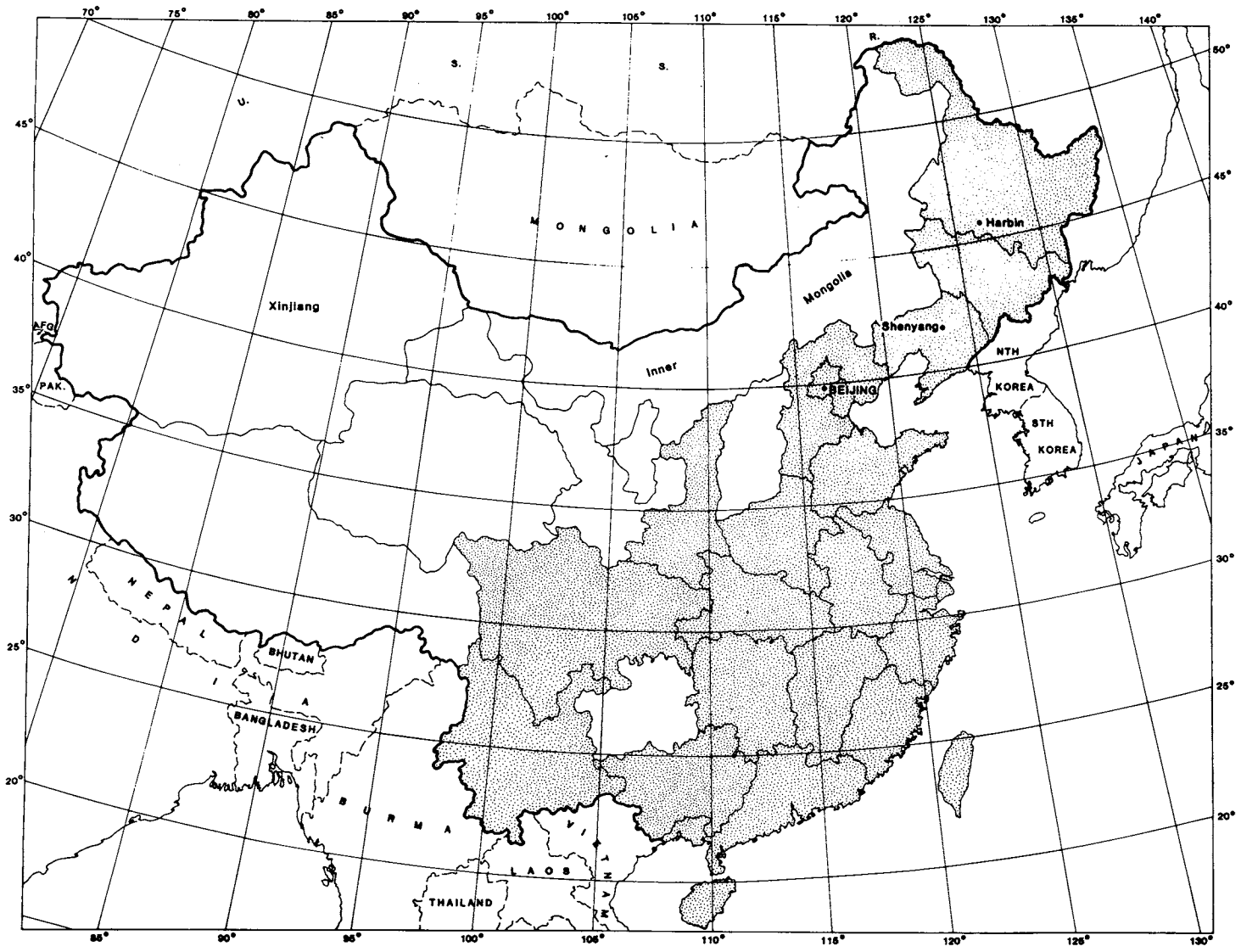

Figure 1. Shaded areas on the map of China indicate provinces where the authors collected hydrilla or where herbarium specimens of hydrilla were collected. Collection sites near the cities of Beijing, Schenyang and Harbin were the northernmost sites at which the authors found hydrilla. Hydrilla was absent in Xinjiang and Inner Mongolia provinces.

While latitude, because of its extremely strong correlation with insolation (solar energy per unit area) and day length, plays a major role in the distribution of plant species, other factors must also be considered. We feel that the amount of rainfall, which is critical to many terrestrial plants, plays only an indirect role in hydrilla's distribution. While aquatic habitats are more common in wet areas, the few aquatic habitats in dry areas may contain hydrilla. This is the case in Australia, where the few aquatic habitats in the arid interior, when they contain water, also frequently contain hydrilla (Balciunas, pers. observation).

Since hydrilla occurs much more commonly in tropical and near-tropical climates, low temperature probably restricts its distribution. The average January temperatures in Beijing, where hydrilla is a common submersed plant, are 0 to -10C, and are similar to those in New York, Chicago and Vancouver (see Figure 2), where hydrilla has (as yet) not been recorded. Hydrilla occurs frequently in Shengyang and Harbin, although not as abundantly as in Beijing. Both of these cities lie in a temperate belt which experiences January temperatures similar to Quebec and Edmonton, Canada, as well as a significant portion of Alaska. Harbin lies on the edge of an even colder temperature belt, which dominates most of the former U.S.S.R. Since Cook and Luond (1982) show over a half-dozen hydrilla sites from this portion of the U.S.S.R., it is clear that hydrilla can survive in climates similar to northern Alaska and Canada.

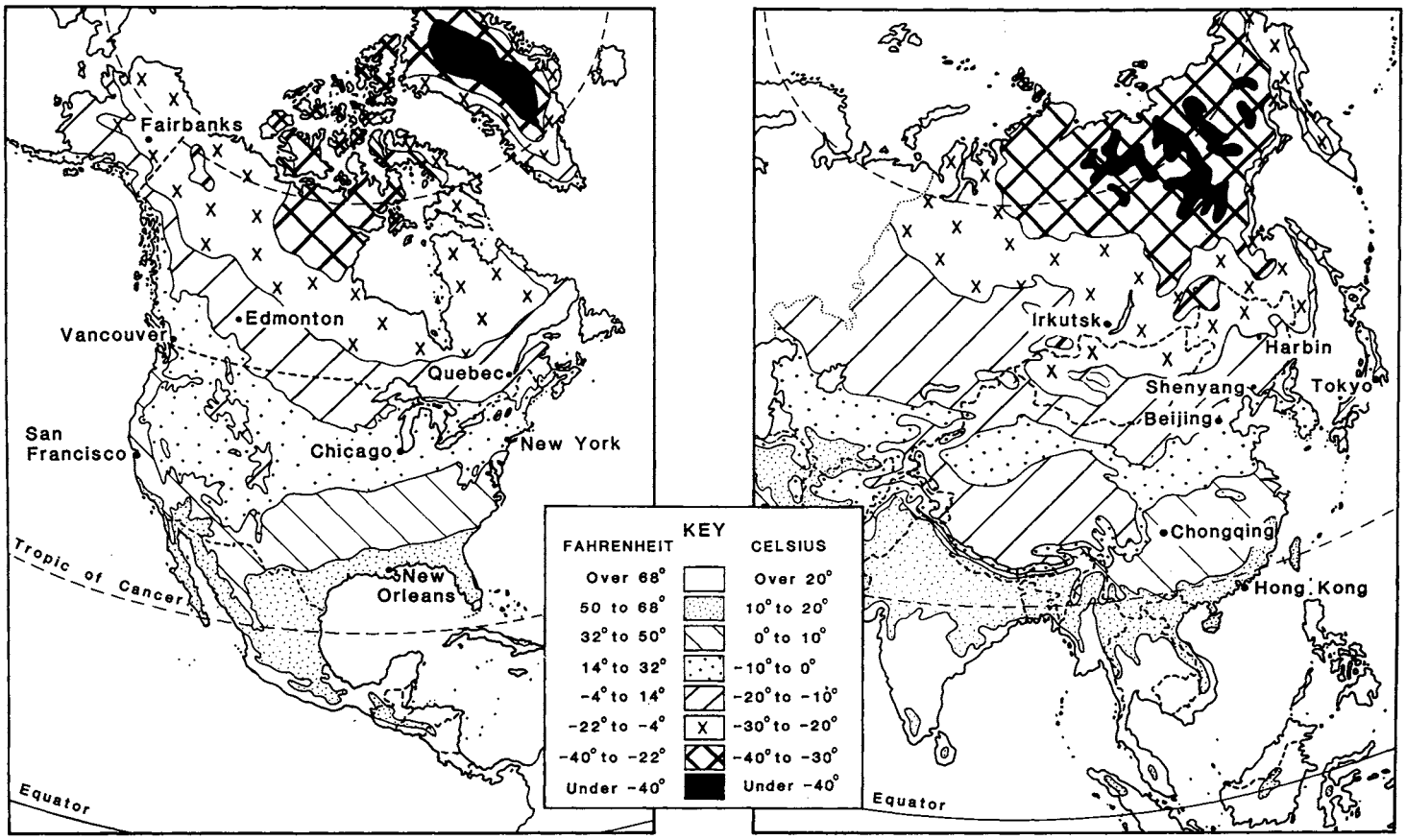

Figure 2. Average January temperatures in North America and Asia (modified and redrawn from Hammond Publication Advisory Board 1991). Winter temperatures in the U.S. and Canada are generally milder than at the same latitudes in China and northern Asia.

Thus, based on both latitudinal and temperature comparisons with China and central Asia, hydrilla has the potential to invade not only all of the continental U.S., but most of Alaska and Canada. However, if hydrilla does eventually occur in northern U.S. or Canada, the infestations are not likely to resemble those in Florida. The hydrilla populations in Ireland, Poland and Lithuania do not seem to be spreading (Cook and Luond 1982). Hydrilla in Beijing does occasionally reach levels that might be considered problematic, but hydrilla in Harbin seldom occurs in pure stands and is usually mixed with *M. spicatum*, *Ceratophyllum* sp. and emergent aquatic plants. However, we did find aquatic weevil larvae associated with hydrilla at one of our Harbin sites (Buckingham 1992), so insect herbivores may be reducing hydrilla growth even in cold climates. Arid areas in high elevations with low rainfall may be relatively "safe" from hydrilla. We have looked fairly carefully in Inner Mongolia which occupies most of China's northern border. Much of Inner Mongolia consists of a dry (precipitation less than 200 mm/yr) and high (over 1000 m) plateau (Sivin *et al.* 1988). Searches of herbarium records, including those at the University of Inner Mongolia, confirm our field observations, and it appears that hydrilla does not occur there. The same holds true for Xinjiang Province. China's most authorative book on aquatic plants, The Illustrated Atlas of Aquatic Plants of China (Wuhan Institute of Botany 1980), upholds our observations about the absence of hydrilla from these regions.

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