Nematol. medit. (1992), *20*: 59-61

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ON THE ORIGIN AND SPREAD OF HETERODERA AVENAE IN AUSTRALIA

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Summary. *Heterodera avenae* is widely established in south eastern Australia and in recent years has been recorded in discrete infestations at far-distant northern locations. The pattern of its detection in Australia and data on host range, relation of hatch to temperature and pathotype reactions are consistent with introduction to southern Australia from Europe in the late nineteenth century.

The generally accepted explanation of the origin of cereal cyst nematode, *Heterodera avenae* Woll. in Australia is the hypothesis of Meagher (1972, 1977) and Brown (1984) that the nematode was introduced to southern Australia, probably South Australia, in the late nineteenth century, from Europe where it probably originated as a parasite of oats or rye (Meagher, 1977).

Origin

Introduction of the nematode first to South Australia and in the late 1800s is historically plausible. Between 1850 and 1890 wheat production expanded dramatically in South Australia, making it the main wheat producing state (Macindoe, 1975). Wheat was grown close to seaports on Gulf St. Vincent and Spencer Gulf and export of wheat from Australia began from these ports. One possibility is that cysts came with ships' ballast which was dumped on wheat land near ports. Solid ballast was often carried by ships sailing from Europe and was dumped at ports where cargo was loaded (Wace, 1985).

Introduction initially into South Australia and spread from there is consistent with the pattern of detection of *H. avenae*. Herbarium material showing *H. avenae* on wheat grown in South Australia in 1904 provides the earliest evidence of the nematode in Australia (Meagher, 1972). In 1930 it was described as a pest of cereals in South Australia (Davidson, 1930) and by 1938 it was recognized as a pest in the Wimmera districts of Victoria (Millikan, 1938). In 1958, Meagher (1958) described it as widespread in both the Wimmera and Mallee districts of Victoria. Recognition of it at Geraldton in Western Australia, 1800 km from previously known infestations, dates from the late 1960s (Meagher, 1977), indicating that a long-distance spread event had occurred by then.

H. avenae was first found in New South Wales in 1967 at Koraleigh in the southern Riverina district, bordering infestations in Victoria (McLeod, 1968). In 1980, Southwell and McLeod (1981) reported it on two farms in northern New South Wales, 800 km north east of previously known infestations. These are still the most northly known infestations in eastern Australia. In 1984 it was detected 250 km south west of the northern infestations (McLeod, 1986a).

The biological data now available support the views that *H. avenae* in Australia is a recent introduction to Australia and that it is closely similar to populations of *H. avenae* in Europe. Fisher (1987) has noted that it has not been found on native Australian plants. The known and preferred hosts of *H. avenae* in Australia are in the genera *Avena*, *Hordeum*, *Lolium*, *Phalaris*, *Secale* and *Triticum* and all of these have been introduced to Australia (Simons, 1983).

The relation of egg hatch to temperature is similar to that reported for *H. avenae* in Europe (Fisher, 1987). This relationship, which relies on low temperature to match hatching to host availability, seems irrelevant to natural Australian conditions where host availability is governed by rainfall rather than temperature.

Pathotype testing within Australia (Brown, 1969, 1974; McLeod, 1976, 1986b) indicates a high degree of homogeneity, consistent with limited and recent introductions. It is considered that the pathotype present in Australia is not identical to any single pathotype found in Europe (Brown, 1982). However, these and other tests (Cook and McLeod, 1980; Andersen and Andersen, 1986) show that of the resistances tested, those in *Avena sterilis* L., *A. strigosa* Shreb, barley CVS KVL 191 and Morocco, wheat cv. Loros and the spring wheat line AUS 10894, operate similarly against European and Australian populations. Thus most of the genes governing host relations are shared. Andersen and Andersen's (1986) study of Australian and Danish *H. avenae* indicated a close relationship between Australian populations and Danish race 12.

Spread

Meagher (1977) suggested that dispersal of cysts of *H. avenae* in wind-borne dust accounts for the colonization of the Mallee region of Victoria, which happened over a period of 50-60 years. Wind-borne dust could also account for infestations in the west Riverina of New South Wales, adjacent to the Victorian Mallee. Short distance distribution of cysts of *Globodera* and *Heterodera* by wind is well documented (White, 1953; Meagher, 1977; Jones, 1980).

Short distance distribution by wind would produce a continuous, expanding-front infestation. The long-jump pattern of detection of *H. avenae* in New South Wales suggests a distribution agent other than wind. Distribution by transport in soil or in soil residues on farm machinery are possibilities. Deliberate transfer of soil from one wheat paddock to another over long distances would occur very infrequently because there is no motive for doing this. Questions to farmers failed to implicate spread by machinery, although spread in soil carried on machinery used previously at an infested site remains a means of long-distance spread. In one case the farmer reported that 18 years previously sheep had been brought to the property from Victoria. Infestation was then found in the same district, in paddocks near a saleyard, which were sometimes used to hold sheep before or after sale. Introduction on sheep, resulting in simultaneous introduction at several points in a paddock, fits the multipatch distribution noted at some new-found infestations (Southwell and McLeod, 1981). Sheep husbandry and winter cereal growing are interlocking enterprises over most of the cereal growing regions of Australia. This combination could well result in a rate of transfer, probably extremely low, of cysts of *H. avenae* together with the other factor needed for spread, a winter cereal crop at the newly infested site within the cysts' survival span. With this mechanism of spread operating, successful containment by quarantine type intervention would be a formidable task.

Long-jump colonization suggests a new phase in the dispersal of this nematode in Australia. Jones (1980) has described two phases in the dispersal of introductions in new territory, (i) the establishment of a few well-defined primary foci with steep gradients of population density at the edge and (ii) development of a larger number of smaller and more diffuse foci derived from them. Spread of *H. avenae* in Australia appears now to be in the second phase. The first phase, consisting of the establishment of large primary foci in South Australia and Victoria, began in the late 1800s, with substantial occupation of available territory taking about 50 years; and the second phase, development of long-jump, derived infestations, evidenced by infestation at Geraldton, becoming apparent after a further 40 years.

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Accepted for publication on 15 January 1992.