Transmission of virus by the progeny of crosses between *Xiphinema diversicaudatum* (Nematoda : Dorylaimoidea) from Italy and Scotland

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SUMMARY

Transmission of the type-British strains of arabis mosaic (AMV-T) and strawberry latent ringspot viruses (SLRV-T) and a strain of SLRV from Italy (SLRV-Ip) by F1 and F2 hybrid *Xiphinema diversicaudatum* was examined in the laboratory. The hybrid nematodes were crossbred from populations which readily (Scotland) and only infrequently (Italy) transmitted viruses. The ability of *X. diversicaudatum* hybrids to transmit viruses was found to be inherited with the choice of both maternal and paternal parents affecting the hybrids ability to transmit viruses. It is possible that the genetic influence on the hybrids ability to transmit viruses was cytoplasmically inherited. The principal factor likely to be involved is the ability of *X. diversicaudatum* selectively and specifically to retain virus particles at sites of retention within its feeding apparatus.

RÉSUMÉ

La transmission des virus par la descendance de croisements entre Xiphinema diversicaudatum *(Nematoda : Dorylaimoidea) provenant d'Italie et d'Écosse*

La transmission de souches de type britannique des virus de la mosaïque arabis (AMV-T), du virus du « ringspot » latent du fraisier (SLRV-T) et d'une souche de SLRV provenant d'Italie (SLRV-Ip) par des hybrides F1 et F2 de *Xiphinema diversicaudatum* a été étudiée au laboratoire. Les nématodes hybrides étaient obtenus par croisements entre populations qui transmettent les virus soit activement (Écosse), soit seulement occasionnellement (Italie). La capacité de transmission des virus montrée par les *X. diversicaudatum* hybrides est héritée suivant le choix des parents maternel et paternel. Il est possible que cette capacité soit héritée cytoplasmiquement, et le facteur principal la concernant paraît être la possibilité pour *X. diversicaudatum* de retenir les particules du virus sélectivement et spécifiquement dans les sites spécialisés de l'appareil nutritionnel.

In laboratory experiments nine of twelve populations of *Xiphinema diversicaudatum* (Micoletzky, 1927) Thorne, 1939 from different parts of the world were effective vectors of two strains of arabis mosaic (AMV) and the type-British strain of strawberry latent ringspot viruses (SLRV-T; Brown, 1985, 1986 *a*). Populations from France, Italy and Spain transmitted these viruses infrequently. A strain of SLRV from Italy was transmitted very infrequently by several populations but nematodes from Italy were consistent vectors (Brown, 1985, 1986 *a*; Brown & Taylor, 1981; Brown & Trudgill, 1983).

Brown (1986 *b*) showed that the populations of *X. diversicaudatum*, including that from Italy, readily interbred with one from Scotland. In this paper the ability of progeny of crosses between the Scottish and Italian population to transmit strains of AMV and SLRV are reported.

Materials and Methods

The populations of *X. diversicaudatum* came from Dundee, Scotland and the Lombardi region, Italy (Brown & Topham, 1985). Progeny were obtained by the method described by Brown (1986 *b*) and came from six parental lines, Italian maternal and paternal (IIP1), Scottish maternal and paternal (SSP1), Italian maternal and Scottish paternal (ISF1), Scottish maternal and Italian paternal (SIF1), ISF1 parentage (ISF2) and SIF1 parentage (SIF2).

The serologically distinguishable strains of virus used were the type-British strains of arabis mosaic (AMV-T; Harrison, 1958) and strawberry latent ringspot (SLRV-T; Lister, 1964) and a strain of SLRV isolated from *Prunus persica* L. growing in Italy (SLRV-Ip; Brown & Trudgill, 1983).

Virus transmission experiments were done in 25 cm^3 plastic-pots which were maintained in a humid atmos-

phere in a temperature controlled cabinet (Taylor & Brown, 1974) at 18° ± 1° and with a minimum day-length of 16 hr. The procedural details have been published elsewhere (McElroy, Brown & Boag, 1977; Trudgill & Brown, 1978; Brown & Trudgill, 1983; Trudgill, Brown & McNamara, 1983).

Petunia hybrida Vilm. was used as the virus-source and as the bait plants for AMV-T; *Chenopodium quinoa* Willd. was used with the two strains of SLRV. Groups of 35 virus-free *X. diversicaudatum* from the Scottish and the Italian populations, *ca.* 50 % of the F1 hybrids recovered from the pots in which reproduction had occurred, or all of the F2 hybrids recovered from each pot were given access for four weeks to the virus-source plant. The ability of these nematodes to transmit virus was examined by transferring one nematode to each virus-free bait plant. Only juveniles (J3's & J4's) were used in the bait test as there were no adult F2 hybrids. After four weeks the roots of the bait plants were tested for the presence of virus and the aerial parts of some of the bait plants were tested for systemically translocated virus. The identity of the viruses recovered from selected *C. quinoa* assay plants was confirmed serologically. Only those bait plants where the nematode was recovered on completion of the bait period were used for compiling Tables 1, 2 and 3.

Results

The type-British strain of AMV and SLRV were transmitted by *ca.* 70 % of the nematodes with Scottish parentage (SSP1) but by less than 5 % of those with Italian parentage (IIP1). Hybrid nematodes of both generations (SIF1, SIF2, ISF1 & ISF2) transmitted AMV-T and SLRV-T with frequencies intermediate to those of the SSP1 and IIP1 nematodes (Tabs. 1 and 2). SLRV-Ip was recovered from only one of 57 and two of 30 bait plants exposed to IIP1 and ISF2 nematodes respectively and was not recovered from bait plants exposed to SSP1, ISF1, SIF1 and SIF2 nematodes (Tab. 3).

Table 1

The transmission of the type-British strain of arabis mosaic virus by *Xiphinema diversicaudatum* from populations from Italy and Scotland and by reciprocally bred F1 and F2 hybrids

P1 parental, F1 parental and F2 grandparental ancestry		*Number of transmissions**		*Proportion of nematodes transmitting virus*	
Female	*Male*	*P1*		*P1*	
Italy	Italy	2/49**		0.041	
Scotland	Scotland	67/84		0.798	
		F1	F2	F1	F2
Italy	Scotland	4/25	9/30	0.160	0.300
Scotland	Italy	9/25	16/29	0.360	0.552

* One nematode per bait plant.
** Numerator is the number of bait plants infected, denominator is the number of plants tested.

Table 2

The transmission of the type-British strain of strawberry latent ringspot virus by *Xiphinema diversicaudatum* from populations from Italy and Scotland and by reciprocally bred F1 and F2 hybrids

P1 parental, F1 parental and F2 grandparental ancestry		*Number of transmissions**		*Proportion of nematodes transmitting virus*	
Female	*Male*	*P1*		*P1*	
Italy	Italy	1/57**		0.018	
Scotland	Scotland	54/77		0.701	
		F1	F2	F1	F2
Italy	Scotland	5/23	9/30	0.217	0.300
Scotland	Italy	0/21	4/27	< 0.048	0.148

* One nematode per bait plant.
** Numerator is the number of bait plants infected, denominator is the number of plants tested.

Table 3

The transmission of a strain of strawberry latent ringspot virus isolated from *Prunus persica* L. growing in Italy by *Xiphinema diversicaudatum* from populations from Italy and Scotland and by reciprocally bred F1 and F2 hybrids

P1 parental, F1 parental and F2 grandparental ancestry		*Number of transmissions**		*Proportion of nematodes transmitting virus*	
Female	*Male*	*P1*		*P2*	
Italy	Italy	1/57**		0.018	
Scotland	Scotland	0/54		< 0.019	
		F1	F2	F1	F2
Italy	Scotland	0/23	2/30	< 0.043	0.067
Scotland	Italy	0/11	0/30	< 0.091	< 0.033

* One nematode per bait plant.
** Numerator is the number of bait plants infected, denominator is the number of plants tested.

Proportionately, twice as many ISF2 and SIF2 nematodes transmitted AMV-T and SLRV-T than did ISF1 and SIF1 nematodes. Similarly, twice as many SIF1 and SIF2 nematodes transmitted AMV-T than did ISF1 and ISF2 nematodes, whereas, the reverse occurred with SLRV-T with nematodes with these same parentages.

Discussion

The results of this study indicate that the ability of *X. diversicaudatum* to transmit AMV-T and SLRV-T is inherited. The ability of hybrid nematodes to transmit these viruses is affected by both maternal and paternal parentage. The inherited ability of the hybrids to be virus vectors may, therefore, be contained in the cytoplasm during fertilization.

Harrison and Murant (1984) suggested that the ability of ISF1 and ISF2 nematodes to transmit AMV-T and SLRV-T is controlled by a single dominant gene. The transmission of AMV-T by SIF1 and SIF2 nematodes do not show any single gene dominance effects whereas their ability to transmit SLRV-T may be attributed to a single recessive gene. However, the present data are not unequivocal evidence for either single gene or polygenic control of the ability of *X. diversicaudatum* to transmit viruses.

The ability of *X. diversicaudatum* specifically to retain virus particles at sites of virus retention within their feeding apparatus (Robertson, 1975; Taylor & Robertson, 1970) is probably the principal factor involved in the inheritance of the nematodes overall ability to transmit viruses. Brown and Trudgill (1983) reported that the relatively infrequent transmission of viruses by a population of *X. diversicaudatum* from Italy (the same as used in the present study) was associated with an apparent inability by the nematodes to retain virus particles. Harrison, Robertson and Taylor (1974) reported that the protein coat of virus particles was important in the specific transmission of viruses by their vector nematodes. Therefore, it seems likely that the method of specific retention of viruses involves some characteristic of the protein coat of virus particles interacting or responding to some inherited characteristic of the cuticle lining the nematodes oesophagus. Carbohydrates, especially sialic acid, gangliosides (charged glyco-lipids; Robertson & Wyss, 1983) and " mucus-like " material (Taylor & Robertson, 1969, 1970; McGuire, Kim & Douthit, 1970; Robertson & Wyss, 1983) have been suggested as possibly being involved in the specific retention of viruses within nematode virus vectors. The inherent differences in the transmission of SLRV-Ip, SLRV-T and AMV-T by hybrid *X. diversicaudatum* may be related to differences in the methods of retention of these viruses within the nematode.

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REFERENCES

BROWN, D. J. F. (1985). The transmission of two strains of strawberry latent ringspot virus by populations of *Xiphinema diversicaudatum* (Nematoda : Dorylaimoidea). *Nematol. medit.*, 13 : 217-223.

BROWN, D. J. F. (1986 *a*). The transmission of two strains of arabis mosaic virus from England by populations of *Xiphinema diversicaudatum* (Nematoda : Dorylaimoidea) from ten countries. *Revue Nématol.*, 9 : 83-87.

BROWN, D. J. F. (1986 *b*). Reproduction and inter-breeding within and between populations of *Xiphinema diversicaudatum* (Nematoda : Dorylaimoidea). *Nematol. medit.*, 14 : in press).

BROWN, D. J. F. & TAYLOR, C. E. (1981). Variazioni nella trasmissione di nematodi vettori Longidoridae. *Atti Soc. Ital. Nematol. Giornate nematol., Firenze, 28-29 nov. 1979 :* 191-204.

BROWN, D. J. F. & TOPHAM, P. B. (1985). Morphometric variability between populations of *Xiphinema diversicaudatum* (Nematoda : Dorylaimoidea). *Revue Nématol.*, 8 : 15-26.

BROWN, D. J. F. & TRUDGILL, D. L. (1983). Differential transmissibility of arabis mosaic and strains of strawberry latent ringspot viruses by three populations of *Xiphinema diversicaudatum* (Nematoda : Dorylaimida) from Scotland, Italy and France. *Revue Nématol.*, 6, 229-238.

HARRISON, B. D. (1958). Raspberry yellow dwarf, a soil-borne virus. *Annls appl. Biol.*, 46 : 221-229.

HARRISON, B. D. & MURANT, A. F. (1984). Involvement of virus-coded proteins in transmission of plant viruses by vectors. In : Mayo, M. A. & Harrap K. A. (Eds) *Vectors in virus biology.* London, Academic Press : 1-36.

HARRISON, B. D., ROBERTSON, W. M. & TAYLOR, C. E. (1974). Specificity of retention and transmission of viruses by nematodes. *J. Nematol.*, 6 : 155-164.

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LISTER, R. M. (1964). Strawberry latent ringspot : a new nematode-borne virus. *Annls appl. Biol.*, 54 : 167-176.

MCELROY, F. D., BROWN, D. J. F. & BOAG, B. (1977). The virus vector and damage potential, morphometrics and distribution of *Paralongidorus maximus. J. Nematol.*, 9 : 122-130.

MCGUIRE, J. M., KIM, K. S. & DOUTHIT, L. B. (1970). Tobacco ringspot virus in the nematode *Xiphinema americanum. Virology* 42 : 212-216.

ROBERTSON, W. M. (1975). *Rep. Scott. Hort. Res. Inst. for 1974,* 21 : 76-77.

ROBERTSON, W. M. & WYSS, U. (1983). Feeding processes of virus-transmitted nematodes. In : Harris, K. F. (Éd.). *Current Topics in Vector Research, Vol. 1.* New York, Praeger Publishers : 271-295.

TAYLOR, C. E. & BROWN, D. J. F. (1974). An adaptable temperature controlled cabinet. *Nematol. medit.*, 2 : 171-175.

TAYLOR, C. E. & ROBERTSON, W. M. (1969). The location of raspberry ringspot and tomato black ring viruses in the nematode vector, *Longidorus elongatus* (de Man). *Annls appl. Biol.*, 64 : 233-237.

TAYLOR, C.E. & ROBERTSON, W. M. (1970). Sites of virus retention in the alimentary tract of the nematode vectors *Xiphinema diversicaudatum* (Micol.) and *X. index* (Thorne & Allen). *Annls appl. Biol.*, 66 : 375-380.

TRUDGILL, D. L. & BROWN, D. J. F. (1978). Frequency of transmission of some nematode-borne viruses. In : Scott, P. R. & Bainbridge, A. (Eds) *Plant Disease Epidemiology,* Oxford, Blackwell : 283-289.

TRUDGILL, D. L., BROWN, D. J. F. & MCNAMARA, D. G. (1983). Methods and criteria for assessing the transmission of plant viruses by longidorid nematodes. *Revue Nématol.*, 6 : 133-141.