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HYSTORY OF NEMATOLOGY IN ITALY

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Notwithstanding nematology is a rather new science, in Italy the first observations and publications on nematodes date back to several centuries ago and are from physicians and botanists. Among them are U. Aldrovandi (1522-1605), who was the first in the word to observe nematodes in insects, and F. Redi, who published in 1684 his observations about "living animals occurring in living animals". However, the first observations on plant parasitic nematodes were made from the second half of 1800 to early 1900. They refer to *Anguina tritici* in wheat kernels (1867), *Meloidogyne* spp. (1875-1904) on several host plants, *Ditylenchus dipsaci* (1897) in oats. The sugar beet cyst nematode, *Heterodera schachtii*, was reported in 1931 and the citrus nematode, *Tylenchulus semipenetrans*, in 1940. The turning point in Italian plant nematology occurred during 1950-1970, when investigations and control trials started on *Xiphinema index*, the natural vector of the *Grape fan leaf virus*. In the same period, the Phytosanitary Service of Pescara addressed much of his efforts on plant parasitic nematodes and the Section of Nematology is established at the Experimental Institute of Agricultural Zoology, of the Ministry of Agriculture, in Florence. Moreover, in 1970, the Italian National Research Councils founded in Bari the Laboratory (later Institute) of Agricultural Nematology Applied to Plants. Later on, nematology attracted also the interest of several other Phytosanitary Services, Universities and firms producing nematicides. While nematology was growing up, research objectives evolved from mainly faunistic and chemical control to many more to encompass all aspects of agricultural nematology and that for number and quality made Italian nematology one of the leading nematology at world level.

KEY WORDS: Historical dates, nematodes, main research focus.

INTRODUCTION

Nematodes are an important and large group (Phylum Nemata) of living animals, adapted to a great variety of habitats because they have evolved surprising survival strategies. Most probably, the first finding of a nematode dates back to 2700 b.C. and refers to human infections by ascarids reported in the Chinese medicine. More observations on human nematodes were reported in an Egyptian papyrus (Papyrus Ebers, 1550 b.C.) and by Greek philosophers/physicians a few centuries b.C. Later, observations on nematodes were made by physicians and botanists and referred to mostly nematodes of humans and animals. However, the nematology science, as we know it today, evolved only in the second half of the 1800s, when the first descriptions and classifications of nematodes were published, and consolidated in the 1900s.

PIONEERS OF ITALIAN NEMATOLOGY

The physician and naturalist U. Aldrovandi (1522-1605) (ALDROVANDUS, 1602), botanist and physician, seems to have been the first in using the word "worm" to indicate a zoological taxon different from insects. He is also considered the first to have observed nematodes in insects (grasshoppers), most probably *Mermis nigriscens* Dujardin, 1842, a nematode common in orthopterans. In the same period, A. Cesalpino (1519-1603) discovered nematodes in the kidney of a dog and G.A. Borelli (1653) probably first observed a nematode in vinegar, quite certainly *Turbatrix aceti*. In 1684 F. Redi (REDI, 1684), physician and poet working at the Medicean court in Florence, published what today can be considered a review on nematodes known until then, including his own observations on " living animals occurring in living animals", mentioning findings by preceding authors and describing nematodes from different hosts. At A. Vallinsnieri (1661-1730), physician and naturalist, were attributed observations on free living nematodes. Also, L. Spallanzani (1729-1799), professor of natural history at Pavia, one of the founders of the modern biology, beside animal parasites was also interested in free living nematodes.

THE BIRTH OF AGRICULTURAL NEMATOLOGY

Although the first observations of a plant parasitic nematodes were those of the wheat seed gall nematode (*Anguina tritici*), made in 1743 by J.T. Needham in England and reported in a letter to the Royal Society of London, the interest in plant nematodes became strong only in the second half of 1800. Of this period are the first descriptions of the bulb and stem nematode, *Ditylenchus dipsaci*, by J. Kühn in 1857, that of a root-knot nematode, presently *Meloidogyne* sp., from cucumber in a greenhouse in England, by Berkeley (1865), and that of a disease of sugar beet in Germany by Schacht in 1859, later described as *Heterodera schachtii* Schmidt, 1871.

It is in this period that nematology became a true new science thanks to the publication of classical works on the taxonomy of nematodes by C.H. Bastian (1865), who described more than 100 species of free living nematodes and 22 new genera. A treatise was written by A. Schneider (1866) in which beside morphological description are also reported anatomical and histological information. L. Orley

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(1880) in his monograph included also plant parasitic nematodes. Researches on free living nematodes and inclusions in paraffin, to obtain thin sections, were made by O. Bütschli (1873-1876). J.G. de Man (1884) published the results of interesting studies on the taxonomy of marine, fresh water and soil nematodes and put the basis for the description of genera and species of nematodes. Finally, N.A. Cobb, in USA (1913-1935), published, among other publications, his "Contributions to a Science of Nematology", which contains extraordinaire descriptions and illustrations of several new species, made aware many colleagues of the importance of plant nematology, obtaining recognition of nematology as an independent discipline in the USA Department of Agriculture.

EARLY PLANT NEMATOLOGY IN ITALY

In Italy also, the first observation on plant parasitic nematodes dates back to the second half of 1800s. In general these observations referred to nematodes causing severe damages and/or typical symptoms. Romanin (1867) was the first to observe "small eels causing stunting of wheat", caused probably by *Anguina tritici*. The botanist G. Licopoli published (1875-1877) descriptions of *Anguillula radicicola* (= *Meloidogyne* sp.) and its root symptoms on *Sempervivum tectorum* and *Vitis* sp., followed by M. Cornu (1878) who described *Anguillula marioni* (= *Meloidogyne* sp.) and the knot it caused on the root that could be confused with those induced by *Phylloxera* sp., and by the Phylloxera delegates B. Bellati and P.A. Saccardo who studied *A. radicicola* on grapes. Later, U. Brizzi (1877), G. Casali (1898), G. Del Guercio (1902) and Trotter (1904) reported *Heterodera radicicola* (= *Meloidogyne* sp.) as the causal agent of hazel tree disease. A. Trotter and G. Cecconi in their "Cecidotheca Italica", mentioning findings from 1900 to 1916, report plants infested by *Tylenchus graminis* (probably *Anguina tritici* or *Ditylenchus dipsaci*). A. Aducco was the first to observe a *Tylenchus* in Italy, while in 1900 Boldrati found a *Tylenchus* causing brownishments of sugar beet roots. In 1905 Pellio informed to have observed damage caused by *Tylenchus devastatrix* (= *Ditylenchus dipsaci*) to wheat since 1897.

Here it must be mentioned that two eminent scientists, who are among the founders of the modern nematology, J.G. De Man and N.A. Cobb, spent short periods at the "Stazione Zoologica" in Naples. De Man spent four months (1876) studying crustaceous and marine nematodes of the Naples bay. Cobb also, soon after obtaining the Ph.D. degree in Germany (1989), spent some time at the same Stazione Zoologica, mounted nematodes in balsam and left nematode specimens permanently mounted and still in good conditions (BARKER, 2004).

Between late 1800 and early 1900, scientists interested in plant nematology were working at the "Istituto Botanico" of Pavia and at the "Regia Stazione di Patologia Vegetale" in Roma, who regularly received plant samples shoving disease problems and took records of the causal agents. Some of these records were published by F. Cavara (1895) and by L. Petri (1927-1942) in a Bulletin of the station and report findings of *Heterodera schachtii* on sugar beet in the Latium region (1931), *Meloidogyne* spp. in several plant species, *Aphelenchoides* on ferns, and *Anguillulina dipsaci* in hortensia. The citrus nematode, *Tylenchulus semipenetrans*, was reported in 1940 at Gallipoli (province of Lecce) by A. Biraghi, and the cereal cyst nematode, *Heterodera avenae*, by A. Mezzetti (1953) on wheat in the Emilia Romagna region. Earlier, E. MAMELI CALVINO (1950) had published her observations made during the preceding 20 years and reported infestations caused by *Aphelenchoides* sp., *Heterodera marioni* (= *Meloidogyne* sp.), *Anguillulina dipsaci* and *A. pratensis* (= *Pratylenchus pratensis*). Also, she greatly contributed to the awareness of nematodes as the causal agents of severe plant diseases in Italy.

THE SECOND HALF OF 1900: AWARENESS OF THE IMPORTANCE OF NEMATODES IN ITALY

All the above made scientists and politicians aware of the importance of nematodes in agriculture and of the need to have agricultural services and research centres to focus on plant parasitic nematodes. Therefore, in early 1950s a nematology laboratory was established at the " Stazione di Entomologia Agraria", in Florence, which in 1968 became "Sezione di Nematologia" of the "Istituto Sperimentale per la Zoologia Agraria" of the Ministry of Agriculture, in the same city, directed by A. Marinari.

Special interest was devoted to plant parasitic nematodes at the "Osservatorio per le Malattie delle Piante (Phytosanitary Service) in Pescara, by its director, A. Scognamiglio. Following the discovery of *Xiphinema index* as the natural vector of the *Grape fan leaf virus*, and due to the importance of grape production in Italy and the Apulia region, in Bari Prof. A. Ciccarone encouraged investigations on the nematode-virus association and chemical control trials to manage the nematode. Also, an Agriculture Nematology course was established at the University of Bari, which was taught for several years.

In the same period, the National Research Council of Italy, while expanding its research laboratory network, founded in Bari the "Laboratorio di Nematologia Agraria Applicata ai Vegetali", transformed later in institute and now Section of the "Istituto per la Protezione delle Piante", directed until 1999 by Prof. F. Lamberti, who had received a master in Nematology at the University of California. Under the guidance of Prof. Lamberti, in 20 years the institute grew up to 30 staff members and widened his research interest to all aspects of the plant nematology science.

At the end of the 1970s a nematology course was established at the University of Naples and taught (now anymore) first by Prof. Scognamiglio and later by Prof. F.P D'Errico.

Special attention was devoted also to plant nematodes by Dr. G. Mancini and Dr. R. Tacconi at the Phytosanitary Services of Torino and Bologna, respectively, and by several nematicide producing companies, to promote and support chemical control trials and the diffusion of the knowledge on nematodes. Attentions is also paid to nematodes in eco-systems at the University of Milan by Prof. A. Zullini (fresh water nematodes) and at the University of Catania by Prof. M.T. Vinciguerra (free living nematodes). Investigations on nematodes focusing mainly on ultrastructure are conducted at the University of Siena (B. Baccetti, R. Dallai, M. Vegni Talluri). Studies on biochemical taxonomy of some groups of nematodes are developed at the Parasitology Institute of the University of Rome (L. Poggi, P. Orecchia, and others). Finally, interest is also devoted to investigations on entomopathogenic nematodes by some universities and Phytosanitary Services.

EVOLUTION OF THE STUDIES

The first studies focused mainly on chemical control, distribution of nematodes to obtain insights on main problems caused to Italian agriculture, and descriptions of new species. Thereafter the spectrum of investigation was broaden to include:

studies on population dynamics, damage caused by nematodes to plants, means of control alternative to chemicals, such as resistant cultivars, biological control, crop rotations, soil solarisation, catch crops, nematicide plants and plant extracts, organic soil amendments;

studies on the dynamics of some nematicides in soils and edible plant parts;

investigations on nematodes with emphasis on their ecology (nematodes in agricultural and natural ecosystems), biology (identification of races and pathotypes), biochemistry, morphometry (sistematics and taxonomy), anatomy (by transmission electron microscopy), biomolecular characterization of phenotype and genotype, characterization of genes for resistance to environmental stresses, identification of markers of resistance genes, cryoconservation.

The nematode-plant interaction is being investigated at histological, histochemical, biochemical and biomolecular level. Here it must be mentioned that in this short review the attention is almost exclusively focused on plant nematodes. Therefore, important researches on other groups of nematodes performed by Italian scientists are necessarily omitted.

MEETINGS AND MAJOR PUBLICATIONS

Following the growing interest in nematology, it was necessary that the results of the researches were published and presented in national and international meetings. Therefore, in 1973 Prof. Lamberti founded the international journal "Nematologia Mediterranea", edited by himself and Prof. C.E. Taylor (UK) until 2003 and thereafter by Drs. N. Greco and K. Evans (UK).

Also, in 1978 Profs F. Lamberti and M.T. Vinciguerra and Drs R. Tacconi and G. Mancini founded the Italian Society of Nematology (SIN), now member of the International Federation of Nematology Societies (IFNS). Since then the SIN holds every three year its congress, of which the proceedings are published, and between congresses one or two annual short meetings to discuss nematological problems of crops of importance in Italy, all promoted by Profs F. Lamberti and F. D'Errico, presidents of the SIN, and by nematologists of the Institute of Agricultural Zoology and different regional Phytosanitary Services.

The first Italian Congress of Nematology was held in Naples in 1975, organized by Prof. Scognamiglio. The first meeting of SIN (Giornate Nematologiche) was held in 1979 at the Istituto Sperimentale per la Zoologia Agraria, Florence, organized by the Committee of the society, while the first congress of the SIN was held in Torino in 1981 and was organized by Dr. G. Mancini.

Besides, the European Society of Nematology (ESN) held its biannual meetings in Italy in 1970 (organized by Prof. Scognamiglio) in Pescara, in 1980 (organized by Prof. Lamberti) in Bari, and in 2004 (organized by Dr. T. Bleve) in Rome. Nematology sections are also organized within the frame of national and international multidisciplinary congresses held in Italy.

In the same period, Prof. Lamberti organized four NATO workshops on: Virus vector nematodes (in 1973 at Riva dei Tessali, Taranto province); Root-Knot Nematodes (in 1977, in Bari); Cyst Nematodes (in 1985) and Advances in Molecular Plant Nematology (in 1993), both in Martina Franca, Taranto province. For each of these workshops were published the proceedings (LAMBERTI *et al.*, 1975, 1995; LAMBERTI and TAYLOR, 1979, 1986).

Among the Italian publications in plant nematology, the books "Nematologia Agraria" by SCOGNAMIGLIO (1978), "Nematodi di Interesse Agrario" by TACCONI (1980) and "Nematodi da Quarantena" by TACCONI and AMBROGIONI (1995) are worthy of mention.

Check lists of nematode species of the Italian fauna were published by MANFREDI *et al.,* (1995), CERIONI *et al.*, (1995) and, limitedly to Tylenchida, by ACCORTI and AMBROGIONI (1978).

ITALIAN NEMATOLOGY COMPARED TO WORLD NEMATOLOGY

As already stated, the Italian nematology as gained reputation as a leading nematology at world level. Because of this achievement, Italian nematologists participate in national and international working groups, regularly publish in national and international journals of several of which are also members of the editorial board. Also, they are invited to chair sessions at national and international congresses, to prepare chapters on nematodes for nematology and multidisciplinary books published in Italy and abroad. Finally some are editors of International journals and cooperative nematology books.

PROSPECTS

Despite the mentioned achievements, the prospects of nematology in Italy are not rosy. The reduction in the number of nematicides available to farmers and the agriculture system going towards a more specialization and mono-cropping is expected, at least in a short period, to increase damages caused by nematodes. Moreover, the enlargement of the European Community and trading globalization require more, precise and rapid phytosanitary controls, including nematodes. Despite Italian nematologists do have the necessary expertise to afford the expected forthcoming problems, nevertheless their number, already not sufficient, because of increased reduction of funds allocated to research, including that in nematology, and lack (or at least greatly reduced) turnover in research centres, universities and Ministry of Agriculture, is becoming more and more reduced.

RIASSUNTO

STORIA DELLA NEMATOLOGIA IN ITALIA

Sebbene la Nematologia sia una scienza piuttosto recente, le prime osservazioni e pubblicazioni sui nematodi in Italia risalgono a diversi secoli fa, ad opera soprattutto di medici e botanici, tra i quali spiccano U. Aldrovandi (1522-1605), per essere stato il primo al mondo ad aver osservato un nematode degli insetti, e F. Redi per aver pubblicato nel 1684 le sue osservazioni intorno agli "animali viventi che si trovano negli animali viventi". Le prime segnalazioni di

nematodi fitoparassiti risalgono alla metà del XIX secolo ed all'inizio del XX e riguardano *Anguina tritici* in cariossidi di grano (1867), *Meloidogyne* spp. (1875-1877, 1878, 1898, 1902, 1904) su diverse piante, *Ditylenchus dipsaci* (1897) su avena. Il nematode cisticolo della barbabietola da zucchero, *Heterodera schachtii*, sarà segnalato solo nel 1931 ed il nematode degli agrumi, *Tylenchulus semipenetrans* nel 1940. La svolta della nematologia in Italia è avvenuta tra gli anni '50 e '70 del secolo scorso, quando iniziarono indagini e prove di lotta contro il nematode *Xiphinema index,* il vettore naturale del virus della degenerazione infettiva della vite (GFLV). Nello stesso periodo l'Osservatorio per le Malattie delle Piante di Pescara prende un indirizzo spiccatamente nematologico, a Firenze nel 1968, presso l'Istituto Sperimentale di Zoologia Agraria del MAF, viene costituita la Sezione di Nematologia ed a Bari, dal CNR, viene fondato nel 1970, il Laboratorio (poi Istituto) di Nematologia Agraria Applicata ai Vegetali. Successivamente, la nematologia susciterà l'interesse degli osservatori fitopatologici, di alcune Università ed anche di case produttrici di fitofarmaci. Notevole è stata l'evoluzione dei temi di ricerca che da faunistiche e basate su prove di lotta chimica, hanno poi abbracciato diversi aspetti della nematologia agraria con indagini che per vastità e qualità di temi affrontati hanno portato la nematologia italiana all'apice di quella mondiale.

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