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GASTROIDEA VIRIDULA DEG. POTENTIAL TO CONTROL MOSSY SORREL (*RUMEX CONFERTUS* WILLD.)

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Abstract: Terrain and laboratory research were conducted to determine the potential of *Gastroidea viridula* Deg. (*Coleoptera: Chrysomelidae*) to control mossy sorrel (*Rumex confertus* Willd.). In a field study, the dynamic of plant biomass and number of larvae occurring on that plant were investigated. The Pearson's linear correlation coefficient of biomass increase in time equalled, to r = 0.96. The regression equation showed, that the plant daily growth reached 29 g; and 210 g per week, consequently. In the laboratory, weight of consumed food by larvae, and larval body weight were measured at 20°C. First generation of *G. viridula* was taken into consideration. Total weight of consumed leaves by all three instars of a single larva, during 50 days of the development amounted to 1.243 g. Also seasonal abundance of larvae was observed. On May 25th the highest observed number of *G. viridula* larvae per plant ranged from 435 to 469 individuals. This species may be of usefulness in biological control of mossy sorrel.

Key words: *Gastroidea viridula* Deg., *Rumex confertus* Willd., biological agent

INTRODUCTION

Weeds are harmful organisms connected with human activities; therefore there is a need for their control. Recently *R. confertus* occurs in Poland and elsewhere the world near the rivers. Mossy sorrel is generally a widely adapted weed, and is considered to be one of the most dangerous, uncultivated plants in the world (Marocchi 1989). This strong expansion has resulted from a very high seed production (Cavers and Harper 1964).

A dominating method of weed regulation is chemical control. However, herbicides are often of low selectivity, they also contaminate the environment and become quickly ineffective because of the resistance of treated plants (Boczek 1996).

The chemical control of *R. confertus* is difficult, because of the rich root system. After the application of herbicides, the above ground parts of the plant dry out, but new leaves emerge again in the late summer.

An alternative to the herbicide treatment is the biological method and the use of herbivorous insects (Whittaker et al. 1979; Kovalev and Zaitzev 1996). *G. viridula* has the potential to control *Rumex* spp. plants (Smith and Whittaker 1980a, b; Speight and Whittaker 1987). Both adults and larvae could be good biological control agents of their host plants. This results from a high reproductive potential. *G. viridula* develops three generations every growing season (Piesik 2000b). Also the life cycle of every generation is short, and the number of their predators is low, either. *G. viridula* is a temperature-dependant insect (Honek et al. 2003).

G. viridula is a very important biological agent that can be part of an integrated programme for regulating the development of undesirable plants (Hatcher et al. 1994a, b; Hatcher 1996; Hatcher et al. 1997).

The aim of the study was to assess *G. viridula* potential to control *R. confertus*.

MATERIAL AND METHODS

The investigations were carried out in 2001, 2003 and 2004. The trials were located in a natural habitat of *R. confertus* in Bydgoszcz vicinity on the marshy meadow near Vistula river, Northern Poland (53°13'N, 18°15'E). The laboratory study was conducted at Department of Entomology, University of Technology and Agriculture in Bydgoszcz. The chrysomelid beetle, *G. viridula* was chosen as a model species. It seems to be relevant as biological control agent for their host plant for many reasons; such as low mobility or oligophagous preferences for *Polygonaceae* plants.

The natural habitat trials

1) In the beginning of 2003 and 2004 *R. confertus* was monitored and selected for the study to determine plant growth dynamic. Eight randomly chosen plants in 10 replications were observed and labeled for farther measurement. The leaves of every rosette were counted and cut off over 50 days from the mossy sorrel plants at 7–8 d. intervals, since April 26th up to June 15th. Leaf petioles were disposed and weight of every single blade determined. The average air temperature for the years 2003 and 2004 was 10,3°C in third decade of April and 16,5°C in the second decade of June. It is suitable period needed by *G. viridula* to conduct full development at temperature of 20°C.
2) The number of *G. viridula* larvae occurring on mossy sorrel plants was recorded on ten randomly chosen plants over 50 days at the time intervals specified for plant growth observations. Captured larvae were counted very precisely, and left on the plants.

The objective of the laboratory experiment was to determine the dynamic of larval feeding on *R. confertus* leaves at 20°C, under controlled moisture conditions and supplied food. The trial was performed in five replications on Petri dishes with filter paper. Every Petri dish contained 10 larvae. The fresh leaves of *R. confertus* were provided to larvae of *G. viridula* every day. Filter paper was also changed daily.

The laboratory observations

1) The weight of consumed leaves of *R. confertus* by larvae of *G. viridula* at 20°C and 80% of relative air humidity was calculated. The observations continued over the whole larval development and, measurements were done every day.
2) The *G. viridula* larval body weight, measured every day, was recorded over the whole larval development.

RESULTS

1. Growth characteristics of the mossy sorrel.

R. confertus plants began to develop the biomass by the end of April, when rosette consisted of 78 leaves. Average weight of a single leaf blade at this time reached 1.35 g, and the whole plant weight amounted to 105.8 g, consequently (Table 1). After one month of plants' development (May 25th) the number of leaves in a single rosette was doubled. Thus, the whole plant weight equalled to 1200 g. It was the most intensive period of the mossy sorrel development. During the next two decades, the number of leaves was similar, and weight of the whole rosette reached 1453 g. The Pearson's linear correlation coefficient between plant biomass development and time of growing achieved the value of r = 0.96. The regression equation showed, that the plant daily growth reached 29 g, and it amounted to 210 g per week, consequently.

2. Characterization of larvae feeding in the laboratory conditions

Three larval instars of *G. viridula*, their development, and feeding on mossy sorrel were investigated. Weight of consumed leaves differed between instars (Table 2).

Table 1. Dynamics of a single plant biomass

Date	Number of leaves* ± S_E	Weight of single leaf (95% confidence interval of mean) (g)	Total potential of plant biomass (g)
26.04	78.4 ± 0.5	1.35 (1.29–1.40)	105.8
04.05	122.4 ± 0.9	2.92 (2.86–3.00)	357.4
11.05	134.2 ± 0.6	4.68 (4.66–4.70)	628.1
18.05	148.4 ± 0.8	6.12 (6.06–6.16)	908.2
25.05	160.8 ± 0.8	7.58 (7.44–7.72)	1218.9
01.06	159.6 ± 0.7	9.10 (7.98–8.18)	1452.4
08.06	161.6 ± 0.5	8.50 (8.40–8.58)	1373.6
15.06	164.0 ± 0.4	8.86 (8.60–9.14)	1453.0

*Mean of 10 plants randomly chosen on each date of 2001, 2003 and 2004

Table 2. Characterization of larval consumption in laboratory

Larval instar	Days of experiment	Average weight of consumed leaves (95% confidence interval of mean) * (g/larva/day)	Total consumed weight of leaves (g/larva)
L_1	12	0.016 (0.015–0.018)	0.192
L_2	15	0.021 (0.020–0.023)	0.315
L_3	23	0.032 (0.029–0.034)	0.736
L_1–L_3	50	–	1.243

*Average of 10 larvae in 5 replications

In the laboratory conditions, during 12 days of the development, one L_1 larva consumed 192 mg of *R. confertus* leaves. Consecutive two instars consumed during 15, and 23 days significantly larger biomass of leaves; 315 mg, and 736 mg, respectively. Total weight of consumed leaves by all three instars of a single larva, during 50 days of the development amounted to 1.243 g. Daily feeding characteristics of L_1 and L_2 showed, that larvae consumed 0.45 mg, and 0.43 mg of leaves, respectively (Fig. 1 a,b). Feeding and daily increase of larval body weight analysis, during 50 days of experiment, showed that the rhythm of biomass of consumed leaves and larval body weight were unsteady (Fig. 2). Moreover, L_1 and L_2 larval body weight increase was significantly less in comparison to L_3. Those larvae were feeding intensively between 10th and 15th day of their development. Daily larval body weight was restricted by shedding, for instance on 27th day of their development. The goodness of fit of the regression equation to analyzed relation was 62%, and this proved that this relation is statistically highly significant. Pre-pupation time, characterized by less consumption of leaves as well as by low larval body increase, significantly affected L_3 larvae (Fig. 1c).

3. Characterization of larvae abundance in natural conditions

Counting of larvae and measuring of leaves were done weakly, from April 26th to June 15th. There was difficulty to assess percentage of participation of each larval instars. In the first week of observation none of L_1 larvae were recorded. In the next two weeks, only some individuals were captured (Table 3). From mid of May the

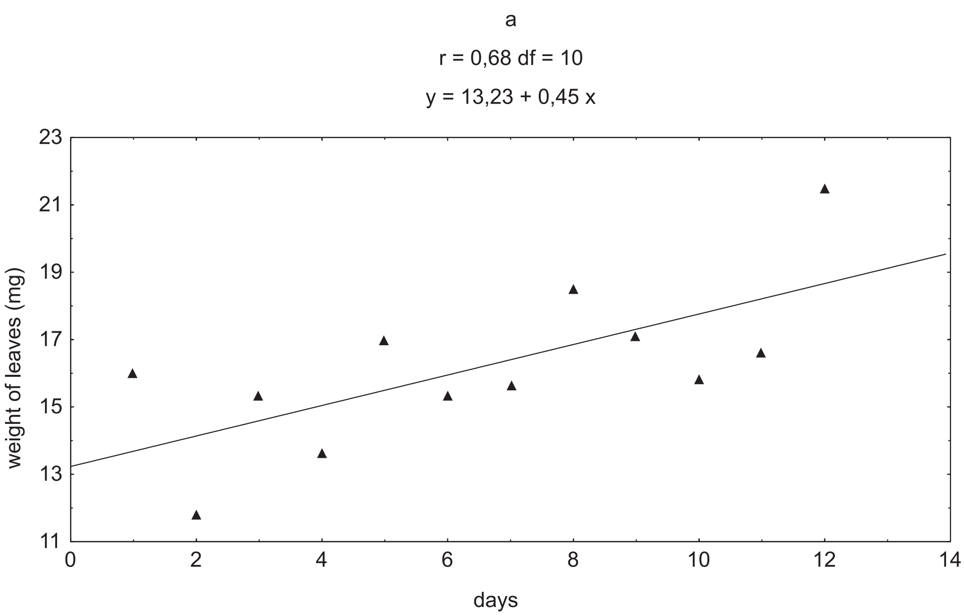

Fig. 1a. Consumption of leaves by L_1 *G. viridula* larvae in time
r – Pearson's linear correlation coefficient
df – degree of freedom

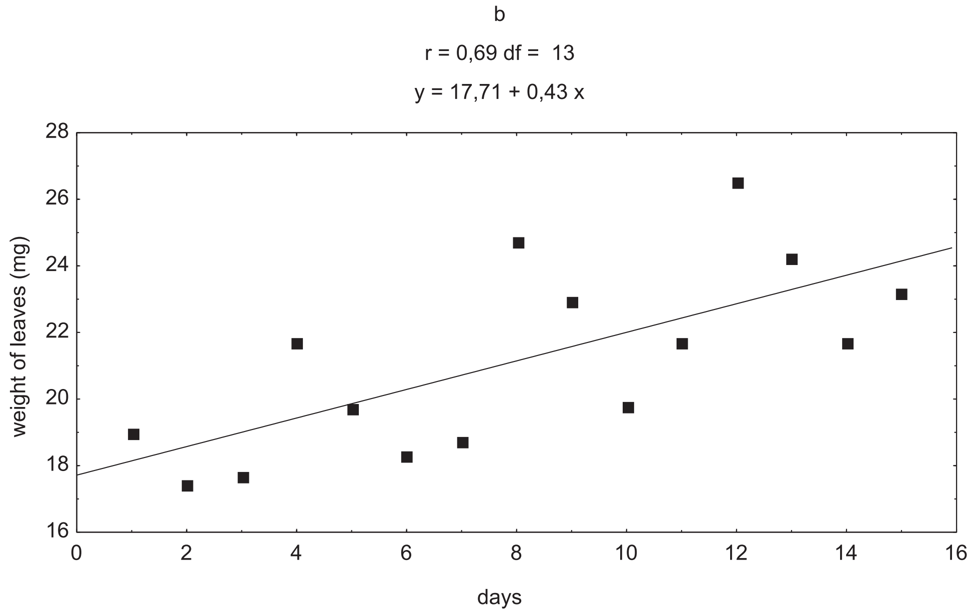

Fig. 1b. Consumption of leaves by L_2 *G. viridula* larvae in time
r – Pearson's linear correlation coefficient
df – degree of freedom

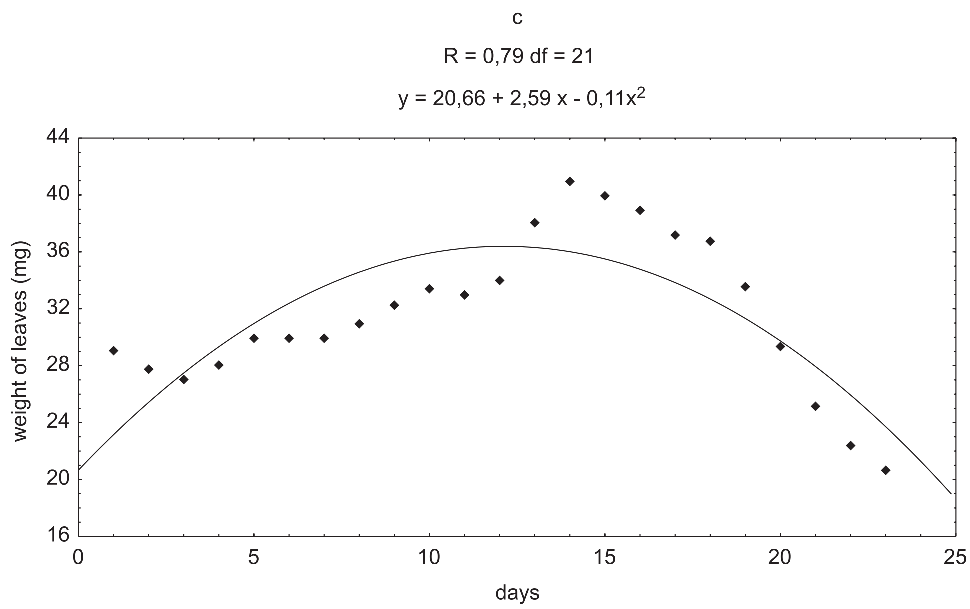

Fig. 1c. Consumption of leaves by L_3 *G. viridula* larvae in time
R – rank correlation coefficient for curvilinear regression
df – degree of freedom

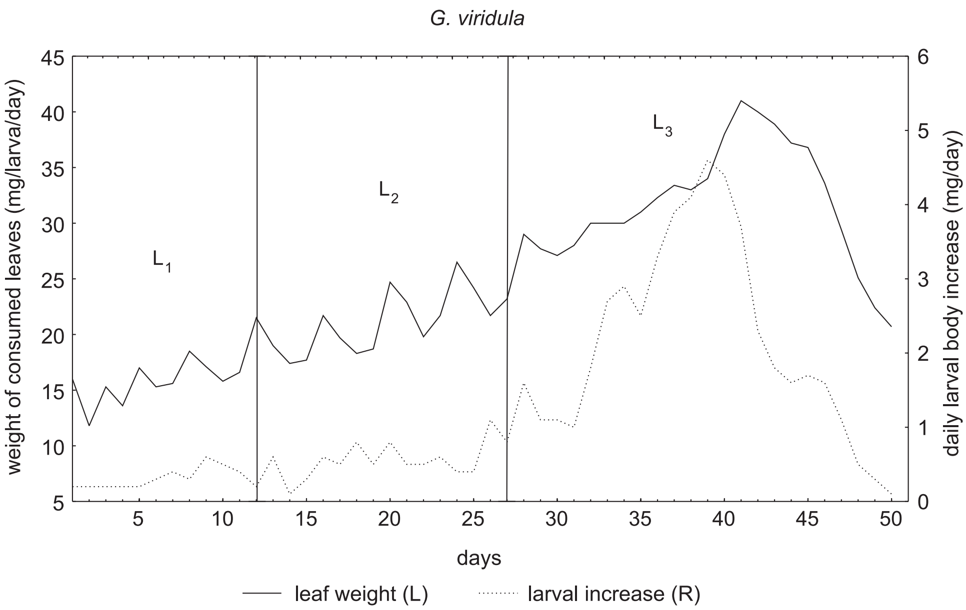

Fig. 2. Dynamics of leaf consumption and larval body increase in laboratory trials

Table 3. Characterization of *G. viridula* larval population

Date	Number of larvae per plant (95% confidence interval of mean)*	Estimation of consumed leaves for L_1 larvae (g)	Estimation of consumed leaves for L_2 larvae (g)	Estimation of consumed leaves for L_3 larvae (g)
26.04	0	–	–	–
04.05	1.8 (0.8–2.8)	0.35	–	–
11.05	8.8 (6.9–10.6)	1.69	–	–
18.05	191.4 (177.5–205.3)	36.74	60.29	–
25.05	452.4 (435.2–469.6)	–	142.51	332.97
01.06	200.2 (174.4–225.9)	–	–	147.35
08.06	16.0 (10.4–21.6)	–	–	11.78
15.06	8.0 (6.0–9.9)	–	–	5.89

*Mean of 10 plants randomly chosen on each date of 2001, 2003 and 2004

larval population increased significantly from 177 to 205 individuals per plant. The domination of L_2 larvae was observed. Besides, L_1 larvae were noticed, this proved a progressive development of the population. On May 25th the highest number of *G. viridula* larvae was recorded (from 435 to 469). The most numerous were L_3 larvae, but also L_2 were present. In the next week significantly lesser seasonal abundance of larvae was observed, and there were only L_3 larvae.

4. Estimation of mossy sorrel leaf consumption by larvae in natural conditions

Weight of consumed leaves by larvae should be taken into consideration as a criterion for assessment. This assumption was made, because the larval age in monitored weeks was different. Additionally, no information about weight of consumed leaves in natural conditions was obtained. However, for estimation of approximate consumed leaves, average number of captured larvae form one plant was taken under consideration in performed calculations. This average number was multiplied by weight of consumed leaves per single larva (Table 3). For 18th and 25th May estimation was difficult, because there is no information what part of leaves were consumed by younger, and much more developed larvae. However this assessment may be useful for the biological control of *R. confertus* by *G. viridula* in the future. If we make the assumption that on May 25th there is equal proportion between L_2, and L_3 larvae; 20% of the mossy sorrel biomass in this time could be reduced.

DISCUSSION

G. viridula (*Coleoptera, Chrysomelidae*) is the most important phytophagous insect occurring on *R. confertus*. Both adults, and larvae can damage plants biting out holes of different sizes, and additionally larvae may skeletonize the leaves (Piesik 2000a). *G. viridula* has damaged the vegetative weight of mossy sorrel to a large extent. The magnitude of the biocontrol effects of *G. viridula* depends on its abundance and the duration of herbivory, which both increase with the number of generations (Honek et al. 2003). Three generations per year in natural conditions were observed. Smith and Whittaker (1980a) also reported three generations per year. Under natural site conditions Whittaker et al. (1979) described this species as a very important biological factor, as well as part of an integrated program for regulating the development of undesirable plants.

Average weight of whole tested plant during the time of experiment (50 days) oscillated from 105.8 mg to 1453.0 mg in the last day of measurement. Consecutively, total consumed weight of leaves (g/larva) for L_1 and L_3 larval instars oscillated from 0.192 mg to 0.736 mg. Taking into consideration all 50 days and number of larvae on the plant, considerable weight of vegetative green biomass was consumed. Previous experiments showed that leaf blades damaged by insects over 50% are drying (Piesik 2004). In that case there is no need for insects to consume 100% of *R. confertus* leaves. Consequently, in natural site conditions approximately 40% of more damage may lead to higher effectiveness of control. Introduction of *G. viridula* adults in the beginning of growing season may increase number of larvae occurring on *R. confertus*, and thus higher damage index may be achieved.

CONCLUSIONS

1. Larvae of *G. viridula* reduced the weight of *R. confertus* leaves. Feeding of three instars was observed over the whole period of larval development.
2. A single larva of L_3 instar consumed over 30% more leaves as compared to both L_1 and L_2. L_3 larvae seemed to be the most useful for biological control, due to the highest ability of mossy sorrel weight reduction.
3. The body increase of L_3 instar was significantly larger in comparison to L_1 and L_2.
4. Over 870 individuals of larvae per plant were captured, during 7 weeks of observation.
5. Introduction of *G. viridula* adults may increase number of larvae occurring on *R. confertus*. High effectiveness of mossy sorrel control may be achieved.

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POLISH SUMMARY

MOŻLIWOŚCI WYKORZYSTANIA *GASTROIDEA VIRIDULA* DEG. DO REGULACJI SZCZAWIU OMSZONEGO (*RUMEX CONFERTUS* WILLD.)

Badania terenowe i laboratoryjne prowadzono w celu określenia możliwości wykorzystania *Gastroidea viridula* Deg. (*Coleoptera: Chrysomelidae*) do ograniczenia populacji szczawiu omszonego (*Rumex confertus* Willd.). W badaniach obejmujących naturalne siedliska określono dynamikę rozwoju biomasy szczawiu oraz liczono larwy zasiedlające tę roślinę. Współczynnik korelacji Persona dla wzrostu szczawiu w czasie wyniósł r = 0,96. Równanie regresji pokazało, że dzienny wzrost roślin osiągnął odpowiednio 29 g i 210 g na tydzień. W badaniach laboratoryjnych ważono masę zjedzonego pokarmu przez larwy oraz przyrost masy ciała w temperaturze 20°C. Badaniu poddano pierwsze pokolenie *G. viridula*. Całkowita masa zjedzonego pokarmu przez wszystkie trzy stadia larwalne, podczas 50 dni rozwoju wyniosła 1,243 g. Obserwowano także dynamikę populacji larw. Największą liczbę larw *G. viridula* na roślinę zaobserwowano w maju 25, od 435 do 469 osobników. Gatunek ten może być przydatny w biologicznej walce ze szczawiem omszonym.

Book Review

Luc, M., Sikora, R., Bridge, J. (Eds.). 2005. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture, 2nd edition. CABI Publishing, Wallingford, 871 pp. ISBN 0 85199 7299.

The first edition of "Plant Parasitic Nematodes in Subtropical and Tropical Agriculture" was published in 1990. Now we have the updated and revised second edition, with 22 following chapters: 1 – "Reflections on Nematology in Subtropical and Tropical Agriculture" (p. 1–10) by M. Luc, J. Bridge and R.A. Sikora; 2 – "Identification, Morphology and Biology of Plant Parasitic Nematodes" (p. 11–52) by D.J. Hunt, M. Luc and R.H. Manzanilla-López (revised by M. Luc, D.J. Hunt and J.E. Machon); 3 – "Methods for Extraction, Processing and Detection of Plant and Soil Nematodes" (p. 53–86) by D.J. Hooper, J. Hallmann and S. Subbotin (revised by D.J. Hooper); 4 – "Nematode Parasites of Rice" (p. 87–130) by J. Bridge, R.A. Plowright and D. Peng (revised by J. Bridge, M. Luc and R.A. Plowright); 5 – "Nematode Parasites of Cereals" (p. 131–192) by A.H. Mac Donald and J.M. Nicol (revised by G. Swarup and C. Sosa-Moss); 6 – "Nematode Parasites of Solanum and Sweet Potatoes" (p. 193–220) by M.L. Scurrah, B. Niere and J. Bridge (revised by P. Jatala and J. Bridge); 7 – "Nematode Parasites of Tropical Root and Tuber Crops" (p. 221–258) by J. Bridge, D.L. Coyne and Ch.K. Kwoseh (revised by P. Jatala and J. Bridge; 8 – "Nematode Parasites of Food Legumes" (p. 259–318) by R.A. Sikora, N. Greco and J. Flávo Veloso Silva (revised by R.A. Sikora and N. Greco); 9 – "Nematode Parasites of Vegetables" (p. 319–392) by R.A. Sikora and E. Fernández (revised by C. Netscher and R.A. Sikora); 10 – "Nematode Parasites of Peanut" (p. 393–436) by D.W. Dickson and D. De Waele (revised by N.A. Minton and P. Boujard); 11 – "Nematode Parasites of Citrus" (p. 437–466) by L.W. Duncan (revised by L.W. Duncan and E. Cohn); 12 – "Nematode Parasites of Subtropical and Tropical Fruit Tree Crops" (p. 467–492) by F.E. El-Borai and L.W. Duncan (revised by E. Cohn and L.W. Duncan); 13 – "Nematodes Parasites of Coconut and other Palms" (p. 493–528) by R. Griffith, R.M. Giblin-Davis, P.K. Koshy and V.K. Sosamma (revised by R. Griffith and P.K. Koshy); 14 – "Nematode Parasites of Coffee and Cocoa" (p. 529–580) by V.P. Campos and L. Villain (revised by V.P. Campos, P. Sivapalan and N.C. Gnanapragasam); 15 – "Nematode Parasites of Tea" (p. 581–610) by N.C. Gnanapragasam and K.M. Mohotti (revised by V.P. Campos, P. Silvapalan and N.C. Gnanapragasam) ; 16 – "Nematode Parasites of Bananas and Plantains" (p. 611–644) by S.R. Gowen, P. Quénéhervé and R. Fogain (revised by S.R. Gowen and P. Quénéhervé); 17 – "Nematode Parasites of Sugarcane" (p. 645–674) by P. Cadet and V.W. Spaul (revised by V.W. Spaul and P. Cadet); 18 – "Nematode Parasites of Tobacco" (p. 675–708) by Ch.S. Johnson, J. Way and K.R. Barker (revised by J.A. Shepherd and K.R. Barker); 19 – "Nematode Parasites of Pineapple" (p. 709–732) by B.S. Sipes, E.P. Caswell-Chen, J-L. Sarah and W.J. Apt (revised by E.P. Caswell, J-L. Sarah and W.J. Apt); 20 – "Nematode Parasites of Cotton and other Tropical Fibre Crops" (p. 733–750) by J.L. Starr, R.G. Carneiro and O. Ruano (revised by J.L. Starr and S.L.J. Page); 21 – "Nematode Parasites of Spices, Condiments and Medicinal Plants" (p. 751–792) by P.K. Koshy, S.J. Eapen and R. Pandey (revised by P.K. Koshy and J. Bridge); 22 – "Management Practices: an Overview of Integrated Nematode Management Technologies" (p. 793–825) by R.A. Sikora, J. Bridge and J.L. Starr.

Apart of the above the chapters there are two appendixes: Appendix A. "Nematicides" (p. 827–829) by R.A. Sikora and P. Marczok; and Appendix B. "Plant Parasitic Nematode Genera and Species Cited" (p. 831–841) by M. Luc and D.J. Hunt. The "Index" (p. 843–871) facilitates use of this very useful volume.

The first edition of the book was warmly welcomed by nematologists. The same positive acceptance will be toward the second edition that is similarly concisely presented and is up to time. Therefore, in my opinion the book will continually be basic publication for all person interested to nematological problems in subtropical and tropical agriculture.

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