Proc. VII. Int. Symp. Biol. Contr. Weeds, 6-11 March 1988, Rome, Italy.
Delfosse, E.S. (ed.). Ist. Sper. Patol. Veg. (MAF), pp. 349 - 56 (1989).

The Seed-attacking Wasp *Bruchophagus* sp. (Hymenoptera: Eurytomidae) and Its Potential for Biological Control of *Acacia longifolia* in South Africa

R.L. Kluge

Plant Protection Research Institute, Private Bag X9059, Pietermaritzburg 3200 Republic of South Africa

Abstract

This undescribed *Bruchophagus* sp. would appear to be as important a cause of seed mortality in Australia as the introduced seed weevil *Melanterius ventralis* which has already been introduced into South Africa. The extended larval diapause of the seed wasp makes it an easy insect to collect, transport and store. *Bruchophagus* is a genus in which most species are specialized seed parasitoids of legumes. Host-specificity studies showed that the species concerned has a limited host range within the genus *Acacia*, and that it does not attack the commercially important *Acacia mearnsii*. *Bruchophagus* sp. has not been recorded from any commercially important species in Australia, and is a different species from the five known pest species in the genus. Evidence is given to show why it is unlikely that *Bruchophagus* sp. will attack southern African acacias. *Bruchophagus* sp. could be a valuable supplement to the existing biological control agents in areas where these are less effective.

Introduction

Acacia longifolia (Andrews) Willdenow (Mimosaceae) is a woody shrub that was introduced into South Africa from Australia in *ca.* 1830 for sand-binding (Boucher and Stirton 1978). It escaped cultivation and has been ranked the second most important threat to the native vegetation in the fynbos biome (Macdonald and Jarman 1984). One of the major reasons for the invasiveness of *A. longifolia* is its copious seed production (Milton and Hall 1981).

Two biological control agents have already been introduced to reduce the seed production of *A. longifolia*. The gall wasp, *Trichilogaster acaciaelongifoliae* Froggatt (Hymenoptera: Pteromalidae), which was introduced in 1982, galls the inflorescences and is reducing pod/seed production at some sites by as much as 99% (Dennill 1988). It also markedly reduces vegetative growth (Dennill 1985). A second agent, the seed weevil *Melanterius ventralis* Lea (Coleoptera: Curculionidae), whose larvae feed on the developing seeds, was released in 1985.

Despite the uncertainty about the status of the genus *Bruchophagus* (Hymenoptera: Eurytomidae) (Ashmead 1984, Neunzig and Gyrisco 1958, Claridge 1961, Strong 1962, Szelenyi 1976, Boucek 1983), it has always been associated with the seeds of legumes (Burks 1957). In this study the biology of a *Bruchophagus* sp. found by S. Neser in 1982 is described, and its potential for biological control of *A. longifolia* in South Africa is assessed.

Methods and Materials

Biology

Three batches of seeds were received each year from *A. longifolia* and the closely related *A. sorphorae* (Labill.) R. Br. from 21 localities in New South Wales and Victoria between 1982 and 1984. Three different collectors were involved and no standardized sampling method was used. Seeds from each site (n = 100 or 200) were mounted on 130 x 65 mm perspex pallets, and X-rayed using a Softex Type EMB X-ray unit (Softex Co., Tokyo, Japan) to determine the levels of *Bruchophagus* infestation and other causes of seed mortality. Exposure factors were 13 kVp and 9 ma for 60 seconds. The neat, round cavity which *Bruchophagus* makes in the seed clearly distinguishes its damage from other types of damage such as that of the seed weevil larva which excavates the seed contents irregularly.

Infested seeds with diapausing *Bruchophagus* sp. larvae were initially kept in 80 x 270 mm gauze-topped, perspex cylinders in a quarantine room at ambient temperatures. When the New South Wales material failed to come out of diapause, even after being given cold treatment (Strong 1962), the seeds were kept outside in sealed 240 x 240 mm gauze bags under a 2 cm layer of *A. longifolia* leaf litter. An emergence tube was mounted on an 8 cm diameter funnel which was fixed to the upper side of the bag. The opposite end of the emergence tube was closed off with fine brass gauze. As soon as the first adults appeared in the emergence tubes, the cages were returned to the quarantine room. All emergence from the cages was recorded. The wasps were kept in 50 x 50 mm glass phials and given honey and water.

For the oviposition and breeding studies adults were sleeved on *A. longifolia* branches in the field. Developing pods appeared to be suitable for egg-laying when they were between 1 to 4 mm in width, or from the time when the cotyledon first became visible until it filled the seed cavity. Pods took approximately 25 d to develop from 1 to 4 mm in width. As soon as the pods had ripened the sleeves were returned to the quarantine laboratory where the infested seeds were collected. Seeds parasitized by *Bruchophagus* sp. are typically bloated proximally (because of the pupal cell) and slightly shrivelled distally. Unlike healthy seeds, the testa is pale brown and not black.

Host-specificity

Because of the confusion regarding the taxonomy of the genus *Bruchophagus*, a host record list was based on the more recent work of Szelenyi (1976) and Zerova (1978) for the Palearctic species, and supplemented with additional records of species from other regions.

The number of plant species that were at a suitable stage of fruiting for inclusion in the host-specificity trial was limited because the stage of development of the pods is critical for successful oviposition, and *Bruchophagus* sp. adults are only available for about 4 wks in the year. Seven Australian *Acacia* spp. that are now growing in South Africa, two native legumes, and three commercially important legumes were tested as possible hosts of *Bruchophagus* sp. The trials were done on established trees or on potted plants. For all the Australian *Acacia* spp., branches bearing pods with weeds in which the developing cotyledons filled less than half the seed cavity were selected. For those legumes where it was not possible to use this index, as wide a range of pod sizes as possible were exposed to the wasps.

Wasps emerging in the laboratory were accumulated for up to two days and kept at 14°C before being used in tests. Four females and two males were sleeved on the branches of each test plant. Tests were replicated 5 to 9 times. There were controls for each set of releases. After the seeds had ripened, the sleeved branches were returned to the quarantine laboratory and checked for damage caused by *Bruchophagus* sp.

Because of logistical problems none of the indigenous *Acacia* species could be included in the host-specificity trials. Apart from *Acacia karroo* Hayne, native *Acacia* spp. do not occur naturally in the southwestern Cape. Also, none of the indigenous acacia species under cultivation in the area had pods at a suitable stage of development for inclusion in the trials. The probability that *Bruchophagus* sp. could use any of the indigenous acacias as alternative hosts was assessed by comparing the phylogeny of the South African and Australian acacias, their reproductive phenologies and geographic distributions.

Results

Biology

Bruchophagus sp. is univoltine and has on obligatory larval diapause lasting from one to four years. There was usually no emergence in the first year after egg laying, with peak emergence in the second or third year. The onset of emergence varied from the beginning of September (1984) to as late as the end of September (1985), depending on the flowering time of *A. longifolia*. Adults emerged over a period of up to 26 d each year. In the 1986 season, pods suitable for development of *Bruchophagus* sp. were available from about 20 September to 15 November, i.e., about 25 d.

The maximum recorded longevity of the adults at room temperature was seven days and ten days at 14°C. The sex ratio for the New South Wales material that emerged varied from 1:1.3 to 1:1.5 males: females in the three batches (*n* = 50, 982 and 240 wasps). Female fecundity as estimated from a breeding cage stocked with 14 females was 40.9 offspring/female.

Before going into diapause, the final instar larva makes a cell by lining the inside of the cavity in the seed with a black secretion. There was never more than one fully developed larva per seed. The infested seeds drop into the leaf-litter together with the healthy seeds, where the testa gradually decomposes leaving only the round larval cell. Pupation occurs just prior to adult emergence. *Bruchophagus* sp. larvae were parasitized by an unidentified species of *Isoplatoides* (Hymenoptera: Pteromalidae), which diapaused as a pupa in the larval cell.

The biology of the material from Stawell in Victoria differed from that described above for the New South Wales stock in that the infested seeds were glued to the pod with two lumps of "cement" on the equator of the seed, the larval diapause only lasted for one year, and it was not necessary to keep the larvae outside to break diapause.

Except in 1984, levels of *Bruchophagus* sp. damage were usually higher than those for the seed weevil *M. ventralis* which was the only other notable cause of seed mortality in the samples (Table 1). *Bruchophagus* sp. damage was also common in the *A. sophorae* samples. *Bruchophagus* sp. was found at all except two of the most northerly collecting sites in New South Wales (Table 1).

Host-specificity

Host records. Host records were found for 34 out of a total of 41 *Bruchophagus* spp. (Hedlin 1956, Burks 1957, Neunzig and Gyrisco 1958, Batiste 1967, Green and Palmblad 1975, Szelenyi 1976, Zerova 1978, Georgevits 1981, Boucek and Brough 1985, Farooqi and Subba (1986). Of these 34, 27 are phytophagous and seven entomophagous. Twenty three of the phytophagous species were reared from legumes. Except for two which could not be confirmed, all belonged to the sub-family Papilionaceae. In 17 of the 19 phytophagous host records where it was specified what material the wasps had been reared from, the wasps had emerged from seeds or pods.

All *Bruchophagus* species have only been reported from one host plant genus, apart from *B. mellipes* Gahan (Burks 1957, Farooqi and Subba 1986), *B. mutabilis* Nikol'skaya (Szelenyi 1976, Gerogevits 1981), *B. ononis* Mayr and *B. sophorae* Crosby (Szelenyi 1976, Zerova 1978). About half of the genus-specific species have been recorded from more than one species in the host plant genus.

In Australia *Bruchophagus* has reliably been recorded from relatively few other *Acacia* spp.: *Acacia cyclops* A. Cunn. ex G. Don (Kluge, R.L., unpublished data), *A. floribunda* (Vent.) Willd (Neser, S., pers. comm., 1987), *A. sophorae* and *Acacia elongata* Sieb. (Auld 1986). (It was confirmed that the "Hymenoptera larvae" referred to in Auld (1986) are *Bruchophagus*). *Eurytoma acaciae* Cameron (probably *Bruchophagus*) was recorded from the seeds of naturalized *Acacia decurrens* Willd. in New Zealand (Cameron 1910).

Table 1. The mean viability and mortality of *Acacia longifolia* (Andrews) Widlenow seeds in samples that were collected from the trees over three years at 21 locaties in Australia. Apart from Stawell (37°4′S; 142°46′E) and Yanakee (38°48′S; 146°12′E) in Victoria, all the samples were collected along the New South Wales coast between Charmhaven (33°16′S; 151°26′E) and Moruyah (35°55′S; 150°5′E). The ranges are given in brackets.

Number of localites	Mean sample size	Mean % viable seeds	Mean % seed mortality			
			Bruchophagus sp.	*Melanterius ventralis* Lea	Physiological	Other
1982 Shipment 10	1400 (100-3400)	56.6 (20-74)	23.4 (0-50)	15.4 (2-36)	3.8 (0-12)	1.2 (0-6)
1983 Shipment 5	14 000 (2600-28800)	50.5 (43-62.5)	34.9 (11.4-57.8)	9.5 (8-12)	4.6 (2.5-7.5)	0.5 (0-1)
1984 Shipment 4	24 000 (10200-46500)	64 (36-78)	5 (0.5-8.5)	21.4 (5.5-46)	6.3 (3-8.5)	3.4 (0-9)

The only other records of *Bruchophagus* in Australia are: *B. fellis* (Girault) on sweet orange and *B. roddi* (Gussakovsky) on lucerne/alfalfa (Naumann, I., pers. comm. , 1987), although there are other Australian species presently in the genus *Eurytoma* which probably belong to *Bruchophagus* (Naumann, I., pers. comm., 1987). The only record of *Bruchophagus* in South Africa is that of *B. roddi* (incorrectly referred as *B. gibbus*) from lucerne (Annecke and Moran 1982).

Five *Bruchophagus* spp., have been recorded from commercially important plant species: *B. fellis* (galls the twigs of a number of citrus varieties including lemon, orange and grapefruit in Australia) and *B. muli* Boucek & Brough (galls the fruit of lime in Papua New Guinea) (Boucek and Brough 1985), *B. gibbus* (Boheman) (Metcalf and Flint 1962), *B. kolobovae* Fedoseeva (Batiste 1967), *B. roddi* (Strong 1962) which parasitize the seed of various clovers, trefoil and lucerne/alfalfa respectively in many parts of the world. *Bruchophagus* sp. is a different species from all these species (Prinsloo, G.L., pers. comm., 1987).

Host-specificity trial. Adult survival in the cages was variable with most adults dying within the first 5 d. Of the twelve species included in the tests *Bruchophagus* sp. was only found infesting the seeds of *A. longifolia* (Table 2).

Discussion

Bruchophagus is apparently as important a mortality factor of developing *A. longifolia* seeds in Australia as the seed weevil *M. ventralis*. Despite the pressure of parasitism it appears to achieve high attack rates similar to that of other *Bruchophagus* spp. (Hedlin 1956, Strong 1960). The extended larval diapause makes *Bruchophagus* sp. an easy insect to collect, transport and store. There appear to be at least two geographic races. These both appear to be compatible with the local *A. longifolia*, although the race from Stawell may be better suited to the Mediterranean climate of the south-western Cape than material from the all-year-round rainfall areas of southern New South Wales.

Despite the apparent biological diversity within the genus *Bruchophagus*, much of which could be attributed to the taxonomic confusion, there has been a major trend in the group towards specialization as seed parasitoids of the Fabaceae. A remarkable feature of the specialization of *Bruchophagus* sp. on *A. longifolia* is the synchronization, even after three or four years of diapause, of the short adult stage with the brief period that developing pods are suitable for egg-laying. The staggered emergence of the adults from diapause is probably a further adaptation to protect *Bruchophagus* sp. populations against unfavourable fruiting seasons. Dennill (1987) has show how pod production of *A. longifolia* can be cyclical, and found that it could drop by as much as 62% from one season to the next.

As with most of the other species in the genus, *Bruchophagus* sp. is host-specific within the genus, but possibly not strictly monophagous since *Bruchophagus* sp. from the closely related *A. sophorae* could reproduce on *A. longifolia*. From the results of the specificity tests, and its apparently limited occurrence within the genus *Acacia* in Australia, it is clear that, except possibly for closely related species such as *A. floribunda*, no other Australian acacias in South Africa, including the commercially important *A. mearnsii*, will be attacked by *Bruchophagus* sp. *Bruchophagus* sp. has also not been recorded from any other commercially important plants in Australia.

The fact that *Bruchophagus* sp. cannot reproduce on many of the Australian *Acacia* species makes it highly improbable (Wapshere 1974) that it will successfully colonize any of the African acacias, which are phylogenetically quite separate; all the African acacias, except for *Acacia albida*, belong to the subgenera *Acacia* Vassal and *Aculeiferum* Vassal, whereas *A. longifolia* like most other Australian acacias belongs to the subgenus *Heterophyllum* (Pedley 1978; Ross 1979). According to Robbertse (1971), the isolation between the Australian and African sub-genera occurred at a very early stage in the phylogenetic history of the genus, maximizing the differences between them. This has been confirmed by the pattern with which non-protein amino acids (Seneviratne and Fowden 1968) and free amino acids Evans

Table 2. A comparison of the predation by *Bruchophagus* sp. of the seeds of *Acacia longifolia* (Andrews) Widlenow and a variety of other legumes, after the exposure of developing pods to four female and two male wasps in sleeved branches.

Test plants	Number of cages i.e., sleeved branches	Number of cages with *Bruchophagus* attack	Mean number of pods/cage	Mean number of seeds/cage	Mean % *Bruchophagus* attacked seeds per cage	Mean % of other non-viable seeds/cage
Acacia cultriformis A. Cunn. *ex* G. Don.	9	0	28.9	115.8	0	4.8
Acacia cyclops A. Cunn. *ex* G. Don.	9	0	14.6	62.1	0	3.9
Acacia longifolia (Andrews) Willdenow	15	12	26.1	145.6	26.4	16.3
Acacia mearnsii De Willd.	9	0	30.2	183.4	0	1.6
Acacia pycnantha Benth.	9	0	23.1	139.3	0	1.0
Acacia salina Labill. Wendl.	8	0	44.8	217.6	0	7.4
Acacia sp. (unidentified Australian sp.)	6	0	3.2	26.3	0	0
Lupinus angustifolius L.	5	0	27.6	77.6	0	23.6
Medicago truncatula Gaertn.	5	0	12.8	69	0	0
Pisum sativum L.	6	0	5.5	23.2	0	1.3
Podalyria calyptrata Willdenow	8	0	11.8	55.8	0	0.8
Virgilia oroboides (Berg.) Salter	8	0	11.0	37.3	0	0.1

et al. (1977) occur in the seeds of many *Acacia* spp. The great morphological diversity of acacia pods, which is a feature of the genus (Pedley 1978), is also known to be related to their phylogeny (Robbertse 1971). Both biochemical (Buttery *et al.* 1982, Kamm and Buttery 1986) and morphological characteristics of pods (Brewer *et al.* 1983, Small and Brookes 1982) have been shown to be important to clover and alfalfa/lucerne seed chalcids for host recognition.

The synchronization of the *Bruchophagus* sp. oviposition period with the reproductive phenology of *A. longifolia* would exclude many of the native acacias as hosts. Only those species bearing young developing pods for a period of approximately 25 d each year from the beginning of September to the end of October could serve as alternative hosts for *Bruchophagus* sp. *A. longifolia* starts flowering in June or July. Twenty nine of the 48 southern African *Acacia* spp. have been known to only start flowering as early as September (Carr 1976, Palgrave 1977, Carr, J.D., unpublished data).

Most southern African acacias also have a more northerly distribution (Robbertse 1971, Palgrave 1977) than that of *A. longifolia* in South Africa (Pieterse, P.J., unpublished data). Only two species, *A. karroo* and *A. caffra* (Thunb.) Willd., occur below 33° latitude where all the seriously-invasive populations of *A. longifolia* occur (Macdonald and Jarman 1984, Pieterse P.J., unpublished data). Of these only *A. caffra* has a reproductive phenology overlapping with that of *A. longifolia.* In Natal, where *A. longifolia* is far less abundant than in the southern and south-western Cape, 14 indigenous acacias occur that have flowering periods which overlap with that of *A. longifolia.* Although some confirmatory testing may be required, the evidence strongly suggest that the indigenous acacias would be unsuitable alternative hosts for *Bruchophagus* sp. in southern Africa.

Although only one seed chalcidid has been used in biological control, it has proved to be effective (Williams 1961, Ung and Yunus 1981). *Bruchophagus* sp., because of its potential for reducing seed production and its apparent safety with regard to indigenous acacias and commercially important crop plants, including *A. mearnsii*, could also be an effective supplement to the biological control of *A. longifolia* in areas where the existing agents may prove to be less effective. Unfortunately since *Bruchophagus* appears to be less common within the genus *Acacia* in Australia than *Melanterius* (New 1983), its use against other invasive Australian acacias in South Africa will be limited.

Acknowledgments

I am grateful to Drs. S. Neser and M.J. Morris and Mr. P. van der Duys for collecting seed material in Australia, to Dr. G.L. Prinsloo for the identification of the chalcidids, to Ms. D. Donnelly and Drs. J.K. Scott and G.B. Dennill for their valuable criticisms of the manuscript, to Prof. D. Donald of the University of Stellenbosch for making the X-ray facilities at the Forestry Faculty available to me, and to Miss G. Samuels for technical assistance.

References

Annecke, D.P. and V.C. Moran. 1982. *Insects and Mites of Cultivated Plants in South Africa.* Butterworths, Durban/Pretoria, 272 p.

Ashmead, W.R. 1984. Descriptions of new parasitic Hymenoptera (Paper No. 1). *Trans. Am. Ent. Soc.* **21**:318-44.

Auld, T.D. 1986. Variation in predispersal seed predation in several Australian *Acacia* spp. *Oikos* **47**:319-26.

Batiste, W.C. 1967. Biology of the trefoil seed chalcid, *Bruchophagus kolobovae* Fedoseeva (Hymenoptera: Eurytomidae). *Hilgardia* **38**:427-69.

Boucher, C. and C.H. Stirton. 1978. Long-leaved wattle. *In*: *Plant Invaders: Beautiful but Dangerous.* Stirton, C.H.. (ed.). Dept. Nature and Envir. Conser. Cape Prov. Admin., Cape Town, pp. 44-7.

Boucek, Z. 1983. On *Buresium*, *Masneroma* (n. gen.) and some other *Eurytomidae* (Hymenoptera). *Ent. Scan.* **14**:186-94.

Boucek, Z. and E.J. Brough. 1985. *Bruchophagus muli* sp. nov. (Hymenoptera: Eurytomidae), a wasp which galls the fruit of lime in Papua New Guinea. *Bull. Ent. Res.* **75**:347-51.

Brewer, G.J., E.L. Sorenson and E.K. Horber. 1983. Trichomes and field resistance of *Medicago* species to the alfalfa seed chalcid (Hymenoptera: Eurytomidae). *Envir. Ent.* **12**:247-51.

Burks, B.D. 1957. A new *Bruchophagus* from a liliaceous plant with a host plant list for the genus (Hymenoptera: Eurytomidae). *Proc. Ent. Soc. Wash.* **59**:273-7.

Buttery, R.G., J.A. Kamm and L.C. Ling. 1982. Volatile components of alfalfa flowers and pods. *J. Agric. Food. Chem.* **30**:739-42.

Cameron, P. 1910. On a new species of phytophagous *Eurytoma* (Chalcididae) from New Zealand. *The Ent.* **43**:114-5.

Carr, J.D. 1976. *The South African Acacias*. Conserv. Press (Pty) Ltd, Johannesburg, 323 p.

Claridge, M.F. 1961. An advance towards a natural classification of *Eurytomid* genera (Hym., Chalcidoidea), with particular reference to British forms. *Trans. Soc. Brit. Ent.* **14**:167-85.

Dennill, G.B. 1985. The effect of the gall wasp *Trichilogaster acaciaelongifoliae* (Hymenoptera: Pteromalidae) on reproductive potential and vegetative growth of the weed *Acacia longifolia*. *Agric. Ecol. Envir.* **14**:53-61.

Dennill, G.B. 1987. The importance of understanding host plant phenology in the biological control of *Acacia longifolia*. *Ann. Appl. Biol.* **111**:661-6.

Dennill, G.B. 1988. Why a gall former can be a good biocontrol agent: the gall wasp *Trichilogaster acaciaelongifoliae* and the *Acacia longifolia*. *Ecol. Ent.* **13**:1-9.

Evans, C.S., M.Y. Qureshi and E.A. Bell. 1977. Free amino acids in the seeds of *Acacia* species. *Phytochemistry* **16**:565-70.

Farooqi, S.I. and B.R. Subba Rao. 1986. Family Eurytomidae. *In*: *The Chalcidoidea (Insecta: Hymenoptera) of India and the adjacent countries, Part II. A catalogue of Chalcidoidea of India and the Adjacent Countries*. Subba Rao, B.R. and M. Hayayt (eds.). *Oriental Insects* **20**:247-77.

Georgevits, R.P. 1981. Seed insects of *Robinia Pseudo-acaciae*. *Dasiko n Ereuno n* **2**:233-55.

Green, T.W. and I.G. Palmblad. 1975. Effects of insects seed predators on *Astragalus cibarius* and *Astragalus utahensis* (Leguminosae). *Ecology* **56**:1435-40.

Hedlin, A.F. 1956. Notes on the life history and habits of a chalcid, *Bruchophagus caragnae* (Nik.) (Hymenoptera: Chalcididae), infesting seeds of caragna. **Can. Ent. 88**:622-5.

Kamm, J.A. and R.G. Buttery. 1986. Ovipositional behaviour of the alfalfa seed chalcid (Hymenoptera: Eurytomidae) in response to volatile components of alfalfa. *Envir. Ent.* **15**:388-91.

Macdonald, I.A.W. and M.L. Jarman. 1984. Invasive alien organisms in the terrestrial ecosystems of the fynbos biome, South Africa. S. *Afr. Nat. Sci. Progr. Rep. No.* **85**., Counc. Sci. and Ind. Res., Pretoria, 72 p.

Metcalf, C.L. and W.P. Flint. 1962. *Destructive and Useful Insects: Their Habits and Control*. McGraw-Hill, New York. 1087 p..

Milton, S.J. and A.V. Hall. 1981. Reproductive biology of Australian acacias in the south-western Cape Province, South Africa. *Trans. R. Soc. S. Afr.* **44**:465-85.

Neunzig, H.H. and G.G. Gyrisco. 1958. Host relationships of seed chalcids reared from birdsfoot trefoil. *J. Econ. Ent.* **51**:409-10.

New, T.R. 1983. Seed predation of some Australian acacias by weevils (Coleoptera: Curculionidae). *Aust. J. Zool.* **31**:345-52.

Palgrave, K.C. 1977. *Trees of Southern Africa*. C. Struik Publishers, Cape Town, pp. 224-53.

Pedley, L. 1978. A revision of *Acacia* Mill. in Queensland. *Austrobaileya* **1**:81-3.

Robbertse, P.J. 1971. A morphological study of the genus *Acacia* Miller in South Africa. Unpublished D.Sc. Thesis, University of Pretoria, Pretoria, S. Afr., 340 p. (*In Afrikaans*).

Ross, J.H. 1979. A conspectus of the African *Acacia* species. *Mem. Bot. Surv. S. Afr.* **44**:1-155.

Seneviratne, A.S. and L. Fowden. 1968. The amino acids of the genus *Acacia*. *Phytochemistry* **7**:1039-45.

Small, E. and B.S. Brookes. 1982. Coiling of alfalfa pods in relation to resistance against seed chalcids. *Can. J. Pl. Sci.* **62**:131-5.

Strong, F.E. 1960. Sampling alfalfa seed for clover seed chalcid damage. *J. Econ. Ent.* **53**:611-5.

Strong, F.E. 1962. Laboratory studies of the biology of the alfalfa seed chalcid, *Bruchophagus roddi* Guss. (Hymenoptera: Eurytomidae). *Hilgardia* **32**:229-48.

Szelenyi, G. 1976. Mongolian Eurytomids (Hymenoptera: Chalcidoidea). III. *Acta Zool. Hung.* **22**:397-405.

Ung, S.H.. and A. Yunus. 1981. The present status of the biological control of *Cordia curassavica* in Malaysia. *Proc. V Int. Biol. Contr. Weeds*, 22-27 July 1980, Brisbane, Australia. Delfosse, E.S. (ed.). CSIRO, Melbourne, pp. 489-98.

Wapshere, A.J. 1974. A strategy for evaluating the safety of organisms for biological weed control. *Ann. Appl. Biol.* **77**:201-11.

Williams, J.R. 1961. The control of black sage (*Cordia macrostachya*) in Mauritius: The introduction, biology and bionomics of a species of *Eurytoma* (Hymenoptera: Chalcidoidea). *Bull. Ent. Res.* **51**:123-32.

Zerova, M.D. 1978. Hymenoptera II. Chalcidoidea 8. Eurytomidae. *Opred. Asek. Evrop. Chasti SSSR* **3**:328-58 (*In Russian*)