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SPECIAL ISSUE

This special issue is primarily devoted to the paper 'Parasitic plants and their control: a history' by Chris Parker, based on the presentation he made at the Strigolactone meeting in Nitra, Slovakia in July 2106. See p. 2.

The opportunity is also taken here to provide a link to the website for the next, 15th, World Congress on Parasitic Plants to be held in Amsterdam in July 2019. The website is: https://www.wcpp2019.org

Also: we alert you to **IUFRO World Congress 2019 -** Technical Session - **Complex interactions of mistletoe, ecosystems, and people.** Sponsored by Working Party 7.02.11 Parasitic flowering plants in forests. Curitiba, Brazil. 29 September – 5 October, 2019. http://www.iufro2019.com/ Contact**:** David Shaw, Oregon State University, dave.shaw@oregonstate.edu **NB. Abstract deadline 31st December, 2018**.

PARASITIC WEEEDS AND THEIR CONTROL – A HISTORY

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Introduction

This special issue of Haustorium is devoted to a presentation given by Chris Parker at the Strigolactone meeting in Nitra, Slovakia, in July, 2016, which has not otherwise been previously published. Chris thanks his co-editors for allowing him this opportunity to share his thoughts and observations from a longish career in parasitic weeds.

This will be far from a complete history but a very selective one, looking at some of the key dates relating to major parasitic weed problems, especially *Orobanche cumana* in sunflower, *Striga* in cereals and in cowpea and *Orobanche crenata* in legumes, with admittedly personal reflections on my own involvement in each of these. There will also be a review of the wider development of literature and meetings on the topic.

Evolution:

To start at the beginning - i.e. some 100 millions of years ago. We know that the parasitic habit evolved independently many times. Certainly 11, maybe 12, according to Dan Nickrent to whom I am grateful for relevant advice in this sphere and particularly for referring me to the paper by Naumann *et al,* (2013) from which this information is drawn. Fig 1 suggests that Balanophoraceae and Loranthaceae both go back about 110 million years, *Cassytha* about 77 million, *Cuscuta* about 35 million and Orobanchaceae 'only' 32 million. These estimates are of course based on DNA rather than actual fossils. Apparently the only fossil record for Orobanchaceae is of pollen and the dating corresponds to that from DNA – this information from Muller, 1981.

110 million years BP

Family/genus	Million years BP
Balanophoraceae	110
Loranthaceae	110
Hydnoraceae	101
Cassytha	77
Cuscuta	35
Orobanchaceae	32
From Naumann *et al.,* 2013; Muller, 1981	

Fig 1.

The Greeks

The first we know of them in literature is that they were recognised as parasites by the Greeks. Theophrastus (c. 371-287 BC) apparently refers to an *Orobanche* species attached to and damaging fenugreek. Pliny and Dioscorides also commented – see Fig2 (all usefully reviewed by Zadoks in 2013). The Greeks also recognised these as 'different' and considered them useful as food or medicine. Ever since then, it seems that, because they are different, and damaging, parasitic plants are somehow expected to have healing or other magical properties, especially if they were particularly rare or unusual. And judging from the numbers of literature items that we scan for Haustorium (and print in blue) I get the impression that parasitic plants are still favoured as the source of traditional medicines. The Greeks felt that the mistletoe *Viscum album* had mystical powers and later in northern Europe, the pre-Christian druids maintained the legend of the 'golden bough', based on the relatively rare occurrence of mistletoe on oak. Pliny describes a Celtic ritual sacrifice and banquet at which a druid dressed in white would climb an oak tree to collect mistletoe using a golden sickle There is a lot more I could include about the history of the European mistletoe and its therapeutic uses in cancer treatment, but time does not allow, other than to say that the most recent reviews, including a meta-analysis by Cochrane suggest there are certainly benefits from use of mistletoe extracts in conjunction with conventional treatment (Horneber *et al.,* 2008). It can also be a significant weed problem, especially in forestry in the Balkan countries, but this is minor compared with others I shall be covering.

300 BC

Theophrastus (c.371-287 BC) – 'On the Causes of Plants'. *Orobanche* attached to and damaging fenugreek. Mistletoe parasitic on trees and seeds transmitted by bird

Pliny (23-79 AD) –dodder on chickpea, bitter vetch and faba beans, mistletoes damaging trees, ritual use by Celts.

Dioscorides (? To 90 AD) - 'Materia medica'. *Orobanche* eaten as vegetable like asparagus, *Cuscuta* on thyme and *Satureja*, and used medicinally.

Zadoks, 2013.

Fig 2.

I am skipping the mediaeval and later centuries which no doubt have many references to the characteristics and uses of parasitic plants but I am not aware of any major advances or developments of note.

Sunflower

My next significant date is 1866. In a recent excellent review, Molinero-Ruiz *et al.* (2015) describe how *Orobanche cumana* (Fig 3) was first recognised as a problem in sunflowers in Russia in 1866, and by the end of the century it had spread to Moldova and Romania. Pustovoit (1967;1976) describes how, in 1912, a resistance breeding programme was initiated (Fig 4). Cubero (1986, 1991) in valuable reviews describes how, by 1916, a range of material had been developed with complete resistance and by 1925, 95% of the sunflower crop grown in Pustovoit's region was based on these resistant lines. However, when they were distributed more widely in the following three years, the resistance failed. This failure was soon explained by the existence of different races of the parasite, the original being designated race A and the more virulent, race B. Unfortunately race B proved to be a complex of different sub-races, making it difficult for the breeders and in due course the resistance to race B was overcome in the 1970s, by race C. And so on until the current situation where we recognise races up to F, G and even H and the breeders are kept busy trying to keep one step ahead in many countries across southern and eastern Europe (Fig 5). I highly recommend the Molinero-Ruiz review which covers the history and the complexity of the topic in great detail. In most regions, resistance is available but the situation keeps changing, keeping the breeders on their toes.

Fig 3.

Sunflower resistance breeding

1912 – First records of breeding sunflower for *Orobanche*-resistance
Pustovoit, 1967, 1976

1916 – First new virulence recorded, followed by further virulent races

Reviewed by:
Cubero 1986
Cubero 1991

Fig 4.

Races of *O. cumana* (Molinero-Ruiz *et al.,* 2015)

Country	Past	Present
Bulgaria	A,B,C,D,E	E,F,G
China	A	A,B,C,D,E,F,G
Hungary	A,B,C,D	E,F
Romania	A,B,C,D,E	F,G
Russia	A,B,C,D	D,E,F,G,H
Spain	B,C,D,E	E,F
Turkey	?	F,G
Ukraine	A,B,C,D	E,F,G

Fig 5.

An alternative to *Orobanche*-resistant varieties is now the availability of naturally (not GM) herbicide-resistant varieties. But I am uncertain how widely they are being used. (On this as on all other topics I am not attempting to be completely up-to-date. I leave that to those still actively involved in the research.)

Striga

1955 - I am now jumping forward to 1955, when *Striga asiatica* (Fig 6) was first recognised in North and South Carolina in USA. It must have been there for decades already, to have spread, as it had, to nearly 200.000 ha. It is assumed to have come in accidentally in wool from South Africa. Farmers had been aware that they had some sickness problem, in their maize/corn, but it took a visiting Indian student to recognise what it was.

Fig 6.

This was not the beginning of the *Striga* problem of course, nor of work on it, but the discovery in USA prompted the preparation of an invaluable bibliography prepared by McGrath *et al* in 1957, which provides a comprehensive record of research on *Striga* and related genera up to that time. It gives us all the early literature on *Striga* species, providing extremely detailed extended abstracts of each paper. The earliest reports of *Striga* as a weed problem are for *Striga asiatica* early in the 20th century, from India (e.g. Barber, 1904) and from southern Africa (Burtt-Davy, 1904). Earliest reports of work on these problems come from South Africa where Pearson (1914) showed the benefit of nitrogen fertilization and Saunders (1942) from 1926 onwards through to 1942, conducted a wide range of studies on biology and control, proposing a number of agronomic approaches and most importantly began the process of breeding and selection for resistance in sorghum, leading to release of the variety Radar. Timson worked on serious infestations of *S. asiatica* in maize in Rhodesia (Zimbabwe) from 1929 onwards. He promoted catch-cropping with sudan grass, together with phosphate fertilizer and crop rotation leading to over 3-fold yield increases in maize over a 4 year period (Timson 1945).

The problem from *S. hermonthica* (Fig 7) in the northern half of Africa did not appear to be recognised until somewhat later. I cannot explain this other than to assume that there was less pressure on land and it was traditionally suppressed by shifting cultivation. McDonald (1928) was one of the first to record it as a problem, on maize in Kenya. Andrews (1945) studied it as a problem in sorghum in Sudan while Portères (1948) documented it in rice and other crops in Senegal, West Africa. Doggett working in

Tanganyika (Tanzania) from 1952 to 1954 developed a number of resistant sorghum varieties, including Dobbs and others which provided the basis for the subsequent work of ICRISAT (Doggett, 1954). (I shall return to those more recent developments later).

Fig 7.

The Witchweed Lab

Meanwhile, back to 1955 in USA, the fear was that it could spread to the corn belt of the mid-West, hence the establishment of the Witchweed Lab in Whiteville, North Carolina where Bob Eplee, from 1965, started to develop his various techniques for the study and eradication of *Striga*, involving quarantine, herbicides, methods for monitoring infestations by separation of seeds from the soil and the use of ethylene to stimulate suicidal germination (which sadly never really worked against *S. hermonthica* in Africa). Much of this work was summarised in the WSSA publication by Sand *et al* (1990) and by Eplee himself (Eplee, 1992). Wide-scale quarantine restrictions were finally lifted in 2009, and 50 years, and $250 million later, the infestation was finally reduced to a few hundred acres over 5 counties in the Carolinas (Tasker *et al.,* 2012).

Oxford

1956 was significant as the year in which I myself first became familiar with *Striga asiatica* in South Africa, though I only began working on it in 1959 when I returned to the ARC Unit of Experimental Agronomy in Oxford and took over a programme that already included the testing of herbicides on *Striga hermonthica*. From then on I spent many years delving into its biology and control in the labs and glasshouses in Oxford and at Weed Research Organization from 1966. We screened innumerable herbicides but found none sufficiently selective. We looked at the effects of nutrients on stimulant exudation in sorghum and confirmed the effect of nitrogen in reducing it and of potassium in stimulating it. Curiously we failed to show the effect of phosphorus in reducing it, now well confirmed by others - and I still do not quite understand why we missed it. Now, it may be possible to exploit this beneficial effect of P very economically by ‘micro-dosing’ (Jamil *et al*., 2014).

We enjoyed demonstrating the profound inhibitory effect of *Striga* extremely early after attachment, such that, at 4 weeks, less than 1 mg of *Striga* seedlings a few mm long could cause 400 mg reduction in the total weight of the host, and at 5 weeks, 13.5 mg caused a total weight loss of 960 mg. (Parker 1984) (Fig 8). (Incidentally this phenomenon is not shown by *Orobanche* species, which in general reduce their host by very little more than their own dry weight). Furthermore, the shoot of *Striga* is disproportionally affected as a result of a significant shift in root:shoot balance (Fig 9) . We also, in conjunction with ICRISAT, screened hundreds of sorghum varieties for their stimulant exudation, not realising at that time that the absence of stimulant might have a down-side.

Early influence of *S. hermonthica* on host (low nitrogen)

	At 4 weeks	At 5 weeks
Striga dry wt.	0.3 mg	13.5 mg
Sorghum dry wt no *Striga*	2060 mg	3560 mg
Sorghum dry wt. + *Striga*	1650 mg	2600 mg
Sorghum dry wt. loss	410 mg	960 mg
From Parker, 1984.		

Fig 8.

Effect of *S. hermonthica* on root:shoot balance

Low N	Root	Shoot	R:S ratio
Sorghum no *Striga*	1.0	4.1	0.25
Sorghum + *Striga*	1.6	2.5	0.61
Higher N			
Sorghum no *Striga*	2.0	9.9	0.21
Sorghum + *Striga*	3.0	7.6	0.41
from Parker, 1984			

Fig 9.

Strigolactones

1972 - A next significant date in the history of *Striga* is when Cook *et al.* (1972) were the first to describe the structure of a strigolactone – strigol, from the roots of cotton. This audience will hardly need to be reminded of the further history of striglactones, including the discovery of their more primary involvements in controlling plant architecture and the growth of mycorrhizal fungi (Akiyami and Hyashi, 2006), but you may not be familiar with the history of the precursors of the very useful strigol analogues GR24 and Nijmegen-1. In 1975, my boss, John Fryer, director of the ARC Weed Research Organization attended an ARC (Agricultural Research Council) dinner and sat next to Prof. Alan Johnson, director of another ARC Unit - of Invertebrate Chemistry and Physiology at University of Sussex. Prof Johnson mentioned that he had a new post grad student from Canada working on the synthesis of simple strigol analogues and already had some products but had no idea how to test them for activity. John Fryer was able to say that I was doing that routinely with sorghum root exudates and would be able to be of service. A week later we had samples of GR2, GR3, GR4, GR5 and GR7 (Fig 10) and within days we had confirmed high activity from several of these (Fig 11). The later analogues, especially GR 24 and Nijmegen 1 are now immensely useful in research, but not so far as a means of control in the field? No doubt Binne Zwanenberg will bring us up to date on this later. It may not be generally realised that the prefix GR refers to Gerald Rosebery, the post-graduate student involved.

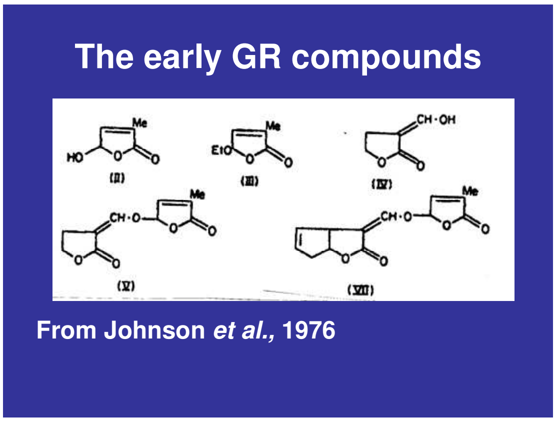

Fig 10.

1976 – GR compounds

Compound	mg/l	Germination %	
		Striga herm.	*Phelipanche ram.*
GR2	0.1/1.0	0/0	44/66
GR3	0.1/1/0	0/0	19/34
GR4	0.1/1.0	0/2	4/6
GR5	0.1/1.0	2/56	77/69
GR7	0.00007/0.01	0/16	55/60
Sorghum exudate		50-70	60-70
Distilled water		0	2-20
Based on Johnson *et al.*, 1976			

Fig 11.

Alectra* and *Striga gesnerioides

In 1985 I visited Charlie Riches in Botswana whose work there included the problem of *Alectra vogelii* (‘yellow witchweed’) in cowpea (Fig 12). By then he had identified a number of cowpea landraces with resistance to *Alectra* (Riches, 1976). I returned to UK with samples of ten of these and put them through a simple screen to look for possible co-resistance to *Striga gesnerioides* (cowpea witchweed) (Fig 13). Nine out of the ten showed no resistance but B.301 showed apparent immunity to at least one race of *S. gesnerioides.* As sunflower shows race-specific immunity to *Orobanche cumana*, so it soon proved that cowpea shows race-specific immunity to *S. gesnerioides.* In 1984, the variety Suvita-2 had been shown to resist *S. gesnerioides* in Burkina Faso, but it was soon shown that this line and another, 58-57 were not resistant in Mali, Niger or Nigeria (Aggarwal *et al.,* 1986). Our further work with B.301 showed that it was immune to the races from all these countries and from Cameroon (Parier and Polniaszek, 1990). Only in 1993 was it found to be overcome by the 'hyper-virulent' Zakpota race from southern Benin (Lane *et al.*, 1993). The recent situation is ably reviewed in the paper by Botanga and Timko (2006) (Fig 14) which includes this table showing that there have been other lines identified by the International Institute for the Semi-arid Tropics (IITA) with broad-spectrum resistance, including to the Zakpota race, but B.301 continues to be valuable to IITA in the development of cowpea lines with dual resistance to both *Striga* and *Alectra* (Poliaszek *et al.,*1991; Singh *et al.*, 1997).

Fig 12

Fig 13.

Botanga and Timko (2006)

	West African races of *S. gesnerioides*						
	SG1	SG2	SG3	SG4	SG4z	SG5	SG6
Cultivar	(Burkina Faso)	(Mali)	(Nigeria/ Niger)	(Benin)	(Benin)	(Cameroon)	(Senegal)
'Tvx-3236'	S	S	S	S	S	S	S
'Blackeye'	S	S	S	S	S	S	S
'UVA-UCR1115'	S	S	S	S	S	S	S
'58-57'	R	S	S	R	S	R	R
'Suvita-2'	R	R	S	R	S	S	R
'B301'	R	R	R	R	S	R	R
'IT81D-994'	R	R	S	R	R	S	R
'IT82D-849'	R	R	R	R	R	R	R
'Tvu-14676'	R	R	R	S	S	R	nt
'IT93K-693-2'	R	R	R	R	R	R	R

Note: S, susceptible; R, resistant; nt, not tested; data from this study, Lane et al. (1996), and Singh and Emechebe (1997).

Fig 14.

More on *Striga*

Returning to *Striga* in cereal crops - over the years there have been continued efforts to find resistance and/or tolerance to *Striga,* led, for sorghum, by ICRISAT who developed a number of valuable ‘SAR’ (*Striga asiatica*-resistant) lines which were later taken on and developed by Gebisa Ejeta in USA for release in Ethiopia and East Africa. For maize, IITA developed *Striga*-tolerant lines which have been released with considerable success in West Africa. In each case they have been exploited in conjunction with other, integrated approaches, in extensive projects funded by the Melinda and Bill Gates Foundation. I had hoped to have updates from the latter and from IITA but they have not been available, so I apologise once again for not being at all up-to-date. Also I am sure there are significant dates for developments and publications in the new fields of genomics and other molecular studies as they relate to parasitic weeds, but I am afraid I must leave that field for others to review.

Although in maize and sorghum there is nothing approaching immunity, in rice there has been more conspicuous success with the NERICA varieties developed by the Africa Rice Centre in East Africa. These involve crosses between *Oryza sativa* and the African *Oryza glaberrima.* These were not developed specifically for *Striga*-resistance but some are proving very effective (Rodenburg *et al.,* 2015a).

1997 – a significant date in the control of *Striga* in cereals was when it was noticed, by a keen-eyed technician that in trials at the ICIPE station in Kenya, where *Desmodium uncinatum* was being tested as a means of repelling stalk-borer from maize plots, the *Striga hermonthica* was much reduced (Khan *et al*., 1997) (Fig 15). Hence in 2000 John Pickett, in conjunction with Dr Z.R. Khan of ICIPE was able to publish their findings that after just a few years of inter-planting maize between the rows of the perennial *D. uncinatum, S. hermonthica* was vastly reduced and the maize greatly invigorated by the additional nitrogen provided by the legume (Khan *et al*., 2000). This technique is now being widely used in East Africa, at least where there is not too long a dry season. ICIPE claim that over 100,000 farmers are already making use of the technique. Recent updates on the topic include those by Murage *et al.,* 2015 and Midega *et al.,* 2015.

Fig 15.

The other significant development in East Africa has been the treatment of naturally herbicide-resistant (non-GM) maize with imidazolinone herbicide. The seeds are coated with the herbicide before planting and good control of *Striga* has been achieved in wide-scale farmer trials. (Abayo *et al,*. 1998; Kabambe *et al.* 2008; Mwangi *et al.,* 2014; Makumbi *et al.,* 2015).

Just one more development worth mention is the use of *Fusarium oxysporum* for biocontrol of *Striga*.There have been many attempts at exploiting this pathogen but the latest reports sound encouraging. David Sands of Montana State University reported to the Strigolactone meeting in Romania last year (2015) that isolate-treated toothpicks are distributed to farmers who culture it further on cooked rice and put some of the rice in the planting hole.

Malta and *Orobanche crenata*

Going back now to another key date - 1972 - this date is when the EWRC (European Weed Research Council) Parasitic Weeds Research Group was established by myself and Dr Abdul Rahman Saghir of the American University of Beirut, Lebanon. We located just over 100 workers on parasitic weeds in 36 countries in Europe and beyond and invited them to attend the Symposium on Parasitic Weeds in Malta in April 1973. About 50 attended (Fig 16). This group photo includes myself and Lytton Musselman, also Jose Cubero and Job Kuijt but not many others that are still around or active. The Proceedings were published by EWRC (now EWRS) and I believe copies are still available. This meeting arose because of a UK-funded project on *Orobanche crenata* (Fig 17) which I had visited in Malta in 1970.

Fig 16.

Fig 17.

I shall return to the Malta meeting as a starting point for other developments but will first use it as a prompt to talk about *Orobanche crenata.* This first picture was in fact taken at the time of that meeting in Malta and shows the devastating effect it can have, especially under dry conditions. Plenty of research had of course gone on before 1972, but the Malta Symposium was an opportunity for a pooling of available information on its distribution and biology, including physiology and germination and on resistance in faba bean, ably reviewed by Jose Cubero (1973), who concluded that there were resistance genes, especially in small-seeded varieties which tended to be dominant, but that they were greatly influenced by the environment. In the years since, there have been many further studies on all these but regrettably no major advance in control. From Egypt the variety Giza 402 showed promise but it was not a productive variety. It has been, however, the source of partial resistance in a number of newer varieties. Fast forward to 2013 and the latest workshop on the problem, held in Rabat, Morocco, which was organised in response to the continuation of its seriousness, not only on faba bean, but also on lentil, pea and other legumes across the Mediterranean region where the nutrition and economy of farmers and countries in the region are being seriously affected. One gleam of hope was the report of useful tolerance in the variety Misr-3 which suffers only 10% yield loss from heavy infestation. More recently the variety Baraca and derivatives from it have shown promise not only for *Orobanche crenata* but also for *Orobanche foetida* (Fig 18), the relatively new problem in Tunisia (Rubiales *et al*., 2014). And in Spain there has been success in developing resistant varieties of field pea. Otherwise, at the 2013 meeting (reviewed by myself and Donal O'Sullivan in Haustorium 64, 2013)), there were novel suggestions for transfer of genes from *Desmodium* to faba-bean, and for creation of herbicide-resistant faba-bean, but without outcome as yet. Meanwhile some useful selectivity has been shown with glyphosate and imidazolinone herbicides which are, I believe, being used locally in Morocco and elsewhere. Biological control with the fly *Phytomyza orobanchia* has been explored repeatedly but never to any practical degree.

Fig 18.

Meanwhile *O. crenata* is still spreading. It was first recorded in Ethiopia in 1989, since when it has spread rapidly to many of the important faba-bean growing areas of the country (Teklay Abebe *et al.,* 2013). And it even popped up in UK in 2013. Just in one or two fields in Kent but devastatingly damaging.

Other *Orobanche/Phelipanche* species
Just briefly to mention other problematic broomrape species. These include *Orobanche cernua* in Solanaceae, and *Phelipanche ramosa* (Fig 19)*,* in Solanaceae and in Brassicaceae, including relatively new infestations in rape-seed in France. And *P. aegyptiaca* (Fig 20) mainly in Solanaceae and Cucurbitaceae. Control of all these depends mainly on herbicides – some treatments are particularly well developed in Israel (Fig 21..

Fig 19.


Phelipanche aegyptiaca

Fig 20.

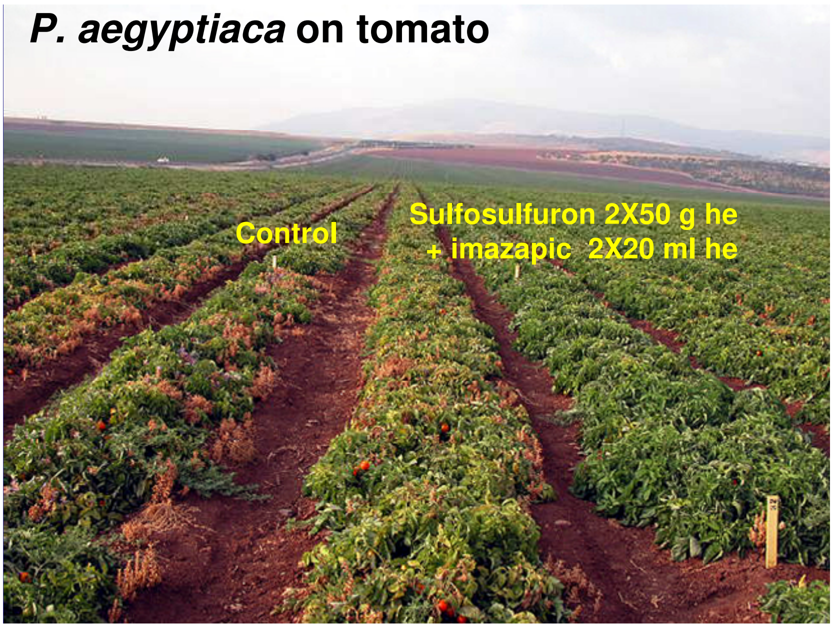
P. aegyptiaca on tomato
Control
Sulfosulfuron 2X50 g he
+ imazapic 2X20 ml he

Fig 21.

Other genera

I am not attempting to cover all the significant parasitic weeds but should briefly mention some of the more important, including *Rhamphicarpa fistulosa* (Fig 22), another root parasite in Orobanchaceae which is affecting rice widely across East and West Africa (Rodenburg *et al*, 2015b).

Fig 22.

Also the dodders, especially *Cuscuta campestris* (Fig23), which can be severe locally on some crops especially when it is a contaminant of crop seed as in lucerne/alfalfa and in niger seed (*Guitzotia abysssinica*), as here in Ethiopia (fig 24). Control depends almost completely on seed-cleaning and on herbicides.

Fig 23.

Fig 24.

The similar but unrelated *Cassytha filiformis* (Fig 25) can be a problem, so far without any developed control measures.

Fig 25.

And the dwarf mistletoes, *Arceuthobium* species (Fig 26) have been described as the most serious disease problem in North American forestry. Control of these depends on cultural methods including fire and thinning.

Fig 26.

Major meetings

Returning now to Malta and the EWRS Parasitic Weeds Research Group. In 1975 this was taken over by the newly formed European Weed Research Society (EWRS), but it was difficult to give adequate emphasis to *Striga* in a European context, so after a brief divorce it re-formed in 1979 as the International Parasitic Seed Plant Research Group which later still was taken under the wing of IPPS Lytton Musselman had been at the Malta meeting and in due course he arranged a Second International meeting in Raleigh, N. Carolina in 1979. These slides shows the full sequence of international meetings since then (including the latest in Asilomar in 2017) (Figs 27, 28).

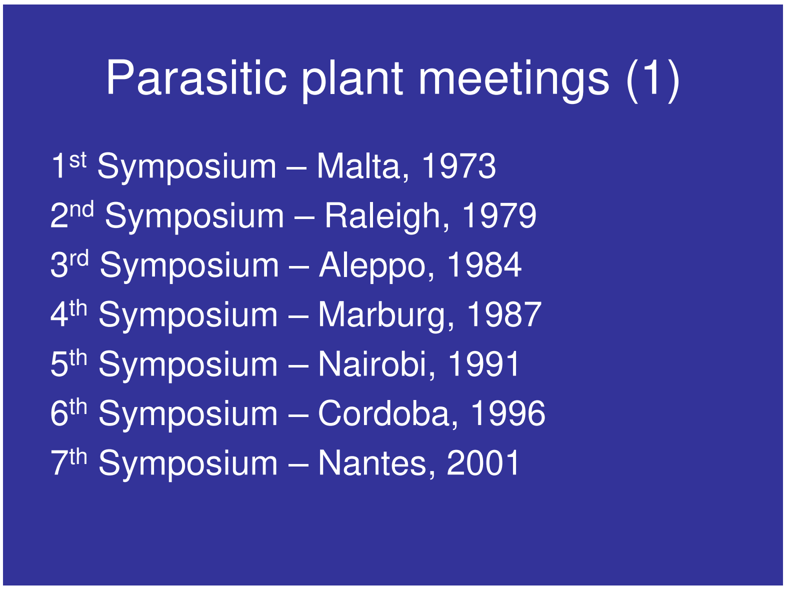

Fig 27.

Fig 28.

Haustorium

There have also many other, more localised or specialised meetings in between those listed above, many of them very important and productive. They are not listed here but one is of particular importance to our story today – the *Striga* workshop arranged in Khartoum in 1978 by IDRC (International Development Research Center which funded a number of projects on parasitic weeds). It was here that Lytton and I first discussed the idea of a parasitic plants newsletter, resulting in the first issue of 'Haustorium' coming out in 1979. It started small and had some lapses and problems of funding documented in the item 'How Haustorium Happens' in our 50th issue, but fortunately it was able to continue and flourish and now endeavours to briefly note and summarise all new literature on parasitic plants (not just weeds) twice a year (Fig 29) Anyone not receiving it is welcome to let me know and be added to the mailing list which currently approaches 500 from some 60 or more countries.

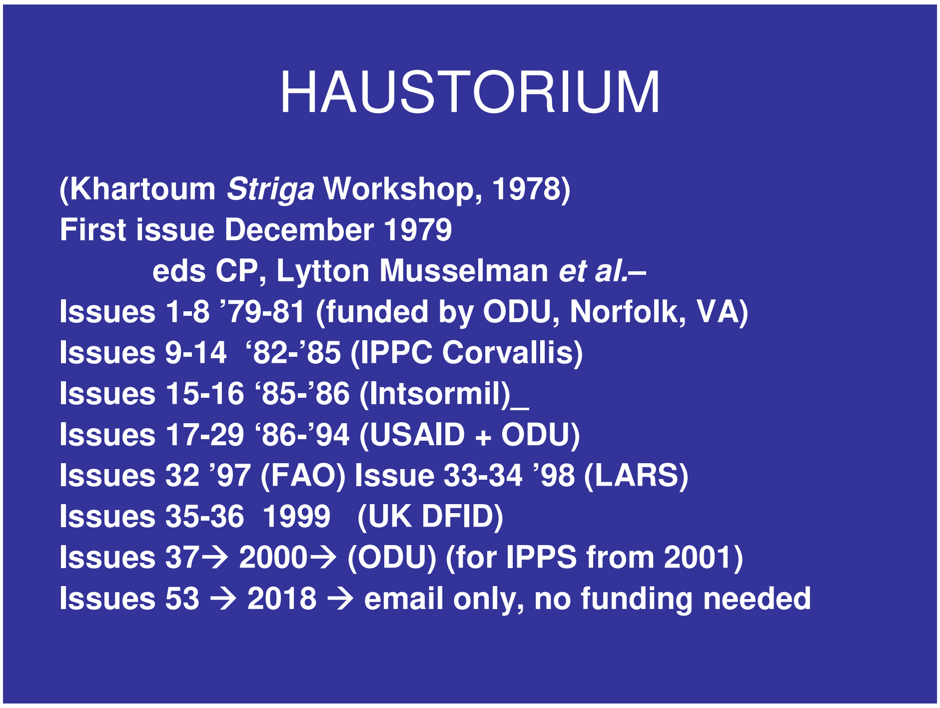

Fig 29.

Publications

Now just one more thread, back-tracking to 1969 - when Job Kuijt published his masterly volume on The Biology of Parasitic Flowering Plants, the first to provide an overall survey of the subject. Since then some of the further major publications have included: Musselman, 1980, Visser, 1981, Parker and Riches, 1993, Press and Graves, 1995, Hawksworth and Wiens, 1996, Joel *et al*., 2007, Heide-Jorgensen, 2008, Joel *et al.,* 2013 but there have been many others.

The future

We already have the relatively new problems which I have mentioned including *Rhamphicarpa fistulosa* in rice, *Orobanche foetida* in legumes in North Africa (Kharrat *et al.,* 1992) and *Phelipanche ramosa* in rapeseed in France (Collin, 1999). Also the serious outbreak of *O. crenata* in Ethiopia. Publications emphasising the potential risks from further spread of parasitic weeds include those by Grenz and Sauerborn (2007) for *O. crenata* and by Mohamed *et al*. (2006) for a range of species (Figs 30, 31). These confirm the risks even without any climate change. That by Venette *et al.* (2013) makes predictions for the substantial spread northwards of *Arceuthobium* species in forestry in N. America, with global warming.

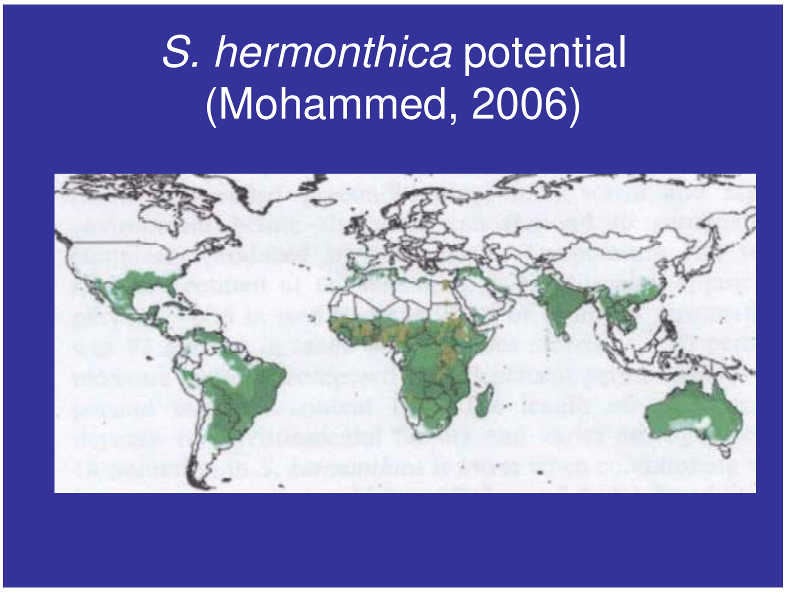

Fig 30.

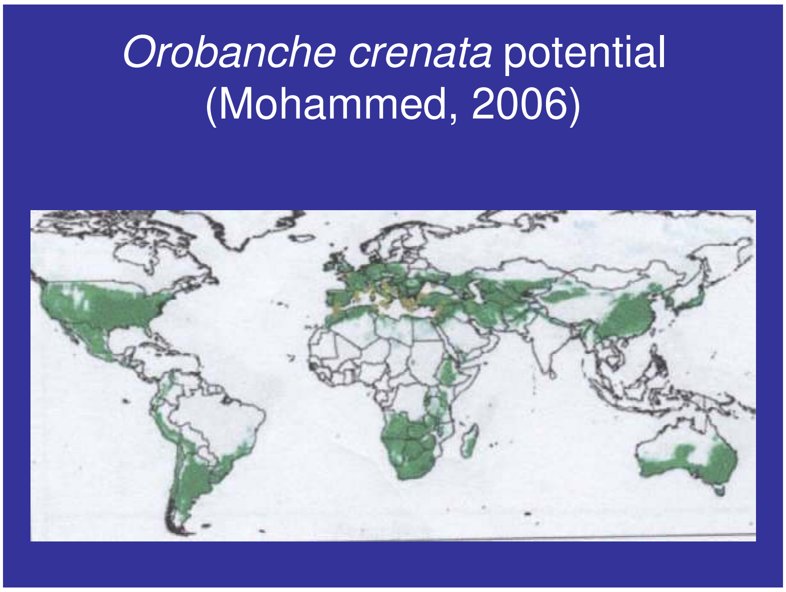

Fig. 31.

Postscript
No attempt has been made to update this text in any way. Needless to say there have been many important developments in the subject published in the literature and presented at the 14th Parasitic Weed Congress in Asilomar in 2017. Many of these have involved cutting-edge genetic studies which in any case are beyond this author to interpret. May the good work continue!

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