HAUSTORIUM

Parasitic Plants Newsletter

Official Organ of the International Parasitic Plant Society

50th ISSUE!

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MESSAGE FROM THE IPPS PRESIDENT

Dear IPPS Members,

The IPPS wishes you a happy festive season and a peaceful and happy 2007. We all wish that the New Year will bring a better understanding of parasitic plants, and new breakthroughs in our ability to control parasitic weeds.

In addition to celebrating the birth of a new year, we are also happily celebrating the issue of the **50th edition of Haustorium**, the well established Newsletter of the parasitic plant research community. It is my pleasure to send our special **thanks and appreciation to the dedicated founding Editors** of Haustorium and honorary members of the IPPS, **Chris Parker and Lytton Musselman**, for their immense long lasting contribution in distributing updated knowledge on parasitic plants to all parts of the world, gathering pieces of information on a variety of aspects of parasitic plant biology and on the management of parasitic weeds, for the benefit of us all.

The first issue of Haustorium was published in December 1978, aiming to present a form of communication that 'would meanwhile serve a useful purpose in keeping workers in contact with each other and with research results which are not always readily accessible to all concerned', with main emphasis on *Orobanche* and *Striga.*

And indeed, during almost thirty years since it was first published, Haustorium reflected the important progress in the knowledge and understanding of parasitic plants, and even more so, in our ability to control *Orobanche* and *Striga.* Haustorium is and has been an important source of information, and a valuable link for new acquaintances between those interested in parasitic plants.

While the main reports during the early years of Haustorium were on taxonomic, anatomical and physiological aspects of parasitic plants, the recent issues also report on significant progress in molecular research of parasitic plants, with emphasis on three main areas: (a) genome studies of parasitic plants, including evolutionary, genetic and physiological considerations; (b) the development of new resistances against parasitic weeds either directly by genetic engineering or indirectly by the employment of herbicide resistance; and (c) the development of molecular markers for diagnostic purposes, and for marker-assisted selection, serving more efficient breeding of various crops for resistance against parasitic weeds.

Another encouraging development of the last decade is the availability of a number of effective means for the control of *Orobanche* and *Striga* in some important crops like maize and tomato. While almost no means for the control of parasitic weeds were available in the seventies and eighties, we now have at least two groups of herbicides (sulfonylureas and imidazolinones) that can effectively control parasitic weeds in low doses.

These aspects and many others will be presented and discussed in the coming Parasitic Plants Congress in Charlottesville (USA) next June. We are looking forward to your registration and scientific contribution to the success of the Congress (for more information see: http://www.cpe.vt.edu/wcopp/index.html).

Daniel M. Joel IPPS President

GUEST EDITORIAL

I am very appreciative of having been asked to set down some thoughts at the 50th issue of 'Haustorium'. Needless to say, the first item on the agenda is to thank the members of the Editorial Team for their splendid work in keeping 'Haustorium' going. It is quite impossible to keep abreast of all publications in this diverse field, and the network that radiates out from the Editorial Team has been invaluable to many of us. May 'Haustorium' long continue!

When I look back over the decades since my 1969 book I am both astonished at the accomplishments and worried about some trends which we see around us. In some areas, progress has been uneven. I do not pretend to be "on top of" the agricultural aspects of parasitic plants, but it seems to me that the early promise of control of the terrible *Striga* problems in Africa seems to be fading, and the same might be said in the *Orobanche* area. Innumerable field trials have been done on a local basis - but the face of starvation continues to stare at us in many places where *Striga* is rampant. Effective control seems to be beyond our grasp. Many of us know that there are significant sociological and political dimensions here which complicate things even further. Looking at the positive side, it is rather remarkable that no economically important parasites have followed our footsteps to lands where they could do serious damage. For years I have sensed the danger, for example, of *Aeginetia* making its way to the sugarcane fields of Hawaii and tropical America. Considering the amount of present international travel, it is a miracle that it has not happened yet.

My own interests, from the beginning, have been of a structural and systematic sort and that bias, naturally, colors my view of what has been accomplished. I feel that the systematics of mistletoes has progressed strikingly in the most recent decades. Brian Barlow has done a splendid job in updating the mistletoes of Australasia, and the magnificent monograph of African mistletoes by Roger Polhill and Del Wiens has set a standard not likely to be reached by anyone else. Africa is a "dark continent" no longer in the mistletoe world. In the neo-tropics, I am struggling to make at least the larger genera a bit more transparent, but have a long ways to go. In the (new) Orobanchaceae, a thorough monograph of *Harveya* has just appeared, and I am told a monograph of the Santalaceous *Thesium* is on the way. It is essential that such monographic studies continue. More and more, they will incorporate vital molecular information. But the backbone of structural information is still feeble in places. As Soltis and Soltis wrote a few years ago, future work 'will require new morphological and molecular data for many groups, including both a search for new characters and filling in data' for many groups. In what used to be called Scrophulariaceae, molecular data have produced great upheavals. All parasites of this alliance are now united with Orobanchaceae, the older family name. In Santalales, Dan Nickrent and coworkers are looking forward to a resolution of phylogenetic affinities which, no doubt, will have some surprising results.

I cannot avoid a feeling of sadness that some aspects of the study of parasitic plants have very nearly been sidelined. Although some individual physiological contributions have been made, what do we really know about the physiology of mistletoes or Orobanchaceae that we didn't know 40 years ago? The crucial penetration into host tissues is no better understood than it was a century ago: the statement that it probably requires a combination of physical and enzymatic processes almost reads like a tired mantra. With a couple of bright exceptions (I am thinking of Brian Fineran's remarkable study of *Nuytsia floribunda*, for example, but also the recent *Arceuthobium* publication by David Lye), the same can be said for haustorial structure. There are still several families in which the structure of the haustorial interface is practically unknown (Lennoaceae, Balanophoraceae, Hydnoraceae). With the exception of a superficial study on *Psittacanthus*, and Jim Mauseth's work on *Tristerix aphyllus*, no anatomical information is available in this area for any tropical Loranthaceae, whether in the Old or in the New World. We can never understand parasitism until we have an adequate grasp of haustorial structure. It is my hope that the next generation may fill many of these serious gaps. The continuance of 'Haustorium' will be a significant help in the future.

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HOW HAUSTORIUM HAPPENS

Publication of the 50th issue of this newsletter and its success as an organ of information on parasitic plants is something that the two of us could not have imagined. Therefore, we thought it would be appropriate if we were to give some history on the newsletter which we have jointly edited since its inception.

The primordium of Haustorium goes back to Chris' involvement with the EWRC (European Weed Research

Council) Working Group on Parasitic Weeds. It had circulated a few newsletters of a sort (sadly none of those newsletters survives; if anyone else has any we would love know) but the main achievement of that group was to arrange the first Parasitic Weed Symposium in Malta in 1973, attended by about 35 enthusiasts including Job Kuijt, Siny ter Borg, Piet Wolswinkel and Jose Cubero in addition to ourselves. Subsequently, it was felt that, because of the increasing emphasis on non-European problems, especially *Striga*, it was no longer justified to use EWRC funds for this activity. Thanks to the initiative of the Canadian International Development Research Centre (IDRC) a *Striga* Workshop was organised in Sudan in November 1978 at which time we discussed the possibility of a newsletter. Lytton suggested the name Haustorium and, despite some serious concern over the title ('It emphasizes morphology over control' was one sentiment) both of us felt that since the haustorium defines parasitic seed plants, this was the most appropriate title. The mimeographed newsletter was launched the very next month with the support of Old Dominion University (ODU) in Norfolk Virginia. That first issue of 'Haustorium' was only a few short pages long and referred to only two literature items (it can be viewed along with all others via the ODU or IPPS websites listed below). So the mouthful was born – the International Parasitic Seed Plant Research Group (IPSPRG).

Subsequent issues of 'Haustorium' appeared approximately twice yearly but with no great regularity. There was never secure funding for its production and for some years it was produced with the kind support of the International Plant Protection Center, Oregon State University, Corvallis before reverting to ODU. When Lytton once again felt that ODU could not be expected to carry the burden, we were able to use funds accruing from sale of spare copies of the Proceedings of the 3rd Symposium in Syria, kindly donated to IPSPRG by The International Center for Agricultural Research in Dry Areas (ICARDA). When those funds were exhausted we were supported for one year by the Crop Protection Programme of the UK Department for International Development. By this time (2000) an increasing number of copies were being distributed by email and since then the reduced costs of mailing have once more been borne by ODU. We are immensely grateful to ODU for its long-term support.

Since the first issue there has been a gradual development of content, the main change being the steady increase in coverage of Literature items which reflected the increased time Chris had available to scout for these and devise suitable brief summaries, as well as the plethora of new research endeavours. For some years now the aim has been to include ALL items of relevance that we encounter. Since closure of the Long Ashton Research Station, Bristol, and removal of its library, this has depended increasingly on CAB International's Weed Abstracts but this does not cover all items of interest and we are glad to have attention drawn to those that might otherwise be missed. While Chris is mainly responsible for the summaries, we are grateful to Jim Westwood for help with those that are beyond our competence. While we have no wish to become a fully-fledged journal we have included brief research notes and would welcome more, in addition to relevant news items..

Composition and formatting of each issue happens on Chris' home computer in a very cluttered study/second bedroom with a wonderful view over Bristol and the Mendip Hills beyond. Electronic copies go out from there but for the postal copies a printed version is sent over to Lytton at ODU in another seaport, Norfolk, Virginia (and the type locality for *Cuscuta pentagona*) for reproduction and mailing. Communication between the two of us has not always been perfect – our computers do not seem to understand each other, and there have been moments of tension, but we get it together in the end and have so far resisted all take-over bids. With the creation of the International Parasitic Plant Society (IPPS) , there have been new Editors appointed, first Jim Westwood and then Diego Rubiales but they have both been very cooperative and allowed us to continue much as before. If serious suggestions for modification of editorial policy are proposed we shall be glad to cooperate but we do insist for the time being that distribution of the newsletter should continue to be independent of IPPS membership.

Rewarding to both of us is the tremendous progress in understanding parasitic plants since our humble newsletter was founded at the Faculty of Agriculture of the University of Khartoum over a quarter century ago. It is not uncommon to find in the archival literature references to articles published in Haustorium, clear indication of its acceptance and stature. If this newsletter has truly functioned as a haustorium in linking host researchers with different plants in different countries, we are sincerely thankful.

It has been interesting to report the creation of a new EWRS Parasitic Weed Research Group after a lapse of over 30 years, and we look forward to exploring ways in which we may interact. As always we welcome any suggestions for extra content and would like to see more of a Correspondence section with readers expressing and exchanging views on any relevant subject. For instance, perhaps not everyone agrees with Job Kuijt's appraisal of the lack of progress in some lines of research. Why not let us know your own thoughts.

Chris Parker and Lytton Musselman.

9TH WORLD CONGRESS ON PARASITIC PLANTS CALL FOR ABSTRACTS

Sunday June 3 to Thursday June 7, 2007 at Omni Hotel, Charlottesville, Virginia USA

Important reminder: The Congress is fast approaching; please note that **March 1 is the deadline for abstract submission and early registration**. Make your plans to attend today!
Register and submit abstracts at:
www.cpe.vt.edu/wcopp

We are looking forward to seeing you at the 9th World Congress on Parasitic Plants in Charlottesville, Virginia this June. We are planning a program featuring speakers from around the world, representing the best in parasitic plant research. We will discuss both biological and agronomical aspects of parasitic plants. In keeping with the tradition of past parasitic plant symposia, the Congress will embrace diverse scientific disciplines aimed at understanding all parasitic species. In addition to oral presentations, ample time will be available for viewing posters and informal discussion with colleagues.

A new programmatic feature of this Congress is the inclusion of a special, cross-disciplinary lecture featuring cutting edge research that may not focus directly on parasitic species, but nevertheless provides new perspective into parasitism. Our speaker for this is Maria Harrison, who will discuss her research on signaling between plants and arbuscular mycorrhizal fungi. Recent reports have demonstrated that arbuscular mycorrhizal fungi increase hyphal branching in response to the same strigolactone signals that trigger germination in *Striga* and *Orobanche*. Dr. Harrison is well-known for her molecular studies of AM fungi and her participation in the Congress is certain to stimulate more thinking about parallels between symbiotic fungi and parasitic plants.

We are also pleased to feature Jeffrey Palmer as an invited speaker. A long-time contributor to the understanding of evolution in parasitic plants, he will provide an update on recent research into horizontal gene transfer involving parasitic species.

In addition, we have invited several plenary lectures from our colleagues on applied and basic aspects of parasitic plant management. Additional speakers will be selected from the submitted abstracts.

We are also planning a rich Poster Exhibition that will cover all aspects of parasitic plants research. This will provide an opportunity for personally presenting and discussing your current research with colleagues who are specifically interested in your work. A special Poster Session will allow ample time for poster discussion.

Please make your plans today to attend the Congress, and do not delay registration. A registration form is provided at the end of this newsletter

Special cross-disciplinary lectures:

- **Maria Harrison** (Boyce Thompson Institute for Plant Research, Cornell University, USA) **Special cross-disciplinary lecture:** 'The arbuscular mycorrhizal symbiosis; genomics approaches to dissect development and function'
- **Jeffrey Palmer** (Indiana University, USA) 'Horizontal gene transfer gone wild in parasitic and other flowering plants'

Invited plenary lectures:

- **Fred Kanampiu** (CIMMYT, Kenya) '*Striga* weed management options under smallholder agriculture in Africa'
- **Alejandro Perez de Luque** (IFAPA-CICE, Spain) 'Mechanisms of resistance to parasitic plants: from field screening to laboratory microscopic studies'
- **Julie Scholes** (University of Sheffield, UK) 'Host gene expression in response to parasitism'
- **Koichi Yoneyama** (Utsunomiya University, Japan) 'Qualitative and quantitative differences of strigolactone exudation determine host specificity of root parasites *Orobanche* and *Striga*.'

Charlottesville Virginia is a wonderful setting for a conference in June. The Omni hotel is located within easy walking distance of numerous restaurants and shops. The area is known for its natural beauty and proximity to historic sites, providing plenty of entertainment options for accompanying spouses and family. The weather should be pleasant, as June temperatures in Charlottesville average a high of 84 F (29 C) and low of 62 F (17 C). See you in Charlottesville,

Jim Westwood (Program Chair)
Mike Timko (Local Organizing Committee Chair)

TOWARDS ENDING THE WITCH-HUNT?

A report on the Symposium 'Integrating New Technologies for *Striga* control: ending the Witch-hunt', Addis Ababa from 5 – 11 November 2006.

The completion of the current phase of the International Sorghum and Millet Collaborative Research Support Program (INTSORMIL) was the catalyst for bringing together the *Striga* research community in Addis Ababa from 5 – 11 November 2006. With generous support from USAID the symposium 'Integrating New Technologies for *Striga* control: ending the Witch-hunt' provided the platform for more than 60 workers from 20 countries in Africa, Europe and USA. The meeting and subsequent field trip to eastern Ethiopia was most ably organized by the Ethiopian Institute of Agricultural Research in collaboration with Purdue University, USA. This was the most comprehensive gathering of *Striga* researchers for some time. The meeting discussed how to build on our current understanding, to make use of emerging research methods and practical technologies to ensure widespread impacts on the lives of the millions of resource-poor households which are affected by these weeds. A list of the presentations made at the meeting is included later in this newsletter. These are being collated into a book that will summarise our current knowledge.

The meeting conveyed a spirit of considerable optimism that at long last the many years of cumulative research on the biology and management of *Striga* are bearing fruit with increasing dissemination and adoption of the current generation of resistant or tolerant cultivars and locally adapted management practices. We never cease to be amazed by the complexities of the parasite/host association. While many questions remain, the meeting reviewed some completely new insights that have been made possible by advances in analytical techniques with emerging molecular methods promising much in the near future.

Results from studies of the chemical signaling involved in *Striga* germination, the molecular basis of host detection by parasites and of allelochemicals associated with *Desmodium* opens up the possibility of engineered resistance in hosts and the development of enhanced activity from trap crops. *John Yoder (University of California, Davis, USA)* described work to identify the genes involved in production of the chemicals associated with haustorial formation in the facultative parasites *Triphysaria* as a route to identifying target genes for future engineering of resistance to parasitic weeds. These are being searched for through the analysis of mapping populations generated from inter-specific crosses of *Triphysaria.* These can parasitise other species in the genus but not themselves. Possibilities include the use of haustorial translocated RNA that is inhibitory for critical functions in the parasite, targeting genes that effect the reduction of quinines to semi-quinones in the parasite root at the critical phase of haustorial formation. Recent work from *Harro Bouwmeester (Wageningen University, The Netherlands)* suggests an important role for mycorrhiza. These use strigolactones to identify the presence of their hosts. Critically there appears to be reduced *Striga* stimulant production from mycorrhiza infected sorghum roots. Mycorrhiza, furthermore, are implicated in phosphate uptake by host plants, particularly on poor soils. This raises the possibilities that phosphate levels may be part of the explanation of why *Striga* is such a problem as soil fertility declines and that soil nutrient management practices that optimize mycorrhiza colonization may also reduce *Striga* infestation. Work at Wageningen has also investigated maize mutants with no carotenoids. These stimulate little or no *Striga* germination suggesting that carotenoids are important in the synthesis of strigolactones. Further understanding of this pathway may lead to opportunities for knocking out strigolactones in engineered hosts. *John Pickett's (Rothamsted Research, UK)* group has investigated the allelochemicals produced by *Desmodium* that appear to be responsible for the death of *Striga* seedlings in the 'push-pull' system. Elucidation of the pathway leading to the production of these uncinanones leads to the possibility that this could be searched for or engineered into food legumes including beans and cowpeas for use in inter-crops or rotation with cereals on *Striga* infested land.

Working with *Striga* resistant rice lines *Julie Scholes (University of Sheffield, UK)* has been working to unravel the molecular genetic basis of resistance by studying quantitative trait loci. The aim is to identify QTLS associated with resistance that are homologous in sorghum and to identify host genes that are either up or down regulated during infection. Those that are up-regulated in association with *Striga* defense reactions in the host could be pyramided to provide durable resistance. Work on the genetic analysis of resistance in cowpea to *S. gesnerioides* and *Alectra vogelii* is now well advanced as part of the international Cowpea Genomics Initiative. *Mike Timko (University of Virginia, USA)* has used mapping populations to identify molecular markers. These are now available for the response of cowpea to different *S. gesnerioides* races. Markers are also under development for sorghum. *Cecile Grenier (Purdue University, USA)* described progress to develop cultivars incorporating resistance from N13 through a process of marker assisted selection and participatory variety selection. The combination of markers and use of the gel bioassay to check for lines with low stimulant production provides a more reliable process to select for resistance than traditional field screening methods.

The considerable efforts to develop the use of fungal biocontrol systems, particularly in West Africa were discussed by *Alan Watson (McGill University, Canada)* and *Fenton Beed (Institute of Tropical Agriculture, Benin)*, particularly those based on *Fusarium oxysporum*. Although effective in on-farm trials, there has been no progress to date to perfect or promote durable delivery systems to farmers. The institutional challenges are immense, particularly for sorghum or open pollinated maize crops that are commonly established from farm-saved seed making reliable seed dressing with fungal spores difficult.

The meeting heard of farmer adoption of outputs of research to develop *Striga* resistant cereal cultivars, and suppression of the parasite by use of the 'push-pull' or herbicide tolerant maize systems. *Gebisa Ejeta (Purdue University)* described the complex of traits that can be employed to confer resistance in sorghum. Breeding work at Purdue led to seed of a number of *Striga* resistant sorghum lines with the low stimulant trait being made available to national programmes for field evaluation in Africa. *Tesfaye Tesso (Ethiopian Institute of Agricultural Research)* and *Ambonesigwe Mbwaga (Uyole Agricultural Research Institute, Tanzania)* described how selection and validation with farmers has led to the release and promotion of Purdue lines as the cultivars 'Gubiye' and 'Abshir' in Ethiopia and 'Hakika' and 'Wahi' in Tanzania. In Ethiopia some 100, 000 households have now received seed while promotion activities in Tanzania have been initiated in nine districts with seed multiplication and demonstrations. The emphasis is on Integrated *Striga* Management based on the use of the resistant cultivars linked to inter-cropping with cowpea or groundnut and application of manure. For farmers with dairy cattle, the 'push-pull' system described by *Zeyaur Khan (International Centre for Insect Physiology and Ecology, Kenya)* produces valuable fodder from the *Desmodium* inter-crop that also contributes to maize stemborer control and *Striga* suppression. This system was being used by over 6,000 farmers by 2006, largely in areas with over 700 mm rainfall per season. The challenge is now to find selections of *Desmodium* that are adapted to the lower rainfall areas and to demonstrate that these can be used here without a detrimental competitive impact on maize yield. Also from Kenya, *Fred Kanampiu (International Maize and Wheat improvement Centre)* highlighted the increasing adoption of herbicide tolerant maize now that the 'Strigaway' herbicide seed dressing has been commercialized. More than 15,000 demonstrations of the technology have been undertaken of the herbicide tolerant cultivar 'Kajongo'. Problems remain of retaining herbicide activity in the maize root zone during periods of high rainfall and work is underway to develop a slow release formulation of the herbicide imazapyr to use as a seed dressing. A dynamic public/private partnership has ensured that the herbicide tolerant maize has become available to farmers in Kenya but in many countries the lack of efficient seed distribution systems constrains out-scaling of the technology.

Sustained donor and national government support for *Striga* research has been a perennial problem. The scale of the *Striga* pandemic is just too great for the limited human resource capacity of many national programmes in Sub-Saharan Africa to deal with without a wider range of scientific expertise that comes from international collaboration. It is to be hoped that the potential for the increasing farm-level impact of our research to date and particularly the exciting future opportunities highlighted by the meeting can be used to demonstrate the very real value of previous funding. This is vital if we are to attract the greatly increased level of support from development agencies and foundations that will be needed to make a truly significant impact on the problem across Sub-Saharan Africa.

The meeting organizer Dr Gebisa Ejeta, the leader of *Striga* research for INTSORMIL and Purdue University, was honored for his contributions to combating *Striga* in Ethiopia and across Africa in a presentation made on behalf of the Ethiopian Government by H.E. Addissu Legesse, Deputy Prime Minister and Minister of Agriculture. Meeting participants added their congratulations for this well deserved award.

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LITERATURE HIGHLIGHT- VOLATILE CHEMICAL CUES

A recent paper in Science (Runyon *et al.*, 2006.) demonstrates that volatile substances are influential in guiding newly germinated seedlings of *Cuscuta pentagona* (= *C. campestris*) towards the host tomato. There was some tendency also to grow towards wheat (a non-host), but when there was a choice between the two hosts, a significant majority 'selected' tomato. Of a range of 7 volatiles emitted by undamaged tomato, β-phellandrine, β-myrcene and α-pinene were shown to have a significant influence on the directional growth of the *Cuscuta* seedlings. The techniques used thoroughly eliminated the possibility of interference by effects of light or moisture. Conversely, the work of Benvenuti *et al.* (2005) suggested that seedlings of *C. campestris* showed a phototropic response resultant in over 60% growing towards a light source with a high far-red to red ratio (represented by dark green leaves of sugar beet) and only about 30% towards one with a high red to far-red ratio (represented by pale green leaves of sugar beet). Interposing a sheet of glass did not influence the result, thus presumably precluding the possibility of chemotropic response to volatiles. It is of interest to consider the relative importance of these chemotropic and phototropic influences, as they affect *Cuscuta* spp.

Although the influence of the gas ethylene is well known to influence germination of the seeds of root parasites such as *Striga* spp., these results represent the first known report of volatile substances influencing directional growth of a parasitic species and raise interesting questions regarding other possible situations for such an influence. There have been a number of demonstrations of chemotropic behaviour in the seedlings of *Striga* spp. (e.g. Saunders, 1933; Williams, 1961) but remarkably little interest in examining the phenomenon further. I was interested in the importance of this phenomenon and asked a mathematician (Brian Bartlett) to help calculate the chances of *Striga* seedlings locating host roots of different diameter from different starting distances (Dixon and Parker, 1984). His calculations suggested that seedlings germinating within 2 mm of a root 1 mm in diameter or within 1 mm of a root 0.5 mm in diameter had only a 1 in 4 chance of making contact with the root in the absence of any chemotropic influence, and those germinating further away had correspondingly reduced chances of making contact. Our assumption at that time was that the modestly positive chemotropism demonstrated towards susceptible sorghum varieties in our tests was a response to a gradient of the germination stimulant or other root-exuded substance in solution. However, on reflection, it would seem just as possible that volatiles could be involved, and that crop varieties could differ sufficiently in their volatile output to affect their susceptibility to the parasite. We look forward to hearing of studies which pursue this neglected aspect of root parasite physiology.

Comments on this 'Highlight' will be warmly welcomed.

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Chris Parker.

FIRST REPORT OF *OROBANCHE AEGYPTIACA* PERS. PARASITISM ON *PARTHENIUM HYSTEROPHORUS* L. *AND ARGEMONE MEXICANA* L. IN INDIA

The two economically important species of *Orobanche* in India are *O. cernua* L. and *O. aegyptiaca* Pers. The primary hosts of *O. cernua* L. (*sensu lato*, including *O. cumana*) are solanaceous crops and members of Asteraceaae, mainly sunflower and safflower (Krishnamurthy *et al.,* 1977), while *O. aegyptiaca* Pers. has the widest host range, parasitizing many members of Solanaceae, Leguminaceae, Brassicaceae and several other families. In India, it is a major parasite on tobacco in parts of Karnataka, Andhra Pradesh, Tamil Nadu and Gujarat, rapeseed-mustard in parts of Gujarat, western Uttar Pradesh, Rajasthan, Haryana, Chatishgarh, and in tomato and potato in Karnataka. The infestation of *O. aegyptiaca* was first observed in the fields of rapeseed and mustard at Pulses and Oilseeds Research Station, Berhampore, West Bengal, during the *rabi* (dry) season of 1971 – 72 by Bandyopadhyay and Mukherjee (1973). Now it is occurring in rapeseed and mustard fields of West Bengal, India especially in the district of Murshidabad.

While studying the parasitism of *O. aegyptiaca* in rapeseed-mustard during *rab*i season, 2005-06, the present author noticed that two noxious weeds, *Parthenium hysterophorus* L. of family Asteraceae and *Argemone mexicana* L. of family Papaveraceae are parasitized by *O. aegyptiaca* in a field of rapeseed-mustard of this research station. Both *P. hysterophorus* and *A. mexicana* are annual herbaceous weeds and are widespread and problematic causing a menace now in many parts of West Bengal and other states of India. They have a very high rate of fecundity, and adaptability to grow under adverse and highly stressed climatic conditions. Seeds of these weeds are disseminated by air, water, soil, animal etc. They may pose an additional potential threat to various crops, if they serve as an alternative host for *Orobanche* spp., particularly in rapeseed-mustard crops.

This is the first report of occurrence of *O. aegyptiaca* parasitism on *P. hysterophorus* and *A. mexicana* from West Bengal, India. Similar reports have been made from Karnataka, India by Bhat *et al.* (1990), where *O. cernua* has parasitized *P. hysterophorus* and from North Bihar, India by Deo Singh (2003), where *Orobanche* was found parasitizing *Parthenium* in a tobacco field. Though *Orobanche* spp. have been recorded parasitizing members of the family Papaveraceae, no such reference is available that *A. mexicana* is also parasitized by *O. aegyptiaca*. The parasite formed distinct haustoria on the roots of both *P. hysterophorus* and *A. mexicana.* To prevent the spread of *Orobanche* spp., *P. hysterophorus* and *A. mexicana* need also to be controlled in rapeseed-mustard fields. The seeds of these genera are very similar to those of the crop and it is difficult to differentiate them. They may also adulterate mustard seeds for oil extraction.

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COST 849 AND EWRS

Present and future coordination on parasitic weed research at the European level

A number of *Orobanche* species are of major importance in Europe: *O. crenata* causes huge damage in legume crops in Southern Europe; *O. cumana* threatens sunflower in Southern and Eastern Europe; *O. minor* is widespread in clover; *O. ramosa* attacks potato, tobacco, tomato and hemp. Species such as *O. foetida* that cause problems in other areas, are also present in Europe. *Striga* is not an agricultural problem in Europe, but there is strong involvement of European scientists in *Striga* research that can benefit the Third World. Other parasitic plant species like *Viscum* and *Cuscuta* are widespread and attract the attention of many European research groups.

COST is an instrument of the European Commission supporting co-operation among scientists and researchers across Europe. COST action 849 (Parasitic Plant Management in Sustainable Agriculture) has served during the past 6 years (2001-2006) as a platform to stimulate active interfacing among botanists, ecologists, anatomists, physiologists, biochemists, molecular biologists, breeders, plant pathologists, weed scientists, chemists, and agronomists, towards informal and formal join research projects. The lack of interdisciplinary involvement had been seen as a major factor that impeded progress in the sustainable control of parasitic weeds. Thus COST 849 aimed to establish a focal point of research on Parasitic Weeds in Europe. The main interest raised has been parasitic weed management, acknowledging the urgent need to re-evaluate control methods in the light of recent developments in crop breeding and molecular genetics and to place these within a framework that is compatible with current agronomic practices.

COST 849 Action has been carried out in accordance with the provisions of COST, that provided an annual budget (variable among years, with an average of 80,000 Euros/year) for organisation of meetings and short stays, but not for research. The Action was co-ordinated by a Management Committee (MC) with representatives of the 18 signatory countries (Austria, Bulgaria, Cyprus, Croatia, Denmark, France, Germany, Greece, Hungary, Italy, Israel, the Netherlands, Portugal, Romania, Serbia, Slovakia, Spain, UK), with Diego Rubiales (CSIC, Spain) as Chairperson and Danniel Joel (ARO, Israel) as Vice Chairperson.

Activities were organised with four Working Groups (WG), each one with a coordinator appointed by the MC: *WG1: biology and ecology of parasitic plants*, coordinated by Dr. Jos Verkleij (the Netherlands); *WG2: parasitic plant - pathogen and pest interaction*, coordinated by Dr. Maurizio Vurro (Italy); *WG3: genetic resistance*, coordinated by Dr. Danny Joel (Israel); and *WG4: integrated control*, coordinated first by Dr. Charlie Riches and then by Dr. Alistair Murdoch (UK).

Major activities have been annual scientific meetings and workshops, whose programmes and proceedings, when applicable, have been displayed on the Action web site (http://cost849.ba.cnr.it/). Experts were invited to the meetings to present their progress and to facilitate interaction. This involved around 80 invitations per year. In addition to this, 41 scientists, either students or seniors, benefited from short stays (from 1 to 10 weeks) to learn or apply techniques in another country. In these ways COST 849 has helped in coordination of existing financed research on parasitic weeds at the different labs and in different countries. Now that activities of COST 849 have come to an end, it is time to review the progress achieved. Certainly, the parasitic weed problems are not all solved, but there has been a valuable, if insufficient, push that needs to be maintained by any possible means.

A promising new tool has now been established in the form of the Working Group on "Parasitic Weeds" within the European Weed Research Society (EWRS) (http://www.ewrs.org) with the mission to facilitate coordination, to increase the understanding of the interaction between weeds and their hosts, and to implement sustainable means to control the parasites. The inaugural meeting of the EWRS Parasitic Weeds Working Group was held at Oieras, Lisbon, November 23-24, 2006, in conjunction with the closing meeting of COST 849. A mailing list is being created by the coordinator (Dr. Maurizio Vurro, maurizio.vurro@ispa.cnr.it) in order to easily circulate news on any initiative related to Parasitic Weeds. We all hope that this new platform will serve to keep helping to prevent the spread, if not to eradicate parasitic weeds. The contribution of researchers on this initiative will certainly by crucial.

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MEETINGS

COST 849 – Parasitic plant management in sustainable agriculture - final meeting, Lisbon, Portugal, 23-24 November, 2006.
See http://cost849.ba.cnr.it/ for full abstracts.

Papers presented were:

Wegmann - Germination physiology as a target for *Orobanche* control.
Pérez-de-Luque - Mechanisms of resistance to broomrape (*Orobanche* spp.): what have we learned during the last five years?
Thalouan - Selection for resistance and characterization of its mechanisms.
Vurro - Biological sources for means to control parasitic weeds.
Hershenhorn - Integrated broomrape control: sanitation, resistant lines, chemical and biological control – can we combine them together?
Bouwmeester - Strigolactones, signals for friends and enemies.
Joel - Does the germination stimulant for *O. cumana* differ from strigolactones?
Matusova - Germination stimulant(s) perception by parasitic plants.
Goldwasser - Initial identification of tomato root stimulants inducing *Orobanche* seed germination.
Chachalis - Potential use of Nijmegen-1 and smoke water solutions to deplete *Orobanche ramosa* seed banks in Greece.
Fernández-Aparicio and Evidente - Specific responses of *Orobanche* species to *Trigonella foenum-graecum* root.
Zwanenburg - Natural germination stimulants as a lead for parasitic weed control.
Streibig - Germination of *Striga hermonthica* in response to Sorghum.
Dor - Interaction between *F. oxysporum* f. sp. *orthoceras* and *Fusarium solani* - two *Orobanche cumana* biocontrol agents.
Cagáň and Tóth - Distribution of *Orobanche* and *Cuscuta* species in Slovakia and possibilities of their biological control.
Economou - Marine algae as a means for *Orobanche* biocontrol.
Pérez-Vich - A multidisciplinary study for determining genetic diversity in *O. cumana* populations from Spain.
Melero-Vara - Virulence of European populations of *O. cumana*.
Pacureanu-Joita - Resistance and the development of virulent *O. cumana* races in sunflower crop in Romania.
Lyra - Application of RAPDs in identification of broomrapes.

Satovic - Genetic variability among *O. foetida* populations collected in Morocco.
Simier - Molecular characterization of metabolic pathways involved in *O. ramosa* development.
Lozano-Baena - Laser Capture Microdissection (LCM): application to study of gene expression in resistance to *O. ramosa* in *Medicago truncatula*.
Aly - Parasitic weed control based on a key metabolic gene silencing in *O. aegyptiaca*.
Batchvarova - Genetic transformation as a tool for broomrape control.
Slavov - Mutagenesis and haploidy as means for obtaining resistant tobacco forms to *Orobanche ramosa*.
Hershenhorn - The resistant mechanism of mutagenised tomato lines resistant to *Orobanche*.
Delavault - Molecular analysis of sunflower resistance to *O. cumana*.
Eizenberg - Precision agriculture and modeling - a novel approach in controlling *Orobanche*.
Rubin - Effect of herbicides inhibiting amino acid biosynthesis on *Cuscuta* spp. and *Orobanche*.
Montemurro - *In vitro* experiments on the control of *O. ramosa* with glyphosate in tomato.
Raranciuc - Chemical control of *O. cumana* by imidazolinone herbicides.
Emeran - *Orobanche crenata* control in Egypt.
Uludağ - *Orobanche* control in potatoes in Turkey.
Riches - Green manures in Tanzania: a *Striga* management technology whose time has come?

International Symposium on Integrating new technologies for *Striga* control: towards ending the witch-hunt. Addis Abeba, November 5-11, 2006.
Proceedings of this meeting are being prepared for publication. See website below for more detail.

Papers presented and discussed were:

Gebisa Ejeta, The *Striga* scourge in Africa: a growing pandemic?
Patrick Rich, Biology of host-parasite interactions in *Striga* species.
John Yoder, Host detection by root parasites: insights from transciptome profiles.
Harro Bouwmeester, Germination of *Striga* and chemical signalling involved: a target for control methods.
John Pickett, Chemical studies on *Striga* control by *Desmodium* and opportunities for developing this trait in edible bean legumes.
Lytton Musselman, Biological diversity among and within *Striga* species: implications for control and potential spread.
Alan Watson, What can *Fusarium oxysporum* do in the battle against *Striga*?
David Sands, Genetically enhancing virulence of pathogens for weed control: why, how, and results.
Fenton Beed, Biocontrol: a critical component of integrated *Striga* management.
Jonathan Gressel, Transgenic biocontrol agents to overcome evolutionary barriers.
Fred Kanampiu, Success with the low biotech of seed-coated imidazolinone-resistant maize.
Cecile Grenier, Marker-assisted selection for *Striga* resistance in sorghum.
Julie Scholes, Genomic approaches to *Striga* control.
Anic de-Framond, Effects on *Striga* parasitism of transgenic maize armed with RNAi constructs targeting essential *S. asiatica* genes.
Gebisa Ejeta, Dissecting the complex trait of *Striga* resistance to simpler components for effective breeding of sorghums with high level of resistance to *S. hermonthica*.
Abebe Menkir, Breeding maize with broad-based resistance to *Striga hermonthica*.
Boukar Ousmane or Mike Timko, Genetic analysis of resistance to *Striga gesnerioides* in cowpeas.
Issoufou Kapran, Introgression of *Striga* resistance genes into African sorghum landraces.
Tesfaye Tesso, An integrated *Striga* management option offers effective control of *Striga* in Ethiopia.
Joel Ransom or Abdel Gabar Babiker, Integrating crop management practices for *Striga* control.
Fasil Reda, Cultural and cropping systems approach for *Striga* management - a low cost alternative option in subsistence farming.
Zeyaur Khan, Field developments on *Striga* control by *Desmodium* intercrops in a 'Push-Pull' strategy.
Ambonesigwe Mbwaga, Integrated *Striga* management for improved sorghum production to meet market demands in Tanzania.
Hugo de Groote, Economic analysis of *Striga* control in maize.

THESIS

Bista. A (Ph.D, B.R.A.Bihar University, India, February, 2005)
Studies on Biology and Ecology of Seed Germination of *Orobanche solmsii* C.D.Clarke.

Out of 150 *Orobanche* species known, only four species are reported to occur in Nepal. Among them O. *aegyptiaca* Pers and *O. solmsii* C.D Clark. prevalent in oilseed (Brassicaceae) and in tobacco (Solanaceae) fields respectively, while *O. alba* and *O. caerulescens* are reported to occur in wild habitats in Nepal. I studied in *vitro* seed germination tests by a Petri-dish method to know the impact of different environmental factors such as temperature, moisture and pH, during pre and post-conditioning period. *Orobanche* species exhibit great variability not only between species but also between populations of the same species found in different geographical parts. For this reason an attempt has been made to understand the role of different ecological factors together with nutrient and non-nutrient chemicals including hormones on the germination of seeds of *Orobanche* population (s) found in our agro-ecological conditions. It is hoped that the base-line data produced by the study might help devise appropriate control measure(s) to be used in *Orobanche* sick fields in order to avoid the problem.

In my studies, I found progressive loss of seed viability of the seeds stored at room temperature and optimum seed germination was observed in nine months old seeds. This could be taken as an ecological adaptation of seeds to remain dormant over the unfavorable wet summer season following shedding. The results of the moisture test suggested that *Orobanche* seeds are unable to survive for a long period in water logged conditions. This could be the reason for low incidence of the parasite in fields used for rice. Seed germination studies conducted at different temperatures showed that the parasite prefers a narrow range of temperature, around 20 ^{0}C for preconditioning and around 25 ^{0}C for post-conditioning/germination. The relationship of temperature and percentage of seed germination could help determine the appropriate sowing date to avoid *Orobanche* infection in the field.

In response to different pH, *in vitro* germination of *Orobanche* seeds was highest slightly acidic condition. The study suggests the application of agricultural lime to acidic soils. In an experiment in which different hormones were used to germinate *Orobanche* seeds. GA_3 (100 ppm) substantially enhanced *Orobanche* seed germination when applied during the preconditioning period (100 ppm); NAA showed inhibitory effects while kinetin failed to stimulate germination at any of the concentrations tested. This suggests that GA_3 can break seed dormancy to some extent if applied during pre-conditioning period.

The experiment also showed that most of the phenolic compounds tested on *Orobanche* seed germination had inhibitory effects. These phenolic compounds have also been reported to be released in the soil from the host plant roots and acts as allelochemicals. Understanding the effects of phenolic compounds could be helpful in the suppression of *Orobanche* parasitization in the field condition provided they do not cause negative effects on host plants.
I have presented the results of seed germination tests in different plant root extracts extracted in different solvents in order to determine the polarity nature of the natural germination stimulant(s). It showed that the polarity of stimulatory chemicals for seed germination present in root extract of host plants corresponds to a value close to that of hexane and ethyl acetate, and the stimulant(s) exist in more than one form. This could be an important step towards the identification of natural germination stimulant(s) of *O. solmsii*.

Finally, I studied the effects of different nutrients chemicals in seed germination during pre and post-conditioning period. The study showed that all forms of nitrogen are not equally effective in reducing *Orobanche* seed germination. The additional outcome of the present study are (i) the inhibitory effect is more pronounced when the chemicals are applied during pre-conditioning period compared to their application during post-conditioning period and, (ii) the ammonium forms of nitrogen inhibit more than the nitrate forms, while urea has an intermediate effect. The inhibitory performance of ammonium forms of nitrogen explains why the chemical applied in *Orobanche* infested fields suppresses the emergence of parasitic plants.

(Editors' note: Dr Bista has followed earlier authors (including Khattri *et al.*, 1991 and Bharati, 1989) in using the name *O. solmsii* for the species attacking tobacco in Nepal. However, Dr Khattri himself, writing in Haustorium in 2002, concluded that the name *O. solmsii* was being misused in Nepal in place of *O. cernua*. Flora of Bhutan, Flora of Pakistan, and Flora of China all describe *O. solmsii* as a yellow-flowered species, while *O. cernua* has purplish coloration. The editors believe that the above thesis work involves *O. cernua* rather than *O. solmsii*.)

GENERAL WEB SITES

For individual web-site papers and reports see LITERATURE

For details of the 9th World Congress on Parasitic Plants see: http://www.cpe.vt.edu/wcopp/index.html

For information on the International Parasitic Plant Society, past and current issues of Haustorium, etc. see: http://www.ppws.vt.edu/IPPS/

NB. For past and current issues of Haustorium note that the ODU site http://web.odu.edu/haustorium is under revision and does not currently include issues 46-49. A new site http://www.odu.edu/~lmusselm/haustorium/ will be functioning in the near future.

For the ODU parasite site see:
http://www.odu.edu/webroot/instr/sci/plant.nsf/pages/parasitic_page

For Lytton Mussleman's *Hydnora* site see:
http://www.odu.edu/webroot/instr/sci/plant.nsf/pages/lecturesandarticles

For Dan Nickrent's 'The Parasitic Plant Connection' see:
http://www.science.siu.edu/parasitic-plants/index.html

For The Mistletoe Center (including a comprehensive Annotated Bibliography on mistletoes) see:
http://www.rmrs.nau.edu/misteltoe/welcome.html

For information on, and to subscribe to PpDigest see:
http://omnisterra.com/mailman/listinfo/pp_omnisterra.com

For information on the EU COST 849 Project and reports of its meetings see:
http://cost849.ba.cnr.it/

For information on the EWRS Working Group 'Parasitic weeds' see: http://www.ewrs.org/

For the Parasitic Plants Database, including '4000 entries giving an exhaustive nomenclatural synopsis of all parasitic plants' the address is:
http://www.omnisterra.com/bot/pp_home.cgi

For a description and other information about the *Desmodium* technique for *Striga* suppression, see:
http://www.push-pull.net

For information on EC-funded project 'Improved *Striga* control in maize and sorghum (ISCIMAS) see:
http://www.plant.dlo.nl/projects/*Striga*/

For the work of Forest Products Commission (FPC) on sandalwood, see: www.fpc.wa.gov.au

For past and future issues of the Sandalwood Research Newsletter, see: www.jcu.edu.au/school/tropbiol/srn/

For information on the work of the African Agricultural Technology Foundation (AATF) on *Striga* control in Kenya, see: http://africancrops.net/striga/

To view the list of presentations and participants at the *Striga* meeting in Addis Abeba, November 2006, see:
http://www.agry.purdue.edu/strigaconference/index.html

LITERATURE

Ahonsi, M.O. and Emechebe, A.M. 2005. *In-vitro* whole-seedling assay for evaluating non-host crop plant induction of germination of witch weed seeds. African Crop Science Journal 13(1): 61-69. (An '*in vitro* whole-seedling assay', involving the growth of individual 2-3-day old crop seedlings in Petri dishes was compared with the 'cut-root' method for comparing different varieties of legume for stimulation germination of *Striga hermonthica.* Both techniques showed groundnut more active than cowpea or soyabean. There was much variation with both techniques but the new method proved at least as efficient, while being simpler and requiring less time, labour and materials.)

Akinlabi, A.K., Aigbodion, A.I., Akpaja, E.O., Bakare, O. and Akinlabi, J.O. 2005. Characterisation of natural rubber latex from mistletoe-infested *Hevea* trees of NIG 804 clones. Journal of Rubber Research 8: 153-159. (Indicating that infestation by unspecified mistletoe species affected latex quantity but not quality – abstract uninformative!)

Alcántara, E., Morales-García, M. and Díaz-Sánchez, J. 2006. Effects of broomrape parasitism on sunflower plants: growth, development, and mineral nutrition. Journal of Plant Nutrition 29: 1199-1206. (Studying mineral content of the crop host as affected by *Orobanche cumana* in Spain, noting reductions in calcium, manganese and zinc in leaves of parasitized plants while differences were less significant for potassium, phosphorus, iron and copper.)

An SuSun, Lee AiYoung, Lee CheolHeon, Kim DoWon, Hahm JeongHee, Kim KeaJeung, Moon KeeChan, Won YoungHo, Ro YoungSuck and Eun HeeChul. 2005. Fragrance contact dermatitis in Korea: a joint study. Contact Dermatitis 53: 320-323. (Patch tests showed high frequencies of positive response to sandalwood oil, from *Santalum album* L.)

Ayongwa, G.C., Stomph, T.J., Emechebe, A.M. and Kuyper, T.W. 2006. Root nitrogen concentration of sorghum above 2% produces least *Striga hermonthica* seed stimulation. Annals of Applied Biology 149: 255-262. (Showing steeply declining germination of *S. hermonthica* between 1% and 2% root nitrogen. Above this level there was zero germination using root exudates but low germination using cut roots. Lag between N application and effective influence on germination was 5 days.)

Badu-Apraku, B. and Menkir, A. 2006. Registration of 16 extra-early maturing *Striga* resistant tropical maize inbred lines. Crop Science 46: 1400-1401. (Registering 16 lines TZEEI 1 to TZEEI 16 (Reg. No. GP-473 to GP-485, PI 641251 to PI 641266), with moderate resistance to *Striga* as well as resistance to streak, rust and blight.)

Badu-Apraku, B., Menkir, A., Kling, J.G. and Fakorede, M.A.B. 2006. Registration of 16 *Striga* resistant early maturing tropical maize inbred lines. Crop Science 46: 1410. (Describing 16 maize lines (TZEI 1-16 with Reg. Nos. PI 641061-641076) with moderate resistance to *Striga hermonthica* as well as resistance to streak, rust and blight.)

Bais, H.P., Weir, T.L., Perry, L.G., Gilroy, S. and Vivanco, J.M. 2006. The role of root exudates in rhizosphere interactions with plants and other organisms. Annual Review of Plant Biology 57: 233-266. (A broad review including reference to parasitic plants.)

Barlow, B.A. 2005. *Tolypanthus* (Loranthaceae): a new genus record for Thailand and a new species. Thai Forest Bulletin (Botany) No.33: 1-7. (Describing *Tolypanthus lageniferus* and a new species, *T. pustulatus*.)

Bennett, J.R. and Mathews, SD. 2006. Phylogeny of the parasitic plant family Orobanchaceae inferred from phytochrome A. American Journal of Botany 93: 1039-1051. (Describing a very extensive sampling of the Orobancaceae, and generally supporting recent findings, but also providing new insight. For example a clade containing *Bungea*, *Cymbaria*, *Monochasma*, *Siphonostegia*, and *Schwalbea* is identified as the earliest diverging lineage of hemiparasites.)

*Besserer, A., Puech-Pagès, V., Kiefer, P., Gomez-Roldan, V., Jauneau, A., Roy, S., Portais, J.C., Roux, C., Bécard, G. and Séjalon-Delmas, N. 2006. Strigolactones stimulate arbuscular mycorrhizal fungi by activating mitochondria. PLoS Biology 4(7): e226. http://biology.plosjournals.org/perlserv/?request=get-document&doi=10.1371/journal.pbio.0040226 (Demonstrates that strigolactones are important branching factors for AM fungi, but that not all parasite germination stimulants are effective as branching factors as assayed on *Glomus rosea*.)

Bland, R.L. 2006. A note on mistletoe hosts. Nature in Avon 65: 61-62. (A survey of *Viscum album* in the Bristol area, S.W. England, showed greatest frequency on *Populus nigra,* but occurring also, in decreasing frequency on *Malus domestica, Tilia cordata, Crataegus monogyna, Robinia pseudo-acacia* and rarely on 7 further hosts.)

Brahim Bouizgarne, El-Maarouf-Bouteau, H., Madiona, K., Biligui, B., Monestiez, M., Pennarun, A.M., Zahia Amiar, Rona, J.P., Yedir Ouhdouch, El-Hadrami, I. and Bouteau, F. 2006. A putative role for fusaric acid in biocontrol of the parasitic angiosperm *Orobanche ramosa.* Molecular Plant-Microbe Interactions 19: 550-556. (Pretreatment of *Arabidopsis* seedlings with fusaric acid reduced germination of *O. ramosa* from 99% to 5%)

Brandt, J.P. 2006. Life cycle of *Arceuthobium americanum* on *Pinus banksiana* based on inoculations in Edmonton, Alberta. Canadian Journal of Forest Research 36: 1006-1016. (Most seeds of *A. americanum* were dormant over winter before germinating in May. Of these about 40% produced shoots in the following summer. About two thirds were pistillate, flowering after 4 years, one third staminate, flowering up to a year later. Most pistillate plants produced seed in the fifth year.)

Burgess, V.J., Kelly, D., Robertson, A.W. and Ladley, J.J. 2006. Positive effects of forest edges on plant reproduction: literature review and a case study of bee visitation to flowers of *Peraxilla tetrapetala* (Loranthaceae). New Zealand Journal of Ecology 30: 179-190. (*P. tetrapetala* was among just 9 species out of 85 to show benefits in reproduction from occurring mainly on forest edges, apparently due to a preference of the bird and bee pollinators for these sites.)

Cameron, D.D., Coats, A.M. and Seel, W.E. 2006. Differential resistance among host and non-host species underlies the variable success of the hemi-parasitic plant *Rhinanthus minor*. Annals of Botany 98: 1289-1299. (While grasses and a legume are susceptible to *R. minor*, *Plantago lanceolata* resists penetration by lignification and encapsulation of the invading haustorium, while *Leucanthemum vulgare* exhibits host cell fragmentation at the host/parasite interface.)

Close, D.C., Davidson, N.J. and Davies, N.W. 2006. Seasonal fluctuations in pigment chemistry of co-occurring plant hemi-parasites of distinct form and function. Environmental and Experimental Botany 58(1/3): 41-46. (Explores chlorophyll and accessory pigment levels across seasons, time of day, and site aspect in a host species, *Leptospermum scoparium*, and two diverse groups of parasites: *Cassytha glabella*, *C. pubescens*, *Leptomeria drupacea*, and *Exocarpos cupressiformis*.)

Correll, R. and Marvanek, S. 2006. Sampling for detection of branched broomrape. In: Preston, C., Watts, J.H. and Crossman, N.D. (eds) 15th Australian Weeds Conference, Adelaide, September 2006: 618-621. (Discussing the problems of monitoring low and declining populations of *O. ramosa* for the purposes of eventual release of land from quarantine)

Costea, M. and Tardif, F.J. 2006. The biology of Canadian weeds. 133. *Cuscuta campestris* Yuncker, *C. gronovii* Willd. ex Schult., *C. umbrosa* Beyr. ex Hook., *C. epithymum* (L.) L. and *C. epilinum* Weihe. Canadian Journal of Plant Science 86: 293-316. (A general review. *C. gronovii* is the commonest native species in Canada, followed by *C. campestris* and *C. umbrosa*. The introduced *C. epithymum*. and *C. epilinum* are occasional only.)

de MacVean, A. and Knapp, S. 2005. (*Langsdorffia hypogaea* (Balanophoraceae): a new registration of genus and species for Guatemala.) (in Spanish) Brenesia 63/64: 29-130. (Describing a new genus and species.)

del Egido Mazuelas, F., Puente García, E., López Pacheco, M.J. and Fernández Rodríguez, A. 2005. (De Plantis Legionensibus - Short notes XIX.) (in Spanish) Lagascalia 25: 177-184. (Including information on the distribution and ecology of *Orobanche mutelii,* in the Léon district of Spain.)

Díaz S.J., Norambuena M.,H. and López-Granados, F. 2006. (Characterization of the holoparasitism of *Orobanche ramosa* on tomatoes under field conditions.) (in Spanish) Agricultura Técnica 66: 223-234. (Studying the phenology of *Orobanche ramosa* parasitizing tomato in Chile, recording crop losses of about 80% and failing to demonstrate any benefit from altered date of planting.)

Dobbertin, M. and Rigling, A. 2006. Pine mistletoe (*Viscum album* ssp. *austriacum*) contributes to Scots pine (*Pinus sylvestris*) mortality in the Rhone valley of Switzerland. Forest Pathology 36: 309-322. (A detailed study of a range of factors involved in the death of 59% of *P. sylvestris* between 1996 and 2004 concluded that infection by *V.* album can be a predisposing factor for tree death, by increasing needle loss following drought, and a contributing factor, by increasing water stress during drought.)

Dugje, I.Y., Kamara, A.Y. and Omoigui, L.O. 2006. Infestation of crop fields by *Striga* species in the savanna zones of northeast Nigeria. Agriculture, Ecosystems & Environment 116: 251-254. (A survey in north-east Nigeria suggested 85% of maize and sorghum fields were infested with *Striga hermonthica*, 81% of cowpea fields with *S. gesnerioides*, 40-59% of rice fields with *S. aspera* and 27-60% of pearl millet fields and fallow with '*S. densiflora*'.)

Eizenberg, H., Colquhoun, J.B. and Mallory-Smith, C.A. 2006. Imazamox application timing for small broomrape (*Orobanche minor*) control in red clover. Weed Science 54: 923-927. (Excellent selective control of *O. ramosa w*as achieved in *Trifolium pratense* with post-emergence applications of imazamox from 10-40 g/ha. Optimal treatment was from 20 g/ha applied 1000 growing degree days after sowing.)

Elias, S., Garay, A., Zavala, J. and Alderman, S. 2006. Laboratory test to detect the presence of small broomrape (*Orobanche minor*) in red clover. Seed Technology 28: 73-79. (Screening samples through a round-hole perforation sieve with a hole diameter of 1.04 mm on a seed shaker, was able to detect a single seed of *O. minor* in 450 g *Trifolium pratense*.)

Franke, A.C., Ellis-Jones, J., Tarawali, G., Schulz, S., Hussaini, M.A., Kureh, I., White, R., Chikoye, D., Douthwaite, B., Oyewole, B.D. and Olanrewaju, A.S. 2006. Evaluating and scaling-up integrated *Striga hermonthica* control technologies among farmers in northern Nigeria. Crop Protection 25: 868-878. (Reporting 50% reductions in *S. hermonthica* seed-bank, and 88% increase in productivity from 2 years of farmer trials of 'integrated *Striga* control', not defined in the rather inadequate abstract, but apparently a follow-up to work reported by Ellis-Jones *et al*., 2004 (see Haustorium 47) involving rotation with soyabean, and use of new maize varieties.)

Garnett, G.N., Chambers, C.L. and Mathiasen, R.L. 2006. Use of witches' brooms by Abert squirrels in ponderosa pine forests. Wildlife Society Bulletin 34: 467-472. (Confirming the use by Abert squirrel, *Sciurus aberti*, of witches' brooms caused by *Arceuthobium vaginatum* for nesting and caching, and recommending the retention of some infested trees for the benefit of wildlife.)

Ghotbi, T. and Shahraeen, N. 2005. (First report on incidence of *Arabis* mosaic virus on ornamental plants in Iran.) (in Persian) Iranian Journal of Plant Pathology 41: 305-306 + 129 (Eng. Summary). (Unspecified *Cuscuta* sp. among a range of ornamental and weedy species infected by *Arabis* mosaic virus.)

Ghulam Jellani, Sumaira Munir, Asghari Bano and Hidayat Ullah. 2006. Effect of growth regulators on growth and yield of tomato cv. Roma parasitized by *Orobanche.* Sarhad 22: 229-232. (Reporting a pot experiment, conducted in 1995, in which foliar applications of GA_3 apparently improved the growth of tomato parasitized by unspecified *Orobanche* sp., presumably *O. ramosa*.)

Han RongLan, Zhang DianXiang and Hao Gang. 2005. Two new species of *Viscum* (Viscaceae) from China. Nordic Journal of Botany 23: 719-724. (Describing two new species, *Viscum macrofalcatum* and *V. hainanense*, both monoecious, from southern and SW China, most closely related to *V. yunnnanense*.)

Hansen, L.O. and Hodkinson, I.D. 2006. The mistletoe associated psyllid *Cacopsylia visci* (Curtis, 1835) (Homoptera, Psyllidae) in Norway. Norwegian Journal of Entomology 53(1): 89-91. (*C. viscid* (=*Psylla viscid*) newly recorded on *Viscum album* in the Oslo Fjord.)

Hashem, A., Patabendige, D. and Roberts, C. 2006. Biology and management of red dodder – a new threat to the grains industry. In: Preston, C., Watts, J.H. and Crossman, N.D. (eds) 15th Australian Weeds Conference, Adelaide, September 2006: 163-166. (*C. planiflora* has been found attacking rapeseed in Western Australia. Studies show: 88% seed dormancy, broken by sulphuric acid; yield reductions of 20% in lupin, 50% in faba bean, 60% in lupin, 75% in chickpea and 100% in subterranean clover; control by various herbicides and/or delayed crop sowing.)

Hedwall, S.J., Chambers, C.L. and Rosenstock, S.S. 2006. Red squirrel use of dwarf mistletoe-induced witches' brooms in Douglas-fir. Journal of Wildlife Management 70: 1142-1147. (Noting that red squirrel *Tamiasciurus hudsonicus* selected larger witches' brooms of types II and III, i.e. those close to the main trunk, for nesting, caching, etc.)

Heinzerling, L., von Baehr, V., Liebenthal, C., von Baehr, R. and Volk, H.D. 2006. Immunologic effector mechanisms of a standardized mistletoe extract on the function of human monocytes and lymphocytes *in vitro, ex vivo,* and *in vivo.* Journal of Clinical Immunology 26:

347-359. ('The most interesting clinical long-term effect is the bystander stimulation of various memory T cells that might mediate *in vivo* antitumor and antiinfectious T-cell response under mistletoe-extract immunization.')

Hernández-Benítez, R., Cano-Santana, Z. and Castellanos-Vargas, I. 2006. (Incidence of infection by *Arceuthobium globosum grandicaule* (Hawksw. & Wiens) in *Pinus hartwegii* Lindl.) (in Spanish) Ciencia Forestal en Mexico 2005 Vol 30(97): 79-86. (Showing that 77% of *P. hartwegii* trees taller than 2 m were infected by *A. globosum,* while only 2% of the individuals shorter than that height were damaged.)

Howell, B., Kenaley, S. and Mathiasen, R.L. 2006. First report of *Psittacanthus macrantherus* on *Pinus devoniana* and *Quercus castanea.* Plant Disease 90: 1461. (Small infestations of *P. macrantherus* observed on *P. devoniana, Q. castanea* and *P. douglasiana* in Mexico.)

Hunsberger, L.K., DeMoranville, C.J., Autio, W.R. and Sandler, H.A. 2006. Uniformity of sand deposition on cranberry farms and implications for swamp dodder control. HortTechnology16: 488-492. (Comparing two methods of applying sand to cranberry fields, 'by water barge, or directly on ice', and concluding that neither gave adequate uniformity of distribution of the desired 25 mm depth of sand for suppression of germination of *Cuscuta gronovii*.)

Hussien, T. 2006. Distribution of two *Striga* species and their relative impact on local and resistant sorghum cultivars in East Ethiopia. Tropical Science 46(3): 147-150. (Recording both *S. hermonthica* and *S. asiatica* in E. Ethiopia and their greatly (over 95%) reduced occurrence on the resistant sorghum cultivar Gubiye/P9401 compared with local varieties.)

Hussien, T., Mishra, B.B. and Gebrekidan, H. 2006. A new parasitic weed (*Alectra vogelii*) similar to *Striga* on groundnut in Ethiopia. Tropical Science 46: 139-140. (Reporting *A. vogelii* 'for the first time' in Ethiopia, though its occurrence near Harar was previously reported by Parker in 1988 (Walia 11: 21-27).)

Idžojtic, M., Kogelnik, M., Franjic, J. and Škvorc, Ž. 2006. Hosts and distribution of *Viscum album* L. ssp. *album* in Croatia and Slovenia. Plant Biosystems 140(1): 50-55. (Field and herbarium surveys revealed 52 taxa acting as hosts of *V. album* ssp. a*lbum*, in 13 families, the commonest being Rosaceae. Three hosts not previously recorded were *Alnus japonica*, *Amelanchier lamarckii* and *Crataegus nigra*.)

Joel, D.M., Bar, H., Mayer, A.M., Verdoucq, V., Welbaum, G. and Westwood, J. 2006. Chapter 31. Characterization of a dioxygenase gene with a potential role in steps leading to germination of the root parasite *Orobanche aegyptiaca*. In: Navie, S., Adkins, S. and Ashmore, S. (eds.) Seeds: Biology, Development and Ecology. Wallingford, UK: CAB International, pp. 296-305. (Description of the expression and localization of a dioxygenase gene associated with seed preconditioning in *O. aegyptiaca*.)

Joel, D.M., Hershenhorn Y., Eizenberg H., Aly R., Ejeta G., Rich P.J., Ransom J.K., Sauerborn J. and Rubiales D. 2007. Biology and management of weedy root parasites. In: Janick, J. (ed.) Horticultural Reviews 33: 267-349 (This comprehensive new survey will be reviewed in the next issue of Haustorium.)

Kalita, R.K., Pathak, K.C., Khatri, P.K. and Anup Chandra. 2006. Severe infestation of mistletoe on *Gmelina arborea* (Roxb.) in the state of Mizoram. Indian Forester 132: 381-384. (Describing *Scurrula parasitica* as a severe parasite of *G. arborea*, and apparently restricted to this host at this location (but occurring on a wide range of hosts in Bhutan – C.P.).)

Kalule, T., Khan, Z.R., Bigirwa, G., Alupo, J., Okanya, S., Pickett, J.A. and Wadhams, L.J. 2006. Farmers' perceptions of importance, control practices and alternative hosts of maize stemborers in Uganda. International Journal of Tropical Insect Science 26: 71-77. (Farmers in Tororo and Bugiri districts of Uganda ranked *Striga* and stemborers as major constraints to maize production.)

Kanyanjua, S.M., Keter, J.K., Okalebo, R.J. and Verchot, L. 2006. Identifying potassium-deficient soils in Kenya by mapping and analysis of selected sites. Soil Science 171: 610-626. (Recommending the use of K in the southern geomorphic area of Kenya, but concluding that NPK was not economical in the northern geomorphic area because of the occurrence of *Striga hermonthica*.)

Kenaley, S.C., Mathiasen, R.L. and Daugherty, C.M. 2006. Selection of dwarf mistletoe-infected ponderosa pines by *Ips* species (Coleoptera: Scolytidae) in Northern Arizona. Western North American Naturalist 66: 279-284. (Suggesting that infestation of *Pinus ponderosa* by *Arceuthobium vaginatum* subsp. *Cryptopodum* increased its susceptibility to the bark beetles *Ips* spp.)

Khan, Z., Nyangol, D., de Groote, H., Kanampiu, F., Rutto, E., Kikafunda, J., Odhiambo, G., Rwiza, I., Vanlauwe, B., Pickett, J. and Wadhams, L. 2006. Integrated pest and soil management to combat *Striga*, stem borers and declining soil fertility in maize. In: Sweetmore, A., Kimmins, F. and Silverside, P. 2006. Perspectives on Pests II. Achievements of research under UK Department for International Development Crop Protection Programme 2000-2005. Ashford, UK: Natural Resources International Ltd. pp. 79-81. (A review of on-farm studies in Kenya, Tanzania and Uganda confirming the value of *Desmodium* intercropping to suppress *S. hermonthica* in maize under relatively wet conditions, while the use of herbicide-resistant maize varieties in conjunction with imidazolinone herbicide was more reliable in drier conditions. Fertilizer and rotation treatments were also included.)

Khan, Z.R., Pickett, J.A., Wadhams, L.J., Hassanali, A. and Midega, C.A.O. 2006. Combined control of *Striga hermonthica* and stemborers by maize *Desmodium* spp. intercrops. Crop Protection 25: 989-995. (Intercropping with *Desmodium uncinatum, D. pringlei, D. intortum* or *D. sanwicense* resulted in striking 90-99% reductions in *S. hermonthica*, and 50-75% reductions in stem-borer in four successive years of this field study in Kenya, with associated 2-3-fold increases in maize yields, compared with sole-crop maize, or maize inter-cropped with cowpea.)

Kong LingXiao, Wang LianSheng, Zhao JuYing, Li QiuSheng and Zhao MiXia. 2006. Occurrence and biocontrol of *Orobanche cumana* on tobacco and sunflower. Acta Phytopathologica Sinica 36: 466-469. (Showing that *Fusarium* sp. strain L2, a strain used to control *Orobanche* infesting tobacco, gave over 90% control of *O. cumana*. Strain L2 was safe to wheat, maize, cotton, tobacco and sunflower. The toxins produced in liquid culture inhibited *Orobanche* seed germination.)

Landa, B.B., Navas-Cortés, J.A., Castillo, P, Pujadas-Salvà, A.J. and Jiménez-Diaz, R.M. 2006. First report of broomrape (*Orobanche crenata*) infecting lettuce in southern Spain. Plant Disease 90: 1112. (Nuclear techniques were used to confirm the infecting species as *O. crenata*, not *O. minor*. Infestation caused severe damage to autumn-sown lettuce crops.)

Lhuillier, E., Buaud, J-F. and Bouvet, J-M. 2006. Extensive clonality and strong differentiation in the insular Pacific tree *Santalum insulare*: implications for its conservation. Annals of Botany 98: 1061-1072. (*S. insulare* reproduces vegetatively by root suckers and thus forms clones. A survey showed 58% clonality. Genetic diversity tends to be low within islands, but high between islands and archipelagos.)

Lian, J.Y., Ye, W.H., Lai, Z.M., Wang, Z.M. and Cai, C.X. 2006. Insights: influence of obligate parasite *Cuscuta campestris* on the community of its host *Mikania micrantha*. Weed Research 46: 441-443. (Introduction of *C. campestris* (wrongly described as 'native' in China?) to fields with 80% cover of *M. micrantha*, reduced growth of that species by 75% and allowed an increase of species number from 7 to 19 over a period of 12 months.)

Lins, R.D., Colquhoun, J.B. and Mallory-Smith, C.A. 2006. Investigation of wheat as a trap crop for control of *Orobanche minor.* Weed Research 46: 313-318. (A range of 6 soft wheat varieties, a durum wheat (*Triticum turgidum*) and a triticale (*T. hexaploide*) all stimulated germination of *O. minor* and greatly reduced parasitisation of a following crop of red clover grown in the same pots.)

Lundquist, J.E. 2005. Patterns in diseased landscapes: a case study of a lodgepole pine forest infected by dwarf mistletoe. In: Lundquist, J.E. and Hamelin, R.C. (eds) Forest pathology: from genes to landscapes. 1999 Montreal APS Annual Convention. St Paul, USA: APS Press, pp.145-153. (A study of the patterns of spread and intensification of *Arceuthobium americanum* in *Pinus contorta* ssp. *latifolia*.)

Malidža, G., Janjic, V. and Dalovic, I. 2006. Genetically modified herbicide-tolerant crops - state and perspectives. Herbologia 7(1): 67-93. (Referring to the potential value of herbicide-tolerant crops in the control of parasitic weeds.)

Mallams, K.M., Goheen, D.J. and Russell, D. 2005. Dwarf mistletoe broom development in mature Douglas-fir trees: a retrospective case study. Northwest Science 79: 273-280. (A study of the brooms caused by *Arceuthobium douglasii* and their possible suitability for use of wild life including nesting by spotted owls.)

Mallik, M.A.B. and Williams, R.D. 2005. Allelopathic growth stimulation of plants and microorganisms. Allelopathy Journal 16: 175-198. (Including reference to strigolactones promoting seed germination of angiospermous parasites.)

Mathiasen, R.L. and Daugherty, C.M. 2005. Comparative susceptibility of conifers to western hemlock dwarf mistletoe in the cascade mountains of Washington and Oregon. Western Journal of Applied Forestry 20(2): 94-100. (A survey of 26 conifer stands in N.W. USA confirmed western hemlock as the only principal host of *Arceuthobium tsugense* ssp. *tsugense*, while *Abies amabilis, Abies procera* and *Tsuga mertensiana* were occasional hosts.)

Mathiasen, R.L., Sediles, A. and Sesnie, S. 2006. First report of *Arceuthobium hondurense* and *Struthanthus deppeanus* in Nicaragua. Plant Disease 90: 1458. (Populations of *A. hondurense* recorded at three new locations on *Pinus tecumanii* and at one on *P. oocarpa*. *S. deppeanus* was observed at one site on *P. tecumanii* and at another on *P. oocarpa*.)

Matthews, J., Miegel, D. and Hayton, D. 2006. Herbicides for the control of branched broomrape (*Orobanche ramosa*). In: Preston, C., Watts, J.H. and Crossman, N.D. (eds) 15th Australian Weeds Conference, Adelaide, September 2006: 653-655. (Reporting preliminary trials with a range of herbicides in a wide range of crops and concluding that useful control can be achieved with sulfonylurea and other ALS-inhibiting herbicides, also withglyphosate.)

Matthews, J., Miegel, D. and Hayton, D. 2006. Seed bank and seed bank reduction of *Orobanche ramosa* in South Australia. In: Preston, C., Watts, J.H. and Crossman, N.D. (eds) 15th Australian Weeds Conference, Adelaide, September 2006: 626-628. (Seed of *O. ramosa* buried in packets in the field showed little loss of viability over a 2½ year period. Drenching soil with 20,000 L. of 5% 'Interceptor' (a product derived from *Pinus* pulp) reduced *O. ramosa* viability by over 95% in the top 10 cm of the soil. This product is safe for most other plant species.)

Mbwaga, A., Ley, G., Hella, J., Kayeke, J., Masangya, E., Mwampaja, Lameck, P., Riches, C.R. and Lamboll, R. 2006. Green manure for enhancing upland rice productivity on Striga-infested fields in Tanzania. In: Sweetmore, A., Kimmins, F. and Silverside, P. 2006. Perspectives on Pests II. Achievements of research under UK Department for International Development Crop Protection Programme 2000-2005. Ashford, UK: Natural Resources International Ltd. pp. 64-65. (On-farm trials have confirmed excellent suppression of *Striga asiatica* and at least 2-fold increase in rice yields following a green manure crop of *Crotalaria ochroleuca*. Farmer involvement has led to widespread adoption of the practice.)

Mishra, J.S., Moorthy, B.T.S. and Manish Bhan 2005. Efficacy of herbicides against field dodder (*Cuscuta campestris*) in lentil, chickpea and linseed. Indian Journal of Weed Science 37(3/4): 220-224. (Pendimethalin pre-emergence at 1 kg/ha was selective and increased yields in lentil, linseed, chickpea. A mixture with imqazaquin was selective only in chickpea, while glyphosate, 50 g/ha, showed selectivity in linseed only.)

Mishra, J.S., Moorthy, B.T.S. and Manish Bhan. 2006. Relative tolerance of linseed (*Linum usitatissimum*) varieties to dodder (*Cuscuta campestris*) infestation. Indian Journal of Agricultural Sciences 76: 380-382. (Yield reduction of 14 linseed varieties due to *C. campestris* varied from 7% in the relatively tolerant Garima to 44% in the most susceptible J 23.)

Mndolwa, M. and Kindo, A. 2005. *Loranthus* species attack on *Acacia mangium* at Ruvu North Forest Reserve, Tanzania. NFT News 8(1): 3-4. (A survey indicated 36% of *A. mangium* being attacked by unspecified *Loranthus* spp.)

Molinero-Ruiz, M.L., Melero-Vara, J.M., Garcia-Ruiz, R. and Dominguez, J. 2006. Pathogenic diversity within field populations of *Orobanche cumana* and different reactions on sunflower genotypes. Weed Research 46: 462-469. (Reporting somewhat complex results, but confirming the high resistance of sunflower genotype P96 to races F and E of *O. cumana*. Type L86 resisted race F but was, unusually, susceptible to race E. Also showing that there are significant variations between subpopulations of race F.)

Mooney, K.A. and Linhart, Y.B. 2006. Contrasting cascades: insectivorous birds increase pine but not parasitic mistletoe growth. Journal of Animal Ecology 75: 350-357. (Excluding birds from *Pinus ponderosa* parasitised by *Arceuthobium vaginatum* resulted in increased damage to pine from aphids, but did not influence insect damage on *A. vaginatum*. Results are discussed in terms of food web theory, intraguild predators and trophic cascades.

Mossahebi, G.H., Okhovvat, S.M. and Damadi, M. 2005. Determination of the races of potato virus X and its host range in Karaj, Damavand and Ardabil, Iran. In: Gullino, M.L. (ed.) Communications in Agricultural and Applied Biological Sciences70(3): 431-433. (Potato virus X was transmitted mechanically but not via unspecified *Cuscuta* sp.)

Muehlenbaur, F.J., Cho, S.H., Sarker, A., McPhee, K.E., Coyne, C.J., Rajesh, P., and Ford R. 2006. Application of biotechnology in breeding lentil for resistance to biotic and abiotic stress. Euphytica 147: 149-165. (Review describing the current state of lentil breeding and the application of genomic tools to improve resistance to stresses and pathogens. Passing reverence to *Orabanche* (sic) as important pathogens.)

Muhanguzi, H.D.R., Obua, J., Oreym-Origa, H. and Vetaas, O.R. 2005. Forest site disturbances and seedling emergence in Kalinzu Forest, Uganda. In: Teketay, D. (ed.) Tropical Ecology 46(1): 91-98. (Studying the effects of previous management on the establishment of a range of species including *Strombosia scheffleri* (Olacaceae).)

Muir, J., Turner, J. and Swift, K. 2005. Hemlock dwarf mistletoe stand establishment decision aid. BC Journal of Ecosystems and Management 5(1): 7-9. (The Stand Establishment Decision Aid summarizes information that relates current management regimes to the spread and effects of *Arceuthobium tsugense* in British Columbia, Canada. It also includes a valuable resource and reference list.)

Nabeela Anjum and Zaheer-ud-Din Khan. 2003. Effect of host species on antimicrobial activity of the ethanolic extracts of *Cuscuta reflexa* Roxb. Mycopath 1(1): 99-104. (Reporting antimicrobial activity of ethanolic extracts of *Cuscuta reflexa* parasitizing *Populus euro-americana, Zizphus hysudrica* and *Clerodendron inerme*.).

Nizhamiding, K., Tuniyazi, Y. and Ma DeYing. 2006. (Establishment of technique system of integration dodder management on alfalfa in Xinjiang.) (in Chinese) Xinjiang Agricultural Sciences 43:180-185. (Reviewing the distribution and control of *Cuscuta* spp., including the use of biological control.)

Okpo, E.S., Lagoke, S.T.O., Ndahi, W.B., Olufajo, O.O. and Tabo, R. 2003. Germination of witchweed [*Striga hermonthica* (Del.) Benth.] seeds in response to stimulation by root exudates of soybean (*Glycine max* L.). Global Journal of Agricultural Sciences 2(1): 25-32. (Among 21 varieties of soyabean tested using a cut-root assay, TGX1681-3F, TGX1479-1 E, TGX1649-11F and SAMSOY-2 stimulated greatest germination of *S. hermonthica*.)

Pérez-Vich, B., Velasco, L., Muñoz-Ruz, J., Domínguez, J. and Fernández-Martínez, J. M. 2006. Registration of three sunflower germplasms with quantitative resistance to race F of broomrape. Crop Science 46: 1406-1407.

(Describing sunflower germplasms AM-1 (PI 641057), AM-2 (PI 641058) and AM-3 (PI 641059) with quantitative resistance to race F of *Orobanche cumana*.)

Qasem, J.R. 2006. Host range of the parasitic weed *Osyris alba* L. in Jordan. Weed Biology and Management 6(2): 74-78. (A survey revealed 23 plant species of 14 families infected by *O. alba* in Jordan. Worst affected fruit trees were almond, vine and olive, while most seriously affected forest trees were *Cupressus sempervirens*, *Acacia cyanophylla* and *Rhamnus palaestina*.)

Reblin, J.S., Logan, B.A. and Tissue, D.T. 2006. Impact of eastern dwarf mistletoe (*Arceuthobium pusillum*) infection on the needles of red spruce (*Picea rubens*) and white spruce (*Picea glauca*): oxygen exchange, morphology and composition. Tree Physiology 26: 1325-1332. (Confirming *P. glauca* to be more susceptible to *A. pusillum* than *P. rubens* but failing to explain the difference in terms of the effects of the parasite on host carbon balance.)

Riches, C.R. 2006. Green manures in Tanzania: a technology whose time has come. TAA Newsletter September 2006: 21-22. (A further account of the work on green manures *Crotalaria, Canavalia* and *Mucuna* which farmers are adopting enthusiastically to improve soil fertility and hence yields of rice and maize, while greatly reducing *Striga asiatica* infestations.)

Rodenburg, J., Bastiaans, L. and Kropff, M.J. 2006. Characterization of host tolerance to *Striga hermonthica.* Euphytica 147: 353-365. (Pot studies with four sorghum varieties and different levels of infection suggested that for resistant genotypes, tolerance can best be quantified as a reduced relative yield loss per emerged *Striga* plant, whereas for less resistant genotypes the maximum relative yield loss can best be used. Complications of screening for tolerance under field conditions are discussed.)

Rogers, Z.S., Malécot, V. and Sikes, K.G. 2006. A synoptic revision of *Olax* (Olacaceae) in Madagascar and the Comoro Islands. Adansonia sér. 3 28(1): 71-100. (Detailed descriptions of 8 species including 3 new spp. *O. antsiranensis, O. capuronii* and *O. mayottensis*, but no mention of parasitism.)

Ross, C.M. 2005. A new way of describing meiosis that uses fractal dimension to predict metaphase I. International Journal of Biological Sciences 1(3): 123-125. (Despite its parasitic nature (making it difficult to culture) dwarf mistletoe has received considerable attention for its peculiarities in meiotic behaviour. This paper is the latest in a series of these studies with broad implications for meiosis in the plant kingdom and beyond.)

Runyon, J.B., Mescher, M.C. and de Moraes, C.M. 2006. Volatile chemical clues guide host location and host selection by parasitic plants. Science 313:1964-1967. (Demonstrating the influence of volatile substances in guiding *Cuscuta pentagona* seedlings towards their host, tomatos. See Literature highlight above.)

SAFGRAD. 2005. Collaborative *Striga* Research and Control Project 2002-2004 Achievements. Oagadougou, Mali: SAFGRAD. 34pp. (In a collaborative project between 7 W. African countries, a range of improved maize varieties averaged 40% yield benefit and 41 % less *S. hermonthica* in over 200 farmer trials. Combinations of the improved variety with legume rotation or intercropping showed little further yield benefit but was believed to have reduced *Striga* seed-bank.)

Salehi, M., Izadpanah, K. and Heydarnejad, J. 2006. Characterization of a new almond witches' broom phytoplasma in Iran. Journal of Phytopathology 154: 386-391. (Transmitted from host to host by unspecified *Cuscuta* sp.)

Samaké, O., Stomph, T.J., Kropff, M.J. and Smaling, E.M.A. 2006. Integrated pearl millet management in the Sahel: effects of legume rotation and fallow management on productivity and *Striga hermonthica* infestation. Plant and Soil 286: 245-257. (One year of cowpea followed by 3 years pearl millet/cowpea intercrop yielded the same total millet as 4 years continuous sole-crop pearl millet, while the cowpea harvested was a bonus. Preceding fallow for 2 years reduced *S. hermonthica* and increased millet yield. Longer fallow up to 7 years reduced *Striga* further, but did not eliminate it.)

Sánchez-Gullón, E., Macías, F.J., Weickert, P. and Valdés, B. 2005. (Contribution to the flora and vegetation of the low valley of the river Guadiana in western Andévalo (Spain).) (in Spanish) Lagascalia 25: 252-257. (Including records of the distribution of *Orobanche schultzii*.)

Secomb, N. 2006. Defining the distribution of branched broomrape (*Orobanche ramosa* L.) by tracing the movement of potential vectors for the spread of seed. In: Preston, C., Watts, J.H. and Crossman, N.D. (eds) 15th Australian Weeds Conference, Adelaide, September 2006: 614-617. (*O. ramosa* was found to be moved from farm to farm mainly via farm machinery and livestock, with contaminated crop seed or hay being less often responsible.)

Siddiqui, A.M.A. and Hussein, M.A. 2005. Floral diversity in Hawf forest. University of Aden Journal of Natural and Applied Sciences 9: 585-594. (Noting the occurrence of unspecified parasitic plants in forest dominated by *Anogeissus dhofarica* in Yemen.)

Singh, B.B., Olufajo, O.O., Ishiyaku, M.F., Adeleke, R.A., Ajeigbe, H.A. and Mohammed, S.G. 2006. Registration of six improved germplasm lines of cowpea with combined resistance to *Striga gesnerioides* and *Alectra vogelii*. Crop Science 46: 2332-2333. (Among 6 improved lines with combined resistance to *S. gesnerioides* and *Alectra vogelii* , IT90K-59 is also resistant to major diseases, while IT97K-205-8 and IT97K-499-35 also have combined resistance to major diseases and insects. The latter has shown consistently high yield.)

Song, W. J. Zhou, W.J., Jin, Z.L., Zhang, D., Yoneyama, K. Takeuchi, Y. and Joel, D.M. 2006. Growth regulators restore germination of *Orobanche* seeds that are conditioned under water stress and suboptimal temperature. Australian Journal of Agricultural Research **57**: 1195–1201. (Seeds of *O. ramosa, O. aegyptiaca* and *O. minor*, germinated less well in response to GR_{24} following conditioning at sub-optimal temperature and moisture: but germination levels were largely restored when various combinations of GA_3, brassinolide and fluridone were applied in conjunction with the GR_{24}.)

Steuer-Vogt, M.K., Bonkowsky, V., Scholz, M., Fauser, C., Licht, K. and Ambrosch, P. 2006. (Influence of ML-1 standardized mistletoe extract on the quality of life in head and neck cancer patients.) (in German) HNO, Hals-, Nasen-, Ohrenärzte 54: 277-286. (In a study involving regular injections of mistletoe extract ML-1 into 200 patients over a 60 week period, no improvements in the quality of life in head and neck cancer patients were demonstrated.)

Tarfa, B.D., Kureh, I., Kamara, A.Y. and Maigida, D.N. 2006. Influence of cereal-legume rotation on soil chemical properties, crop yield and *Striga* control. Journal of Agronomy 5: 362-368. (Recording increases in soil organic matter and maize yield in maize following soyabean or cowpea, compared with continuous maize. Effects on *S. hermonthica* and soil pH not clear from the abstract.)

Teryokhin, E.S. 2004. The origin of "dust" seeds in parasitic and mycoparasitic angiosperms: a hypothesis for symbioses. Beiträge zur Biologie der Pflanzen (2001) 72: 381-397. (The late Edward Teryokhin contributed immensely to our understanding of parasites. In this posthumous paper he returns to one of his early research interests, the morphology of seeds. Like mycotrophs, seeds of many parasitic plants are remarkably reduced.)

Torres, A.M., Román, B., Avila, C.M., Satovic, Z., Rubiales, D., Sillero, J.C., Cubero, J.I. and Moreno, M.T. 2006. Faba bean breeding for resistance against biotic stresses: towards application of marker technology. Euphytica 147: 67-80. (A review of faba bean breeding, containing a section that concisely summarizes challenges and progress in breeding resistance to *O. crenata*.)

*Torres, M.J., Tomilov, A.A.,Tomilova, N., Reagan, R.L., Yoder, J.I. 2005. Pscroph, a parasitic plant EST database enriched for parasite associated transcripts. BMC Plant Biology 5(24): http://www.biomedcentral.com/content/pdf/1471-2229-5-24.pdf (Describing the generation of a database containing over nine thousand sequences generated from suppression subtractive libraries enriched for transcripts regulated in *Triphysaria* roots exposed to *Arabidopsis* roots or DMBQ. The web site also provides BLAST functions and allows keyword searches of functional annotations.)

Véronési, C., Benharrat, H., Delavault, P. and Simier, P. 2006. (Resistance of rape-seed to branched broomrape.) (in French) Phytoma – La Défense des Végetaux 599: 45-47. (Oil-seed rape variety 'Darmor' proved highly resistant to *Orobanche ramosa* compared with variety 'Yudal'. Kinetic studies of enzymes showed an early build-up of lipoxygenase and peroxidase after infection and suggest these may have a role in resistance.)

Virtue, J., DeDear, C., Potter, M.J. and Rieger, M. 2006. Potential use of isothiocyanates in branched broomrape eradication. In: Preston, C., Watts, J.H. and Crossman, N.D. (eds) 15th Australian Weeds Conference, Adelaide, September 2006: 629-632. (Confirming useful germination stimulant activity on *O. ramosa* from methyl isothiocyanate, 2-phenylethyl isothiocyanate and 2-propenyl isothiocyanate. Activity of root exudates of a number of *Brassica* species, assumed due to release of brassinolides /isothiocyanates, was high in some tests but inconsistent.)

Warren, P. 2006. The branched broomrape eradication program in Australia. In: Preston, C., Watts, J.H. and Crossman, N.D. (eds) 15th Australian Weeds Conference, Adelaide, September 2006: 610-613. (Reviewing the Australian eradication programme for *Orobanche ramosa* which currently affects over 6,000 ha. Now in its 8th year and costing A$4M per annum, the campaign involves, research, quarantine across an area of nearly 200,000 ha, methyl bromide fumigation and other procedures to prevent new seed production.)

Westbury, D.B., Davies, A., Woodcock, B.A. and Dunnett, N.P. 2006. Seeds of change: the value of using *Rhinanthus minor* in grassland restoration. Journal of Vegetation Science 17: 435-446. (Seeding *R. minor* into various types of species-poor grassland was shown to suppress grass growth and increase species- diversity in some instances but depended on a range of factors. Establishment of *R. minor* was improved by sward scarification.)

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Yonli, D., Hess, D. E., Abbasher, A.A., Sérémé, P. and Sankara, P. 2005. Biological control of witch weed in fields of Burkina Faso using isolates of *Fusarium* *oxysporum.* African Crop Science Journal 13(1): 41-47. (Belatedly reporting studies from 1997/98 which showed no significant differences between 15 isolates of *F. oxysporum* and achieved about 50% reductions in biomass and emergence of *S. hermonthica* in both years.)

Zhang LingLing, Han ShiChou, Li LiYing and Liu WenHui. 2006. Progress in studies on the control of invasive weed *Mikania micrantha* H. B. K. Journal of Tropical and Subtropical Botany 14(2): 162-168. (Reviewing control methods for *M. micrantha* in China, including the use of *Cuscuta campestris, C. chinensis* and *C. australis*.)

Zheng GuoQi, Song YuXia, Guo ShengHu, Ma HongAi and Niu DongLing. 2006. Soluble sugar accumulation and the activities of sugar metabolism-related enzymes in *Cistanche deserticola* and its host *Haloxylon ammodendron.* Acta Botanica Boreali-Occidentalia Sinica 26: 1175-1182. (Parasitism of *H. ammodendron* by *C. deserticola* altered sugar metabolism in the host.)

ERRATA

We regret that the final two pages of our last issue, Haustorium 49, were omitted from the printed copy sent from Old Dominion University. These are included in the copy on the Haustorium web site but if printed copies are needed, please email Lytton Musselman at: lmusselm@odu.edu.

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