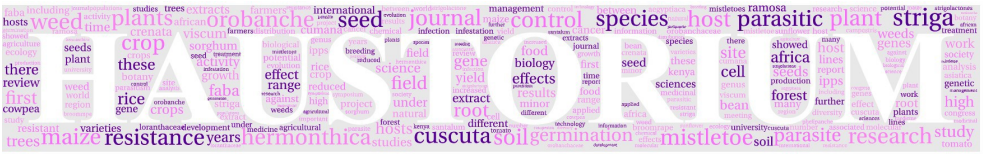

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PRESIDENT'S M ESSAGE

Dear IPPS members

In the previous issue of Haustorium we were looking back to the successful World Congress on Parasitic Plants (WCPP) held in Nairobi, Kenya (see: https://www.parasiticplants.org/2022/07/16th-world-congress-on-parasitic-plants-3-8-july-2022-nairobi-kenya-a-great-success/). Now I can announce that the organization of the next WCPP, which will be held in Nara, Japan, 3-7 June 2024 is in full swing (see https://www.parasiticplants.org/2023/01/the-17th-world-congress-on-parasitic-plants-3-7-june-2024-nara-japan/). Keep an eye on the IPPS website for details and more information on this meeting. I hope that many of you plan to attend this meeting.

This spring, the IPPS started again with the on-line monthly seminar series (see ZOOMINARS below). The next two will be held on 7 June and 5 July, On 5 July, after the seminar we will also host the IPPS General Assembly, online, using the same Zoom link as for the seminar. I hope you will all join to discuss IPPS matters and strategy with the EC. We will continue to host the online IPPS seminars throughout 2023. If you or one of your students wants to contribute to these seminars, please drop a line to Jonne Rodenburg at j.rodenburg@greenwich.ac.uk .

To keep the IPPS website lively and up to date we have several dynamic features, such as a Scopus and Google Scholar feed readers showing the latest publications on parasitic plants. Our Twitter feed was temporarily out of order but is working again and shows IPPS as well as #Parasiticplants hashtagged tweets. And the website has an option for IPPS members to post news and vacancies. Please check them out on www.parasiticplants.org! To post news yourself, login into the member area where you can post your most recent paper or project funding, as well as job vacancies. These will also automatically be Tweeted from the IPPS Twitter account, giving you even more exposure. I would also greatly appreciate if you'd update your member profile, with your picture and that of your institution and with a short description of your research area, if you have not already done that.
On an administrative note, all IPPS members received an email explaining that we have changed the membership year from the academic to the calendar year. In this way we hope there will be less confusion about when the membership fees are due. We use these fees to run the society and to support the organization of the WCPP and its attendance by young researchers from developing countries. Membership entitles you to a reduced fee for WCPP attendance and gives you access to the member area of the IPPS website. If you are reading Haustorium but are not an IPPS member yet, consider becoming a member, see www.parasiticplants.org for details and an online membership fee payment option.

In this issue of Haustorium you can find again a great selection of parasitic plant related news. Remarkable is the article on the protection, moreover, sowing of mistletoe in Australia to support bird wildlife. Another parasitic plant related fact that attracted a lot of media attention already is "How rare island bunnies do a parasitic plant's bidding". Haustorium is also paying attention to the possible use of parasitic plants and parasitic plant extracts for treatment of disease, including a *Viscum album* extract for treatment of cancer. Of course, it also includes plenty of articles like '*Cuscuta* conundrum: Amarbel poses great risk to greenery in Dwarka (Gujarat)' discussing problems caused by parasitic plants. Enjoy reading!

I wish you all a good summer break.

Harro Bouwmeester

LITERATURE HIGHLIGHT

Crop diversification and parasitic weed abundance: a global meta-analysis (Scott and Freckleton, 2022.)

Parasitic weeds like *Striga* cause significant losses to crop production in sub-Saharan Africa, resulting in billions of dollars in damages annually. A recently completed PhD project by Donald Scott at the University of Sheffield in the group of Professor Rob Freckleton has taken an ecological approach to help improve our understanding of this pernicious weed and how it can be better managed in the future.

Large-scale data on the distribution of *Striga* is scarce, impeding efforts to control and predict its

spread. To address this issue, Donald developed a method for monitoring *Striga* populations on a large scale. He applied this approach in Madagascar to investigate the factors influencing the abundance and distribution of *Striga asiatica* at a landscape scale. Having established large-scale transects that traversed the country, he collected data on crop management, soil structure, and environmental conditions and he identified correlations between *Striga* density and factors such as crop variety, companion crop, and previous crop.

The study also revealed a positive relationship between *Striga* density within a field and the density of neighbouring fields, highlighting the significance of spatial configuration and habitat connectivity in the spread of *Striga*.

Notably, the study emphasizes the importance of crop varieties and cropping patterns as potential control options, leveraging existing practices rather than relying on new technologies. Crop variety and legumes played key roles in driving *Striga* density, while precipitation seasonality, mean temperature, and altitude also had significant effects. This work emphasized the need for a multifaceted approach to manage *Striga* effectively, as single measures were deemed insufficient. One output of this work was a composite management index that incorporated various cultural practices, offering guidance for integrated *Striga* management beyond the study's geographical scope.

Taking a broader context, Donald conducted a meta-analysis encompassing 67 studies across 24 countries that examined the relationship between parasitic weed density, crop yields, and diverse cropping systems. The analysis of 1525 paired observations revealed that both spatial (intercropping) and temporal (crop rotation) diversification had a significant impact on reducing parasitic weed density. The study highlighted that spatial diversification had a stronger suppressive effect than temporal diversification. Additionally, intercrops that altered microclimate and soil chemistry, such as *Crotalaria, Stylosanthes*, Berseem clover, and *Desmodium*, showed the most effective management of parasitic weeds. This analysis further underscores the potential of crop diversification as a tool to enhance global food security by mitigating the impact of parasitic weeds.

Although Donald's project has now finished, work on weeds continues at Sheffield and the group would be more than happy to talk to anyone about possible collaborations (r.freckleton@sheffield.ac.uk).

Scott, D., Scholes, J. D., Randrianjafizanaka, M. T., Randriamampianina, J. A., Autfray, P., and Freckleton, R. P. 2021. Identifying existing management practices in the control of *Striga asiatica* within rice–maize systems in mid-west Madagascar. Ecology and Evolution, 11: 13579-13592. https://doi.org/10.1002/ece3.8085

Scott, D. and Freckleton, R.P. 2022. Crop diversification and parasitic weed abundance: a global meta-analysis. Scientific Reports 12: 19413. https://doi.org/10.1038/s41598-022-24047-2

Scott, D., Scholes, J. D., Randrianjafizanaka, M. T., Randriamampianina, J. A., Autfray, P. and Freckleton, R. P. 2020. Mapping the drivers of parasitic weed abundance at a national scale: a new approach applied to *Striga asiatica* in the mid-west of Madagascar. Weed Research, 60(5): 323-325. https://doi.org/10.1111/wre.12436

CONGRATULATIONS

Lytton Musselman

Lytton J. Musselman, Professor and Eminent Scholar celebrated his retirement from Old Dominion University, Norfolk VA USA where he served 50 years (since 1973) with a splendid retirement gala at the Norfolk Botanical Garden, February 18th, 2023. Dr. Musselman was celebrated in a packed garden ballroom, with old friends, colleagues, former and current students, and scores and scores of children and grandchildren stacked up like cordwood, and most importantly his wife and life partner, Libby Musselman. Stories of Musselman's extensive field work abroad, spanning the globe and many decades, and his positive impact on lives of so many, were recounted through individual stories and tributes at the event. As Dr. Musselman would say, the lively event was "fine and dandy like sugar candy", a Lytton-ism recounted by many of his students. Among his PhD students that spoke were plant parasite workers, Kamel Mohamed, Daniel Nickrent, and Jay Bolin.

Dr. Musselman's impressive influence on literature of plant parasites, his enterprise in the establishment of Haustorium and in many of the international metings is well known to our readers, and he continues to make contributions to the ecology and taxonomy of quillworts, longleaf pine communities, plants of the holy books, and ethnobotany. In retirement his infectious enthusiasm for plants continues unabated, he is currently the editor of the *Chinquapin* the newsletter of the Southern Appalachian Botanical Society and completing a book (his 10th!) titled 'Parasitic Plants in African Agriculture' with Jonne Rodenburg that should be released by CABI Press in August 2023.

The event was a fitting tribute to a pillar of IPPS since its inception and a kind man whose contributions to plant parasite biology will echo for years.

Jay Bolin

IPPS ZOOMINARS

April 5, 2023

Changsheng Li - Hunan University, China **- Elucidation of the biosynthetic pathway and biological functions of strigolactones in maize and rice.**

Strigolactones are a class of plant signaling molecules of great importance, with diversified structures and diverse biological roles in and outside the plant, in the rhizosphere. Maize (*Zea mays*) is one of the most important staple crops in the world. However, its yield is severely compromised by the parasitic witchweeds. In the maize work, by using a combination of approaches, we revealed natural variation in the maize strigolactone production, identified three new maize strigolactones, and elucidated their complete biosynthetic pathways.

We discovered a novel cytochrome P450, ZmCYP706C37, catalyzing several steps in the biosynthesis of maize strigolactones. Among those, two (zealactol and zealactonoic acid) showed much lower activity than zealactone, in inducing *Striga* germination. We also showed that changes in the composition of the strigolactone blend in some lines correspond to differences in *Striga* germination and infection.

Similar strategies were used in the rice project. A new strigolactone 4-oxo-MeCLA was identified and its biosynthetic pathway was further elucidated, in which OsCYP706C2 was involved. Moreover, bioassays using *Striga* and AM fungi indicate that *oscyp706c2* mutants were not affected in *Striga* germination inducing activity but showed delay in AM fungi colonization.

Taken together, we show how intricate strigolactone biosynthesis (in maize and rice) is and shed further light on their biological significance.

Moez Amri - University Mohammed VI, Morocco - **Breeding for resistance to broomrapes in cool season legumes: the cornerstone of a successful control strategy.**

He has selected, development and released to the farmers several faba bean, chickpea, lentil and grass pea varieties in Tunisia and the CWANA and Sub-Saharan regions. Most of the faba bean released varieties are carrying good resistance to the broomrapes *Orobanche crenata* and *O. foetida*. These varieties are now largely adopted by farmers and highly recommended by the seed companies and extension agencies. Association (APBA) Executive committee representing NA region.

May 3, 2023

Hanan Eizenberg - Newe Ya'ar Research Center, Israel - **Predicting the dynamics of broomrape parasitism as a basis for decision support systems to control the parasite. What**

have we learned after twenty years of research?

Root parasites (*Phelipanche* and *Orobanche* spp.) are serious pests in Israeli agriculture. Species of economic importance include Egyptian broomrape (*P. aegyptiaca*), crenate broomrape (*O. crenata*), and sunflower broomrape (*O. cumana*). Crops affected by broomrape include mostly plants from the botanical families of Solanaceae, Fabaceae, Asteraceae, and Umbellifers. The damage caused by the aforementioned broomrape species in field and vegetable crops can be highly severe and may result in total yield loss. Current broomrape control protocols are exclusively targeted at the specific host-parasite interaction.

Chemical-based solutions (herbicides) may be suitable for different broomrape species parasitizing the same host, however, they are not always efficient for hosts from other botanical families. There are several reasons for this: a) as reported in many papers, the interactions between the parasite and the host are different in terms of the dynamics of parasitism; b) selectivity of the hosts to different herbicidal modes of action; c) different herbicides application methods. The major challenge in developing principles for smart broomrape management is based on the fact that most of the parasitic plant life cycle occurs below the soil surface, resulting in great difficulty to determine the optimum timing for herbicide applications. Other issues that may prevent successful management are; the spatial variations in seed infestation within plots, the duration of herbicide action and depth in the soil, the timing of subsequent applications, and the most appropriate dosage for each stage of parasite infection. Therefore, the basis for smart broomrape management is the study of the temporal and spatial dynamics of the parasite in the agricultural field, and the correct and precise herbicide application using the most effective application systems available at each farm. Over twenty years of research, we have developed several decision support systems based on these principles for the control of Egyptian broomrape in tomatoes, carrots, and cabbage and also for the management of sunflower broomrape in sunflower.

These decision support systems allow growers to cultivate crops such as tomatoes, carrots, cabbage, and sunflower in fields infested with broomrape with minimal damage. In my talk, I will describe different models for predicting host-parasite dynamics based on soil temperature measurements, I will discuss approaches for studying the spatial variation of broomrape in the field and the means for precise application of herbicides. In addition, I will discuss various obstacles encountered by farmers in the field using these models and how research is addressing issues of herbicide-induced damage, herbicide degradation in soil, and the role of the microbiome in broomrape control with herbicides.

Ahmet Uludag – Çanakkale Onsekiz Mart University, Turkey **- Broomrape control in tomato growing: one method is not enough.**

Tomato has worldwide importance from nutritional value to economical value. Broomrapes (*Orobanche* and *Phelipanche* spp.) are among foremost problems in tomato growing. Five out of seven important crop parasitizing broomrapes have been recorded on tomato, namely *P. ramosa, P. aegytptiaca, O. cernua, O. cumana* and *O.crenata.* The motto of broomrape control has been 'one method is not enough'. In this presentation, methods to control broomrape will be reviewed although there have been several high-quality reviews published. Knowledge on the implementation of measures and our experiences will be blended to convey our view to colleagues.

7th June
Sylvia Mutinda, Kenyatta University
James Bradley, University of Toronto

5th July

Elvin Mulaa, ICRISAT
Natsumi Aoki, Nara Institute
to be followed by an online IPPS General assembly.

PRESS REPORTS

Rare parasitic plant rediscovered in dunes over Lake Michigan

The Wisconsin Department of Natural Resources (DNR) today announced that a population of a rare parasitic plant was rediscovered on the dunes overlooking Lake Michigan in Manitowoc County. A trained volunteer for the Rare Plant Monitoring Program spotted the clustered broomrape (*Orobanche fasciculata*), which has not been seen in over 44 years. This discovery

and others are featured in the Rare Plant Monitoring Program's recently released 2022 Annual Report. Almost 15% of Wisconsin's 2,366 native plant species are considered rare, meaning they are listed as endangered, threatened or of special concern.


Photo credit: Robbin Moran

More than 50 trained volunteers from around the state submitted over 220 reports of rare plants in 2022, including 42 populations in areas of Wisconsin where they have not been documented before.
'These new discoveries are very exciting. They help increase our understanding of the number and locations of rare plant species in Wisconsin so we can better monitor and protect them,' said Kevin Doyle, DNR Natural Heritage Conservation Botanist and Rare Plant Monitoring Program Coordinator. 'Volunteers also revisit known locations, another important part of the conservation process. If we don't check on these populations, we won't know when they are in trouble.'

Since 2013, the DNR's Rare Plant Monitoring Program has trained and sent volunteers to check on the health and size of rare native plant populations. The volunteer program is Wisconsin's largest source of rare plant data and is unique in the Midwest for its breadth of surveys statewide.

KevinF.Doyle, Antigo Times, May 15, 2023.

PS For short video from Nature World News see: https://youtu.be/Jg14zGuZFSs

Striga invasion in plants may be prevented through strigolactones

Researchers are exploring the role of plant hormones known as strigolactones (SLs) in preventing infestations by the parasitic plant *Striga hermonthica*. Plant architecture, plant development and stress response are regulated by SLs in cereal crops. The SLs released by plant roots attract mycorrhizal fungi, which provide plant nutrients. But SLs are also known to induce germination and invasion by the parasitic plant *Striga*, with severe impacts on agricultural production, particularly on cereal yields in Africa. Researchers say they have managed to show that canonical SLs do not affect plant architecture in rice.

The researchers employed CRISPR/Cas9 technology to generate rice lines without canonical SLs and compared them to wild-type plants. The shoot and root phenotypes did not differ significantly between the mutants and the wild type, indicating that canonical SLs are not major regulators of rice architecture. The research showed that canonical SLs do contribute to a symbiosis with mycorrhizal fungi and play a major role in stimulating seed germination in root parasitic weeds. Modulation of SL content by gene editing is a long-term solution, but the application of specific inhibitors of SL biosynthesis may lead much faster to cereal plants lacking the canonical strigolactones.

The team set out to identify chemicals that inhibit canonical SL biosynthesis in rice. They found a chemical enzyme inhibitor TIS108 significantly lowered *Striga* infestation without affecting plant growth or grain yield. They also tested the effect of TIS108 on Indica rice and sorghum, both major crops in *Striga*- infested regions in Africa. Once again, they observed lower *Striga* germination activity from the root exudates isolated from treated plants. Al-Babili says direct application of TIS108, as well as employing gene editing, represents promising strategies for alleviating the threat posed by Striga and other root parasitic plants to global food security.

The group is now investigating the effect of TIS108 on pearl millet, a wider project funded by the Bill & Melinda Gates Foundation, aiming to improve the architecture of this cereal and increasing its resistance towards *Striga*.

T4MAG Technology magazine. 3 November 2022.

Maize varieties resistant to *Striga* weed unveiled - YouTube

In a bid to fight striga weed that has ravaged maize plantations in Busoga region of Uganda, the national Agriculture and research organization[NARO] has unveiled eight new varieties of maize which are resistant to the witchweed. Researchers say that the new maize varieties have been under experiment in demonstrations gardens set up in Iganga district.

Click on YouTube above for short video.

Birdlife Australia working with Aboriginal land council to return mistletoe to burnt woodlands

Mistletoe is often associated with Christmas, yet native mistletoe is something of an unsung hero when it comes to woodland birds. It provides food, shelter, and nest sites, including for the critically endangered regent honeyeater, but repeated bushfires in recent years have wiped it out from a key breeding area in New South Wales' Lower Hunter region. Mistletoe does not regenerate after bushfires and, without intervention, it will take many years to re-establish in the Tomalpin Woodlands — time the regent honeyeater does not have, as there are only about 300 left in the wild.

A male mistletoe bird feeds on box mistletoe (Photo: Allan Richardson)

Hoping to 'fast-track' the restoration of mistletoe and boost the regent honeyeaters' chances of survival, Birdlife Australia (BA) has partnered with the Mindaribba Local Aboriginal Land Council (LALC) in a seed-planting project. 'It's really exciting work. As far as we know this is a world first,' BA NSW Woodland Bird program manager Mick Roderick said. 'Waiting for [the seed-spreading] birds to go off somewhere else, eat mistletoe and bring it back, could take at least 30 years and we don't have that much time.' Mistletoe relies on a host plant to survive and there are 97 different species across Australia.

Planting mistletoe in treetops

NSW Woodland Bird project officer Kristy Peters said the project, which was launched a few years ago, was very hands-on. 'The idea started from a project that Professor David Watson and his team at Charles Sturt University had been working on with the City of Melbourne, where they had been planting mistletoe into trees in Melbourne to boost biodiversity in urban areas,' she said. 'We have a team of arborists who climb into the treetops and pick the mistletoe fruit from the canopy for us. 'Then you need to squeeze the ripe fruit out, and it has this sticky coating over the seed, and you basically wipe it onto the underside of a branch and that's mimicking what a mistletoe bird would do naturally. 'Then you sit and wait patiently and hope you get a new mistletoe plant growing from that.'

Project proving successful

About 2,000 mistletoe seeds had been planted since the summer of 2020-21 and early monitoring was showing signs of success. Mr Roderick said in the wild about 10 per cent of mistletoe seeds deposited by birds and animals grew into a healthy mistletoe clump, and the project was achieving a similar success rate. 'It hasn't been done before, so we have been learning as we are going,' he said. 'We've learnt there's a certain width of branch, which is best to plant the mistletoe on. 'You also need to check the tree to make sure the bark isn't shedding, otherwise the mistletoe can't attach. 'I like to say that mistletoe supercharges a woodland. Wherever you get mistletoe you are going to get way more diversity of birds and other fauna.'

Summer planting to occur

A large number of seeds would again be planted in the Tomalpin Woodlands this summer. 'The mistletoe will be fruiting around Christmas time and into January and that's when we will be getting out with our arborists,' Mr Roderick said. 'We are aiming to have about 2,000 seeds planted up into the canopy this season.' The idea has attracted interest from other areas, including the Manning region where the MidCoast Council has sought information. 'It's been great to see the expanding interest throughout NSW, because there are species of mistletoe that regent

honeyeaters and a lot of other woodland birds rely on all along the coast,' Ms Peters said.

Birds released into area
The restoration work is being undertaken in conjunction with a regent honeyeater captive-breeding program, with 50 regent honeyeaters recently released into the Tomalpin Woodlands.
'Those birds are helping boost the wild population,' Ms Peters said. 'So we are really hopeful, if we continue doing the habitat restoration, in hand with these captive releases, that we can eventually reverse the steep decline in regent honeyeaters we have unfortunately seen over the past 20 year

By Emma Siossian and Cameron Marshall. 23 Dec 2022

Mistletoe decline could threaten nectar-feeding bird populations

The regent honeyeater often relies on mistletoe nectar, fruit and foliage during drought. (Photo: Lachlan Hall)

Ecologists fear the widespread loss of native mistletoe due to drought could leave nectar-feeding birds even more vulnerable.

Key points:

- Researchers have discovered a concerning decline in mistletoe across Australia
- Mistletoe can be the only source of food for nectar feeding birds during droughts
- Ecologists say more needs to be done to protect the shrub

Charles Sturt University ecology professor David Watson said birds relied on mistletoe nectar, fruit and foliage during drought. But researchers recently discovered a concerning decline in the shrub while monitoring nectar-feeding birds at 2,000 sites across south-eastern Australia.
'(We) found that during the height of the drought, when it was not just really dry, but critically also quite warm at night, almost all mistletoes died,' Professor Watson said. 'And we were like, 'Oh gosh, this is the one plant that seems to be really important for holding these guys together'.'

Misconceptions about mistletoe
There are almost 100 species of mistletoe in Australia. Professor Watson said there was a misconception that mistletoe was a pest, due to its parasitic nature. 'But mistletoes are a native plant, they've been in Australia as long as kangaroos and wattle,' he said.
'And when it's very dry and crispy and plants are struggling to get enough water to survive, mistletoes don't care, they just slurp water out of the tree.'

Professor Watson was a co-author of a report on the decline that was led by Australian National University's Difficult Birds Research Group member Ross Crates. Birdlife Australia national public affairs manager Sean Dooley said the study's discoveries didn't come as a surprise.
'This research is confirming our worst fears,' Mr Dooley said. He said the critically-endangered regent honeyeater was among the most vulnerable nectar-feeding birds. 'Saving these birds is important not just because they're wonderful birds, but they're also part of of our woodland ecosystem and are really important pollinators,' he said. 'We need them to keep our forests healthy.'

Threats to survival
Mr Dooley said woodland bird populations were declining across south-east Australia due to historical and ongoing land clear ing. 'We need to preserve what we have left, and often the best areas of woodland are remnants on private land,' he said. He said work needed to be done to protect and enhance woodland on public and private property. 'And it may come down to trying to transplant or grow mistletoe in areas where it has disappeared because of drought,' he said. Mr Watson said something needed to change urgently before it was too late. 'If we keep pushing the lever of climate change just a little further, things are going to start succumbing,' he said.

Charmayne Allison and Sandra Moon, 18 Jul 2022

Cuscuta conundrum: Amarbel poses great risk to greenery in Dwarka (Gujarat).

Cuscuta filiformis, commonly known as 'Amarbel' is now posing a great risk to the greenery of the sub city these days. Be it road side plants or trees or the horticulture of a park or green areas - all are getting affected with the parasite leading to a slow death. The devastating effect of Amarbel can be seen easily on trees and plants in many areas of the city. Morning walkers and the nature lovers have been witnessing its growth all across the city. An environment activist from Dwarka, Diwan Singh says, 'I have noticed the parasites on the vegetation in various sectors this time. The attack is damaging the greenery of the area.'

Credit:CitySpidey

The plants with new leaves and shrubs besides the roads have been attacked by such parasites. 'I have witnessed that in Sector 12. The effect is worst on the greenery. In my every day notice during morning walk for five years, I must say that this time the *Cuscuta* affect is much greater than previous years. DDA must look into the matter seriously,' said T Sampat Kumar, a resident of Vikram Nagar. In various sectors, the parasites can be seen in parks, along the major roads of the city, service lanes, etc. Trees and particularly ornamental plants are getting infected with Amarbel.

Vijay Dhasmana, naturalist and ecological conservator says, '*Cuscuta* is a dangerous parasite plant, marring the beauty of the areas killing the plants. These are parasitic plants which suck their food from the host plants and finally cause the death of host plants. These need to be trimmed and removed at an early stage to save or ensure good health and growth of plants. These should be manually removed by the horticulture department as soon as possible.' He further added, 'Such parasites spread from one tree to another by 'carriers'. These parasites are carried by the birds in their excreta. Though such parasites are sticky in nature, the excreta of the birds stick on the branches of the trees and thus *Cuscuta* reproduces itself. These plants are like green thread and mainly affect the arid area's plants.'

January 06, 2023

How rare island bunnies do a parasitic plant's bidding.

The world's only wild black-furred rabbit has a very important job — distributing seeds for a parasitic plant.

Photo: Kyodo News Stills, via Getty Images

The five-pound, black-furred Amami rabbits of Oshima Island and Tokunoshima Island in Japan are sometimes called 'living fossils' because their ancestors have died out on mainland.

In February 2020, an amateur naturalist named Yohei Tashiro was walking through the evergreen forests of the islands, situated about halfway between mainland Japan and Taiwan. On the ground, nestled against the roots of a tree, he noticed a cluster of strange, red globes — like strawberries crossed with red cap mushrooms. Even more interesting: Something clearly had been going to town on the ruby-red growths, the fruits of a weird little plant called *Balanophora yuwanensis*. A plant oddity, *B. yuwanensis* does not perform photosynthesis, but rather leaches its energy from the roots of other plants. Technically, it's a parasite.

While scientists had long figured that *B. yuwanensis* relied on the wind to spread its seeds, dense plants growing beneath the tree canopy cut down on how much air can blow through the forest. In addition, the plant's seeds are tightly packed, dry and rather unappealing aside from their vibrant color. 'Yes, I tried it,' said Kenji

Suetsugu, an ecologist at Kobe University in Japan, 'but it was not sweet and not tasty.' Birds have been known to eat the fruits, but only sparingly, leaving the scientists to wonder: Could the parasitic plant get around by advertising its seeds to an ancient, endangered and equally weird mammal instead?

The *B. yuwanensis* fruit does not perform photosynthesis, but leaches its energy from the roots of other plants. Technically, it's a parasite.Credit...Kenji Suetsugu and Hiromu Hashiwaki

Enter the nocturnal *Pentalagus furnessi*, or Amami rabbit, the world's only dark-furred wild bunny. In a study published this week in the journal Ecology, Dr. Suetsugu and Hiromu Hashiwaki, a co-author also of Kobe University, posit an evolutionary bargain between Amami rabbits and *B. yuwanensis*. The root-sucking plants give food in exchange for seed dispersal services — something that has never been documented between a mammal and a parasitic plant. The five-pound Amami rabbits have died out on mainland China. But on two small, volcanic islands known as Oshima Island and Tokunoshima Island, about 5,000 of the short-eared bunnies soldier on. The International Union for Conservation of Nature considers the species endangered, a result of a combined habitat about 130 square miles, and the ever-present threat of annihilation by nonnative predators on the islands, including mongooses, cats and dogs as well as logging operations by humans. Amami rabbits hold cultural significance to the people who live on these islands and they are a flagship species for conservation and tourism. But not a lot is known about them, Dr. Suetsugu said.

Acting on a hunch that it was the rabbits gnawing the fruits to their nubs, the scientists trained three infrared camera traps on *B. yuwanensis* fruit bundles in January 2021. By March, they had an answer. During the day, pale thrushes and Ryukyu robins visited the bright red fruits, but the birds tended to consume only a little bit of fruit at a time. Invasive rats also infrequently dined on the fruits. But when night fell, the Amami rabbits feasted, sometimes gobbling up a whole, golf-ball-sized globe in a single sitting. Combining the frequency of visits and the amount of fruit consumed, the scientists concluded that the rabbits were the main creatures feeding on the parasitic plants.
On a hunch, the scientists trained three infrared camera traps on *B. yuwanensis* fruit bundles and captured the Amami bunnies feasting.

Photo: Kenji Suetsugu and Hiromu Hashiwaki

To further investigate their hypothesis, the scientists then set out to find Amami rabbit feces in the wild. Examining five pellets - the small sample size a result of the rarity of the species - they confirmed that each one contained at least one viable *B. yuwanensis* seed. Using a combination of the wild rabbit droppings and Amami rabbits housed at the Kagoshima Hirakawa Zoo, the scientists found that nearly 55 percent of the *B. yuwanensis* seeds to pass through the animals' digestive tracts were still viable. Compared with similar studies of the European rabbit, which show an average of just 5 percent viability with 19 other plant species, it would seem the Amami rabbits have greater success planting new seeds. Most importantly, it's possible that these bunnies are much more effective parasitic-plant seed dispersers than birds, because of their natural behavior of digging burrows at the base of large trees, where *B. yuwanensis* requires a host plant's roots to survive. In other words, the rabbits' dropping

patterns are less random, in the evolutionary eyes of the parasites.

While Amami rabbits and Balanophora plants may not be household names, the study reveals yet another complex relationship that has evolved through the ages, said Dr. Suetsugu. It also hints at the greater toll incurred when we drive species to extinction.
He added: 'The loss of the Amami rabbit could also have a ripple effect on the entire ecosystem.' All the more reason to study the Amamis before they're gone.

Ref. Suetsugu, K. and Hashiwaki, H. 2023.

Jason Bittel, New York Times, January 26, 2023

Mistletoe glue could one day be used to seal wounds

The adhesive was made from a substance surrounding the seeds in mistletoe berries, known as viscin. (Photo: Depositphotos)

In order to spread to other host trees, the parasitic mistletoe plant has very sticky seeds that cling to bird feathers, bark, and other materials. According to a recent study, the 'glue' on those seeds could inspire new biomedical adhesives.

Contained within the plant's berries, mistletoe seeds are surrounded by a mucus-like substance known as viscin. It is in turn made up of cellulose nanofibers suspended within a gelatinous matrix. The basic idea is that when birds are eating the berries, the seeds will stick to their beak or feathers, then get transferred onto the bark of other trees. There, they'll grow into other mistletoe plants.

Assoc. Prof. Matthew Harrington, from Canada's McGill University, became curious about the potential human applications of viscin after seeing his daughter playing with a sticky mistletoe berry. Working with colleagues from Germany's Max Planck Institute of Colloids and Interfaces, he proceeded to devise a technique in which wetted viscin fibers could be formed into thin films or three-dimensional structures. The resulting adhesive was applied to a number of different materials, then allowed to dry. As it did so, the cellulose fibers aligned with one another and bonded together. As a result, the adhesive was found to stick well to synthetic materials like metal, plastic and glass, along with biological tissues such as skin and cartilage.

That said, raising the relative humidity of the adhesive (by exposing it to water vapor) caused the fibers to swell and release their hold on one another – thus making the adhesive easy to remove from the various materials. And as an added bonus, it's both biocompatible and biodegradable. In one experiment, a film of the viscin-based adhesive was successfully used to seal wounds cut into non-living pig skin. While that film was flexible enough to move with the skin without breaking, it could still be taken off as needed. Plans now call for more research to be conducted, to better understand what chemistry is at work within the adhesive.

By Ben Coxworth
June 16, 2022

Kiss of life for rare dwarf mistletoe species

A naturally uncommon mistletoe species that only grows in a handful of spots across the Kāpiti Coast has been given a kiss of life thanks to a decade of work by a local biodiversity champion.

Rhys Mills, Reserve Supervisor at Ngā Manu Nature Reserve has spent the last 10 summers painstakingly harvesting locally endangered *Korthalsella salicornioides* seeds, one of eight species of mistletoe found in Aotearoa New Zealand.

'We're seeing incredibly heightened groundwater levels across the district which are effectively drowning two of the three main mānuka habitats where you could find mistletoe growing naturally. 'It's an all-out effort to get as much seed out as possible now.' Unfortunately, Mills'

ability to collect seeds this year was hampered by a hand injury, so he called on Kāpiti Coast District Council for some help. ‘Rhys has really been an unsung hero in the conservation of this threatened species,’ says Andy McKay Team Leader Environment and Ecological for Council. ‘We’ve been more than happy to help out with harvesting this year at ecological sites in Waikanae Park, which has dying mānuka currently sitting in a metre of water,’ says Mr McKay.

Dwarf Misletoe growing in Kapiti

Collecting seeds isn’t as simple or easy as it sounds, however. This mistletoe sheds its seeds explosively, similar to a mushroom shedding spores. The seeds travel between 60 to 100cm from the plant into the surrounding canopy. ‘We’re not sure what the release trigger is but we know that it generally happens in February for about four weeks. That means we need our sites prepped, ladders in place and manpower on standby by the end of January,’ says Mills. ‘The seeds are tiny so we set traps of fine mesh curtain secured by cable ties over each plant that catch expulsions. We need to check the cloth every 24 hours and when we find seeds, we use a slushy straw to gently scrape them off into an old pill canister. ‘To help the seeds stick to a new host, they are ejected with a gelatinous substance that dries on the cloth, so we dampen it to help remove them, then sow onto new hosts in a safer ecosystem. We spray them with a 10 percent solution of PVA glue and water to reduce transpiration.’

Mills says that over the years he has experimented with locations, including a successful planting programme at Ngā Manu Nature Reserve. ‘Dwarf mistletoe needs a dense canopy habitat of either kānuka or mānuka so that the seeds can spread but we don’t have that at the remaining sites in Kāpiti anymore. Our species prefers mānuka which only has a 20-year lifespan so I’m now trialing seeds on kānuka as it has a lifespan of up to 120 years,’ says Mills. ‘Humidity is important for success, too. Seeds take better by open water so I think if we can do some planting on the edge of the wetlands in Waikanae Park, we’ll have a good shot at reintroducing dwarf mistletoe back to the area in the future – but it will be years away.’

So, after countless hours, year upon year, dedicated to saving a tiny exploding native parasite, has it all been worth it? Mills thinks so. ‘Native mistletoe is extremely overlooked and gets a bad rep as a parasite but we have to remember that not all parasites are bad,’ says Mills. ‘So many of the modern and traditional medicines we rely on originate from compounds found in plants. What if there is something that could be important in mistletoe? I think it’s worth saving. If we lose it, it’s gone forever.’
Mills celebrated 30 years of tenure at Ngā Manu in February, a huge achievement and testimony of his dedication to conservation work in Kāpiti.

Kapiti Coast District Council 4 April 2023

How mistletoes are expected to fare on a warming planet.

As ecosystems degrade in our warming world, many animals and birds are coming to rely more heavily on common, berry-bearing parasitic plants like mistletoes. Mistletoes also provide cool havens for nesting birds and welcome shade for animals resting below. They may even help to cool cities. But mistletoes also are exceptionally vulnerable to bouts of extreme weather like droughts. Climate change is taking a heavy toll on them, just as animals come to rely on them more.

David Watson knows these things well. In both academia and the media, he has come to be referred to as ‘the mistletoe guy’ — ever since his student research project stumbled on the fact that certain desert birds were found only in places with mistletoes in the trees. He has since tracked mistletoes across the globe, and coauthored a paper in the 2022 issue of Annual Review of Ecology, Evolution, and Systematics about the role of parasitic plants in a warming world. (see Watson *et al.* 2022 below.

Why are mistletoes particularly sensitive to environmental stress, like drought or frost?
The fundamental reason is just basic physiology. They've got no storage organs, no way to store carbohydrates. They've got no root system, no bulbs, no rhizomes. So when they lose their leaves, that's it, they're screwed. That could happen through herbivory, like if a whole lot of caterpillars come along, or a low-level fire that comes through and crisps up the canopy. If the host plant is drought-stressed and starts to wilt, mistletoes will just curl up and die. They're weirdly sensitive to a lot of these disturbances. That's why the world isn't full of them, because they're actually quite picky. They're hard to grow.

How are these plants faring in the face of climate change?
We see again and again that when climates shift, foods and things that depend on those foods can often be out of sync — a shift to earlier springs, for example, might mean most berries are produced too early for animals that need them later in the season. We're seeing that mistletoe becomes disproportionately important in many systems because other stuff is out of whack, but mistletoe is still there — it's reliable. Any month of any year, you can find a mistletoe in most parts of the world that's either fruiting or flowering. They're just good at what they do. So there's increased reliance on mistletoe as a resource.

But then, we're also seeing mistletoe die-offs. We're seeing increased sensitivity to disturbances, whether it's heat waves or drought or fire. So, on the same page, you've got animal communities leaning more and more heavily towards this group of plants, but those plants struggling to persist.

My colleague, Francisco Fontúrbel, works in southern Chile. Where mistletoe is around, because it's a reliable nectar source, the southernmost hummingbird (*Sephanoides sephaniodes*) becomes resident. They pollinate the mistletoes, but they also pollinate all sorts of other plants. After drought, mistletoes die, and those hummingbirds become migrants: They pack up, they follow the nectar further and further north. One study showed mistletoe deaths doubling in the dry year of 2015, and visits from hummingbirds dropped. When the hummingbirds leave, the local plants don't have pollinators anymore. This is predicted to trigger a community-wide cascade of extinctions, although that hasn't been documented yet.

In Australia, large-scale research shows that mistletoe is super-important during drought as a sort of last-ditch nectar resource. But then, that same work shows that drought kills many mistletoes: In the summer of 2009, for example, there was a prolonged heat wave in Melbourne, including the hottest day ever recorded — and nearly 90 percent of a monitored set of mistletoes died. That caused a crash in bird numbers and insect-eating animals.

It's not across the board. Some tropical systems, some temperate forest systems, are not showing those early warnings of system failure, these mistletoe deaths. But in many arid zones, and in some southern forests at higher latitudes, we're already seeing food webs breaking down. We don't want to ring the alarm bells and say the sky is falling, but it's not looking good.

Albury-Wodonga, December 17, 2022, speaking with Knowable Magazine about the latest results. The interview has been edited for length and clarity.

PARASITIC PLANTS IN MEDICINE

We decided some years ago to cease covering the literature on the use of parasitic plants in medicine. There seemed to be no great interest among our readership, and there are often serious doubts about the identification of the species involved as was noted in Haustorium 66, p.7 'Mistletoes and medicine: a plea for better taxonomy' by Dan Nickrent, commenting on the widespread assumption that the species involved in many studies in Nigeria and elsewhere in West Africa, was *Viscum album*, which does not occur in that region.

It is very striking, however, how the literature on therapeutic uses dominates the literature, being well over 50% of the abstracts on parasitic plants in e.g. CABIDirect. Perhaps parasitic plants are not over-represented, considering the great interest in plants as sources of medicine? Perhaps it is a bias in the assembly of the CABI database? Are they over-represented simply because their lifestyle suggests special properties? Or are they really special? **If anyone has a theory we would love to hear about it.**

Meanwhile the one quite well-established example is the use of extracts of *Viscum album* in at least moderating the effects of certain cancers.

The following provides a useful updated survey of the recent studies on the evidence:

U.S. study of intravenous mistletoe extract to treat advanced cancer

The findings are from a small study at John Hopkins Kimmel Cancer Center reported online Feb. 9 in Cancer Research Communications. *(*Paller *et al.*, 2023)

Mistletoe extract (ME), known as Helixor M, was studied in 21 patients with advanced and treatment-resistant cancers of various types. The phase I trial used dose escalation to determine the maximum dose that could be safely tolerated by patients. ME was delivered intravenously three times per week until disease progression or until toxicity. The study concluded that dose to be 600 milligrams of ME.

The median follow-up duration on mistletoe was 15.3 weeks. Stable disease was observed in five patients and lasted, on average, for 15 weeks. Tumors in three participants decreased in size, and remained stable for two to five months, however, this did not meet official criteria for partial response. Patients also reported overall improved quality of life via a questionnaire. The most common side effects reported were fatigue, nausea, and chills and they were noted as manageable. 'Intravenous mistletoe demonstrated manageable toxicities with disease control and improved quality of life in this group of patients, who had already received multiple cancer therapies,' says Paller, adding that additional phase II studies in combination with chemotherapy are the next step, pending additional funding.

In addition, Paller says, laboratory research to better decipher ME's mechanisms are needed, as the cytokines (cell-signaling proteins) measured in this study are preliminary and hypothesis generating.

Mistletoe extract is from *Viscum album* with several active ingredients that, in preclinical studies, appear to directly cause the death of tumor cells and stimulate an immune response. It has been used in Europe for several decades as a complementary medicine approach to cancer treatment alone or in combination with chemotherapy and radiation therapy, but it has not been evaluated in clinical trials. ME is not currently FDA approved for cancer treatment in the U.S. but is listed in the Homeopathic Pharmacopoeia and is offered in integrative care clinics.

Johns Hopkins Medicine, February 22, 2023

Mistletoe Extract for Cancer Treatment: Composition and Usage

Photo: Natalia Golubnycha via Shutterstock

Cancer is a major cause of death globally, leading to nearly one in six deaths each year. Several traditional treatments are available for cancer. However, they can cause adverse side effects which deteriorate people's quality of life. In such scenarios, the effectiveness of complementary treatments like mistletoe can be of interest.

Key takeaways:

Mistletoe (*Viscum album*) is a semiparasitic plant that has been used as a traditional medicine in Europe for centuries.

The first use of mistletoe as a cancer treatment was proposed by Rudolf Steiner in 1920.

Mistletoe helps in cancer treatment by showing anti-tumor activity as well as improving the patient's quality of life.

Further research is required to understand how mistletoe impacts people with cancer.

Mistletoe extracts have been used for centuries to treat several human diseases along with cancer. It has been used in different forms for the treatment of various diseases such as hypertension, headache, epilepsy, asthma, infertility, menopausal symptoms, and dermatitis. It is capable of growing on several types of trees. The chemical composition of the extracts depends on:

- Species of the host tree
- Time of the year when the tree was harvested
- Preparation of the extracts
- The commercial producer

Mistletoe extracts are made either in water-based solutions or solutions of water and alcohol. Some extracts are made as per homeopathic preparations, while others are not.
The main active compounds found in mistletoe are:

- Lectins
- Flavonoids
- Viscotoxins
- Phenolic acids
- Fatty acids
- Alkaloids
- Phenylpropanoids
- Terpenoids
- Lignans
- Sterols

These active compounds help to mediate the pharmacological activities of mistletoe extracts. Administration of mistletoe extracts mostly takes place by subcutaneous injections, which are given 2–3 times a week. However, the duration of treatment is variable.

The side effects of mistletoe extracts are limited and not life-threatening. A few of the side effects include:

- Headache
- Fever
- Soreness at the injection site
- Chills
- Swelling of lymph nodes

However, a few cases of severe side effects such as anaphylactic shocks have been reported. Mistletoe plants and berries can also be poisonous to humans. Moreover, high doses of recombinantly-produced mistletoe lectins were reported to cause reversible hepatotoxicity in a few cases.

Research suggests that mistletoe extract can help to treat cancer in various ways. It was demonstrated that the extract can kill cancer cells through the down regulation of genes involved in malignancy, progression of cancerous tumors, as well as cell invasion and migration. Moreover, mistletoe extract can fight cancer through modulation of the immune system activation of dendritic cells, activation of natural killer cells, increase in cytokine secretion, as well as enhancement of humoral and cellular responses. The mistletoe extract can also inhibit angiogenesis. This helps to prevent the formation of new blood vessels, which in turn can inhibit the growth of tumors.

Above mentioned anticancer properties of mistletoe are mostly mediated by two active compounds, lectins and viscotoxins:

Lectins are proteins that easily bind to carbohydrates, in this way they are able to attach to the cell's surface and cause biological changes in them.
Viscotoxins are proteins that have both immune system-stimulating and cell-killing properties.

Extensive research has been carried out regarding the impact of mistletoe extract on cancer. Findings from more than 50 clinical trials have been published concerning the use of mistletoe extract in cancer patients. Most of these studies indicated an improvement in the quality of life of the patients. A systematic review of 26 studies reported an improvement in fatigue, emotional well-being, depression, vomiting, concentration, and nausea. Another systematic review also reported improvement in chemotherapy-associated fatigue along with other quality-of-life measures. A 2020 study also indicated mistletoe extract to improve physical functioning, insomnia, and cancer-related fatigue in 319 non-metastasized breast cancer patients.

However, most of these studies suffered from one or more limitations. A two-part review indicated that mistletoe extract did not show any improvement in the quality of life and survival of patients with various types of cancer.
Therefore, the use of mistletoe extract for the treatment of cancer patients is controversial. Some studies have shown it to have beneficial effects, while others have shown it to have little or no beneficial effects.
More studies aimed at improving the current limitations are needed to understand whether mistletoe extract should be considered as a treatment option for cancer patients.
Legal aspects of mistletoe extract cancer therapy.
Mistletoe extract is an extensively studied alternative cancer therapy that is commonly used for the treatment of cancer patients in Europe. However, it is not approved for treatment in the United States.

Many studies have reported that mistletoe extract can be useful to improve quality of life, survival rates, and cancer-related fatigue in cancer patients. However, a few studies have also reported no positive or beneficial effects of mistletoe extract. Therefore, is it important to

consult an oncologist before taking mistletoe extract for the treatment of cancer.

Mistletoe extracts are mostly used to treat cancer in German-speaking countries. A few of the commercially available formulations of European mistletoe include Iscador, Plenosol, Helixor, Eurixor, abnobaVISCUM, Iscucin, and Isorel.

It is worth mentioning that, mistletoe extracts are not sold in the United States since they have not been approved by the Food and Drug Administration (FDA).

Resources:

National Cancer Institute. Mistletoe Extracts (PDQ®)–Health Professional Version.
Archives of Pharmacal Research. Biological activity of mistletoe: in vitro and in vivo studies and mechanisms of action.
Integrative Cancer Therapies. Impact of Oncological Therapy and Viscum album L Treatment on Cancer-Related Fatigue and Internal Coherence in Nonmetastasized Breast Cancer Patients.
Journal of Cancer Research and Clinical Oncology. Mistletoe in oncological treatment: a systematic review : Part 1: survival and safety.
Journal of Cancer Research and Clinical Oncology. Mistletoe in oncological treatment: a systematic review : Part 2: quality of life and toxicity of cancer treatment.
World Health Organization. Cancer.

Milda Alksnė, PhD medically reviewed this article
Suchandrima Bhowmik, MSc, Healthnews, March 15, 2023

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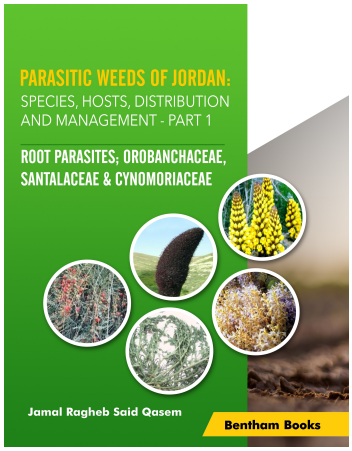
Johns Hopkins Medicine, February 22, 2023

BOOK REVIEWS

Parasitic Plants Eds: Gonzalez, A.M. and Sato, H. 2021. Bentham Books.

Over six chapters, this book deals with different aspects of parasitic plants, from generalities to specific case studies.
https://www.intechopen.com/books/10772



1. Parasitic Plants in Agriculture and Management. Pervin Erdogan
A well-illustrated general review of the major groups of parasitic weeds, and available management options.

2. Parasitic Plants as Vectors for Pathogens. Anupam Gogoi and others.
A valuable review of the importance of parasitic plants, mainly *Cuscuta* spp. in the transmission of virus, phytoplasma and proteobacteria pathogens, listing the many instances of resulting damage to commercial crops. Also discussing the endophytic bacterial and fungal communities of parasitic plants and the exchanges that can occur between parasite and host, quoting interesting examples.

3. Aspects of the Biology and Ethnobotany of Parasitic Angiosperm Species in Nigeria. Odoligie Imarhiagbe.
A comprehensive, nicely illustrated, listing of the genera of parasitic species in Nigeria, and the traditional uses of many of them, refreshingly free of the errors in identification which have occurred in many papers from that region.

4. Anatomy, Embryology and Life Cycle of *Lophophytum*, a Root-Holoparasitic Plant. Hector Arnaldo Sato and Ana Maria Gonzalez (see Haustorium 81)

5. Parasitic Plants in Forage Legumes – *Medicago sativa* L. Rozafa Fetahaj and others.
Reviewing the importance of *Cuscuta* spp. on lucerne/alfalfa, but lacking detail.

6. A Review on the Botanical, Phytochemical and Pharmacological Characteristics of *Cuscuta* spp. Khahdijeh Ahmadi and others.
Listing 16 species of *Cuscuta* used medicinally and reviewing their phytochemistry (flavonoids, alkaloids, lignans, saponins, phenolics, tannins and fatty acids). and their traditional uses as anti-bacterial, anti-oxidant, anti-osteoporotic, hepatoprotective, anti-inflammatory, anti-tumor, antipyretic, antihypertensive, analgesic, anti-hair fall and anti-stereogenic agents.

Parasitic Weeds of Jordan: Species, Hosts, Distribution and Management. Part I. Root Parasites: Orobanchaceae, Santalaceae & Cynomoriaceae. by Jamal Ragheb Qasem. 2022. Bentham Science Publishers, Sharjah, United Arab Emirates. 365+xxiii pages. ISBN 978-1-68108-4. Price not given.
and:
Parasitic Weeds of Jordan: Species, Hosts, Distribution and Management. Part II. Stem Parasites: Cuscutaceae, Loranthaceae & Viscaceae. by Jamal Ragheb Qasem. 2022. Bentham Science Publishers, Sharjah, United Arab Emirates. 301+xxiii pages. ISBN 978-1-68108-5. Price not given.

For its size, Jordan has a remarkable diversity of parasitic angiosperms not all of which are 'weeds' but rather benign components of the local flora. No one knows these plants better than Jamal Qasem who provides an exhaustive overview of most Jordanian parasitic plants. In person, he is enthusiastic about these parasites; this enthusiasm and depth of knowledge comes to print in this book and provides the most comprehensive national treatment of such plants.

The volumes (I am treating them together) are clearly laid out. After a thorough introduction to these unusual organisms, enough to introduce someone who knew little about parasitic angiosperms. This is followed by treatments of each family and genus including the following: germination and development (particularly germane when discussing parasites), contact and attachment; biology, ecology and physiology; distribution and host range, economic importance (including ethnobotany), and control. The section is concluded with many images, and an extensive reference. Based on the author's intimate knowledge of the weedscape, it is surprising there are no distribution maps for the species.

One could argue over some relatively less important things like an updated taxonomy. For example, *Cuscuta* has been shown to clearly belong in the Convolvulaceae. The genus *Orobanche* taxonomy is in state of flux and the author can be excused for using some names not currently recognized. More serious is the exclusion *Parentucellia viscosa* (Orobanchaceae), which is not mentioned even though it has been a weed problem in other parts of the world. Same for the genus *Bellardia*, also Orobanchaceae, but a less weedy group. Both genera are reported for Jordan. A truly authoritative work would try to determine the species in the group. For example rather than *Cuscuta* sp., give the species name, e.g.,*Cuscuta speciesname.*

The volumes are well edited, the images are not. This would be a magisterial work if there were proper images. They are of poor quality, often out of focus, and frequently do not clearly display the features mentioned in the legends. And there are too many of them. How many images of branched broomrape on tomato do I need to see to learn that branched broomrape attacks tomato?

A few images are even misidentified, especially in the *Cuscuta* chapter. On page 129 showing *Cuscuta monogyna* on an orange tree, the flowers having two stigmas places this plant in the subgenus Grammica, not the subgenus Monogyna where it belongs, making it most likely to be *C. campestris.* I am leery of claiming that *Cuscuta* and *Orobanche* species can parasitize grasses but the images purport that are too poor a quality to verify the connection.

A major thrust of the author's work is the documentation of host range. Like other workers, he does not clearly distinguish between host preference and host range. However, unlike some parasitic plant workers, Qasem attempts to show the host-parasite connection, the only way to document authentic parasitism, but again the problem is the blurred picture. Inclusion of pictures showing parasites 'under' or 'near' a possible host are not helpful. His compilation of hosts the most complete I know of and is based on his extensive review of the literature as well his many years studying plants firsthand.

Despite the failure to provide clear images for many if not most of the parasites, this is a contribution of value to agriculturalists, botanists, ethnobotanists, and extension workers in Jordan as well as those beyond the borders of the Hashemite Kingdom. It is a major contribution to the literature of parasitic angiosperms,

Lytton John Musselman

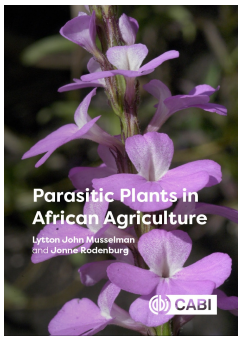
Strigolactones, Alkamides and Karrikins in Plants Recent Updates and Future Prospects. Eds: Soumya Mukherjee, Tariq Aftab. Routledge, 2023.

Chapterrs cover:

• Regulation of strigolactone biosynthesis.
• Strigolactones and plant stress tolerance.
• Strigolactones and parasitic plants (see: Ennahali *et al.* below).
• Alkamides and plant-microbe interaction in rhizosphere.
• Pharmacological potential of alkamides.
• Molecular associations of strigolactones and karrikins.
• Karrikins in plant biotechnology.
• Commercial realities of karrikins in biodiversity restoration.

FORTHCOMING BOOK

Parasitic Plants in African Agriculture, Lytton John Musselman and Jonne Rodenburg. **https://www.cabidigitallibrary.org/doi/book/10.1079/9781789247657.0000**



THESES

Williams Oyifioda Antey. 2022. Molecular perspectives on the ecologically inconsistent effectiveness of the mycoherbicide *Fusarium oxysporum* f. sp. *strigae* against *Striga hermonthica*. DSc University of Hohenheim. Advisor Dr Franke Rasche.

Conclusion:
Among the tested *Fusarium* exometabolites, diacetoxyscirpenol (DAS) was unequalled for completely inhibiting *S. hermonthica* seed germination *in vitro*, and preventing *S. hermonthica* incidence *in planta*. Notwithstanding the promising attributes of DAS in this study, there is need to further investigate its specific mode of action against the germination of *S. hermonthica* seeds. This investigation would be a critical step, before performing in situ verification (field trials) of the *S. hermonthica*-biopesticidal efficacy of DAS. Through this, DAS specificity of action against the target weed (*S. hermonthica*) at very low concentrations (≤ 20 µM), as opposed to non-target soil organisms, will be clearly understood.

Also, our study revealed that contrary to *F. venenatum, F.oxysporum* f. sp. *strigae* (*Fos*) is a non-producer of DAS. It therefore raises the question if *F. venenatum* could be a complementary bioherbicide for controlling *S. hermonthica*. In this regard, an additional positive feature of this ubiquitous soil-borne saprophytic fungus is its inability to produce some mycotoxins, including T-2, deoxynivalenol, nivalenol, zearalenone and sambucoin.

Furthermore, *F. venenatum* is phylogenetically closely related to the phytopathogenic fungi *F. graminearum*, which is globally notorious for causing *Fusarium* head blight in cereals and vascular wilt to non-cereal plants, however, the non-phytopathogenic status of *F. venenatum* was confirmed. Thus, as part of future research directions, *F. venenatum* could be tested for its *S. hermonthica* incidence prevention *in planta*. This will reveal whether the quantity of DAS produced by *F. venenatum* in the soil will sufficiently prevent *S. hermonthica* germination, whilst unaffecting non-target organisms. Therefore, *F. venenatum* could serve as a sustainable, cheaper (compared to isolated/purified DAS), and proactive biocontrol agent for *S. hermonthica* eradication. Another option would be to test if the co-inoculation of *F. venenatum* and *Fos* isolate (with known pathogenicity towards the given *S. hermonthica* population) will better increase the overall *S. hermonthica* biocontrol efficiency through synergism. This is based on the assumption that DAS from *F. venenatum* will primarily attack *S. hermonthica* germination, while *Fos* will attack the incidence of germinated or attached *S. hermonthica* seedlings that escaped the reach of DAS in the soil.

Li Changsheng, 2022. Elucidation of the biosynthetic pathway and biological roles of strigolactones in maize and rice. PhD thesis University of Amsterdam, Promoter: Prof. H.J. Bouwmeester

Summary:
Strigolactones (SLs) are a class of plant signaling molecules of great importance, with diversified structures and diverse biological roles in and outside the plant, in the rhizosphere.

In **Chapter 1**, I introduce the SLs, and review their discovery and biological functions, the regulation of their production by nutrient availability, and their perception and downstream signaling. I particularly emphasize the biosynthesis of SLs, including carlactone biosynthesis and the structural diversification of the SLs generated in the biosynthetic pathways downstream of carlactone. In this process of SL structural diversification, a range of enzymes such as cytochrome P450s are involved of which many are still unknown. I pay attention to possible approaches of SL biosynthetic gene discovery and characterization of their function. (Parasitic plants employ a haustorium to connect to the vasculature of their host plants, through which they then absorb water, assimilates, and nutrients. As root parasitic plants are obligate parasites, depending completely on a host for their survival, they need to closely coordinate their lifecycle with that of their host. Hereto, parasitic plants have evolved a number of host detection/host response mechanisms.)

In **Chapter 2** the germination stimulants, triggering germination of the Orobanchaceae, one major parasitic plant family, are reviewed, in which SLs are the major class. We review how these compounds are produced and in which host plants. And we discuss why they are reliable signals, how parasitic plants have evolved mechanisms that detect and respond to them, and whether they play a role in host specificity. The knowledge underlying this signaling relationship between host and parasitic plant will improve our understanding of the evolution of plant parasitism and will facilitate the development of more effective control measures in cases where these parasitic plants have developed into weeds.

In **Chapter 3 and 4**, I elucidated the biosynthetic pathway and biological functions of maize and rice SLs. Maize (*Zea mays*) is one of the most

important staple crops in the world. However, in Africa, its yield is severely compromised by the parasitic witchweeds, *Striga hermonthica* and *Striga asiatica*. Maize roots exude at least six SLs but only two of them were structurally identified when I started my PhD project. The identity of the other maize SLs, as well as their role in *Striga* germination and their biosynthetic origin, all remained elusive. In **Chapter 3**, by using a combination of approaches, including co-expression analysis and (transient) gene expression in *Nicotiana benthamiana* and yeast, I revealed natural variation in the maize SL production, identified three new maize SLs, and elucidated the biosynthetic pathway of the maize SLs. We discovered a biosynthetic gene cluster for zealactone biosynthesis and a novel cytochrome P450, ZmCYP706C37, catalyzing several steps in the biosynthesis of maize SLs. Among these SLs, zealactol and zealactonoic acid showed much lower activity than zealactone, in inducing *Striga* germination. I also showed that changes in the composition of the SL blend in some mutant lines correspond to differences in *Striga* germination, and, as a consequence, *Striga* infection.

In **Chapter 4**, similar strategies were used to screen and characterize candidate genes involved in rice SL biosynthesis. Intriguingly, *OsCYP706C2*, a homolog of *ZmCYP706C37*, attracted our attention. Its expression is induced by phosphate starvation and it closely co-expresses with known rice SL biosynthetic genes. Mutant analysis and chemical synthesis allowed us to identify a new rice SL, 4-oxo-MeCLA and show that *OsCYP706C2* is required for its biosynthesis. Using heterologous expression in *Nicotiana benthamiana* and yeast, I further elucidate the biosynthetic pathway of 4-oxo-MeCLA, in which 4-oxo-19-hydroxy-carlactone is an intermediate. Moreover, bioassays using *Striga* and AM fungi indicate that *oscyp706c2* mutants were not affected in *Striga* germination inducing activity but did have decreased AM fungi colonization. Taken together, in **Chapter 3 and 4**, I show how intricate SL biosynthesis (in maize and rice) is, and shed further light on their biological significance.

In the past decades, an increasing number of natural SLs have been identified in a range of plant species. However, the low production of natural SLs hampers their identification, discovery of new biosynthetic genes and our further understanding of their biological roles and agricultural applications. Thus, exploring suitable heterologous expression systems may contribute to addressing those issues and provide opportunities for better utilization of SLs. *Nicotiana benthamiana* has been widely and increasingly used for transient expression of plant natural product biosynthetic pathways.

In **Chapter 5**, I established methods to increase the SL production, through transient expression, in *Nicotiana benthamiana.* Several β-carotene pathway genes/gene combinations were co-expressed with the carlactone pathway genes (*OsD27*, *OsCCD7* and *OsCCD8*) to investigate their boosting activity in carlactone production. Among the tested constructs, an *Arabidopsis PSY-GGPS11* fusion and *Zea mays ZmPSY1* showed capability in boosting the metabolic flux towards β-carotene and increased carlactone production. The possibility to further improve the flux by RNAi silencing of endogenous competing pathways of carlactone was also investigated (*NbLCYE*, *NbCHYB*), although it did not further increase carlactone level. To take this to the next level, I showed that coexpression of *Arabidopsis PSY-GGPS11* and *ZmPSY1* can also increase the heterologous production of two natural SLs, orobanchol and zealactone, up to 2-3 fold. This provides us with a new tool for the characterization of unknown strigolactone biosynthetic genes and possibly the production of reference standards.

Finally, in **Chapter 6** I summarize the main findings of my thesis and discuss several aspects of SL biosynthesis, including the importance of SL structural diversification under selection pressure and how to control parasitic plants through modification of SL biosynthesis. Finally, I present an outlook on future research and remaining scientific challenges.

FUTURE MEETINGS

5th International Symposium on Broomrape in Sunflower, 1-3 November 2023, Megasaray Westbeach Hotel, Antalya, Turkey
www.orobans.com

8th International and Interdisciplinary Mistletoe Symposium, Nonnweiler, Germany, 9-11 November, 2023, See:
https://www.mistelsymposium.de

28th Asian-Pacific Weed Science Society Conference 2023. during 26-29 November 2023

in Phuket, Thailand. Will include a session on parasitic weeds.. www.apwss2023-phuket.com.

17th World Congress on Parasitic Plants Nara, Japan 3-7 June, 2024. https://www.parasiticplants.org/2023/01/the-17th-world-congress-on...

9th International Weed Science Congress, 7-11 July 2024 Jerusalem. https://www.iwsc2024.com/

COMPOSITE FILES

A reminder that all previous issues of Haustorium are available in two PDF documents, 'Haustorium1-48' and'Haustorium 49-82 (shortly to be updated) via the ODU Haustorium website - https://sites.wp.odu.edu/musselmanpage/haustorium/

WEB SITES

For individual web-site papers and reports see LITERATURE

Some websites may need copy and paste.

For information on the International Parasitic Plant Society, past issues of Haustorium, etc. see: http://www.parasiticplants.org/

For Dan Nickrent's 'The Parasitic Plant Connection' see: http://www.parasiticplants.siu.edu/

For the Parasitic Plant Genome Project (PPGP) see: http://ppgp.huck.psu.edu/ (may be temporarily unavailable)

For Old Dominion University Haustorium site: see https://sites.wp.odu.edu/musselmanpage/haustorium/

For a description of the PROMISE project (Promoting Root Microbes for Integrated *Striga* Eradication), see: http://promise.nioo.knaw.nl/en/about

For *Striga* Solutions, led by Prof. Salim Al-Babili, KAUST, Saudi Arabia: https://strigasolutions.com

For PARASITE - Preparing African Rice Farmers Against Parasitic Weeds in a Changing Environment: see http://www.parasite-project.org/

For the Toothpick Project – see https://www.toothpickproject.org/

For the Annotated Checklist of Host Plants of Orobanchaceae, see: http://www.farmalierganes.com/Flora/Angiospermae/Orobanchaceae/Host_Orobanchaceae_Checklist.htm

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

For information on the work of the African Agricultural Technology Foundation (AATF) on *Striga* control in Kenya, including periodical 'Strides in *Striga* Management' and 'Partnerships' newsletters, see: http://www.aatf-africa.org/

For Access Agriculture (click on cereals for videos on *Striga*) see: http://www.accessagriculture.org/

For information on future Mistel in derTumortherapie Symposia see: http://www.mistelsymposium.de/deutsch/-mistelsymposien.aspx

For a compilation of literature on *Viscum album* prepared by Institute Hiscia in Arlesheim, Switzerland, see: http://www.vfk.ch/informationen/literatursuche (in German but can be searched by inserting author name).

For *Viscum album* Genespace Database see: viscumalbum.pflanzenproteomik.de/

For an excellent publication by the Universidade Federal do Rio Grande do Sul on Southern Brazilian Mistletoes (Dettke, G.A. and Waechter, J.L. 2013) see: https://fieldguides.fieldmuseum.org/sites/default/files/rapid-color-guides-pdfs/493.pdf

For a participatory website cataloguing tools for the identification and localization of fauna and flora, including parasitic plants see: https://nadaba.net/fr

SELECTED LITERATURE

With acknowledgement to CABIDirect as a major source.

Adam, J.H and 6 others. 2022. *Rafflesia tunku-azizahiae* (Rafflesiaceae), a new species from Pahang, Malaysia. Sains Malaysiana 51(11): 3843-3855. [Describing *R. tunku-azizahiae* which differs from *R. tuanku-halimii* by larger flower diameter, broader diaphragm and disc diameter, larger aperture diameter and longer ramenta.]

Aguilar-Venegas, M. and 8 others. 2023. Protein profiling of *Psittacanthus calyculatus* during mesquite infection. Plants 12(3): (https://doi.org/10.3390/plants12030464) [Proteomic analyses revealed cell wall-degrading enzymes cellulase and β-1,4-glucosidase active in haustorium development, while xylanase, endo-glucanase, and peptidase were highly active in the

haustorium penetration and xylem connection stages.]

Albanova, I.A., Zagorchev, L.I., Teofanova, D.R., Odjakova, M.K., Kutueva, L.I. and Ashapkin, V.V. 2023. Host resistance to parasitic plants - current knowledge and future perspectives. Plants 12(7): (https://doi.org/10.3390/plants12071447) [A detailed review of host resistance, pointing out the underestimated aspect of cross-resistance/tolerance to multiple stresses, and how the epigenetic regulation of host response and resistance to parasitic plants is a surprisingly understudied area.]

Aliyu, K.T. and 10 otherrs. 2023. Spatial modelling indicates *Striga* seedbank density dependence on rainfall and soil traits in the savannas of northern Nigeria. Weed Research (Oxford) 63(2): 88-101. [Determining the optimum conditions for *S. hermonthica* across N. Nigeria where 60% of fields have moderate to high infestation, Finding 550mm rain optimal and certain sil types.]

Aoki, N, Cui SongKui and Yoshida, S. 2022. Cytokinins induce prehaustoria coordinately with quinone signals in the parasitic plant *Striga hermonthica*. Plant and Cell Physiology 63(1): 1446-1456. [Reporting that cytokinins are effective in inducing haustoria in *Orobanche* and *Phelipanche* spp. while DMBQ is not effective as it is in *Striga* spp. However, cytokinins can also be effective in *Striga* sp., but not in *Phtheirospermum japonicum*. Also showing that host root exudates may include cytokinins.]

Banerjee, A. and Stefanović, S. 2023. A comparative study across the parasitic plants of *Cuscuta* subgenus *Grammica* (Convolvulaceae) reveals a possible loss of the plastid genome in its section *Subulatae*. Planta 257(4): (https://doi.org/10.1007/s00425-023-04099-y) [Showing that 13 of the 15 sections of the 153-species subgenus *grammica* retain plastids and some photosynthetic activity, while section *Ceratophorae* and 3 species within section *Subulatae* lack plastids and are totally holoparasitic.]

Bari, V.K., Singh, D., Nassar, J.A. and Aly, R. 2022. Silencing of a mannitol transport gene in *Phelipanche aegyptiaca* by the tobacco rattle virus system reduces the parasite germination on the host root. Plant Signalling and Behaviour 17(1): (https://doi.org/10.1080/15592324.2022.2139115) [Demonstrated on tobacco.]

Bian PengXuan, Sun Chang, Cao XiaoLei, Yao ZhaoQun, Zhang XueKun and Zhao SiFeng. 2002. Screening of haustorium induction factors of *Phelipanche aegyptiaca* Pers. based on metabolome analysis of *Cucumis melo* L. root exudates. Agronomy 13(1): (https://doi.org/10.3390/agronomy13010128) [Determining that scopoletin, quercetin, IAA, and DMBQ from *C. melo* exudates had relatively high haustorium induction activity on *P. aegyptiaca*.]

Cope, K.R., Kafle, A., Yakha, J.K., Pfeffer, P.E., Strahan, G.D., Garcia, K., Subramanian, S. and Bücking, H. 2022. Physiological and transcriptomic response of *Medicago truncatula* to colonization by high- or low-benefit arbuscular mycorrhizal fungi. Mycorrhiza 32(3/4): 281-303. [Comparing 2 AM fungal species. *Rhizophagus irregularis* led to greater benefit, associated with elevated expression of genes contributing to increased P, N and ammonium transport, photosynthrsis and sugar transport, *Glomus aggregatum* mainly stimulated stress-related genes.]

Cuccurullo, A., Nicolia,A., Vurro, M. and Cardi, T. 2022. Genetic and agronomic approaches to control *Orobanche* and *Phelipanche* spp. parasitic weeds in vegetables and legumes. Romanian Journal of Horticulture 3: 63-82. [A wide-ranging review concluding that a combination of different genetic resistance mechanisms with agronomical management practices is mandatory to develop a durable containment strategy.] .

David, O.A., Obiakara, M.C., Fabolude, G.O., Akomolafe, G.F. and Ajiboye, M.D. 2022. Habitat suitability and dispersal of invasive *Striga* species under climate change in Africa. African Journal of Ecology 60(4): (https://doi.org/10.1111/aje.13064) [An interesting assessment of the likely future distribution of *Striga* species under moderate or extreme global warming. Concluding that *S. hermonthica* would see moderate expansion, mainly into forest areas, *S. asiatica* would see a small increase, and *S. gesnerioides* a considerable decrease. Breeding of polyploid *S. hermonthica* which causes sterility is considered as an alternative biological control to its spread.]

El Amri, M., Amri, M., Kadir, E.M., Triqui, Z.E.A., Khayi, S. and Mentag, R. 2023. First report of the branched broomrape (*Phelipanche s chultzii* (Mutel) Pomel.) on fennel (*Foeniculum v ulgare* Mill.) in Morocco. Horticulturae: (https://doi.org/10.3390/horticulturae9050567) [*P. schultzii*, known from the Mediterranean region on hosts *Galium* spp., *Distichoselinum tenuifolium* and *Scorpiurus, also on* olive and almond trees, now reported in fennel in Morocco, causing estimated yield loss of 20%-50%.]

En-Nahli and 7 others. 2023. Host–parasitic plant interaction - the key role of strigolactones. In Eds

Soumya Mukherjee, Tariq Aftab. Strigolactones, Alkamides and Karrikins in Plants Recent Updates and Future Prospects. 13 pp. [A review focusing on strigolactone biosynthesis, structural diversity, production, role in the host-parasite interaction, and potential use for parasitic weed control.]

Feller, B., Dančák, M., Hroneš, M., Sochor, M., Suetsugu, K. and Imhof, S. 2022. Mycorrhizal structures in mycoheterotrophic *Thismia* spp. (thismiaceae): functional and evolutionary interpretations. Mycorrhiza 32(3/4): 269-280. [An intriguing, well-illustrated description of the differing structures of AM hyphae in different host cells and suggesting their different functions.]

Garrett, N., Viruel, J., Klimpert, N., Gomez, M.S., Lam, V.K.Y., Merckx, V.S.F.T. and Graham, S.W. 2023. Plastid phylogenomics and molecular evolution of Thismiaceae (Dioscoreales). American Journal of Botany 110(4): (https://doi.org/10.1002/ajb2.16141) [Concluding that gene losses in Thismiaceae occurred early and rapidly, following the initial loss of photosynthesis in its stem lineage. As a species-rich, fully mycoheterotrophic lineage, Thismiaceae provide a model system for uncovering the unique and divergent ways in which plastid genomes evolve in heterotrophic plants.]

Gibot-Leclerc, S and 8 others. 2022. Screening for potential mycoherbicides within the endophyte community of *Phelipanche ramosa* parasitizing tobacco. FEMS Microbiology Ecology 98(3): (https://doi.org/10.1093/femsec/fiac024) [374 isolates studied, mostly *Fusarium s*pp., of which 87 inhibited germination of *P. ramosa*. Best was *F. venenatum* causing germination inhibition and necrotic activity, and non-pathogenic to tobacco.]

Hatt,, S.A., Cameron, D.D. Grace, O.M., Rocamundi, N., Cocucci, A.A..Martel, C. and Thorogood, C.J. 2022. *Prosopanche*: A remarkable genus of parasitic plants. Plants, People, Planet. Flora Obscura: (https://doi.org/10.1002/ppp3.10340) [A detailed description of this genus of Hydnoraceae, comprising 7 species from S. and Central America, emphasising the need for more research into their ecology, host range and germination requirements.]

Hatt,, S.A., Thorogood, C.J., Bolin, J.F., Musselman, L.J., Cameron, D.D. and Grace, O.M. 2023. A taxonomic revision of the genus *Hydnora* (Hydnoraceae). bioRxiv: (https://doi.org/10.1101/2022.10.13.512068) [A detailed monograph with descriptions, full synonymy, distribution maps, and discussion concerning confusable taxa, along with notes on ethnobotany, ecology and conservation. Including the newly described *H. bolinii* Particular emphasis is placed on the taxonomic value of osmophore geometry and positioning which are highly consistent within species. Richly illustrated. Worthy of the coffee table!]

Henrique, H and 8 others. 2023. Spread of *Striga asiatica* through suitable climatic conditions: Risk assessment in new areas producing *Zea mays* in South America. Journal of Arid Environments 210: (https://doi.org/10.1016/j.jaridenv.2022.104924) [A risk assessment indicated that the Southeast and Northeast of Brazil are at the most significant risk of *S. asiatica* invasion. Projections for climate change between 2040–2059 showed expansions in areas suitable for *S. asiatica* compared to the current climate of South America.]

Hosseini, P., Osipatan, O.A. and Mesgaran, M. 2022. Seed germination responses of broomrape species (*Phelipanche ramosa* and *Phelipanche aegyptiaca*) to different sanitation chemicals. Weed Technology 36(5):1-17. [Findings suggest that quaternary ammonium compounds could be used as potential sanitation agents to disinfect agriculture machinery from *P. ramosa P. aegyptiaca* seeds.]

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International Journal of Plant Sciences 184(1):1-18. [Concluding that that Lennoaceae should not be treated as a separate family. Aberrant fruit morphology of *P. arenarium* appears to be driven clearly reflects a position in Ehretiaceae.]

Kawada, K. and 10 others. 2023. Synthesis of carlactone to develop a novel inhibitor of strigolactone biosynthesis. ACS Omega **8**(15): 13855-13862. [Using rice enzyme Os900 which oxidises carlactone to deoxyorobanchol (4DO) to synthesize 10 carlactone derivatives, some of which inhibited strigolactone synthesis *in vitro* and *in vivo*.]

Kimathi, E., Abdel-Rahman, E.M., Lukhoba, C., Ndambi, A., Mudereri, B., Niassy, S., Tonnang, H.E. and Z. Landmann, T. 2023. Ecological determinants and risk areas of *Striga hermonthica* infestation in western Kenya under changing climate. Weed Research (Oxford) 63(1): 45-56. [Predicting future spread of *S. hermonthica* in western Kenya under predicted climate change up to 2050. Concluding minimum 19% and maximum 53% spread, with elevation, annual precipitation, land use and land cover, temperature seasonality and soil type were determined to be the most influential ecological predictor variables.]

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Lombard, L. and 7 others. 2022. *Fusarium* diversity associated with the Sorghum-*Striga* interaction in Ethiopia. Fungal Systematics and Evolution 10(1):177-215. [Studying 439 isolates of *Fusarium* spp. associated with sorghum and *S. hermonthica,* including 3 new spp. *F. extenuatum* and *F. tangerinum* from sorghum soils and *F. pentaseptatum.* Also identifying the gene associated wirth pathogenicity against *Striga* in *F. oxysporum* ssp. *strigae* in several other *Fusarium* spp.]

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Lurthy, T., Perot, S.,Gerin-Erveillard, F., Rey, M., Wisniewski-Dyé, F., Vacheron, J. and Prigent-Combaret, C. 2023. Inhibition of broomrape germination by 2,4-diacetylphloroglucinol produced by environmental *Pseudomonas.* bioRxiv (https://doi.org/10.1101/2023.03.01.529533) [Demonstrating the potential herbicidal effect of the bacterial model *Pseudomonas ogarae* F113, a PGCs-producing bacterium, on germination of *Orobanche ramosa* without detrimental effect on oilseed rape.]

Martinez, L., Pouvreau, J-B., Montiel, G., Jestin, C., Delavault, P., Simier, P. and Poulinm, L. 2022. Soil microbiota promotes early developmental stages of *Phelipanche ramosa* L. Pomel during plant parasitism on *Brassica napus* L.. Plant and Soil: (https://doi.org/10.1007/s11104-022-05822-6) [Finding that a range of soil bacteria may contribute to the susceptibility of rape seed to *P. ramosa,* by converting the crop-released glucoisnolate, gluconasturtin, into germination stimulants.]

Miao YuJing, Zhang XinKe, Pei Jin, Liu Chang and Huang LinFang. 2023. Adaptive bacterial and fungal matching between a parasitic plant and its host: a case of *Cistanche deserticola* and *Haloxylon ammodendron*. Industrial Crops and Products 191. (https://doi.org/10.1016/j.indcrop.2022.115932) [Results suggest that the root microbiota of *C. deserticola* was highly congruent with those of the host plant, consistent with the phenomena of 'parasitic equilibrium', providing a new line of evidence for the complex interaction of parasitic plants and their hosts.]

Moreno-Robles, A., Peralta, A.C., Soriano, G., Zorrilla, J.G., Masi, M., Vilariño-Rodríguez, S., Cimmino, A. and Fernández-Aparicio, M. 2022. Identification of allelochemicals with differential modes of phytotoxicity against *Cuscuta campestris*. Agriculture 12(10): (https://doi.org/10.3390/agriculture12101746) [Assessing the effects of 9 metbolites on *C.* Peralta *campestris* and finding 2-benzoxazolinone, hydrocinnamic acid and pisatin caused the strongest inhibition of seedling growth.]

Moreno-Robles, A., Peralta, A.C., Zorrilla, J.G., Soriano, G.,Masi, M., Vilariño-Rodríguez, S., Cimmino, A. and Fernández-Aparicio, M..2022. Structure−activity relationship (SAR) study of trans-cinnamic acid and derivatives on the parasitic weed *Cuscuta campestris.* Plants 12(4) (https://doi.org/10.3390/plants12040697) [Further to the item above, finding that among 24 analogs of trans-cinnamic acid, the methyl ester derivative of trans-cinnamic acid was the most active.]

Mounde, L.G. Anteyi, W.O. and Rasche, F. 2023. Tripartite interaction between *Striga* spp., cereals, and plant root-associated microorganisms: a review. 2022. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources: (https://doi.org/10.1079/PAVSNNR202015005) [A detailed review of the 3-way interactions involving cereal, *Striga* spp. and plant growth promoting micro-organisms, and identifying research gaps.]

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Niassy, S. and 11 others. 2022. Performance of push-pull technology in low-fertility soils under conventional and conservation agriculture farming systems in Malawi. Sustainability 14(4): (https://doi.org/10.3390/su14042162) [Results confirmed the benefits of push-pull technology in Malawi, achieving 70% reductions in *Striga asiatica* and stemborer. The cost of labour was described as a challenge, and research to identify more suitable *Desmodium* species is needed. The current study suggests the release of the technology in Malawi, emphasizing the value of *Desmodium* and *Brachiaria* as animal fodder.]

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Okunlola, G., Badu-Apraku, B., Ariyo, O., Agre, P., Offernedo, Q. and Ayo-Vaughan, M. 2022. Genome-wide association studies of *Striga* resistance in extra-early maturing quality protein maize inbred lines. G3: Genes, Genomes, Genetics 13(2): (https://doi.org/10.1093/g3journal/jkac237) [Scanning 41 inbred lines and identifying 22 SNP makers associated with improved response to *S. hermonthica* infection, of potential value in further breeding work.]

Osei, R. and Ansong, M. 2023. Drivers of mistletoe (*Tapinanthus bangwensis*) density in cocoa (*Theobroma cacao*) agroforests in Ghana. International Journal of Pest Management 69(1): 46-53. [Infestation of *T. banguensis* was significantly less in row-planted cocoa than in random planting.]

Paller, C.J. and 17 others 2023. Phase I Trial of intravenous mistletoe extract in advanced cancer. Cancer Research Communications: https://doi.org/10.1158/2767-9764.CRC-23-0002 [see PRESS REPORT above.]

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Roobroeck, D.;, Kimutai, G., Kanampiu, F., de Nowina, K.R. and Vanlauwe, B. 2023. Effective *Striga* control and yield intensification on maize farms in western Kenya with N fertilizer and herbicide-resistant variety. Field Crops Research 296: (https://doi.org/10.1016/j.fcr.2023.108924) [Finding that IR maize is best at reducing *S. hermonthica* emergence, while N is most effective at increasing maize yield.]

Sakici, O.E., Özcan, G.E., Seki, M. and Sağlam, F. 2023. The effects of pine mistletoe (*Viscum album* subsp. *austriacum*) on the growth of Scots pine and Crimean pine in Turkey. Forest Pathology.53(2): (https://doi.org/10.1111/efp.12802) [Showing that growth of both species suffered ca. 25% reduction in growth over a 10 year period.]

Scott, D. and Freckleton, R.P. Crop diversification and parasitic weed abundance: a global meta-analysis. Scientific Reports 12(11): (https://doi.org/10.1038/s41598-022-24047-2) [Using meta-analysis of 67 studies to compare occurrence of *Cuscuta, Orobanche, Phelipanche* and *Striga* as weeds of crops in the presence of a second crop. Finding that intercrops which alter both microclimate and soil chemistry (e.g. *Crotalaria, Stylosanthes*, Berseem clover and *Desmodium*) are most effective in parasitic weed management. See SYNOPSIS above.]

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Fruits of *Mitrastemon yamamotoi*. Their white-pink flowers and berry-like fruits become visible on the forest floor only during their reproductive phase.]

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(https://doi.org/10.3389/fpls.2022.1064378) [Identifying two new strigolatones from tomato, stimulating germination of *Phelipanche ramosa* described as phelipanchol and epiphelipanchol. NB. See https://doi.org/10.3389/fpls.2023.1151993 for minor corrigendum.]

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Walas, Ł., Kędziora, W., Ksepko, M., Rabska, M., Tomaszewski, D., Thomas, P.A., Wójcik, R. and Iszkuło, G. 2022. The future of *Viscum album* L. in Europe will be shaped by temperature and host availability. Scientific Reports 12(10): (https://doi.org/10.1038/s41598-022-21532-6) [Predicting that, with future increases in temperature, the range of *V. album* ssp. *abietis* will be markedly reduced; that of *V. album* subsp. *austriacum* will see slight changes in range, *V. album* ssp. *album* will expand non-directionally.)

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Xi Jiao, Xu TengQi, Liu YuTao, Ma YongQing, Xue QuanHong and Lin YanBing. 2023. Effect of *Streptomyces rochei* D74 on sunflower, *Orobanche cumana*, and their rhizosphere microorganisms. (in Chinese) Acta Microbiologica Sinica 2023(2): 745-759. [Inoculation with *S. rochei* D74 reduced *O.camana* emergence by 28-46% and increased sunflower yield by 30%.]

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Ye XiaoXin, McErlean, C.S.P. and Ma YongQing. 2023. Nitrogen and phosphorus supply strongly reduced the control efficacy of maize against sunflower broomrape. Archives of Agronomy and Soil Science 69(3): 431-435. [Application of N and P to maize, when grown as a trap crop, reduced its effectiveness in stimulating germination of *O. cmana.*]

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Zhou Di and 11 others. 2022. ACC deaminase-encoding *Pseudomonas putida* arrests seed germination: an alternative strategy for grass and weed control. Plant and Soil 480(1/2): 391-406. [1-aminocyclopropane-1-carboxylic acid (ACC) deaminase-encoding *Pseudomonas aeruginosa* inhibits germination of Nipponbare rice and other species. this study showed that wild-type *P. putida* does likewise, thanks to down-regulating ethylene synthesis and up-regulating abscisic acid, while a mutant form of *P. putida* lacking the

ACC deaminase gene was safe on rice, while still inhibiting certain weed species including *Striga asiatica*.]

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has been edited by Chris Parker, 6 Royal York Crescent, Bristol BS8 4JZ, UK (Email chrisparker5@compuserve.com), Lytton Musselman, Parasitic Plant Laboratory, Department of Biological Sciences, Old Dominion University, Norfolk Virginia 23529-0266, USA (fax 757 683 5283; Email lmusselm@odu.edu) and Luiza Teixeira-Costa, Vrije Universiteit Brussel
Pleinlaan 2. 1050 Brussels. Belgium.??
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