Parasitic Plants Newsletter
ISSN 1944-6969
Newsletter of the International Parasitic Plant Society,
Amsterdam, Javakade 712, 1019 SH, The Netherlands
(http://www.parasiticplants.org

Haustorium 85 **May 2024**

PRESIDENT'S MESSAGE

Dear IPPS members

Before you, a new issue of Haustorium, with probably my last message as President of the IPPS. At this very moment the Society is electing a number of new Executive Committee members, and the presidency will go to the current Vice-president, Jonne Rodenburg, as of 1 August this year. A good moment to look back at the past 12 years, in which I served the IPPS as Member at large, Vice-president and the past 4 years as President. As Member at large my primary role was to help Chris Parker with input for Haustorium. Then, just as now, however, Chris did the majority of the work of composing Haustorium, and my contribution mostly consisted of a few short abstracts for the more molecular papers on parasitic plants.

As Vice-president, I served under Julie Scholes, and I remember that as an interesting period of nice teamwork in which we paved the way for taking the IPPS into a next phase. We decided to have a new, more interactive, website built and to try to improve the registration and administration of IPPS membership. Under my presidency, in the past 4 years these things were indeed realized, and I am proud of the EC team, consisting of Jonne Rodenburg, Airong Li, Renate Wesselingh, Susann Wicke, Luiza Teixeira and Pradeepa Bandaranayake, who helped me make this happen. As a result, the IPPS now has an interactive and up to date website, a bank account, and an up-to-date member registration and administration. In addition, the IPPS has a fantastic newsletter, Haustorium, that you are currently reading, is active on social media (X fka Twitter) and has a MailChimp account for updates through email. One of my last contributions to the Society, as President, will be the launch of an electronic Newsletter, through Mailchimp, sometime soon.

The IPPS is dedicated to advancing scientific research on parasitic plants. Our goals include increasing the understanding of these amazing plants, providing a platform for exchange among and beyond the scientific community as well as helping to decrease the crop damage inflicted by weedy parasitic plants. Membership fees are used to realise these objectives and to support early career scientists from developing countries to attend the World Congresses on Parasitic Plants that the IPPS organizes, such as the 17th World Congress on Parasitic Plants, 3–7 June 2024, Nara, Japan I hope that many of you will attend this meeting! Membership entitles you to a reduced fee for WCPP attendance and gives you access to the member area of the IPPS website. www.parasiticplants.org/2023/12/registration-open-for-the-17th-world-congress-on-parasitic-plants-3-7-june-2024-nara-japan and https://www.kuba.co.jp/wcpp17/index.html.

The IPPS website has a number of attractive features, such as a Scopus and Google Scholar feed readers showing the latest publications on parasitic plants, and a Twitter feed showing IPPS as well as #Parasiticplants hash tagged-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, members can login into the member area where they can post interesting news, such as recent papers or project funding, as well as job vacancies. These will also automatically be messaged from the IPPS X (fka Twitter) account, further increasing your outreach.

If you are reading Haustorium but are not an IPPS member yet, consider becoming one, see www.parasiticplants.org for details and an online membership fee payment option.

In this issue of Haustorium, editor Chris Parker, compiled again lots of interesting news about our beloved parasitic plants. For example, that Gebisa Ejeta was awarded the National Medal of Science; that CRISPR-edited crops break new ground in Africa including in the control of Striga; a note on the intriguing origin of the species name for *Pedicularis groenlandica*, Elephanthead lousewort; how mistletoes were brought back to the trees of Melbourne (while avoiding hungry possums!); how researchers in California are trying to deal with the threat of broomrape in tomato; and a report on bat pollination of a New Zealand underground parasitic plant. Enjoy reading!

I wish you all a good summer season.

Harro Bouwmeester, IPPS President.

PROFILE

Parasitic plant research in Japan.

In Japan, the oldest record of the root parasitic plant, *Aeginetia indica*, can be found in "Man-yo-shu" the oldest surviving anthology of Japanese poetry compiled about 1200 years ago during the Nara period. This plant was called 'Omoigusa', musing (wondering) plant in those days, as the flower is borne downward like a person wondering about something. This parasite caused considerable damage to upland rice production until chemical fertilizers became available at reasonable prices in the 1960s.

In the 1970s, field dodder (*Cuscuta campestris*) was first found in Tokyo and soon became a troublesome weed in Japan. Tetsuo Takematsu, Makoto Konnai and Yasutomo Takeuchi (IPPS honorary member) at Weed Control Research Center (WCRC), Utsunomiya U reported that a diphenyl ether herbicide was effective to control the parasite in sunflower (Takematsu et al. Weed Sci., 23: 57-60, 1975). In collaboration with scientists at U Tokyo, they also found that the plant hormone, abscisic acid (ABA) accumulated in the host plants infested by the dodder (Kimura et al. Agric. Biol. Chem., 46: 1071-1073, 1982). Such a collaboration study on plant hormones in parasitic plants continued. For example, analysis of gibberellins (GAs) in *A. indica* and its host *Miscanthus sinensis* revealed that the parasite produces its own GAs (Suwa et al. Biosci. Biotechnol. Biochem., 59: 1712-1715, 1995).

After Yasutomo returned from his sabbatical leave (1987-1988) at Douglas Worsham's lab, North Carolina State U, USA, where he had examined effects of plant hormones on seed germination of *Striga asiatica*, started studies on root parasitic weeds at WCRC, Utsunomiya U. He used mainly *Orobanche minor* which had been introduced to Japan in the 1930s. He and co-workers including Koichi Yoneyama, Xiaonan Xie, Takahito Nomura (Utsunomiya U), Kaori Yoneyama (Saitama U), Takao Yokota (Teikyo U), Tadao Asami (U Tokyo), Yukihiro Sugimoto (Tottori U, Kobe U) and Atsushi Okazawa (Osaka U, Osaka Metropolitan U) have since been working on structural determination of germination stimulants strigolactones (SLs), biosynthesis of SLs, molecular design of SL agonists/antagonists and SL biosynthetic inhibitors, regulation of biosynthesis, germination biology, and control measures of root parasitic weeds. Danny Joel (IPPS honorary member, Israel), when he was the IPPS president, stayed at Utsunomiya U as a visiting professor in 2002. During his stay, he encouraged staff, visiting scientists, and students to be involved in studies on parasitic weeds. One of the visiting scientists, Weijun Zhou (Zhejiang U, China) continues his work on parasitic weeds in China. Yaakov Goldwasser (Hebrew U, Israel) stayed as a visiting scientist and introduced various *Arabidopsis* culture systems to study host-parasite interactions. He kindly described sophisticated control measures of root parasites in Israel. The members at WCRC (later changed to Weed Science Center, WSC) conducted international collaboration projects with Maurizio Vurro (ISPF, CNR) and Antonio Evidente (Napoli U) in Italy and with Phillipe Delavault, Phillipe Simier, and Jean-Bernard Pouvreau (Nantes U) in France on SL degrading microbes and *Phelipanche ramosa* germination stimulants produced by rapeseed, respectively. Similar collaboration works on root parasitic weeds were conducted with Imen Trabelsi (INRAT, Tunisia) and Mónica Fernández-Aparicio (INRA, France).

Tadao (U Tokyo) has been collaborating with Salim Al-Babili (KAUST, Saudi Arabia) and Binne Zwanenburg (IPPS honorary member, Netherlands) in the development of *Striga* control measures based on the induction of suicidal germination by SL agonists. He and his colleagues including Shinsaku Ito (Tokyo U Agric) have created SL agonists/antagonists and various inhibitors of biosynthesis and signal transduction of SL; these compounds have been utilized as molecular tools for parasitic weed research.

The late Abdel Gabbar Babiker (IPPS honorary member, Sudan) stayed as a visiting professor at Arid Land Research Center, Tottori U in total 39 months during1994-1999. He introduced *Striga* and root parasite issues in Africa and gave great impetus to staff and students there. Among them, Yukihiro was greatly inspired and decided to spend his sabbatical leave Binne’s lab at Nijmegen U, Netherlands in 1996, where he was involved in the synthesis and structure confirmation of sorgolactone. In 2002, he also stayed at the lab of Malcolm Press and Julie Sholes (both IPPS honorary members, Sheffield U, GB) where he deepened his understanding of host-root parasite interactions. After he returned to Japan and moved to Kobe U, he has been continuing studies on characterization of SLs and SL biosynthetic pathways with Kotomi Ueno (Tottori U), Hisato Takikawa (U Tokyo), and Takatoshi Wakabayashi (U Tokyo). Yukihiro organized international collaboration projects between Japan and Sudan (Asia-Africa Science Platform Program and SATREPS) which have contributed greatly to the advancement of parasitic weed research in both Sudan and Japan. Yukihiro's group conducted field trials with simple synthetic SL agonists as inducers of suicidal germination of *Striga* seeds in Sudan. Yongqing Ma (Northwest A & F U, China) obtained his PhD degree on the work with Yukihiro and Abdel-Gabbar, and continues studies on parasitic weeds, mainly *O. cumana*, in China. Later in 2006, he stayed at Utsunomiya U as a visiting professor.

Atsushi Okazawa (Osaka U, Osaka Metropolitan U) has been working with *O. minor* and clarified its specific biochemical characteristics. He and co-workers cloned a cryptochrome gene, identified planteose as a storage carbohydrate for early germination process, and found nojirimycin as a specific inhibitor of *O. minor* germination. He was also involved in the international collaboration projects led by Yukihiro. Yoshiya Seto (Meiji U), who has been working on biosynthesis and signal transduction of SL, is also involved in research on parasitic plants. He developed novel SL agonists and identified SL receptors of *O. minor*.

At RIKEN, Ken Shirasu and Satoko Yoshida have been working on genetics and biochemistry of root parasitic plants and interactions between hosts and root parasites. They work mainly with the facultative root parasite, *Phtheirospermum japonicum,* to clarify the mechanisms of parasitism and host-parasite interactions. Satoko moved to Nara Institute of Science Technology. They found horizontal gene transfers between host plants and root parasites, and reported the whole genome of *S. asiatica*. Developmental processes and biochemical functions of the haustorium have been unveiled by Satoko and co-workers. She is organizing the 17th IPPS meeting WCPP 2024.

Yuichiro Tsuchiya (Nagoya U) and Shigeo Toh (Meijo U) started their careers as root parasitologists at Peter McCourt' lab (Toronto U, Canada). They identified highly sensitive strigolactone receptor in *S. hermonthica*, developed fluorescent molecular probes to monitor SL signal transduction in *Striga* seeds. Yuichiro has been involved in *Striga* control projects by using highly active SL agonists in collaboration with KALRO, Kenya.

In the 1990s, Katsuhisa Furuhashi and colleagues at Niigata U conducted intensive study on *Cuscuta japonica* and established an in vitro culture to observe parasitic behavior. They found that the parasitism was controlled by far-red irradiation and proper tactile pressure. Recently, Ryusuke Yokoyama (Tohoku U) and co-workers including Koh Aoki (Osaka Metropolitan U) clarified regulatory modules involved in the degradation and modification of host cell walls during *C. campestris* invasion. Koh and co-workers developed a bioinformatics approach to distinguish *C. japonica* and host transcriptomes in interface tissue by classifying RNA-Seq reads and uncovered the coordination of cellular processes between the parasite and its host. He also studied bidirectional exchanges of mRNAs between *Cuscuta* and its host and found that long-distance transport of *Cuscuta*-derived small RNAs without secondary siRNA production. In addition, he examined *P. aegyptiaca*–tomato interactions and revealed that phloem-conducting cells in haustoria are different from conventional sieve elements.

A few studies on the germination biology of *Cistanche* spp. have been reported (only in Japanese) as they are important Chinese traditional medicines. In Japan, some health drinks contain their extracts. Pharmaceutical and medicinal characteristics of *Cistanche* extracts have been extensively examined at Toyama U and Kindai U in collaboration with Peking U and other research institutions in China.

In Japan, there has been no serious damage in agriculture or forestry due to parasitic plants. However, we notice heavy infestations of sawtooth oaks by mistletoe, presumably *Viscum album,* and hear about spreading infestation by *Cuscuta campestris*. In addition, broomrapes are potential threats to production of vegetables, tomatoes, cucumbers, carrots, and potatoes in Japan. Since clover broomrape (*O. minor*), first found in 1937, is now parasitizing clovers and various plant species everywhere in Japan except for cool Hokkaido, more aggressive broomrape species like *P. ramosa* would spread easily and rapidly. We may have *Striga* problem in southern part of Japan in the near future due to the global warming. Therefore, we must continue studies on parasitic plants, weedy or otherwise.

Although some Japanese parasitologists including Yasutomo Takeuchi, Koichi Yoneyama, Tadao Asami, and Yukihiro Sugimoto have retired from their institutions, the others are actively working on parasitic plants and will contribute a lot to the progress and advancement in this important and interesting research area.

Publications on the work mentioned above can be found in the LITERATURE of past issues of Haustorium.

Koichi Yoneyama (Utsunomiya U), Yoshiya Seto (Meiji U) and Shinsaku Ito (Tokyo U Agric)

MEETING REPORTS

8th International and Interdisciplinary Mistletoe Symposium, Nonnweiler, Germany, 9-11 November, 2023.

A series of 52 detailed papers covering the latest research into the well-established therapeutic uses of extracts from *Viscum album* in the treatment of cancer. Also including:

Lucie Schröder *et al.*- The photosynthesis apparatus of European mistletoe.

Konrad Urech *et al.*, Distribution and abundance of *Viscum album* ssp. *album* in France.

Full details at:
https://www.liebertpub.com/doi/10.1089/jicm.2023.29117.abstracts

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

Papers:

L. Velasco - Broomrape resistance from wild species.

D. Miladinovic - New approaches for achieving durable resistance to broomrape in sunflower.

M. Demirci - CLEARFIELD control of broomrape parasite & weeds: a success story in sunflower.

S. Munos - The STIGO project: Deciphering the molecular dialog of O. *cumana* seeds germination.

Ningning Yan and Zhao Ju -Transcriptome analysis and gene mining of broomrape in sunflower-broomrape pathosystem.

Zhang Jian *et al.* - Jinmiao Target in Inhibiting *Orobanche cumana* parasitism of sunflower.

Ayse Nuran Cil *et al.* - Determination of resistance of oil sunflower maintainer lines to broomrape populations in the Çukurova region.

Dmitrii Savichenko *et al.* - DNA marker for marker-assisted selection for sunflower resistance to race G of broomrape.

Clothilde Boubée *et al.* - Genetic diversity analysis of broomrape (*Orobanche cumana*) populations in sunflower growing areas in Europe.

Zhang Yu-Kuan *et al.* - Application of SSR markers to reveal the genetic diversity of sunflower broomrape in China.

Havva Akar - Molecular characterization of some wild sunflower Species (Helianthus spp.) and Interspecific Hybrids based on broomrape resistance.

Yakov Demurin - Effect of gene dose on broomrape resistance in sunflower.

Kubilay Yıldırım *et al.* - Development CRISPR / CAS9-mediated resistance in sunflower against O.*cumana*.

Bao Ting-Ting - A preliminary study on the identification of different sunflower varieties with the level of resistance to Race G minor species and the mechanism of resistance.

Milan Jocković *et al.* - In the race with the broomrape - is there a winner?

Burak Uğur - Determination of agricultural policy factors and their effects affecting producers' preference for production of oily sunflower: the case of Thrace region.

Deniz İnc *et al.* - Advancing biocontrol strategies for broomrape management.

Tatiana Antonova *et al.* - Evolution of *Orobanche cumana* Wallr. in intensive sunflower cultivation in regions of Russian Federation.

Yalcin Kaya - Recent developments in broomrape in sunflower in the world.

Maria Pacureanu - Recent situation of chemical control on broomrape.

Begona Perez - Update of sunflower broomrape situation in Spain.

Garyfalia Economou - Monitoring of *Orobanche cumana* Wallr races in sunflower fields of Northeast Greece.

Full Proceedings at: https://agribalkan.congress.gen.tr/files/site/21/files/BROOMRAPE%202023%20PROCEEDING%20of%20ABSTRACT%20BOOK(1).pdf

73º National Botany Congress, Belém, Pará state, from Oct 29 to Nov 4. 2023.

A symposium entitled 'Parasitic plants in Brazil: little known and little studied'.

Papers included the following:

Claudenir Simões Caires - What and how many mistletoes are there in Brazil?

Rodrigo Fadini (Ufopa) - Opportunities for the use of mistletoes in silvicultural systems as study models.

Grazielle Sales Teodoro - Do mistletoes bother a lot of people? Responses of *Vochysia thyrsoidea* to parasitism by *Psittacanthus robustus* depend on the degree of infestation.

Aretha Franklin Guimarães Gomes -The danger is next door: effects of mistletoe parasitism on infected and uninfected branches.

The meeting began with expressions of honour to Job Kuijt.

JOB KUIJT

Following the enquiry in Haustorium 84 and thanks to Dan Nickrent and Job Kuijt's son Ian, we now have heard from Job, who comments that since retiring from University of Victoria some 10 years ago, he now has some health issues, and is living in Fernie, in the southern Canadian Rockies, close to family. His last paper was on a new species of *Ombrophytum* (Balanophoraceae) from the Chilean Atacama desert - 'A rather nice 'finis' to my career, the only Chilean species in that family. How I wish I had been able to see it - it is quite spectacular. I have been in Chile twice, but only further south, looking for mistletoes, when I did not know about this spectacular parasite.' (see Haustorium 78).

PROJECT UPDATES

PROMISE - Breaking the witches' spell.

The development of effective strategies to control *Striga,* also referred to as witchweed, has been a major focus of research in the past decades. Among the current approaches with most impact are those based on agricultural practices (e.g., soil management, push-pull), resistance breeding and chemistry. To date, however, none of these strategies is singularly effective on different crops, against different *Striga* species/ecotypes and across a diverse range of agroecosystems. In the PROMISE program (Promoting Microbes for Integrated *Striga* Eradication: https://promise.nioo.knaw.nl), we focus on characterizing microbial communities associated with *Striga* and its host plants (i.e. sorghum, rice, millet) to understand their role in the life cycle and infection process of this root parasitic weed. More specifically, we study a diversity of mechanisms by which soil and root-associated microorganisms could diminish the *Striga* seed bank or interfere with the early stages of root infection to enhance crop productivity. The experimental work ranges from studying the effects of edaphic factors on microbial community diversity and functioning across different agroecologies and crop cultivars to microbe-mediated changes of host root architecture, root exudation, and induction of *Striga* resistance. In the first 5-year phase of PROMISE, we discovered the functional potential of soil and root-associated bacteria and fungi to i) disrupt the early stages of the parasite's life cycle through the production of volatile organic compounds, ii) cause *Striga* seed decay or suicidal germination, iii) degrade host-derived germination signals and haustorium-inducing factors, and iv) induce structural barriers (aerenchyma, suberin) in the host plant roots. In collaboration with research institutes in sub-Saharan Africa and companies, the recently started Phase 2 program of PROMISE is focused on translating these findings into novel prototype products to augment *Striga*-suppressive activities of indigenous soil microbiomes and/or to introduce microbial inoculants as a key component of an integrated management strategy for effective and consistent *Striga* control in field settings.

Jos M Raaijmakers, Netherlands Institute of Ecology, Department of Microbial Ecology, Wageningen, the Netherlands, and 21 others from a total of 6 institutions.

LGSMAIZE - Proof- of-Concept grant to control witchweed infection in maize

LGSMAIZE is a Proof-of-Concept Grant from the European Research Council (ERC). With this grant Harro Bouwmeester will test whether it is possible to make African maize genotypes resistant to parasitic witchweeds using gene editing in the strigolactone pathway. This can be an enormous asset in the fight against *Striga* spp.

The parasitic witchweeds pose an enormous threat for production of cereal crops, such as maize, especially in the African continent. Witchweed seeds can lay dormant in the soil until their germination is triggered by strigolactones that are exuded by the roots of maize. In their research, the Bouwmeester lab found a North American cultivar that is resistant to witchweed, but is not adapted to the African climate (see Li et al., 2023 Science). It carries a mutation altering the composition of the strigolactones which results in less germination, and less witchweed infection. Together with researchers, Anindya Bandyopadhyay and Amos Alonya of the International Maize and Wheat Improvement Center (CIMMYT) the team will test whether editing this gene in African maize genotypes will result in the same phenotype. This will also be tested in the field in Kenya to test this in a relevant agricultural setting. If this works, this will create a new opportunity to control witchweed infection in maize in Africa.

The ERC Proof of Concept competition is open only to ERC grantees. Worth €150.000 each, the grants will be used to explore the commercial or societal potential of the results of grantees research projects. This funding is part of the EU's research and innovation programme, Horizon Europe.

Harro Bouwmeester.

Ref: Li, C. *et al.* 2023. Maize resistance to witchweed through changes in strigolactone biosynthesis. Science 379: 94-99. In Haustorium 83.

ZOOMINARS

IPPS seminars December 6, 2023

Jeanmaire Molina (Pace University, USA) - 'Reviving the corpse flower: unraveling the enigmatic biology of the iconic plant parasite *Rafflesia* for ex situ conservation'.

A rare spectacle to behold, *Rafflesia's* massive red-orange bloom stands out in the rainforestwith a malodor targeting carrion flies—hence the common name corpse flower–yet people are equally drawn to it. Unique to the rapidly deteriorating rainforests of Southeast Asia, *Rafflesia* species are in danger of extinction. Much like the panda, a charismatic icon of conservation, but unlike it, we don't understand enough of *Rafflesia* biology to cultivate it. *Rafflesia* is an endophytic holoparasite, completely dependent on its host vine *Tetrastigma* for nutrition, living inside it throughout its life and only emerging to flower. However, only a few *Tetrastigma* species support an infection, and it is unknown what makes certain species susceptible. Since 2015, I have been collaborating with the US Botanic Garden on the ex situ propagation of Philippine *Rafflesia* in the US, and we have been attempting to grow propagules of *Rafflesia* and their *Tetrastigma* hosts in Washington DC. Over the years, we've only had incremental success, but we have uncovered various aspects of *Rafflesia's* enigmatic biology—from understanding the effects of a *Rafflesia* infection on host chemistry, to elucidating the genetics of the *Rafflesia* seed, as well as characterizing its microbial symbionts. Our results have horticultural applications and bring us a step closer to growing Philippine *Rafflesia* in the US.Towards this end, I am also using my platform as a college teacher to engage young people here and abroad in plant research, so we not only cultivate *Rafflesia*, but also future scientists who will be able to carry on biodiversity conservation. Timing is critical, because once extinct, we can no longer revive the corpse flower.

Jian You (Eric) Wang (King Abdullah University of Science and Technology, Saudi Arabia) – 'Disruption of the rice MORE AXILLARY GROWTH1 (MAX1) uncovers specific functions of canonical strigolactones in the rhizosphere' Strigolactones (SLs) exert various biological functions as a plant hormone and signaling molecules.

They are best known for their role in regulating shoot architecture, inhibiting branching/tillering, and promoting symbiosis with mycorrhizal fungi. However, released SLs also induce seed germination in root parasitic weeds, such as *Striga hermonthica*, paving the way for host infestation. Rice and many other plants contain two types of SLs, i.e., canonical and non-canonical, defined by their structure. Albeit the progress that has been made in SL biology, the question of whether the two SL sub-families and their members have specific functions remains largely unanswered. However, identifying specific functions of the two SL subfamilies may enable the development of *Striga*-resistant cereals and/or engineering plant architecture. Currently, we showed that CRISPR/Cas9 rice mutants lacking canonical SLs do not exhibit the high tillering and dwarf phenotypes characteristic for SL-deficient plants, but release exudates with a significantly reduced *Striga* seed-germinating activity. This result indicates a particular function of canonical strigolactones as rhizospheric signals. Furthermore, genetic analysis of further SL mutants affected in the biosynthesis of canonical SLs demonstrate that a particular canonical SL plays a specific role in regulating root and shoot development as well as in rhizospheric communications. In conclusion, our work uncovers that rice canonical SLs are not tillering regulators, identifies specific hormonal functions of canonical strigolactones, paves the way for targeted engineering of rice architecture, and opens up the possibility of developing cereals with increased resistance to root parasitic weeds.

Sylvia Mutinda - 'Allele mining of the sorghum accession panel unravels new lgs1-1 mutants with resistance to the parasitic plant *Striga*'.

Sylvia is a Doctorate student of Molecular Biology and Biotechnology at Pan African University, Institute for Basic Sciences, Technology and Innovation. She doubles up as a research fellow at the Runo Lab, Kenyatta University, Kenya. Sylvia holds a Master's degree in Biotechnology from Jomo Kenyatta University of Agriculture and Technology. Upon completion, she obtained a PhD fellowship from the Pan African University, an African Union initiative and which she's currently finalising. She is a Mawazo fellow at The Mawazo Institute – a Kenyan-based organisation supporting the next generation of African women researchers and the uptake of home-grown and evidence-based solutions to local and global development needs. Sylvia's research focus has been on use of advances in plant sciences (genomics, genetics and molecular biology) to manage the parasitic plant, *Striga*, which greatly limit production of Africa's most staple cereals. In 2022, she was awarded research grants from the International foundation for Science (IFS) and the Mawazo fellows fund to support her research in harnessing natural sources of *Striga* resistance in sorghum.

Sorghum is a food staple for millions of people in sub-Saharan Africa, but its production is greatly diminished by parasitic weeds of the *Striga* genus. An efficient and cost-effective way of managing *Striga* in smallholder farms of Africa is to deploy resistant varieties. Here, we leverage genomics and the vast genetic diversity of sorghum – evolutionarily adapted to cope with *Striga* parasitism in Africa – to identify new *Striga* resistant sorghum genotypes. We exploit a *Striga* resistance mechanism that hinges on essential communication molecules – strigolactones (SLs) exuded by hosts to trigger parasite seed germination. We mined for mutant alleles of the LOW GERMINATION LOCI 1 (LGS1) that are ineffective in stimulating *Striga* germination from the sorghum accession panel (SAP). Our analysis led us to identify new lgs1-1 sorghum genotypes which we named SAP- lgs1-1. SAP lgs1 had the SL exudation profile of known lgs1-1 sorghum whose hallmark is production of the low inducer of germination, orobanchol. Laboratory and field resistance screens showed that the SAP-lgs1-1 genotypes also exhibited remarkable resistance against *Striga*. By potentially reducing crop losses due to *Striga* parasitism, our findings have far-reaching implications for improving food security in Africa.

PRESS REPORTS

Purdue researcher honored for service to nation in research of plant genetics.

Gebisa Ejeta stands in a sorghum field at Purdue's Agronomy Center for Research and Education. Photo: Thomas Campbell.

WEST LAFAYETTE, Ind. – President Joe Biden on Tuesday (Oct. 24) awarded the National Medal of Science to Gebisa Ejeta, Distinguished Professor of Plant Breeding & Genetics and International Agriculture, executive director of the Purdue Center for Global Food Security and Purdue University Presidential Fellow for Food Security and Sustainable Global Development. The award is the highest recognition the nation bestows upon scientists.

Ejeta studies sorghum, an ancient grain used widely as a food source for humans and livestock. He received the 2009 World Food Prize for his research in creating sorghum hybrids that are resistant to both severe drought and the destructive parasitic *Striga* weed. The resulting dramatic increase in sorghum production has helped feed hundreds of millions of people in sub-Saharan Africa.

'Gebisa Ejeta is one of the most impactful geneticists in the world, a remarkable leader at Purdue in food security research, and a role model of perseverance for all Boilermakers. Our university celebrates another prestigious and richly deserved honor, bestowed by the president of the United States, to Gebisa, and I am delighted to join him on behalf of our university at the White House ceremony today,' said Purdue University President Mung Chiang. 'With this latest exciting news, Purdue faculty and alumni have received 19 National Medals of Science, of Technology and Innovation, of Humanities or the Presidential Medal of Freedom, including three current faculty members.'

According to the White House, Ejeta was honored for outstanding contributions to the science of plant genetics. By developing sorghum strains that withstand droughts and parasites, he has improved food security for millions. His advocacy for science, policy and institutions as key to economic development 'has lifted the fortunes of farmers and strengthens the souls of nations.'

Ejeta has served at the highest advisory levels of science and national policy, including as special advisor to the administrator for the U.S. Agency for International Development, as science envoy of the U.S. State Department, and as a member of the National Academy of Sciences Board on Agriculture and Natural Resources. He also has been a member of the U.S. Board for International Food and Agricultural Development and the U.N. Secretary's Scientific Advisory Board.

Ejeta is an advocate for purpose-driven research. His own work is focused on elucidating the genetic and physiological mechanisms of important sorghum traits. Grain sorghum is the world's fifth-most important cereal crop. With its superior drought tolerance and broad adaptation, sorghum is grown worldwide, serving as a staff of life for over 500 million people in developing countries, and is the second-most important feed crop in the United States. Ejeta's research addresses some of the most crucial traits of sorghum production and utilization, including nutritional quality; drought and cold tolerance; and resistance to pests, diseases and *Striga*. He also investigates concerns of global biodiversity, gene flow and the use of sorghum as a biofuel crop.

The goal of Ejeta's sorghum research program is the development, release and deployment of improved sorghum cultivars for both food and feed use. His sorghum research is generally characterized by its sustained commitment to translational approaches that generates products and technologies from research findings to impact farm productivity and the eventual utilization and profitability of the crop postharvest. He utilizes a variety of research tools and works in interdisciplinary collaboration with a number of other scientists and programs. Ejeta has released many inbred lines and improved sorghum varieties and hybrids for use both in the United States and in Africa. His cultivars have been successfully deployed in several African countries.

Graduate education, mentoring of professionals and developing partnerships are integral components of his sorghum research program. Ejeta has trained and mentored a large cadre of domestic and international students and professionals at Purdue and in collaboration with other institutions. He has led many collaborative agricultural research and development projects, catalyzed the creation of public and private seed enterprises, and facilitated the formation of public-private partnerships in collaborating countries.

Ejeta was born and raised in a small rural community in west-central Ethiopia and was awarded the nation's National Hero Award, Ethiopia's highest honor, in 2009. He earned his master's and PhD in plant breeding and genetics from Purdue, where he has been a College of Agriculture faculty member and researcher since 1984.

Purdue University is a public research institution with excellence at scale. Ranked among top 10 public universities and with two colleges in the top 4 in the United States, Purdue discovers and disseminates knowledge with a quality and at a scale second to none. More than 105,000 students study at Purdue across modalities and locations, with 50,000 in person on the West Lafayette campus. Committed to affordability and accessibility, Purdue's main campus has frozen tuition 12 years in a row. See how Purdue never stops in the persistent pursuit of the next giant leap, including its first comprehensive urban campus in Indianapolis, the new Mitchell E. Daniels, Jr. School of Business, and Purdue Computes, at https://www.purdue.edu/president/strategic-initiatives .

CRISPR-edited crops break new ground in Africa. Scientists in the global south use the popular technique to protect local crops against local threats.

Molecular biologist Steven Runo once thought that his team would make history as the first to plant gene-edited seeds in African soil. The competition turned out to be stiffer than he'd anticipated. A research group working on maize 'beat us by two or three months', says Runo, who works at Kenyatta University in Nairobi and whose gene-editing project focuses on sorghum. 'But that's good — African countries will see that this is actually possible.'

The friendly rivalry is a sign of progress. Researchers have long hoped that the relative ease and low cost of CRISPR gene-editing systems would make it possible for scientists in low- and middle-income countries to produce crops with traits tailored to the needs of local farmers — rather than relying on seeds developed in foreign countries. Now scientists are overseeing at least a dozen efforts to develop such gene-edited crops.

Among those projects is Runo's effort to engineer sorghum to be resistant to *Striga hermonthica*, a troublesome species of a parasitic plant known as witchweed. Field trials of the new variety are scheduled for later this year, Runo said at the Plant and Animal Genome Conference in San Diego, California, on 16 January. 'It's not as easy as people make it out to be to do gene editing, but it is pretty accessible,' says Kevin Pixley, a research director at the International Maize and Wheat Improvement Center in Texcoco, Mexico. 'Runo is a perfect example of that.'

Sorghum is a hardy crop that is used widely in Africa for food, building materials and feedstock. But more than 60% of African farmland is contaminated with species of *Striga*, a parasitic plant that attaches itself to sorghum roots and siphons away nutrients and water. A witchweed infestation can wipe out an entire crop. Some wild varieties of sorghum are resistant to *Striga* because they carry mutations that alter the crop's production of compounds called strigolactones, which promote germination of *Striga* seeds. Runo and his collaborators have used CRISPR–Cas9 to mimic these mutations.

Under Kenya's 2022 regulations governing gene-edited crops, such plants are treated like conventionally bred crops because they do not contain DNA from another species. This means that these gene-edited plants can bypass some of the heavy testing and requirements imposed on genetically modified crops that contain foreign DNA. Nigeria and Malawi have similar policies, and other African countries, including Ethiopia and Uganda, are expected to follow suit, Runo says. Last year, Kenyan authorities gave Runo and his collaborators permission to grow the gene-edited seeds under those regulations, and he plans to launch field studies later this year. It is a significant step, Runo said at the conference, because *Striga* is not a problem in wealthier regions — meaning that large, multinational corporations have little incentive to develop solutions for it.

Runo has relied on funding from the US Agency for International Development and has collaborated with Corteva Agriscience, an agricultural company in Indianapolis, Indiana. Pixley and his team have received funds from the Bill & Melinda Gates Foundation in Seattle, Washington, and have also gotten technical assistance from Corteva. Runo is mindful that this support might not always be available. He and his team are working on cutting the cost of lab supplies and equipment and finding alternative funding sources. Also unknown, says Pixley, is how intellectual-property battles over CRISPR gene editing will ultimately affect efforts in Africa, and whether foreign markets — particularly in Europe — will be open to African-grown gene-edited crops.

But as for local acceptance of the crops, Runo says the farmers he has spoken to feel more comfortable with crops developed by a local researcher than with seeds developed abroad. 'This is not a multinational company. The people using the technology are people you have grown up with,' he says. 'The narrative is very different.'

Heidi Ledford, Nature
See also: doi: https://doi.org/10.1038/d41586-024-00176-8

In Kenya, Nigeria and Malawi, gene-editing is saving crops.

A dozen genetic-editing projects for crops in Africa are achieving incredible results. For more than 20 years, European countries have been repressing this technology, due to pressure from certain environmental groups

On the African continent, a dozen genetic-editing projects are being put at the forefront of agriculture. However, for the past 20 years, European countries have been repressing this technology, due to pressure from certain environmental groups and — above all — uncritical acceptance by a large part of upper-income countries. These opinions contradict science. As Norman Borlaug — the father of the Green Revolution — noted in a past interview with EL PAÍS: 'environmentalists oppose GMOs because their bellies are full.'

Greenpeace made the biggest mistake in its history by turning its opposition to GMOs into one of its main campaigns, alongside the rightful battles that it wages against radioactive waste, ocean pollution and climate change. Scientists have been pointing out this anomaly for decades, but the directors of Greenpeace have insisted on being on the side of irrationality… even after a hundred Nobel Prize winners accused them of crimes against humanity for maintaining this position. Fortunately, the situation is changing, right where it's most-needed.

Sorghum is an essential crop in many African countries, not only for food, but also as building material. However, 60% of the continent's fields are suffering from a devastating invasion of *Striga hermonthica*, a parasitic plant sometimes called 'witchweed.' This weed attaches itself to the roots of sorghum and sucks away water and nutrients, until it destroys the entire crop.

Scientists from all over the African continent have solved the problem with CRISPR, the groundbreaking gene-editing technique that has revolutionized biology laboratories in recent years. Field trials will begin this year. Molecular biologist Steven Runo — from the University of Kenya in Nairobi — announced this at the Plant & Animal Genome Conference held in mid-January in San Diego, California.

CRISPR has two advantages over its transgenic predecessors. Firstly, it's cheap and easy to use. This allows any country to modify seeds to solve its local problems — be they pests or nutritional deficiencies — instead of depending on those generated by a few multinationals, such as the defunct Monsanto, whose commercial practices were the main cause of opposition from environmentalists. But what we're talking about now has nothing to do with Monsanto — rather, it has to do with human health and bolstering nutritional security in developing countries.

Secondly, CRISPR doesn't require adding foreign genetic material to solve agricultural problems. In fact, it can introduce a genetic variant into a plant that already exists in nature and that, therefore, could be obtained through conventional crosses that farmers have used for 10 millennia. Nobody has the slightest ethical objection to such a process. Obtaining the desired hybrid sans technology, however, is a frustratingly slow process, especially given the pressing needs of low and middle-income countries. CRISPR achieves the same results in the blink of an eye. Dr. Runo has applied it successfully to the case of sorghum in Kenya.

While the members of the European Union debate about whether CRISPR deserves to be excluded from a ban on genetically-modified plants that it imposed 20 years ago (without the slightest scientific argument), various countries in Africa have pushed forward with more rational regulations.

Since 2022, Kenya, Nigeria and Malawi have approved that plants edited with CRISPR should be classified in the same way as any conventional variety. Uganda and Ethiopia are in the process of doing the same.

Sorghum is just the beginning. Regardless of what the EU stipulates, African and Asian countries will use genetic-editing more and more, because they have perceived that it will be useful to improve the nutrition of their human populations and their livestock. As far as we know so far, researchers working in Africa and Asia have set up projects to generate corn that's resistant to necrosis, pearl millet that isn't ruined by oxidation shortly after it's grinded, peanuts that are resistant to infection by carcinogenic fungi and — going from the plant world to the animal world — cows that produce more milk, despite high temperatures.

Those who work at Greenpeace are good people with the best intentions. Many of their campaigns are laudable. If Greenpeace didn't exist, it would have to be invented. But we all make mistakes on occasion. And it's best to recognize this, to stop confusing the public and delaying vital advances for disadvantaged populations.

Javier Sampedro, Madrid - Feb 03, 2024

Further notes on Elephanthead lousewort, *Pedicularis groenlandica*.

From the scientific name *P. groenlandica,* one might think the species is widely distributed in Greenland, however, it is only known from one locality, Præstefjord, about 27 km southeast of the main city Nuuk where it grows on a moist river bank (Fig. 1). The Danish botanist Johannes Vahl found it in 1790ties and assumed it was a new species. Therefore he sent herbarium material to Linné in Sweden, who passed it on to his pupil A J Retzius, who became a professor in Natural History at the University of Lund. Retzius was unaware that the species occurred in many localities in North America and he named it *P. groenlandica* Retz. based on the material from the type locality in Præstefjord. Funny enough, its presence in Greenland was forgotten for more than 150 years and it was first rediscovered in 1940 by botanists. - The twisted upper lip of the flower resembles an elephant's trunk and is preserved in the ripe capsule for longer time (Fig. 2). No doubt the shape of the lip inspired P A Rydberg when he established the synonym *Elephantella groenlandica* (Retz.) Rydb., which was published in 1900 in Mem. New York Bot. Gard. 1: 363.

Of cause, it is unknown how *P. groenlandica* came to Greenland, but snow geese most likely have transported seeds across the Baffin Bay from Canada. Snow geese raise young in many places in Greenland during summer and migrate to North America for the winter. Most likely they have also introduced another lousewort from Canada to Greenland in recent time, exactly *P. albolabiata* (Hulten), Y P Kozh. which Ib Johnsen and I found at Qaanaaq in 1994 as the second of only two known localities in Greenland.

Henning S. Heide-Jørgensen

Kākā numbers skyrocket in annual Landsborough Valley bird count.

Kaka. Photo: 123RF

DOC principal scientist, Colin O'Donnell says the standout number of kākā observed in the most-recent survey was likely due to the birds being attracted by an abundance of flowering mistletoe in the valley. Figures from the most-recent bird count in a South Westland valley show numbers of kākā have doubled in the last year. The Department of Conservation (DOC) has been carrying out an annual bird count in the Landsborough Valley for the last 25 years. Data show eight native bird species have steadily increased in number over this time, while six other species remain stable. Overall, native birdlife has more than doubled in this remote beech forest-clad valley.

O'Donnell said the Landsborough was a showcase for how forests and wildlife responded when rats, stoats and possums were effectively managed long-term. Predator control began in the Landsborough in 1994, and DOC also carries out aerial applications of 1080 (sodium fluroacetate for rat control) and extensive trapping in the area. Figures showed native birds were continuing to increase, including species like pīpipi/brown creeper, tītitipounamu/ rifleman and kākāriki/yellow-crowned parakeet. ‘Kākā were the standout in the most recent results with numbers doubling from the previous year - no doubt attracted by the mistletoe which was flowering in big splashes of red across the valley.’ When the bird count started 25 years ago only 18 kākā were spotted, and in the most recent year 116 kākā were observed.

There had also been an impressive increase in mohua/yellowhead over the course of the study, with only 14 seen in the first count, and 485 in the most recent. Overall, native bird numbers in the areas had doubled over the 25 years, he said. ‘The birds are so abundant, the forest is alive with birdcall all over the place. The kākā numbers were really high which was gratifying but some of the other birds that have increased steadily over the years are maintaining increases which is really exciting to see.’

There were, however, some declines. The number of silvereye/tautou and long-tailed cuckoo/koekoeā numbers had both declined. Greater competition for nectar from tuī and bellbird may have suppressed silvereye numbers, and long-tailed cuckoo migrate to the Pacific islands each winter and may be being affected by conditions there, O'Donnell said. Introduced bird numbers had also declined.

The DOC team spends several days in early summer each year doing 5-minute bird counts at 174 stations in the Landsborough. Since the monitoring began 25 years ago the teams have counted around 106,000 birds.

New Zealand West Coast, 4 September 2023

How we brought mistletoes back to the trees of Melbourne – while warding off hungry possums

Until recently, mistletoes were regarded as problematic pests across Australia. They were seen as having been introduced from elsewhere, exploiting helpless trees and driving their premature demise. Around the world, arborists and plantation managers used to be trained to remove mistletoes as part of routine maintenance. They went to extraordinary lengths to rid trees of these dense parasitic clumps, using flamethrowers, high-powered rifles, even herbicide-spritzing drones. But just as we now know that hollows are essential for wildlife, including many threatened species, awareness of the positive side of parasitic plants is growing. Mistletoes have been shown to boost biodiversity and increase resilience of wildlife populations to drought, habitat loss and predators. However, unlike other plants that can be grown as seedlings and planted out, mistletoes rely on animals to plant their seeds on the branches of host trees. This means they aren't included in revegetation efforts, and it was unclear whether it would even be possible.

Mistletoebirds spread the mistletoe seeds. Photo: Jeremy/Flickr, CC BY

We set out on a world-first trial to attempt to reintroduce mistletoe to the trees of Melbourne. As our recently published research shows, we succeeded. Some of the mistletoes are now even bearing fruit. The only factor that stood in the way of success was the bane of many gardeners' lives – hungry brushtail possums.

Mistletoes provide many benefits for local biodiversity. Their flowers provide reliable nectar that encourages pollinators to linger longer. They then boost the populations of other plant species they visit. The nutrients in mistletoe leaves boost soil health and dramatically increase insect numbers when they fall to the forest floor. The ripples of these interactions spread right through woodland food webs. One study demonstrated the most significant impacts on ground-feeding insect-eating birds, whose numbers have declined across eastern Australia. Many birds nest in mistletoes. Their dense evergreen foliage provides cover from predators.

All of Australia's mistletoes are native species. Most hail from ancient lineages dating all the way back to Gondwanaland.
The knowledge we have gained about mistletoes has led to an about-face in natural resource management. Managers are rethinking mistletoe removal and embracing these native plants as ecological keystones. In some areas where mistletoes no longer occur, restoration practitioners have suggested reintroducing them. It had been unclear if this was feasible.

Working closely with City of Melbourne staff, research scientists from the Gulbali Institute undertook a world-first trial of the reintroduction of a native mistletoe to street trees. Rather than eucalypts or other native trees, we decided to use plane trees, a European species that is a feature of city streets the world over. In Australia, very few things interact with plane trees — nothing eats them, which is one reason they're popular street trees. Rather than replace these established trees with more fitting local species and waiting a few decades for them to grow, we tried something a little different. We added a native mistletoe to their canopies to boost the resources available to urban wildlife.

We chose creeping mistletoe (*Muellerina eucalyptoides*), which is now scarce in Melbourne, but is just as happy growing on exotic deciduous trees as the evergreen eucalypts this species depends on as hosts in the bush. Our research paper summarizes the outcomes of the trial. Almost 900 seeds were carefully wiped on the branches of 28 plane trees. We were replicating the efforts of mistletoebirds, which usually spread these sticky seeds.

Five years after inoculation, we found mistletoes had established on five trees. Even better, two of these plants were full of fruit. There is now a ready-made seed source in the heart of Melbourne for further expansion of these beneficial native plants.

Rather than establishment depending on the size of the branch, the age of the tree or which direction it faced, the only factor that emerged as a significant determinant of success was whether or not the tree was fitted with a possum collar. These acrylic or metal sheets wrapped around the trunk are too slippery for possums to climb. The city's tree management team routinely uses these collars to grant a reprieve to trees whose canopies have been badly damaged by these marsupials. Previous work has found possums love to eat mistletoe foliage. This is likely due to their high concentration of nutrients and lack of chemical defences that eucalypts have. Our study is the first to provide direct evidence of the effect of common brushtail possums on mistletoe recruitment. Its findings reinforce reports from New Zealand, where introduced brushtail possums have devastated three mistletoe species and been implicated in the extinction of a fourth, the only mistletoe known to have gone extinct worldwide.

Time will tell how the addition of these plants to the urban forest will affect Melbourne wildlife. Already, gorgeous imperial jezebel butterflies have been spotted emerging from creeping mistletoes in Princes Park.

The imperial jezebel lays its eggs only on mistletoes. David Cook/Flickr, CC BY-NC

Even better, our work has inspired three other urban mistletoe reintroductions elsewhere in Melbourne. In New South Wales, Birdlife Australia and Mindaribba Local Aboriginal Land Council are working together to restore mistletoe to woodlands on Wonnarua Country. The mistletoe will supply missing nectar resources for the critically endangered regent honeyeater. Collectively, this work is helping to shift the public perception of these native plants – from pernicious parasites to ecological keystones.

David Watson and Rodney van der Ree, September 11, 2023.
See: Watson *et al.* 2023 below.

Agago, Uganda - *Striga* weeds destroy 600 acres of crops.

Striga weeds have destroyed an estimated 600 acres of crops in Agago district. The most affected parishes are; Aywee, Gudi, Kiwaro, Ngwero and Luzira in Lokole Sub-County. Also known as witchweed, *Striga hermonthica*, is a parasitic weed that attacks mostly cereal crops such as maize, rice and millet. By attaching its roots to the roots of the crop to obtain nutrients, the weed leaves the crop undernourished and stunted.
David Okwera, a farmer in Ogolo Village says he planted four acres of sorghum and three acres of maize which have all been destroyed by the weed. According to Okwera, the weed seems to affect even non-cereal crops such as cassava and sunflower. He explains that cassava intercropped with *Striga* weed tastes bitter, while the sunflower doesn't produce many seeds. Okwera appealed to the Department of Agriculture and Production and the Ministry of Agriculture Animal Industry and Fisheries to devise means to kill the weeds when they have just germinated.

John Oryem Alutu, a farmer in Roma Village, Aywee Parish, Lokole Sub-County says he planted four acres of maize and harvested only three bags. Alutu appeals to the District Agriculture Officer to undertake massive sensitization of the farmers on the kinds of crops to plant so that they are not left food insecure because of the weed.

Agago District Agriculture Officer Charles Ojwee says *Striga* weed seeds can survive up to 30 years in the soil and thinks that the *Striga* weed invaded the area even before the people were displaced in the camps. He advises farmers to practice early planting and crop rotation to mitigate the effect of the weeds.

According to NARO, maize yield losses attributed to *Striga* infestation exceed 70 per cent, mainly when the weed combines with other constraints such as drought, disease, and nitrogen stresses. Statistics indicate that Uganda has 262,000 hectares of *Striga* weed.

The Independent, September 9, 2023.

Parasitic weeds threaten tomato plants on California farms.

At first glance, *Orobanche ramosa* looks like an interesting blossoming plant, one that could add a unique flair to flower arrangements. But it's a parasitic weed that attaches to roots, sucks out nutrients and is threatening California's lucrative $1.5 billion processing tomato industry. Its resurgence is concern for state regulators and industry, which is helping fund multidisciplinary research at the UC Davis, on ways to detect, manage and fight the weed.Across three colleges at UC Davis, researchers are working on ways to detect the pest, manage it in the field throughout its life cycle and develop long-term solutions to minimize the threat to California agriculture. The work is happening in labs and the field, using drones, human spotters and new techniques to sniff out volatile organic chemicals that are emitted when the weed is present. They are also testing ways to sanitize farm equipment to reduce the risk of spreading seeds from contaminated fields to clean ones. And they are testing dozens of other crops to see if they are susceptible or could be used as false hosts to kill off the *Orobanche* seeds in the soil.

The California Department of Food and Agriculture and industry had a program from the 1950s through the 1970s to eradicate the weed, which is commonly known as branched broomrape. But the weed showed up again in Yolo County in 2017. 'Believing it to be eradicated, the industry moved on to other challenges,' said Zach Bagley, managing director for the California Tomato Research Institute Inc., or CTRI. 'We've been aggressive, with this as our top priority, and we've been putting the funding behind it.'

CTRI's research budget for 2022 and 2023 is nearly $1 million, and half of that money has gone to fund six researchers and their teams at UC Davis and UC Davis Chile, as well as some work at University of Wisconsin.

It's hard to know quite how far *Orobanche* has spread. Yolo County farmers reported 71 to 403 acres affected between 2017 and 2022, with some years seeing less and others more. No cases have been reported this year, Yolo County Agriculture Commissioner Humberto Izquierdo said.
But *Orobanche* weeds could be sprouting up elsewhere. 'The issue with this pest is that growers are very reluctant to report it and it's not an easy issue to spot,' Izquierdo said. 'The regulatory requirements are very strict. Once it's found, we limit harvesting on that field.' The weed is considered a quarantine pest in California and because of that, crops must be destroyed once a case is reported, and no susceptible crops can be planted for two years. Agriculture commissioners can also quarantine fields up to a mile away. Izquierdo works with canneries and the CTRI to promote good sanitation policies, so the weeds don't spread. But with a limited number of inspectors, it's hard to get a handle on the extent of the problem without consistent reporting. 'If we don't know where the problem is, we can't deal with it,' he said. 'It really takes cooperation from industry to be able to move forward.' The low reporting numbers combined with the hardiness, number and sheer longevity of *Orobanche* seeds requires more than regulatory action.

A local grower recognized the issue needed research and allows Hanson, Fatino and other UC Davis scientists access to a 3-acre plot in Woodland where tomatoes are planted in infected soil. There, researchers test out different ways to control the weeds on the ground and others take to the air to scan for evidence of the pest. In Fatino's experiment, different herbicides of varying concentrations have been applied via irrigation to the rows in an attempt to gauge what may work best controlling the *Orobanche*. The chemicals must be authorized with the state and have restrictions on use.

At that same plot, Ph.D. student Mohammadreza Narimani and others from the Digital Agriculture Laboratory, which is run by associate professor of Cooperative Extension Alireza Pourezza, use drones equipped with special cameras and technology to scan the field. Four drones fly over the field, equipped with Light Detection and Ranging, or LIDAR, scanners, RGB, multispectral and hyperspectral cameras. As the drones fly, real-time images appear on a laptop, filling in the screen square by square with images and data from the camera's sensors to be analyzed later in the lab. The LIDAR measures height, area and volume for each plant, and that information is used to create detailed 3D models, which can be used to compare healthy and infected plants remotely. Hyperspectral imaging captures a wide spectrum of light beyond what the human eye and normal cameras can detect, allowing for in-depth analysis and sorting. It can also detect plant traits such as leaf structure and monitor during different plant life stages. The team also collects leaves to be scanned and analyzed in their lab. 'Different characteristics of plants reflect light in a different way, which results in them appearing in different colors,' Narimani, the drone pilot, said. 'We can monitor different levels of nutrients in the plant and identify if there are any signs of broomrape.'

Back on campus, the weeds are carefully studied in a secure environment known as the Contained Research Facility, or CRF, which is dedicated to studying invasive plant pests, ranging from pathogens and weeds to nematodes and certain invertebrates like spiders and insects.

The facility is the first of its kind in the west and houses labs, greenhouses and growth chambers. In a small space set aside for *Orobanche*, postdoctoral scholar Pershang Hosseini has a handful of projects. One is in conjunction with plant pathologist Cassandra Swett, an associate professor of Cooperative Extension, testing if certain sanitizing chemicals can kill the seed, removing the threat of *Orobanche* and other pathogens spreading on farm equipment. Another involves planting more than two dozen crops to see if they are susceptible to *Orobanche* or if they could serve as false hosts. Hosseini is also studying a chemical that is similar to one tomato plants contain that signals *Orobanche* to germinate when no host exists, essentially causing it to commit suicide.

Other professors are also using the space for related research, and one project involves smelling volatile organic chemicals. 'We're basically sniffing out diseases or infections or parasites,' said Cristina Davis, professor of mechanical and aerospace engineering. Davis and her lab director and staff researcher Mitchell McCartney developed a sensor to detect *Orobanche* by measuring odours emitted from plants affected by the weed. 'The plants tend to give off gas as an alert signal around themselves to warn other plants. There's all this information that's being passed around us in the air, but the human olfactory nerve isn't sensitive enough to pick up on those changes.' At the Contained Research Facility, tomato plants are enclosed in an airtight space and fresh air is pumped in, while a sponge-like sensor collects what is emitted into the air. Back at their home lab in the College of Engineering, Davis and McCartney superheat the sponges to release volatile organic chemicals. 'It captures a snapshot of odour,' he said. If a unique chemical signature can be isolated, fields could one day be sniffed for *Orobanche* weeds, serving as an alert system.

Professors Neelima Sinha and Siobhan Brady in the College Biological Sciences are examining how early infections of *Orobanche* affect a tomato plant's genetics, specifically its RNA. 'The goal is to figure out if there are very early gene expressions when plant roots are attached by broomrape,' Sinha said. 'Early response is where we feel resistance will lie.' Brady is looking at if the cell types of tomato plant roots could be modified to create a barrier to the weed from attaching. 'It's a combinational approach to attack from all these different points in the life cycle,' Brady said of the UC Davis research. 'It's attacking the attacker.'

For Hanson, the research is among the most collaborative that he's been a part of and shows how real-world problems can be addressed when industry, regulators and researchers work together. 'We're making progress on a major threat to California agriculture,' he said, 'and it's really rewarding to be a part of the research team.'

By Emily C. Dooley, UC Davis News Service

Take on Nature: Ancient threads run through festive celebrations.

The mistle thrush defies the desolate winter with its song of hope. Although the natural world appears now only as a quiet backdrop to our busy human sphere amidst Christmas preparations, it does still weave its way into the Christian festival, evident through symbols and some of the accompanying secular activities.

Timely then, when last week I observed some mistle thrushes amongst a mixed flock of redwings and fieldfares, winter thrushes here for winter from Iceland and Scandinavia to feast on berries and invertebrates. Deargán sneachta, Irish for redwing, translates as 'red snowbird' alluding to its winter association and red patches along its flank. The fieldfare has a distinctive grey head and nape, and both share the speckled breast of our resident mistle and song thrushes.

The mistle thrush is closely linked with mistletoe, a parasitic plant found around the fringes of Christmas celebrations as a lure to encourage romance. A non-native, mistletoe appears in yellow clumps on deciduous trees, its bright green leaves and luminous sticky white berries standing out in the dark of winter as its twigs branch out into little boughs.

It is this stickiness, noted in its Latin name *Viscum album*, 'white sticky stuff' which helps it transfer to different trees such as hawthorn and willow, with the thrush's assistance. The mistle thrush will, after feeding on berries distribute seed by wiping its bill on the barks of other trees, where rootlets will penetrate and feed off the new host tree, hence the bird's name.

Stephen Colton, Life, December 15, 2023.

For the song of the mistle thrush:
https://www.google.com/search?sca_esv=a5f19286ad197ea8&hl=en&q=mistle+thrush+song&tbm=vid&source=lnms&prmd=vinbmtz&sa=X&ved=2ahUKEwjZnYblup-FAxXdUUEAHZcnCf0Q0pQJegQIEBAB&biw=1068&bih=806&dpr=1#fpstate=ive&vld=cid:6517494b,vid:68jDXIGUBMo,st:0

New Zealand's underground parasite plant pollinated by bats.

Photo: DOC

A parasitic plant that is pollinated by the short-tailed bat is now only found in a few spots across the North Island, but was once widespread across both islands. *Dactylanthus taylori* is New Zealand's only indigenous, fully parasitic, flowering plant, and Department of Conservation Hauraki operations manager Avi Holzapfel works to protect them.The Māori name for the plant is pua o te reinga - flower of the underworld - which relates to the way its flowers emerge from below ground. ‘It's a very unusual plant and most people wouldn't recognise it as a flowering plant,’ he said.’It looks when you come across it like a warty bit of wood or like a root burr. But it's an underground plant that lives on the roots of host trees. It's a parasitic plant, which means that it's fully dependent on these trees for its survival, mainly completely underground.’Only when it flowers, it comes above the forest floor.’
The underworld plant can only be seen by those who are lucky enough to see it in flower, or if they can see an exposed part of the plant's body.’When it flowers it has a very strong smell, a very sweet smell, a bit like ripe melon or over ripe fig.’When it is not flowering, humans cannot smell the plant - but pigs can.It is a very unique type of parasitic plant that does not occur anywhere else in the world, Holzapfel said.’It has no green leaves. It doesn't produce chlorophyll when it grows, it grows together with the host root. It doesn't harm the host. Doesn't harm the tree.’And then when it flowers, it produces these enormous amounts of nectar at a time when hardly anything else flowers in autumn in New Zealand. And so lots of animals are using the nectar and feed on it.’It's a little bit like a meeting point on the forest floor, like a pub.’

There is another part of the pua o te reinga story that is unique, Holzapfel said. The plant is pollinated by the New Zealand short-tailed bat.’It's probably one of the only flowering plants that's pollinated by bat on the ground.’Because bats normally fly around and pollinate things in flight, but in this case our bat is really well adapted to crawling on the forest floor.’It sort of crawls on its elbows. It seeks out the dactylanthus and it feeds on the nectar, and while doing that it gets pollen on its face and flies to another plant and puts the pollen there.’That's the one pollinator that we know of. I'm pretty sure there are other pollinators as well that we just haven't seen.’

Photo: DOC

The flower of the underworld grows in the North Island only, in a few spots including the Central Plateau, East Cape and Little Barrier Island. But once upon a time it was widespread across both islands, Holzapfel said.’It's not as common as it should be and it's not limited by habitat because the host trees that it grows on, they are everywhere. We don't have any shortage of whole trees.’It's the lack of reproduction that makes it so endangered today, and that mainly comes from browsing by introduced puzzles, rats and mice.’Holzapfel said people can get involved in helping to bring the flower of the underworld to more areas of the country.’We're trying to now increase the population - basically creating new plants, new populations, and you can do it by taking seed and sewing it into suitable places where there are host trees.

‘The places where we've done it, quite a few of them have been successful. And the beauty is that those young populations there will be probably there for 30-40 years. So the plants are very long lived and that is a long time to again produce seeds and you basically take that seed and put it somewhere else.’You can grow them exponentially once you've established them in a new place. So it's feasible. Otherwise the plants are just getting older, and the older they get, the fewer female flowers they get and the fewer chances they have to actually reproduce.’
See also: https://www.nzgeo.com/stories/flower-of-hades/

Vast DNA tree of life for plants revealed by global science team using 1.8 billion letters of genetic code.

A new paper published April 24 in the journal Nature by an international team of 279 scientists led by the Royal Botanic Gardens, Kew presents the most up-to-date understanding of the flowering plant tree of life. Using 1.8 billion letters of genetic code from more than 9,500 species covering almost 8,000 known flowering plant genera (ca. 60%), this incredible achievement sheds new light on the evolutionary history of flowering plants and their rise to ecological dominance on Earth.

Credit: Sidonie Bellot, RBG Kew

(Including) Parasitic plant family mystery solved: *Pilostyles aethiopica*, member of the stemsucker family (Apodanthaceae). Sequenced from plant tissue collected in Zimbabwe in 2012 by Kew's Sidonie Bellot. This weird parasite lives inside the branches of other plants and is only visible when it erupts into flower. Previously thought to be closely related to pumpkins and begonias (Cucurbitales), study found it sits in the group Malpighiales.

Royal Botanic Gardens, Kew

***Rafflesia* featured by Ted-Ed.**

https://www.youtube.com/watch?v=4dPV9UnDEFY l

Many of you may be familiar with Ted (Technology, Entertainment, Design) for the conferences and talks it has organized for several decades. You may be less familiar with one of its other products called TED-Ed, a YouTube channel that features short animations on many different topics (see ed.ted.com). Over the past year I have been involved with the people at TED on a project focused on *Rafflesia*. Although not my choice, they titled the video "Why does this flower smell like a dead body?" The animation can be found here: https://www.youtube.com/watch?v=4dPV9UnDEFY. The video lasts for only 5.5 minutes and is packed with information on the biology of the "Queen of Parasites," such as its morphological and anatomical features, holoparasitic nature, distribution, life cycle, horizontal gene transfer, floral biology and pollination. As its name implies, the goal of Ted-Ed is education, and these short animations are a great source of information not only for students of various ages but adults as well. There are over 200 results when "plant" is searched, including ones on carnivorous plants and mistletoes.

Dan Nickrent

THESIS

Maddu, Venkata Siva Sankar 2023. Reconstructing the germination pathway from the Rafflesia seed transcriptome. Master of Science (MS). Long Islasnd University, USA. Advisors: Jeanmaire Molina, Fatma Abo, Joseph Morin.

Abstract

Rafflesia (Rafflesiaceae) produces the largest flowers in the world but has no stems, roots, or leaves. It is a holoparasitic angiosperm that derives all its nutrients from its host vine, *Tetrastigma.* All species are also threatened with extinction, but propagating it has been incredibly challenging. Its germination from seed has never been observed. The thesis aims to reconstruct the germination pathway of *Rafflesia* from its published seed transcriptome to gain insight into its molecular genetics and understand what germination genes can be stimulated to facilitate infection of its host for ex-situ propagation. The published seed transcriptome of *Rafflesia speciosa* was annotated. These were then bioinformatically compared to the seed germination pathway genes in the model photosynthetic plant Arabidopsis (Brassicaceae) and in another parasitic plant, *Striga* (Orobanchaceae), to determine if there are similar genes conserved, especially the Strigolactones-responsive gene which promotes *Striga* germination in response to hormones called strigolactones. The assembled *Rafflesia speciosa* seed transcriptome contained more than 123,000 transcripts. Out of more than 123,000 de novo assembled transcripts, 7025 with blast hits were mapped and annotated. Among these, genes involved in abscisic acid, auxin, brassinosteroids, cytokinin, and ethylene signalling were detected in *Rafflesia,* in common with those in Arabidopsis.

Still, no Strigolactones-responsive genes were detected in *Rafflesia.* This study showed that some germination signalling genes are conserved between *Rafflesia* and *Arabidopsis* but not with another parasitic plant. This suggests that strigolactones will not be useful in stimulating *Rafflesia* germination for propagation attempts.

BOOKS

Chris Thorogood 2024. Pathless Forest. The Quest to Save the World's Largest Flowers. Penguin Books, 269 pp.

A botanist goes in search of the vast, stinking Rafflesia in its natural habitat.

If you think of flowers as beautiful, fragrant, decorous and domesticated – something you order from an online florist or pick up at your local garden centre – Chris Thorogood's Pathless Forest should come with a health warning. It's a love letter to the largest flowers in the world: the monstrous blooms of the 40-odd species – no one knows quite how many exist, or may have already been driven to extinction – of Rafflesia. This stinking, sprawling 'corpse flower' grows in the tropical rainforests of Malaysia, Thailand, Indonesia and the Philippines, and from its nickname on, nothing about it is pretty. It's a parasite that mimics the odour and appearance of rotting flesh to attract its favoured carrion fly pollinators, with a bouquet featuring notes of 'blocked drains', 'sewage', 'pigs' shit' and 'bad chicken'.

It's also the lifelong love of Thorogood, a botanist and academic who admits to a relationship with Rafflesia that echoes the monomania of any Werner Herzog antihero. 'Dragged helplessly to heaven through hell and back, he became half-sick with his obsession to find it,' he writes of himself; like its subject, his prose is undemure, supersized, unbound by convention. The story starts with Thorogood as a plant-bewitched child, modelling Rafflesia blooms from papier-mache in an overgrown cemetery behind his family home. (He's also a botanical artist with a popular Instagram account, and Pathless Forest is illustrated with his own detailed, atmospheric drawings and paintings of expedition colleagues, rainforest plants – and Rafflesia in all its liver-coloured, white-splotched glory.)

Several degrees later, Thorogood is now deputy director of the 400-year-old Oxford Botanic Garden. Like Britain's other great scientific gardens, from Kew to Cambridge and Edinburgh, it flourished under an empire that drew much of its wealth from colonial cash crops: cotton, spices, tea, coffee, sugar, tobacco, indigo, opium. For the 'plant hunters' of this age, botanical knowledge was inextricably linked with imperial conquest. Rafflesia itself is named after the British colonial administrator Stamford Raffles, who saw it flower in Bengkulu, Indonesia in 1818, the year before he established the trading post that would become Singapore.

But, unlike more tractable plant trophies, it has since refused to be cultivated in botanic gardens or even successfully stored in seed banks; the only institution in the world that has managed to coax it into bloom by grafting it on to a host vine is Bogor Botanical Gardens, near Jakarta. With more than 90% of forest cover lost in the Philippines alone, its dependence on its original habitat has left Rafflesia at severe risk of extinction – a ticking clock that n propels Thorogood's race to help document it in the wild and learn the secrets of its propagation.

In this overwhelming, densely woven setting, the boundaries between person, plant and environment start to dissolve.

The journey transports him from the orderly glasshouses, lily ponds and walled gardens of his Oxford base into the titular pathless forests of Rafflesia's range. This is a world of plants on the loose – Thorogood describes a dizzying profusion of species as he pushes through undergrowth, scrambles up mountainsides, and wades rivers with local researchers and guides. Birds and animals barely get a mention except as pollinators or antagonists (step forward Sunda porcupines and Java mouse-deer, which cause much botanist heartbreak by gnawing on Rafflesia blooms). These forests aren't the familiar backdrop of nature documentaries; here, they're the stars.

In this overwhelming, densely woven setting, the boundaries between person, plant and environment start to dissolve, along with old assumptions about what plants are. 'I'm starting to think like the forest,' Thorogood writes. At intervals, his book takes on the voice of Rafflesia itself: wily, patient, bent on survival. The plant pushes up against the margins of scientific knowledge: though its blooms can be a metre across, Rafflesia spends most of its life as a microscopic thread within the tissues of a host vine, behaving, as Thorogood's research with Harvard colleagues has shown, much like fungi, neither plant nor animal.

The experts here are not western academics – Thorogood admits that 'at times I can barely name a single plant' in the forest – but the local scholars, foresters and indigenous guides who lead the way to Rafflesia's home. The book's hero turns out to be the elderly, unassuming Mr Ngatari, the 'wizard' of Bogor who holds the secret to successfully propagating the plant, and therefore securing its future. Pathless Forest closes with Thorogood and Filipino colleagues poring over his cryptic instructions, and praying over their own grafted vine. Whether or not a foul-smelling, magnificent Rafflesia eventually blooms, this is a gripping, Technicolor account of why their efforts matter.

Rachel Aspden, The Guardian, 1 Mar 2024.

(see also New Scientist https://www.newscientist.com/article/mg26134821-100-saving-the-worlds-largest-flowers-in-the-philippines/)

Tony Start and Kevin Thiele, 2023. Mistletoes of Western Australia. CSIRO Publishing. 152 pp.

Mistletoes of Western Australia is a guide to identification, mistletoe ecology, conservation, biogeography and evolution, including how mistletoes cope with fire. The book explores the relevance of mistletoes to the biodiversity of the communities in which they live, and provides information on their hosts and simple identification keys to species. Each species is illustrated and described in simple terms, with photos illustrating the species and a map of its known distribution in Western Australia. Featuring 7 genera and 42 species, this comprehensive illustrated guide will be essential for botanists, conservationists and anyone interested in Australian flora.

Bashri Gausiya, Hayat Shamsul, Bajguz Andrzej (Eds). Strigolactones: Synthesis, Application and Role in Plants, 2024. Academic Press, 240 pp.

Chapters:

1. Strigolactones as plant hormone: An overview
Yamshi Arif*et al.*
2. Nature and biosynthesis of strigolactones in plants
Andrzej Bajguzmmm
3. Synthetic analogs of strigolactones and their applications
Mohammad Faizan *et al.*
4. An update on strigolactone signaling in plants
Magdalena Korek and Marek Marzec
5. Role of strigolactones signals in plant roots for fungal symbionts and parasitic weeds
Dheeraj Pandey *et al.*
6. Cross-talk of strigolactones with auxin and cytokinin
Shikha Arora *et al.*
7. Cross-talk of strigolactones with abscisic acid, gibberellins, ethylene, and other hormones
Anita Bhoi *et al.*
8. Strigolactones interplay with signaling molecules of plant
Hokuto Aiba and Mikihisa Umehara
9. Strigolactones: Biosynthesis, regulation, signaling, roles, and response to stress
Romica Verma *et al.*
10. Regulatory role of strigolactones in biotic stress tolerance
Bonia Francis *et al.*
11. Regulatory role of strigolactones in abiotic stress tolerance
Nimisha Amist and Narsingh Bahadur Singh
12. Implications of strigolactones in plant biology: Achievements, future perspectives, and challenges
Asif Hussain Hajam *et al.*

Abdelbagi, M. A. Ghanim, Shoba Sivasankar, Patrick J. Rich (Eds), 2024. Mutation Breeding and Efficiency Enhancing Technologies for Resistance to *Striga* in Cereals. Springer, 182 pp.

This open access book is a compilation of protocols developed through a Coordinated Research Project of the Joint FAO/IAEA Center of Nuclear Techniques in Food and Agriculture, specifically focused on mutation breeding for resistance to *Striga*. The book consists of three sections; (i) a general introduction on *Striga* biology and impact and mutagenesis in cereal crops; (ii) protocol chapters focusing on field, screenhouse and laboratory screening and diagnostic for resistance to *Striga* asiatica and S. hermonthica in sorghum, upland rice and maize, and; (iii) efficiency enhancing technologies such as rapid crop cycling, doubled haploid production and genomics for mutation discovery and marker development. These chapters were written by well recognized experts in *Striga* biology and physiology, and cereal breeders. The book is intended to serve as a unique reference and guide for plant breeders and geneticists engaged in breeding for resistance to *Striga* in cereals.
This book is open access, which means that you have free and unlimited access: https://link.springer.com/book/10.1007/978-3-662-68181-7

- Introduction to Mutation Breeding in Cereal Crops for Resistance to *Striga*
- *Striga* as a Constraint to Cereal Production in Sub-Saharan Africa and the Role of Host Plant Resistance, Patrick J. Rich
- Physical Mutagenesis in Cereal Crops, Abdelbagi M. A. Ghanim
- Screening for Resistance to *Striga hermonthica* in Mutagenized Sorghum and Upland Rice in Burkina Faso, Djibril Yonli, Philippe M. Nikiéma, Hamidou Traoré, Abdelbagi M. A. Ghanim
- Mutation Breeding for Resistance to *Striga hermonthica* in Sorghum and Rice for Sustainable

Food Production in Sudan, Ayman Abdel Maged Awad

- Phenotyping for Resistance to *Striga* asiatica in Rice and Maize Mutant Populations in Madagascar, Noronirina Victorine Rakotoarisoa, Harimialimalala Jhonny Rabefiraisana, Berthe Rasoamampionona, Xavier Rakotonjanahary, Abdelbagi Mukhtar Ali Ghanim
- An Agar-Based Method for Determining Mechanisms of *Striga* Resistance in Sorghum, Patrick J. Rich
- Histological Analysis of *Striga* Infected Plants, Mafrikhul Muttaqin, Songkui Cui, Satoko Yoshida
- *Striga* Germination Stimulant Analysis, Benjamin Thiombiano, Kristýna Floková, Aimee Walmsley, Harro J. Bouwmeester
- Identification of Closely Related Polymorphisms with *Striga* Resistance Using Next Generation Sequencing, Songkui Cui, Abdelbagi M. A. Ghanim, Satoko Yoshida
- Rapid Cycling and Generation Advancement for Accelerated Mutation Breeding in Sorghum, Abdelbagi M. A. Ghanim, Adel B. Ali, Ayşe Sen, Ivan Ingelbrecht, Shoba Sivasankar
- Anther Culture of Rice for Haploidy Induction and Accelerated Development of *Striga* Resistant Germplasm, Ayşe Şen, Necmi Beşer

FUTURE MEETINGS

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 49-83 via the ODU Haustorium website - https://sites.wp.odu.edu/musselmanpage/haustorium/

GENERAL 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://ww2.odu.edu/~lmusselm/haustorium/index.shtml

For information on the new Frontiers Journal 'Advances in Parasitic Weed Research' see: http://journal.frontiersin.org/researchtopic/3938/advances-in-parasitic-weed-research

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://*Striga*solutions.com

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 (NB see above re 7th Symposium)

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

For Phytoimages, a useful source for photos of weeds, including many parasitic species, see: http://www.phytoimages.siu.edu

SELECTED LITERATURE

Abd El-Wahab Mohamed, I., Hassan, M. and Aboulela, M. 2024. New hosts and diagnostic characteristics of Orobanche crenata (Orobanchaceae) in Egypt. Acta Botanica Croatica 83(1): (https://doi.org/10.37427/botcro-2024-003) [Recording *O. crenata* on *Arctotis fastuosa, Callistephus chinensis, Ammi majus, Lactuca serriola, Melilotus indicus, Carthamus tinctorius* and *Tropaeolum majus.*]

Alagbo, O.O., Akinyemiju, O.A. and Chauhan, B.S. 2023. Management of *Striga hermonthica* (Del.) Benth in Nigerian savanna upland rice fields – current challenges and approaches. International Journal of Pest Management, 1–10. (https://doi.org/10.1080/09670874.2023.2264802) [Noting the increasing spread of *S. hermonthica* in rice the Nigerian savanna and predicted spread into the rainforest zone, and recommending the development of a site-specific model to determine the optimum combination of trap crops, nitrogen fertilization and use of resistant and tolerant varieties.]

Auriac, M-C. and 7 others. 2023. The penetration of sunflower root tissues by the parasitic plant *Orobanche cumana* is intracellular. New Phytologist 241(6): 2326-2332. (https://doi.org/10.1111/nph.19495) [Reviewing the literature on intra-cell penetration by and of root parasite haustoria, and concluding that the haustoria of *O. cumana* do indeed penetrate the cells of its host.]

Balbuena, M.S, Buchmann, S.L, Papaj, D.R. and Raguso RA. 2024. Organ-specific volatiles from Sonoran desert *Krameria* flowers as potential signals for oil-collecting bees. Phytochemistry: (https://doi.org/10.1016/j.phytochem.2023.113937 [Volatiles such as diacetin are produced as biproducts of oil metabolism, but unlike most plants these are not produced by *Krameria* to attract oil collecting bees. Instead, *K. bicolor* produces the raspberry scented β-ionone whereas *K. erecta* produces a blend of anise-related aromatics.]

Bawin, T. and Krause, K. 2024. Rising from the shadows: selective foraging in model shoot parasitic plants. Plant, Cell & Environment 47:1118-1127. [https://doi.org/10.1111/pce.14781] [A review of the amazing physiology of *Cuscuta* which can use host chemical cues to sense location and quality of host plants.]

Bradley, J.M., Butlin, R.K. and Scholes, J.D. 2024. Comparative secretome analysis of *Striga* and *Cuscuta* species identifies candidate virulence factors for two evolutionarily independent parasitic plant lineages. BMC Plant Bioogy 24(251): (https://doi.org/10.1186/s12870-024-04935-7) [Contributing to the understanding of the genome-wide complement of putative secreted proteins from parasitic plants, and their expression during host invasion, advancing understanding of virulence mechanisms used by parasitic plants to suppress/evade host immune responses and to establish and maintain a parasite-host interaction.]

Brun, G., Leman, J.K.H. and Wicke, S. 2023. Comparative gene expression analysis of differentiated terminal and lateral haustoria of the obligate root parasitic plant *Phelipanche ramosa* (Orobanchaceae). People, Plant and Planet: (https://doi.org/10.1002/ppp3.10464) [Enhancing our knowledge of the different gene expression between primary and lateral haustoria in *P. ramosa.*]

Brun, G., Pöhl, J. and Wicke, SA. 2023. Aging seeds of weedy broomrapes and witchweeds lose sensitivity to strigolactones as DNA demethylates. bioRxiv: Plants, People Planet: (https://doi.org/10.1101/2023.02.27.530112) [Showing that seeds of both *Striga* and *Orobanche* lose their sensitivity to strigolactones with age, apparently associated with a decrease in global DNA methylation.]

Ding, A., Wang, R., Liu, J., Meng, W., Zhang, Y., Chen, G., Hu, G., Tan, M., and Xiang, Z. 2024. Exploring Information exchange between *Thesium chinense* and its host *Prunella vulgaris* through joint transcriptomic and metabolomic analysis. Plants 13: https://doi.org/10.3390/plants13060804] [Study shows an extensive transfer of metabolites in both directions between host and parasite as well as mobile mRNAs that could facilitate haustorial formation.]

Djibril, Y, Hamidou, T. and Boubacar, A.K. 2024. Weed and *Striga* management in pearl millet production systems in sub-Saharan Africa. Chapter 7 in Vilas, T. *et al.* (eds) Pearl Millet in the 21st Century: food-nutrition-climate resilience-improved livelihoods. Singapore: Springer, pp. 395-414. (https://doi.org/10.1007/978-981-99-5890-0_15) [Noting the occurrence of *Buchnera hispida, Striga asiatica* and *S. hermonthica* in pearl millet, he latter being of greatest importance. There are few recommendations for control other than crop rotation and intercropping. Suggesting priorities for research into herbicide and varietal resistance and interactions with soil microflora and nutrient availability.]

Dossa, E.N., Shimelis, H., Shayanowako, A.I.T. and Laing, M.D. 2024. Screening tropical and sub-tropical maize germplasm for resistance to *Striga hermonthica* and *S. asiatica* and yield-related traits.

Euphytica 220: (https://doi.org/10.1007/s10681-024-03309-2) [130 tropical and sub-tropical maize lines were assessed for their reaction to both *S. hermonthica* and *S. asiatica* resulting in the identification of 19 with potential dual resistance.]

Haider, I., Yunmeng, Z., White, F., Li, C., Incitti, R., Alam, I., Gojobori, T., Ruyter-Spira, C., Al-Babili, S., Bouwmeester, H.J., 2023. Transcriptome analysis of the phosphate starvation response sheds light on strigolactone biosynthesis in rice. Plant Journal 114: 355-370. https://doi.org/10.1111/tpj.16140

Jamil, M., and 7 others. 2024. Abscisic acid inhibits germination of *Striga* seeds and is released by them likely as a rhizospheric signal supporting host infestation. Plant Journal 117(5): 1305-1316. (https://doi.org/10.1111/tpj.16668) [Showing that ABA is exuded by germinating *Striga hermonthica* seeds and tends to inhibit the germination of nearby seeds, also attracting host roots to grow towards the germinating seedling.]

Jamil, M. and 11 others. 2024. Evaluation of granular formulated strigolactone analogs for Striga suicidal germination. Pest Management Science: (https://doi.org/10.1002/ps.8136) [Describing the development of slow-releasing granular formulation of two potent germination stimulants 'Methyl Phenlactonoate 3' and 'Nijmegen-1' and the assessment of their activity under laboratory, greenhouse, mini-field, and field conditions. Easier to apply than liquid formulations, but no evidence that they are any more effective – or any more readily marketed?]

Konli, Y.,Mawuli, A., Timko, M.P. and Modom, B.E. 2023. Identification of sources of resistance to *Striga gesnerioides* Willd. Vatke among cowpea (*Vigna unguiculata* [L.] Walp) germplasm from Togo. Plant Breeding 143(2): 215-221. (https://doi.org/10.1111/pbr.13150) [Identifying 3 lines, TG20_66, TG20_82 and TG20_108 with phenotypical resistance to *S. gesnerioides*. All show the prersence of the RSG3-301 resistance gene.]

Liu, Y. and 5 others. 2024. Chemical constituents from the whole plant of *Odontites vulgaris* Moench and their chemotaxonomic significance. Biochemical Systematics and Ecology 112, (https://doi.org/10.1016/j.bse.2023.104764) [Identifying 40 compounds from *O. vulgaris,* many for the first time in the family Orobanchaceae.]

Lurthy, T., Perot, S., Gerin-Eveillard. F., Rey. M., Wisniewski-Dyé, F., Vacheron, J and Prigent-Combaret, C. 2024. Inhibition of broomrape germination by 2,4-diacetylphloroglucinol produced by environmental *Pseudomonas*. Microbiological Biotechnology: (https://doi.org/10.1111/1751-7915.14336) [Confirming that phloroglucinol compounds (PGCs) produced by the bacterial model *Pseudomonas ogarae* F113 inhibited germination of *Phelipanche ramosa* without having any adverse effect on its host, oilseed rape.]

Molina, J. and 23 others. 2024. The endophyte's endophytes: the microbial partners of the endangered plant parasite *Rafflesia speciosa* (Rafflesiaceae) reveal clues about its cryptic biology and cues for cultivation. Journal of Plant Interactions, 19(1) (https://doi.org/10.1080/17429145.2024.2304221) [Characterizing the bacterial microbiome of seeds of *R.speciosa* and cuttings of its host, finding *R. speciosa* seed has similar bacterial profiles to its infected host. Finding no evidence for mycorrhizal taxa in the microbiome.]

Mutinda, E.S. and 10 others. 2024. The genus *Balanophora* J. R. Forst. & G. Forst. - its use in traditional medicine, phytochemistry and pharmacology: a review. Journal of Ethnopharmacology 319(3): (https://doi.org/10.1016/j.jep.2023.117276) [A major review, with 145 references indicating a wide range of reported uses.]

Mwangangi, I.M, Büchi, L., Haefele, S.M. and Rodenburg, J. 2024. Macronutrient application rescues performance of tolerant sorghum genotypes when infected by the parasitic plant *Striga*. Annals of Botany (https://doi.org/10.1093/aob/mcae031) [Use of fertilization to reduce *S. hermonthica* benefited tolerant sorghum varieties more than susceptible ones.]

Obico, J.J.A., Lapuz, R.S.C., Barcelona, J.F. and Pelser, P.B. 2024. What explains the high island endemicity of Philippine *Rafflesia?* A species distribution modeling analysis of three threatened parasitic plant species and their hosts. American Journal of Botany: (https://doi.org/10.1002/ajb2.16267) [Although the environmental requirements for the host *Tetrastigma* are met in many places in the Philippines, *Rafflesia* does not currently occur in all. The authors suggest limited inter-island dispersibility and/or specific environmental requirements to explain island endemicity of the three *Rafflesia* species studied.]

Okazawa, A. and 7 others. 2023. The structure-activity relationship of aryloxyacetylthioureas for the inhibition of *Orobanche minor* radicle elongation. Journal of Pesticide Science 48(4): 149-155. 10.1584/jpestics.D23-034) [In *Orobanche minor* seeds, planteose is hydrolyzed by an α-galactosidase, OmAGAL2, during germination. It was found that the OmAGAL2 inhibitor, PI-28, suppressed the radicle elongation of germinating *O. minor* seeds.]

Qin, L., Lu, E., Chen, K., Bao, R., Liang, L. and Hu, X. 2023. The complete chloroplast genome of *Striga asiatica* (L.) Kuntze 1891 (*Orobanchaceae*), a hemiparasitic weed from Guangxi China. Mitochondrial DNA Part B, 8(4), 497–500.

(https://doi.org/10.1080/23802359.2023.2197089) [Self-explanatory.]

Rodenburg, J. and Bastiaans, L. 2024. Host interactions, pathology, economic impacts and management of the facultative parasitic weed *Rhamphicarpa fistulosa*. Crop Protection: (https://doi.org/10.1016/j.cropro.2024.106688) [Reviewing then status of *R. fistulosa* in Africa, where it is estimated to affect 140,000 farms and to cause losses of $82M per year. Control methods include the use of resistant varieties NERICA-L-41 and NERICA L-31, and early sowing. It is not suppressed by extra fertilizer.]

Rodenburg, J. and Bastiaans, L. 2024. Differences in the ecology of witchweed and vampireweed: implications for rice farming in Africa. *Plants People Planet*. (https://doi.org/10.1002/ppp3.10491) [Emphasising that delayed sowing may reduce infection by *Striga* spp. while reverse is true for *Rhamphicarpa fistulosa.* Other techniques for reducing *Striga* including no-till, fertilizer and trap crops are not suitable for *R. fistulosa*. Control of the latter after emergence is also more effective for the latter than for *Striga.*]..

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Rouamba, A., Shimelis, H., Drabo, I., Shamuyarira, K.W. and Mrema, E. 2024. Management of the *Striga* epidemics in pearl millet production: a review. CABI Agriculture and Bioscience 5: (https://doi.org/10.1186/s43170-023-00210-1) [Noting that pearl millet is grown on 32M ha and in Burkina Faso, is the 3rd most widely grown crop. Reviewing the importance of *Striga hermonthica,* noting the current lack of control methods, and providing a guide to the use of the best breeding strategies to accelerate the breeding of new pearl millet cultivars that are best-performing and resistant to *S. hermonthica.*]

Rouamba, A. and 7 others. 2023. Genome-wide association analyses of agronomic traits and *Striga hermonthica* resistance in pearl millet. Science Reports 13: (https://doi.org/10.1038/s41598-023-44046-1) Twenty-eight SNPs significantly associated with a low number of emerged *S. hermonthica* are valuable genomic resources for accelerated breeding and variety deployment of pearl millet with parasite resistance.]

Rouamba, A., Shimelis, H., Drabo, I., Mrema, E. and Gangashetty, P.T. 2024. Screening pearl millet genotypes for resistance to *Striga hermonthica* and compatibility to *Fusarium oxysporum* f.sp. *Strigae.* Crop Protection 178: (https://doi.org/10.1016/j.cropro.2024.106573) [IP-3098, IP-6112, IP-9242, IP-10579, and IP-11358 were identified as exhibiting *S.hermonthica* resistance and were compatible with the *Striga* bio-control agent, *Fusarium oxysporum* f. sp. *Strigae* (FOS).]

Rouamba, A. and 7 others. 2023. Combining ability and hybrid breeding in pearl millet (*Pennisetum glaucum* [L.] R. Br.) for agronomic traits and resistance to *Striga hermonthica.* Euphytica: (https://doi.org/10.21203/rs.3.rs-3317778/v1) [Reporting the development of 4 new experimental hybrids for further evaluation in *S. hermonthica*-infested sites.]

Rubiales, D. 2023. Managing root parasitic weeds to facilitate legume reintroduction into Mediterranean rain-fed farming systems. Soil Systems 7(4): 99. (https://doi.org/10.3390/soilsystems7040099) [Reviewing the occurrence of *Orobanche crenata, O. minor, O. foetida* and *Phelipanche aegyptiaca* and recent achievements in prospects for broomrape management and resistance breeding arising from recent developments in phenomics and genomics.]

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(https://doi.org/10.1016/j.tplants.2024.02.013) [Concluding that canonical strigolactones are not involved in tillering/branching, but in arbuscular mychorrhizal fungi symbiosis and parasitic plant germination.]

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HAUSTORIUM 85
has been edited by Chris Parker, 7, Oatley House, Cote Lane, Bristol BS9 3TN, 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. (luiza.teixeirac@gmail.com). It has been produced and distributed by Chris Parker and published by IPPS (ISSN 1944-6969).
Send material for publication to any of the editors.