

the INNOVATOR

Charles Sturt University



Department of Primary Industries

SUMMER 2016-17 EDITION

The Newsletter from the GRAHAM CENTRE for Agricultural Innovation



Photo: Sharon Kiss

Warmest Wishes for a Merry Christmas and a Happy New Year

from the Graham Centre Team

From the Director

Welcome to the Summer edition of *the Innovator*. After a very wet start to spring, conditions have eased, and in most areas conditions for harvest look good. Pasture conditions are such that most people feel understocked, and with the season being later than in recent years, pasture quality has held on reasonably well to enable good animal growth rates for this time of year.

Since the last newsletter, we have been advised of reaccreditation until the end of 2021, subject to addressing a few minor issues in our strategic planning documents. Again, a big thank you to all who have contributed to the Centre's performance over the past five years, and to those who made significant contributions to the strategic plan and associated documents. Particular thanks to our administrative team who have worked tirelessly to achieve this outcome.

The new Governance structure for the Centre is functioning well, with the first Centre Board meeting held recently. The Board meeting covered a lot of ground, and the Board are very invested in seeing the Centre succeed. I look forward to working with the new Board to ensure the centre strategy is implemented. Particular thanks to John Mawson for taking on the role of Chair.

A recommendation from the Centre review was to increase our international collaboration. I recently visited three Universities in China to discuss strengthening or developing our linkages with them. We already have good linkages with Fujian Agriculture and Forestry University in plant sciences, and will look towards formalising and strengthening these. Yangzhou University are keen to collaborate with us in animal science, and potentially plant sciences, and we

will look toward to a joint workshop with key researchers in each organisation in the New Year to scope our project proposals. Both organisations have excellent facilities that are complementary to ours.

The next month will be a busy period for our administration team as we seek to implement the new membership policy, as well as call for and assess applications for the 2017 RCF scheme. We also received a good response from members to the Expression of Interest for Pathway Leaders, and I plan to have new Pathway Leaders in place by the end of the year. This will be important to implement our strategy from next year.

Finally, as this will be last Innovator for the year, I wish everyone a safe and enjoyable festive season.

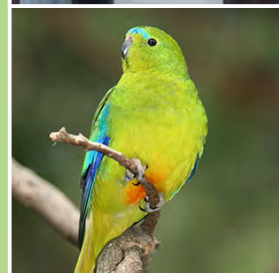
Professor Michael Friend

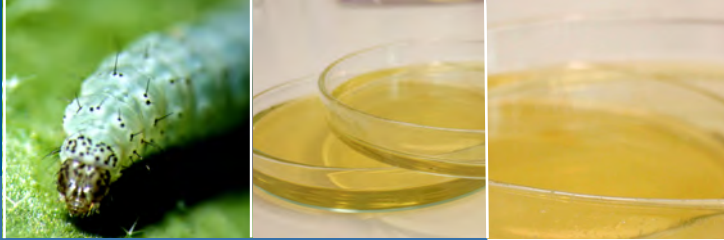
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NEWS

CSU students pick of the crop

Charles Sturt University Agricultural Science students have again taken out top honours in the Australian Universities Crops Competition. The 2016 competition, sponsored by Grain Growers, was held at Temora, NSW on 28-30 September.

Nine universities, including four from the United States, competed with the CSU team winning 2nd place in the University Teams Category.

In the Individual Category, Javier Atayde, 3rd year Agricultural Science student won 3rd place. The CSU 2016 team included Jessica Simpson, Hayden Petty (Graham Centre 2016 Intern), Grace Rogers, Tyler Austin (Graham Centre 2016 Intern), Javier Atayde, Tim Callan, Caitlin Langley and Jack Hogan. Graham Centre 2016 Honours Student Harriet Brickhill supported this year's team, while Graham Centre member Dr Sergio Moroni, CSU, mentored the team. Dr Moroni has mentored CSU's teams since 2009. The competing universities in the competition for 2016 are listed below.

2016 Competing Universities:

- Charles Sturt University
- Curtin University
- Sydney University
- La Trobe University
- University of Western Australia
- Virginia Tech
- University of Wisconsin-Platteville
- Iowa State University
- Kansas State University

Contact: Dr Sergio Moroni,
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CSU's crop judging team took out 2nd place in the University Teams Category at the Australian Universities Crops Competition in Temora, NSW on 28-30 September.

Academic promotions well deserved

Congratulations to the following Graham Centre members on their recent academic promotions, recognising academic leadership and outstanding contributions to their disciplines and the work of CSU.

Senior Lecturer

- ▷ **Dr Andrew Peters**
School of Animal and Veterinary Sciences, CSU
- ▷ **Dr Marie Bhanugopan**
School of Animal and Veterinary Sciences, CSU
- ▷ **Dr Julia Howett**
School of Agriculture and Wine Sciences, CSU
- ▷ **Dr Celia Barril**
School of Agriculture and Wine Sciences, CSU

Associate Professor

- ▷ **Dr Jane Heller**
School of Animal and Veterinary Sciences, CSU
- ▷ **Dr Jane Quinn**
School of Animal and Veterinary Sciences, CSU
- ▷ **Dr Shokoofeh Shamsi**
School of Animal and Veterinary Sciences, CSU

CSU to establish an AgriTech Incubator Hub

With funding from the NSW Government, CSU is establishing an AgriTech Incubator Hub at the Wagga Wagga campus to resource technology innovation and incubate start-ups in regional Australia.

The grant to CSU is part of a wider program of investment by the NSW Government in partnership with universities across NSW to boost business innovation across the state. The CSU Multi-Region Hub Program will also include a Digital Showcase and Start-Up Hub for regional business acceleration and connectivity based in Bathurst, and a state-wide mobile Indigenous Entrepreneurship Pop-Up Innovation Hub to help individuals and communities generate business ideas.

The AgriTech Incubator Hub program and location are currently being finalised and CSU is seeking expressions of interest from individuals and enterprises who may wish to participate in the first incubation program, which is expected to commence early in 2017.

Contact: Prof John Mawson,
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CSU researcher achieves industry accolades

Congratulations to Graham Centre member Dr Shokoofeh Shamsi, School of Animal and Veterinary Sciences, CSU on her recent election to the Executive Committee for the Japan Society for the Promotion of Science (JSPS) Alumni Association in Australia. Shokoofeh is the NSW/ACT representative on the committee.

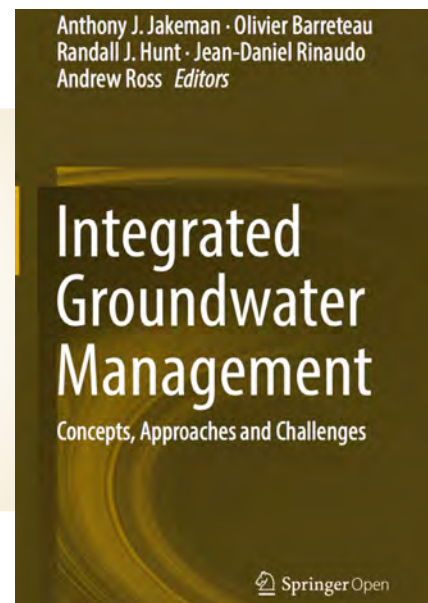
The Chair of the Association's organising committee, Professor Peter Koopman FAA, said the geographical, gender and discipline diversity amongst the Executive Committee was reflective of the wide variety of alumni who have been part of JSPS programs over the years.

Contact: Dr Shokoofeh Shamsi,
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Integrated groundwater management

A new book looking at integrated groundwater management spans the range of disciplines engaged in groundwater research through the National Centre for Groundwater Research and Training including; characterising aquifers and aquitards; hydrodynamics; surface water – groundwater interactions; groundwater – vegetation – atmosphere interactions; socioeconomics, policy and decision support. Download your free copy at <http://link.springer.com/book/10.1007/978-3-319-23576-9>



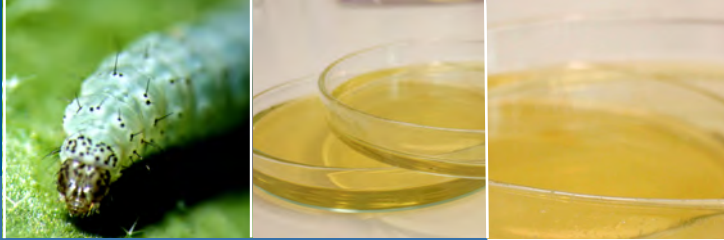
News from Orange...

Geoff Gurr returned from his Thousand Talents program work at Fujian Agriculture and Forestry University, China by a circuitous route, presenting keynotes at Ecosummit in Montpellier and the International Congress of Entomology in Orlando. He will now settle down for a while in Orange and work on a new lucerne seed wasp project with Ainsley Seago, NSW DPI.

Syed Rizvi is about to finalise his PhD on light-brown apple moth having received excellent reports from his thesis examiners.

Contact: Prof Geoff Gurr,
T: 02 6365 7551, E: ggurr@csu.edu.au





NEWS

Field evaluation of Australian wheat genotypes for competitive traits and weed suppression

Herbicide-resistance in both grasses and broadleaf weeds is on the rise across Australia, with an increasing number of cropping weeds experiencing resistance to multiple herbicides. Highly competitive wheat cultivar genotypes typically have the ability to access better light, nutrients, and water resources in a limited space, thus suppressing the growth and reproduction of neighbouring weed species.

In addition, benzoxazinoids (BXs) are important allelochemicals present in wheat, barley and rye, and their suppressive effects on weeds, pests and diseases are of great interest in sustainable agriculture. They are known to play important roles in plant defence against herbivory, in plant interactions including allelopathy. BXs are considered to be natural pesticides. When produced in excessive amounts, BXs are stored in the form of glucosides that are enzymatically converted to aglycone forms under stress conditions. BXs comprise a number of chemical groups, the most important being lactams and hydroxamic acids

Graham Centre PhD student James Mwendwa is researching the competitive and weed suppressive traits of Australian wheat genotypes as part of his PhD. James gave an oral and poster presentation on his findings at the 20th Australasian Weeds Conference (AWC), in September in Perth, Western Australia.

He has found that the differences in weed suppression are largely impacted by crop architecture and phenology early in the growing season. Cultivar competitive traits are also influenced by genotype and environmental factors, as shown by clear differences in cultivar performance, yield and

weed suppression among both locations. Cultivars Condo and Espada were superior performers for yield and weed suppression in both locations and years analysed. This data supports the concept that choice of wheat cultivar can prove to be a cost effective means of weed management.

Metabolic profiling of wheat cultivar shoots, roots, and soils resulted in detection of up to 14 BXs including BX glycosides and other metabolites of interest. Both qualitative and quantitative differences in benzoxazinoids were observed and were cultivar and location dependent. Plant part and rhizosphere location (distance from root) also impacted BX concentration. Additional metabolic profiling is now underway and will provide crucial information regarding crop metabolism and biosynthesis of metabolites associated with weed suppression in commercial wheat cultivars.

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Why the species of Synglycaspis (Hemiptera: Psylloidea: Aphalaridae) induce galls only on *Eucalyptus macrorhyncha* (Myrtaceae)?

Charles Sturt University researcher and Graham Centre member Anantanarayanan Raman, recently presented his findings on the host relations and specificity of a hemipteran bug that feeds solely on the leaves of *Eucalyptus macrorhyncha* from the Orange, NSW bioregion at the International Congress of Entomology, Orlando, Florida.

Raman looked at why this bug feeds only on this particular species of Eucalyptus, with his answer sought by the analysis



Graham Centre PhD student James Mwendwa gave an oral and poster presentation on his PhD research findings looking at competitive and weed suppressive traits of Australian wheat genotypes at the 20th Australasian Weeds Conference (AWC), in September in Perth, Western Australia.



Graham Centre member and CSU researcher Anantanarayanan Raman presented an oral paper 'Why the species of synglycaspis induce galls only on eucalyptus macrorhyncha' at the International Congress of Entomology, Orlando, Florida during September.

of complex lipids and sterols in the chosen leaves of *E. macrorhyncha* sampled over a 12-month period. LC/MS-MS and GC-MS tools were used to characterise the lipids.

The results indicate the high-level incidence of 440.3 umol sterol in the young leaves of *E. macrorhyncha* and its gradual decline, with the further development of the nymphs (young stages) and maturation of leaves. The bug has demonstrated that the sterol 440.3 umol controls the fidelity of these insects.

Raman also delivered the opening address at the 'Host relations of gall-inducing insects' symposium. He gave a number of seminars and invited lecturers at the Universities of Montana and Nebraska during his stay.

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Waste not, want not: the circular economy to food security

In August 2016 Graham Centre PhD Students Shumaila Arif, Shiwangni Rao and Thomas Williams were given the opportunity to attend the annual Crawford Fund Conference, held in Canberra. Supported by the Crawford Fund, Functional Grains Centre and the Graham Centre respectively, the students travelled to Canberra to attend the one day conference and its concurrent scholar sessions.

The conference presented a proactive discussion focused on food security and research for development (R4D). Its arrangement provided an insight into whole-system based research, firstly describing the scientific basis, followed by case studies and application in the field. Themes including the difficulties of success and the need to be malleable in field were reinforced throughout the day.

The scholar program was developed to cultivate mentor/mentee relationships between early career and senior researchers, teaming up students and academics (including former Director of the Graham Centre, Deirdre Lemerle) with similar academic interests. Scholar program activities and discussions focussed on pursuing careers in R4D and food security. Louise Fresco, President of Wageningen University, and Andrew Campbell, CEO of the Australian Centre for International Agricultural Research (ACIAR), lead discussions during the conference, and were invited to talk at the scholar days. Their stories depicted progression in careers focussed on food security and R4D and described some of difficulties that arise, and how they can be overcome.

One of the take home messages for all students was the realisation that there are a magnitude of academics working in areas of R4D and food security. These researchers offered positivity, encouragement and support to each of the attending scholars. Through discussion, early career



(L to R) Shumaila Arif, Shiwangni Rao, Thomas Williams, Deirdre Lemerle and Cathy Reade, The Crawford Fund, Director, Public Affairs and Communication, catch up during the 2016 Crawford Fund Conference.

researchers agreed they often feel lost or alone when working in R4D. The linkages with senior researchers made possible by this conference and concurrent scholar days gave students a renewed perception of research in R4D, as well as a confidence to pursue careers in it.

Shumaila, Shiwangni and Thomas would like to thank their respective sponsors for the opportunity to attend, and would also like to encourage anyone with an interest in R4D and food security to apply and attend the 2017 conference.

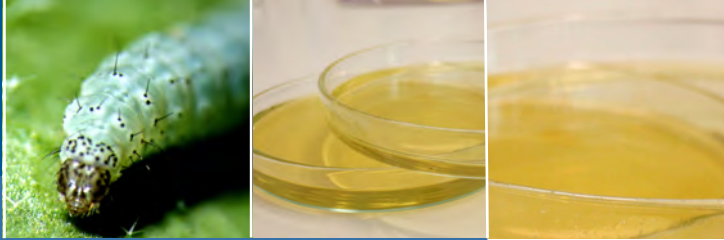
Contact: Mr Thomas Williams, E: twilliams@csu.edu.au
Ms Sumaila Arif, E: sarif@csu.edu.au
Ms Shiwangni Rao, E: srao@csu.edu.au

Graham Centre scientists in Thailand

Graham Centre Masters student Cassius Coombs and supervisor Dr David Hopkins, both based at the NSW DPI in Cowra, presented their recent project findings in Bangkok, Thailand, as a part of the 62nd International Congress of Meat Science and Technology.

Lamb loins were aged in an abattoir for up to eight weeks and analysed fortnightly at NSW DPI Cowra, where they were cut into blocks and subjected to mechanical measures of quality including shear force (tenderness), liquid losses (juiciness), water activity (susceptibility to microbial spoilage) and colorimetric measurements. These measures were collected with the aim to explore the optimal chilled storage duration for lamb meat using a number of different quality parameters.

Results from the first experiment indicated that two or four weeks chilled ageing produced improved tenderness and colour of fresh lamb loins with minimal effects on flavour or microbial spoilage potential.



NEWS

The next experiment tested freezing of this lamb meat for eight weeks and comparing its quality with the lamb chilled for eight weeks, giving cooked samples to consumers to test. From this, the clear preference was for chilled lamb, echoing the positive effect of chilled ageing on quality, though freezing may also have caused detriment.

The third experiment tested beef and found that as the meat was aged (chilling, then freezing), colour was better retained if lactic acid bacteria counts were higher. Meanwhile, more rapid discolouration of beef meat was linked to proliferation of a different type of bacteria, Enterobacteriaceae. Some good news from this was that beef could be chilled for five weeks and frozen for six months without food safety spoilage thresholds being breached.

This research is funded by the Australian Meat Processor Corporation.

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Graham Centre masters student Cassius Coombs presented his research findings at the 62nd International Congress on Meat Science and Technology, Bangkok, Thailand. Cassius' research looked at the effect of chilled storage on lamb meat quality traits, compared chilled and frozen storage on lamb sensory quality parameters and used colorimetric measurements to predict microbial loading.

Entomology without borders

NSW DPI researcher and Graham Centre member Dr David Gopurenko recently returned from a quick trip across the planet to attend the XXV International Congress of Entomology (ICE), held at the Orange County Convention Centre, Orlando, Florida, United States. The Congress occurs every four years and draws insect scientists from across the globe to report trends and advances in cutting edge entomological research. Close to 5400 oral and poster presentations were delivered, along with 298 symposia and keynote talks by two Nobel Laureates and talks by eight plenary speakers. The current congress drew over 6600 international delegates from 102 countries, representing the largest single gathering of entomologists in history.

Dr Gopurenko delivered his presentation on DNA barcoding of Australasian biting midges at the 'Ecology, Surveillance, and Control of Biting Midges' symposium. The symposium brought together biting midge researchers from a variety of nations including Australia, France, Israel, Japan, Spain, South Africa, Switzerland, United Kingdom and the US, to focus on these economically important pest insects that are vectors for transmission of debilitating arbovirus diseases among livestock.

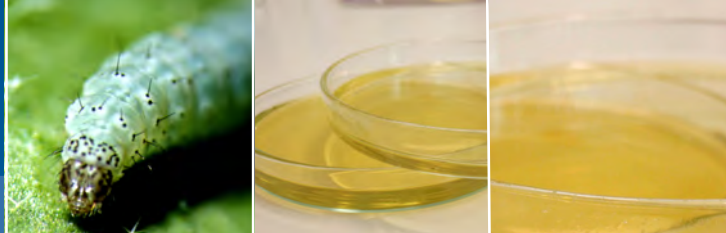
Dr Gopurenko presented genetic evidence of cryptic species diversity in the distributions of a variety of midges thought to be cosmopolitan in Australasia and East Asia, many of which are known pest species and responsible for spread of arboviruses to livestock. His presentation further demonstrated the discovery of such diversity was enhanced by specimen contributions from international collaborators. He argued that future research to identify vector competency among these various novel midge species will be best achieved through continued international collaborations.

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International Congress for Tropical Medicine and Malaria

Graham Centre PhD students Thomas Williams and Cara Wilson, along with their supervisors Associate Professor Shokoofeh Shamsi and Dr David Jenkins, and honours students Eleanor Steller and Isaac Kane, travelled to Brisbane in September to attend the International Congress for Tropical Medicine and Malaria (ICTMM). Thomas presented a poster on his PhD research on parasites in buffalos in Pakistan, while Shokoofeh, David and Cara gave oral presentations.



NEWS

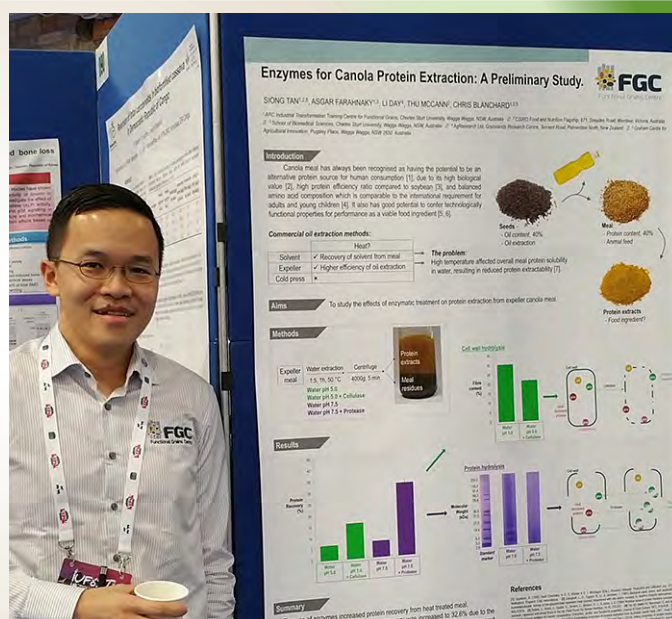
Canola research findings presented at World Food Congress

The need for collaboration between industry, government and academia, and the need for a sustainable food system were the two critical points highlighted by all presentations at the World Food Congress.

Dr Siong Tan presented his research findings on the residual anti-nutritional components in the Australian canola and non-canola grade meal proteins. He also presented a poster on his research using enzymes to assist canola protein extraction.

Contact: Dr Siong Tan,

T: 03 9731 3547, E: siongtan@csu.edu.au



Summer Scholarships 2016-17 Recipients

Congratulations to the following students who have been successful in winning a Graham Centre Summer Scholarship for 2016-17.

Name	Supervisor(s)	Project
Nicholas Condoleon	Associate Professor Paul Prenzler Dr Greg Doran Dr Julia Howitt Dr Celia Barril	Green Analytical Chemistry.
Emily Cross	Professor Jade Forwood Professor Shane Raidal	Drug targets for Nipah virus.
Patrick Hawkins Jr	Dr Sergio Moroni	Optimised Canola Profitability - Understanding the relationship between physiology and tactical agronomy management.
Yvette Kadlec	Professor Leslie Weston Dr Thiru Vanniasinkam	The culture and identification of novel soil microbes important in plant signalling and plant growth regulation.
Quincy Zhang	Dr Ali Ghorashi	Detection of antimicrobial resistance in Staphylococci in farm and companion animals using molecular biology techniques.

Keep up to date with the Graham Centre on social media ...

Don't forget to follow the Graham Centre on **Twitter** @GrahamCentre



and like us on **Facebook** <https://www.facebook.com/GrahamCentreForAgriculturalInnovation?ref=hl>

and on **Instagram** [grahamcentre05](https://www.instagram.com/grahamcentre05)



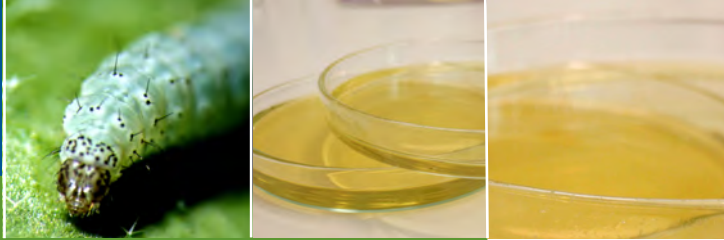
Conference Support Scheme 2017 Recipients

Congratulations to the following members/associates who have been awarded Conference Support funding.

Name	Conference	Location	Presentation title
Thomas Nordblom	61st Australian Agricultural and Resource Economics Society Annual Conference	Brisbane, Australia	<i>Straw and living mulches compared with herbicide for under-vine weed suppression in a Public-Private Benefit Framework.</i>
Ben Ovenden	Plant and Animal Genome (PAG XXV)	San Diego, USA	<i>Genomic Selection for Increased Water Soluble Carbohydrate Accumulation in Wheat.</i>
Chris Petzel	Australasian Dairy Science Symposium	Sydney, Australia	<i>Differential impact of concentrates and rumination level on carbon gas fluxes and milk production of dairy cows in a pasture-based AMS.</i>
Olivia Reynolds	Third FAO-IAEA International Conference on Area-wide Management of Insect Pests: Integrating the Sterile Insect and Related Nuclear and Other Techniques	Vienna, Austria	<i>Area-Wide Management of the Queensland Fruit Fly in Australia: a Model System.</i>
Shokoofeh Shamsi	Annual Conference of the Australian Society for Parasitology	Leura, Australia	<i>A revision of pentastomid parasites in Australian hosts.</i>
Bing Wang	IUNS 21st International Congress of Nutrition	Buenos Aires, Argentina	<i>N-glycolylneuraminic acid and ketodeoxynonulosonic acid levels in different organ of animal species and potential relationship with meat quality and human disease.</i>
Leslie Weston	8th World Congress of Allelopathy	Marseille, France	<i>Investigation of quinones produced by living roots: their potential roles in rhizosphere regulation and allelopathy.</i>
Xiaocheng Zhu	8th World Congress of Allelopathy	Marseille, France	<i>A tale of two invaders: Chemistry, ecology and genetics of invasive <i>Echium</i> spp. in southern Australia.</i>

Congratulations to the following HDR students who have been awarded Conference support funding.

Name	Conference	Location	Presentation title
James Mwendwa	8th World Congress of Allelopathy	Marseille, France	<i>Metabolic profiling for benzoxazinoids in weed-suppressive and early vigour wheat genotypes.</i>
Dominik Skoneczny	8th World Congress of Allelopathy Marseille, France	Marseille, France	<i>Metabolic profiling of bioactive secondary metabolites in <i>Echium plantagineum</i> – comparison of native European and invasive Australian populations.</i>



RESEARCH ACTIVITIES

Reducing reproductive wastage

Research by CSU Masters student Greg Sawyer, under the supervision of Dr Edward Narayan, School of Animal and Veterinary Sciences, CSU and Graham Centre Director Prof Michael Friend, has provided much excitement amongst the local merino industry. Greg's research integrates the fundamental areas of animal science (reproductive and stress physiology), to better understand how females respond physiologically to stressors while being able to maintain and/or enhance reproductive performance and quality within artificial breeding or natural joining production systems.

Applying non-invasive physiological hormone monitoring techniques in combination with body temperature, wool staple length, nutrition and seasonal climate, Greg will be able to quantify the key determinants of ewe reproductive (ova) quality and wastage.

The research will provide an understanding of the intra and inter-individual variation in cortisol, LH, P and E2 profiles and how this will relate to variations in climatic data (cross-talk between the physiological stress response and climate). It will also provide scientific data about this interaction and how it influences the thermal profiles of females and their ability to cycle properly and produce quality ova.



Wool grower and CSU Masters of Philosophy student Greg Sawyer is investigating the use of non-invasive physiological hormone monitoring techniques along with body temperature, wool staple length, nutrition and seasonal climate to quantify the key determinants of ewe reproductive quality and wastage. Photo: Toni Nugent.

Additionally, nutritional/condition score status of the ewes will also feed directly/indirectly into this hypothesis.

Exposure to seasonal environmental related stressors (such as warm-cold months and worm burden) will impact on body temperature, with sub-clinical influences on key reproductive and stress hormones that will determine the reproductive success of ewes in artificial insemination/embryo transfer and/or natural joining programs.

Greg's research was 'singled out' as providing key research into the future developments of the merino ewe and her successful reproduction by leading Australian merino ram and ewe breeder Matthew Coddington in his presentation at the World Merino Insight Conference held in Adelaide, SA during September.

Throughout the conference many participants spoke about the need to increase reproductive and genomic success at a time where pricing for wool, sheep meat and replacement ewes are commanding historical price premiums, along with the desire to seek a greater understanding into productivity, profitability and genetic gains by reducing reproductive wastage.

Greg's research also has the ability to further enhance the application of drone and group management of flocks. Currently this research has limited commercial funding, but there is commercial potential for investors through two main areas:

1. Provide the science for the development of an electronic ear tag that monitors body temperature through the use of drones that can monitor stock remotely to gain a further insight to sheep that are suffering disease or reproductive health in its initial stages of development. This would provide the farmer with accurate current data on the monitored stock through the use of GPS technology, drones and apps.
2. Providing the knowledge that there is the possibility that through the use of non-invasive methods, a simple reproductive test of hormone and stress levels of ewes prior to joining, during pregnancy and post lambing will provide further genomic gain within flocks worldwide.

Greg's desire to delve into this area of research stems from his 25+ year involvement in the industry and the long held belief that Australia needs to breed more merino ewes to increase on-farm livestock production in sustainable ways, research that will also assist sheep breeders globally to reduce reproductive wastage.

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Breakthrough on virus infecting rare and endangered parrots

Australian researchers have unravelled the molecular makeup of a virus threatening some of the world's most endangered species, paving the way for the potential development of a vaccine to save dwindling populations of the Australian birds.

The research, led by Charles Sturt University (CSU) scientists and published in the prestigious international journal *Nature Communications* overnight, revealed the structure of the smallest self-replicating virus behind the beak and feather disease (BFD).

The virus causes a debilitating disease affecting four rare species of native parrot, including the Western ground and Orange-bellied Parrots, of which less than 50 remain in the wild.

CSU Professor in Biochemistry Jade Forwood said, "We now have a unique way of thinking about the virus and how it self-assembles. We know at the atomic level, the structure of the virus and how it fits together."

CSU Professor in Veterinary Pathobiology Shane Raidal said, "The finding is significant because, by confirming how the viral structure forms, we can begin to develop a vaccine to interrupt these processes."

The BFD virus programs only two proteins to drive its replication and spread: one to assist the reproduction of the viral DNA, and one to construct the outer shell of the virus. This shell is built from 60 individual capsid proteins that self-assemble and fit together in a highly specific and ordered arrangement around the viral DNA.

The outcomes of this research provide the atomic coordinates of approximately 200 000 atoms which make up the virus, and insights into how the viral DNA can bind to the shell, ensuring the protection and delivery of the viral DNA.

At the Australian Synchrotron in Melbourne, landmark research infrastructure of the Australian Nuclear Science and Technology Organisation (ANSTO), the Micro Crystallography (MX2) beamline produced X-rays more than a million times brighter than the sun to create intricate diffraction patterns as light bounced off microscopic crystals of the viral capsid proteins. This allowed the researchers to identify the locations

of the individual atoms and broader structure of the viral shells in stunning 3D detail.

The research team, involving scientists from CSU, Monash University, the Australian Synchrotron, and Spain's National Microbiology Centre and the Autonomous University of Madrid, have been working on the project since 2009.

Along with the loss of habitat and feral predators, the BFDV is one of the main threats to the affected parrots, which also include the Norfolk Parakeet (Norfolk Island) and the Swift Parrot (eastern and southern states). Infected birds face starvation and death as their feathers moult and their beaks soften.

Professor Raidal said, "The disease has caused significant problems, in particular, for the Orange-bellied Parrot since 2006 when it reappeared in the captive recovery program.

"The Parrot is a small and vulnerable migratory bird which breeds only on Tasmania's south-west coast, flying north to spend the winter in coastal Victoria and South Australia, so we look forward to building on this work to find new approaches to restoring their numbers in the wild."

Mr Barry Baker, Chair of the national Orange-bellied Parrot Recovery Team said it's important new and innovative fields of science work across conservation projects to protect Australia's at-risk fauna.

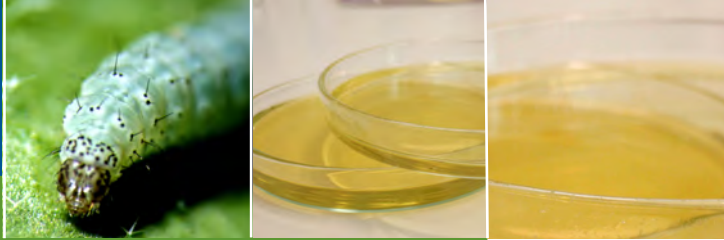
"BFDV is an awful disease, especially in small, short-lived species like Orange-bellied Parrots - young birds with the virus stand little chance of survival in the wild, and affected captive birds are often compromised, as the virus can affect the bird's ability to fight off other health issues."

"Although recent Orange-bellied Parrot recovery efforts have proven effective, in 2014 the wild population suffered from a spillover of BFDV (from another wild species) and we believe there are currently less than 30 birds out there - another outbreak of the disease in the wild would be a disaster, so the ability to vaccinate would be a leap forward in parrot conservation, also benefitting captive populations and our ability to release to the wild."

'Structural insights into the assembly and regulation of distinct viral capsid complexes' by Dr Subir Sarker, Dr Maria Terron, Dr Yogesh Khandokar, Dr David Aragao, Mr Joshua Hardy, Dr Mazdak Radjainia, Dr Manuel Jimenez-Zaragoza, Dr Pedro de Pablo, Associate Professor Fasseli Coulibaly, Dr Daniel Luque, Professor Raidal and Professor Forwood



Orange bellied parrot.
Photo: Shane Raidal



RESEARCH ACTIVITIES

was published in the international journal, Nature Communications on Tuesday 4 October.

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Prof Jade Forwood,
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Professor Jade Forwood, Post-Doctoral Researcher, Dr Ian Patterson and Professor Shane Raidal, CSU Wagga, have unravelled the molecular makeup of a virus that threatens some of the world's most endangered bird species.
Photo: Courtesy of CSU Media

Microbes to the rescue - Helper bacteria in the biserrula mycorrhizosphere

David Orchard, Graham Centre PhD student, wants to know how bacteria affect mycorrhizal fungi. Mycorrhizas are beneficial symbioses that form between soil fungi and the roots of plants. These relationships have been reported to contribute as much as 90 % of total plant phosphorus, and are found in the majority of crop and pasture plants.

While mycorrhizas are conventionally thought of as plant-fungus mutualisms, recent evidence indicates that certain soil bacterial strains play important roles in facilitating or promoting formation. These mycorrhiza helper bacteria are of interest for their impacts on plant nutrition and disease

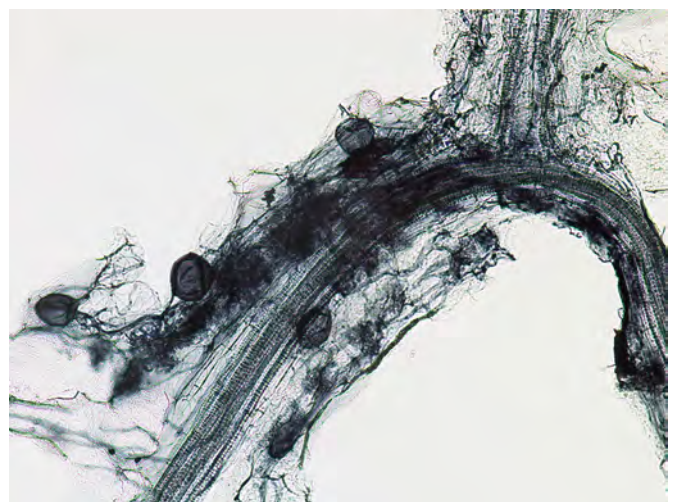
resistance, but very little is known about the mechanisms involved in the helper effect.

David's research aims to determine whether these beneficial interactions occur in the root environment of biserrula (*Biserrula pelecinus* L.), a deep-rooted and hard-seeded pasture legume first commercialised in Australia in 1997. Biserrula is valued primarily for its tolerance to drought and acid soils and has been cultivated successfully in districts receiving as little as 325 mm of annual rainfall. In these marginal zones, the importance of mycorrhizas (and, consequently, helper bacteria) in plant nutrition increases. While the association of biserrula with specific strains of N₂-fixing rhizobia is well known, no published data concerning mycorrhizas in biserrula exists.

"The discovery of arbuscular mycorrhizas in glasshouse-grown biserrula plants in the early stages of this project represents the first known record of mycorrhization in this species," David said.

The project further aims to address the possible role of bacterial secretion, the direct transfer of molecules between a bacterium and its neighbouring organisms, in the 'helper effect.'

David is field sampling to map the bacterial community structure of the biserrula root environment and determine if biserrula roots recruit specialised bacteria, including helper strains, from the soil. A glasshouse study involving mycorrhizal and non-mycorrhizal biserrula plants to investigate the possible preferential association of bacteria possessing secretion capabilities with mycorrhizal roots will follow. Once determined, David aims to focus on the mechanics of the bacterial secretion systems.



A micrograph showing fungal tissues, including spores and arbuscules, colonising the root of a biserrula plant and forming a mycorrhiza. Photo: David Orchard

RESEARCH ACTIVITIES

This project is supported in part by a Graham Centre Top-Up Scholarship and is supervised by Drs Sandra Savocchia, Gavin Ash, Ben Stodart and Bree Wilson.

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Irrigation water productivity modelling of crops

Associate Professor Xiaojun Shen, a visiting scientist from the Farmland Irrigation Research Institute of the Chinese Academy of Agricultural Sciences, is working on the irrigation water productivity modelling of irrigated wheat with Drs Ketema Zeleke (CSU) and De Li Liu (NSW DPI). He is using the APSIM-WHEAT model to evaluate different irrigation scenarios, to determine which one results in the highest irrigation water use efficiency.

Associate Professor Shen has calibrated and validated the model using the above-ground biomass and grain yield from three seasons of field experiments. The validated model was used to simulate the grain yield, water use and irrigation



Associate Professor Xiaojun Shen is using the APSIM-WHEAT model to simulate grain yield and water use efficiency of wheat under different irrigation treatments.
Photo: Toni Nugent

water use efficiency of wheat under different irrigation treatments using daily meteorological data from 1960-2010.

The results show that irrigating only one time during turning green and joining stages of wheat can result in the highest yield and water use efficiency. However, two irrigation treatments, at reproductive and grain filling stages respectively, results in higher grain yield and slightly lower water use efficiency than one irrigation treatment. Dr Shen will use the APSIM-WHEAT model to simulate the grain yield and water use efficiency of wheat under future climate change scenarios.

Read the earlier article about Assoc Prof Xiaojun Shen's 12 month visit to Australia at http://www.csu.edu.au/_data/assets/pdf_file/0003/2194626/Autumn-16-email.pdf

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Sustainable management of Chinese grasslands

China has 400 million hectares of grasslands, mainly on the Mongolian, Tibetan and Loess plateaux, and 90 % of this area is considered degraded. In 2001, Professor David Kemp was invited by the Chinese to visit and discuss ideas for collaborative research to improve the grasslands that enhanced the resource base, and could also improve the livelihoods of herders. When this work started the average income per capita of herder households was less than \$2/head/day.

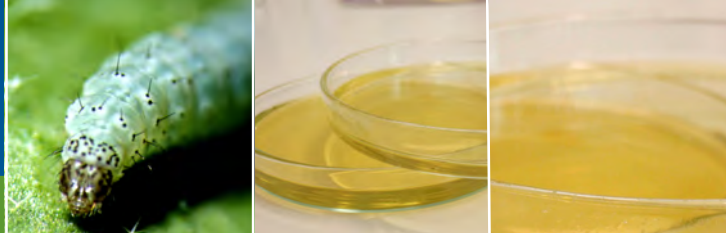
CSU and the Graham Centre have been the lead Agency in this large program headed by Professor Kemp and funded by the Australian Centre for International Agricultural Research (ACIAR) (several projects), the Department of Agriculture, Fisheries and Forestry (DAFF), the Australian Greenhouse Office and Chinese Agencies. The total budget to date is over \$30 million.

After 15 years of work, a book is being written on the achieved results. The program has involved the development of four computer models used to analyse the current farm system, farm surveys of a few thousand households, farm demonstrations of improved practices and a range of large experiment programs evaluating grazing practices, ecological studies and greenhouse gas mitigation.

The program has shown that stocking rates can be reduced by 50 % and with many other system changes, this results in improved household incomes and improvements in grassland condition.

Professor Kemp took up an Academic writing residency at the Rockefeller Bellagio Centre earlier this year in northern Italy to begin preparation of the book. The book will be published in 2017.

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RESEARCH ACTIVITIES

Development of village-based forage seed enterprises through participatory research

Shoaib Tufail has recently completed his PhD investigating the development of village-based forage seed enterprises (VBFSE) using participatory research. A comparison of the practices before and after VBFSE research trials and adoption rates are shown in Table 1. The benefits of the varietal selection and evaluation, seed production and establishment of VBFSE ranged from capacity building of the seed entrepreneurs (farmers) in knowledge and skills for Berseem clover (*Trifolium alexandrinum*) forage and seed production, to financial benefits (income generated from the VBFSE). Smallholder farmers in the Kasur and Okara districts

of Punjab, Pakistan not only had access to seed from improved varieties, but also knowledge that this variety had been evaluated under the local conditions operating on their farming systems.

The research shows huge potential for promoting local seed supply to the formal seed supply system, and improves the profit margins of the smallholder farmers through quality seed production and marketing. In terms of adoption, farmers adopted 100 % of the improved variety seed and 62-87 % of improved agronomic practices compared to their traditional practices that were evaluated on the farms using the participatory research approach.

Contact: Dr Shoaib Tufail,
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Table 1. The comparison of the adopted improved practices before and after village-based forage seed enterprises (VBFSE) by smallholder farmers in the districts of Kasur and Okara, Punjab, Pakistan.

Practices	Before VBFSE	After VBFSE
Use of improved varieties of Berseem clover	Smallholder farmers used low yielding indigenous local varieties (74 %). These varieties had lower forage, Dry Matter and seed yields.	Improved seed of Agaitti Berseem-2002 variety was obtained from the government plant breeding research station (FRI, Sargodha). All surveyed farmers were satisfied with the research station variety when compared with local and market seed varieties. There was a 36.9 % (55.29 versus 75.67 t/ha) increase in forage yield and 82.5 % (171 to 312 kg/ha) increase in seed yields recorded from this improved variety at the completion of the VBFSE trials in the 2015-16 growing season. Another improved variety (Anmol-Berseem) was also introduced by a smallholder farmer that complemented the importance of improved quality seed as well as the willingness of farmers to adopt new improved varieties at the farm level
Use of <i>Rhizobium</i> inoculum	Smallholder dairy farmers were not aware of inoculum practice and did use it.	Berseem clover was grown for the first time using <i>Rhizobium trifolii</i> seed inoculation in VBFSE trials. However, its availability is still a big problem and the VBFSE farmers (62 %) are using soil from an old Berseem clover field and spreading it before sowing the new Berseem clover crop, as recommended/described in the VBFSE trials if inoculum was not available.
Cutting schedule/ harvesting management	Smallholder dairy farmers did not follow a cutting schedule to get more forage cuts per season. They usually cut Berseem clover at earlier growth stages, affecting crop stand and persistence and final forage and seed yields.	Smallholder dairy farmers followed the cutting schedule from the VBFSE trials. The first cut was taken 60 days after sowing and later cuts were made at 30-35 day intervals. Further, farmers (87 %) are getting four forage cuts prior to the crop being left for seed production. This is closer to the VBFSE trial recommendations of three forage cuts.
Use of honeybees as pollinators	Smallholder dairy farmers were mostly unaware of the role of honeybees in Berseem clover seed production.	Introduction of honeybees to increase the efficiency of pollination more than doubled seed yields in the VBFSE trials. The availability of honeybees in the market was problematic, but at the time of pollination naturally available honeybees in the area helped farmers to accomplish this task. Moreover, farmers (75 %) selected the fields closer to natural honeybee hives, showing their increased awareness of the importance of these pollinators in Berseem clover production.

RESEARCH ACTIVITIES

Practices	Before VBFSE	After VBFSE
Seed production and marketing through VBFSE	Average seed production was 192 kg/ha and the selling price was 250 Rs/kg. The average net profit generated was 155031 Rs/ha.	<p>There is no well-planned and regular system of seed collection and multiplication of improved forage crop varieties in Pakistan. Under VBFSE trials the production and marketing aspect has been identified and now the majority of the smallholder dairy farmers (75 %) of the survey produced their own Berseem clover seed. They produced 296-346 kg/ha (average 312 kg/ha) and were more confident after adopting improved agronomic practices for forage and seed production. The VBFSE farmers are now selling seed to village farmers at the rate of PKR 425 Rs/kg which is premium priced compared to the market rate of PKR 250 Rs/kg. One VBFSE farmer who was unable to produce seed at the time of the VBFSE trials due to financial and time constraints, has been motivated and is currently producing Berseem clover seed (237 kg/ha) and selling it through VBFSE.</p> <p>On adopting the improved agronomic practices of growing Berseem forage and VBFSE technology, the seed entrepreneurs (farmers) are now generating average net incomes of 314,358 Rs/ha (3216 US\$/ha), which is four times higher than they earn from any other cash crop grown in the region. The partial budget analysis of VBFSE farms revealed that the average benefit: cost ratio was 4.78:1 with marginal rate of returns of 378 %. These results are close to the 2012-2014 VBFSE trials on these farms.</p>

Economically viable options for retired irrigation land (EVORIL) in the Central Murray

The Western Murray Land Improvement Group supported by Murray Local Land Services through funding from the Australian Government's National Landcare Program is investigating the biophysical and economic feasibility of a number of grazing systems for retired irrigation land. Part of this strategy is to evaluate a range of pasture (annual and perennial legumes and grasses), and fodder (saltbush and shrubs) species able to persist or regenerate under district rainfall of 300-375 mm.

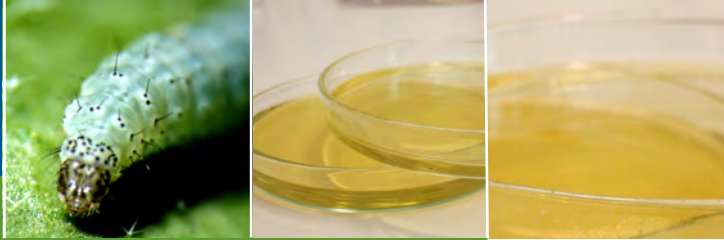
As part of this study Dr Peter Orchard is quantifying the seedbank dynamics of hard-seeded legumes at two of the trial sites following poor spring conditions in 2013-15. Soil samples collected in April 2016 prior to the autumn break were grown out under glasshouse conditions and showed marked differences between species and sites. At site 1, good germination was observed for Gland and Bladder Clovers, Spineless Burr Medic and Parragio Barrel Medic, while at site 2, Bladder and Parragio germinated well along with the Snail Medics Silver and Sava and Balansa Clover Taipan. The measurements aligned with growth and botanical composition assessments in July.

These results will provide an excellent contrast to new sowings in 2016 under much more favourable spring conditions.

Further details can be found on the Western Murray Land Improvement Group (WMLIG) website <http://www.westernmurraylig.org/>

Contact: Dr Peter Orchard, T: 02 6933 2707, E: porchard@csu.edu.au





RESEARCH ACTIVITIES

How do nutrient components alter metabolic responses in piglets?

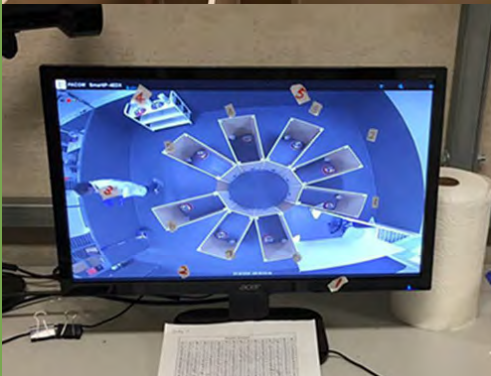
In June 2016, Professor Bing Wang's team, School of Animal and Veterinary Sciences, CSU started a research project to elucidate the molecular basis of how nutrient components alter metabolic responses important in growth, development and neurocognitive function in piglets, an animal model of humans.

The research approaches being used include in-vivo assessment of piglet brain development using Magnetic Resonance (MR) technology in collaboration with Professor Gary Egan at Monash Bio-Imaging Centre, an analysis of gene and protein expression in specific brain regions using a newly developed Porcine PCR array, Western blot (WB) and ELISA methods, characterisation of the molecular cellular architecture of the brain using immunohistochemistry and animal learning memory behaviour tests.

The team members include three research fellows, Dr Hong Xin Wang, an experienced MRI and MRS specialist, Dr Ziaul Haque, neuroanatomy and neurophysiology scientist, and Dr Castle Yue Chen, pig behaviour and molecular biology scientist. CSU animal science Masters Student Wenxi He, carried out the project and 30 CSU Animal and Veterinary Science students participated in the project under the supervision of Professor Wang and her team. The undergraduate students contributed approximately 640 hours to the project at the CSU Pig Behaviour Unit as a part of their placement work to learn practical skills in animal handling, feeding, bodyweight monitoring, health and medication monitoring, diarrhoea faecal sample score monitoring and animal behaviour testing.

This research will provide new insights into the molecular and cellular mechanisms whereby nutrition interventional studies during early postnatal life can improve neural development and cognition. Neurodevelopment and cognition in the neonatal piglet model can be translated into an understanding of the essential nutritional requirements of the developing human brain. The project outcomes will benefit pig health, production and reproduction, but more importantly, also have the potential to influence the neonatal care of children, particularly those born prematurely. The research will potentially also influence the field of cognitive neuroscience, the developing field of molecular nutrigenomics and the food industry.

Contact: Prof Bing Wang,
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From top to bottom: The research team Ziaul Haque, Kristie Addyman, Yue Chen, Wenxi He, Bing Wang (Photo: Skookoofeh Shamsi); CSU Animal and Veterinary Science student weighing piglets, part of the morning routine; The research team's behaviour analysis room showing the maze and the maze on the recording system. Piglets walk through the maze trying to find their way out and the results are recorded electronically. (Photos: Castle Yue Chen).

RESEARCH ACTIVITIES

Unlocking sorghum's export potential

Investigating how Australian sorghum can be used in the manufacture of the popular Asian alcoholic drink, Baijiu, is under the microscope of Charles Sturt University (CSU) researchers.

The Functional Grains Centre (FGC) at CSU in Wagga Wagga has secured a new, five-year Grains Research and Development Corporation (GRDC) research project.

FGC Centre Director Professor Chris Blanchard said, "The potential of sorghum, which is mainly grown in Queensland, is currently not being fully realised by Australian farmers. It is used domestically as a low value animal feed, however, there is increasing interest from Chinese customers to use Australian sorghum in Baijiu production.

"We believe there are opportunities to add real export value to the grain for Australian producers by understanding the science behind Chinese Baijiu production.

"To do this, we will need a deeper understanding of the size of the sorghum export market and the suitability of Australian sorghum varieties for Baijiu.

"In a further bid to add value to sorghum, we will also investigate how it can be used in food products. Sorghum is already used to make the new gluten-free Weet-Bix by Sanitarium.

"There is a growing demand for gluten-free food products and sorghum is ideally placed to be used in these foods due to its lack of gluten proteins and its reputation as a grain with a low glycaemic index. Sorghum also has a high level of natural phenolic compounds which have been associated with a range of health benefits.

"Our aim at the Functional Grains Centre is to transform cereals, pulses and canola into high value food and beverage products. This project - focussed on sorghum - certainly fits the bill."

The three-staged project, *Expanding options for sorghum - food and distilling*, will also draw on the expertise of other CSU staffing including: Professor of Perceptual Psychology Anthony Saliba; Professor of Food Engineering John Mawson; food science and technology researcher Dr Asgar Farahnaky; and Postdoctoral Scientist Dr Zhong Kai Zhou.

The CSU team will also collaborate with the University of Sydney to develop new sorghum food products based on market research to determine what products consumers are demanding.

The Functional Grains Centre is an Australian Research Council (ARC) Industrial Transformation Training Centre located at CSU in Wagga Wagga.

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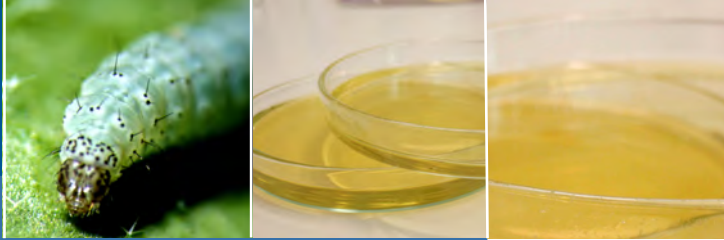
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A new five year GRDC funded research project through the Functional Grains Centre, CSU, Wagga Wagga will investigate how Australian sorghum can be used to manufacture the popular Asian alcoholic drink Baijiu. Photo: Courtesy of CSU Media



Photo: Sharon Kiss



IN THE LIMELIGHT

In the Limelight

Iain Hume

Position: Research Officer, NSW Department of Primary Industries (NSW DPI) and Adjunct Senior Lecturer, Charles Sturt University

Organisation: NSW Department of Primary Industries

Career Brief Undergraduate studies in the UK at the Cranfield Institute of Technology, part of Reading University. Immediate postgraduate work carried out in London with the UK Ministry of Agriculture's Chief Scientist's Group, which commissioned and managed research throughout the UK. My first 'hands on' job was with the UK Agricultural Development and Advisory Service Farm Waste Unit. This unit undertook research into the management, treatment and beneficial use of farm waste. My research looked at the aerobic treatment of piggery wastes to minimise odour and maximise fertiliser benefit. I was extremely popular when it came to odour testing panels!

I am a walking souvenir meeting my Australian wife in London. I immigrated to Australia and spent 18 months getting used to December being hot and June and July cold, working on farms and properties around the Wagga district. I got back into the science saddle with a job at NSW DPI (then NSW Agriculture) investigating the water balance of irrigated and dryland crops from a salinity point of view, (i.e. the aim was to use water and prevent

salinisation, unlike our current focus on minimising water use to preserve water in droughts). The highlight of this phase was the development of ways to use electromagnetic instruments to identify and remove 'leaky' prior streams from rice growing land, therefore saving water.

I have always been interested in spatial science and got the opportunity to satisfy this interest in my PhD studies using remote sensing to quantify forage vegetation in Queensland woodlands. After completing my studies at the Australian National University, Canberra, I returned to NSW DPI at Wagga to continue research into least cost solutions to salinity issues. This led to interesting collaboration with economists, and exposure to economic experiments.

Research activities: Remote sensing of rice Nitrogen uptake; benchmarking cotton water use efficiency from remotely sensed data; and estimating soil water content by EM38 electromagnetic induction measurements.

Teaching activities: I have no formal teaching load but I am active participant in the R-users group at Wagga. As a regular presenter at our meetings I enjoy sharing new ways of using this powerful software package with students and colleagues and also learning from them.

A typical day for me includes: Lately I have been dragging myself away from the computer and email, e-meetings, reports and funding submissions to re-examine the application of electromagnetic instruments to measure soil water. This involves getting my hands dirty and I've been building calibration rigs out of PVC plumbing fittings, a really welcome change from thrashing the keyboard.

My main project at the moment is: Estimating soil water from EM38 measurements.

My favourite part of my job is: Surprising results and collaboration with smart people.

When I am not in the office I like: I have a passion for cycling and I can be found riding, either my mountain or road bike or coaching junior cyclists to be the best they can. We have recently bought a camper trailer, so take as many opportunities as we can to get away either to the hills or preferably to a desert somewhere.

When I am driving I like to listen to: Just about anything from Ska/Reggae to conversation hour podcasts.



Iain Hume has a passion for cycling and can be found riding his mountain bike or road bike, or coaching local junior cyclists to be the best they can be when not at work.

Shumaila Arif

Supervisor(s): Dr Jane Heller, Dr Marta Hernandez-Jover, Dr Peter Thomson, Dr David McGill

Thesis title: Epidemiology of brucellosis under a smallholder farming system of Pakistan

Funding body: Australian Centre for International Agricultural Research (ACIAR)

Relevant Current Employment: Full time PhD student

Career and studies till now:

- Doctor of Veterinary Medicine (DVM) (2011)
- Training Manager for three years in the dairy extension-research project (ASLP) funded by ACIAR (2011-14)

Currently studying: Doctor of Philosophy (PhD) by research through the School of Animal and Veterinary Sciences, Charles Sturt University, Wagga Wagga

Research interests: My current interests revolve around veterinary epidemiology, zoonotic diseases, emerging infectious diseases, disease modelling and use of participatory approaches to provide disease awareness. There is often a shortfall of information regarding zoonotic diseases and their preventive measures among smallholder farming communities, allowing opportunities for applied research. I also love to be involved in international agriculture research especially in developing countries

Professional Links:

- Researcher in Agriculture for International Development (RAID)
- Member of Pakistan Veterinary Medical Council (PVMC https://www.researchgate.net/profile/Shumaila_Arif)

A typical day for me includes: Rising early in the morning, a prayer for being thankful for having a new day in my life, a short walk followed by a quick breakfast. When in the office I check and reply to emails, analyse data, write my PhD chapters/articles, read research articles and try to convince myself to read that Dohoo chapter from Veterinary Epidemiologic Research (which rarely happens). In the evening I like going for a walk or catching up with friends, cooking dinner, watching TV, skyping my family and telling my whole day's story to my dad (which I love to do!). My day usually finishes around 11 pm.

My main project at the moment is: Assessing knowledge, attitude and practices regarding brucellosis in smallholder farmers in Pakistan, estimating the herd-level prevalence of bovine brucellosis and evaluation of diagnostic tests for bovine brucellosis with latent class analysis. I am also

investigating the risk assessment for human brucellosis and the use of participatory epidemiological tools to provide awareness regarding zoonotic diseases.

My favourite part of my studies is: I like my whole project. I really enjoyed my field work (travelling, talking to farmers and sampling). Currently I am loving the learning of new skills including modelling and latent class analysis.

When I am not studying I like to: I like to catch up with friends, go for long drives and spend some time with horses. I also enjoy watching my favourite TV drama series, walking around Lake Albert, cooking yummy Pakistani dishes and skyping my mum and dad.

When I am driving I like to listen to: Rahat Fateh Ali Khan, Nusrat Fateh Ali Khan, Atif Aslam, Rihanna and Selena Gomez.



Outside her PhD studies, Shumaila Arif enjoys the company of her friends and horses. She also likes to cook traditional Pakistani dishes, go walking, skype her family at home in Pakistan and go for long drives.

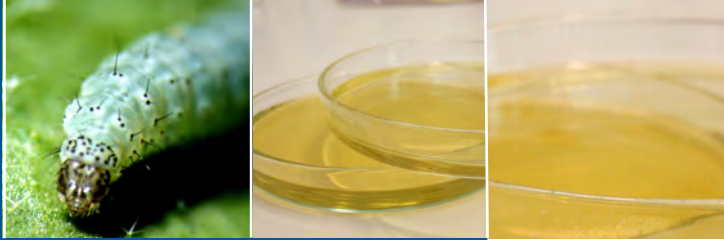
Autumn Edition of the Innovator

The Autumn Edition of *the Innovator* will be available March 2017. Submission of articles for this edition close

on

27 February 2017.

Please email articles to Toni Nugent.



2017 EVENTS CALENDAR

Date	What	Where	More information
2 & 23 June	Science and Agriculture Enrichment Day	Graham Centre, Wagga Wagga	Toni Nugent E: tnugent@csu.edu.au
7 July	Graham Centre Sheep Forum	Convention Centre, CSU Wagga Wagga	Toni Nugent E: tnugent@csu.edu.au
4 August	Graham Centre Beef Forum	Convention Centre, CSU Wagga Wagga	Toni Nugent E: tnugent@csu.edu.au
10 & 11 August	Agribusiness Today Forum	Location and Venue TBC	Dr Karl Behrendt E: kbehrendt@csu.edu.au



Photo: Greg Nugent

Christmas/New Year Close-down

CSU and the Centre office will close at 12.30 pm, Friday 23 December and re-open on Tuesday 3 January 2017.

NSW DPI will close at 12.30 pm, Friday 23 December and re-open Monday 9 January 2017.

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Photo: Sharon Kiss

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Department of
Primary Industries