ScionConnections

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Our one shot to move from fossil fuels

Dr Paul Bennett is Chair of the world's foremost bioenergy research collaboration the International Energy Agency Bioenergy group. He is also on the NZ Bioenergy Association Board, and a trustee at the National Energy Research Institute. Paul has spent 15 years researching biofuels, preceded by 20 years working on automotive fuels at BP. Now he leads Scion's portfolio on integrated bioenergy.

If you ask Paul why he chose to come to New Zealand from the United Kingdom, his answer is straight forward. When he looked at New Zealand, he saw a small country that punches above its weight in international influence and is well suited to adopting biofuels and bioenergy on a national scale. Here are his thoughts on New Zealand's opportunity with biofuels and bioenergy.

"We'll only get one opportunity to choose the new systems and technology that move us away from fossil fuels. Once we set off down our chosen path, there's no getting that time or investment back.

"The Government is beginning to chart that path now. We know it won't be straight forward. The Climate Change Commission's (CCC) draft report says that New Zealand's shift away from fossil fuels won't be resolved with a single silver bullet. Instead we will have to employ a network of solutions.

"The Government has announced that bioenergy will be an important part of the equation. We already have the technology to begin transitioning some of New Zealand's big greenhouse gas emitting sectors – transport and energy for industrial processes – away from fossil fuels.

"Some industrial energy users (manufacturing, production and construction) have already begun switching to low-carbon fuels by installing new biomass boilers that produce energy from renewable resources like forestry residues. However, we can save industry from replacing costly infrastructure.

"There are solid biofuel options available now that can directly replace coal. This solid biofuel can be used in existing coal boilers, and it is made with biomass from our local, sustainable forestry sector (see "'Bio-coal' for better burning bioenergy", in this issue of *Scion Connections*). The biofuel coal replacement is easy to transport, store (doesn't absorb water or grow mould), has similar energy density to coal, and is grindable (as required for some existing coal boilers). It's an easy win for now.

"The draft CCC report also recommends replacing three percent of transport fuels

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CCC's advice reinforces importance of forests and trees

The recently released draft advice from He Pou a Rangi – the Climate Change Commission is a very thoughtful piece of work. The draft advice raises some important issues for New Zealand and reinforces that forestry has a critical role in both reducing gross greenhouse gas emissions and in using indigenous trees to offset hard-to-reduce emissions.

Trees and forests cast in their supporting role provide a wonderfully flexible buffer for our climate response. If some areas of the economy decarbonise quicker than projected then less forests would need to be planted, but if rates of decarbonisation are slower than anticipated then more could be planted.

The Commission's draft advice is visionary in its promotion of indigenous plantings or restoration for carbon storage. It's said the best time to plant a tree is 30 years ago, the second-best time to plant is now!

The advice to plant indigenous species now so they can contribute to ongoing carbon storage from 2050 to help offset those emissions that can't be avoided, such as nitrous oxide emissions from agriculture or residual industrial process emissions, is very exciting. This gets us a great head start. Plus gives us many extra environmental benefits in the meantime – from slope stabilisation and control of soil erosion to biodiversity enhancement.

The draft advice is understandably conservative and reliant on existing technologies to meet our targets, and it's heartening to see the Commission project we can meet those targets without reliance on new or yet unproven technologies.

In Scion's research area into the forest-based circular bioeconomy we see many opportunities for new low-carbon technologies where successful development will allow New Zealand to help accelerate the progress towards our emissions reduction targets. We are focussing on closing the waste loop, biofuels, bioplastics, novel biochemicals from trees and new timber technologies.

Moving away from the dichotomy of natural forests purely for conservation and exotics for timber production to a far more diverse approach to forests in New Zealand is a particularly exciting opportunity.

Trees and forests cast in their supporting role provide a wonderfully flexible buffer for our climate response. If some areas of the economy decarbonise quicker than projected then less forests would need to be planted, but if rates of decarbonisation are slower than anticipated then more could be planted.

It's important to recognise the concern in New Zealand about the need to decrease on-farm livestock emissions and fear about the impact of large-scale plantings on local communities.

Learning from international trends in pastoral systems, where trees, pasture and livestock are integrated, opens many avenues for new farm systems incorporating trees for more than just carbon sequestration. Riparian trees would be planted for stream water quality and ecological value, multi-tiered crops for animal welfare, trees for timber and new materials, niche high-value food crops or medicine, or high-value chemicals. The future farm could look very different to today's while meeting climate, environmental, social and economic needs.

All these new technologies and a reimagining of trees and forests in the landscape gives us the opportunity for the development of small-scale distributed processing facilities in addition to large centralised wood processing plants. In other words, opportunities to take the processing to the trees.

Rapid advances in bioprocessing technologies is making this more and more feasible. Examples include solar-based small timber drying kilns, or bioenergy or biochemical digester plants. This 'small is beautiful' approach offers regional opportunities for new small businesses and enhanced employment opportunities.

So, the Climate Change Commission's recommendation of ~700,000 hectares of new trees and forests could give benefits well beyond carbon sequestration and climate change mitigation and have a very significant positive impact on the environment and the wellbeing of regional communities.

I welcome your thoughts on this vital topic and any other matter raised in this newsletter.

Dr Julian Elder
Chief Executive

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John Lee sets a wood disc into the DiscBot for testing.

Quick and efficient wood quality testing

Versatile plantation-grown radiata pine is used in a wide range of applications. To ensure we grow wood suitable for both volume- and value-based applications, we need a way to predict final wood quality.

The range of factors that cause variation in the type, number, size, shape, physical structure and chemical composition of the wood elements means this is not easy. However, Scion has been developing an automated system to efficiently analyse a range of attributes that affect wood quality.

The DiscBot robot moves samples in the form of discs or 'slices' of trees, cut from the log ends of felled trees, through a range of sensors.

X-rays are used to measure wood density, which is associated with high lumber strength and stiffness.

A near infrared camera is used to detect the different light absorbing qualities of lignin, cellulose and other chemicals in the wood, which can provide an estimate of pulp or energy yield, for example.

Ultrasound is used to measure the speed that soundwaves travel through the wood and is used as an indication of wood stiffness.

The distortion of visible light (RGB or red, green and blue) is used to measure wood grain angle. Grain angle can significantly affect wood strength and performance with as little as a 15-degree deviation causing a 50 percent strength loss.

Wood quality scientist John Lee says, "the DiscBot can test multiple discs quickly and efficiently. If we have a series of discs taken from the base to the tip of a stem, we can get a picture of the quality of wood that's been laid down throughout the whole tree and how that varies."

Why test?

Testing wood from trees at the end of a rotation provides essential information for both forest managers and researchers. Running a full suite of tests on trial trees with known genetics, silviculture and the environment provides a wealth of data that can show how interventions have affected wood quality, and how returns have been improved and what might be improved in the future.

Assessing wood properties post-harvest is also important for segregating wood prior to processing. For example, structural timber needs to be stiff. Ensuring the right wood goes to the right place will bring about savings in terms of reduction in wastage of wood and reduced manufacturing costs.

The DiscBot is currently busy carrying out work for local forestry companies who are interested in ensuring their trees will meet product specifications at harvest. In particular, they want to know if rotation lengths could be shortened without affecting wood quality and to make sure they are sending the most suitable logs to sawmills and pulp mills.

New capability

A new capability under development is the ability to assess wood quality of standing trees using 12 mm bark to pith cores. This means trees with good genes for wood density and stiffness can be identified early in a rotation and the information can be fed back into breeding programmes, speeding up the tree improvement process. Currently, the density, chemical composition and an RGB image of the cores are possible. Further work is needed to be able to assess the stiffness and grain angle of core samples.

The wood qualities of other species such as Eucalyptus is also of interest. If eucalypts with as little as one percent extra cellulose could be identified it could be worth millions of dollars to the wood pulping industry.

FOR FURTHER INFORMATION on wood quality testing using the DiscBot, contact John Lee at john.lee@scionresearch.com

The building's name 'Te Whare Nui o Tuteata' was gifted by Ngā Hapū e Toru who hold mana over the whenua. The name Te Whare Nui o Tuteata acknowledges the mana of the tupuna Tuteata, from whom Ngā Hapū e Toru descend.

Building Te Whare Nui o Tuteata

Scion's new building, Te Whare Nui o Tuteata, is the culmination of Scion's vision for an innovative timber building and the work of a team of engineers, designers and builders who weren't afraid of a challenge.

Now that the build is complete, a few of the key designers have reflected on what it meant to them to work on a project that showcased timber as an innovative, low-carbon construction material and how it felt to be part of Scion's 'opening up' to the wider community.

Dunning Thornton – Structural design

Alistair Cattanach, Director at Dunning Thornton, led the structural engineering team that worked on Te Whare Nui o Tuteata since 2016.

Initial designs called for the building to sit on deeply entrenched piles, but the extent of deep geothermal activity meant that the resistance needed to brace the building would not be found in the ground. Alistair recollects that this led to the idea of a flexible diamond structure to provide the required bracing for seismic resilience. To connect the timber 'diamonds', the Dunning Thornton engineering team designed flexible, energy-absorbing steel plates that sit between the timber diamond sections (UFP plates).

UFP plates absorb and disperse seismic energy.

Creating the timber-to-timber nodes that join the diamonds together was also a new experience for the team. The timber connections were requested by Scion, pushing engineers to investigate interlocking laminated joints using cross-banded high grade LVL. Engineers were able to calculate the strength of the timber grains as they go in different directions and create strength through the layers as they cross over.

Alistair says Te Whare Nui o Tuteata represents a new generation of wooden office buildings. "Early timber offices haven't always done the material justice. Initial designs used the template of steel and concrete builds and replaced the material with wood. Now, the industry is on a journey to design new buildings that bring wood to life. The next generation of wooden buildings will be taller and more efficient thanks in part to this project."

Te Whare Nui o Tuteata has become a reference point for industry. As a demonstration of timber engineering, the building gives a voice to what is inexplicable about wooden buildings – the feeling they give. Alistair says, "This building is an example we can point to, and it will help more timber builds to happen."

RTA Studio and Irving Smith Architects – co-designers of Te Whare Nui o Tuteata

RTA Studio and Irving Smith Architects welcomed Scion's brief to push the boundaries with timber technology. To them, the building represents more than

10 years of advancement and sophistication in the way timber structural buildings are conceptualised.

Scion's desire for timber innovation led to the creation of the novel timber-to-timber connections and the use of timber structural elements as prefabricated diamonds and triangles. This reduced the amount of timber needed to around 25 percent less than comparable projects. The cost and environmental savings were also passed on through resourcing, transporting and constructing the building.

A life cycle assessment commissioned by RTA Studio and Irving Smith Architects confirmed that Te Whare Nui o Tuteata achieves embodied carbon zero for raw material mining, manufacturing, transport and building construction. This was only possible because of the low-embodied carbon of the timber components and the amount of carbon stored in the wood.

Rich Naish, Executive Director and founder of RTA Studio, said that "Te Whare Nui o Tuteata represents a real prototype rather than just a possibility for all future buildings. We see this project as a marker on our journey to make New Zealand carbon zero by 2050."

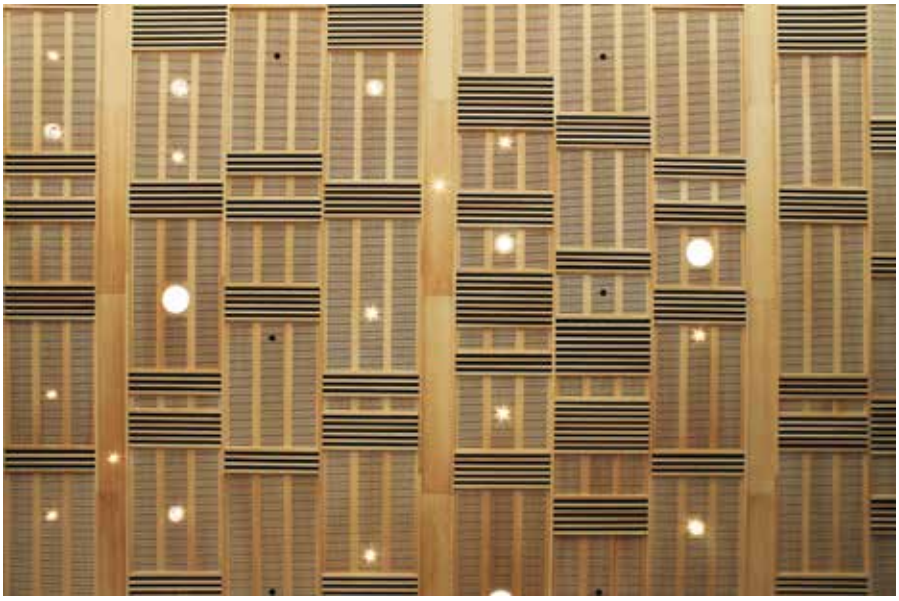
Jeremy Smith, a founder of Irving Smith Architects, asserts that one of the biggest benefits brought about by the project was the opening of Scion to the Rotorua community and the public. "Te Whare Nui o Tuteata provides an invitation to researchers, the timber industry and the community to come and be part of the future. We hope everybody joins the adventure and helps use timber sustainably to improve our participation with the planet."

Professional Consulting Services (PCS) Limited – Electrical design

Leslie Eckard, director of PCS Ltd in Auckland, undertook the electrical engineering and lighting design for the building. Leslie says he used minimal exterior lighting to accentuate the building and make Te Whare Nui o Tuteata glow like a 'lantern in the forest'.

On the ground floor, interior lighting was selected to bring out the colour and warmth of the timber diagrid structure and to create a minimalistic look that suited the architecture. The fixtures selected are LED technology with low power consumption and minimised maintenance requirements.

Carla Eckard undertook the building information modelling (BIM), which helped plan the extensive electrical services and communications technology, and allowed coordination between the architectural model and other building services. Carla says, "Experiencing the completed product in real life after spinning a 3D model on a virtual screen for many hours during design certainly brings great satisfaction, and I feel humbled to have been part of this project".



The atrium ceiling lighting was inspired by the Matariki night sky.

Leslie says creating the Matariki inspired lights in the atrium ceiling was a highlight of his career. The feature aims to simulate the Matariki star cluster. It uses different sizes of circular lights to bring a sense of depth to the environment, and through programming sequences to create the impression the lights are glittering in the sky. "It makes the ceiling come alive," says Leslie.

Reflecting, Leslie said that the building has provided him with challenges and proud moments. "I was sitting across from someone recently and they began to tell me about their holiday to Rotorua. He was talking about travelling down a long forest road which led to the most incredible building. He didn't know I was involved with the building and I didn't tell him, I just listened and felt a surge of quiet pride."

A shout out to others

Julian Elder, CEO of Scion, says that the visitor experience is part of what Scion wanted to achieve. "We wanted to provide the opportunity for the wider community to experience the future that a forest-based circular bioeconomy can deliver, and provide the public with examples of the research Scion is doing to support a low-carbon and renewable future for Aotearoa."

The office building, public and exhibition spaces are open to the public to enjoy and learn about Scion's work to transition to a circular bioeconomy.

Other contractors involved in the design and build of Te Whare Nui o Tuteata include project managers RDT Pacific, construction firm Watts & Hughes, engineered wood fabricators Timberlab and Xlam, exhibition designers and producers The Gibson Group, mechanical and hydraulic designers eCubed Building Workshop, and fire engineers Cross Fire.

FOR FURTHER INFORMATION on Te Whare Nui o Tuteata visit www.scionresearch.com/te-whare-nui-o-tuteata

Samples of Scion's 'bio-coal' – woody biomass that has been torrefied and densified.

'Bio-coal' for better burning bioenergy

Swapping coal for bio-coal from renewable resources is a fast way for New Zealand to remove the greenhouse gas equivalent of up to 20 percent of light vehicles from our roads. Utilising this technology would reduce our greenhouse gas emissions, rejuvenate regional economics and create jobs. How do we make it happen?

Sustainable energy

The Climate Change Commission's recent draft advice on decarbonising New Zealand's economy calls for the country to reduce its carbon emissions and points out this can be done with technology we already have. This is definitely the case when it comes to phasing out fossil fuel use in heating and industrial boilers.

What stops New Zealand from using forestry biomass instead of coal and gas in industrial boilers? The largest source of biomass for biofuels in New Zealand comes directly or indirectly from forestry. Waste products from sawmilling, papermaking and other wood processing operations are already burnt to provide energy to these processes. In cases like Red Stag Timber, wood waste is used to generate electricity and heat to kiln dry timber, with any excess power being fed into the national grid.

Forestry and mill residues could fuel boilers in other industries, but their low bulk density, high moisture content and low energy content in comparison to coal means in many cases they cannot directly replace coal in existing boilers. However, heat and pressure can transform wood waste into high energy, high density bio-coal.

The process of heating biomass to temperatures of up to 300°C in the absence of oxygen is called torrefaction. When woody biomass is torrefied, bound water is removed, which increases the energy density, and makes it less likely to reabsorb water. The wood cell walls are also weakened, making it easier to compress the torrefied wood into dense pellets or briquettes, which further increases the volumetric energy density (GJ per cubic metre).

Scion researchers are optimising the torrefaction and densification of woody biomass to produce solid biofuels that are durable, moisture resistant and have an energy density close to that of sub-bituminous coal (20 to 21 GJ per tonne and 17 GJ per cubic metre).

Peter Hall, bioenergy researcher at Scion, says torrefied wood pellets or bio-coal can be robust and shipped and handled like coal so it can be used in existing supply chains/boilers. In some cases, it could replace coal or be used as a co-firing fuel.

Scaling-up

On a regional scale, Gisborne would be a logical place to establish a solid biofuel plant. Considering local raw material availability, Peter has calculated a plant processing 120,000 green tonnes of wood residues could produce 50,000 tonnes of torrefied wood pellets per annum and reduce New Zealand's greenhouse gas emissions by around 100,000 tonnes per annum, the equivalent of taking 40,000 cars off the road.

A torrefied wood pellet plant of this size, using off-the-shelf and locally made technology, would cost around NZ$50 million and could be up and running in two to three years. Overall, the plant would create at least 50 jobs locally, plus around 30 extra jobs collecting and delivering the residues and add $14 million to the regions and country's GDP.

Nationwide, New Zealand burns around one million tonnes of coal every year, creating around two million tonnes of greenhouse gas emissions. We could replace that coal use permanently by switching to solid biofuels, with a dedicated forest estate roughly the size of Wellington City, to ensure the supply of the renewable biomass feedstock (120,000 ha harvesting 5,000 ha per annum). This one change would be the equivalent of removing between 600,000 and 800,000[1] cars from the road, 15-20 percent of all of New Zealand's light vehicles.

A movement to replace coal with biomass is unlikely to happen by itself. New Zealand needs leadership at a national level and a national commitment to do things right. The investment needed is large but necessary to reduce the country's dependence on fossil fuels, reduce our greenhouse gas emissions and help rejuvenate regional economic and employment growth as we head to a more sustainable future.

[1] Assuming the average car travels 14,000 km per year (aa.co.nz) and uses seven to 10 litres per 100 km (transport.govt.nz).

FOR FURTHER INFORMATION on Scion's bio-coal, contact Bing Song at bing.song@scionresearch.com or Peter Hall at peter.hall@scionresearch.com

Paul Bennett: Our one shot

(Continued from page 1)

with liquid biofuel by 2035. We need to target that by reducing emissions from aviation and marine sectors.

"In aviation, alternative energy sources such as electrification and hydrogen are unlikely to replace fossil fuels for the long-haul flights which make up a large proportion of jet fuel use in the near to mid future. Liquid biofuels from biomass feedstocks are an option available now, and they are in use already, blended with fossil fuel. Governments in Norway and Sweden have already mandated the use of biofuel blends in their air transport operations, and many countries in Europe have targets/mandates set for future biofuel use in aviation. New Zealand will need similar policy settings to encourage deployment of aviation biofuels by our air carriers.

"The future for the marine sector is similarly linked to liquid biofuels. At present, more than 99 percent of ships use liquid fossil fuels, and over 97 percent of ships 'on order' to replace the current fleet will also require a liquid fuel. We will have to replace like for like (liquid fossil fuel for liquid renewable fuel) to have a significant impact on these emissions within the next 30 years. Batteries and hydrogen could power up a small portion of new ships, but, by and large, liquid biofuels will be the only alternative for a sustainable marine fleet in the future.

"Our work at Scion includes research in this area. We are developing technology based on transforming wood into liquid biofuel in a one-step approach. This technology is designed to be simple enough that we could build smaller scale processing plants close to feedstock sources, which is ideal for New Zealand's dispersed population, as well as reducing the need to transport biofuels around the country. Once marine biofuel production is up and running, we hope to further refine the technology to make a suitable diesel replacement for fossil fuel in cars and trucks.

"With just a few examples, it's plain to see that there's a lot of potential in biofuels. To really make these options viable, we need detailed planning. The Government will need to think beyond the three percent reduction needed to put us on track to meet our climate change commitments and make long-term plans to support the production of biofuels.

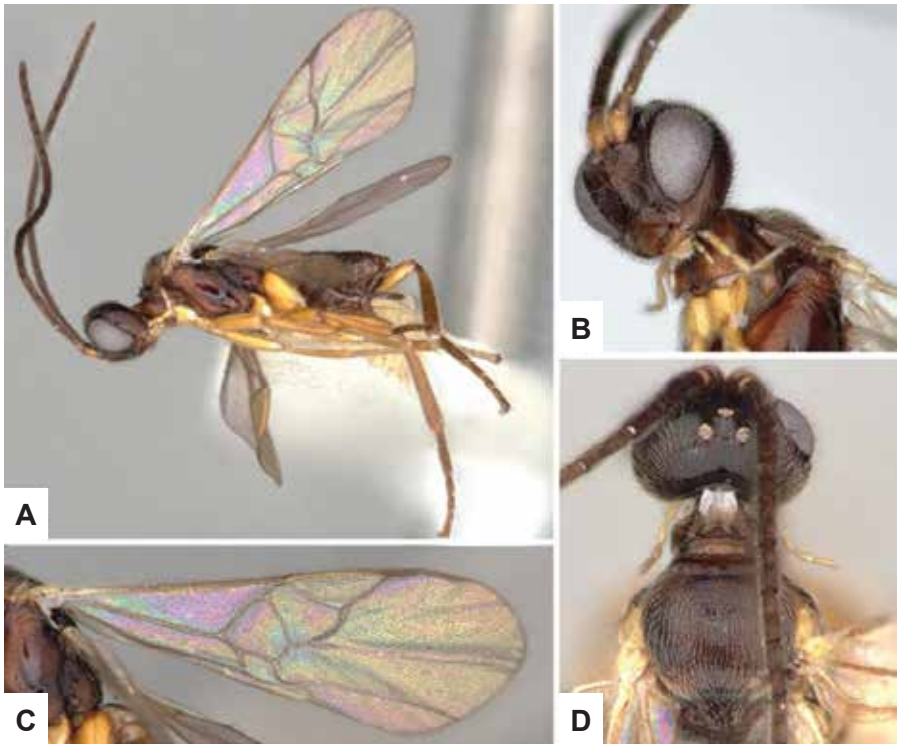
"For example, if forestry biomass is the preferred feedstock, the current waste residues will help us to reach the three percent reduction, but beyond that we will have to consider new plantings of specialised feedstock and answer questions like what tree species is best for which application? What planting regime should we use? When do we plant and where? We also need to factor in sustainability of land-use, pests and diseases.

"Through my leadership of the IEA Bioenergy there is a real opportunity for Scion and New Zealand to stay aware of latest international developments in the sector, including technology developments, policy implementation, sustainability and value chains. We then have an opportunity to import and modify these developments so as they are appropriate for New Zealand, e.g. feedstock type, scale, demand profile.

"None of this can be done unless we have strong Government support and policies that support the strategy necessity for biofuels, e.g. climate change, energy security, regional economic development. Every country that has successfully increased their use of biofuels and bioenergy has had strong policies to back the change. Our Government has announced their desire to have biofuels form part of our climate change response, but the emphasis is now on providing the right advice to decision makers to ensure that policy decisions are well informed."

For further information and preliminary modelling of different scenarios for biofuel use and planting across New Zealand, read our Biofuels Roadmap.

FOR FURTHER INFORMATION on our biofuels and bioenergy research, contact Dr Paul Bennett at paul.bennett@scionresearch.com



Wasp named after Scion entomologist

A new genus of tiny parasitoid wasps named *Notogaster* (family Braconidae, subfamily Microgastrinae) has been described. So far 10 species have been described to this new genus, all endemic to New Zealand.

Authors and taxonomists Jose Fernández-Triana and Darren Ward used this opportunity to recognise their collaborating entomologists (co-researchers on Better Border Biosecurity research project) for their contributions to New Zealand applied entomology. One of the 10 was named *Notogaster withersae* after Scion entomologist Dr Toni Withers. *N. withersae* has a brown body, iridescent wings and has only been found on Quail Island, Banks Peninsula.

To date, *Notogaster wasps* have been found at sites from Northland to Stewart Island. Species of *Notogaster* appear as 'generalists' and are found at elevations of between 80–1800m occupying a range of habitats (swamp, southern beech forest, and in moss/ferns on the forest floor). There are many additional endemic species of Microgastrinae in New Zealand waiting to be discovered. Researchers estimate there are between 100 and 200 endemic species in New Zealand currently unknown.

Parasitoid wasps live in close association with a host upon which they rely on and eventually kill. Interestingly, the host of the *Notogaster* is not yet known, but is suspected to be one of many species of native caterpillars. Learning the host of *Notogaster* species will help pinpoint their specific habitat requirements.

Namesake Toni Withers says, "Parasitoid wasps form an important and complex but often over-looked role in the food chain. They are among hundreds of species that play a vital role in natural biological control of insect pests every day around the globe. It was an honour to have an endemic species named after me, and I am very humbled. Congratulations to the authors for another fine publication from the New Zealand Arthropod Collection".

This work was supported by Manaaki Whenua and the Royal Society of New Zealand.

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