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THE PATH TO COMMERCIALISATION OF THE SPIKEY® TECHNOLOGY FOR THE DETECTION AND TREATMENT OF FRESH URINE PATCHES

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Abstract

Development of the Spikey® technology for detecting fresh urine patches in 2016 has focused on designing and building a much wider (8m) unit for mounting on a farm tractor 3-point linkage. This size has been determined as being the most practicable and cost-effective option for medium-large dairy farms who want their own Spikey®. Travelling at 12 to 16 km/hr, it takes less than 10 min/ha to detect and treat fresh urine patches, or 30 min on a typical 120 ha farm grazing 3 ha a day. The unit comprises a centre 2.8m module, and two outer 2.8 modules which are hydraulically foldable to allow passage through gates and along lanes.

Recent commercial investment will allow Pastoral Robotics Ltd to build up to 6 of these 8m units in 2017 for delivery to high-profile dairy farms throughout NZ. Retail prices are expected to be in the vicinity $50,000 (+GST). Ultimately, it is intended to build wider units for contractor use and to integrate other features such as prilled urea spreading (ONEsystem®).

This investment will also permit further development of the prototype Mini-ME® autonomous robotic tow vehicle. For cost and OSH reasons, Mini-ME® is small (1.2m length) and is designed to travel at only 4 km/hr and pull a 2m-wide Spikey®. However being driverless, these size restrictions are not commercial barriers, as the Mini-ME® towed Spikey® will easily be able to cover the land grazed in any one day in about 8 hours. Commercialisation of Mini-ME® is expected in 2019, and will enable many other farm tasks that are currently require considerable labour input to be conducted simultaneously.

Research into appropriate treatments to simultaneously apply to the fresh urine patches detected is being conducted by several research institutions and by Pastoral Robotics Ltd (PRL) itself. Given the current unavailability of the nitrification inhibitor DCD, PRL considers that its proprietary product ORUN®, which contains the urease inhibitor nbpt and

the growth promotant gibberellic acid (GA3), to currently be the most advantageous from a combined environment and farm profitability perspective, except in high drainage conditions.

In 2017 PRL is initiating an independent nationwide series of trials to determine the average increase in size and DM of urine patches and reduction in nitrate leaching obtained from realistically-applied real urine in a wide range of soil and moisture.

Spikey® Development Timeline

April 2013: Bert Quin meets mechatronics engineer Geoff Bates for the first time at the powhiri for Bert's sister Mary Quin at Callaghan Innovation, Auckland. They realise they share a passion to improve nutrient efficiency and reuse in farming, especially dairying. They set up Pastoral Robotics Ltd (PRL) and get to work on ideas (Bates and Quin 2013).

Late 2013: Geoff and Bert come up with the idea of using near-surface soil electrical conductivity is a means of detecting fresh urine patches. Geoff builds a small hand-pulled device to test the idea, which works well; the conductivity of fresh urine patches is much higher than in the surrounding soil due to the high content of K^+, $S0_4^{2-}$, and HCO_3^-in urine.

Fig. 1. An early small hand-pulled device for detecting urine patches.

Early 2014: A 1.2 m wide, 12-wheeled quad-bike tow-behind device, nick-named 'Spikey' is built to commence field testing of urine patches in different soil and moisture conditions, at

varying time intervals after application. Spray nozzles are trialed for optimum treatment of patches. DCD is originally intended to be used. With the withdrawal of DCD from the market, PRL develops its own spray ORUN®, a mix of the urease inhibitor nbpt and gibberellic acid GA3.

Fig. 2. The 1.8m-wide 'Spikey' device being towed by quad-bike.

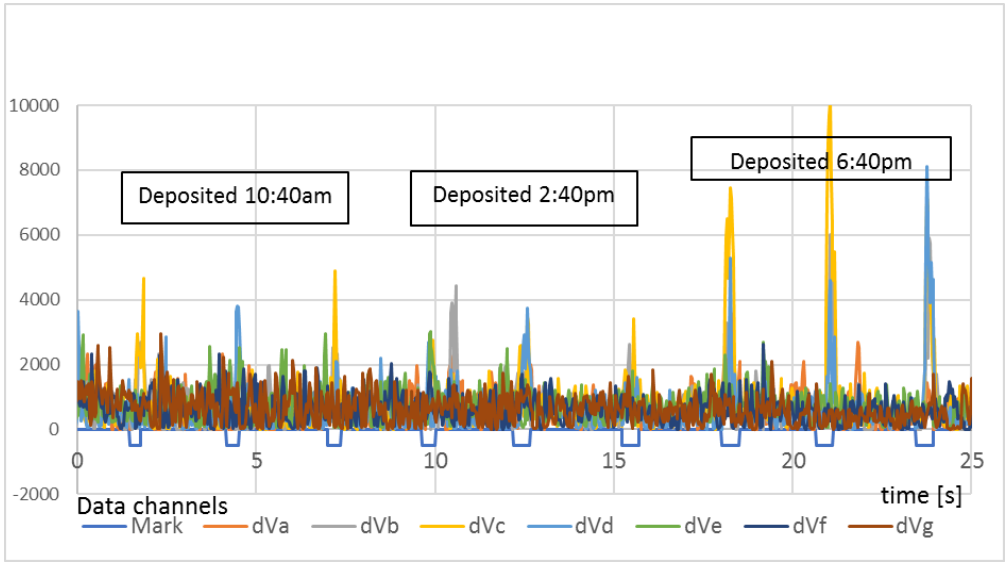

Fig. 3. Graph of soil electrical conductivity-related signal. The colours relate to different electrode sets.

Mid 2014/early 2015: PRL receives its first research funding grant, from the New Zealand Greenhouse Gas Research Centre (NZAGRC), to improve the sensing and electronic processing capability (Bates et al. 2015). These developments enable a larger side-by-side towed 2.8 m version to be built. Further NZAGRC funding enables the effects of ORUN® to be studied by Massey University. These show that ORUN® enlarges urine patch size and N

uptake by 70%, partly through the nbpt retaining urine-urea in this form for several days, allowing the urea to migrate laterally if rainfall is not excessive (Bates et al. 2015). Earlier modelling work had predicted substantial increases in urine patch diameter and volume resulting from nbpt application (Bishop and Quin 2010). Reductions in nitrate leaching (40-50%) and N_2O emissions (27-37%) were measured, and reductions in nitrate leaching of 48% estimated.

Registration of the Spikey® and ORUN® names were granted this year.

Fig. 4. Early Massey University field urine patch research with ORUN®, Dec 2014-Jan 2015.

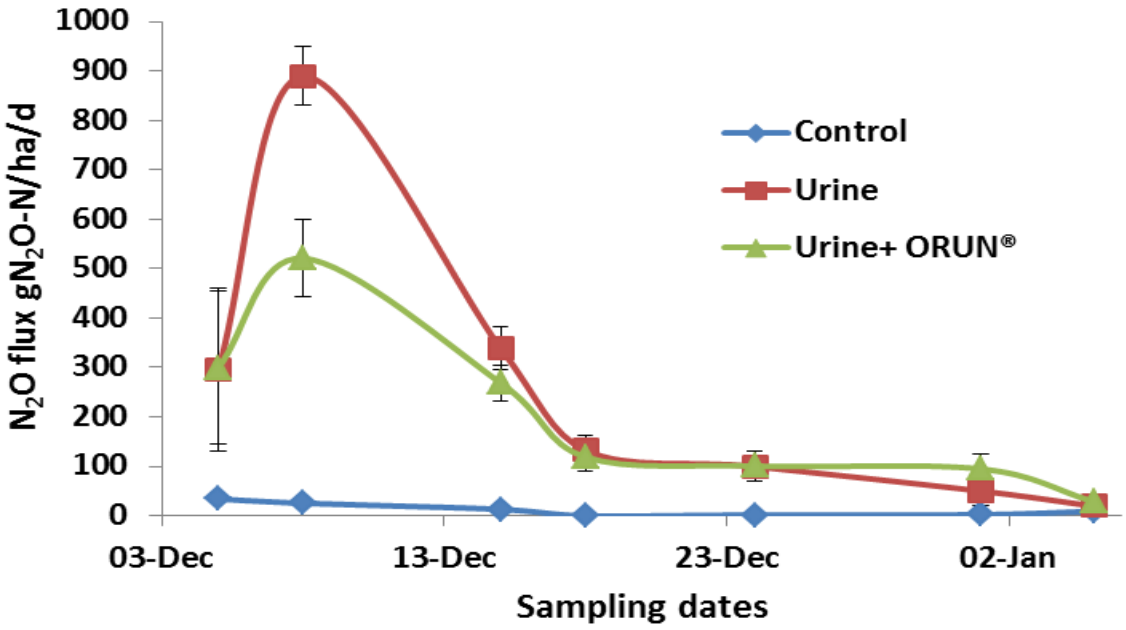

Fig. 5. Trial data showing reductions in nitrous oxide emissions, summer trial).

2015: The detection capability of the 2.8m version of Spikey® is tested rigorously on farms throughout New Zealand, with excellent results. PRL does its own series of trials measuring the effect of ORUN® application on the ultimate size of real urine patches (Quin et al. 2016). PRL wins 'Most Innovative' award for Spikey® at the 2015 National Fieldays (June 2016).

Fig. 6. A 2.8m-wide Spikey® trialling on a Landcorp farm, towed by a side-by-side.

2016: Woods et al. (2016) publish results showing no reductions in nitrate leaching from GA applied to lysimeters to which urine had been applied to the entire lysimeter surface. It subsequently becomes known that because conditions were too cold to for any growth response by the pasture to the urine N. This rendered the entire experiment pointless, as GA will have no effect on growth, and therefore nitrate leaching, in conditions that are too cold for growth.

More recent work (P.Bishop, *pers.comm.)* has demonstrated that even the use of temporarily placed gas collection or anti-urine flow rings can greatly diminish the effect of nbpt plus GA by restricting lateral movement of the urine-urea. PRLs own field work with real, unrestricted patches finds average increases of 70% in the average size of and N recovery by urine patches on three dairy farms in Southland, Canterbury and the Waikato (Table 1, from Quin et al. 2016).

Late 2016: A big ending-

(a) The first farm-sized 8m–wide Spikey (Spikey® 8M) is built for tractor 3-point mounting, with folding wings for passing through gateways and down lanes.
(b) Preliminary results from the second NZAGRC grant (made to Landcare Research) comparing a range of treatments show positive results for several Spikey® -applied treatments in small ringed urine patches even in the absence of 'growing-room' for the patches (Bishop 2016).
(c) PRL appoints a formal board, including Andrew MacPherson (chair), Lachlan McKenzie and Ross Simpson.
(d) PRL goes to selected interested individual investors for funding for 2017.

Table 1 The effects of ORUN® on urine patch DM.

	Dry matter production (kg DM ha^{-1})			
	Trial 1	Trial 2	Trial 3	Average
Location	Southland	Canterbury	Waikato	
Control (no urine)	1732	2025	2388	2048
Increase above 1200 kg DM/ha grazing residual (GR)	532	835	1188	848
Urine only	2111	2717	3332	2720
Incr. above 1200 GR	911	1517	2132	1520
Urine plus ORUN	2763	3160	3686	3203
Incr. above 1200 GR	1563	1960	2486	2003
Increase in DM above urine with ORUN application	*652*	*443*	*354*	*483*
LSD 5%	*169*	*301*	*247*	*210*

Figs 7a and b. The first Spikey® 8M, wings down and up.

Fig 8. Pastoral Robotics Ltd board, November 2016

January 2017: Private-sector investment funding drive for the 2017/18 development program fully subscribed.

February 2017: Lysimeter trial data presented at the 2017 FLRC Conference (Hoogendoorn et al 2007) demonstrates much lower ammonia and N_2O emissions under extremely wet conditions; inhibitors have little additional effect.

The focus is now turning to developing a predictive system for farmer users of Spikey® for selecting the most appropriate urine patch treatment under various soil and moisture conditions.

Later 2017: Return to development of Mini-ME; commercialisation is intended for 2019/20.


Figs 9a and 9b. Original imported and Massey University-built prototypes of the Mini-ME® autonomous robotic tow vehicle.

2018: Spikey® 8M is planned to be in full production, complete with a computerised Decision Tree for selecting the optimum urine patch treatment for the conditions present.

Conclusions

The development of the Spikey® towards commercialisation has provided a steep learning curve for the start-up company Pastoral Robotics Ltd. In less than 4 years it has moved from a basic idea to building the first farm-scale (8m-wide) unit, creating much valuable detection and construction IP along the way.

The testing of potential alternative urine-patch treatments to PRL's proprietary ORUN® product has been made possible by free and open discussion between PRL and the various CRIs and University research groups who wished to become involved. This research has demonstrated that no one single treatment product is likely to be effective in all conditions, and that extremely wet conditions are perhaps the most challenging.

The focus of this cooperative research is moving towards (i) using Spikey® to develop a much deeper understanding of more naturally applied, in-field urine patches, and (ii) developing a computerised, predictive system for enabling farmer users of Spikey® to select the most appropriate treatment for various soil, climate and moisture conditions.

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References

Bates, G. and B.F. Quin 2013. Robotic urine-patch treatment and effluent application – technology to support intensification of New Zealand dairy farming while protecting the environment. *Proceedings of the New Zealand Grassland Association 75*: 125-130.

Bates, G., Quin, B.F. and P. Bishop 2015. Low-cost detection and treatment of fresh cow urine patches. In: *Moving farm systems to improved attenuation.* (Eds L.D. Currie and L.L. Burkitt). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 28. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. 12 pages.

Bishop, P. and B.F. Quin 2010. Modelling of the effect of combined DD and urease inhibitors on the post-detection size of urine patches – implications for decreased N losses and increased pasture production using the "Taurine' tail-attached dispenser. In: *Farming's future: Minimising Footprints and Maximising Margins.* http://flrc.massey.ac.nz/publications.html. Occasional Report No. 23. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. Pages 268-273.

Bishop, P.A. 2016. Survey of potential nitrification inhibitors to replace DCD for targeted application to urine patches. In: *Soil, a balancing act downunder*. Joint conference for the NZ Society of Soil Science and Soil Science Australia. Queenstown, New Zealand, 12-16 Dec 2016, abstract page 37.

Hoogendoorn, C., Saggar, S., Jha, N., Giltrap, D., Bishop, P., Berben, P., Palmada, T., Lindsey S., Bates, G., Quin, B. and M. Hedley 2017. Efficacy of Spikey®-applied nitrogen transformation process inhibitors for reducing nitrogen losses from urine applied to well-drained dairy soils in autumn-winter. In: *Science and policy: nutrient management for the next generation.* (Eds L.D. Currie and M.J. Hedley). http://flrc.massey.ac.nz/publications/html. Occasional Report No. 30. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. 16 pages.

Quin, B.F., Bates, G. and P. Bishop 2016. Locating and treating fresh cow urine patches with Spikey®; the platform for practical and cost-effective reduction in environmental N losses. In: *Integrated nutrient and water management for sustainable farming.* (Eds L.D. Currie and R.Singh). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 29. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. 8 pages.

Woods R.R., Cameron, K.C., Edwards, G.R., Di, H.J. and T.J. Clough 2016. Does gibberellic acid reduce nitrate leaching losses from animal urine patches? In: *Integrated nutrient and water management for sustainable farming.* (Eds L.D. Currie and R. Singh). http://flrc.massey.ac.nz/publications.html. Occasional report No. 29. Fertilizer and Lime Research centre, Palmerston North, New Zealand. 5 pages.