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University Centre Reaseheath

Scholarly:
having or showing knowledge, learning, or devotion to academic pursuits

Research:
the systematic investigation into and study of materials and sources in order to establish facts and reach new conclusions

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Introduction: UCR Scholarship and Research Journal, Issue 3

Samuel Saunders and Deb Swift

Welcome to Issue 3 of University Centre Reaseheath's (UCR) annual *Scholarship and Research Journal*. Issue 2, published in 2021, showcased just what the research activity taking place in UCR is capable of producing, and effectively highlighted the sheer variety of subjects, topics and projects that our staff are interested in. Issue 3 continues this theme, presenting a broad selection of papers that both introduce new areas of interest and provide updates on projects meted in the previous edition. We hope you enjoy reading through these papers, and that they provide you with, at the very least, some food for thought.

Scholarship, Research and Publication: Progress in UCR

Much has changed in terms of research activity in UCR since the publication of Issue 2 of the Scholarship and Research Journal. Reaseheath College and University Centre Reaseheath has recently implemented a brand-new model for research activity, which provides a strong opportunity to grow research output and develop new collaborative links both within and without of the institution. Internally, the College and University Centre are moving more closely together through the formation of the new Innovations Hub Steering Group, which will monitor, review and support internal projects and develop collaborative working between staff members, students and external stakeholders. We have also built a new research-based relationship with the University of Chester through the establishment of the Innovation of Sustainability and Food Innovation (IoSFI), which is set to transform the way research is conducted in collaboration between UCR and our university partner.

Once again, UCR's Scholarship and Research Journal showcases our institutional commitment to pushing the boundaries at the forefront of knowledge and passing that knowledge on to our students. Research is a burgeoning, yet key component of UCR's rapidly developing identity as a higher education institution, and the papers published in this issue, as well as those that will appear in subsequent ones, also reflect the sheer diversity of activity taking place inside the faculty.

Issue 3: Turning an Outward Gaze

While the overarching theme of Issue 2 of UCR's Scholarship and Research Journal was one of 'reflection' upon ourselves and (in particular) the position of scholarship in our own practice as academics, Issue 3 opts for a far more outward-facing view. It continues with the theme of 'reflection' but turns its gaze onto some of the pressing issues and concerns in and amongst our disciplines of interest, as well as in the wider land-based (and indeed the general) higher education sector.

Vivek Mathur and Chris Buckle's piece on 'decolonising the curriculum' in the land-based higher education sector, for example, takes a hard look at land-based higher education through the lens of the global contemporary movement to 'decolonise' HE curricula, and concludes that the land-based sector's strong connection with tradition and history, mixed with its interest in innovation and progress, makes it both essential to, and particularly fertile ground for, 'decolonisation'.

In a somewhat connected vein, Sam Saunders's paper on land-based higher education and the arts and humanities also seeks to diversify the curriculum on offer in the land-based sector, arguing that the conflation between 'land-based' and 'STEM' is largely arbitrary, that arts and humanities disciplines have the potential to be just as 'land-based' as any other subject, and that to attract a new calibre of student into land-based HE the sector should consider embracing the arts, humanities and social sciences side of the curriculum.

From a more subject-specific perspective, Alex Sawyer's paper on the illegal hunting and persecution of birds-of-prey reflects on the failures and weaknesses of both the law and its application in protecting endangered raptor species from persecution in the name of agricultural protection and/or to protect hunting/grousing land.

Again, from a subject discipline perspective we welcome our colleague from Further Education Animal Management Joao Louro to our journal. Joao's paper explores the surprisingly controversial topic of tortoise nutrition. Analysis of nutrient composition of commercially available tortoise and rabbit food was conducted, and the results analysed to determine whether the nutritional value was similar and whether this type of feed could be a cost friendly alternative. The results are presented and discussed along with the potential impact on the herpetocultural world with a view to extend this study further in the coming academic year.

Clare Ellis provides us with a short project outline identifying her ongoing research into thermo regulation and zoo enclosure design for tropical and subtropical species. In her research outline Clare introduces us to the changed nature of zoo enclosure design and highlights the somewhat neglected area of 'thermo-comfort zones'. The initial pilot study started in the summer of 2022 at Reaseheath Mini Zoo. Undergraduate students will be engaged in data collection, and this will continue throughout the academic year. This project exploring the optimal welfare conditions in enclosure design for a range of species could potentially lead to a more longitudinal behaviour study which is rare in this field.

In the introduction we highlighted the development of the Innovation Hub and our last paper authored by Tom Guy CREST Research Manager provides us with three varied case studies looking at vermiculture, biochar and compost teas. These case studies serve to illustrate the wealth of research taking place at UCR and the impact this has for Shropshire businesses and stakeholders.

Ensuring that we are all informed and aware of the ongoing research projects and research passions that are part of UCR is a key criterion for the Scholarship and Research Journal and at the same time an essential component for the development of our academic scholarly community.

We hope you enjoy the collection of papers this year and encourage you to use the journal as a means of sharing your ideas, thoughts, research passions and associated activities. We urge you to take the opportunity to go public with your knowledge and work collectively to support the development of our academic community here at UCR.

Writing for the Journal

As always, prospective authors are actively encouraged to submit work for publication in the next issue of the UCR Scholarship and Research Journal, which appears annually at the start of the academic year. Discipline is no a barrier to publication; any form of research or scholarship is welcome, in a multitude of formats ranging from full academic articles to short, informal think-pieces. We are also happy to receive project updates, ideas for future projects or collaborations, book reviews, conference write-ups and thought experiments. A guide to Contributing to the UCR Scholarship and Research Journal is provided in Back Matters.

Research Articles

Land-Based Higher Education and the Environmental Humanities

Samuel Saunders

It is sometimes said, in academic circles, that when a subject, discipline or topic gets its own *Cambridge Companion*, it has 'made it' as an academic field. For those who are not yet aware, the *Cambridge Companions*, alongside the similarly-themed *Oxford Handbooks*, are authoritative yet largely-introductory essay collections that are themed around specific topics. They are mostly designed for an undergraduate and/or postgraduate readership (though researchers do often make use of them), meant to acquaint readers with the salient points of a (usually, although not always) somewhat-burgeoning field of study. Almost anything can (and potentially does) have a *Cambridge Companion*; there are such diverse volumes as the *Cambridge Companion to Plato (1992)*, the *Cambridge Companion to Antisemitism (2022)*, the *Cambridge Companion to Sherlock Holmes (2019)* and even the rather specific *Cambridge Companion to the Drum Kit (2021)*. Indeed, the areas covered by both the *Cambridge Companions* and *Oxford Handbooks* are so comprehensive that it has led to a number of jokes on academic-themed social media about whether there now needs to be an *Oxford Handbook of Cambridge Companions*, or similar (Fafinski, 2022).

'Environmental Humanities' (EH) and, to a lesser extent, 'Environmental Studies' (ES) are burgeoning, cross-disciplinary critical fields, designed to bring together the physical sciences and the humanities/social sciences, in order to explore, examine, and help to address (or perhaps redress) pressing contemporary environmental issues that affect everyone (Cohen & Foote, 2021). It aims to bridge the often-well-entrenched gap between Humanities and STEM disciplines, arguing that the common factional approach between the two areas is largely damaging and unnecessary (UCLA, n.d.).

For the past three decades, the Environmental Humanities/Studies fields have actually been largely fragmented into a loose collection of approaches to studying the human relationship with the physical world. These approaches have been largely divided across a multitude of disciplinary lines, as researchers with an interest in 'the environment' have all worked in a variety of critical fields, and have thus naturally created their own approach for studying it through their own subject-based lens. Literary studies, ethics, politics, urban planning, education, and even various aspects of geography, history, religious studies and classics all developed their own individual approaches to studying the human impact on the natural world, and all have hitherto existed and operated largely separately from each other (Cohen & Foote, 2021). Researchers in each of these areas have also applied different, universal theoretical lenses to explore their own discipline's intersection with the natural world; feminist, Marxist, postcolonial, post (or non) human, psychoanalytic or materialist theoretical approaches have all shaped humanities scholars' understanding of the intersections between their own fields and the human impact on the environment around us. In fact, within literary studies at least, the point of intersection has developed into its own 'ism' in the form of 'Ecocriticism', an approach to literature defined by Derek Gladwin as:

> [A] broad way for literary and cultural scholars to investigate the global ecological crisis through the intersection of literature, culture, and the physical environment (Gladwin, 2017).

It is only recently, however, that Environmental Humanities as a field has coalesced to a point where it is recognised as a cogent (and subsequently highly relevant) field of study, and, inevitably, in 2021 *The Cambridge Companion to Environmental Humanities* was published. The collection itself immediately recognises and gestures towards the fractious history of the EH field to which I have already alluded, but it also argues that there are (and indeed have always been) some unifying aspects to it:

> More than anything, what unites the environmental humanities is a sense of shared and open endeavour [sic] addressed towards the remediation of environmental harm [...] (Cohen & Foote, 2021).

The UK's land-based higher education sector, typified for the purposes of this article by institutions like University Centre Reaseheath (UCR), shares the same ultimate goal as the environmental humanities;

to explore and remediate environmental damage. The land-based higher education sector is loudly committed to the sustainability agenda, and dedicated to producing graduates with the skills, knowledge and expertise to shape the future of the environment, land and planet on which humanity depends for its survival. Indeed, a letter from the Chair of the Environment, Food and Rural Affairs Committee to the Secretary of State for Education in April 2021 argued that:

The introduction of [the Environmental Land Management scheme] alongside specific new targets for tree-planting, restoring habitats and biodiversity clearly call for a highly skilled land-based workforce, an imperative which will only grow as the UK moves towards its ambitious net zero target. *Land-based education is therefore more vital now than ever* [my emphasis] (Parish, 2021).

When understood this way, then the overall purpose of the environmental humanities is not far removed from the purpose of land-based higher education; to use their respective platforms and disciplinary contexts to, in essence, make the world a better, safer, more diverse, more sustainable, and ultimately a more habitable place for future generations. One might go so far as to say that land-based higher education is ideologically aligned with the purpose of the environmental humanities.

Yet relatively few courses that explore the human relationship with, and impact on, the environment through a creative, arts-based, humanities-based or social-science lens exist in land-based higher education, and when compared to the amount of programmes on offer that market themselves as 'hard science', the numbers are nothing short of striking.[1] It is therefore the purpose of this short paper to present a gentle, tentative and initial argument for a new and hitherto-unexplored focus on humanities-based approaches to land-based higher education in the UK, and to argue that this would have a number of benefits both to the sector, and to its students.

It is well-documented that the Humanities and the Social Sciences are of critical value to both higher education and to society at large, despite the continued prevalence of a (largely populist) myth that the Humanities subjects are of little 'use'. Even in Science, Technology, Engineering and Mathematics (STEM) fields, the Humanities have been widely acknowledged in published research as essential for effectively, and necessarily, contextualising the work done in a variety of disciplines that sit under the STEM umbrella, and for improving understanding of the universal applicability of various forms of scientific innovation. A paper by Britta M. Thompson, et al., published in 2016, explored the impact that studying the Humanities had on a group of medical students, and concluded that 'requiring [H]umanities as part of the required preclinical curriculum can [...] act as a bridge to contextualise the purpose of medicine', thereby helping students to remember that medicine is fundamentally about *people* (Thompson et al., 2016). More broadly, Daniela Dumitru argues that the Humanities helps to foster critical thinking, allowing other fields to make more intelligent decisions about where, when and why their efforts are applied in specific ways (Dumitru, 2019). To put it in simple terms, STEM disciplines can build a bridge; but it is the Humanities that helps justify its existence; decide where to place it and explain why it needs to be placed there (or *not* placed there); justify its presumably astronomical financial cost; and determine the economic, cultural and physical impacts it will have on the various communities that will use it. A second, perhaps more relevant example given recent events (and which hearkens back to the Thompson paper) would be to suggest that STEM subjects can make a vaccine, but it's the Humanities that helps its potential recipients to recognise and reject any misinformation that might otherwise cause them to decline it.

In the land-based higher education sector this idea is just as applicable. A commitment to exploring the land-based disciplines through a Humanities and Social Science-based lens will help us to explore the human relationship with the environment more critically and comprehensively, by helping people to better articulate and contextualise what they see and experience in their everyday lives. Students studying the land-based industries and disciplines in this fashion can, and will, create artistic, written, musical, theatre, or film-based pieces that deconstruct, critique and (crucially) better *articulate* the issues that surround the human relationship with the environment for others to see and consume. Students will also get the opportunity to examine the responses that have been made so far through the contextual lens of, for example, Marxist, feminist, historicist or psychoanalytic frameworks. Graduates can then move into creative industries, where those articulated messages are passed on to the public. As well, students will also be able to more effectively spot things like 'greenwashing'[2] because of their increased critical ability, thereby helping to reduce this unhelpful and largely cynical practice in future years.

Similarly, a commitment to humanities-oriented land-based education can help us to better understand our environmental *past* – and subsequently our cultural present. An immediate set of questions that spring to mind when considering this, for example, could be: how much of our visible landscape is shaped by the legacy of the British Empire? How many plant or animal species visible across the UK's countryside, that are today considered commonplace, were introduced because of the Empire? Or, in more specifically, how many of the UK's stately homes possess landscaped gardens that are chock-full of plants that were sourced from the 'colonies' and brought back to the UK – potentially as a showcase of Britain's Imperial influence, reach and wealth? And, crucially, how many people walk through these gardens in complete ignorance of the garden's occasionally-uncomfortable history? These questions, and more, are receiving more and more critical attention; as recently as 2020, the National Trust (NT) has implemented and/or accelerated a number of projects designed to explore the colonial history of country houses and their links to historic slavery (Davies, 2020). For example, the NT has set up the innovative 'Colonial Countryside' project in collaboration with Corrine Fowler at the University of Leicester, funded by the National Lottery and Arts Council England, to explore 'African Caribbean and Indian connections at 11 [NT] properties' and which hopes 'to inspire a new generation of young advocates for talking about colonial history' (National Trust, n.d.). Elsewhere, and slightly away from the colonial legacy of the countryside and how the countryside can help us to understand our colonial past, other questions we might pose include: to what degree are current agricultural practices influenced by historical agriculture from ages gone by? How are we to understand this in the contemporary context? What tensions exist between tradition and innovation in the UK's agricultural sector? And how can exploration of our past agricultural practices, in the pre-Industrial Revolution days for example, shape sustainability for the future? All of these, and more, are debates, projects, discussions and ideas that are attractive and relevant to the land-based higher education sector, and embracing the Humanities side of the land-based curriculum would naturally provide students with opportunities to do so.

The slightly tongue-in-cheek question above about the tensions that exist between current and historic agricultural practices actually highlights a third benefit of adopting a humanities-based approach to land-based education; it can help us to deconstruct some of the contradictions that exist in the land-based discipline(s). For example, there is a substantial tension in the land-based industry between the move to 'rewild' swathes of the UK countryside in an effort to boost biodiversity, protect or reintroduce exceptionally-rare species, and to elicit passive natural resource management, and the necessity to farm in order to continue to produce enough food to sustain the population, not to mention keep the agricultural industry fiscally solvent. This tension is nicely and succinctly articulated in an article by Julie Baber of the Sustainable Food Trust in 2021, where she argues that large-scale rewilding projects usually elicit

> "a knee-jerk response from farmers, that is both scathing and defensive (Baber, 2021)."

Barber goes on to argue

"And what of farming? [...] I fail to understand why a millionaire 'returning swathes of the British farmland to wilderness' is a cause for celebration. [...] Ultimately, we all have to eat and, (laboratory-produced 'food' aside), the source of our sustenance is the land. Are we seriously suggesting that it is in the interest of the planet to import our food whilst 'returning' our own farmland to a pseudo 'wilderness' state? And why is it always farmland in these either/or scenarios? Do we value our food production (and food producers) less than golf courses, shopping malls, industrial estates? How about 'rewilding the countryside' one business park at a time? (Baber, 2021)."

[1] At time of writing, only one honours-level course – Writtle University College's innovative BA (Hons) Art and the Environment – exists in UK land-based HE that could perhaps fit into this category.

[2] Greenwashing: defined by environmental activist group ClientEarth as '...where a company uses advertising and public messaging to appear more climate friendly and environmentally sustainable than it really is' (ClientEarth, n.d.).

There are numerous questions and tensions that Barber raises here, including questions surrounding how we manage both farmland *and* wilderness simultaneously; how we enhance biodiversity and yet also create sustainable food supplies for the population; the ethical considerations of what she (somewhat scathingly) refers to as 'laboratory-produced 'food''; and, in broader terms, the question of the value system generally ascribed to different 'lands' under a capitalist economic structure – in short, shopping centres and business parks valued over farms and farmland. These can, and should, *all* be topics for discussion in land-based higher education. Students and graduates should be identifying, deconstructing and exploring these tensions for themselves, in spaces where they are at the forefront of the curriculum and institutional remit – in other words, where they in a position to make the most difference.

In slightly more tangible terms, offering Environmental Humanities/studies-based courses within land-based higher education also has the potential to assist, diversify, and indeed transform, the sector's highly-active employability agenda, as well as improve access to higher education for students who are interested in, or passionate about, land-based disciplines but who are perhaps not technically- or scientifically-oriented. The land-based education sector has traditionally been tied quite closely to specific industries in terms of career-paths for which graduates are prepared. Many students enter land-based higher education with designs on working in zoos, in wildlife conservation, in the equine sports and management industry, in the canine training industry, in veterinary nursing and or in agriculture, and this tends to be the professional spaces at which students are consciously directed throughout their degrees. Indeed, much of the curriculum in land-based higher education is understandably designed and delivered to be 'in line' with the respective industries at which students are often-deliberately pointed, to prepare students for roles within them upon graduation. The specific industrial contexts against which courses in land-based higher education are set has generated some resistance to offering other subjects that perhaps do not have such a specific 'industry' to openly target – like the Humanities, which historically and famously is not tied to a specific 'industry'. But far from being a barrier to successful employment, land-based Environmental Humanities disciplines would prepare students for a *multitude* of employment options upon graduation, and would diversify the professional settings that land-based HE graduates could potentially enter. Graduates would be well-prepared for roles working in sectors such as (but not limited to) heritage conservation, local and/or national government, specific agencies such as DEFRA or the Environment Agency, as advisors for the green energy or utilities sector, national infrastructure, teaching and education/training, marketing or communications (particularly in terms of sustainability), long-term or large scale projects, or as independent creatives dedicated to the sustainability and/or environmentalist agenda. In fact, *any* company with a sustainability agenda would be a potential employer. The jobs are out there for the taking; for example, at time of writing (May 2022), there is a live advertisement for an Education and Arts Marketing Officer for the Forestry Commission, attracting a salary of over £27,000 per annum – a perfect opportunity for an Environmental Studies/Humanities graduate from a land-based HEI. As well, an applicant coming from a specialist, land-based higher education institution (as opposed to a traditional university) would actually have a significant edge over others in a competitive employment market.

That said, it is not just about diversifying the fields into which land-based HE graduates could potentially go; embracing the humanities/social sciences side of the curriculum provides the land-based higher education sector with a unique opportunity to promote change within the already-established industries to which it is already aligned. The widely-accepted notion of producing graduates who have completed a highly-authentic course that aligns with current industrial standards in their respective disciplines has one major issue; it tends to *accept those disciplines for what they are*, rather than critique and deconstruct the processes, prejudices and issues that might exist within them and thereby promote change. To put it simply, students are frequently told things like 'that's how it is in industry' when they are working through their course. The natural response we should have to that is: *'why'*? An intransigent acceptance of the status quo leaves very little room for progressive practices to develop in graduates, but to embrace criticality through progressive subjects would produce graduates who could then go on to *shape* that industry for the future. By its very nature, Humanities education fosters the exact culture of critique and creativity that land-based HE graduates should take with them when they leave, allowing them the opportunity to refine, change, progress and ultimately improve the industries in which they work in future (Dumitru, 2019).

The final, and perhaps most simple, point to make about the potential to develop the Humanities and/or Social Science side of the curriculum in land-based higher education would be that it would actually increase the visibility of the land-based higher education sector as a whole, which (it is probably fair to say) currently operates slightly under the radar of the public consciousness – particularly when compared to traditional HEIs. Reaching out to a new kind of potential student would simply increase the amount of publicity and marketing activity that individual institutions could potentially undertake. As well, graduates of Humanities-based subjects (who, as we have seen, are more likely to enter more diverse sectors than those that land-based higher education traditionally targets) will go with stories of their experiences of land-based HE into industries where they may not have heard of the sector at all.

In short, then land-based higher education sector should consider embracing the Humanities and Social Sciences, where possible, into its future curriculum offering to prospective students. There is significant scope for the insertion of these subjects into 'land-based' higher education, and the act of doing so has the potential to transform *both* of them. The only potential question mark that could potentially be raised is whether courses themselves could be adequately considered to be 'land-based', but there actually is no concrete definition of what 'land-based' actually is. In fact, the UK Government's own definition (established in this example by OfSTED) of a 'land-based' education is surprisingly open, as it states that it covers

> a broad range of subjects, including agriculture, horticulture, animal care, equine studies, countryside and wildlife management and environmental conservation (OfSTED, 2014).

As such, developing a humanities aspect to land-based higher education would not be to the detriment of *extant* course offerings, and nor would it dilute the 'land-based' identity that the sector has worked very hard to construct. If anything, it would simply increase the visibility, diversity, and success of an already-successful sector, and would certainly help to prevent the sector from being 'left behind' in the face of global conversations about the future of the world and humanity's place in it. It would provide more opportunities for students to explore the human interaction with the environment (and the consequent impact humanity has on its own existence) through a more sophisticated critical and theoretical lens; it would open up a far broader swathe of employment prospects for graduates of the land-based sector outside of the traditional industrial routes; it would develop new links with a broader set of industrial and cultural institutions and employers, and (crucially) it would provide improved and widened access to land-based higher education for a new, previously disregarded set of students.

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A wing and a prayer?: Raptor Persecution in the UK

Alex Sawyer

Birds of prey have long been one of the most hotly-contested focal points for an often-hostile dispute that exists between those with shooting interests and wildlife conservationists in the UK. Since 2018, there have been multiple incidents of suspected foul play and illegal killings of many species, including golden eagles *(Aquila chrysaetos)*, white-tailed eagles *(Haliaeetus albicilla)*, goshawks *(Accipiter gentilis)*, buzzards *(Buteo buteo)* and hen harriers *(Circus cyaneus)*. However, despite strong penalties in place for offences against raptors, which are protected by the Wildlife and Countryside Act 1981, prosecutions are disappointingly rare (RSPB, 2019a). The persecution of these birds is today considered a national wildlife crime priority (NWCU, 2021a) but, despite this, raptor persecution continues, and has even increased since COVID-19 lockdown restrictions began in the UK in 2020 (RSPB, 2020a).

Outlining the Problem

Attacks on wildlife, whether unintended or deliberate, present a significant challenge. Poisoning is particularly difficult for forensic toxicologists, and cases in the UK involving birds of prey are worryingly common. Indeed, 25 out of 89 (28%) confirmed raptor persecution incidents in 2019 involved poison (RSPB, 2019a), and this was a trend that continued into 2020; in March of that year, North Yorkshire Police discovered two separate poisoned buzzards in North Yorkshire (North Yorkshire Police, 2020a; North Yorkshire Police, 2020c), while a poisoned red kite (Milvus milvus) in Ruthven, Scotland was found in October 2020 (NWCU, 2020b). A number of poisoned peregrine falcons (Falco peregrinus) were also discovered: one in Barnsley in October 2020 (NWCU, 2020c), and two in Belfast in March 2021 (Beattie, 2021).

Any criminal inquiry that involves the death of a wild animal will be generally comprehensive, usually consisting of a crime scene investigation, a post-mortem examination, and (in a case of suspected poisoning), a toxicological analysis (Brown *et al*., 2005). Techniques such as gas or liquid chromatography mass spectrometry are commonly used to identify the chemical composition of any suspected poisons, and quantify the amount present within the victim's tissue (Luzardo *et al*., 2014). Alternatively, analysis of muscle samples using chromatographic techniques with tandem mass spectrometry is also a suitable methodology due to its particularly high sensitivity (Sabater *et al*., 2020).

However, decomposition of the animal, alongside the sheer number of different chemicals that can cause lethal poisoning, are both major sources of difficulty for forensic investigations (Luzardo *et al*., 2014). Even further complications arise when dealing with raptors because of their dietary ecology; for many species, poisoning from rodenticide may actually be secondary, following the bird's consumption of rodents that have been legally poisoned for control. Some licensed veterinary ectoparasite products may also cause problems if livestock die and their bodies are subsequently scavenged (Millins *et al*., 2014).

This highlights perhaps the most significant issue concerning raptor persecution; it is often very difficult to produce enough evidence for a case to progress to prosecution, and it is even more difficult to prove deliberate intent. Even when poisoning has been deliberate, or has at least involved the use of illegal or banned substances, a lack of sufficient evidence to take an offender to court is still common. One of the aforementioned cases involving buzzards from Yorkshire involved a cocktail of 4 pesticides – three of which, Carbofuran, Isofenphos and Chloralose, were, and remain, banned substances. That said, and despite the difficulties of gathering sufficient evidence, charges are sometimes brought forward; in April 2020, for example, a man was charged over the deaths of more than 20 birds of prey and other wild birds near Castle Douglas in Scotland after a multi-agency investigation (NWCU, 2020a). The case is ongoing, and though due to appear in April 2021, at the time of writing (July 2022) it has still not been heard.

It is not just in cases of suspected poisoning where law enforcement authorities struggle to bring perpetrators to justice. Sometimes it is simply a lack of evidence, combined with an apparent lack of urgency. For example, in November 2018, a hen harrier that disappeared from a roost location on a driven grouse moor in North Yorkshire (RSPB, 2019b). Despite the bird's tag giving off an exact location at the end of March 2019, which confirmed that the bird was dead, the body was only retrieved by the RSPB and police on 5th April 2019, meaning a number of days had elapsed between identification and recovery. Once it had actually been recovered, the carcass underwent X-ray testing by the police, which confirmed that the body contained pieces of shot. However, even with the tag showing the disappearance over a grouse moor, and the evidence of the body containing shot, no individual was accused or brought to trial, leaving it a seemingly perpetrator-less crime. In another incident from 2019, an eyewitness directly observed a hen harrier being shot and was able to direct police to an area of trampled vegetation with fresh tyre tracks. However, no body was ever recovered, and so no crime can be proven to have occurred (RSPB, 2020b).

In 2020, a similar incident involved a man who was recorded by RSPB investigators shooting two buzzards after illegally using a live eagle owl (Bubo bubo) to lure them to him (RSPB, 2021). The video was passed to North Yorkshire Police, who conducted a raid on a gamekeeper's home. Despite the presence of some highly incriminating evidence (including the suspect arriving home during the search in the same type of vehicle seen during the shooting with a live eagle owl on the back of it) without an admission of guilt the available evidence did not meet the requirements of the Crown Prosecution Service (CPS) to progress the case, and so it was not pursued. Other similar cases involving video evidence have also been dismissed even when they do make it to court; in a Crown case from April 2016, which involved the interference of peregrine falcons at their nest site on Bleasdale Estate in Lancashire, the gamekeeper faced 9 charges including 2 counts of killing a schedule 1 wild bird (Raptor Persecution UK, 2018). Video surveillance was obtained by the RSPB at the nest site, and after police searched the defendant's premises, a knife and a hammer were confirmed by forensic analysis to have been in contact with peregrine falcon. However, the case collapsed in March 2018, after a District Judge ruled the RSPB surveillance evidence inadmissible at Preston Magistrates Court.

Both of these cases help to illustrate both the limitations of the law and the hinderances that prevent law enforcement agencies from applying it. Police agencies are often relatively slow to seek information when dealing with cases of raptor persecution, occasionally appealing to the public weeks or even months after discovering evidence of criminality. For example, after another hen harrier was illegally shot in North Yorkshire in October 2019, Police only appealed for information online in March 2020 (North Yorkshire Police, 2020b) – a delay of five months.

While this could be interpreted as a lack of interest on the part of police agencies in securing convictions, we must also consider the difficulties that law enforcement encounters in application of the law. To put it frankly, the law (as applicable to raptor persecution) is ineffective, and prosecutions are consequently rare. The difficulty stems from the law's inability to gather sufficient and appropriate evidence to show intent on the part of the suspect, and so despite the fact that there have been some prosecutions, they tend to be few and far between, and convictions are even rarer. In 2019, for example, only one out of 85 confirmed raptor persecution incidents resulted in a conviction (RSPB, 2019a), while in 2020 out of 137 confirmed raptor persecution incidents, only two resulted in convictions (RSPB, 2020a). This absence of conviction and punishment further adds to the difficulty in effectively dealing with raptor persecution, as even when caught, the likelihood of meaningful long-term consequences seems as rare as hen's teeth.

Raptor persecution therefore remains a serious problem, which is sadly exacerbated by the birds' behavioural traits. For example, the wandering behaviour seen in the pre-breeding years of many raptors, who travel large distances and pass over multiple estates, means their persistent killing can affect their population numbers over large areas (Newton, 2021). Some estates therefore become 'ecological traps'; raptors are territorial, and will often occupy and defend a territory for many years when undisturbed. But if birds are persistently killed, then the now-unoccupied territory can attract more birds who then face the same persecution, which thus eventually depletes the overall population (Newton, 2021). Populations are therefore maintained below the carrying capacity, largely because of ongoing illegal persecution, and the most recent population estimates are given by Woodward et al. (2020) as: 510 pairs of golden eagles, 500 female hen harriers, 122 pairs of white-tailed eagles, and 4650 pairs of peregrines. By comparison, land-cover maps indicate that 21% of the UK offers suitable nesting habitat for hen harriers, potentially supporting 2514-2653 pairs based on density estimates from places where current populations of

harriers are undisturbed (Fielding et al., 2011). This clearly indicates the extent to which this particular species is currently well below their potential numbers.

To specifically combat the decline in hen harriers, in 2016 the Department for the Environment, Food and Rural Affairs (DEFRA) launched the Hen Harrier Action Plan, involving a brood management scheme to be undertaken by Natural England (NE). This involves rearing hen harrier eggs or chicks in captivity when they are found on driven grouse moors within 10km of another breeding pair. The chicks are then released into upland habitat once reared. Despite the scheme's intentions, it is actually controversial, partly because the International Union for Conservation of Nature (IUCN) reintroduction guidelines states that threats that caused the decline in the first place must be identified and removed (which is certainly not the case here) (IUCN, 2013), and partly because of a recent financial agreement signed between NE and representatives of the grouse shooting industry, the British Association for Shooting and Conservation (BASC Press Team, 2020), worth £10,000. The Memorandum of Agreement between the two parties includes a clause that "Both Parties shall ensure that their respective communications solely in relation to the Programme contain no derogatory remarks about the other Party or the Programme, nor shall any communication contain any message that is contrary to the principles of the Programme" (BASC & NE, 2020). This effectively limits the ability of a NE as a Government conservation organisation to criticise any suspect actions of BASC members.

A Ray of Hope

Despite the ongoing crisis of raptor persecution, new measures are being implemented to try and help combat the problem. The monitoring of wildlife, habitats and their threats has been significantly boosted by technology, which provides tools to improve data collection and allow for more informed management decisions. Indeed, technology has become an indispensable part of conservation thanks to its rapid advancement, potential for reduced cost, and improved availability of existing tools, which has the potential to empower conservation organisations in the fight against illegal activities that threaten biodiversity. Satellite and telemetry technologies are regularly used to monitor wildlife (Kays *et al*., 2015), and the use of drones is becoming increasingly common in wildlife monitoring (Turner et al., 2003). Satellite tracking devices, in particular, have the potential to assist conservation by identifying hot spots of illegal activity, thereby allowing informed management strategies to be made (Wellsmith, 2012; Newby *et al*., 2013). By providing geo-referenced data, multiple birds of prey have been tracked and monitored, which assists in both the identification of instances of illegal killing (Kendall & Virani, 2012; Smart *et al*., 2010) and investigations into suspicious patterns in tag disappearances (and associated land uses and other illegal activities) (Whitfield & Fielding, 2017; Murgatroyd *et al*., 2019). Acoustic listening devices are also available; Hill et al. (2017), for example, developed a small, energy efficient and low-cost acoustic detector that included an algorithm with the potential to identify a shotgun blast at distances up to 1km, the application of which could potentially yield positive results. Even more interestingly, a mobile phone application has also been developed by a schoolboy from Clutton in Cheshire, which enables the user to report suspicious activities potentially linked to wildlife crime; creates a report with information about the incident, vehicles, suspects, witnesses; and pinpoints the location using the phone's GPS, all of which can be sent to the police (NWCU, 2015).

The ability to develop and detect latent fingermarks on the surface of raptor feathers is also a relatively recent innovation; it has been available since 2015 after publication of a successful methodology on bird of prey feathers by McMorris, Farrugia & Gentles (2015) (although issues remain with both discovery of bodies and the deterioration of evidence over time in open environments). In a follow up study, McMorris *et al*., (2019) were able to reliably identify latent fingermarks on bird of prey feathers that had been kept indoors for up to 60 days, and more encouragingly still, could even develop fingermarks from feathers that had been unprotected and exposed to the elements for up to 21 days. However, they noted that these would not be of the quality required by law to identify an individual beyond the 14-day point. Still, these are promising results that hint that if a concealed carcass was discovered, the protection offered from environmental conditions by concealment could allow successful development of better-quality fingermarks, potentially allowing for the use of this type of evidence in raptor persecutions.

Furthermore, one of the fastest developing tools with significant potential for conservation and wildlife crime applications is environmental DNA (eDNA). Environmental samples such as soils and water, contain genetic material present in skin cells, urine, faeces, or extracellular DNA, which can be amplified by polymerase chain reaction, and used to identify species (Xing et al., 2022; Ruppert *at al*., 2019; Ficetola et al., 2008; Barnes & Turner, 2016;). E-DNA methods meet required legal standards for admission as evidence in most courts (Sepulveda *et al*., 2020), are being refined for use as a counter-terrorism measure (Young & Linacre, 2020) and have previously been applied to successfully combat wildlife crime, having previously provided enough evidence to support a conviction for eel (Anguilla anguilla) smuggling in Hong Kong (Cardeñosa, Gollock & Chapman, 2019). Interestingly, it has been demonstrated to allow for identification of mammals, and humans from air-collected eDNA (Clare et al., 2021). Though currently this is not a sophisticated enough technique for forensic applications such as identification of perpetrators, one need only look at the rapid advancement of the use of DNA in criminal cases, to see how future development of methods may occur.

Despite the multitude of new technologies and detection methodologies, as well as the substantial amount of data obtained from intelligent tags, raptor persecution sadly continues. Hen harriers, for example, are protected under Annex 1 of the EU Birds Directive (2009/147/EC) and Schedule 1 of the Wildlife and Countryside Act 1981 (as amended). But, as hen harriers are predators of red grouse *(Lagopus lagopus scotica)*, they are still frequently killed illegally to ensure high grouse numbers on shooting moors. Indeed, 52 hen harriers have been killed or disappeared in suspicious circumstances, since 2018 (Raptor Persecution UK, 2021). Murgatroyd et al., (2019) looked at UK data from 58 hen harriers that were satellite-tagged between 2007-2017, and found that while only 4 showed direct evidence of illegal killing, 38 had disappeared suddenly with no evidence of tag malfunction. This, naturally, strongly intimated at tag destruction and disposal of the bird's carcass. They concluded 72% of the birds had been illegally killed, but also found that harriers spent more time on grouse moors in their final week alive than in previous weeks, and that the likelihood of them disappearing increased significantly when they spent time in landscapes that were specifically managed for grouse shoots. The tags used in this study, and many that are still in use, are limited in the location information that can be provided in the event of a bird's death. Technological progress however, marches on, and since 2019 a new type of satellite tag has been developed as part of a collaborative effort between the British Trust for Ornithology, the Cairngorms National Park Authority (CNPA) and Scottish Natural Heritage and subsequently used on golden eagles around the Cairngorms National Park (CNPA, 2019). These new tags use the 'geostationary Iridium' satellite network, which ensure that signal information is always available, and have multiple sensors, providing an instant fix with an exact location in the event of unusual behaviour, allowing for rapid identification and recovery of any birds that die.

Ultimately, it is the current weak, ineffective legislation that must be reformed in order to significantly reduce wildlife crime and the harms associated with it (Salum et al., 2017). This could include laying responsibility onto the landowner for proven illegal activities that occur on their land. In fact, some thought is being given to licencing of grouse shooting, although it is a little unconvincing; a vicarious liability law was enacted in Scotland in 2012, although not in England or Wales (Newton, 2021). In 2016, an RSPB press release about an eighth suspicious disappearance of a golden eagle on grouse moors in the Monadhliaths over a period of five years sparked a government investigation to be commissioned, and the resulting report highlighted the link between the driven grouse shooting industry and golden eagle persecution, and lead to the commission of the Werrity report in 2017. This took two years to be produced, and just a further year after its recommendations were made, the Scottish government in November 2020 committed to grouse moor licencing (Gov.Scot, 2021), enabling licences to be withdrawn if law-breaking is proven. The 2021 grouse shooting season came and went, and the 2022 season rapidly approaches, but there has been no movement on this issue from the Scottish government. The procrastination and lack of motivation has seen more birds of prey discovered killed illegally (Raptor Persecution UK, 2021b), including a deliberately poisoned golden eagle found dead on a grouse moor on Invercauld estate (NWCU, 2021b). Whilst the Scottish government's stalling drags on, at least Holyrood have made some commitment to grouse moor licencing. In the House of Commons, no such promise has been made. On June 21st 2021, a debate was held regarding an outright ban on grouse shooting, after a petition gained 111,965 signatures (Petition.Parliament.UK, 2021), but the ban was rejected (*Hansard*, 21 June 2021 col 237WH). However, following that debate the Labour Party, at the time in opposition, called for grouse moors in England to be licenced (Wildmoors, 2021).

While welcome, the Scottish and potential English & Welsh reforms would not solve the overarching issue of a lack of sufficient evidence of illegal activity having taken place for cases to progress to court. The threshold of evidence required to prove that the terms of a licence has not been adhered to, or that the law has been broken, need not be so stringent, and perhaps the loss of a licence, and any subsequent earnings, would prove deterrent enough to reduce the intense persecution of birds of prey.

Overall, a fundamental shift in attitude is needed from all stakeholders to tackle the unjust persecution of raptors. To put it mildly, there are problematic attitudes towards this crime from all sides, and any reform requires both impetus and political will, both of which appear to be in short supply. Firstly, and perhaps understandably, gamekeepers view raptors as a threat to their grouse stocks, but they may also be acting under other employment-related influences (such as direct instructions from their employers, or the receipt tips obtained from shooters as acknowledgments for 'big bags' (Burnside & Pamment, 2020)). Secondly, grouse moors are often owned by wealthy landowners, some of whom sit as peers in the House of Lords, and who therefore wield considerable power to veto unwelcome laws, and who can also count serving politicians, who may not be above feathering their own nest, among their friends (Phillips & Hillman, 2020). It is not in their considerable financial interest (£5000 per brace of grouse (Grouse Moor Management Group, 2019), yielding profit of £10,000 per days driven shooting for the landowner (Thirgood *et al*., 2000)) to address this problem.

Thirdly, since the Protection of Birds Act 1954, it has been illegal to kill raptors, but the legal powers to detect the persecution of raptors and bring the perpetrators to justice have simply never been implemented. Wildlife crime cases, as 'summary-only' offences, are tried in Magistrates Courts, rather than Crown Courts, and Magistrates have limited powers of sentencing (Lorraine Ellwood, personal communication, 01 April 2021), causing the law itself to remain relatively toothless. A potential explanation for the constant foot-dragging, stalling, lack of will and clarity when it comes to tackling this crime is simply that they often serve the interests of the privileged and influential few. It intimates at severe misuse of political influence, and it should be considered a scandal.

The first step to enabling change is raising awareness and making people conscious of the plight of the hen harriers, golden eagles, buzzards, goshawks, peregrines, and other raptors that suffer needlessly in this nation of animal lovers. As a land-based educational institution, UCR is in a privileged position; we work directly with the future leaders of the sector, and the next generation of ecologists and conservationists walk our halls and sit in our lecture theatres. Let us use that privilege for good, to raise awareness and push for change. The difficulty in applying wildlife crime laws and obtaining convictions are clear, and it seems that, for the majority of the charismatic raptors that fall victim to illegal persecution, their killers will remain free as a bird. But change is coming, technology is racing to catch up, collaborations are forming, awareness is building, and with hope and effort, the talons of justice will be sharp.

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Zoo enclosure design for tropical and subtropical species

Dr Clare Ellis

The design of zoo enclosures has evolved from the 'disinfectant era' of the early 20th century that focused on hygienic and sterile environments that were easy to clean (Hyson, 2000) to a more recent focus in the final decades of the 20th century towards a naturalistic design that both engages visitors and, ideally, stimulates natural behaviours in the animals. However, a particular area of zoo enclosure design that has received little critical attention to date is the how animals use the environment in relation to each species' thermo-comfort zone (a temperature range at which optimal metabolic processing can occur). Previous research indicates that species-specific response(s) to thermal discomfort needs to be understood to achieve optimal welfare conditions in zoos (Vanitha & Baskaran, 2010; Young et al., 2013; Wark *et al.*, 2014; Sha *et al.*, 2020).

Zoos attempt to provide a thermal gradient within enclosures, by using buildings and artificial sources of heating and cooling to provide optimal temperatures for the animals housed. However, there is currently limited research to describe how successful these facilities actually are for promoting natural activity patterns in species that are housed outside of their natural climate. For example, tropical mammalian species that are housed in a zoo in a temperate climate may adjust their behaviour during times when the ambient temperature is either below or above their thermal comfort zone, by either seeking shade or a source of warmth. Such behaviour may result in the animal only utilising a small amount of space within the enclosure by huddling under a heat lamp or rarely using any outdoor space when the outside temperature is below their thermo-comfort zone for extended periods of time. Such behaviour patterns would not be observed in the wild and may lead to possible welfare implications such as boredom. There may also be other effects of these kinds of restrictions in 'comfortable' space availability, such as increased social aggression due to competition for access to thermoregulatory resources such as artificial heat sources.

To contribute to the currently-limited research on zoo enclosure design, third-year dissertation students at University Centre Reaseheath (UCR) will be participating in a pilot study at Reaseheath Mini Zoo, collecting behavioural and environmental data. The project has started this summer (2022) to monitor the behaviour and enclosure utilisation of the Slender-tailed Meerkat *(Suricata suricatta)*, Yellow Mongoose *(Cynictis penicillate)*, Common Marmoset *(Callithrix jacchus)* and Cotton-top Tamarin *(Saguinus Oedipus)*. Data collection also involves extensive environmental measures that may impact thermoregulation, including ambient air temperature and the surface temperature of substrates and furnishings, precipitation, humidity, shade availability, and wind chill. Alongside the more traditional animal behaviour observations, environmental monitoring equipment, including thermal imaging (Figure 1), is being used, which will provide opportunities for students to develop skills using these technologies that can be applied to their future work roles or postgraduate research activities. It is hoped that an observational report can be produced for each species that shows trends in behaviour as regards to thermal comfort, providing an evidence-base for adjustments to the design of each enclosure to promote natural behaviour patterns year-round. The pilot project is planned to run initially for a year, after which it is hoped that additional species, and potentially other zoos, can be included.

Longitudinal studies such as this are rare in zoo welfare research due to the time needed for long term behavioural studies, but it is only through looking at behavioural welfare impacts over the whole year and multiple seasons that we can hope to ensure that new enclosures are designed to promote optimal welfare for zoo animals. The opportunity to apply this zoo animal welfare research at Reaseheath Mini Zoo will hopefully therefore benefit the keepers and zoo animals, in addition to providing research opportunities for our animal science undergraduate students.

Figure 1: *shows a thermal image of the Yellow Mongoose outdoor enclosure at Reaseheath Mini zoo in June 2022.* **Figure 2:** *shows a photograph of the same enclosure. Different substrates and furnishings help to create a thermal gradient within the enclosure incorporating cooler and warmer areas.*

Figure 1

Figure 2

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Cross-taxa herbivory: Nutrient composition is largely similar in commercially available Tortoise and Rabbit pelleted food

Joao Louro

Abstract

Completed pelleted feeds are often recommended as a staple diet across taxa, with complementary variation added through the provision of mixed vegetation as treats. As nutrition provides a key challenge to feeding exotic pets, analysis of pelleted feed across two taxa was undertaken to identify similarities in diets. Composition analysis was carried out across tortoise and rabbit pelleted feed for reported values found on retail websites and feed packaging. Tortoise and rabbit feed nutrient composition did not differ majorly, and so rabbit food was found to provide a potential suitable alternative nutritional source for tortoises to other commonly fed vegetation. Promoting rabbit pellets as an alternative to at least part of the animal's diet, especially amongst uninformed or new keepers, may therefore increase the welfare of tortoises, especially those faced with economic challenges. If not as the whole diet, then as a proportion of this, rabbit food is likely to increase quality of nutrition offered.

Introduction

Nutrition has been previously identified as an overlooked area of conservation (Oftedal & Allen, 1996). When compared to reproduction (as is necessary for the increase of a population), nutrition can act as a limiting factor both to reproductive potential and to reintroduction/in-situ initiatives. Reproduction may therefore be the first thought that occurs when considering a species protection plan, whether in -situ or ex-situ. However, maintaining and increasing fitness in current individuals, to then identify how populations can self-sustain requires an understanding of endemic ecology and nutritional cycles. Due to this, nutrition may indeed be a more important factor to consider than the rate of reproduction for a dwindling population. Oftedal and Allen (1996) discussed the importance of procurement of nutrition and self-sustaining flora from both an economic and reintroduction viewpoint when identifying how to successfully breed species for translocation efficiently. The desert tortoise, *Gopherus agassizii,* when reintroduced into the Mojave Desert, was deemed to have greater reliance on nutritional quality of plant matter rather than seasonal or annual availability. Their conclusion being that it is imperative, nutrition be given a central role in conservation initiatives if species are to reproduce thus increasing in number.

Exotic pets have witnessed an enormous rise in popularity in recent years (Bush et al., 2014; D'Cruze et al., 2020; Jensen et al., 2019). There are a number of reasons for this, not in the least the relative ease of obtaining them, as well as the perceived ease of care. Reptiles and amphibians being the focus in these reports. Tortoises *(Testudinidae)* have particularly risen in popularity, One species having recently been identified as one of the top 6 most common reptile pets (Heyrman, 2020). In captivity, however, tortoises are frequently affected by "pyramidal growth syndrome" also known as "carapacial scute pyramiding" (CSP). This is a raising of individual scales(Scutes) that forms a distinct ridge, accompanied by a decrease in bone mass and density (Heinrich & Heinrich, 2016). By contrast, wild tortoise shells (for most species) will typically be smooth and well rounded (Fig.1a) as opposed to having distinctive raised scales on the carapace (dorsal shell region., Fig.1b, c, and d). The captive condition has been attributed to a range of factors in recent years, but no single factor has been identified as the major cause, presenting itself as a multifaceted condition. Wiesner and Iben (2003), for example, investigated the effect of humidity and nutritionally dense feed (specifically high protein), on the appearance of pyramiding, and found significant differences between a greater degree of pyramiding in dryer enclosures and protein rich diets compared to humid enclosures and nutritionally poor diets. This is understandable when one considered the natural history of tortoises; as explained by Wiesner and Iben (2003), this is a clade with that has adapted to the stochastic principles of seasonality, spends much of its time hiding in moisture-rich caves and burrows

to cool down, and therefore possesses a highly variable feeding regime. A similar concept was also investigated by Heinrich and Heinrich (2016), who investigated the effect of supplemental heat on the development of CSP. In that study, tortoises kept in enclosures with ambient heat 24/7 showed significant gains in growth and CSP, when compared with their cooler counterparts. Most recently, however, nutrition has been identified again as a factor that affects CSP. High starch offerings have been linked to greater CSP, as has lower bone mass, and lower bone density often associated with age (Mendoza et al., 2022). On the contrary, however, there is actually a negative correlation between CSP and age; older tortoises are less likely to present with CSP. While this may sound initially positive, what it actually suggests is that CSP simply leads to a lower life expectancy (Ritz et al., 2012).

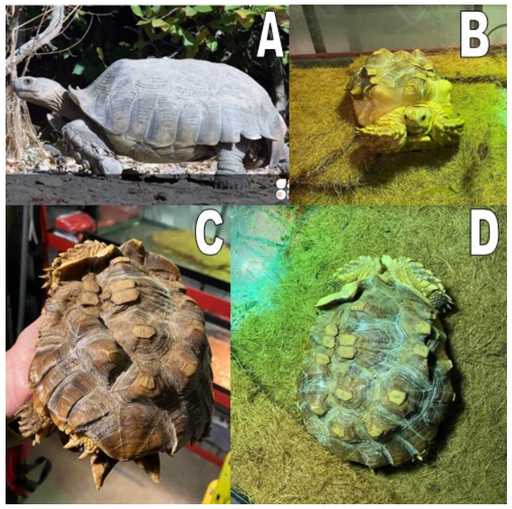

Figure 1: The African Spur-thighed Tortoise, *Centrochelys sulcata*, demonstrating both minimal, and severe carapacial scute pyramiding. A) Wild type shell growth with minimal carapacial scute pyramiding taken from the IUCN page © Tomas Diagne. B) + C) + D) demonstrating severe pyramiding of the same captive specimen taken from a post on the Facebook Group "Sulcata Tortoise Care Group". B) Anterior Dorsal view, C) Posterior Dorsal view, D) Dorsal View.

Whilst the concept of animal management and maintaining species in captivity may not immediately align itself to the concept of conservation in the wild, the theories underpinning ex-situ conservation closely align to those concerning pet ownership. Petrozzi et al (2021) recently assessed a commonly sold species, the African Spurred/Sulcata tortoise *(Centrochelys sulcata)* as being endangered. One could argue that species within the 'Endangered' category on the IUCN Red List must have a special focus on their dietary requirements, in order to conserve the species. But this raises the question: do keepers of these tortoises immediately become conservationists? If not when caring for an actively endangered animal, then when? And to what extent then can we label the average tortoise keeper as a conservationist? And if not, then what are the ramifications for the species that requires conserving?

It is well-established that tortoises are a common exotic pet (Heyrman, 2020), and that they are subject to neglect through poor husbandry, which can lead to complications such as CSP. Tackling nutrition may be a method available to almost "tick-off" a list of variables that have the potential to cause the condition. If the average keeper, however, is presented with costly diagnoses and veterinarian visits, they may be less likely to return in the future, even if it is necessary to do so. As a result, prevention of the condition in the first place would be the ideal scenario. An answer may lie in the concept of cross-taxa homology. Both tortoises and lagomorphs are hindgut fermenters that share a similar niche in their herbivorous digestion of coarse, fibrous, nutritionally-poor plant matter. The rabbit is particularly well studied in terms of its digestive systems (Blas & Wiseman, 2020; Cheeke & Dierenfeld, 2010), thus this is not a new concept. It has previously been explored that the homology and apparent polyphyletic principles of the fundamental processes that underpin herbivorous digestion is shared in these clades, and indeed in others (Bjorndal, 1997). Tortoise digestive systems have been actively compared to those of grazing herbivores such as rhinoceros, horses, and hippopotamus. The presence of these functions across mammalian and reptile digestive structures presents a distinct opportunity for improving economic efficiency in conservation nutrition. Franz et al., (2011a) argues for the same case with the principles of herbivore nutrition being universal across clades, and Yuan et al.,(2015) go so far as to compare tortoise gut microbiota with herbivorous grazing mammals. As tortoises in the wild grow more slowly, it is thought that poor feeding may, in turn, contribute to overall poor health of captive tortoises and limit their life expectancies (Ritz et al., 2012; Robinzon et al., 2005). Rabbit *(Oryctolagus cuniculus)* nutrition is very well studied (with the

rationale behind rabbit feeding now all but cemented). Rabbit food for a common, alloenzymatic hindgut fermenter is therefore readily available in major retail stores. However, it also serves as a potential candidate for the economical replacement of tortoise food. As tortoise food is a more niche product, it would not be surprising to discover that rabbit food would be a more economical option for tortoise owners to purchase than relatively expensive tortoise pellets that must usually be bought in specialised shops.

As an aside, domestic rabbits may also be fed a homemade feed mixture, however it is generally recommended that keepers use a concentrated pellet feed, both for ease of care and to ensure that the animal's dietary requirements are met (Blas & Wiseman, 2020). The use of a homemade mixture is generally linked to poor animal health due to the potential for error when trying to meet all the required nutrient quantities. Muesli or free choice-based diets may increase the potential for picky eating/ preference based exclusion of less palatable feed items. Rabbits, as common caecal fermenters, thus act as an excellent model with which to compare food quantities.

The purpose of this study was to investigate the link between commonly available commercial tortoise and rabbit complete pelleted feeds. The parameters were the specific nutrient composition of the food, and the study was designed to identify how these foods might differ, and to what extent if they do. This study does not concern itself with comparing digestive tracts, as this is beyond the scope of the aims set out here, for this reason only a brief overview was given previously as to the similarities of internal digestive systems. It was hypothesised that commercially available pelleted food across clades did not significantly differ, and that rabbit food may serve as a cost-effective replacement for expensive tortoise pelleted food. This would in turn serve to aid in raising welfare standards in the private home setting. It was also anticipated that, due to the differences in calcium synthesis and utilisation (i.e., supplementation being a staple action in herpetological husbandry) between reptiles and mammals, that calcium quantity may be higher in feed specified for tortoises.

Methods

Nutrient composition data and pricing was collected from general online retail websites aimed at customers in the UK for the macronutrients and minerals (henceforth including moisture, and interchangeably identified as 'nutrients' for simplicity) present on pet food packaging (Table 1). Websites used included VioVet Ltd., Pets at Home PLC., Internet Reptile Ltd., and Swell Reptile Ltd. Data was collected according to the values present on nutritional information, i.e., packaging and reported values on product page. Nutrients were accepted as percentages (%) of the total feed composition. Naming conventions affected data collections, as these differed across different companies. 'Digestible fibre' was accepted if this was present over 'beneficial fibre', due to the lack of companies publishing figures for the latter. Nutrients classed as "crude" were accepted in the same manner as those classed without the "crude" labelling. Distinctions were not made between neutral detergent fibre and acid detergent fibre, again due to the lack of reporting amongst companies.

Table 1: Variables evaluated as candidates for similarity. "Crude" variants on packaging were accepted, beneficial fibre was excluded due to the rarity in appearance of this on packaging.

Variables	
Protein	Moisture
Fibre	Calcium
Oil/Fat	Phosphorus
Ash	Sodium

Nutrient composition data gathered were split into Tortoise (n=16) and Rabbit (n=22) categories. Data was analysed in RStudio (RStudio Team, 2020) using the ANOVA method for Crude Fibre, Crude Oil/ Fat, Moisture, Phosphorous, and Sodium. A Kruskal-Wallis was used for Protein, Crude Ash, and calcium, following a significance *(p=<0.05)* in Levenes test for homogeneity of variances. Significance was set at *p=<0.05.* Pricing was not analysed using a statistical test as the purpose of gathering this was purely to highlight descriptive differences in sums as opposed to inferential statistical variance.

Results

Nutrient composition utilised in the study did not show significance across rabbit and tortoise pelleted food, except in protein *(chi-squared = 6.9053, df = 1, p-value = <0.01)*, Moisture *(f=7.366, d.f.=1, p= 0.01)*, and calcium *(chi-squared = 4.9147, df = 1, p-value = 0.03)*. As expected, Fibre as a major component of hindgut digestion remained largely similar *(f=3.599, d.f.=1, p= 0.07)*, despite this, analysed rabbit food had a higher average percentage of fibre, with a result of 20% compared to tortoise food at 17.1%. A larger sample size may have allowed rabbit feed to be significantly different in the crude fibre category. Unexpectedly, however, the range of protein (%) found in the feeds was larger in the Tortoise category than in the Rabbit (fig. 2). The figure displays the error bars at the 95% confidence interval, demonstrating a substantial difference. While rabbit food has a greater average protein percentage, it seems that this may be a better alternative than a randomly selected tortoise pelleted feed, which could potentially be higher in protein than the average rabbit food. Rabbit feed protein margins remain tight when compared to the Tortoise range. Standard deviation is included in Table 2 for comparative purposes. Oil/Fats *(f=0.031, d.f.=1, p= 0.85)*,

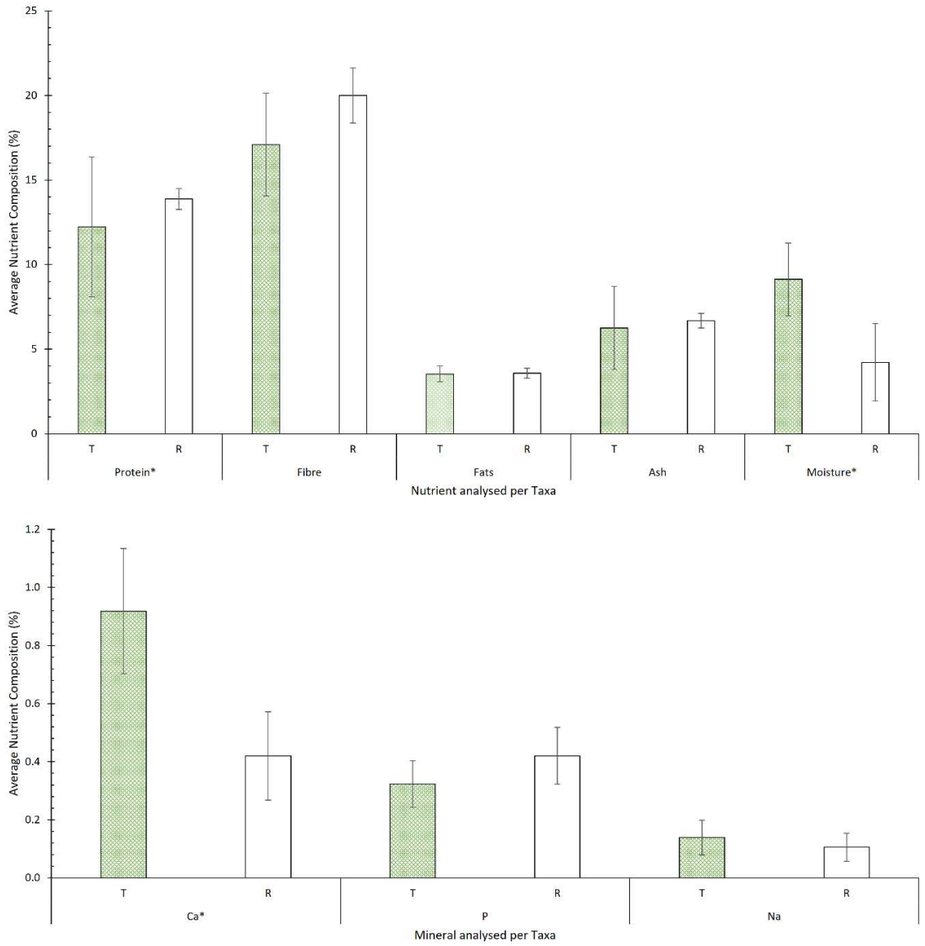

Figure 2: Mean nutrient composition of commercially available tortoise and rabbit food in the UK, as categorised by animal advertised. Error bars set at 95% CI. n= 38 (Tortoise = 16, Rabbit =22). *Ca = Calcium, P= Phosphorous, Na = Sodium, T= Tortoise, R= Rabbit, *= significance at p<0.05.*

The significant difference present in moisture was unexpected, as these were presumed to be at a similar level. The significance in difference between calcium amongst rabbit and tortoise food was expected, confirming prior suspicions. The differences are not particularly large, as there is an average of 0.5% greater calcium presence in tortoise specific feed than rabbit specific feed. The 95% confidence intervals look visually similar, and this is corroborated by the Standard Deviation being 0.4 for both tortoise and rabbit food. However, for a taxon that is reliant on external sources of calcium and both food groups containing <1% of calcium, this may necessitate additional supplementation, were rabbit food to replace tortoise specific pelleted feed. Phosphorous *(f=0.418, d.f.=1, p= 0.522)* and Sodium *(f=0.517, d.f.=1, p= 0.477)* did not show significant differences between the groups.

Table 2: Average figures per nutrient of commercially available tortoise and domestic rabbit food in the UK, as categorised by animal advertised. n= 38 (Tortoise = 16, Rabbit =22).

	Protein*		Fibre		Fats		Ash		Moisture*		Ca*		P		Na	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Average (Mean)	12.2	13.9	17.1	20.0	3.5	3.6	6.3	6.7	9.1	4.2	0.9	0.4	0.3	0.4	0.1	0.1
SD	8.4	1.5	6.2	3.9	1.0	0.7	5.0	1.0	4.4	5.5	0.4	0.4	0.2	0.2	0.1	0.1
SEM	0.5	0.1	0.4	0.2	0.1	0.0	0.3	0.2	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0

*Ca = Calcium, P= Phosphorous, Na = Sodium, T= Tortoise, R= Rabbit, *= significance at p<0.05.*

When comparing prices, it is clear that tortoise food is wildly more expensive per kg than rabbit pelleted feed (Figure 3). The average price of tortoise food per kilo being £14.95 is a stark contrast to £3.03 for the average rabbit pellet feed. The price difference again, similar to the nutrient composition is much tighter within the error bars (SEM), making rabbit food just under 5 times cheaper per kg than the tortoise pelleted feed. A randomly selected tortoise food can thus range from approximately £12 up to almost £18 per kg (using the SEM) when compared to the rabbit food which does not cross the £5 per kilo threshold.

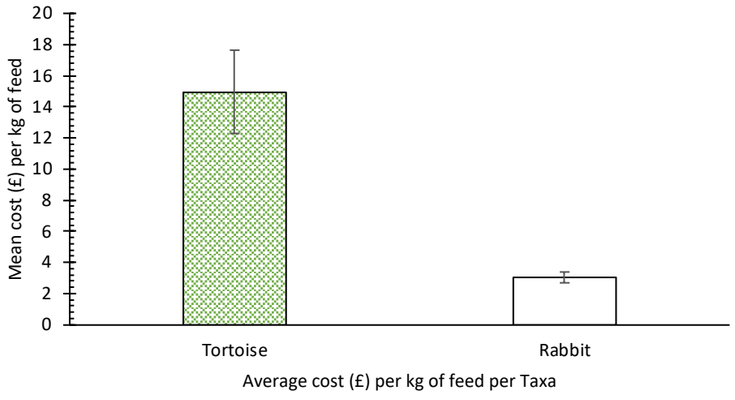

Figure 3: Mean price(£) per weight (kg) of commercially available tortoise and rabbit food in the UK, as categorised by animal advertised. Error bars set at SEM. n= 38 (Tortoise = 16, Rabbit =22).

Discussion

Concerning our significant results, the major factors for discussion are the calcium and protein differences. Calcium is well acknowledged for its role in its uptake in reptiles and the D3 cycle, with protein having been identified as being an active cause of CSP in tortoise species. This being said, the protein range in rabbit food is very tight with the Standard Deviation of this being 1.5, when compared to tortoise feed that has a Standard Deviation of 8.4. This indicates a wide range in the values and their distance from the mean (Table 2). Tortoise diets utilised in the study are advertised for grassland species *(i.e. Centrochelys sulcata, Stigmochelys pardalis, Testudo spp)*, and none advise feeding to opportunistic omnivorous species such as the Redfoot Tortoise *(Chelonoidis carbonaria)* (Mendoza et al., 2022). This challenges the relevance of food that is advertised as not being for species that may occasionally recover protein from scavenging but rather for species that are essentially obligate herbivores. Diets advertised as being for grassland species should not have as large a range as is currently present amongst the tortoise pelleted food sold in the UK. Recent study into the diets of Redfoot Tortoises have identified similar feeding paradigms as those identified in grassland species, namely that high fibre, less digestible diets (this is not to be confused with palatability) are more beneficial, leading to slower but more even overall growth and reduced CSP than a diet higher in starch or lower in fibre (Mendoza et al., 2022). Additionally, the concept of caecotrophy has not been considered in this study, and it is accepted that the impact of digestion in this manner may impact on an analysis of cross-taxa herbivory.

Concerning the difference in calcium, whilst this may look dramatic on first glance from inferential statistics, this may not actually be a significant problem for the case against the use of rabbit pelleted feed. Considering the wide availability of rabbits as pets, consequently leading to easy access to rabbit feed, as well as the comparatively cheaper price in purchasing complete pelleted feeds marketed to rabbits (fig.3), this may negate the need for pre-supplemented calcium presence. In fact, calcium is recommended to be added to the diet (Chitty & Raftery, 2013; Liesegang et al., 2001, 2007) with specific ratios being recommended to be added regardless of the food type given. This has been a consensus that greater calcium "Dusting" (the process of sprinkling calcium over food prior to feeding)/addition of calcium to the diet, is beneficial to meet the needs of the animal when compared to a lower availability of calcium. Greater calcium presence in the diet having been linked to greater calcium uptake in two separate grassland species, one of which is readily available in the pet trade (Liesegang et al., 2001, 2007). The issue of hypercalcaemia could then be raised, however self-regulation through the addition of a cuttlefish bone or a limestone block could mitigate for this.

Certain food items are often exempt from a mixed "fresh" tortoise diet that consists of vegetation. These include but are not limited to: lettuce, cabbage, spinach, and a range of cruciferous (Brassicaceae spp) and leguminous (Fabaceae spp) species. The reasons behind these species' inclusion mostly concern the levels of goitrogens (thyroid disrupting hormones) and oxalates (naturally occurring calcium binding molecules) found within some of these food items. However, while it is generally accepted that these plants do contain these compounds, they have been suggested in Tortoise medicine to actually be safe to feed to tortoises (Chitty & Raftery, 2013). Chitty and Raftery (2013), in *Essentials of Tortoise Medicine and Surgery* have refuted the claims by suggesting that whilst high levels of goitrogens may lead to a swelling of the thyroid gland, this has not actually been documented in the literature and no clinical cases had been seen at the time. A similar case occurred with Oxalates; it was suggested that food items high in Oxalates/Oxalic acid (such as spinach) was often incorrectly demonised. The high levels of bioavailable calcium overcome the levels of calcium binding, providing a good source of calcium overall. This study concerns the use of pelleted diets in an aim to standardise tortoise diets and increase welfare. Chitty and Raftery (2013) briefly discussed complete pelleted diets and were concerned with high levels of protein leading to higher levels of growth, and thereby CSP, if the husbandry parameters were not correct to enable the species to grow. Due to this, it was recommended that a complete pelleted diet form up to 50% of the total diet, to account for inaccuracies in the average owners' husbandry. Additionally, no tortoise feed utilised in the study was specifically marketed for one of the reportedly omnivorous tortoise species, as the focus was on grassland species. As a result, if cost, availability, or preparation time were a factor in providing excellent nutrition, then rabbit pelleted feed may provide an answer here. Other species utilising more varied, mixed diets would also be encouraged to utilise pellets as a part of the whole diet as recommended by Chitty and Raftery (2013).

The information pertaining to the husbandry of exotic animals as pets by the average person has begun to arise from social media, and will only grow as the access to information increases (D'Cruze et al., 2020). As the information availability increases, so too does the dissemination of incorrect husbandry, again often transported through social media. As this information gets rapidly disseminated by (likely well-meaning) groups, afflictions associated with poor husbandry rise, which leads to an increase in welfare

issues and animal suffering (Jensen et al., 2019). Again, with Petrozzi et al (2021) having assessed the African Spurred/Sulcata tortoise, *Centrochelys sulcata*, as being endangered (despite its ease of availability for purchase) and with no current focus on optimising their nutrition whilst in the hands of the average keeper, it seems nothing may have changed since Oftedal and Allen (1996) declared that nutrition is still an overlooked area of conservation.

A final comment comes in the acknowledgement of COVID-19. The "Pandemic Puppy" or "Lockdown Puppy" phenomenon has been sensationalised in both the media and animal management circles – to the point where it has now become not only an accepted, but a studied concept (Packer et al., 2021). Exotic pets have owed their rise in popularity to their perceived ease of care, but with specific regard to buying trends over the lockdown period, it seems that COVID-19 had a minimal effect on exotic pet demand (Ribeiro et al., 2022). This is a noteworthy revelation, considering that the pandemic was likely started by a zoonotic disease. The aforementioned study finds that the fear of zoonotic diseases has not scared would be owners to exotic pet care as one might first think. However, as owner numbers rise, so too will the proportion of animals existing in poor welfare conditions. Increasing the ease of care for would-be owners, with the economic value of nutrition being raised by the purchase of rabbit pelleted food as opposed to commercial pelleted tortoise food, may be a useful tool that conservationists have, in an often disappointingly small toolbox.

Next steps

This study forms the backbone of research I will be conducting for publication in the coming months. The major ideas and themes that have been explored will be summarised further, with an increased discussion into the digestive tract and qualitative data from a survey that has recently been approved by the UCR Ethics Committee. The survey will explore key nutritional themes which are considered by tortoise owners, and identify how wide the knowing-doing gap is between empirical evidence and the average pet owner behaviour. Nutritional themes may include reasons for/against feeding certain foods, factors that prevent good nutrition and sources of information regarding nutrition. The study will also expand the dataset further, as I have recently discovered further brands of food for both sides which may tip some of the nutrients into being significantly different amongst the food groups. Additionally, an investigation into ingredients and their safety will be appropriately carried out. Please do reach out if you would like to find out more or discuss this!

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A year of innovation – How CREST@UCR has supported Shropshire Businesses

Tom Guy

Introduction

The Centre for Research in Environmental Science & Technology (CREST) programme was first conceived in 2016 at the University Centre Shrewsbury, part of the Faculty of Science & Engineering at the University of Chester. The programme is partly funded by the European Regional Development Fund (ERDF) and allows businesses to realise their productivity and (in the case for CREST) environmental goals.

Reaseheath College and University Centre joined the programme as a delivery partner and has found success in supporting Shropshire based SMEs with their projects. Tom Guy & Janice Woolley joined the team as Research Manager and Business Innovation Manager respectively in 2020. However, due to the macroeconomic consequences of BREXIT, the COVID-19 pandemic and the growing climate emergency, businesses were struggling with maintaining viability in a hostile environment.

Despite this, The CREST@UCR team have rallied to support these businesses succeed against adversity by utilizing the leading edge expertise and resources available at Reaseheath. Our position is unique in that Reaseheath is a prominent land based college with excellent networks in the agri-food supply chain.

The business case studies below are just a snapshot of the potential for future collaboration once ERDF funding ends and a new cycle of business support emerges, with the advent of the Institute of Sustainability & Food Innovation (IoSFI – in partnership with the University of Chester) playing a pivotal role towards achieving success in the future.

Case Study 1 - Worm Soil LTD

Meet Luke & Steph

When we first met Luke Boxall he came to us with an interesting project - selling worm poo!

Luckily, it's not as off-putting as it sounds, as worms have been the quiet heroes of the natural world, busying away creating homes in and amongst organic material and the soil beneath. They truly are natural powerhouses when it comes to composting.

This is where Worm Soil LTD come into the picture with Luke, Steph and family relocated to a quiet village in Shropshire in search of the good life. Ever the budding entrepreneur, Luke hatched a plan with their farming neighbour to make use of his surplus farmyard manure and, after some research, decided that the humble worm would be perfect for the job. But not just any worm, composting worms to be precise.

About the Project

Luke obviously had a great product and a clear business plan with the support of Marches Growth Hub but required more evidence of the potency of his product and the potential routes to market he may have missed. An initial consultation revealed a clear project plan centring around market analysis, R&D, process improvement and validity of their product through technical trials.

The result? As part of the package of support created by Tom Guy at CREST@UCR, we've produced the following deliverables:

- A detailed marketing & sales report outlining potential strategies for entering high-impact routes to market, identifying business demographics, their strengths & limitations and analysing how Worm Soil LTD can support them.
- A comprehensive trial across several common plant species to evidence the correct application rate for their product.
- A technical review of their operations - discussion of their current strengths & weaknesses, process improvements and options for scaleup.
- A review of current legislation around worm composting, detailing the requirements Worm Soil LTD need to evidence to obtain accreditation and so add value to their product.

About Worm Soil and Worm Composting

There are several species of worm, and each category thrives within certain depths of soil and organic material. The typical 'earthworm' that many children take pleasure (or disgust!) in finding in their back yards is actually not a great composter, choosing to burrow deep into the ground and take food with it. Then there are those that dwell within the roots of plants (the rhizosphere), feeding on the abundance of microbes and organic material there, occasionally popping their heads up above the soil when it gets too wet.

Then there are the true composters, and Worm Soil's business partners, who devote their entire lives feeding above ground where fresh organic material starts to decay. They are so good at their jobs that they can eat half their body weight a day, reproduce in a matter of weeks and live long healthy lives of up to 5 years. Maybe Luke should give them a raise?

Enter Luke, who's main job is to keep his workers happy. Like Goldilocks, they like it just right - not too hot or cold, not too wet, lots of fresh air and food, and a cosy place to sleep (not that worms sleep anyway, but you get the point). Luke feeds them manure, green and brown waste, and waters them regularly in a purpose-built set of containers. Once fed, the result is a rich compost-like material that he can harvest and prepare for sale.

The uses of worm compost (vermicompost, vermicast or worm castings are other names) are endless, added as a top dressing, or as part of a potting mix, or even added to water for a nutritious plant tea. Many domestic and commercial customers are now commenting on the potency and value Luke's Worm Soil has added to their work, with Worm Soil currently expanding operations to meet demand.

From the beginning, Luke & Steph at Worm Soil LTD have aspired to scaling up and, with the support from CREST, have managed to visualize what that looks like and the necessary resources to deliver on that goal. From working manually using traditional methods, to building a semi-automated unit (see above), to planning for high volume production, CREST has enabled them to create a rich future full of growth, much like their product!

The Results

Lettuce Trails

Lettuce were growth using increasing ratios of vermicompost supplied by Worm Soil LTD, mixed into a peat-free growing media.

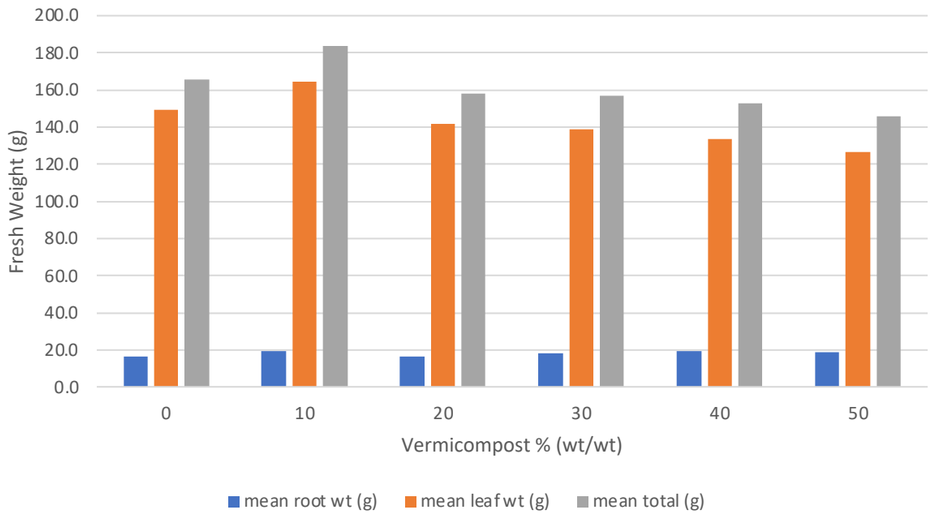

Fig. 1 – Graph showing mean fresh weigh yield with increasing vermicompost

The results shows a fresh weight increase in lettuce yield at 10% wt/wt vermicast, which coincided with similar results in literature (Edwards, 2010, pp. 106, 121, 574).

Radish Trail

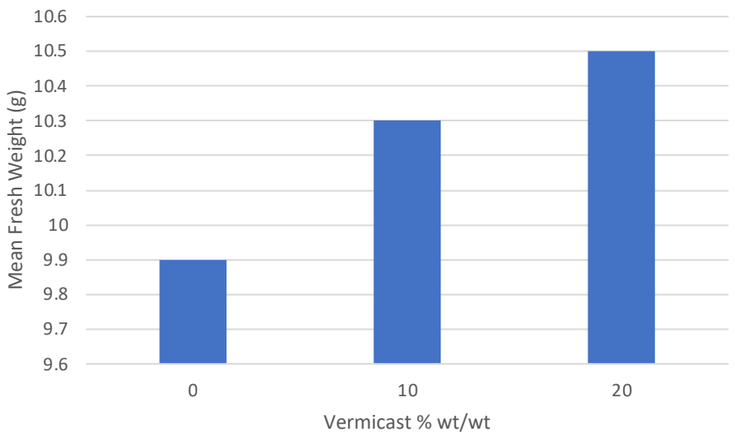

Fig. 2 – Graph showing mean weight yield of radish with increasing vermicompost

Results after harvest, washing and weighing (taking the mean value from the total yield by mass and number of radish) show a 10.7% increase in mean weight at 20% wt/wt vermicompost mixed with untreated soil grown in an outdoor environment. This corresponds well with literature (Edwards, 2010, pp. 106, 121, 574) on similar improvements in yield when vermicompost is applied to field-grown crops.

Tomato Trail

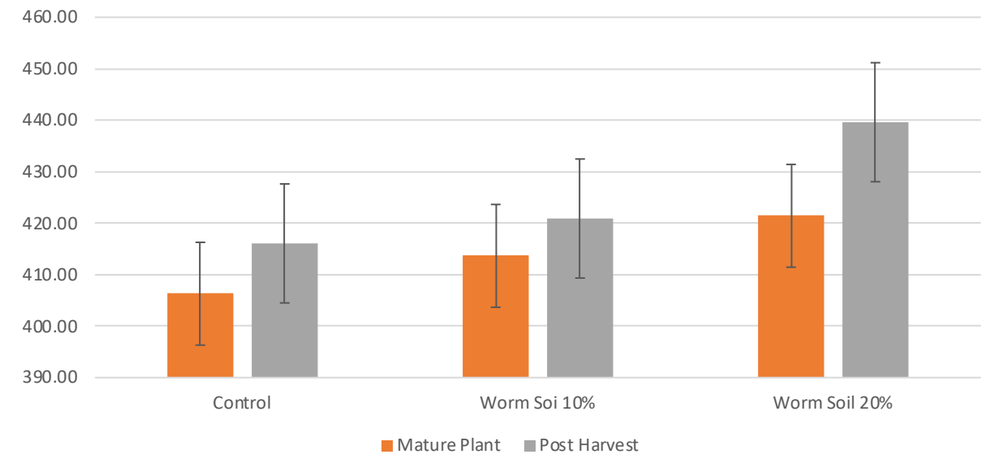

Fig. 3 – Graph showing height data (in mm)

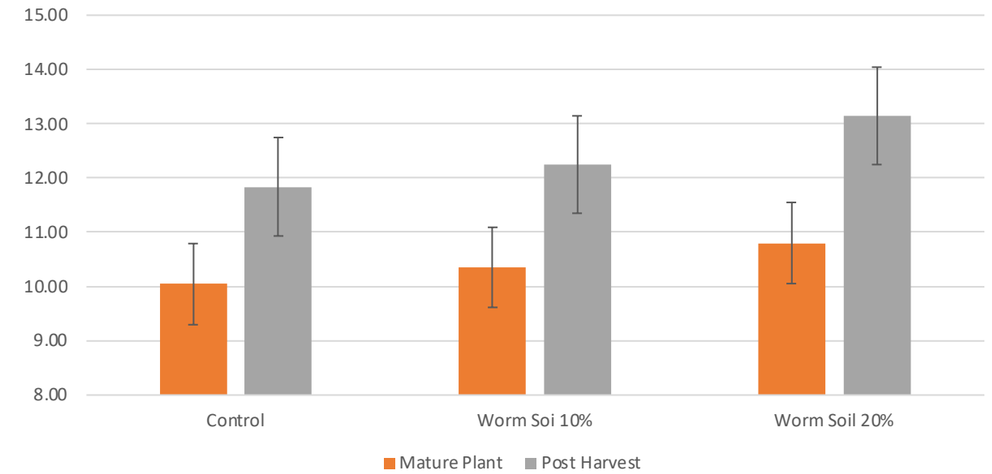

Fig. 4 – Graph showing aerial biomass data (in grams)

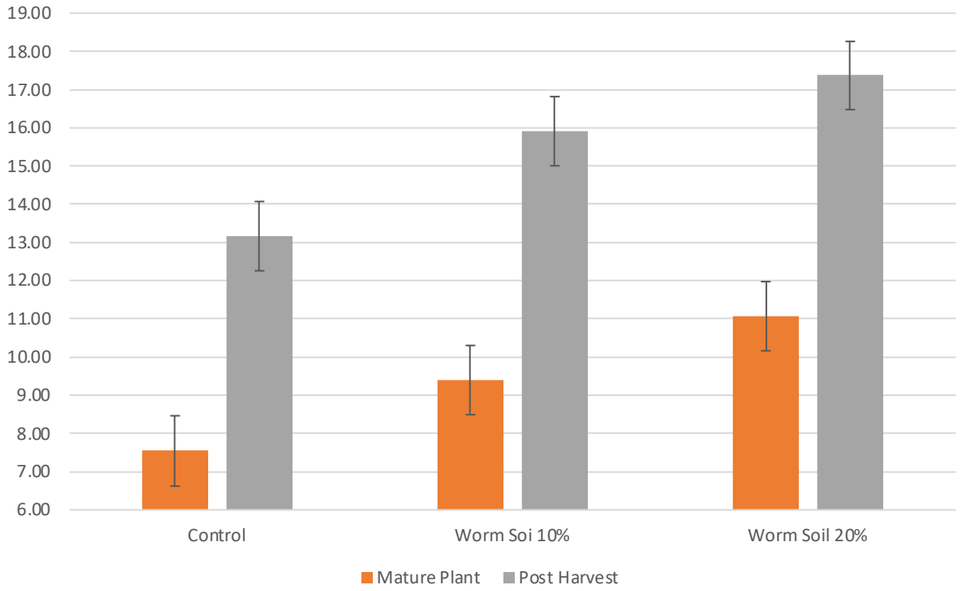

Fig. 5 – Graph showing root biomass data (in grams)

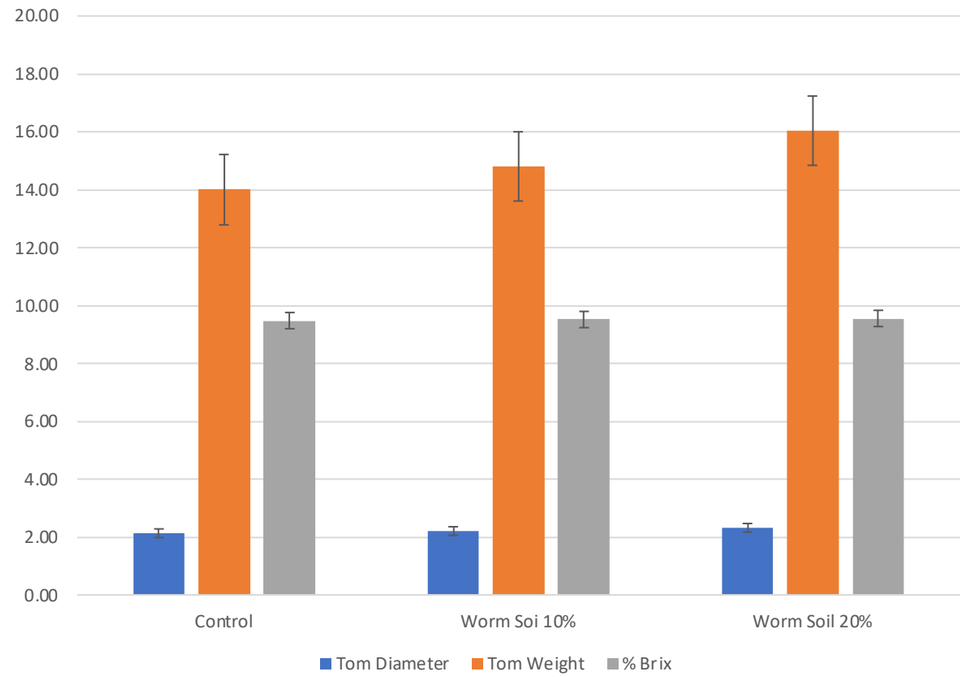

Fig. 6 – Graph showing tomato harvest data; diameter (in mm), weight (in g) and sugar content (in % Brix)

The results from the data show a significant improvement in all metrics measured over time, especially at the early stages of growth, where vermicompost seems to yield the biggest benefits. This coincides with literature (Wang, 2017) (Alcantara, 2020) (Abduli M.A., 2013) when vermicompost is applied in solid and/or liquid extract form.

Case Study 2 - Caradoc Charcoal LTD

Meet Charlotte & Kevin

We first met Charlotte and her business partner, Kevin Fryer, when we were introduced to them via our partners at CREST@UCS, who had completed their work with Caradoc coordinating specialist services at EBRI - Energy & Bioproducts Research Institute via Aston University. Caradoc have also received support via Marches Growth Hub, ran by the Marches Local Enterprise Partnership. Dr Jane Yardley led initial support and felt that University Centre Reaseheath would be an excellent fit to provide further research in their product - biochar.

The work at CREST@UCR utilized Reaseheath College's state-of-the-art horticulture facilities to complete a comprehensive series of plant growing trials. Unfortunately, due to unforeseen circumstances, we could not complete the animal feeding trial on-site, so we enlisted the support of a trusted local farmer with good connections to the college.

The results of the research enabled Caradoc Charcoal LTD to:

- Provide optimal formulations on a weight and volume basis for their range of size grades of biochar and for various applications in horticulture and agriculture.
- Provide a feasibility study on the short-term impact of dairy cattle health & wellbeing, as well as the resulting milk quality, with the potential as an industrial research project in the future.
- Assess any potential effects (positive & negative) of biochar on the growth characteristics and performance of several common horticultural crops, leading to biochar production process improvements.

About Caradoc Charcoal LTD & Biochar

Caradoc Charcoal LTD are manufacturers of some of the finest sustainably sourced hardwood charcoal in the UK. Taking Forestry Commission certified local hardwood, they cut to size, kiln and create high quality charcoal via a process called pyrolysis. Pyrolysis is the heating of organic material in the absence of oxygen, creating carbon-black products rich in nutrients with high carbon sequestration potential and fuel efficiency. The process itself is very efficient, in that no heat is wasted from main production, being used to dry fresh wood, and preheat the equipment.

Caradoc also sell a variety of outdoor cooking ingredients like sustainable fire starters, species specific wood chips and chunks of a variety of flavours (excellent for live fire cooking), in recyclable packaging of varying sizes to cater for domestic and commercial. Caradoc have gained a viral following after social media influencers and top UK Chefs like Adam Purnell (aka Shropshire Lad), and have been seen touring foodie events like Meatopia, Pub in the Park, Ludlow Food Festival and many more!

Biochar is a by-product of making charcoal and at its simplest is the small sized particles that can't be graded for lump wood charcoal. Caradoc have further innovated by taking their biochar and forming potentially the UK's first sustainable and natural BBQ briquette, which boasts similar cooking quality to the prestigious binchotan briquettes.

Biochar can be used as is, much like the above and added to soil and growing media to improve growing conditions, soil health & quality and improve carbon sequestration. It can also be added to a ruminant's diet to improve their digestion, potentially lowering methane emissions. Biochar can also be made via pyrolysis at specific conditions to change its properties for other uses, such as conversion to activated carbon, increasing its cation exchange capacity and porosity or to improve its mineral composition.

Plant Growth Trials

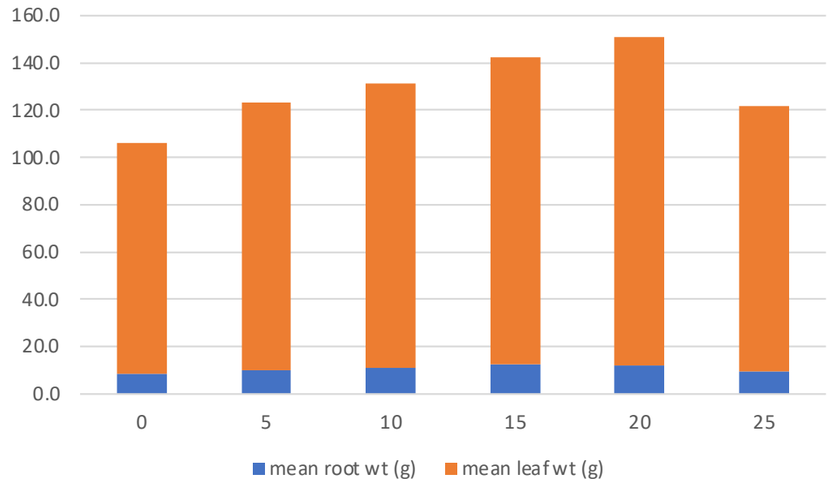

Fig 7 – Chart of compound data from both trials showing individual leaf and root fresh biomass weights (with cumulative total) with increasing biochar concentrations

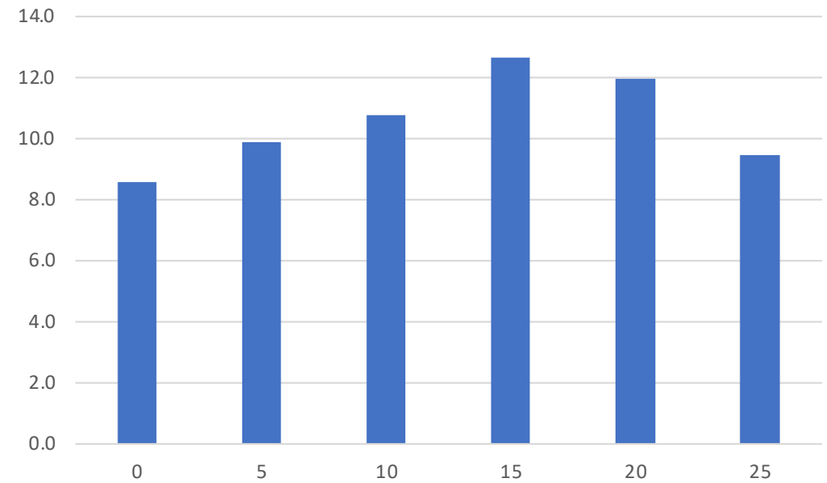

Fig 7a – Expanded view of compound data, showing mean root growth (g) only

The results show a general maximum at week 12 for root growth is 15% wt/wt biochar and for leaf growth is 20% wt/wt biochar. As such a general range of 15-20% for leafy green crops is acceptable. The resulting maximal increase vs the control is 48% and 42% for root and leaf growth respectively. The data in literature couldn't be matched as each study used a different particle size range compared to our trial, but conclusions can be drawn that there is a net increase in growth characteristics and therefore yield, that is comparable to results shown here (Dilfuza Jabborov, 2021).

Cattle Feeding Trial

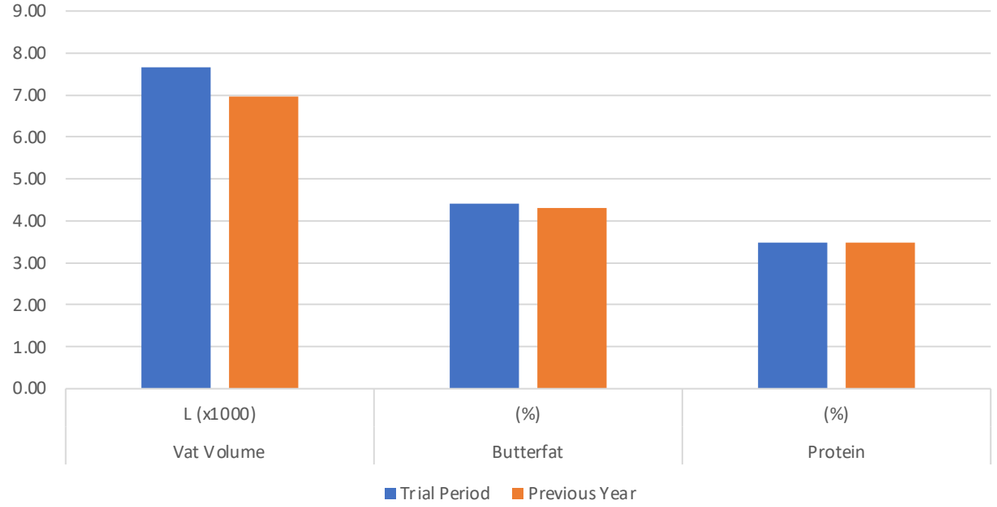

Fig. 8 – Graph showing Vat Volume, Butterfat % and Protein % trial data

Fig. 9 – Graph showing Somatic Cell Count (SCC), Freezing Point Depression (FPD) and Urea concentration trial data

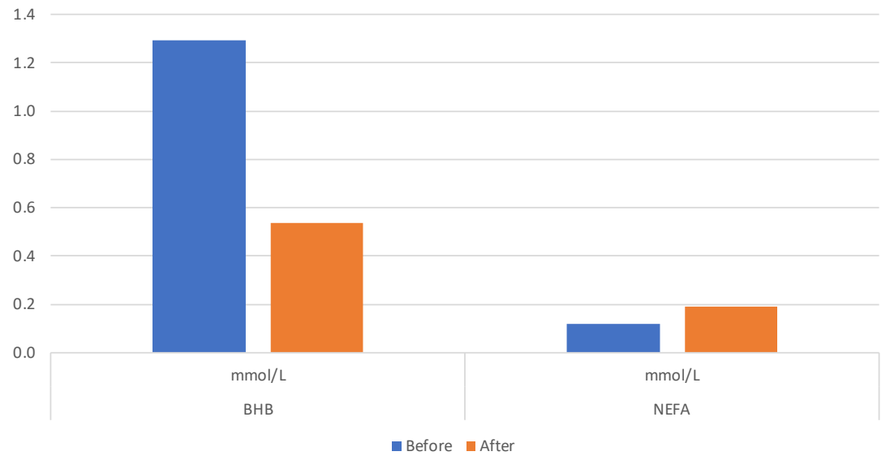

Fig. 3 – Graph showing serum BHB and NEFA data

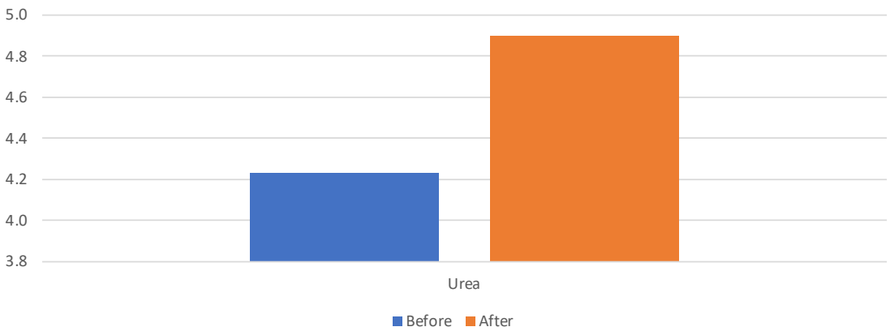

Fig. 10 – Graph showing serum urea data

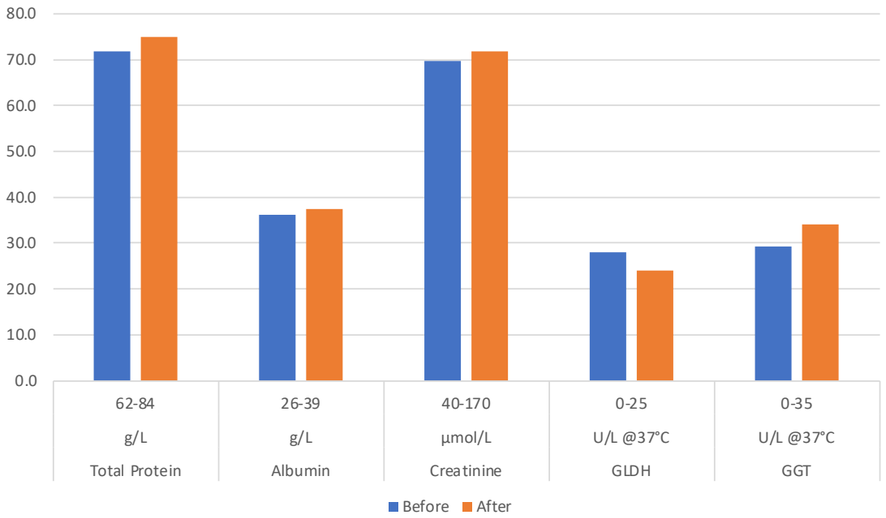

Fig. 11 – Graph showing serum total protein, albumin, creatinine, glutamine dehydrogenase (GLDH) and gamma-glutamyl transferase (GGT) data

Milk quality data shows a 10% improvement in yield, 2% increase in butterfat content and 14% increase in milk urea, indicating a potentially better conversion rate of nitrogen and so productivity of each animal. Statistical analysis however shows no significance within the sample size taken, so there is opportunity to conduct the trial again to determine the validity of the trial.

Blood metrics show a marked improvement in nitrogen utilisation by increase blood urea toward the optimal range (<3.7mmol/L indicates low N absorption and/or negative protein energy balance, highlighted in yellow), as well as improvements in liver and kidney function and improvements of metabolic efficiency by reduction in ketone bodies (>1.0 mmol/L BHB is a sign of sub-clinical and clinical ketosis, highlighted in yellow and red), whilst maintaining sufficient NEFAs to avoid chronic ketosis despite being in negative energy balance throughout the lactation period in the sample.

The only anomaly is the slightly raised GGT results that, on consultation with the on-call vets for this project (for ethical considerations), could be explained by acute minor liver damage in the sample taken caused by outside influence (parasites being a common cause).

The results correspond well with the literature summarised by (Ka Yan Man, 2020)

Case Study 3 – E4Environment LTD

Meet the Company

E4Environment are an environmental consultancy based out of a working farm in North Shropshire. Mandy Stoker is one of the senior leadership team there and has been working on repurposing the farm's agricultural waste into compost for commercial sale.

Considering how to add value to this by-product, she used her expertise and experience gained from her PhD thesis to research the effect residential microbes have on the potency of organic soil amendments. Taking inspiration from Dr Elaine Ingham's Soil Food Web research, she set out to express her product's unique selling point by evaluating how an extract of her compost (commonly called compost tea) compares to synthetic and sterilised alternatives. Anecdotal evidence suggests that there is merit in her idea, but she required external validation of her evidence so that she can justify marketing claims for her new brand Soil Life.

E4Environment LTD contacted her network and so reached out to CREST@UCS, who conducted initial research into the quality of her solid compost. Realising that the essence of their brand is missing (and so the key question to ask), University Centre Shrewsbury connected Mandy with CREST@UCR. Utilising the leading-edge facilities at Reaseheath College and University Centre Reaseheath (UCR), the team were able to achieve her goals.

The work at CREST@UCR enabled E4Environment LTD to:

- Identify the correct dosing application for various uses via an analysis of the compost tea's nutritional value against a synthetic baseline using electrochemical and wet chemistry techniques.
- Quantitatively measure Soil Life's performance against alternatives with the same nutritional profile.
- Quantitatively measure the growth-enhancing properties of Soil Life's microbiome when compared to a similar product, a sterilised control and a commercial product with known microbial activity.
- Provide technical support for businesses looking to produce their extract at scale and/or produce the extract in-house.

Tomato Growth Trial

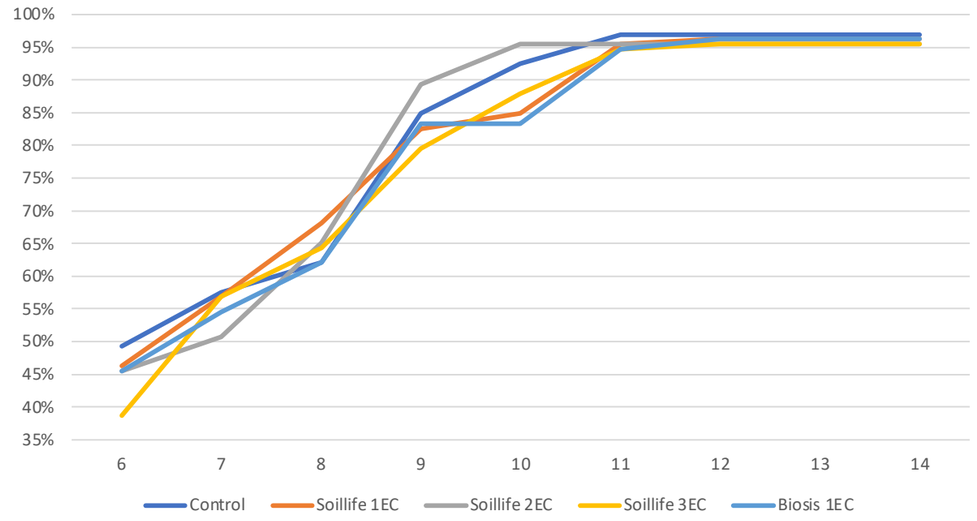

Fig 12 – Germination rate over time (EC = electrical conductivity, unit = mS/cm)

Soil Life at a conductivity of 2mS/cm appears to show the quickest germination rate to maximum achieved of 96%, followed by the positive control (Biosis), but analysis shows not statistical significance in the value (n=66)

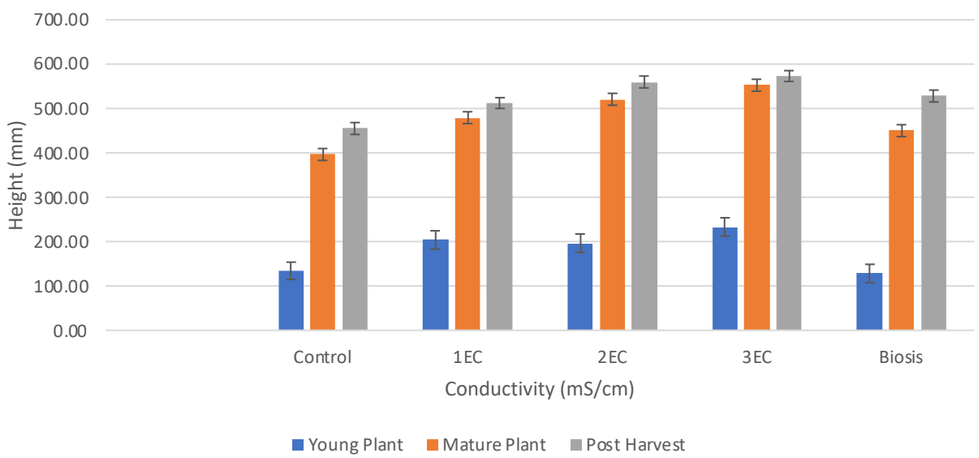

Fig 13 – Graph showing height data for variables at each stage of growth (control & Biosis conductivity fixed at 1mS/cm)

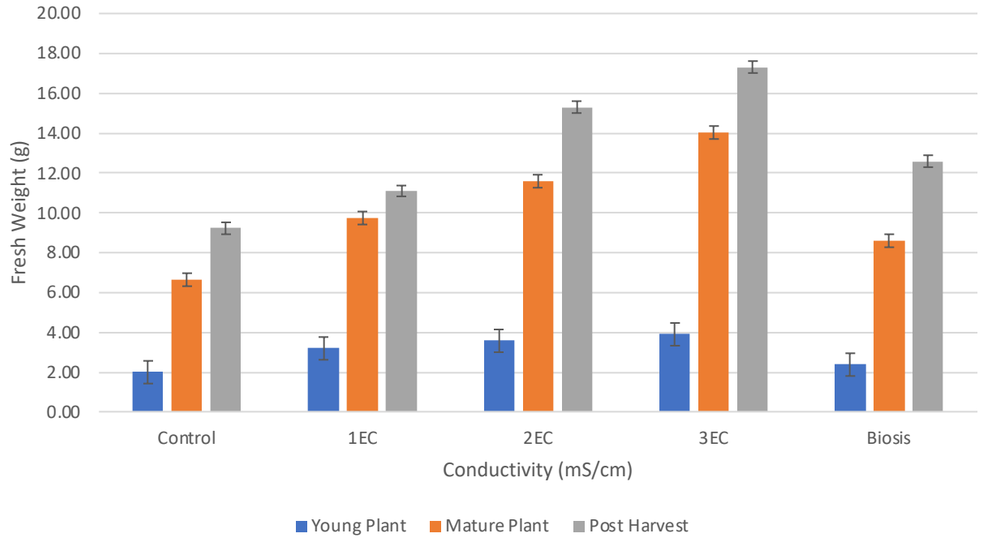

Fig 14 - Graph showing aerial biomass data for variables at each stage of growth (control & Biosis conductivity fixed at 1mS/cm)

Fig 4 - Graph showing root biomass data for variables at each stage of growth (control & Biosis conductivity fixed at 1mS/cm)

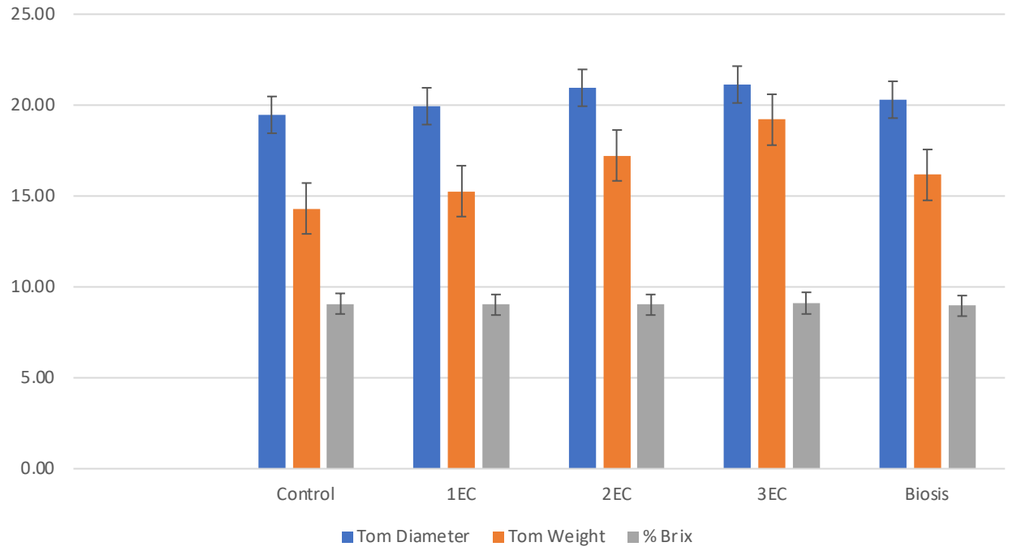

Fig 5 - Graph showing post-harvest data for variables at each stage of growth (control & Biosis conductivity fixed at 1mS/cm. Units: Diameter = mm, Weight = g)

The growth trial shows a positive trend with increasing EC value of Soillife across all metrics apart from sugar content. One anomaly occurred whereby the Biosis treated variable was lower than the control, which could be explained by insufficient watering of that tray across the trial period, leading to stunted growth. However, this is rectified in the later parts of the trial.

From a nutrition perspective, there is evidence to suggest that there is a linear correlation with aerial biomass throughout the trial, reflecting a steady-state process of creation of new tissue under current conditions. The microbial influence is harder to analyse, since the community within Soillife appears to drive faster initial growth through the vegetative stage but it not able to support flower and fruit production as well as Biosis, which has a balanced nutrient and microbial profile, for the same nutrient concentration.

For root biomass, there is a trend represented by a sigmoid (s-shaped) curve, which is likely due to the restrictions for growth by the container toward the later stages of growth. The exponential phase reflects the accumulation of root structures allowing the interaction with microbial populations and access to bioavailable nutrients, which is seen when comparing the negative (abiotic) control with the positive microbially rich positive control. The data shows that for root biomass, microbial interactions play a key part in growth and that Soillife is almost equidistant between the two values for the same nutrient concentration up to the point of fruit setting.

With regards to height, nutrient concentration increases it logarithmically across all variables, which is logical in that stem length is generally determined by genetics and photosynthetic parameters (which are controlled for). Therefore the rate limiting step is macronutrient availability, which is more readily available to the plants' roots and the result of less competition from an abundance of microbes. From a microbial perspective, apart from the initial anomaly relating to irrigation of the Biosis tray, rate of aerial growth could be modulated by the biodiversity within the compost extract.

Analysing each Soillife variable over time there appears to be a higher rate of vegetative growth with increasing concentrations of Soillife. From fruit setting to the end of the growth cycle, a logarithmic progression is seen, indicating the genetic cues to switch to flower/fruit production for this cultivar (a determinant tomato variety). However, both controls follow a less steep curve, indicating a steady state and balanced growth profile.

Analysing the post-harvest data, all plants produced 6-7 trusses of 7-9 flowers, of which up to 3 aborted per truss for the abiotic (negative) control and 1EC Soillife, 1-2 for 2EC Soillife and Biosis and the terminal flower from approximately 1/3 of the trusses from 3EC Soillife. Of the remaining flowers, all set fruit and matured within 1 week from end of fruit growth. Only a small proportion of immature fruit were aborted prior to ripening, approximately 5-10% of negative control and 1EC Soillife. Time of ripening was not analysed for each variable.

Tomato diameter increased modestly with increasing Soillife but is relatively unaffected by microbial influences. Tomato weight increased significantly with both Soillife concentration and microbial influence, with Soillife being half the intensity of Biosis for the same concentration. Sugar content is unaffected by nutritional or microbial influences.

Other observations are considered in that the negative control and 1EC Soillife variables shown signs of leaf chlorosis of the lower leaves from week 8 onwards with some leaf drop occurring, indicating nitrogen as a limiting nutrient. Biosis shown similar deficiencies at week 12 and 2EC Soillife on fruit setting on about 20% of plants. 3EC shown no deficiencies. All plants shown resistance to disease and pests, with only minor leaf miner damage observed, despite nearby plants being more severely affected by leaf miner and downy mildew.

The results correspond well with current literature (Nasim Golestanehzadeh, 2022) (Martin, 2019

Conclusions

Despite the economic and physical burden of a pandemic, Shropshire businesses have shown immense resiliency, which has been further strengthened by governmental support schemes such as CREST. Through CREST@UCR, 3 businesses have been highlighted as case studies by the Shropshire Local Enterprise Partnership, with Worm Soil being recommended for the Queen's Award for Enterprise 2022. Through the efforts of these businesses to create innovative environmental solutions, we are proud to support them to realise their goals through this programme and are immensely proud to be part of their journey. CREST@UCR is looking to build on these achievements by supporting more businesses through the programme until it ends in March 2023. The experience of working on the CREST projects with innovators and employers has enabled us to extend our practices and gain valuable insights into the potential for research and development. This will ultimately inform the scope of the Institute of Sustainability & Food Innovation (IoSFI), a partnership between Reaseheath College & University Centre Reaseheath and the University of Chester to support businesses on a national and international scale.

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Decolonising the curriculum and addressing the BAME attainment gap in land-based higher education

Vivek Mathur and Chris Buckle

Access, participation and BAME attainment gap

Since its inception in 2018, the Office for Students (OfS) have been clear in their mission and associated objectives. The underpinning message is that "every student, whatever their background, should have a fulfilling experience of higher education that enriches their lives and careers" (Office for Students, 2022). Subsequently, their 3-pronged attack to ensure this revolves around participation, experience and outcomes. Participation, meaning that all students from all backgrounds with the ability and desire to undertake higher education can do so. Experience, meaning that those students have a 'high quality' experience while studying, and outcomes, which looks at their degree classification, employment opportunities and, ultimately, earnings over their lifetime.

To support equality of opportunity, HE providers charging their students more than the basic fee rate are requested to write an Access and Participation Plan (APP), a document which outlines where providers have gaps between underrepresented groups and their peers and asks what actions they are going to take to close or eliminate those gaps. Strict targets, timescales and investment plans are required, along with the promise of annual monitoring returns and strong regulatory action against those providers who do not making sufficient progress. For providers charging students more than the basic fee rate, an Access and Participation Plan is condition A1 of their OfS registration.

One such underrepresented group identified by the OfS were Black, Asian and Minority Ethnic (BAME) students. The data showed that your race and ethnicity were likely to have a stark effect on your degree outcome, with an attainment gap of 13% between white students and those from black, Asian or minority ethnic backgrounds (Universities UK, 2019). Universities and HE providers were asked to look at their data pertaining to BAME students, identifying their own attainment gap, but also the degree to which access and progression were also different to non BAME students. Providers were asked to set challenging targets around their BAME recruitment and commit time and resources to tackling the issues and closing the gaps in their own institutions.

In land-based institutions such as UCR, these gaps are often most stark when considering the 'access' stage of the student lifecycle. Low numbers of BAME students are often reported within land-based institutions, with much research being carried out as to why this is the case. In some cases, this has led to institutions being asked to set challenging, perhaps unrealistic targets for the intake of BAME students, with one such institution pledging that 16% of the student intake will be from black, Asian or minority ethnic backgrounds by the end of their approved APP. Discussions amongst the sector also indicate the industries to which we align similarly report low levels of diversity within their workforce, particularly in more senior and executive positions.

This focus on BAME student attainment, the so called 'attainment gap', the low intake of BAME students and poor representation in certain sectors, particularly land based has further opened up the conversation about the degree to which UK universities and HE providers are 'decolonising' their curriculum and confronting the harmful legacy of colonialism. The next section provides an overview of the links between science and colonialism.

Legacy of colonialism in science

Science is neither ahistorical, nor universal or singular. Knowledge is always produced under specific economic relations, material conditions, political and economic hegemony and socio-political contexts. These shape what is considered legitimate knowledge and legitimate ways of developing that knowledge. Knowledge systems are hence shaped by the beliefs, aims, priorities and endeavours of the society in which they develop. It follows that societies that considered themselves superior to others, aimed to extract and plunder resources from other societies, would have developed scientific approaches and knowledge that justified and facilitated that extraction and domination. In turn, these extractive and suppressive approaches would have enabled or supported the conduct of that scientific enterprise.

Our curriculum is located within the 'modern scientific system'. This curriculum is a white curriculum. White curriculum centres white European figures as authoritative, innovative and the 'first to discover'. In modern science, the white man is the genius. After a white man from a colonising country studied the wildlife in a colonised part of the world, he was the first to develop the theory of evolution – or so we have been taught. We must question whether this way of framing scientific theories and discoveries shuts out the possibility of learning about non-European knowledge systems. How could we, and our students learn about how Arab scholars before or around the same time as Darwin engaged with these issues? Malik et al. (2018) reviewed Muslim scholarship between the 8th century and the 14th century to identify eight well known scholars who advanced evolutionary theories before Darwin. This omission from the modern biology curriculum not only deprives us of valuable intellectual resource but more importantly, it overplays and perpetuates the perceived conflict between Islamic teachings and the science of evolution (ibid.).

The foundations of most of modern science is shaped by the methods, priorities and agendas that were developed between 17th and 19th century. Carl Linnaeus' system for classification and organisation of animals and plants which is the foundation of current classification systems had also classified humans into four categories based on physical characteristics (European white, American reddish, Asian tawny and African black) –this is recognised as one of the origins of scientific racism (Kenyon-Flatt, 2021). These classification systems were developed by naturalists and collectors in Europe who built up their collections of plants and animal specimens using the networks of the Trans-Atlantic slave trade (Middleton, 2020). Chatterjee (2021) has highlighted how the rubber trees came to Kew Gardens illegally, forests the colonies was portrayed as unproductive to explain replacing them with large rubber plantations, which justified shipping of cheap labour across colonies causing ecological disruptions as well as human exploitation. Thus "the botanical sciences aided the colonial enterprise and were, in turn, organized by it" (Chatterjee, 2021). This alignment of colonial extraction and suppression with science was not limited to botany. As Hodge (2011) has pointed out::

"The development of astronomy, cartography, geography, meteorology, natural history and oceanography as bodies of natural knowledge … overlapped closely with the early overseas expansion of Europe. Such sciences played an important role in identifying, surveying, ordering and taking possession of new lands, resources and peoples." (p. 6)

The actions and pursuits of European explorers, missionaries, scientists and trade envoys were inevitably intertwined in the colonial undertaking. The legacy of Eurocentrism and colonialism in science continues to perpetuate through language, terminology, research questions as well as continued marginalisation of other knowledge systems. Figure 1 illustrates how a large number of scientific names for birds in the previously colonised parts of the world are named after European persons. This nomenclature continues to reinforce the notion that they were first discovered by Europeans. Moreover, it also displaces the local names which in many cases, carried a lot more ecological information related to species habits (Trisos et al., 2021).

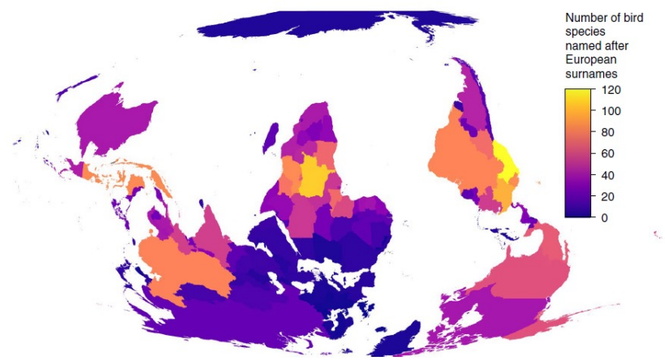

Figure 1: World map showing estimates of number of bird species named after European surnames (Trisos et al., 2021)

When it refers to non-European societies, modern western science either focuses on the obscure or seemingly dramatic practices and portrays them as exotic (without seeking to understand it from within their own belief and knowledge system); or refers to it in relation to European being the 'norm' (as less-advanced, or under-developed in comparison) and the 'other' non-European cultures as less scientific and more superstitious. In some instances within science even today, practices from colonised parts of the world may continue to be portrayed as primitive or uncivilised; their knowledge unauthoritative and merely belief-based. While direct colonial rule may have ended, recognising the continuing impact of colonialisation on science is a vital but only the first step in the multifarious activity of decolonising of curriculum. The next section outlines the purpose of decolonialisation of the curriculum to build upon that first step.

What does the decolonising of curriculum intend to achieve?

At the beginning of this paper we referred to the experiences of BAME students within the higher education sector in the UK and highlighted the particular challenge of the identified BAME attainment gap. The experiences of BAME students in UK higher education are shaped by the impacts of the legacy of colonialism in science. Arday et al. (2021) conducted an in-depth study with fifteen BAME students and three academics to examine their perspectives on decolonisation of curriculum. This study emphasises how eurocentrism in curriculum and the culture in academia which marginalises BAME students, and hence the process of decolonisation of curriculum must be connected addressing that discriminatory culture (ibid.).

Keele University, in their staff guide for decolonising the curriculum, set the purpose of decolonising of curriculum as:

"Decolonising is about rethinking, reframing, and reconstructing the current curriculum in order to make it better, and more inclusive … It is about considering how different frameworks, traditions and knowledge projects can inform each other, how multiple voices can be heard, and how new perspectives emerge from mutual learning." (Keele University, 2021: 17)

Considered in this way, decolonisation of curriculum is about de-centring it from its Eurocentric ways of knowing. It is a process of reflecting on what ends our main scientific principles and methods might continue to serve. For instance, it is about questioning whether wildlife conservation disciplines centre western science and bring in 'indigenous' or 'alternative' knowledge systems at a somewhat lower pedestal. It requires identifying the value judgements embedded in what counts as scientific knowledge, and what gets termed only as traditional or often 'folk' knowledge. It may require us to step back from some of the underlying assumptions/foundations of the dominant scientific system and to ask ourselves for instance, whether deriving the 'scientific' principles for natural resource management from a Māori taxonomic system for the environment may present a more ethical approach which could potentially be better suited to addressing the sustainability challenges that we face (Te Rire, 2012).

Hence, while it is important to diversify reading lists, the overall purpose of decolonisation of curriculum must be to start to redress the unequal power relation between our mainstream eurocentric science and other ways of knowing. This immense purpose though presents opportunities for working collaboratively with our students and colleagues to make our curriculum more inclusive in creative ways.

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Back Matter: Scholarly Activity Fund Application Form

The Scholarly Activity Fund Committee meets three times a year. Suggested form submission deadlines for those wishing to access funds in the academic year 2022-23 are as follows:

Monday 3 October 2022
Monday 6 February 2023
Monday 24 April 2023

Applications, once completed, must be authorised by your line manager and emailed to the Academic

Development Manager **debra.swift@reaseheath.ac.uk** Any queries can also be emailed to this address. Applications may be submitted on an ad hoc basis throughout the year, but it is strongly advised you attempt to align with one of the dates outlined above to ensure a timely response from the committee.

Funding, if awarded, may be full or partial, and will be offered in accordance with the overall strength of your application as well as the level of competition for funding from other applicants, and the amount of money remaining in the fund at your time of application.

We look forward to receiving your application!

Please complete the details below.

Name & Position	
Department	
Type of Scholarly Activity for which you are seeking funding	Please check all boxes that apply • Research project (discipline based) • Research project (teaching based) • Conference participation (poster / presentation) • Article publication • Other (please specify)
Anticipated output from the proposed activity	Please check all boxes that apply • Contribution to in-house Research and Scholarship Journal (required) • Generation of new knowledge / information for inclusion in the curriculum • Dissemination of findings to colleagues (e.g., tutor briefing) • Engagement with external stakeholders • Dissemination of findings to external parties (e.g., conference audience / industry collaborators) • Peer-reviewed publication (e.g., book chapter / journal article) • Other (please specify)
Aims & Objectives of proposed activity	Please briefly state the purpose of your proposed activity, i.e., what do you hope to find out or achieve? And what gaps in our existing knowledge does it seek to address?

Rationale behind the proposed activity	Benefits to UCR Please briefly explain your reason(s) for wishing to undertake this activity (why is it important for you and UCR?) Benefits to Students Please detail how this activity will impact upon the student experience, stating: (a) What module(s) will be impacted, and how (b) Approximately how many students will be impacted (c) Whether this will be a one-off impact, or whether will it recur across years and cohorts
Breakdown of resources and time required for the proposed activity	Please include: (a) Full details of all anticipated costs (b) A full description of the resources / equipment / staffing required (c) An estimated timeframe and remission requirement for the activity, with key interim stages identified if necessary
Applicant signature	Please add your signature here once you have completed the form and read and agreed to the terms and conditions detailed below.
Confirmation that activity is supported by your line manager	Please ask your line manager to sign in this box once they have read and approved your application.

Terms & Conditions

If funding is awarded by the committee, please note that we will expect you to provide us with one or more updates regarding your progress with the activity. You will be provided with a simple form to complete in due course to enable you to do this. Upon completion of your activity, you will also be required to provide evidence of the output from your work, for instance a submission to the UCR in-house journal (required), and evidence that you have disseminated your findings to students, colleagues and/or external parties via another channel.

Back Matter: Contributing to the UCR Scholarship and Research Journal

Deb Swift

This is your journal, your mechanism for sharing the outcomes of your research with the UCR academic community. We have the opportunity to exchange knowledge, stimulate thought and discussion and use these experiences to enrich and enhance the undergraduate learning experience.

Whatever your research and enquiry passion we encourage you to share these experiences and outputs with all of us here at UCR. Our scholarship is part of our identity as UCR lecturers and contributing to your UCR Journal is one of the mechanisms in which we are able to connect identities and grow as a research community.

We welcome contributions from all members of UCR staff and would be delighted to receive

- Full academic papers
- Short abstracts
- Case studies
- Reflective accounts
- Thinkpieces
- Research Templates / Short Communications
- Action research projects
- Articles
- Features

We would also be interested in hearing about your experiences

- Presenting a paper or poster at a conference
- Writing Journal articles or textbook chapters
- Engaging in Professional Practice and/or Industrial Updating
- Engaging in field work and experiential learning

How do I go about contributing?

Please contact UCR Academic Development Manager **debra.swift@reaseheath.ac.uk** with your idea for inclusion in the journal ideally during the Autumn Term but submissions will be considered as late as April with a deadline for submission early May each year.

Even if you are unsure of the format, if you have an idea for publication let us know.

Producing a paper for the UCR Scholarship and Research Journal

- Your paper should ideally be between 1,000 and 3,000 words.
- You will need to submit a short abstract summarising your paper in no more than 300 words.
- Use British, not US spelling for example programme not program, analyse not analyze.
- Use single quotes for quotations unless the quote is within another quote.
- All acronyms/abbreviations should be spelled out the first time they are introduced in text and references. Thereafter the acronym can be used as appropriate for example Teaching Excellence Framework (TEF).
- Material to be emphasised should be italicised, please use such emphasis sparingly.
- When referring to numbers in a study the abbreviation (n) should be used, and similarly % for percent should be used.

Referencing

Please use the APA 7 system of referencing guides can be found on the Graduate Toolkit site under referencing.

Producing an Abstract

Abstracts are written to provide a brief holistic summary of your research. The research you present could be taken from a post graduate enquiry, a dissertation thesis, action research or field work undertaken as part of teaching and learning.

A good abstract should provide sufficient information so as to allow the reader to quickly ascertain the paper's purpose, usefulness, and engagement.

Abstracts are normally submitted to the editorial boards of journals or conference organisers; they are used as the basis for selecting for publication or presentation. Abstract length varies by discipline and publisher requirements but typically ranges from 100 to 500 words.

A well written abstract should convey the overall theme or flavour of the research and should include the background, relevance, introduction, objectives/questions, methods, results, and conclusions.

Producing Case Studies and Reflective Accounts

Case studies can be a way of sharing the results of small-scale action research or reflective activity with peers. They are particularly useful for showcasing innovative practice and can be used as a means of capturing experiences or critical learning incidents such as for example: your management of an unusual occurrence or circumstance, a story of individual student success or the impact of your scholarly activities on the student learning experience.

Each case study should be between 500 and 1000 words and should be organised as follows:

- Title
- Author's name and email contact·
- The Case Study outlining
- The context
- The initial prompt/problem
- Strategies and interventions employed and rationale behind them
- The impact of the intervention
- An analysis of costs/benefits
- An evaluation
- Recommendations
- References

Producing Action Research Reports

Action research reports should be between 1,000 and 3,000 words and should be organised as follows:

- Title
- Author's name and email contact
- The Action Research Report outlining:
- The context
- The initial prompt/problem
- Literature review
- Strategies and interventions employed and rationale behind them
- The impact of the intervention
- An analysis of costs/benefits
- An evaluation
- Recommendations
- References

Producing Articles, Features and Thinkpieces

Articles, Features and Think pieces are a way for authors to express their thoughts on hot topics in the wider contexts. They can be focussed on topics in the subject discipline, pedagogy, or research in the College Higher Education sector.

An article, feature or thinkpiece should be a free written piece of approximately 1,000 to 1,500 words, presenting personal opinions, analysis, or discussion, rather than bare facts.

Research Templates / Short Communications

For work that is still in progress, or too small-scale to warrant a full article write-up, a more simple format could be used where you will be able to outline the main aims of your project as well as including a simple methodology and summary of your key findings to date Please get in touch if you require further details.

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