



Centre for Ecology and Conservation

# Annual Report 2019

# Welcome

## Centre for Ecology and Conservation: Making the most of an identity crisis

As Director of the Centre for Ecology and Conservation, I'm incredibly proud that our 'brand' has reached a global audience, attracting scholars and collaborations from all over the world; recruiting hundreds of undergraduate, masters and postgraduate research students with a similarly international profile; and delivering education and research that has real global impact. The Academic Ranking of World Universities places the University of Exeter 7th in the world (in the WORLD!) for the quality of its research in Ecology. That is real testament to the hard work of members of the Centre for Ecology and Conservation and the Environment and Sustainability Institute on our Penryn Campus in Cornwall.

The Centre for Ecology and Conservation continues to grow not just in reputation but also in size. We are about to reach 60 permanent faculty; we host over 150 postgraduate researchers and nearly 100 postdoctoral researchers; and we share learning with nearly 1,000 undergraduate and masters students, annually. It's difficult to think of other universities that host such an incredible concentration of whole-organism biologists. Yet, with this growth and momentum comes an important challenge. Who are we and what is the Centre for Ecology and Conservation? You have to stretch the definitions of ecology and conservation quite wide to encompass the breadth of topics that we share through education and improve

through research. The case studies held within the pages of this annual report demonstrate this breadth, describing... evolutionary biologists and molecular microbiologists collaborating to explain the coevolution of hosts and their pathogens; behavioural ecologists and mathematicians collaborating to explain the behaviour of bird flocks; conservation biologists and environmental scientists collaborating to describe the global prevalence of microplastics in marine wildlife.

So it's clear that we do more than ecology and conservation. We also do Behaviour and Cognition; Environmental Science; Evolutionary Dynamics and Theory; Sensory Biology; Movement and Migration; Human Sciences;

Marine Biology; Demography and Epidemiology; Microbiology; Physiology; Systems Theory... the list of these research clusters is long, and in each cluster we host several faculty members and their research groups. We have no intention of damaging the CEC's established brand, but we worked hard in 2019 to develop a substructure of research clusters that will provide support and collaborative opportunities for all our staff and students.

My job as Director of the CEC is not just to celebrate success but also to support all our staff and students to achieve their best, with a focus on four pillars: research, education, collaboration and community. Science and education are performed by people, and the best performance is achieved by people who are simultaneously contented AND challenged. There's probably a natural selection analogy to be made here. As villages grow into towns and then cities, it can be difficult to maintain a sense of community and shared purpose. Success in 2020 will be measured not just in the global reach of our research and education, but also in the structures of support, mentorship, training, collaboration, empathy and inclusivity that we foster in our Centre.

So, yes we have grown, and rapidly. Yes, this brings challenges and an identity crisis. We will remain the Centre for Ecology and Conservation, but we will be writing next year about the successes of our research

clusters and our homegrown and international collaborations. Flick to the publications list at the end of this report, to see just a small subset of papers authored by faculty, postdocs, postgrads and undergrads, alongside names of collaborators from around the UK and around the world. The CEC is an amazing place to work, learn and visit. Did I mention that we are based on the coast, in Cornwall, surrounded by beaches, cliffs and moorland? That our university is sector leading for its policies on inclusivity and parental benefits? That we are acting on the Climate and Environment Emergency? That, whatever Brexit brings, we will fight to maintain our globality? That we are working through the Covid-19 global crisis and learning new ways of working while physically distanced? Blimey. Check us out online or, even better, and when deemed safe to do so, come and see the CEC for yourselves.



**Professor Dave Hodgson**

**Director, Centre for Ecology and Conservation  
Head of Department, CLES Cornwall**



# Research Highlights

## It's dog eat dog on the canine social ladder

Top dogs in a pack are known to assert their dominance, but scientists studying a group of free-roaming mongrels found high levels of aggression in the middle of the dominance hierarchy. Most theories predict more aggression higher up the ladder. However, this research showed that when dogs were less sure of their ranking relative to those around them, they tended to also be involved in more aggressive interactions like biting and chasing. Rank was hardest to predict in the middle of the hierarchy, which contained younger individuals still establishing their dominance relationships with each other. This led to high levels of aggression in the middle of the hierarchy as well as at the top. Increased aggression can be costly for these individuals by increasing the risk of injuries or taking time away from other activities like feeding. The results confirm that these dogs have a similar age-graded hierarchy to wolves and reveal a potentially unavoidable cost of climbing the social ladder. Published by Matthew Silk, Michael Cant, Simona Cafazzo, Eugenia Natoli and Robbie McDonald in *Proceedings of the Royal Society B*.



Credit: Simona Cafazzo

## Humans closer to seeing through the eyes of animals

Humans are now closer to seeing through the eyes of animals, thanks to an innovative software framework developed by researchers from the University of Exeter and the University of Queensland. Until now, it has been difficult to understand how animals really saw the world, as most species have very different visual systems to humans. The Quantitative Colour Pattern Analysis framework uses digital image processing techniques and analytical tools to help solve this problem. "We have known for many years that understanding animal vision and signalling depends on combining colour and pattern information, but the available techniques were near impossible to implement without some key advances we developed for this framework," said Dr Jolyon Troscianko. The framework's use of digital photos means it can be used in almost any habitat – even underwater – using anything from off-the-shelf cameras to sophisticated full-spectrum imaging systems. The flexibility of the framework will allow research into the colour patterns and natural surroundings of a wide range of organisms. For example, there can be new insights into the impact of coral bleaching for camouflaged reef creatures. "We're helping people to cross the boundaries between human and animal visual perception. It's really a platform that anyone can build on, so we're keen to see what future breakthroughs are ahead," said Dr Karen Cheney. Published by Cedric van den Berg, Jolyon Troscianko, John Endler, N. Justin Marshall and Karen Cheney in *Methods in Ecology and Evolution*.

Montage of a flower simulated with different visual systems. Top: eagle (showing LW, MW and SW only); top right: honeybee with UV vision; bottom left: human; bottom right: cat. All simulated from 1m away, except for the honeybee, which was 10cm.

Credit: Simona Cafazzo



## Mob mentality rules jackdaw flocks

This paper by members of Alex Thornton's Wild Cognition Research Group, led by former MbyRes student Jenny Coomes, shows that jackdaws are more likely to join a mob to drive off predators if lots of their fellow birds are up for the fight. Across many animal species, individuals come together to drive away threats, but the cognitive processes underlying such collective responses are poorly understood. As there is safety in numbers, the team hypothesised that jackdaws might benefit from assessing how many others are already involved in mobbing before deciding whether to join. To test this, they recorded the anti-predator "scolding calls" of different individual jackdaws, and then broadcast bouts of scolding featuring the calls of different numbers of individuals. The jackdaws in the experiments always hear the same total number of scolding calls, but more birds flew in to join the mob if the calls had been produced by multiple different individuals. These findings show that jackdaws can tell one another's voices apart to assess how many birds are involved in a mob. Whereas collective behaviour in animals is generally assumed to be controlled by simple, fixed rules of interaction, these results reveal an important role for cognitive processes in guiding decision-making and thus shaping collective responses. Published by Jenny Coomes, Guillam Mclvor and Alex Thornton in *Biology Letters*.



Credit: Alan McCarthy

## Penguins and their chicks' responses to local fish numbers informs marine conservation

Fishing is one of the biggest drivers of biodiversity loss in the ocean. It is so widespread that we lack an understanding of the 'natural' relationships between marine predators and their prey, and thus the extent to which predators are disrupted by competition from fisheries. Research led by Dr Richard Sherley used a unique opportunity created by a three-year commercial fisheries closure around Robben Island, South Africa, to study how African penguins directly respond to natural changes in the local abundance of their prey – anchovies and sardines. The researchers estimated fluctuations in prey fish populations within the fisheries closure zone using hydro-acoustic surveys, which detect the presence of anchovies and sardines by bouncing sound waves off their swim bladders. At the same time the researchers used GPS-temperature-depth loggers to monitor the penguins' fishing behaviours, studied the diet of breeding adults, and measured the body condition of chicks. When fish abundance was lower, adults foraged for longer, swam further and dived more often. Chick body condition also declined, as finding fish became more challenging for breeding adults. This direct link confirms a common assumption about predator-prey relationships that has rarely been tested in the absence of fishing. These results also indicate that penguin foraging behaviour and chick condition could be used as powerful early warning signs to inform fisheries' policies and local marine conservation efforts. Published in the *Journal of Applied Ecology* by Dr Richard Sherley. Published by Kate Campbell, Antje Steinfurth, Les Underhill, Janet Coetzee, Bruce Dyer, Katrin Ludynia, Azwianewi Makhado, Dagmar Merkle, Johan Rademan, Leshia Upfold, Richard Sherley in *Journal of Applied Ecology*.



Credit: Richard Sherley

## Plastic in Britain's seals, dolphins and whales

Microplastics have been found in the guts of every marine mammal examined in a new study of animals washed up on Britain's shores. Researchers from the University of Exeter and Plymouth Marine Laboratory examined 50 animals from 10 species of dolphins, seals and whales – and found microplastics (less than 5mm) in them all. Most of the particles (84%) were synthetic fibres – which can come from sources including clothes, fishing nets and toothbrushes – while the rest were fragments, whose possible sources include food packaging and plastic bottles. "It's shocking – but not surprising – that every animal had ingested microplastics," said lead author Dr Sarah Nelms. "We don't yet know what effects the microplastics, or the chemicals on and in them, might have on marine mammals." Though the animals in the study died of a variety of causes, those that died due to infectious diseases had a slightly higher number of particles than those that died of injuries or other causes. "We can't draw any firm conclusions on the potential biological significance of this observation," said Professor Brendan Godley. "We now have a benchmark that future studies can be compared with." Published by Sarah Nelms, James Barnett, Andrew Brownlow, Nick Davison, Rob Deaville, Tamara Galloway, Penelope Lindeque, David Santillo and Brendan Godley in *Scientific Reports*.



Credit: Frazer Hodgkins

## Skin bacteria could save frogs from virus

Emerging infectious diseases pose a significant threat to amphibian biodiversity around the globe. Host-associated microbial communities form a vital component of the amphibian immune defence against pathogens, but to date most of our knowledge about microbiome-disease relationships is derived from studies on the chytrid fungus *Batrachochytrium dendrobatidis* (Bd). In the UK, Common Frogs (*Rana temporaria*) have suffered extensive declines due to the viral pathogen ranavirus, the causative agent of the disease ranavirosis. Though some



Credit: Chris Sargeant

common frog populations have suffered catastrophic outbreaks of ranavirosis, others have not exhibited any signs of the disease and their populations remain relatively stable. The drivers of these differences in disease outcome, remain a puzzle. Here, we provide evidence for systematic differences in the skin microbiome structure between populations suffering from ranavirosis and those that are putatively disease free. This research implicates skin-associated microbes as important for determining disease outcome in both fungal and viral pathogens. Understanding the relationship between skin microbiome and disease severity in UK common frogs is vital for amphibian conservation. It will allow us to predict the susceptibility of naive populations to future outbreaks of ranavirosis based on their skin microbiome composition, and provide a vital foundation for the development of probiotic therapies to mitigate ranaviral infection in the wild. Published by Lewis Campbell, Trenton Garner, Kevin Hopkins, Amber Griffiths and Xavier Harrison in *Frontiers in Microbiology*, 10:1245.

## Study reveals how bacteria beat immune systems

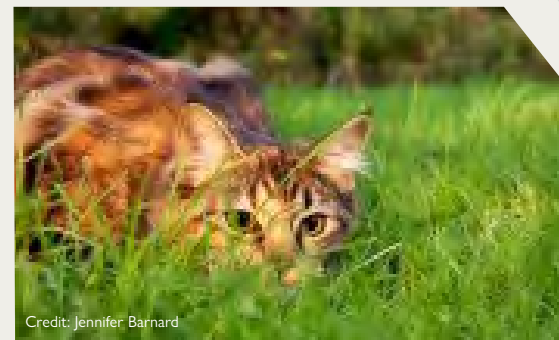
Humans and animals can, over time, develop resistance to the harmful pathogens that infect them, or they can become resistant through the use of antibiotics or vaccines. In turn, it is usually assumed that pathogens will respond by evolving to multiply faster, which will allow them to transmit faster to other hosts before they are cleared by the immune system of their current host. Such increased replication rate is thought to explain why pathogens evolve to become more harmful (virulent) in resistant hosts. This study shows that pathogen virulence and replication rates can, in fact, evolve separately. Tests of how pathogens evolve can be conducted in natural populations that are not subject to intense human intervention in order to stop disease spread. Using a natural epidemic outbreak of an infectious bacterium that killed millions of wild North American songbirds, shows bacterium has evolved to become more virulent in resistant hosts, but did not evolve to replicate faster. Instead, increased virulence was found to be likely driven by an improved ability of the bacterium to manipulate the host immune system in order to generate the symptoms necessary for its transmission. These results could have implications for novel therapeutic approaches aimed at slowing down pathogen evolution, and which would combine treatments that both eliminate the pathogen and prevent it from manipulating the host immune system. Published in *Proceedings of the National Academy of Sciences* by Luc Tardy, Mathieu Giraudeau, Geoffrey E. Hill, Kevin J. McGraw and Camille Bonneaud.



Credit: Geoff Hill

## Roaming cats prey on their owners' minds

University of Exeter scientists have found that cat owners often dislike their feline companions' compulsion to catch wildlife but feel unable, or unwilling, to control it. The researchers interviewed cat owners about their pets' roaming and hunting behaviour. Hunting was seen as natural behaviour, with owners who wanted to limit this, finding it difficult to achieve without locking cats indoors and thus negatively affecting their pet's welfare. "We found a spectrum of views on hunting, from owners who see it as positive for pest control to those who were deeply concerned about its consequences for wild animal populations," said Dr Sarah Crowley. Cats vary in the amount they hunt, with some catching multiple birds and small mammals every week, while many others stay indoors or rarely lift a predatory paw. With up to 11 million cats in the UK, some conservationists are nevertheless concerned about the effect hunting cats might have on wildlife, especially declining species like house sparrows. "Cat owners understandably make their pets' health and well-being a priority, and many feel that cats need free access to the outdoors," said Professor Robbie McDonald. "At the same time, having such independent pets creates extra anxieties for owners about both their cats' safety while ranging free, and their impacts on wildlife." The researchers are now working closely with cat owners and cat welfare organisations, aiming to find practical ways to reduce hunting, while enhancing cat welfare. Published by Sarah Crowley, Martina Cecchetti and Robbie McDonald in *People and Nature*.



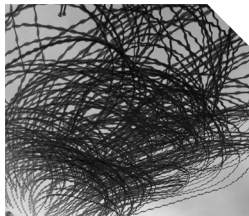
Credit: Jennifer Barnard



# Research Highlights

## Study reveals how social relationships transform bird flocks

Flocks of birds see, to move with a single mind, but new research jointly led by Alex Thornton of the CEC in collaboration with physicists at Stanford, USA, and computer scientists at Simon Fraser University in Canada shows that jackdaws stick with their mates – even though it harms the flock. Victorian naturalists were so perplexed by flocks of birds moving together like a single super-organism, they thought birds must be communicating telepathically. Since then, mathematical models have shown that this collective behaviour can emerge if every bird in a flock responds to its neighbours by following identical rules. However, as this new study shows, flocking jackdaws do not all follow identical rules. Instead, pairs of jackdaws – which mate for life – fly together within the crowd. The team used 3D stereo-imaging to track the movement and wingbeat frequency of very bird within large flocks of jackdaws. The findings reveal a trade-off: paired birds benefit because they use less energy in flight, but because paired birds pay more attention to each other than to their neighbours, information spreads more slowly when flocks contain many pairs, reducing the flock's ability to react to predators. These findings highlight previously unknown trade-offs in collective behaviour, and suggest that some animals are likely to face substantial cognitive demands to recognise and track specific individuals when moving as part of a group. Published by Hangjian Ling, Guillam McIvor, Kasper van der Vaart, Richard Vaughan, Alex Thornton & Nicholas Ouellette in *Nature Ecology and Evolution*.



## Wild carnivores stage a comeback in Britain

Once-endangered carnivorous mammals such as otters, polecats and pine martens have staged a remarkable comeback in Britain in recent decades, a review by researchers at the University of Exeter, Vincent Wildlife Trust, UK Centre for Ecology & Hydrology and Scottish Natural Heritage found. The study found that – with the exception of wildcats – the status of Britain's native mammalian carnivores (badger, fox, otter, pine marten, polecat, stoat and weasel) has “markedly improved” since the 1960s. The researchers collected survey reports from the last 40 years and compared changes in the species' distribution extent and population sizes. They also reviewed human activities that have helped or hindered Britain's native carnivores in recent decades. The species have largely “done it for themselves” – recovering once harmful human activities had been stopped or reduced, although reintroductions have played a part of the recovery of pine martens and otters. The wildcat position remains precarious, with recent declines caused by extensive inter-breeding with domestic cats. Thought must now be given to how growing numbers of these animals interact with humans. Some of the species can pose problems for gamekeepers, anglers and farmers, and work must be done to find ways to prevent conflict and allow long-term co-existence as the species expand their ranges and numbers.



## Wild insects ‘get old’ before they die

It turns out that even wild insects ‘get old’ – losing some of their physical abilities – before they die. The very existence of ageing, in the sense of physical decline, has been a phenomenon that at first was thought to be confined to humans, but we now realise it is likely to apply to most life-forms. Insects are used to study ageing in laboratories, but it wasn't clear whether they only reach ‘old age’ because they are protected from a harsh natural environment. In one of the first studies to examine ageing in wild insects, a population of crickets in a Spanish meadow was continuously monitored using more than 130 video cameras over a ten-year period, recording reproductive effort, ageing and survival. There was no evidence that some crickets ‘live fast and die young’ compared to others, but it was clear that those that put more energy into reproduction early in life declined faster as they aged. Crickets that invested more in reproduction showed signs of ‘ageing’ – chirping less and losing more fights. “Why we fall apart as we get old is fundamentally an evolutionary question” said Professor Tom Tregenza. “Ageing is not about inevitable decline, it's about our genes making copies of themselves; we age because instead of using energy to maintain our bodies, we put it into reproduction.” Published by Rolando Rodríguez-Muñoz, Jelle Boonekamp, Liu Xingping, Sophie Haugland-Pedersen, Ian Skicko, David Fisher, Paul Hopwood and Tom Tregenza in *Evolution*.



## Breakthrough in battle against invasive plants

Invasive plants cause harm to people, industry, livestock, wildlife and natural ecosystems worldwide – but predicting which plants could become invasive is very difficult. A team of scientists from across Europe, led by senior author Professor Dave Hodgson from the Centre for Ecology and Conservation, developed and analysed a global database of plant life cycles to tackle this puzzle.



“Invasive plant populations grow fast in their invaded range, but not in their native range. So you can't use population growth to predict invasiveness. However, invasive plant species have an amazing ability to bounce back from disturbances, and we can see this in both their native range and their invaded range. We should therefore avoid the export of plant species that grow well in disturbed environments.”

PhD student and ecological consultant Kim Jelbert, lead author of the paper, said: “The kinds of species that bounce back from disturbance tend to be species that produce lots of seeds from large flowers. This is a real problem, because large flowers are popular with gardeners all over the world. These species should not be traded internationally. We also discovered patterns of ancestry. Close relatives of invasive plants are also likely to be invasive if they escape their native range.”

Professor Hodgson added: “For the first time, we have a strong clue to the identity of future invasive plants. Weedy plants of disturbed environments – and their close relatives – should not be exported.”

Published in *Nature Communications*

## Five rules for resistance management in the antibiotic apocalypse



Resistance management is the practice of slowing the evolution of resistance to toxic agents and is widely pursued in very diverse fields including insect pest management, HIV treatment, cancer therapy, and anti-malarial drug therapy. Many of these different fields re-invent successful practice. Resistance management for drugs targeting bacteria, sometimes called antimicrobial stewardship, faces a wide range of challenges and the best course of action is still a matter of controversy. Moreover, clinical trials that seek to slow the evolution of resistance sometimes misunderstand the theoretical basis of resistance management practice. This review takes a critical view of best practice from different fields and describes some of the latest clinical evidence in order to set out some guidelines for pragmatic resistance management for antibiotics. These are summarized in five rules. These rules emphasize the importance of early pre-emptive action and the value of reducing the supply of

genetic novelty to bacteria under selection. The weight of evidence also cautions against strategies that over-rely on the fitness costs of resistance or low doses. The potential (and pitfalls) of shorter courses, antibiotic combinations and varying antibiotic prescribing in space and time are discussed in depth. Importantly, some of the variability in the success of recent trials of resistance management strategies could be explained by the number and diversity of drugs in a trial, as well as whether trials encompass single wards or the wider transmission network that is a hospital. Resistance management strategies that quickly respond to data on the prevalence of resistance are also likely to be more effective. The review emphasises that diverse strategies are likely to give the best results, thus reduction in selection pressure, interference with the transmission of problematic genotypes and multidrug approaches are all likely to be required for sustainability and the protection of forthcoming drugs. This article has attracted some media attention and has already led to an invited review in a clinical facing journal (the *Pharmaceutical Journal*). Published in *Evolutionary Applications* by Dr Ben Raymond.

### CASE STUDY

## Herring gulls take longer to approach food when they're being watched

In August, a study by Madeleine Goumas, Laura Kelley and Neeltje Boogert hit the headlines as people in coastal towns around the world united in their experiences of having their food taken by a hungry gull.

Herring gulls often swoop in to take food from behind their unwitting targets, or otherwise catch them unaware. The researchers wondered if this meant that gulls are paying attention to where people are looking: perhaps gulls choose to approach food when they are likely to go undetected.

In the study, MbyRes student Madeleine Goumas singled out individual gulls and placed a bag of chips on the ground between herself and the gull. She timed how long it took the gull to peck at the bag after starting its approach. Each gull was tested twice. In one trial, she looked directly at the gull and, in the other trial, she looked away. Overall, gulls took more time to approach the bag of chips when they were being watched, suggesting that they use human gaze as a cue when deciding whether and how to approach people's food.

However, the researchers found that the gulls differed widely in their approach times. Some gulls were very quick to peck at the bag of chips in both trials, while others appeared to be much more wary and did not touch the bag at all while the experimenter was looking at them. This suggests that some individuals are bolder than others. Most of the gulls targeted for the trials would not approach the experimenter at all.

As herring gulls are much-maligned and often the target of intense control measures, the researchers believe that a better understanding of how human behaviour affects gulls' foraging decisions, may identify ways of reducing the frequency of negative interactions between humans and gulls. “If people are aware that herring gulls respond to their behaviour, then they can take steps to change it,” said lead author Madeleine Goumas. “For example, just being aware of where the gulls are and staying vigilant is likely to help people who are eating outside avoid having their food taken.”

The study was published in *Biology Letters*.





# Student Societies



## MarineWatch

After a very successful spring term, MarineWatch ended its first year as a society on a high note, winning Best Society, Adopt a Charity Award and Best Committee Member for our President at the FXU/Student Union's Society Awards, being shortlisted for Most Improved Society of the Year at NUS National Society Awards!

This year, we were also involved with under the sea social with Kayaking Society, wildlife paddle with SUP's, boat party, rock pool project event, marine themed yoga event, RNLI sea safety talk and set up blog with a Cornish wildlife presentation. As our new committee took over this autumn, MarineWatch has continued to offer a range of events, talks and opportunities for all its members. We ran several boat trips out of Falmouth Bay including a collaborative plastic trawl alongside The Beach Clean Project and Beach Guardian, Emily Stevenson, where we were shocked to find microplastics in every sample analysis. Our members have also had the opportunity to become certified marine mammal and bird surveyors through partnership with the charity MARINELife. We are now able to record sightings for all the boat trips we run and submit this data to MARINELife, supporting their research and conservation efforts. MarineWatch has also continued to raise money for them, through events such as the Christmas Quiz and guest talk by Springwatch presenter Gillian Burke!

## Generation Wild

**Generation Wild** is a student-led volunteering project that delivers weekly environmental outreach sessions for local primary schools and extracurricular children's groups.

From rock pool rambles and evening stargazing, to creating bug hotels and learning fire lighting skills, 2019 has been a great year for us! Over the course of 2019 we have had the pleasure of working with over 470 children across Cornwall, with help from our fantastic partnership with Cornwall Wildlife Trust. These sessions have only been possible with the help of over 30 of our wonderful volunteers, who come from various courses. We've done some brilliant collaborations with other student groups such as EcoSoc and BeeSoc, and have held several training days for our volunteers, hosted by Camp Kernow and Adventure Bandits. We've had so much positive feedback from the local community, it's really heartening to see young people so enthusiastic about getting back out into nature, and the positive impacts that environmental education can have on the local community. We look forward to what 2020 will bring!

# Athena SWAN Penryn Campus

The Athena Swan Charter was established in 2005 with the aim to "to encourage and recognise commitment to advancing the careers of women in: science, technology, engineering, maths and medicine (STEMM) employment in higher education and research." In 2015 the Charter was extended to include non-STEMM staff and students and trans staff and students with a broader focus on gender equality.

We are proud to have held an Athena Swan Silver award since 2014 in recognition of our actions to support women in STEMM, however our broader aim is to support all our staff and students and promote equality and diversity in all its forms. We are all different and we bring different ideas and opinions to the table, but if we do not use these in our decision-making, we may not be making the right choices or developing future research needed to tackle the global societal problems we are all facing.

Over the past year we have established regular meetings with our students and staff at all levels to discuss issues such as career progression, gender equality and well-being. We aim to ensure that everyone is provided with the same

opportunities and that there is a route for all to report issues of concern. We continue to work towards improving our recruitment and progression processes for

all students and staff to make the Centre for Ecology and Conservation a more inclusive environment in which to study and work.



## Funding Awards 2019

CEC enjoyed many research funding successes during 2019, securing awards totalling £5 million.

Funders include the Arts and Humanities Research Council (AHRC), AXA, Bayer Crop Science, Biotechnology and Biological Sciences Research Council (BBSRC), British Academy, British Eventing, Chelonia Limited, Darwin Initiative, Department for Environment, Food and Rural Affairs (DEFRA), Deutsche Forschungsgemeinschaft (DFG), Economic and Social Research Council (ESRC), Edwin Warth Trust, European Commission, European Maritime and Fisheries Fund (EMFF), European Regional Development Fund (ERDF), Human Frontiers in Science Programme, Innovate UK, Natural Environment Research Council (NERC), Royal Commission for the Exhibition of 1851 and Society for the Protection of Turtles. Awards were made to Professor Chris Bass, Professor Jon Blount, Professor Annette Broderick, Professor Angus

Buckling, Professor Michael Cant, Dr Thomas Currie, Professor Brendan Godley, Dr Kimberley Hockings, Professor Dave Hodgson, Dr Chris Kaiser-Bunbury, Professor Robbie McDonald, Professor Juliet Osborne, Dr Ben Raymond, Dr Benno Simmons, Professor Martin Stevens, Dr Barbara Tschirren, Dr Stineke Van Houte, Dr Steve Votier, Professor Edze Westra, Professor Alastair Wilson and Professor Gab Yvon-Durocher.

Highlights include multiple UK Research and Innovation grants: a BBSRC award to Professor Juliet Osborne investigating the threat of invasive Asian Hornets to pollinators; a NERC award to Professor Mike Cant whose team will use drones and novel computer vision methods to investigate the evolution of decision making during conflict in banded

mongoose and a BBSRC award to Professor Angus Buckling working with industrial partner Amur Energy to enhance biogas production for industrial applications. Early career researchers are again celebrated with a number of fellowship awards including: a Royal Commission for the Exhibition of 1851 Research Fellowship to Dr Benno Simmons investigating the effects of invasive species on plant-pollinator networks; a Human Frontiers Science Program Fellowship to Dr Patrick Green to consider contests between groups of social-living animals and EU Horizon 2020 Marie Skłodowska-Curie Fellowships to Dr Theresa Rueger (supervisor Professor Mike Cant), Dr Anne Chevallereau (supervisor Professor Edze Westra), Dr Ana Angela Romero-Haro (supervisor Dr Barbara Tschirren), and Dr Sean Meaden (supervisor Professor Edze Westra).



# Field Course Fortnight

At the Centre for Ecology and Conservation, BSc finalists and MSc students embark on a Field Course in their final year, to learn about natural systems in the real world.

We pride ourselves in offering an extensive range of field courses across our Biosciences programmes with exciting local, national and international destinations.

These field courses not only allow you to apply the knowledge gained in the classroom to real-world situations in superb locations, but also provide a fantastic opportunity to forge lasting relationships with fellow students and academics.

Depending on students' programme of study, they have the opportunity to choose from a range of options including: understanding

the ecology and evolutionary biology of Switzerland or the Pyrenees, studying tropical biodiversity in Borneo, learning about special ecosystems of North Cyprus, visiting impressive seabird breeding colonies in Scotland or watching grizzly bears fish for salmon in Alaska, to name but a few.

Field Course Fortnight is a social media campaign where students and staff document their experiences via different social media channels using the hashtag **#fieldcoursefortnight** to show the world what our students get up to.

*My personal highlight was the Osa Peninsula and our close wildlife encounter. This location felt like a tropical paradise, and it became even more special when we saw a tapir one evening. A group of us sat in silence in a banana plantation, whilst watching a tapir which was munching on bananas literally metres away from us and even came to sniff some of us.*

Ellie Stockwell, Costa Rica

You can see this social media activity on the Global Field Courses website:  
<http://blogs.exeter.ac.uk/fieldcourses>

*The trip is great for our programme because it happens in our final year so is a real highlight of our degree that allows us to really put into practice what we've been learning about in lectures in an amazing location with some of our best friends. I'm a Zoology student myself, interested in behaviour, but regardless of whether you had more of a conservation, ecology or evolutionary perspectives, there were discussions and field sessions on the course that catered to all. It was also a great chance to really consolidate our natural history and identification skills – many people started the course probably using binoculars for the first time but left as aspiring ornithologists able to identify over 100 species of Indian birds!"*

Kingsley Hunt, India



'Maasai Tribe' – Eve Tuckey, Kenya

*Freediving with hundreds of hammerhead sharks had to be the highlight of the field course for me, they're my favourite animal and being immersed in their environment felt so special.*

Jade Getliff, Galapagos



Flamingo – Grace Hunt, Galapagos

*This field course has prepared me for any hardships I might face if I choose to go into a field research based career. It's helped me communicate, test my scientific knowledge and learn more about wildlife in North America.*

Emily Gilford, Alaska



## Science with the Community

### Schools Outreach

During 2019, CEC researchers, staff and students were once again involved with various outreach events across Cornwall. We reached over 2,500 students through partnerships with schools and colleges in Cornwall. For the fifth time we ran a Bioscience strand of the Exeter Scholars Scheme (formerly Exeter Progression), a programme designed for Year 12 students to develop their knowledge and passion for a subject. 40 students from Devon and Cornwall took part in five practical lab and field sessions, all led by academics and students. We also took part in the Exeter Scholars Residential where 33 students from all over the country stayed on campus for the week and took part in various Bioscience activities, including rock-pooling on Gylly Beach. Our collaboration with Penryn College has developed over the past year and has been central to the How Science Works and Science of Christmas projects.

### Science in the Square

For our 8th annual Science in the Square event 'Hidden Worlds' was the theme. Despite the torrential rain and gales, 2,000 visitors attended for the free family event held as part of Falmouth Week in August. This event invited people of all ages to come and have their scientific questions answered through a series of engaging talks. Our expert scientists gave talks on such topics as "The Hidden World of Fluorescence" and "Exploring the Oceans' Hidden World with Underwater Robots",

with one talk culminating in (planned!) explosions in the marquee! The event also gave visitors the chance to explore our seven interactive zones, where they could learn about the creatures you might find in a rock pool, what an elephant skull looks like, or how to hold live insects! Thank you to all the speakers, staff and students who worked extremely hard to make sure the event was a huge success!

### Science of Christmas

This was the sixth year of running our Science of Christmas event; however, this year we decided to do it a little differently. Previously we have worked with the Poly in Falmouth to deliver the event, but this year we worked with Penryn College in order to hold the event on campus during the day and for it to be attended by all children in Year 3 from seven local primary schools. The 90 children that attended were all super excited and Prof Dave Hodgson encouraged their festive spirit by compering with his own brand of Christmas magic. Prof Chris Bass, Helen Mylne and Dr Jolyon Troschianko all provided engaging and interactive talks about the grinch of Christmas, how Father Christmas knows who to give gifts to and why Rudolph's nose is red. The children particularly enjoyed their teachers being encouraged to eat various invertebrates! It was really good fun having so many young people on campus. We were also grateful to some of our students who helped with the travel and logistics of the event.

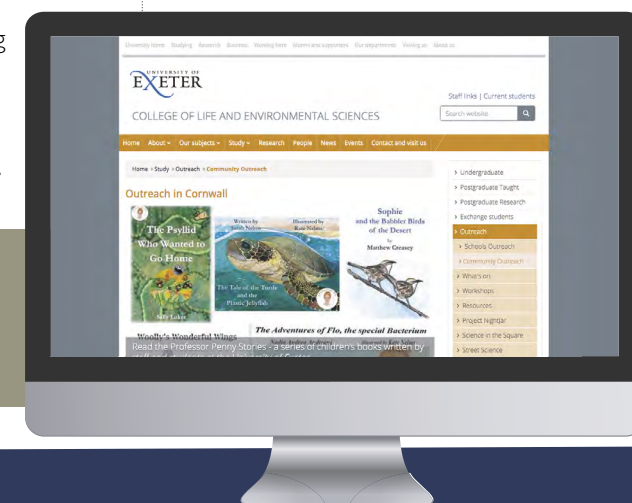
### How Science Works

In the spring and autumn terms we collaborated with Penryn College on the How Science works project. In each term, after a training session at Penryn College, groups of our students visited surrounding schools over four weeks and helped the year six children to design and deliver scientific research projects. All of the schools then came to campus for a conference to show the posters that the children had produced and to listen to talks from our students and pupils of Penryn College. This project is extremely exciting as it enables us to work with children in the surrounding schools on their own scientific research project.

### Student-led Activities

As usual our students were involved in a range of outreach activities working with local schools and groups of young people. Generation Wild, a student-led volunteering project teaching children about the environment, has been as busy as ever over the year and our annual student-led BioBlitz was held in May for families with exhibitions from local conservation organisations, wildlife identification sessions, pond dipping and mammal trapping.

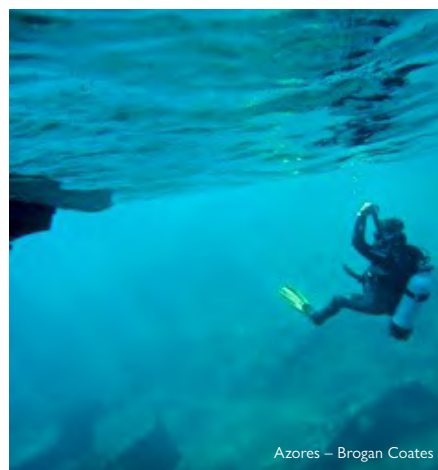
More information about our outreach activities can be found at:  
[lifesciences.exeter.ac.uk/outreach/cornwall](http://lifesciences.exeter.ac.uk/outreach/cornwall)



'Poison Dart Frog' – Katie Smith, Costa Rica



'Blue and Gold Macaw' – Maia Jones, Hong Kong



Azores – Brogan Coates



# Awards and Prizes

## Prize Winners

**Professor Alistair Wilson** – Nominated for the prestigious Genetic Society Award, **Mary Lyon Medal**.

**Dr Xiaoya Ma** – Nominated for the **Hodson Award**, a major prize in the Palaeontological Association (PalAss).

**Professor Nina Wedell** – Awarded a Certificate of Distinction by the **Council of the International Congress of Entomology**.

**Professor Tom Tregenza** – Appointed chair of the University's **Leverhulme Trust** Funding Area Network

See also Selected Highlights for accolades to **Professor Annette Broderick**, **Professor Brendan Godley** and **Professor Edze Westra**.

### Student Prize Winners:

**Christophe Patterson**, MRes in Conservation Ecology, was the joint winner of this year's **Sir Geoffrey Holland Prize** with his work exploring the effects of the St Piran's Crab on Cornwall's biodiversity.

## Graduation Awards

Congratulations to the following CEC students who were awarded PhDs in 2019:

**Lewis James Bartlett** – On the Evolutionary Ecology of Infectious Diseases and Intersections with Apiculture

**Samuel Barton** – Understanding the Responses of Marine Phytoplankton to Experiment Warming

**Katherine Beadle** – Understanding the Molecular and Biochemical Basis of Insecticide Selectivity Against Solitary Bee Pollinators

**Matthew John Stanley Creasey** – Social Specialists? Personality Variation, Foraging Strategy and Group Size in the Chestnut – Crowned Babbler, *Pommatostomus ruficeps*

**Emily Duncan** – The impact of Plastic Pollution on Marine Turtles

**Kimberley Jane Jelbert** – The Comparative Demography of Invasive Plants

**Christopher James Manktelow** – Virulence and Evolutionary Ecology in the Entomopathogen *Bacillus thuringiensis*

**Paula Helena Marjamaki** – The Genetic Basis of variation in Bovine Tuberculosis Infection, Progression and Diagnosis on a Wild Animal Host

**Sara Mynott** – The Impact of Climate Change on Intertidal Species, Camouflage and predation

**Sarah Elizabeth Nelms** – Marine Litter, Microplastics and Marine Megafauna

**Liliana Poggio Colman** – Ecology and Conservation of the Leatherback Sea Turtle (*Dermochelys coriacea*) Nesting in Brazil

**Ian Skicko** – Condition-Dependant Sexual Selection in a Wild Population of the Field Cricket, *Gryllus campestris*

**Robin Thomas Ernest Snape** – Investigating Conflict between Threatened Marine Megavertebrates and Mediterranean Small-Scale Fisheries

**Dominic Giles Tilley** – The Green Sea Turtle: Adaptation and Resilience to Climate Change

**Alice Jean Williams** – Modelling the Evolution of Socio-Political Complexity

**Michael Kings** – Foraging tactics and Social Networks in Wild Jackdaws

## Graduation Awards

### Schools Commendations:

Chloe Balmer

Jeff Chan

Cassie Chanin

Teeanna Cleary-Skelton

Sophie Corrigan

Tirion Dowsett

Charlotte Epps

Jade Getliff

Emily Gilford

Megan Godley

Laura Goodhead

Kingsley Hunt

Sasha Pinto

Tom Ridgeon

Sam Salt

Alex-Lee Spain

Catherine Walker

### Top Project Marks:

Emily Abrahams – BSc Marine Biology with Study Abroad

Moira Connor – BSc Conservation Biology and Ecology

Robin Fisher – BSc Zoology with Study Abroad

Susanna Kenney – BSc Zoology with Study Abroad

Arthur Newbury – BSc Evolutionary Biology

### Highest Overall Average Mark:

Meaghan Castledine – MSci Evolutionary Biology

### Top BSc Overall Mark:

Arthur Newbury – BSc Evolutionary Biology

### Top MSci Project Mark:

Sophie Corrigan – MSci Marine Biology

### Top MSci Overall Mark:

Meaghan Castledine – MSci Evolutionary Biology

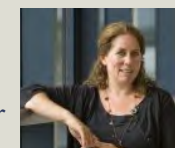
### Oxford University Press – Achievement in Biosciences (for most improved student)

Olivia Stocker – BSc Conservation Biology and Ecology

# Selected Highlights

## Marine conservation scientist wins ZSL award

Professor Annette Broderick, of the University of Exeter earlier this year won the ZSL Marsh Award for Marine and Freshwater Conservation.



The award is given each year for “contributions of fundamental science and its application to conservation in marine and/or freshwater ecosystems”. Professor Broderick said: “I am really honoured to have been recognised through this award, especially seeing the list of previous recipients, all scientists for whom I have a huge amount of respect.”

“All of my research involves a large team of staff and students at the Centre for Ecology and Conservation in Cornwall and our overseas collaborators, including scientists, NGOs and government agencies around the world, and I'd like to take this opportunity to thank them all for their hard work, commitment and collaborations over the years.”

“My research has focused on understanding and conserving marine species and ecosystems for us all to benefit from in the future.”

“We are only now beginning to appreciate the importance of our oceans for the health of our planet, and it is fantastic to see this topic move up the political agenda, thanks to the public interest in this area.”



Stineke van Houte and Edze Westra

## University of Exeter's world-leading plastics research wins Queen's Anniversary Prize



Scientists from the University of Exeter were awarded a Queen's Anniversary Prize for Higher Education for the pivotal role it has played to expose the devastating effect that plastics pollution has on the health of humans and wildlife. This prestigious national honour has been approved by The Queen on the advice of the Prime Minister following recommendations by the Awards Council of the Royal Anniversary Trust, which administers the Prizes' scheme.

Exeter's pioneering research has been led by Professors Tamara Galloway, Brendan Godley, Lorna Harries and Dr Ceri Lewis. The University has been awarded the prize in the 13th round (2018–20) of the distinguished award for its submission, entitled “Identifying and combating the effects of marine plastic pollution”.

It has focused on a series of in-depth studies into the global impact plastics of micro and nano-plastics – small plastic particles less than 1mm in length – which are increasingly contaminating the natural environment. Crucially, this can have implications for the rest of the food chain, including humans.

Significantly, the research project has played a leading role in shaping the worldwide blueprint for not only reducing the use of microbeads in cosmetics, but also directing a clarion call to action to tackle the modern “throwaway culture” which has led to vast floating islands of plastic waste plaguing many of the world's oceans.

The pioneering research achieved a series of notable successes including giving advice to a cross-party committee of MPs sitting on the UK Environmental Audit Committee, shape the Government's most recent blueprint to improve the natural environment, called ‘A Green Future: Our 25 Year Plan to Improve the Environment’ with a central theme eliminating avoidable plastic use by 2042, echoed many of the findings from the institution's research projects.

## Congratulations!

**Edze Westra** Edze Westra was promoted to Professor of Microbiology and we were lucky enough to attend his inaugural lecture at the start of the new term. This inaugural lecture was held on 11 October 2019. Edze is already one of the world's leading microbiologists having won 2 national awards in the Netherlands for his PhD in 2013 and 2014, and then going on to win the Heineken Young Scientist Award for Biochemistry and Biophysics in 2016. Many of Edze's family travelled from the Netherlands to attend, adding to the general atmosphere of excitement and underlining the fact that these events are very much a personal story as well as a celebration of professional success. Edze also paid tribute to the continuing support received from his colleague and partner, Stineke van Houte and everyone in their research group.” This year, Edze was one of five researchers who

received a Heineken Young Scientists Award. **Heineken Young Scientists Awards** offer important encouragement to talented young scientists who set an example for other young researchers and scientists. Edze was also selected for the prestigious **Fleming Prize** by the Microbiology Society which is given to an early career researcher who has achieved an outstanding research record. This was awarded for his work on the molecular mechanisms and evolutionary ecology of CRISPR-Cas systems and will be presented next year.

**Alex Mesoudi** was promoted to Professor of Cultural Evolution.

**Dave Hosken** was appointed Pro-Vice Chancellor for the University of Exeter in Cornwall.

**Kim Hockings and Chris Laing** were promoted to Senior Lecturers.





# Selected CEC Publications from 2019

**Crowley, S. L., Cecchetti, M., & McDonald, R. A.** (2019). Hunting behaviour in domestic cats: An exploratory study of risk and responsibility among cat owners. *People and Nature*, 1(1), 18-30.

Rodríguez-Muñoz, R., Boonekamp, J. J., Liu, X. P., Skicko, I., Fisher, D. N., Hopwood, P., & **Tregenza, T.** (2019). Testing the effect of early-life reproductive effort on age-related decline in a wild insect. *Evolution*, 73(2), 317-328.

Jones, C. M., Parry, H., Tay, W. T., Reynolds, D. R., & **Chapman, J. W.** (2019). Movement ecology of pest Helicoverpa: implications for ongoing spread. *Annual review of entomology*, 64, 277-295.

**Beadle, K., Singh, K. S., Troczka, B. J., Randall, E., Zaworra, M., Zimmer, C. T., ... & Bass, C.** (2019). Genomic insights into neonicotinoid sensitivity in the solitary bee *Osmia bicornis*. *PLoS genetics*, 15(2), e1007903.

van Sluijs, L., **van Houte, S.**, van Der Oost, J., Brouns, S. J., **Buckling, A., & Westra, E. R.** (2019). Addiction systems antagonize bacterial adaptive immunity. *FEMS Microbiology Letters*, 366(5).

**Derex, M., Bonnefon, J. F., Boyd, R., & Mesoudi, A.** (2019). Causal understanding is not necessary for the improvement of culturally evolving technology. *Nature human behaviour*, 3(5), 446-452.

**Haywood, J. C., Fuller, W. J., Godley, B. J., Shutler, J. D., Viddicombe, S., & Broderick, A. C.** (2019). Global review and inventory: how stable isotopes are helping us understand ecology and inform conservation of marine turtles. *Marine Ecology Progress Series*, 613, 217-245.

Reynolds, S. J., Hughes, B. J., Wearn, C. P., Dickey, R. C., Brown, J., **Weber, N. L., Weber, S. B., ... & Ramos, J. A.** (2019). Long-term dietary shift and population decline of a pelagic seabird - A health check on the tropical Atlantic? *Global change biology*, 25(4), 1383-1394.

**Kuijper, B., Hanson, M. A., Vitikainen, E. I., Marshall, H. H., Ozanne, S. E., & Cant, M. A.** (2019). Developing differences: early-life effects and evolutionary medicine. *Philosophical Transactions of the Royal Society B*, 374(1770), 20190039.

Garrett, J. K., Donald, P. F., & **Gaston, K. J.** (2019). Skyglow extends into the world's Key Biodiversity Areas. *Animal Conservation*.

Whitehouse, H., François, P., Savage, P. E., **Currie, T. E., Feeney, K. C., Cioni, E., ... & ter Haar, B.** (2019). Complex societies precede moralizing gods throughout world history. *Nature*, 568(7751), 226-229.

**Kuijper, B., & Johnstone, R. A.** (2019). The evolution of early-life effects on social behaviour – why should social adversity carry over to the future? *Philosophical Transactions of the Royal Society B*, 374(1770), 20180111.

**Soriano-Redondo, A., Jones-Todd, C. M., Bearhop, S., Hilton, G. M., Lock, L., Stanbury, A., Votier, S.C., & Illian, J. B.** (2019). Understanding species distribution in dynamic populations: a new approach using spatio-temporal point process models. *Ecography*, 42(6), 1092-1102.

**Brakes, P., Dall, S. R., Aplin, L. M., Bearhop, S., Carroll, E. L., Ciucci, P., ... Thornton, A., ... & Rutz, C.** (2019). Animal cultures matter for conservation. *Science*, 363(6431), 1032-1034.

Campbell, K. J., Steinfurth, A., Underhill, L. G., Coetzee, J. C., Dyer, B. M., Ludynia, K., ... & **Sherley, R. B.** (2019). Local forage fish abundance influences foraging effort and offspring condition in an endangered marine predator. *Journal of Applied Ecology*, 56(7), 1751-1760.

**Fielding, H. R., McKinley, T. J., Silk, M. J., Delahay, R. J., & McDonald, R. A.** (2019). Contact chains of cattle farms in Great Britain. *Royal Society open science*, 6(2), 180719.

Couchoux, C., & **Field, J.** (2019). Parental manipulation of offspring size in social groups: a test using paper wasps. *Behavioral ecology and sociobiology*, 73(3), 36.

Groothuis, T. G., Hsu, B. Y., Kumar, N., & **Tschirren, B.** (2019). Revisiting mechanisms and functions of prenatal hormone-mediated maternal effects using avian species as a model. *Philosophical Transactions of the Royal Society B*, 374(1770), 20180115.

**Tilley, D., Ball, S., Ellick, J., Godley, B. J., Weber, N., Weber, S. B., & Broderick, A. C.** (2019). No evidence of fine scale thermal adaptation in green turtles. *Journal of Experimental Marine Biology and Ecology*, 514, 110-117.

Woodcock, B. A., Garratt, M. P. D., Powney, G. D., **Shaw, R. F., Osborne, J. L., Soroka, J., ... & Jauker, F.** (2019). Meta-analysis reveals that pollinator functional diversity and abundance enhance crop pollination and yield. *Nature communications*, 10(1), 1-10.

Duxbury, E. M., Day, J. P., Vespasiani, D. M., Thüringer, Y., Tolosana, I., Smith, S. C., ... & **Longdon, B.** (2019). Host-pathogen coevolution increases genetic variation in susceptibility to infection. *Elife*, 8, e46440.

Okada, K., Okada, Y., **Dall, S. R., & Hosken, D. J.** (2019). Loser-effect duration evolves independently of fighting ability. *Proceedings of the Royal Society B*, 286(1903), 20190582.

**Hughes, A., Liggins, E., & Stevens, M.** (2019). Imperfect camouflage: how to hide in a variable world? *Proceedings of the Royal Society B*, 286(1902), 20190646.

**Hawkes, M. F., Duffy, E., Joag, R., Skeats, A., Radwan, J., Wedell, N., Sharma, M. D., Hosken, D. J., & Troschianko, J.** (2019). Sexual selection drives the evolution of male wing interference patterns. *Proceedings of the Royal Society B*, 286(1903), 20182850.

**Plummer, K. E., Risely, K., Toms, M. P., & Siriwardena, G. M.** (2019). The composition of British bird communities is associated with long-term garden bird feeding. *Nature communications*, 10(1), 1-8.

**Wotton, K. R., Gao, B., Menz, M. H., Morris, R. K., Ball, S. G., Lim, K. S., ... & Chapman, J. W.** (2019). Mass seasonal migrations of hoverflies provide extensive pollination and crop protection services. *Current Biology*, 29(13), 2167-2173.

**Dimitriu, T., Marchant, L., Buckling, A., & Raymond, B.** (2019). Bacteria from natural populations transfer plasmids mostly towards their kin. *Proceedings of the Royal Society B*, 286(1905), 20191110.

Pick, J. L., **Postma, E., & Tschirren, B.** (2019). The more you get, the more you give: Positive cascading effects shape the evolutionary potential of prenatal maternal investment. *Evolution letters*, 3(4), 412-423.

**Silk, M. J., Cant, M. A., Cafazzo, S., Natoli, E., & McDonald, R. A.** (2019). Elevated aggression is associated with uncertainty in a network of dog dominance interactions. *Proceedings of the Royal Society B*, 286(1906), 20190536.

**Goumas, M., Burns, I., Kelley, L. A., & Boogert, N. J.** (2019). Herring gulls respond to human gaze direction. *Biology letters*, 15(8), 20190405.

**Klümper, U., Recker, M., Zhang, L., Yin, X., Zhang, T., Buckling, A., & Gaze, W. H.** (2019). Selection for antimicrobial resistance is reduced when embedded in a natural microbial community. *The ISME journal*, 13(12), 2927-2937.

**Silk, M. J., Hodgson, D. J., Rozins, C., Croft, D. P., Delahay, R. J., Baets, M., & McDonald, R. A.** (2019). Integrating social behaviour, demography and disease dynamics in network models: applications to disease management in declining wildlife populations. *Philosophical Transactions of the Royal Society B*, 374(1781), 20180211.

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Russell, J. C., & **Kaiser-Bunbury, C. N.** (2019). Consequences of multispecies introductions on island ecosystems. *Annual Review of Ecology, Evolution, and Systematics*, 50, 169-190.

Mackintosh, A., Laetsch, D. R., **Hayward, A.,** Charlesworth, B., Waterfall, M., Vila, R., & Lohse, K. (2019). The determinants of genetic diversity in butterflies. *Nature communications*, 10(1), 1-9.

**Nelms, S. E., Parry, H. E., Bennett, K. A., Galloway, T. S., Godley, B. J., Santillo, D., & Lindeque, P. K.** (2019). What goes in, must come out: Combining scat-based molecular diet analysis and quantification of ingested

microplastics in a marine top predator. *Methods in Ecology and Evolution*, 10(10), 1712-1722.

**Barrios-O'Neill, D., Kelly, R., & Emmerson, M. C.** (2019). Biomass encounter rates limit the size scaling of feeding interactions. *Ecology letters*, 22(11), 1870-1878.

Engesser, S., Holub, J. L., O'Neill, L. G., **Russell, A. F., & Townsend, S. W.** (2019). Chestnut-crowned babbler calls are composed of meaningless shared building blocks. *Proceedings of the National Academy of Sciences*, 116(39), 19579-19584.

Vos, M., Buckling, A., & **Kuijper, B.** (2019). Sexual selection in bacteria? *Trends in microbiology*, 27(12), 972-981.

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**Dimitriu, T., Ashby, B., & Westra, E. R.** (2019). Transposition: A CRISPR Way to Get Around. *Current Biology*, 29(18), R886-R889.

**Hayward, A., Beadle, K., Singh, K. S., Exeler, N., Zaworra, M., Almanza, M. T., ... Bass, C. & Nauen, R.** (2019). The leafcutter bee, *Megachile rotundata*, is more sensitive to N-cyanoamidine neonicotinoid and butenolide insecticides than other managed bees. *Nature ecology & evolution*, 3(11), 1521-1524.

Huestis, D. L., Dao, A., Diallo, M., Sanogo, Z. L., Samake, D., Yaro, A. S., ... **Chapman, J. W., ... & Lehmann, T.** (2019). Windborne long-distance migration of malaria mosquitoes in the Sahel. *Nature*, 574(7778), 404-408.

Harrison, M. E., Ottay, J. B., D'Arcy, L. J., Cheyne, S. M., **Belcher, C., Cole, L., ... Feldpausch, T., Gallego-Sala, A., ... Mang, S., Mercado, L., Morrogh-Bernard, H. C., ... Rowland, L., Santos, E. M. ... & van Veen, F. J. F.** (2019). Tropical forest and peatland conservation in Indonesia: Challenges and directions. *People and Nature*.

**Padfield, D., Castledine, M., & Buckling, A.** (2019). Temperature-dependent changes to host-parasite interactions alter the thermal performance of a bacterial host. *The ISME Journal*, 14(2), 389-398.

**March, D., Boehme, L., Tintoré, J., Vélez-Belchi, P. J., & Godley, B. J.** (2019). Towards the integration of animal-borne instruments into global ocean observing systems. *Global change biology*, 26(2), 586-596.

**Maclean, I. M.** (2019). Predicting future climate at high spatial and temporal resolution. *Global change biology*, 26(2), 1003-1011.

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White, S. J., Pascall, D. J., & **Wilson, A. J.** (2019). Towards a comparative approach to the structure of animal personality variation. *Behavioral Ecology*.

**Sherley, R. B., Winker, H., Rigby, C. L., Kyne, P. M., Pollom, R., Pacoureaux, N., ... & Dulvy, N. K.** (2019). Estimating IUCN Red List population reduction: JARA – A decision-support tool applied to pelagic sharks. *Conservation Letters*, e12688.

**Trew, B. T., Grantham, H. S., Barrientos, C., Collins, T., Doherty, P. D., Formia, A., ... Godley, B. J., ... Pikesley, S. K., Tilley, D., Witt, M. J. & Metcalfe, K.** (2019). Using cumulative impact mapping to prioritise marine conservation efforts in Equatorial Guinea. *Frontiers in Marine Science*, 6, 717.

**Harrison, X. A., Price, S., Hopkins, K. P., Leung, W., Sergeant, C., & Garner, T.** (2019). Diversity-Stability Dynamics of the Amphibian Skin Microbiome and Susceptibility to a Lethal Viral Pathogen. *Frontiers in Microbiology*, 10, 2883.

**Jelbert, K., Buss, D., McDonald, J., Townley, S., Franco, M., Stott, I., ... Silk, M., Sargent, F. Rolph, S., Wilson, P. & Hodgson, D.** (2019). Demographic amplification is a predictor of invasiveness among plants. *Nature Communications*, 10(1), 1-6.

**Field, J., & Toyoizumi, H.** (2019). The evolution of eusociality: no risk-return tradeoff but the ecology matters. *Ecology Letters*, 23(3), 518-526.





'Lantern Bug' – Cameron Goodhead, Borneo



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