

The Linnean

Communicating nature since 1788

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Cougars

*Reintroducing the species in
the Eastern United States*

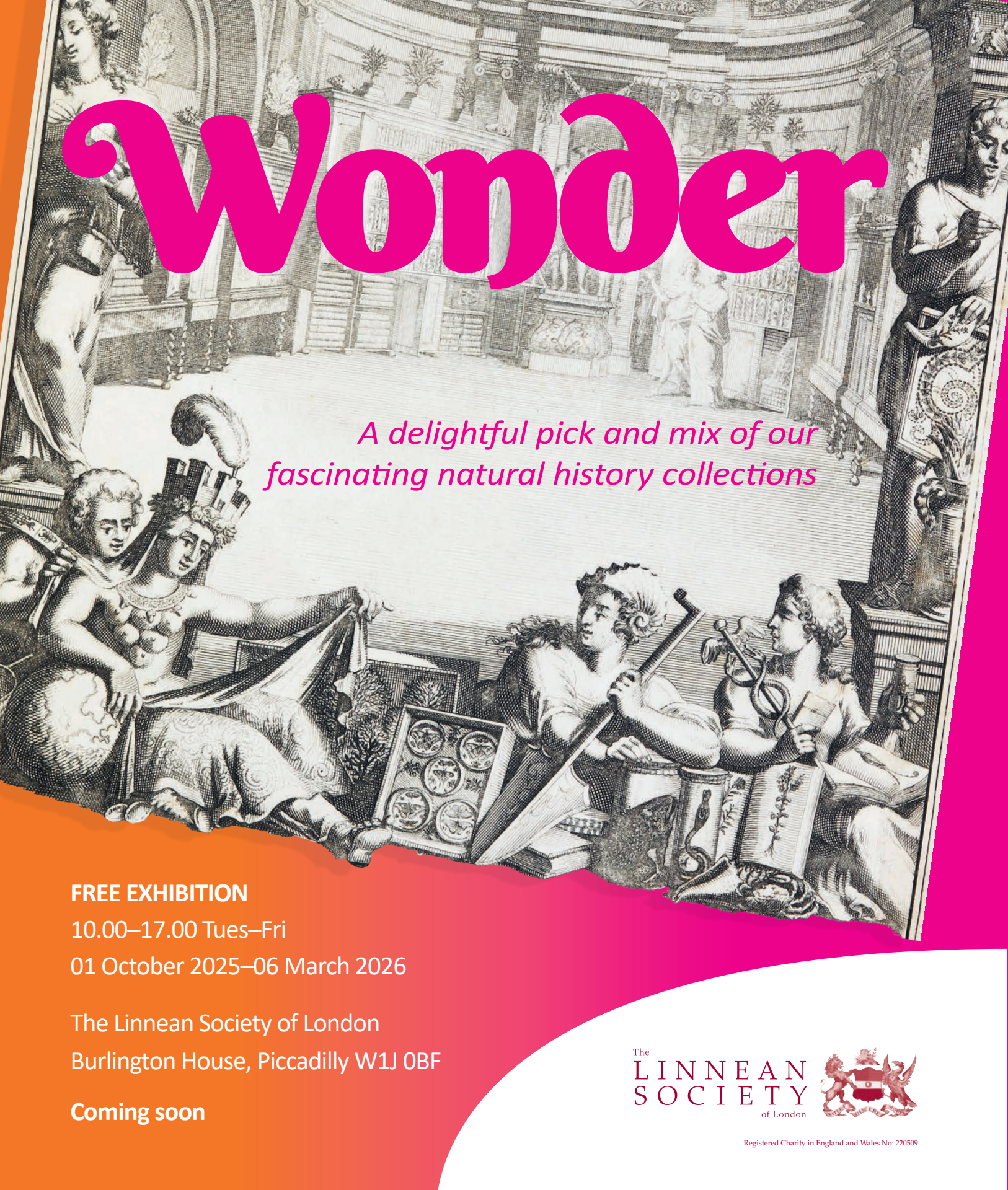
THE GREATEST
GARDENER OF
HIS TIME

*160th anniversary of
Joseph Paxton*

*Coconut
crabs*

*Investigating
colour variation
in Zanzibar*





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of London



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About us

The Linnean Society of London is the world's oldest active society devoted to natural history. Founded in 1788 by botanist Sir James Edward Smith (1759–1828), the Society takes its name from the Swedish naturalist Carl Linnaeus (1707–1778), whose botanical, zoological and library collections have been in our keeping since 1829. These collections, awarded Designated status by Arts Council England, are of fundamental importance as a primary reference for the naming of plants and animals. They are enhanced by the Society's own rich library which provides key resources for scientific and cultural research.

Our vision is a world where nature is understood, valued and protected. To do this we aim to inform, involve and inspire people about nature and its significance through our collections, events and publications. Thanks to the wide-ranging expertise of our membership and our unique collections, we are a hub for science communication through interdisciplinary learning and engagement.

Cover image: Cougar © Jim Cumming

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Dear Fellows,

We are beginning to build up to our busy autumn programme, with a plethora of online and onsite events. On 20 November we'll also be holding a day meeting in support of a Special Issue of the *Biological Journal of the Linnean Society*, 'Organismal resilience in a rapidly changing world', so please do get involved.



In this issue of *The Linnean* we look at the potential of reintroducing the cougar to the East Coast of the US with Chadwick Hagan FLS; Rosie Ryland outlines her research investigating how rising temperatures influence the feeding habits of amphibians and reptiles; and Sarah Bilston FLS studies the archives of the Selborne Society in the Linnean Society's holdings. Selborne is also the focus of our Founder's Day Lecture on 2 December with author Jenny Uglow FLS.

Nominations for our 2026 medals and awards will close on 30 September—don't forget we now have two categories of Linnean Medal, one for 'Research' and the other for 'Advocacy'. There are many ways to celebrate an outstanding individual from the realms of science, the arts and conservation, so visit www.linnean.org/medals to nominate now.

Finally, our *Naturalists' Notebooks* exhibition ends on 20 September to make way for *Wonder* on 1 October, which will be a delightful pick and mix of the Society's collections.

Leonie

Leonie Berwick

Editor, *The Linnean* and Publications Manager (leonie@linnean.org)

You can also find the online interactive version of this issue in the Members' Area.

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Publish

The Linnean is published three times a year, in spring, summer and winter (UK). All contributions are welcome, but please contact the Editor or see the *Guidelines for Contributors* document on our website before writing and submitting articles (www.linnean.org/thelinnean).

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Image: The Linnean Society of London

What's on



THE DRAMATIC EVOLUTION OF BIRDS ON MADAGASCAR

Speaker: Sushma Reddy

7 Oct 2025 | 18.00 BST (Online: Free)

Islands are natural laboratories to study how species evolve in novel environments. Colonisation of new geographic areas can expose lineages to ecological opportunities and unique selective regimes, which sometimes leads to spectacular radiations. In Madagascar, a biodiversity hotspot with an exceptional diversity of endemics, several lineages of birds have undergone this experiment with varying results. Sushma Reddy uses Madagascar as a model system in her work, to study comparable endemic birds on a single landmass.



BEING TREE-ISH: NOTES ON *THE GENIUS OF TREES*

Speaker: Harriet Rix FLS

9 Oct 2025 | 18.00 BST (Onsite: £)

When modern humans evolved about 40,000 years ago, there were an estimated six trillion trees on the planet. By the time we appeared on the scene, trees had already altered the planet's air, changed the flow of water, used fire as a tool and built relationships with the plants and animals around them.

Harriet Rix will dip into her book *The Genius of Trees*, talking about the science of trees and how trees have used biochemistry to shape the world.



A QUIETENING OF THE WOODS: THE DECLINE OF WOODLAND BIRDS

Speaker: Richard Broughton

23 Oct 2025 | 18.00 BST (Onsite: £)

Partnership event with the British Ornithologists' Club

Europe's forest ecosystems are under enormous pressure from habitat loss, mismanagement, invasive species and climate change, leading to rapid biodiversity loss. This is especially acute in Britain, where severe declines of woodland birds are of major conservation concern. Richard Broughton will explore the story of two of the fastest declining woodland birds, the marsh tit and willow tit, as sentinels of woodland habitats and the issues they are facing.

To book for these and other events not shown, visit linnean.org/whatson



LINNEAN LENS: TREASURES OF THE LINNAEAN SHELLS COLLECTION

Speaker: Jon Ablett

4 Nov 2025 | 14.00 GMT (Online: Free)

Carl Linnaeus (1707–1778) described and named over 800 molluscan species, including many of the most familiar and widespread species.

Join Jon Ablett, Senior Curator in Charge of Molluscs at London's Natural History Museum as he tells us about some of the amazing species found in the collection—from sex changing seashells to killer cone shells and how humans globally have used molluscs for dyes, clothing and even musical instruments.

FOUNDER'S DAY LECTURE: GILBERT WHITE, THE REVOLUTIONARY OUTDOOR NATURALIST

Speaker: Jenny Uglow FLS

2 Dec 2025 | 18.00 GMT (Onsite: £)

Gilbert White's *Natural History of Selborne* (1789) was a quietly ground-breaking book. No one had written so vividly before, combining scholarship and science with close observation in the field. In this illustrated talk, Jenny Uglow explores White's life, ideas and habits of recording in journals and letters. Asking how he came to be called 'the father of ecology', she looks at his insistence that all nature is interlinked.



HYBRID DAY MEETING: ORGANISMAL RESILIENCE IN A RAPIDLY CHANGING WORLD

Speakers incl.: Patricia Schulte, Chris Wheat, Luis Chevin
20 Nov 2025 | 9.30–18.00 GMT (Online/Onsite: £)

Over the course of their evolutionary histories, organisms have adapted to cope with an unending array of challenges, and they continue to cope with novel pressures to this day. This resiliency is not without limits, and in our current era of rapid environmental change, the resilience of many organisms is being profoundly tested.

Join us in person or online for this day meeting in support of a special issue of the *Biological Journal of the Linnean Society*.

TREASURES TOURS 2025

Guides: Our fantastic Collections Team

2 Oct (BST), 7 Nov, 3 Dec (GMT) | 14.00–15.30 (Onsite: £)

Join our expert staff on one of our ever-popular Treasures Tours, an in-depth, behind-the-scenes journey around our unique home at Burlington House in central London. See Carl Linnaeus's own collections and library, and come away with fascinating information about their scientific, historic and artistic importance, and the story of the Linnean Society itself.

Join the journey—book your place!



News

BIG PICTURE: NATHANIEL WARD PORTRAIT CONSERVED

Regular visitors to our Meeting Room may have noticed a conspicuous absence over the past few months: a large gilt picture frame standing mysteriously empty! This space houses a magnificent portrait of Nathaniel Bagshaw Ward (1791–1868), Victorian naturalist and Fellow of the Linnean Society.

Ward was a doctor by trade but is celebrated in natural history circles for his invention of the revolutionary ‘Wardian case’: a specially-designed glass enclosure that enabled the transport of live plants on long sea voyages. A wonderful example, on loan from the Royal Botanic Gardens, Kew, has recently been on display at the British Library’s *Unearthed* exhibition, alongside Charles Darwin’s vasculum (on loan from the Linnean Society).

The scale of Ward’s portrait—painted by John Prescott Knight and presented by subscription to the Society in 1858—is a mark of the Society’s esteem. Sadly, it has suffered in the subsequent 167 years. The surface layers were considerably yellowed and darkened by a century and a half of Piccadilly soot. Splashes and smears from a ceiling leak in 2008 further disfigured it.

Following a generous donation from Keith Salvesen FLS, the Society was able to undertake a programme of restoration. Expert paintings conservator Amanda Paulley painstakingly cleaned the picture with a mixture of smoke sponge brushing and petroleum spirit. Minimal retouching of damaged areas with sympathetic colours was followed by a light varnish.

The change is profound. Ward’s face and expression are given new freshness, and the details of the background are revealed. For the first time in many years, one can clearly see the glass cloches to Ward’s left, the spectacles on the table, and a delicate fern under glass to his right. Amanda’s work reveals a composition full of lively scientific and botanical detail, previously hidden under decades of London grot. As our benefactor Keith Salvesen says: ‘It is wonderful to see him looking so splendid, and in his element.’

If you would like more information about how you can support us, please email Head of Membership and Development Pru Shackley at development@linnean.org.

Will Beharrell, Librarian



Image: The Linnean Society of London

Our Local Nature: A small but powerful change

It's been a fantastic year for the Our Local Nature grant scheme. Supporting projects around the UK that are designed and led by young people, the scheme aims to help them effect positive change and improve local relationships with their natural surroundings.

From botanical excursions to beehive building, these youth-led nature projects have gone above and beyond. Of particular note is The Cheer Up Squad, who work with children undergoing treatment in hospitals. With the Society's support, they provided 50 plant-growing kits to children aged 3–10 after being discharged.

Young volunteers assembled the kits, coordinated logistics and sourced sustainable, recycled materials. The feedback was incredibly inspiring and we hope to do even more with the next round of funding.

It takes my son some time to get out of bed after coming home from the hospital. Now, he checks his plant first thing every morning.
It's been such a small but powerful change.

—Parent of growing kit recipient

Helping to build the kits made me feel like I was giving something real. I'm proud of what we accomplished.

—Youth volunteer (17)

I didn't know anything about gardening, but now I want to grow more! I named my sunflower 'Smiley'.

—Growing kit recipient (8)

Festival Frogs: Amphibian conservation at Glastonbury

In June, the Society hosted a stall at Glastonbury Festival, making our very first appearance at the beloved Science Futures area. We interacted with over 500 people who had not previously engaged with the Society.

Manned and designed by Scarlet Forrester and Georgia Cowie (pictured), the main attraction was 'Toad in the Hole', a carnival-style game encouraging visitors to launch froggy beanbags (hand-made by Alice Cheetham) through holes in a suspended board with the aim of educating them on amphibian conservation. Many visitors revealed they didn't know about the threats faced by amphibians, and our game allowed them to learn specifics without being intimidated, before directing them towards related organisations where they could learn more.

The team presented a 30-minute live show for the Laboratory Stage at the heart of Science Futures, aptly named 'What do you call a fish with no eyes?'. There was a turnout of about 50 people in the audience, nicely filling the tent and asking some fantastic questions at the end. A number of audience members followed up afterwards and joined us at our stall to continue the conversation about taxonomy, Linnaeus, and the history of our Society.



We also kitted out visitors with customisable hats. With a selection of hand-carved lino stamps based on illustrations from our collections, visitors were able to mix and match stamps to create their own 'franken-animals' and wear them around the festival. A few even made it onto the BBC!

After five days of toads, live talks and terrifically terrible word play, we're certain that Glastonbury won't soon forget us.

Scarlet Forrester, Engagement Officer

New Look Library Catalogue

Our library catalogue is always evolving, with new information being made available all the time. We know that it is an incredible research tool for many, which is why we are happy to announce that enhancements have been made to improve your experience.

Regular visitors to the catalogue will have noticed some changes as we upgraded to a new interface in August (<https://thelin.cirqaHosting.com/cirqa-web-app/>). This upgrade, the first in some years, will give us much more control over the catalogue's appearance, and comes with handy new features, including cross-platform searching, embedded video and proper support for users on mobiles and tablets. There is also improved functionality for members self-managing their library loans.

The upgrade is being offered free-of-charge by the catalogue's provider. Readers should find routine searching works just as before. However, please contact the Collections Team should you experience any difficulties (library@linnean.org).

We hope you will enjoy using the new site and trust it will make it easier to discover and access our wonderful library holdings.



Welcome to Jo Macdonald

In May we welcomed Jo Macdonald (josie@linnean.org), who will be heading up Operations until Helen Shaw returns from maternity leave in 2026. As part of the Senior Management Team, Jo contributes to the Society's direction and the wider team's well-being. Jo says:

'I was genuinely excited to join the Linnean Society because I really believe in the value and beauty of the natural world. Our mission to help people connect with nature, understand it and safeguard it is something I care about deeply. I know firsthand how important being in nature is for our physical and mental health and I am proud to contribute, even in a small way, to its protection.'

Before my current role, I managed Administration and HR at a public art gallery. Like the Linnean Society, it was a free-entry organisation and a charity. What motivates me professionally is making a positive impact and working alongside people who care about the world we live in.'

East Coast Cougar Reintroduction

A CASE STUDY
IN CONSERVATION
AND HABITAT
CONNECTIVITY

by Chadwick Hagan FLS



Exploring the feasibility and ecological necessity of reintroducing cougars (*Puma concolor*) to the Eastern United States, Chadwick Hogan FLS draws on recent habitat connectivity models and demographic analysis by Yovovich *et al.* (2023). It situates the discussion in a broader rewilding context, drawing parallels with lynx reintroduction efforts in Britain. By reviewing biological, infrastructural and political conditions, the case for predator restoration as a keystone strategy for ecological balance in human-dominated landscapes is presented.

OPPOSITE: Cougar (*Puma concolor*) in the Rocky Mountains, December 2024.

Once, the American cougar roamed across nearly the entirety of the continental United States (US). Agile, elusive and ecologically indispensable, it was the dominant apex predator of the eastern US until rifles, railroads and relentless persecution drove it to regional extinction.

The US Fish and Wildlife Service formally declared the Eastern cougar extinct in 2018—a bureaucratic determination reflecting the absence of verified breeding populations, rather than the total disappearance of cougars from the East. Yet some states still list the animal as endangered, and confirmed sightings suggest dispersing individuals from western populations continue to cross the Mississippi.

Unlike most extinction narratives, this one carries a remarkable twist: the habitat remains. The prey remains. The ecological niche is unfilled.

In the absence of the cougar, eastern ecosystems have become increasingly unbalanced. White-tailed deer have exploded in number, decimating forest understories and weakening trophic integrity (Ripple *et al.* 2014). Today, a serious ecological question is resurfacing with renewed urgency: is it time to bring the cougar back?

This article examines that question through the lens of Yovovich *et al.* (2023), whose work offers a rigorous assessment of habitat suitability and connectivity for cougars in the eastern U.S. Their findings, grounded in geospatial modeling, prey density analysis and corridor mapping, suggest that reintroduction is not a fantasy but a scientifically plausible and ecologically necessary endeavor.

Similar debates are unfolding in Britain, where the reintroduction of the Eurasian lynx (*Lynx lynx*) is under active consideration. As this article will argue, the American experience could offer vital insights not only for apex predator recovery, but for a broader rethinking of conservation in human-dominated landscapes.

The loss and legacy of the Eastern cougar

Eastern cougars once ranged from the Carolinas to New England and deep into the Appalachian interior. Genetically distinct but ecologically similar to their western counterparts, they were largely extinguished by the early 20th century through deforestation, bounty hunting and agricultural expansion.

While the U.S. Fish and Wildlife Service formally declared the Eastern cougar extinct in 2018, Western cougars have occasionally dispersed eastward in recent decades—some traveling extraordinary distances (LaRue *et al.* 2012). One notable case occurred in Troup County, Georgia, where a cougar was killed in 2008 and later confirmed through genetic testing to have originated from South Dakota. Other confirmed dispersers have appeared in Connecticut, Tennessee and even New Brunswick, Canada. These rare sightings underscore the species' mobility and resilience, but they remain isolated events—not evidence of population recovery.

That may now be changing. In March 2025, the Michigan Department of Natural Resources verified the first cougar cubs born in the state since the big cats were hunted out of existence there in the early 1900s. 'It's pretty exciting, considering this could be the first known cougar reproduction in modern times in the Western Great Lakes states,' said Brian Roell, the DNR's large carnivore specialist.



ABOVE: Cougar cubs have been seen for the first time in certain areas since the early 1900s.

The cubs, photographed without their mother, have not been seen since. ‘Those young cougars are very vulnerable right now,’ Roell noted. ‘We don’t know where they are or if they’re even alive. Mother Nature can be very cruel.’ In a separate email exchange, Panthera biologist Mark Elbroch echoed the concern—and added that the timing of the birth was unusually early and likely out of season.

Ironically, the landscapes that once supported cougars are, in many regions, more intact today than they were a century ago. The Appalachian Mountains, Adirondacks and northern New England have undergone significant reforestation and rural depopulation. White-tailed deer, once nearly extirpated themselves, now number in the tens of millions—an ecological imbalance with cascading effects.

Western cougars, particularly dispersing males, have already breached the Mississippi barrier. Confirmed sightings in Illinois, Michigan and Tennessee point to the biological feasibility of natural recolonisation. What remains in question is whether we will meet this phenomenon with planning—or paralysis.

The Yovovich Study: A roadmap for reintroduction

Yovovich *et al.* (2023) offer a rare fusion of ecological theory and applied conservation planning. Using geospatial habitat modeling, they identify core habitat patches across the East with sufficient cover, prey availability, and connectivity to support viable cougar populations.

Three zones emerge as particularly promising:

- **The Appalachian corridor (Virginia to Maine):** Continuous forest canopy, high prey densities and large public landholdings, though increasing human population in the north presents challenges.
- **The Ozark and Ouachita ranges (Arkansas and Missouri):** Relatively unfragmented forests and lower human density make this region highly suitable.
- **The Upper Midwest (Minnesota, Wisconsin and Upper Michigan):** Existing cougar presence and substantial habitat continuity, though harsh winters may limit long-term viability.

Applying the Krueger model for carnivore viability (Zeller *et al.* 2012), they estimate 4,800 km² of connected habitat to support 50 individuals. Southern Appalachia exceeds this, making it a prime candidate for phased reintroduction.

However, habitat alone is insufficient. Fragmentation, particularly due to road infrastructure, remains a critical barrier. Road mortality is already the leading cause of death for dispersing juveniles in the Midwest. Without investment in wildlife crossings and ecological corridors, reintroduction efforts will falter (Gilbert *et al.* 2016). As Panthera’s Mark Elbroch has emphasised, natural recolonisation is highly unlikely without human intervention. The chances of breeding pairs successfully navigating the web of highways and reestablishing themselves in the East are slim to none—though nature has surprised us before.

Habitat viability and ecological imperatives

The eastern U.S. is not merely suitable for cougars—it is perfect. An abundance of prey, particularly *Odocoileus virginianus*, has created an unsustainable ecological imbalance (Ripple *et al.* 2014). Overbrowsed understories, collapsed forest regeneration and biodiversity loss are symptoms of a landscape missing its keystone predator.



Cougars thrive in dense cover and varied terrain, exactly the features found across much of the Appalachian spine. When combined with targeted conservation easements and riparian corridor management, the East's forest matrix can sustain a viable population.

Connectivity remains the linchpin. Fragmented populations risk demographic collapse through inbreeding and isolation. Western landscapes benefit from vast wilderness areas and contiguous habitat. The East must rely on proactive landscape design. Utility corridors, river basins and even urban greenways could serve as connective tissue if integrated into a larger vision.

Challenges remain. The East is far more densely populated than cougar-occupied western states. Conflict with livestock owners, pet predation and public safety fears are all foreseeable. But decades of wolf and grizzly management in the West show that these challenges can be addressed through non-lethal deterrents, compensation schemes, GPS tracking and public education (Treves *et al.* 2009).

Political hurdles and public perception

Legal protections vary widely across the East. While states such as Maine, Vermont and Pennsylvania list the cougar as endangered or extirpated, others consider it absent. Any reintroduction effort will require state-led initiatives tailored to local conditions.

Public opinion is complex—fear of predators remains culturally ingrained, but so does fascination. Media coverage of cougar sightings, real or imagined, routinely attracts national attention. Surveys suggest that public support increases when the ecological role of predators is explained and when communities are offered meaningful input (Manfredo *et al.* 2016). As recently as July this year, research showed strong support for puma reintroduction in the eastern United States. Of the 2,756 respondents sampled across seven states—Massachusetts, Maine, New Hampshire, New York, Pennsylvania, Vermont, and West Virginia—support outweighed opposition, ranging from 4:1 to 13:1 (Elbroch *et al.* 2025).

Conflict is inevitable but not insurmountable. Lessons from the Yellowstone wolf reintroduction underscore the importance of involving landowners early and often. Mitigation strategies should not be reactive but anticipatory, harnessing modern tools like motion-sensor cameras, tracking apps, and geo-fencing to reduce risk and build trust.

ABOVE: The dense forests of the Ouachita Mountains in Arkansas have potential as an area of reintroduction.

OPPOSITE:

Reintroduction of the Eurasian lynx (*Lynx lynx*) is being considered in Europe. Can cougar reintroduction in the Eastern US offer useful insights?

BELOW: The Eastern US can support cougars—pilot programmes in the Appalachians will show how possible larger scale efforts can be.

The cougar as catalyst for ecological restoration

The ecological rationale is unambiguous: the East can support cougars and the prey base is abundant. The habitat exists and the need is urgent. The Yovovich study provides a blueprint not only for feasibility but for strategy.

However, conservation does not move on science alone. Reintroduction will require political pluck, civic buy-in and a willingness to think in decades, not election cycles. Pilot programmes, especially in the southern Appalachians, can serve as test cases for broader efforts. Success here could catalyse a continental rethinking of predator restoration.

Crucially, the cougar is not just a symbol of wildness. It is a biological keystone. In western ecosystems where cougars persist, studies have documented cascading benefits:

- Deer densities in cougar-inhabited areas are 3 to 5 times lower than in predator-free zones, reducing overbrowsing and allowing native vegetation to regenerate.
- Riparian ecosystems show higher tree and shrub diversity in cougar territories, linked to decreased ungulate pressure.
- Bird and rodent populations benefit indirectly from improved ground cover and plant complexity, increasing overall biodiversity.
- In Zion National Park, cougar-induced trophic cascades have led to a 33 % increase in cottonwood recruitment and doubled songbird density along stream banks within a decade
- Roadkill and agricultural damage from deer, currently costing states like Pennsylvania and Virginia hundreds of millions of dollars annually, decline when natural predation returns.
- The cougar's presence also displaces coyotes. Their booming populations have altered small mammal communities and contributed to nest failure for ground-nesting birds. In areas of cougar recolonisation, coyote densities drop by as much as 30 to 40 %, leading to a rebalancing of mesopredator dynamics.

The return of the cougar would do more than heal fragmented ecosystems. It would signal that apex predator conservation is no longer the exclusive province of the American West. It would position the East, historically a site of ecological loss, as a frontier of restoration.



Images: Gerard Lacz; Tomas Hulik

And it could inform transatlantic dialogues. As Britain debates the reintroduction of the lynx and wolf, the American experience may serve as precedent. Lynx, in particular, are ideally suited to the Scottish Highlands and upland England, where roe deer populations are unsustainably high and native woodland recovery is stalling. As a shy, low-conflict species, lynx pose minimal threat to people and livestock and are already thriving in similar European landscapes. A study by Lynx UK Trust found that over 9,000 km² of suitable habitat exists across northern England and Scotland, capable of supporting at least 100 individuals in a managed metapopulation.

Importantly, Britain's unique land ownership structure, anchored by large private estates and conservation-minded landowners, offers a viable model for reintroduction through property-level licensing and collaborative stewardship



frameworks. Estate-led rewilding, as seen at Alladale in Scotland and Knepp in southern England, could accelerate the return of apex predators by bypassing state inertia and tapping into a growing network of rural landholders committed to ecological recovery.

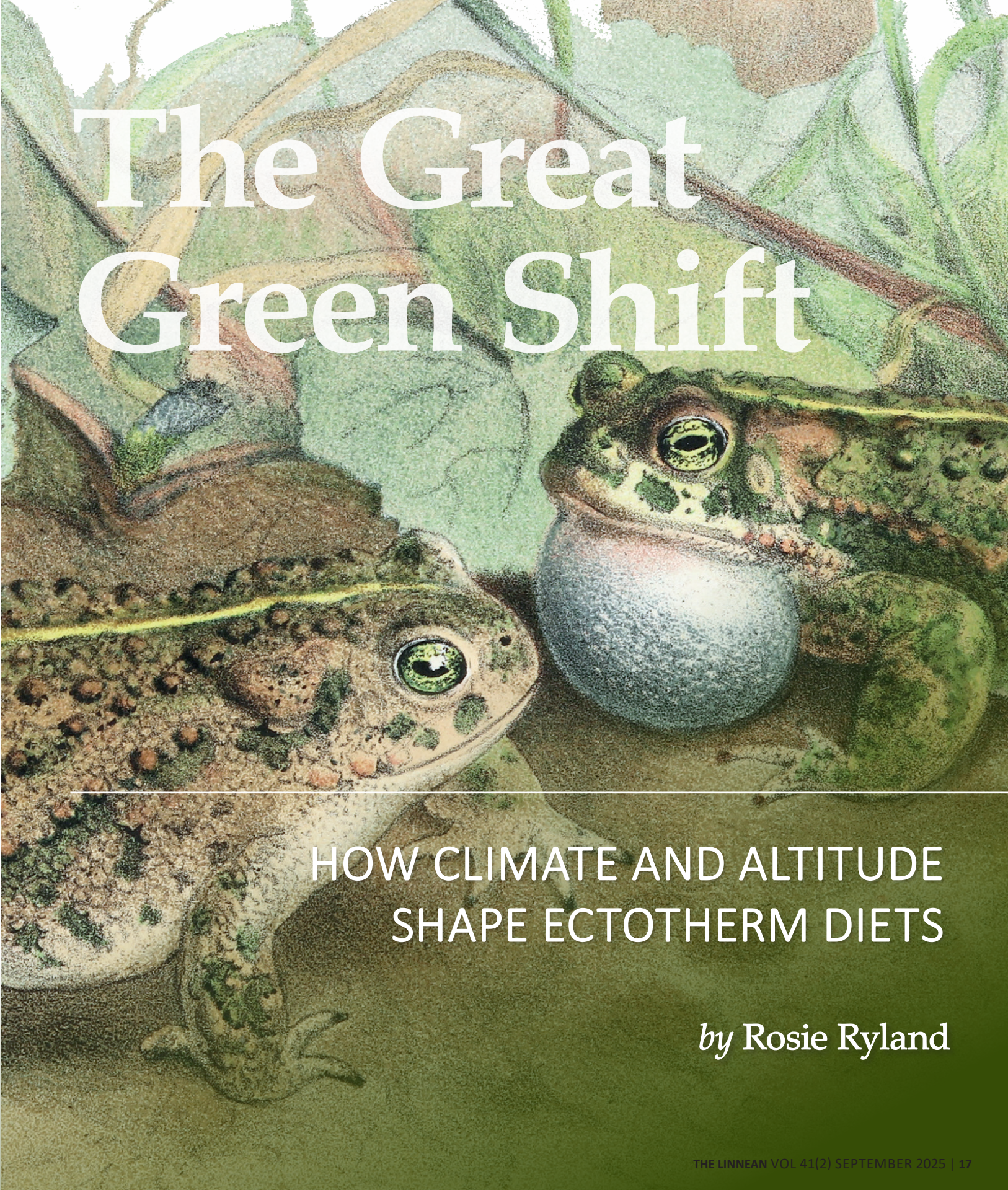
Whether in Appalachia or the Highlands, restoring apex predators is not an indulgence but a necessity, a duty to the land, to the future, and to ourselves. And in the case of the cougar, as with the lynx, the hour is late, but perhaps not too late.

Chadwick Hagan FLS (chad@haganfamily.org)
Chair, HFF Nature

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Plans are in progress for a day meeting to discuss rewilding at the Linnean Society in 2026. Keep an eye on our website for details.
www.linnean.org/whatson



The Great Green Shift

HOW CLIMATE AND ALTITUDE
SHAPE ECTOTHERM DIETS

by Rosie Ryland

PREVIOUS PAGE:

Natterjack toads from *The Tailless Batrachians of Europe* by G. A. Boulenger/Ray Society (1897–1898).

BELOW: Shallow pond with sandy substrate used by the high-altitude population of the Natterjack toad as a breeding habitat in Serra da Estrela, central Portugal.

Ectotherms like amphibians and reptiles depend on environmental temperature for biological processes, so understanding the ongoing effects of climate change is crucial for their conservation, especially in ectotherm-dominated ecosystems (such as freshwater). With global temperatures continuing to rise, Rosie Ryland set out to investigate how these increases influence ectotherm feeding, and the role of local adaptation in shaping these responses—a factor previously overlooked.

As part of my master's project with Dr Pavel Kratina's Aquatic Food Web Ecology group at Queen Mary University of London (QMUL), I visited the Faculty of Sciences of the University of Lisbon. My research was part of the 'EDGES—Temperature and nutrient interactions in aquatic ectotherms: individuals, populations and communities at latitudinal edges' project, led by Dr Bruno Carreira. For two months I worked with the team, both in the field and in the laboratory, investigating how local adaptations of aquatic ectotherms shape feeding responses to temperature across environmental gradients (including altitude and latitude).

Feeding in a warming world

Warming temperatures tend to increase ectotherms' metabolic rates, which leads to higher food intake. This is often accompanied by shifts in dietary preferences, as animals seek foods that better meet their changing nutritional needs. In aquatic species such as snails, fish and amphibians, studies have shown a general trend toward increased herbivory (Zhang *et al.*, 2020; Guinan, Kapuscinski & Teece 2015; Carreira *et al.*, 2016, 2017, 2020), but reasons for these shifts are unknown. With some changes in diet being maladaptive, there is a need for species-specific studies to give clearer insights.

Ectotherm feeding is also influenced by varying environmental factors associated with altitude, which then shapes local adaptations like thermal tolerances and feeding behaviours. Previous studies often overlook these effects, despite their potential ecological consequences.



Images: (Previous page) The Linnean Society of London; (This page) Rosie Ryland

Tadpoles, temperature and isotopes

As part of my research, I investigated how temperature and altitude affect the feeding habits of Natterjack toad tadpoles (*Epidalea calamita* Laurenti, 1768). Tadpoles from low (400 m) and high (1900 m) altitude populations were reared at four temperatures (15°C, 18°C, 21°C, 24°C) and on three diets—animal, plant or mixed. Once they had metamorphosed, I used stable isotope analysis (SIA) to determine the proportion of assimilated plant or animal food.

With the increase in temperature the tadpoles consumed less animal material, dropping from 63% at 15°C to 46.8% at 24°C. This significant dietary shift supports findings from other ectotherms like caterpillars and frogs, where warming drives the intake of carbohydrates.

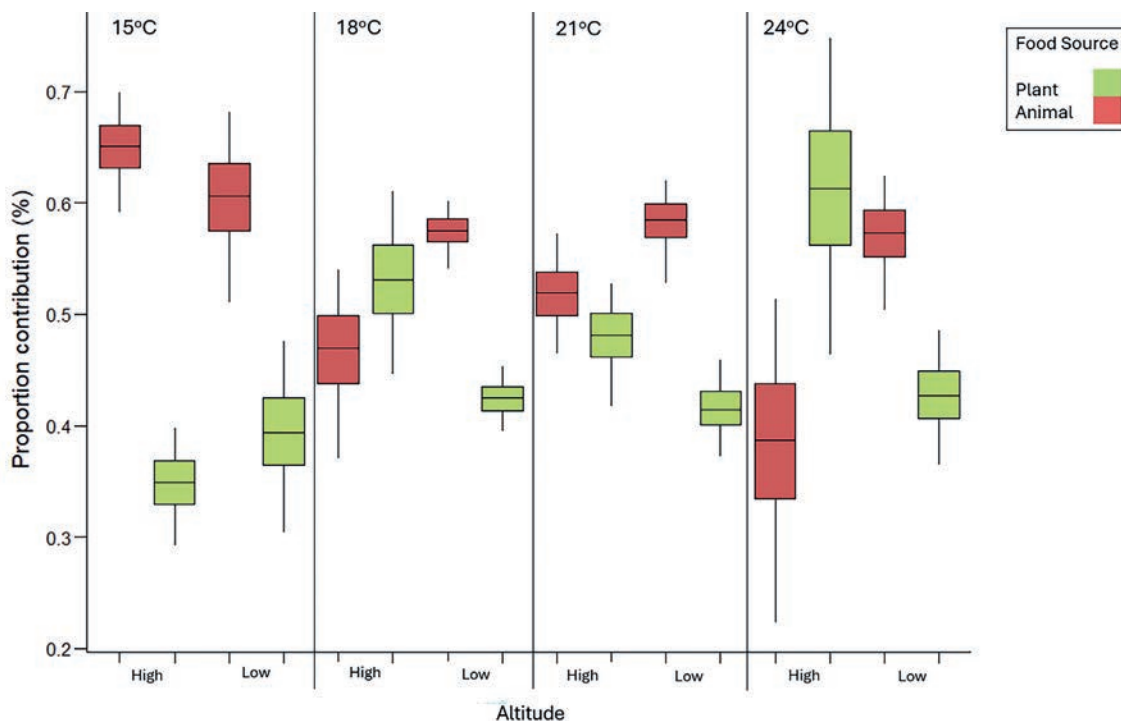
Although the mechanisms behind these dietary shifts are presently unknown, the trends observed are supported by the Metabolic Theory of Ecology (MTE). The MTE hypothesises that the metabolic rate—the rate at which organisms take up and use energy and material—controls ecological processes at all levels.

In this case, heightened metabolism at higher temperatures causes a greater increase in the respiration rate than in growth rate, which favours the intake of carbon over nitrogen and phosphorus. The role of gut microbiota has also previously been explored, showing enhanced plant digestion as temperatures increase towards the tropics (Sepulveda & Moeller 2020). However, further research on the physiological mechanisms that underlie dietary shifts is required to understand their ecological impacts on species and, consequently, ecosystems.

Dietary Shifts: A story of local adaptation to altitude

Regarding altitude, the low and high-altitude groups showed notable differences in food proportions at temperatures 18°C, 21°C and 24°C. Tadpoles from low altitudes maintained a higher proportion of animal food in their diets when compared to their high-altitude counterparts. This is consistent with research that suggests altitude affects ectotherm thermal tolerance and feeding preferences (Bovo *et al.* 2023), possibly due to local adaptation.

BELOW: Proportions of animal (red) and plant food (green) assimilated by tadpoles that were fed on a mixed diet (per temperature at high and low altitude). The horizontal bar represents the median, and the top and bottom of the boxes represent the lower and upper quartile ranges respectively.





ABOVE: The author conducting fieldwork in Serra de Grândola, Southwest Portugal.

Looking at interactions between altitude and temperature, the proportion of animal food assimilated decreased with rising temperatures at high altitudes (from 65% at 15°C to 38.5% at 24°C), while remaining relatively stable at low altitudes (60.5% at 15°C, decreasing slightly to 57.2% at 24°C) (see graph). The observed dietary shift among high-altitude tadpoles, compared to low, might be attributed to their increased sensitivity to temperature fluctuations. High-altitude environments are more variable and often subject to extreme temperature changes, potentially driving a need for greater flexibility (plasticity) in feeding behaviour. In contrast, low-altitude tadpoles, which experience more stable environmental conditions, may not face the same pressures and therefore exhibit a more consistent feeding behaviour, regardless of temperature.

Why this matters

The shift to a more plant-based diet in response to warming may reduce pressure on animal prey while increasing competition for plant resources, potentially disrupting food webs and ecosystem stability, especially in sensitive high-altitude environments. Understanding these shifts is crucial for developing more effective conservation strategies. The Portuguese team is currently conducting long-term field studies, tracking macroinvertebrate populations and environmental conditions in ponds located in Northern (Sweden) and Southern Europe (Portugal), investigating dietary shifts in nature and assessing changes in food web structure. If omnivorous tadpoles increasingly favour plant-based diets, competition for vegetation could intensify, reshaping freshwater ecosystems. They are also continuing monitoring on other ectotherm species as research should consider local adaptations and physiological responses to more accurately predict species' responses to climate change. To predict the future of our ecosystems, we must first understand what's on the menu.

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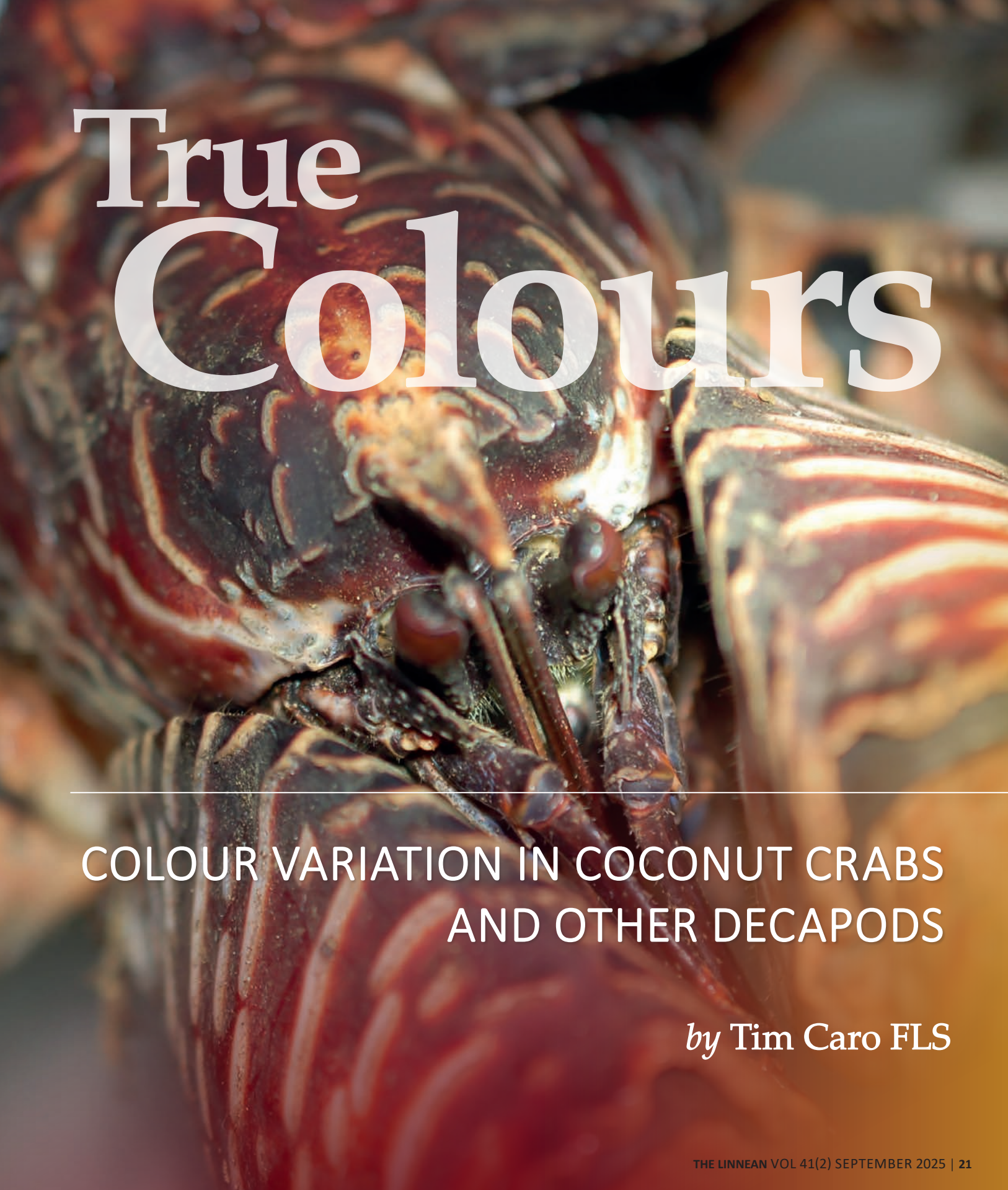
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True Colours

COLOUR VARIATION IN COCONUT CRABS
AND OTHER DECAPODS

by Tim Caro FLS

PREVIOUS PAGE: Coconut crab, close up of red morph.

BELOW: Some alterations in appearance are more predictable, like that of the horned ghost crab.

Although individuals of a species resemble each other reasonably closely, there is always a certain amount of variation in the appearances of any two individuals. Tim Caro FLS has been investigating colour variation in coconut crabs in Zanzibar, with some support through the Linnean Society's Appleyard Fund.

In some species, individuals differ in their appearances quite strongly. One example is between the sexes, but also within sexes, with those males employing different mating tactics sometimes having different structures or morphologies. In other species, noticeable differences in appearance aren't linked to mating strategies but where members of the same population and same sex have different appearances (Ford 1945; Gray & McKinnon 2007). These colour polymorphisms are not uncommon in nature and, conceptually, we know how they evolve and how they are maintained in populations. It can be due to several factors:

- Predators targeting the most common colour, which gives an advantage to rarer forms (a process called negative frequency-dependent selection).
- Better camouflage (background matching) in different microhabitats or lighting conditions, which favours different colours in different environments.
- Mating preferences, where individuals prefer to mate with rarer-coloured partners, again favouring less common morphs.
- Genetic links between colour and other beneficial traits such as immunocompetence or being a heterozygote (individuals with two different versions of a gene).
- Random genetic changes over time (genetic drift), especially in small populations.

In many cases it is difficult to tease these evolutionary alternatives apart (Briolat *et al.* 2019) and this is sometimes be further impeded by incorrect identification of the polymorphism in the first place. In nature, it is often difficult to ascribe two entirely distinct non-overlapping colour morphs to a population. More often than not, intermediaries exist but in low numbers.



Colour in decapods

Many decapod crustaceans are beautifully and variously coloured (Caro 2018). In some species coloration is labile, or prone to change, simply because individuals change colour within minutes (Hemmi *et al.* 2006), or their appearances alter predictably over the course of 24 hours, as with ghost crabs (Stevens *et al.* 2013). Yet other species change colour between moults (Nokelainen *et al.* 2019). The underlying mechanisms responsible for such colour changes are alterations in astaxanthin pigment and crustacyanin deposition over time, either within a moult, or between moults. Often the exquisite match of these animals to their background suggests colour changes are a means to avoid detection by predators. Mechanistically, individuals have differently coloured exoskeletons which remain permanent over time and these differences arise because of mutations at alleles coding for different colour pigments (Cianci *et al.* 2002; Tlusty and Hyland 2005). Contrary to the classic evolutionary mechanisms responsible for colour polymorphisms (as listed previously), a novel explanation has recently been proposed for colour polymorphisms in decapod crustacea.



LEFT: A signal crayfish matches the colour of its habitat at the bottom of the river Traun, Austria.

Freshwater crayfish species are particularly variable in colour with 115 instances documented so far, the majority of these being unusual blue individuals (Graham 2003). Variable appearances are also seen in sand crabs (Nasir & Faulkes 2011) and spiny lobsters (Landa-Jaime *et al.* 2018). Why should this be? In semi-terrestrial burrowing freshwater crayfish, which show particularly conspicuous colour variation of reds, blues and yellows, species spend most of their lives in burrows, rarely venturing out into open water and are subject to little predation. Moreover, they occupy small, separated populations which limit gene flow and mixing between individuals. Free-swimming aquatic crayfish, on the other hand, are usually brown to match their muddy river bottom habitat, probably because they are in danger of being detected by predatory fish, and they are interconnected with other populations (Graham and Perez 2024). While this is interesting, as of yet there is no experimental evidence to support the idea that relaxed predation allows colour variation to flourish.

Coconut crabs

Coconut crabs are the world's largest terrestrial arthropod, the species can reach a 1 m legspan, 4 kg in weight and can live for 60 years. They have the strongest pinch force in the animal kingdom (Oka *et al.* 2016), with a morphology reminiscent of small tanks, and have no known predators aside from humans. The species is almost entirely terrestrial. Adults mate on land, and females carry eggs to the sea to deposit them. Hatchling zoeae (larvae) drift for three weeks before metamorphosing into actively swimming glaucothoe that acquire a mollusc shell. These then move to land, but discard the shell completely after a few months and never return to the sea.

Adult coconut crabs come in two colour morphs: red dorsa (the top or back of the crab) with, usually, white ventra (the underside), or blue dorsa and blue ventra (see overleaf; Nokelainen *et al.* 2018). I have studied the red-blue colour polymorphism in coconut crabs (*Birgus latro*) on Zanzibar for 10 years.

Having examined whether colour morphs differed by size, sex, habitat, behaviour or by chelae pinch force, I found no differences between morphs, save for a slight tendency for blue crabs to be out on darker nights (Caro 2021). Instead, crabs are found in a 3:1 ratio of red to blue across different populations globally. This suggests that the colour difference might be following a simple Mendelian pattern of inheritance although affecting gene expression rather than the crustacyanin gene itself. Reminiscent of freshwater crayfish, coconut crabs apparently constitute another example of relaxed predation in a nocturnal decapod.



ABOVE: Coconut crab colour polymorphism (red morph on the left, blue on the right).

Ongoing research

A great many questions remain: genetic underpinnings, how coconut crabs actually see each other, and the nature of the colour polymorphism itself because there is considerable variation within colour categories: 'red dorsa' vary from light orange to brown, blue dorsa from blue through purple to black, and a small minority are difficult to classify, being blue-brown. The vast majority of colour polymorphism classifications of other species are subjective too. We therefore need to assess whether this species really shows colour polymorphism, and use it as a way to shed light on studies of colour polymorphism in other species.

This work is ongoing and involves genetic exploration of the colour polymorphism, experiments determining whether coconut crabs pay attention to each other's coloration, classifying their coloration into a colour space, and finally, revisiting other instances of putative colour polymorphism in both invertebrates and vertebrates.

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The Selborne Society in the Archives

WHAT THE LINNEAN SOCIETY'S HOLDINGS
TELL US ABOUT EARLY CONSERVATIONISM

by Sarah Bilston FLS

The conservation movement took shape in Britain in the late 19th century as the impact of rapid industrial and urban growth became impossible to ignore. The Selborne Society is one of the nation's oldest conservationist organisations; its archives are in the care of the Linnean Society. Sarah Bilston FLS, author of recent publication *The Lost Orchid*, investigates the highs and lows of the Selborne Society's roots, as found within the archives.

OPPOSITE: Selbornian photographs centre around rural practices and traditions under threat by the end of the century.

Named in homage to Gilbert White—19th-century Selborne resident, clergyman and observer of nature—the Selborne Society positioned itself as a vigorous defender of vanishing species and a celebrant of the nation's rural past. Yet it struggled to pitch its ideals and grow its membership. The Linnean Society's rich holdings of magazines, photographs and letters offer fascinating insights into challenges present at the very birth of British conservationism.

'To preserve from unnecessary destruction'

The 'Selborne League' was formed in the 1880s by George and Theresa Musgrave in opposition to the multinational trade in birds and their plumage. In an August 1885 letter to *The Times*, George calculated that over 773,000 birds and their parts had been used, in the previous five months alone, by 'milliners, upholsterers, and dealers in fancy articles'. He noted a particular surge in the use of canaries that season because of 'the prevailing craze for yellow' (Musgrave 1885; see also Clark 2004). Soon the organisation's focus expanded, and the Selborne Society for the Preservation of Birds, Plants and Pleasant Places trumpeted its goals as:

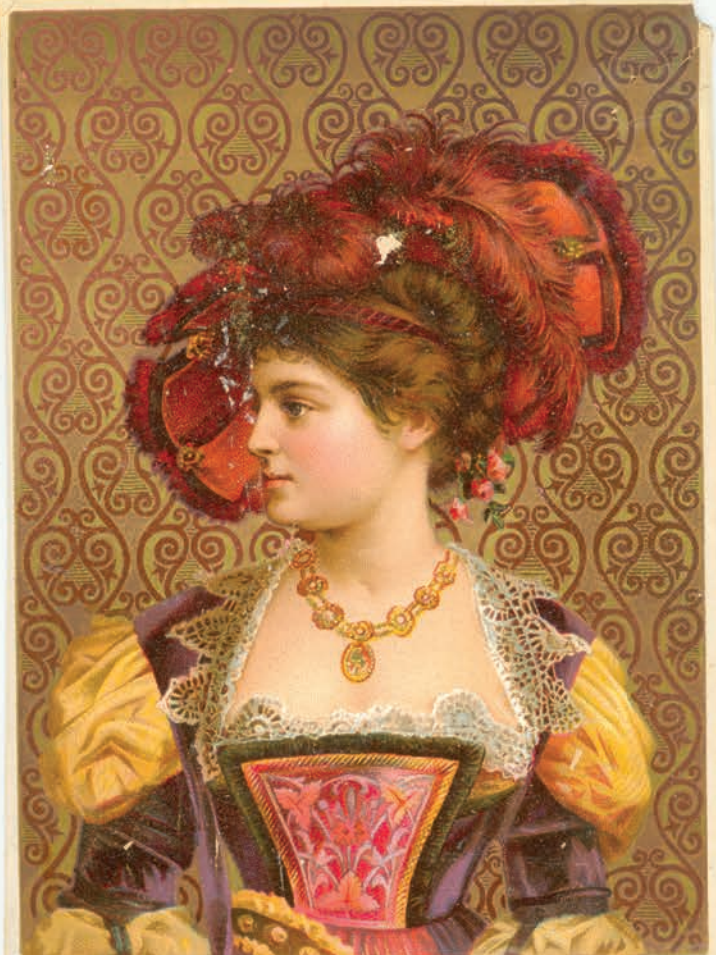
- a) to preserve from unnecessary destruction such wild birds, animals and plants as are harmless, beautiful, or rare.
- b) to discourage the wearing and use for ornament of birds and their plumage; except when the birds are killed for food or reared for their plumage.
- c) to protect places and objects of natural beauty or antiquarian interest from ill-treatment or destruction.
- d) to promote the study of natural history. (Selborne Society 1880; see also Clark 2004.)

But while the contemporaneous Society for the Protection of Birds achieved over 20,000 members as early as 1898, the Selborne Society reached a peak of about 3,000 members before dropping, by 1939, to just 433 (Clark 2004). Perhaps the embrace of 'Birds, Plants, and Pleasant Places' was *too* broad. The organisation was also self-consciously pragmatic; notably, the group's leaders were willing to countenance the killing of birds if '*reared* for their plumage', likely to protect British trade interests. This alienated some activists. Scientist James Buckland threatened to rescind his offer to lecture when the Society's magazine published an advertisement for a book written from the perspective of those engaged in the bird trade. In a dolorous, black-edged letter to the Chair, dated 27 September 1910, Buckland wrote:

It will be within your memory that I undertook to write gratuitously for the Selborne Magazine a series of articles on the destruction of plumage birds; but, in my deliberate opinion, the appearance in its pages of an advertisement of a book published in the interests of those who slaughter and exterminate bird life for coin compels me to most carefully reconsider my promise.

Dudley W. Buxton responded that organisations like theirs needed to platform disagreement. In a reply dated 4 October the Chair explained that 'fighting in the open was better for the cause': 'We should pay you a poor compliment if we appeared to burke enquiry and bolster up your articles by refusing to listen to adverse criticism.'¹

1 James Buckland to Chair of Selborne Society, 27 September 1910; Dudley W. Buxton to James Buckland, 4 October 1910; Linnean Society, SS/1.



Selbornians and White Friars

For all that some considered the Society too vague or lax, the group expressed a remarkably strong sense of identity and purpose in its periodicals through deployment of the noun and adjective ‘Selbornian’. All three of the Society’s early magazines—*Selborne Society Letters*, *Selborne Magazine*, and *Nature Notes*—use the term on almost every page. To be ‘Selbornian’ meant to be obsessed with Gilbert White and his works; to be fascinated by the etymology of species names and enthralled by myths and legends of the countryside; to abhor urban and suburban growth; and to crowdsource observations on natural phenomena (the pitch of cuckoo song, for instance—members spent months deciding whether it was a minor third, major third, fourth or even fifth). Selbornians sought to change hearts and minds through education; to be attentive to the risks of importing non-native species; to be wary of killing of animals for sport; to yearn to be a part of a community of men and women engaged with the environment; and to be committed to reading and discussing literary works about nature (the President of the Society was Alfred Lord Tennyson). Above all, Selbornians believed that the rural past was a site of potential social, cultural, environmental and even spiritual renewal.

Photographs and a pamphlet memorialising an 18 May 1901 trip to Selborne make this particularly clear. The Society verged on the cult-like in its veneration of White: an inner group terming themselves the ‘White-Friars Club’ called their visit to his home or ‘shrine’ a ‘pilgrimage’. The trip’s goal was, with every footstep, to remind members of a vanishing England, a world of bucolic hayricks and quiet streets; there are few people and certainly no factories or railways in the photographs they took. The privately printed guide pamphlet encouraged the Friars to stop on their walk and see past the *now* to the *then*:

a pause will be made at a straw-rick on our left. Here the foot-path [once] bore a little to the right, and a great gap in the hedge on the north marks the spot where the path crossed the fields to a line of trees.

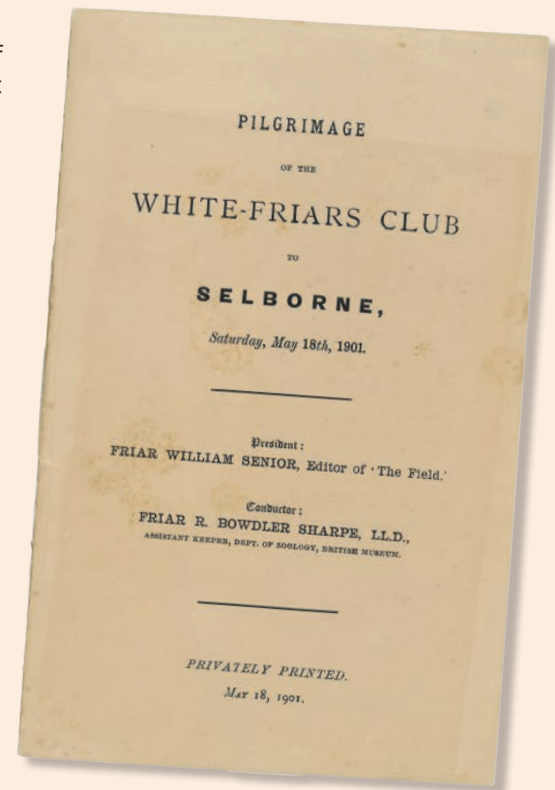
Looking down on Selborne, ‘the observer must again obliterate from his mind all reminiscence of this ‘new’ road by which he has travelled. In Gilbert White’s time and for more than half a century later, this road formed part of the surrounding fields.’² At a time of angst about industrial development and urban sprawl, the Friars encouraged one another to find the past afresh. Carefully curated photographs celebrate an English rural heritage miraculously preserved.

Membership struggles

It took, of course, leisure to participate in this kind of activity, and the Society’s membership struggles may also have stemmed from the ways in which Selbornianism was connected with the interests, commitments and worldviews of a comparatively small, upper-middle-class group of white men and women in England’s south-east. Early branches of the Society were in London and the Home Counties, particularly in affluent areas like Richmond, Hampstead and Highgate, and it was the landscape of these rapidly suburbanising areas that the Society especially yearned to protect. Contributors to the magazines regularly quoted in Latin; articles presumed education and income. Authors bemoaned the ways in which the era’s conservation efforts were ruined by those who did not understand or know enough, those who did not deploy the right kind of expertise: there is a strong *us* versus *them* dynamic in the magazines’ columns and the former tends to be well-heeled, educated, metropolitan. Provincial natural history museums, for instance, were poorly kept, according to the Rev. T. A. Preston, because those running them did not understand what they preserved (Preston 1888). ‘They’ were also evoked as the

OPPOSITE: Examples of fashionable millinery c. 1890, around the time of the foundation of the Selborne Society, with numerous birds feathers on full display.

BELOW: A pamphlet for the ‘White-Friars Club’ on their ‘pilgrimage’ to Selborne in 1901.



2 'Pilgrimage of the White-Friars Club to Selborne, Saturday May 18th, 1901.' Privately Printed. Linnean Society, SS/1; 2–3.



ABOVE: The White Friars' photographs rarely include people, never railways or industry. They encourage viewers to find afresh the rural past in an urban present.

denizens of new buildings, new villas—the *nouveaux riches*. Charles Tomlinson, for instance, lamented how 'our beautiful fields' in Highgate had recently been 'converted into roads, with villa residences on each sides' (Tomlinson 1888). The magazine framed itself as supplying necessary knowledge to those who lacked it, and the education it advocated often involved the passing down of information through traditional class hierarchies. The informed educated must enlighten the uniformed and ill-educated—as when 'a word in season may be spoken,' explained Susan Porson Hawes loftily, to 'domestic servants, or gardeners, or gamekeepers, or with the village boys and girls.' (Porson Hawes 1889.)

A powerful testament

The Society, arguably the first of its kind in Europe, depended on the expertise, education and cultural capital of the well-placed to broadcast its message. Yet the dominance of a geographically small elite, resistance to change, with an inability to imagine ways in which conservationism could learn from and grow out of practices *outside* the upper middle class, likely did not help it expand. The many passionate letters and glorious sepia photographs in the archive are a powerful testament to late-Victorian and Edwardian conservationism; they are also a reminder to us all to look forwards as well as back.

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Join us on 18 November for Sarah's talk on 'The Lost Orchid: Hunting An Icon in the Linnean Society Archives'. Book at www.linnean.org/whatson.

'The Greatest Gardener of His Time'

SIR JOSEPH PAXTON FLS (1803–1865)



by Glenn Benson FLS

PREVIOUS PAGE: *Victoria amazonica*, or the giant Amazonian waterlily, from John Lindley's *Victoria Regia* (1837). In 1849, Joseph Paxton was able to coax the species to flower at Chatsworth in Derbyshire.

BELOW: Engraving of Joseph Paxton.

This June saw the 160th anniversary of the death of innovative gardener, engineer and architect, Joseph Paxton. In honour of Paxton's legacy, Glenn Benson FLS, the Linnean Society's Honorary Curator of Artefacts, reflects on the achievements of Paxton, and on how nature often influenced his design.

Joseph Paxton's story is one of rags-to-riches; one of nine children born into a poor farm labourer's family, he would ultimately float to horticultural and architectural fame and fortune on a waterlily. When he died on 6 June 1865, *The Times* newspaper described him as 'the greatest gardener of his time, the founder of a new style of architecture and a man of genius'.

Between 1821 and 1860, Joseph Paxton would create 30 parks, gardens and cemeteries, design 35 glass structures and 33 more conventional buildings (not all realised). Largely self-taught, he would take on the roles of gardener, architect, engineer, businessman, publisher, writer and politician through his relatively short life. It is no wonder that Charles Dickens (1812–1870) described him as 'the busiest man in England' (Dickens 1851). In 1831 he was elected a Fellow of the Linnean Society, and knighted in 1851, following his role in the success of London's 'Great Exhibition' that same year.

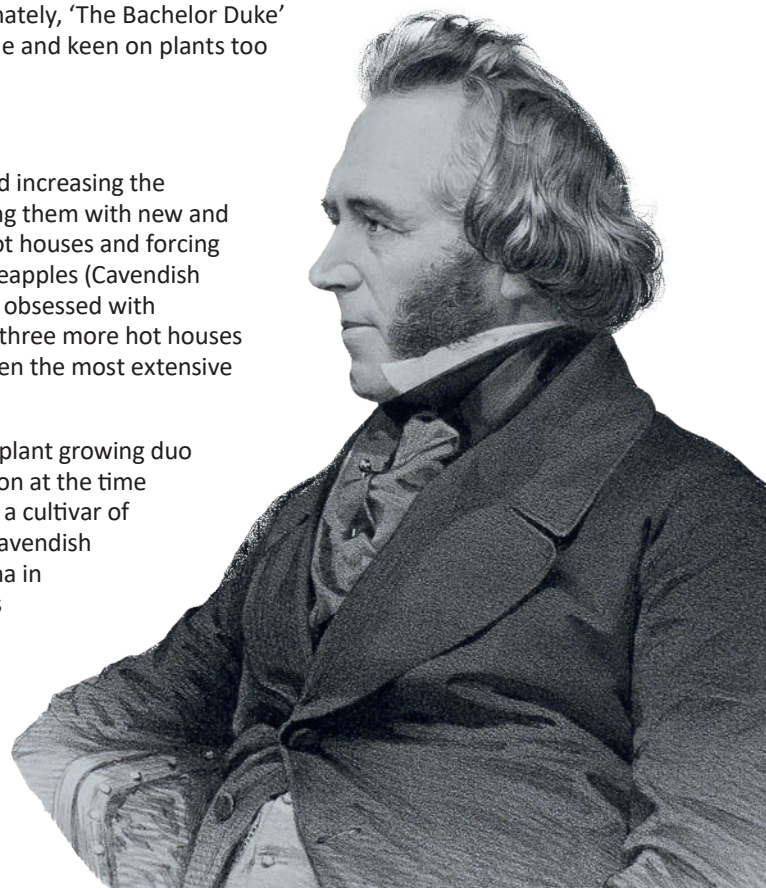
By all accounts Paxton was clever, inquisitive, visionary, hardworking and determined, and had a keen eye for business and self-promotion. Perhaps he was also fortunate—Paxton was born in 1803 at the end of one great era of discovery, and the start of an era technological innovation. He would become an adult during a period of great social change and—critically for his career as a horticulturalist—an era of plant hunting and appreciation. He worked with some influential gardeners and garden owners when horticulture was the height of fashion for the rich, before becoming popular with other classes of British society.

Paxton worked in several large estates before entering the Horticultural Society's gardens at Chiswick as a labourer in 1823. Elected a Fellow of that society in 1826, he was appointed Superintendent of the vast (14,000 hectares) Chatsworth House estate in Derbyshire that same year, where he would work for William Cavendish, the 6th Duke of Devonshire (1790–1858) until the Duke's death. Fortunately, 'The Bachelor Duke' (as he was known) was wealthy, fashionable and keen on plants too (Markham 1935).

The greenhouse effect

From 1828, Paxton set about improving and increasing the glasshouses on the Chatsworth estate, filling them with new and exotic botanical discoveries. By 1832, 22 hot houses and forcing pits had been built, four specifically for pineapples (Cavendish 1999). In the early 1830s the Duke became obsessed with collecting orchids, and Paxton would build three more hot houses to accommodate what was said to have been the most extensive private collection of orchids at the time.

Perhaps the most famous plant tied to the plant growing duo was the Cavendish banana (named by Paxton at the time as *Musa cavendishii* but now recognised as a cultivar of *Musa acuminata*). The origin story of the Cavendish banana—the most widely consumed banana in the world today—relies heavily on Paxton's account in his *Magazine of Botany* in 1837, drawing on information supplied by John Cameron (1787–1848), Curator of the Birmingham Botanical Garden.





LEFT: In 1835 Paxton and his team at Chatsworth encouraged a *Musa* plant to flower. In 1836, it would bear fruit—which would go on to become recognised as the Cavendish banana worldwide. From Paxton's *Magazine of Botany* (1837).

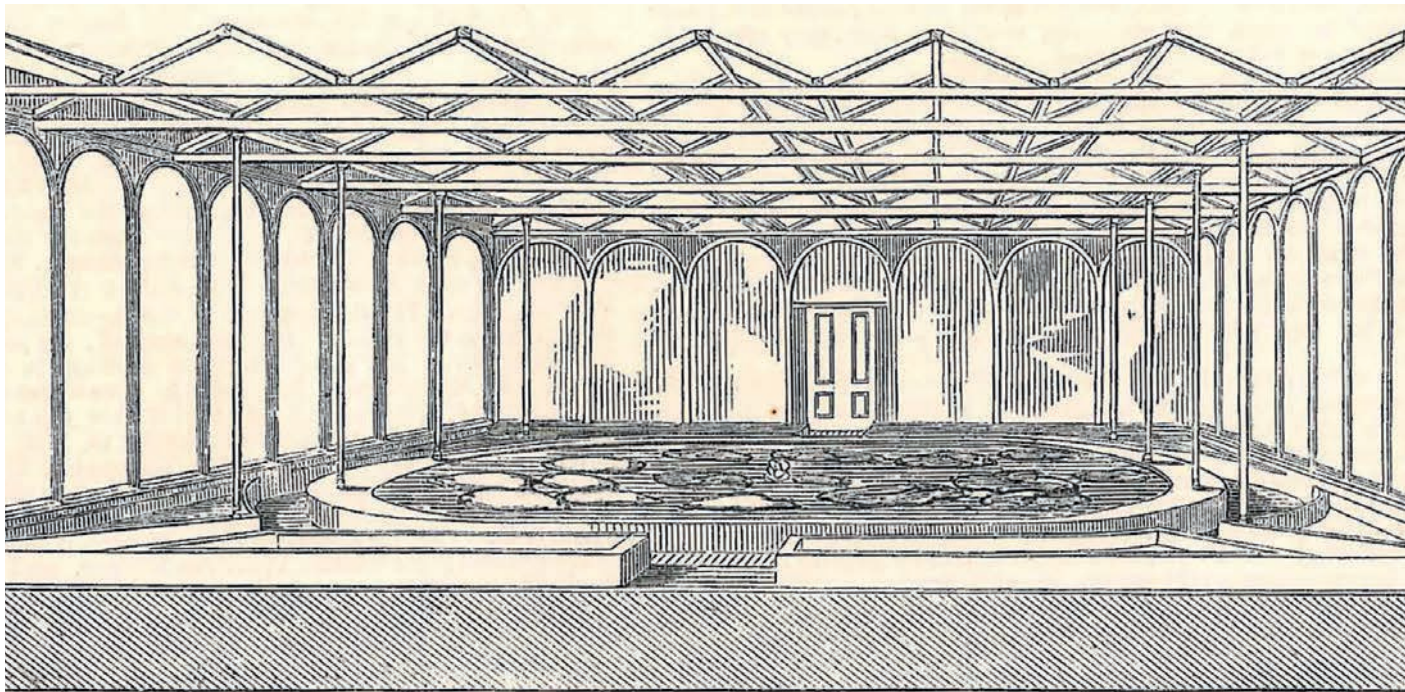
The tale is thus: in 1826 Charles Telfair (1778–1833), superintendent of the Royal Botanic Garden of Pamplemousses in Mauritius (now The Sir Seewoosagur Ramgoolam Botanic Garden), led an expedition to southern China where he discovered the low growing banana plants. Around 1829, two of the dwarf banana plants were shipped from Mauritius to keen gardener and brewer Robert Barclay (1751–1830) in Surrey. On his death, the plants were acquired by nurserymen Messrs Charles, James and Peter Young who sold one to the Duke of Devonshire in 1830 for £10 (almost £1,000 in today's money). Paxton, working his usual magic, provided the plant with 'plenty of water, rich loam soil and well-rotted dung'—the banana flowered in 1835, and produced fruit in May 1836 (Chatsworth 2022).

Amherstia

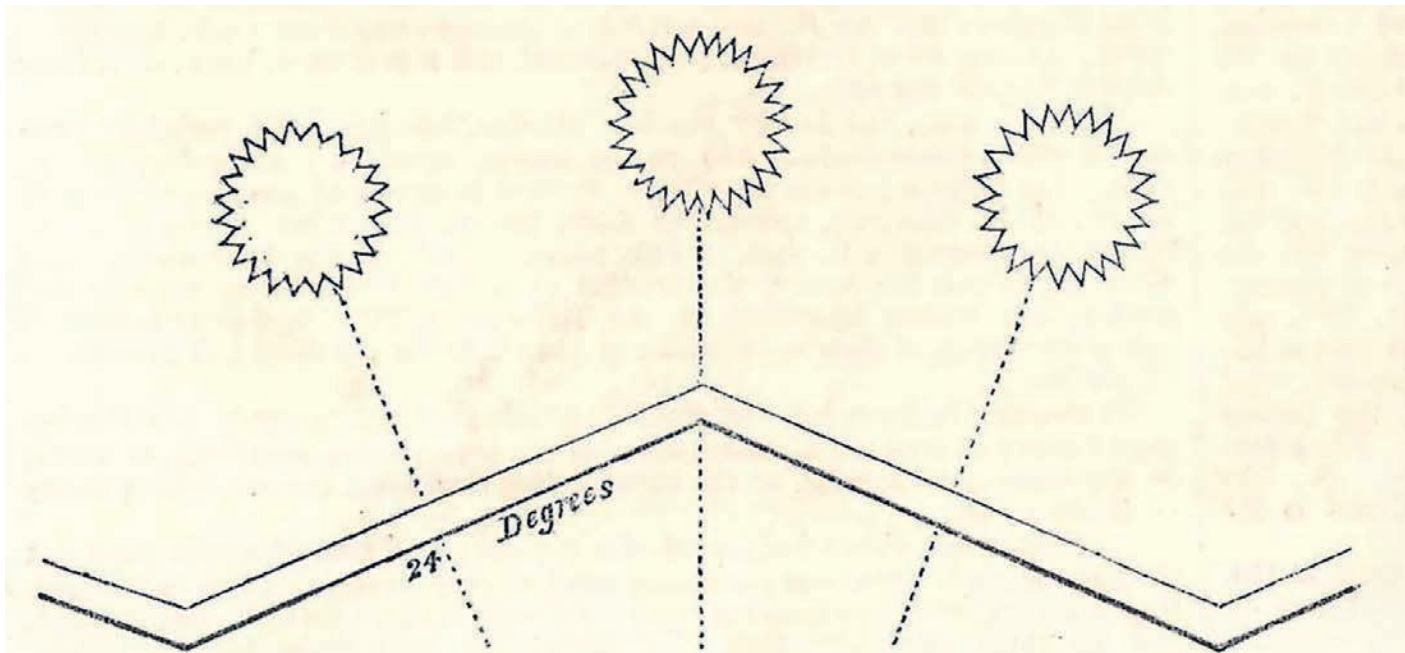
Paxton's 'Midas touch' did not always bear fruit. One of his failures involved the much-desired plant *Amherstia nobilis*, more commonly known as the Pride of Burma. Once its existence was made known to the British, the game was afoot to cultivate the species in the glasshouses of England. The Duke wanted one, of course, and Paxton dispatched John Gibson, one of Chatworth's gardeners, to collect specimens:

Mr Gibson appears fully alive to the work that is given to him, when he sees the *Amherstia nobilis* or a new orchidia he runs round it clapping his hands like a boy who has got three runs in a cricket match... (Masters 1836).

On the day of the plant's final arrival at Chatsworth in 1837, the Duke ordered his breakfast to be served in the Painted Hall, where he ate beside the plant. Paxton built a special glasshouse to house the new plant, but even he could not induce it to flower. This would take another decade, with the



THE NEW VICTORIA REGIA HOUSE.—INTERIOR.



THE RIDGE AND FURROW ROOF.

honours going to one of Paxton's keenest rivals, horticulturalist Louisa Lawrence (1803–1855). She would send one of the first three flower spikes from her plant to Paxton.

The 'Titanic water plant'

If the competition to coax *Amherstia* to flower was fierce, this would be overshadowed by the contest to induce the giant Amazonian waterlily to do the same. The plant had been known to western explorers of South America since the early 1800s—the local people longer still—but it was Sir Robert Schomburgk (1804–1865) who is credited with rediscovering the 'Titanic water plant' in 1837 while paddling up the Berbice River in Demerara, Guyana (Dickens 1851). Later that year, botanist John Lindley (1799–1865) published a monograph, naming the plant *Victoria regia* in honour of Queen Victoria (1819–1901), who had recently ascended the throne. (It would be renamed *Victoria amazonica* after her death.) The first seeds of the great plant reached England in 1840, with varying degrees of success in their germination. It was in 1849 that the Royal Botanic Gardens, Kew, successfully germinated the plant, and seedlings were distributed to various plant growers. The race to encourage a specimen to flower outside of its native range was well and truly on.

Paxton collected his seedling from Kew on 3 August 1849, and finally, in November 1849 the celebrity plant flowered at Chatsworth. Paxton took great pride in delivering the initial flower and one of the plant's giant leaves (growing up to 3 m in diameter) to Queen Victoria.

Natural engineering

Paxton was said to have admired the giant Amazonian waterlily for more than just its beauty. He was fascinated by the structure and strength of the of its leaves, with an intricate network of ribs and supporting structures on the underside, allowing them to support significant weight. Fascination with the plant extends to modern day study, with papers as recently as 2022 exploring the plant's leaf venation and structural architecture (Box *et al.* 2022).

Though this has been questioned in recent years (Elliott 2019), in some form the waterlily may have had an influence on his most iconic project; the glass building in London built in 1851 to house the 'Great Exhibition of the Works of Industry of all Nations' (or the 'Great Exhibition')—essentially, the very first world's fair, at London's Hyde Park. At 1,848 feet long, the timber and iron structure with over 293,655 panes of glass was soon nicknamed 'The Crystal Palace'.

The vast roof of the building used the ridge-and-furrow arrangement of the panes of glass, a design first used by Paxton between the longitudinal curvilinear ribs of the 'Great Stove' glasshouse at Chatsworth (built 1836–1840), later applied to the level roof of the conservatory at Darley Hall (1840) and the glasshouse he created for the giant Amazonian waterlily (1849). The zigzag style of glazed roof was first suggested by another Linnean Fellow, John Claudius Loudon (1783–1843) in 1816/7, who set the panes of glass at angles to maximise light and heat, particularly in the early morning and late evening, when the sun was low in the sky (Loudon 1817).

OPPOSITE: 'Victoria Regia House' at Chatsworth, in *The Illustrated London News*, 16 November 1850. The 'ridge and furrow' roof maximises light and heat.

BELOW: Paxton was fascinated by the strength and structure of the leaves of the giant Amazonian waterlily. Image shows the underside of a leaf, from John Fisk Allen's *Victoria Regia; or the Great Water Lily of America* (1854).

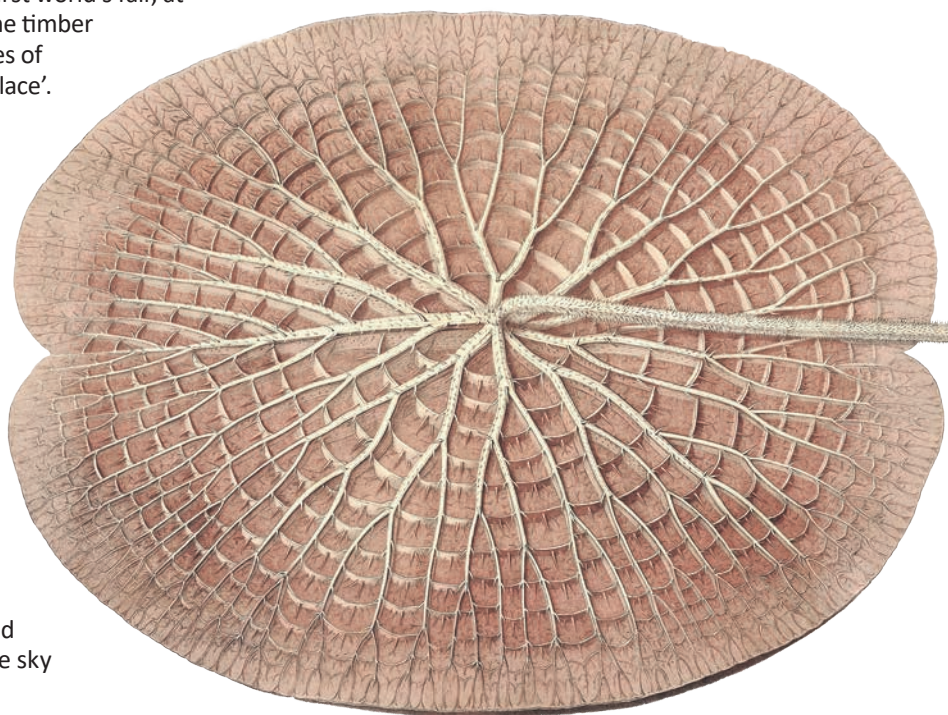


Image: BHL



The *Transactions* of the Society for the Encouragement of Arts, Manufactures and Commerce (now the Royal Society of Arts) record an address given by Paxton on 13 November 1850 about his design for the 'Great Exhibition Building'. In it, he explained that the design for what would become 'The Crystal Palace' was, in essence, the waterlily house at Chatsworth on a huge scale. It took him only 10 days to draw up the plans because '...having the whole matter already digested, and the system of ridge-and-furrow *flat* roofs so fully in my mind, it only required the adaptation of the principle on a large scale to suit the vast building for the Exhibition' (Paxton 1850).

Paxton apparently illustrated his speech with an illustration of a giant Amazonian waterlily leaf:

The most interesting illustration was a specimen of the leaf of the *Victoria Regia*, five feet in diameter, the growth of five days. The underside of the leaf presents a beautiful example of natural engineering in the cantilevers that radiate from the centre where they are nearly two inches deep, with large bottom flanges and very thin middle ribs with cross girders between each pair to keep the middle ribs from buckling; their depth gradually decreases towards the circumference of the leaf, where they also ramify (Paxton 1850).

While similar cantilevers radiate outwards in the tall arched transepts that were added to Paxton's original flat roof design, there is currently no irrefutable proof that the two are linked. These transepts were included to accommodate, *in situ*, three large elm trees (*Ulmus procera*) in the building's chosen location. As can be seen in Claude Marie Ferrier's glass negative, Paxton also left voids in the roof of the on the north side of the building for other trees to continue to grow.

The Great Exhibition ran from May to October 1851, with some six million visits made. 'The Crystal Palace', being of modular construction, was dismantled and moved to another part of London, where it was enlarged and opened to the public again in 1854. It remained in use until a fire destroyed almost all of it in 1936.

OPPOSITE: Inside 'The Crystal Palace' at Hyde Park, at the refreshment stand during the Great Exhibition. The curved transept can be seen in the background, built to accommodate the large trees in the foreground. Watercolour by Louis Haghe, 1851.

BELOW: Glass negative (inverted) of a photograph of 'The Crystal Palace' by Claude Marie Ferrier in 1851. Two trees can be clearly seen growing through the roof of the north-west corner of the building.



Images: Victoria and Albert Museum, London

Long they'll talk of the 'Grand Gardener'

After the Great Exhibition, Paxton's business interests, fame and wealth continued to grow, and he served as a Liberal Member of Parliament for Coventry from 1854 until his death. His was a life of dedication, luck and success. At his death, *Punch* magazine poetically summarised:

No gentler life, no truer heart, no quicker, keener brain,
E'er closed, or ceased from labour, than his that lieth here;
Long they'll talk of the 'Grand Gardener' round Chatsworth fair demesne,
and many a hard hand, at his name, will wipe a well-earned tear. (Anon. 1865)

He remains the subject of much study, as technical publications to this day debate his design for 'The Crystal Place'. In 1954, almost 90 years after his death, at the opening ceremony of the Royal Horticultural Society's new student accommodation, then-President Sir David Bowes Lyon stated, 'I hope we may look forward to the steady emergence of a whole string of budding JOSEPH PAXTONS' (Elliott 2004).

Glenn Benson FLS (gdben1@aol.com)
Honorary Curator of Artefacts, Linnean Society

Acknowledgement

Many thanks to Abby Matthews at the Royal Society of Arts for her efficiency and help with all queries Paxton.

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Reviews

Biology, Ecological Importance and Diversity of Southern African Insects

Clarke H. Scholtz and
Hennie de Klerk

822 pp, Protea Book
House, Pretoria
2024 (Hardback)
ISBN 978-1-4853-1129-4
Col. Illust. £65



This accessible yet academic book on southern African insects gives the reader a vivid sense of the biology and exceptional diversity of these organisms in the subcontinent.

If you read and digest the contents of this mighty 822-page volume you will have learnt a great deal of entomology. And given the increasingly documented threat to insect populations around the world, there is assuredly a need for everyone to know more about the subject. This book complements the authors' 2021 biome-based opus, *Pollinators, Predators and Parasites: The ecological roles of insects in southern Africa*, the lead author on both having produced the text for two hefty volumes within three years—such is the life of an emeritus professor!

This volume does not fit easily into a standard category, though that is a strength rather than a criticism. Given its scope and extensive content, it resembles in many ways a textbook of entomology, but the scope of the discipline is now so diverse and the literature so voluminous as to make a comprehensive treatise almost impossible, even in a work of this size. Although a lot of standard structure and biology of insects is covered, the emphasis is on the environmental associations of these organisms and their many curious or extraordinary life-histories. A strong natural history flavour, therefore, flows throughout the book, highlighting so much remarkable insect behaviour. Furthermore, unlike a conventional textbook there are relatively few line illustrations of structures. Rather, the natural history leaning

is evident from the numerous (c. 3,200) high-quality colour photographs of live insects, which grace almost every page.

Although the focus of the book is on the insects of southern Africa, the exceptional diversity of these organisms in the region renders the work of broad interest. Plainly, it will appeal to entomology students in Africa, and especially the African subcontinent, but anyone seriously interested in insect diversity and biology will benefit from having access to such a volume, as will all those concerned with whole-organism biology in general. Those who teach entomology will surely value an up-to-date treatise on the subject thanks to the expansive coverage on offer, and so will all natural historians given the enormous presence and environmental significance of insects in all parts of the world. Moreover, the wealth of information included about insect natural history in southern Africa should encourage further exploration of the exceptional diversity of life-histories and biology of these organisms.

The work is written in an accessible style, enhanced not only by the photographs but by the many boxes, which highlight insects or topics of special interest and segregate them to avoid breaking the flow of the main text. The 21 chapters include: insects and their significance; insects and humans; the origin of insects; systematics; adaptations to harsh habitats; morphology and physiology; sensory systems; metamorphosis and growth; reproduction and brood care; defence; social insects; the fundamentals of feeding; interactions between insects and plants; feeding on plants; feeding on algae, fungi and lichens; feeding on vertebrates; feeding on insects and other invertebrates; feeding on dung, soil and animal remains; inquilines; and migration. The final chapter (classification and diversity of insect orders), which is just over 100 pages in length, provides a helpful conspectus of the insect orders represented in southern Africa with summaries of each of the families. A list of references follows each chapter, showing the wide range of publications sourced and synthesised.

There are several books on southern African insects, but this mammoth volume puts it beyond competitors in providing an up-to-date treatise with authors who clearly have a strong background of observing insects in the field. There is a telling photograph at the front of the book showing the authors, emeritus professor Clarke Scholtz (with net) and retired metallurgist and long-time natural history photographer

Hennie de Klerk (with camera), in what looks like an expanse of Karoo vegetation.

Given the increasingly documented and shocking decline of insect abundance around the globe, one might hope that this book, with its informative and richly illustrated text, will encourage a wider cohort of *Homo sapiens* to appreciate just what we are under threat of losing. Despite its accessibility, it is unlikely that members of the general public will buy this book given its quasi-academic style, which is a pity as everyone should understand more about insect life on planet Earth. Moreover, who can fail to be moved by the amazing and extraordinary diversity of habits and life histories of the insects that this book so beautifully reveals in text and images.

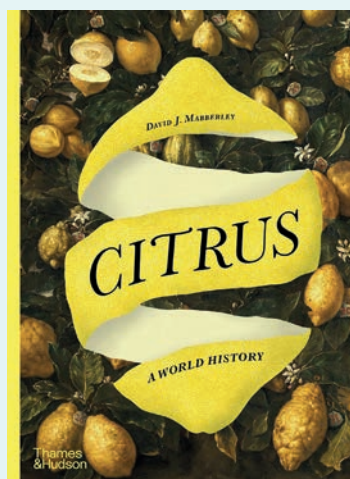
Malcolm Scoble FLS

Citrus: A World History

David J. Mabberley

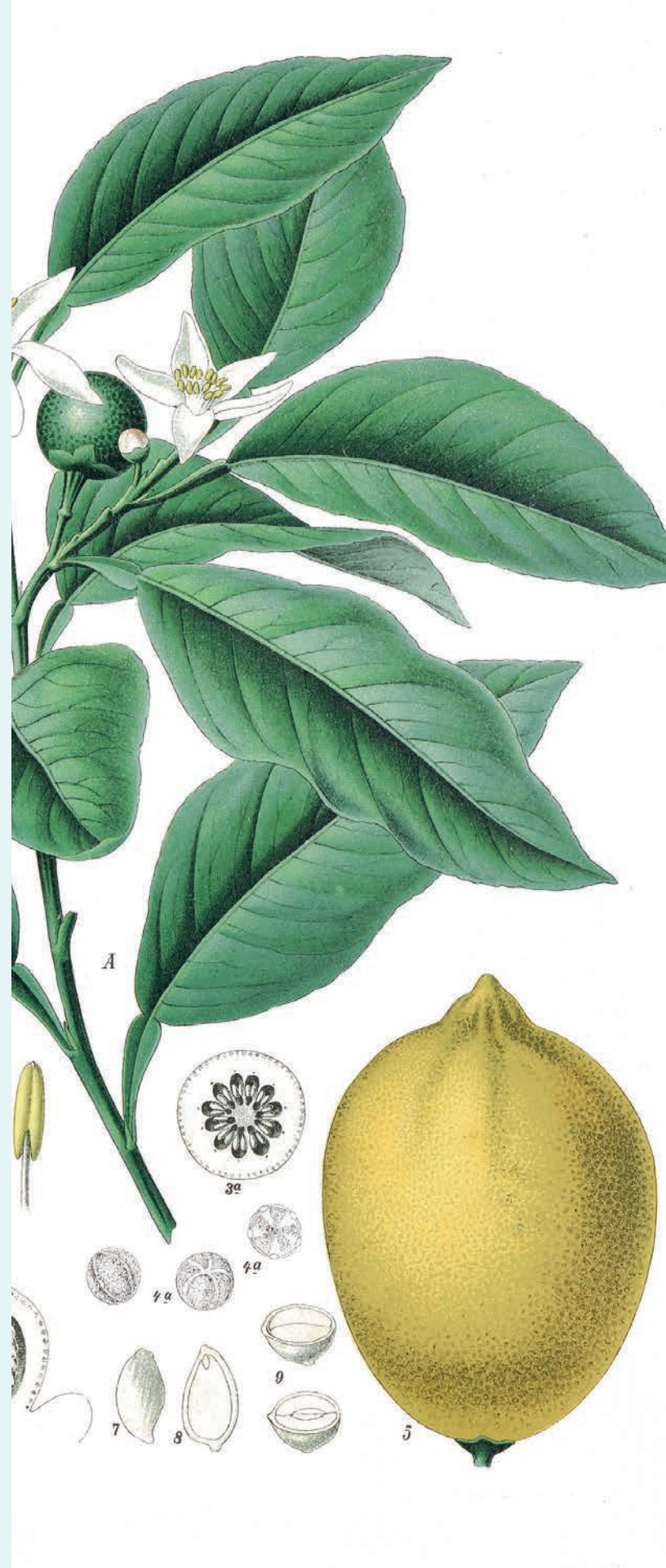
272 pp,
Thames and Hudson
2024 (Hardback)
ISBN 9780500026366
Col. illust. £22

An aesthetically stunning book full of thorough research about species we all *think* we know. A brilliant compendium.



Citrus: A World History is a wonderful, well-researched book by an authoritative author. David Mabberley is a renowned botanist with over 30 years of research into the natural history and taxonomy of citrus species. Everything one could ever want to know about citrus, and more besides, is contained within. It even answers the age-old question: are oranges so-named because they are orange...or is the colour named after the fruit? (The colour is named for the fruit—from personal experience, one can get very sweet oranges in the tropics that are green in colour.)

The chapters relate the history of everything known about citrus fruits, from the ancient world to the present—what they are, their cultivation, their uses and their inclusion in art (with comprehensive references to all cited sources). *Citrus* explores their cultivation in detail, showing that many are



hybrids stemming from a handful of wild species, and how, over centuries, they have influenced trade and empire.

Perhaps one of the most valuable aspects of the book is the most wide-ranging collection of illustrations of the subject ever assembled: manuscripts, herbals, botanical illustrations, paintings, adverts and photographs explore the beauty of citrus species, as well as their social and economic impact.

The comprehensive bibliography directs the reader to an enormous additional resource. Personally, I may have preferred precise citations to works by, for example, Theophrastus, but one needs to draw the line somewhere.

A singular criticism might be the size of the typeface chosen by the publishers (not, of course, a criticism of the contents). Presumably this was to prevent the book being physically larger than it already is, but that's a tiny quibble for such a fascinating and scholarly work. Simply put, it is a brilliant compendium.

Gavin Hardy FLS

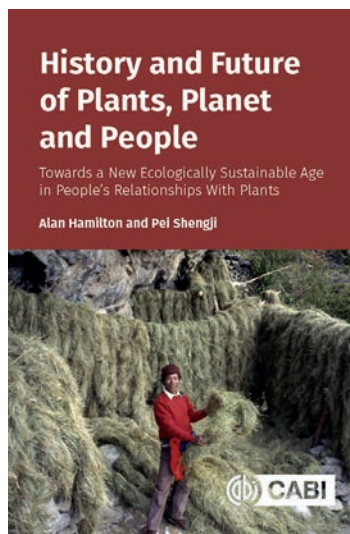
History and Future of Plants, Planet and People: Towards a New Ecologically Sustainable Age in People's Relationships with Plants

Alan Hamilton and Pei Shengji

417pp, CABI
2024 (Hardback)
ISBN 9781789248920
Col. Illust. £115.00

A most interesting and useful book covering a large range of topics from vegetational history, useful plants, conservation and local peoples with ethnobotany predominating throughout the text.

The combination of a British author with extensive experience in east Africa and a leading Chinese botanist brings together the knowledge and philosophies of two experienced



conservation minded ethnobotanists from very different cultures. This works well to make an informative book with many good ideas about what needs to be done to preserve the plants of the world. The text includes accounts of the personal field experiences of each author with an emphasis on examples from China and Buganda. The Preface that gives the background about the lives of the two authors is well worth reading and helps one to understand their approaches to conservation.

The first nine chapters are a useful summary of the history of human interactions with plants from prehistory to the present times. It is a story of success and disaster as population has increased. Examples vary from the Pacific voyages and the Silk routes to the colonial history of plants such as sugar, rubber, quinine and tea in China—all useful information for anyone interested in the history of plant uses. The message and uniqueness of this book particularly emerges in the chapter of worldviews, comparing the approaches of peoples from China, Britain and Buganda. The similar collectivist views of China and Buganda contrast with the more individualistic approach of the West. (There is so much good information in these chapters that is impossible to do them justice in this short review.) Important to the message here is the chapter on the history of plant conservation which flows from traditional practices associated with religious beliefs to the reintroduction of endangered species in Uganda. The authors then investigate ecosystem-based plant conservation, which seeks to consider all the contributions plants can make towards maintaining a sustainable world that respects the value of ecosystem services.

Chapters 10 through to 21 are fascinating accounts about the various conservation projects with which the authors have been involved. While the history of the introduction of rubber to Asia is mentioned earlier in the book, here we learn the lesser known history of the introduction of rubber into China specifically, and how this led to the foundation of the now famous Xishuangbanna Tropical Botanical Garden. Two other cases from China follow this: the commercialisation of the Han's use of flea grass (*Adenosma buchneroides*) and the restoration of Dai traditional beliefs after the cultural revolution. These two cases are presented as good examples of the application of the Convention on Biological Diversity (CBD) where indigenous property rights are respected.

Alan Hamilton offers two very personal accounts of his experiences in Africa: the first, of his well-known work on the vegetational history of east Africa through his palynological research. The second is about the consequences of destructive logging in the East Usambara Mountains of Tanzania, with a similar experience in Oaxaca, Mexico a year later. Hamilton then takes us with him to Mount Kinabalu in

Malaysia, Ayuba National Park in Pakistan and Dolpo in Nepal. All offer interesting narratives of working alongside local people using ethnobotany to promote the sustainable use and conservation of palms, fuelwood and medicinal plants. The importance of ethnobotany for conservation is evident in Hamilton's experience in the Bwindi Impenetrable Forest National Park in Uganda, where conflict surrounding gorillas was resolved by reaching an agreement between the local people and the Park, allowing the harvest of various natural resources in a controlled and sustainable way. In the final chapter, author Pei Shengji explores a project between the Kunming Institute of Botany and a local community in Ludian to develop more sustainable use and marketing of medicinal plants.

The combination of two authors from such different backgrounds works well and shows how much plant conservation is an international, cross-cultural issue. The message is clear that humans have devastated the Earth's ecosystems and that it is urgent to shift to a more sustainable approach. We still have a lot to learn from the traditional uses of plants by those with local knowledge—it could be where many solutions lie.

Sir Ghilleen Prance PPLS

***Mangifera indica*: A Biography of the Mango**

Sopan Joshi

408 pp, Aleph Book Company, New Delhi, India
2024 (Hardback)
ISBN 9789395853774
£23

A fascinating journey through the Indian 'mangoverse', brought alive through great quality of writing.

Although South-east Asia is the centre of diversity of mangoes (30+ species), *Mangifera indica* is, of course, the Latin name of the mango tree so beloved of the inhabitants of the Indian subcontinent (as the author regularly reinforces).



This book takes the reader on a journey through the Indian 'mangoverse', traversing the country and spending time with scientists and their geological artefacts, traders in Mumbai markets and amateur mango breeders, among many others. It is a veritable compendium of mango facts based broadly around mango culture, mango biology, growing/trading mangoes and finishing with a journey of exploration of some of the different varieties of mangoes available in India. For those of us in temperate regions whose mango delectations are limited to the 'table' mangoes that can travel across continents successfully, be prepared to learn all about the 'sucking' mangoes and their entirely different way of consumption, along with innumerable other mango varieties.

Although there are numerous academic books dealing with mangoes, this is probably the first popular book on this fruit and, as such, is very readable. This is at least partly due to the journalistic background of the author who blends a broad range of disciplines in the book and brings them alive with his writing style, making them accessible for a broad audience. Although there are no illustrations in the book, these are not really needed as the quality of writing allows easy visualisation of the topics discussed.

The book is very Indo-centric and readers may need to have some understanding of Indian geography and culture to fully appreciate it. Surprisingly, there is very little on the equally (if not more so in my experience) mango-loving Pakistanis, other than when 'mango diplomacy' is invoked in interactions between the two acrimonious countries. Nevertheless, this book is full of mango facts and you'll learn things about mangoes you didn't even know you wanted to know! Highly recommended for both mango fans and Indophiles alike.

Francis Q. Brearley FLS

Books for Review

Please contact the Editor before sending books for review (leonie@linnean.org).

Books for review should be sent to the attention of the Editor at:

Burlington House, Piccadilly, London W1J 0BF

Please note: While the Society aims to review as many books as possible, a review is not guaranteed, and is dependent on finding a reviewer and the decisions of the Editor and Linnean Steering Group.

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Please join us in welcoming the following new members to the Society (elected May–August 2025):

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Lives remembered

John A. Allen
(15 August 1946–17 April 2025)



John's colleagues and friends at the Linnean Society were saddened to hear the news that he passed away in April. A long-standing member of the team producing the Society's journals, John was Editor-in-Chief (EIC) of the *Biological Journal of the Linnean Society* from 1997 to 2023.

Born in Reading in 1946, John studied Zoology (with a special interest in population genetics) at the University

of Edinburgh, from where he received his BSc and PhD. He met Eleanor (a student of geography) there, and they subsequently married. After John completed his PhD, they decided that they would like to experience living in the Tropics, and this came to pass when John accepted a position at the University of Dar es Salaam in Tanzania, where they stayed for the next five years. During these formative years as a university teacher, he also conducted research in this biodiversity-rich country, focusing on snails and butterflies.

In 1976, John accepted a lectureship at the University of Southampton, bringing him back to the UK, and he stayed in Southampton for the rest of his career (in due course becoming a senior lecturer and then a professor). He also acted as Head of the Biodiversity and Ecology Division and Deputy Head of School (Education) for periods during his time at Southampton. After his retirement in 2010, he continued as an emeritus professor.

John's research interests included the evolutionary causes of biological diversity (at molecular, morphological and behavioural levels), frequency-dependent selection and the behaviour of predators. In retirement he continued with a programme of fieldwork during which he aimed to unravel the reasons why unrelated land snails in areas as far apart as Europe, East Africa and Cuba showed similar diversity in shell coloration.

With his interests in zoology, evolution and genetics, John was proud to be EIC of the *Biological Journal of the Linnean Society*, in the predecessor of which Darwin and Wallace had published their seminal work on the origin of species. John succeeded David Lees as EIC of the journal in 1997, and he continued in the role until he and his fellow Editors-in-Chief of the other Linnean Society journals stepped down in 2023, following the introduction of terms of office for editors by the Society.

With a tenure exceeding 25 years, John oversaw and experienced many changes in journal production. In his early days as EIC, he was not a fan of the need to do everything with paper copies, and he lamented the need for manuscripts to be sent backwards and forwards via 'snail mail' between the editor, reviewers and authors. As a result, he was an early

champion of the move to online submission and the use of manuscript handling software in 2006—in his words ‘It just revolutionised everything!’ He took the move to electronic publishing, the move away from in-house publishing and, in later years, the advent of open access and electronic-only publishing in his stride, trying to find advantages in the new systems rather than focusing on the disruption that some of these caused, at least in the short term. The covid pandemic was another time of big upheaval, but John kept the *Biological Journal* going throughout this difficult time.

John was a great believer in a hands-on approach and a keen advocate for a close interaction between editor and authors. He mostly used his Editorial Board as advisors, rather than getting them to handle manuscripts themselves, and many authors commented on the positive experience of the resultant personal interactions with the EIC. As a new EIC, taking over the *Botanical Journal* in 2008, I benefited greatly from John’s experience, especially concerning the complicated workings of the online system. He was generous in sharing his knowledge. We sat through many Editorial Committee meetings over the following 15 years, at the Linnean Society or at the publishers in Oxford (Wiley in the early days of my editorship, followed by Oxford University Press), and I have many happy memories of conversations with John, often sprinkled with comments demonstrating his wry sense of humour. We agreed about most things in our time working together. In fact, the only real disagreement I can remember regarded the ‘Oxford comma’ and what we should say about its use in the Instructions to Authors. John thought it was a good idea—I didn’t! My experience of John’s collegiality was similarly felt by Louise Allcock, who edited the *Zoological Journal of the Linnean Society* for several years. Louise writes ‘John’s immense knowledge of all things editorial smoothed my transition into the role of Editor-In-Chief, and I hugely enjoyed delving into dark corners of Manuscript Central with him and discussing fine details of style’.

Editing a journal for more than quarter of a century to a consistently high standard is a great achievement and a milestone that few EICs reach. The high quality of the journal and its international reputation are an important part of John’s legacy.

I was delighted when, in recognition of his long-service as Editor, John was made a Fellow *Honoris Causa* by the Society in 2024—John, in contrast, wasn’t quite sure what all the fuss was about! In 2023, an interview with John was published in *The Linnean* [Vol. 39(1): 25–26] in which he discussed highlights of his time in the role.

The condolences of the Society and his fellow editors go to Eleanor and the family.

by Mike F. Fay
Royal Botanic Gardens, Kew

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Biological Journal of the Linnean Society (2025, 145, blaf033)

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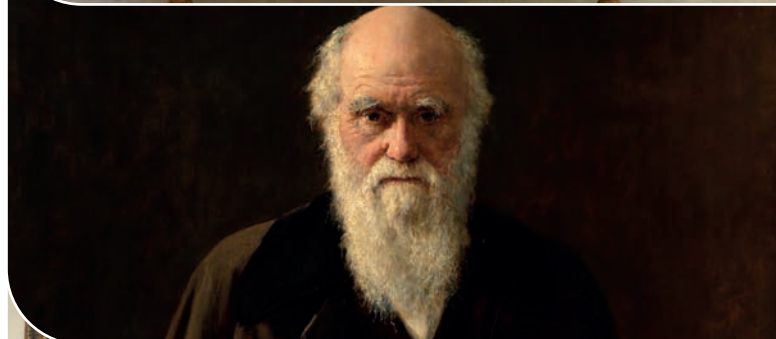
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