The Glasgow Naturalist

Journal of the Glasgow Natural History Society

Volume 28 Part 4

Glasgow Natural History Society

(formerly The Andersonian Naturalists of Glasgow)

www.gnhs.org.uk

The Glasgow Natural History Society (GNHS) is a registered charity (SC012586) with about 250 members living in Glasgow, the West of Scotland, throughout the U.K. and overseas. GNHS arranges a full programme of events throughout the year in Glasgow and district and occasionally further afield (www.gnhs.org.uk/meetings.html). These are at both popular and specialist level, designed to bring together the amateur and the professional, the beginner and the expert. GNHS has its own library, provides grants for the study of natural history, and has microscopes and some field equipment that can be used by members. Further details about GNHS can be obtained by contacting the Secretary, The Glasgow Natural History Society, c/o Graham Kerr (Zoology) Building, University of Glasgow, Glasgow G12 8QQ, Scotland (E-mail: info@gnhs.org.uk).

The Glasgow Naturalist

The Glasgow Naturalist is published by the Glasgow Natural History Society ISSN 0373-241X. It was first issued in 1909 and is a peer-reviewed journal that publishes original studies in botany, zoology and geology, with a particular focus on studies from the West of Scotland. Full details of the journal can be found at www.gnhs.org.uk/gnat.html

A digital version of *The Glasgow Naturalist* from 1909 to the present is available at the Biodiversity Heritage Library at www.biodiversitylibrary.org/bibliography/38981#/summary
Hard copy back issues of the journal may be purchased by contacting GNHS.

Information for contributors is given on the back inside cover of this edition and at www.gnhs.org.uk/documents/gn_advice2021.pdf. For questions or advice about submissions please contact the Editor Mr Mike G. Rutherford (E-mail: Editor@gnhs.org.uk) c/o Graham Kerr Building, University of Glasgow, Glasgow, G12 8QQ

Publications of the Glasgow Natural History Society

GNHS has published a number of books on the flora and fauna of Scotland. Details can be found at www.gnhs.org.uk/publications.html

Front cover Toad (*Bufo bufo*), near Cardhu Distillery, Moray, Scotland, Spring 2025. (Photo: Scott Shanks)

Back cover Jellyfish **(***Cyanea capillata*) stranded at Kames Bay, Isle of Cumbrae, Scotland, 30th August 2025. (Photo: Penny Healy)

The Glasgow Naturalist
Volume 28 Part 4

Edited by: Iain C. Wilkie & Ruth Maclachlan

Contents

EDITORIAL
Things to come. I.C. Wilkie 1

FULL PAPERS
Insects and other invertebrates in Glasgow Botanic Gardens, Scotland: 2025 update. R.B. Weddle 5
The wild vascular plants of Glasgow Botanic Gardens. M. Philip 11
An initial snapshot of the dipteran superfamily Chironomoidea at Holy Loch Nature Reserve, Argyll, Scotland, as revealed by automated DNA barcoding. N. Hammatt & Wellcome Sanger Institute BIOSCAN Collective 20

SHORT NOTES
Notes on the shieldbugs and allied species (Hemiptera: Coreoidea, Pentatomoidea and Pyrrhocoroidea) found in the Clyde area, Scotland. R.B. Weddle 32
A fish trap at Millport, Great Cumbrae, Scotland. J. Parnell 38
Going wild on woodchips: the alien wrinkled fieldcap mushroom *Agrocybe rivulosa* in Glasgow, Scotland. M. O'Reilly 41
Natural regeneration of the seagrass *Zostera noltii* in the Holy Loch, Argyll, Scotland. P. Rawlins & N. Hammatt 45
Mass stranding of the scyphozoan jellyfish *Cyanea capillata* at Kames Bay, Isle of Cumbrae, Scotland. P.G. Moore 47

BOOK REVIEWS 50

PhotoSCENE 2025-26 58

BLB GRANT AWARDS 63

PROCEEDINGS 2025 64

The Glasgow Naturalist (2026) Volume 28, Part 4, 1-3

EDITORIAL

Things to come

I.C. Wilkie

School of Biodiversity, One Health and Veterinary Medicine, University of Glasgow, Glasgow G12 8QQ

E-mail: iain.wilkie@glasgow.ac.uk

This, the fourth and final issue of Volume 28 of *The Glasgow Naturalist*, comprises eight articles and so, like the previous issue (nine articles), is a rather slim affair. Although the number of manuscripts submitted for inclusion in this issue – ten – was the same as for last year's, one was rejected after peer review and the revised version of another, which was anticipated following a supportive review, was not provided due to the author's personal circumstances. In general, this confirms that, since 2019, there has been a sustained decline in the annual submission rate of routine (i.e. not supplement-related) manuscripts. Because the reasons for such an obviously concerning trend are unclear, it is difficult to suggest a course of action to reverse it. A tentative suggestion for at least mitigating it, as well as permanently buffering the journal against "lean times", is that some of the material currently published in the *GNHS Newsletter* could in future be diverted to the journal. I am thinking of, as an example, excursion reports, which often contain important information (see e.g. Moss, 2024; Gray, 2025) that might have a better chance of reaching the wider scientific community if safeguarded in a regular section of the journal. Such reports would not need to be peer-reviewed. Another relevant factor is that the journal is very dependent on contributions from GNHS members: over the past eight years members have authored or co-authored on average 67% of the articles in each issue, the range being 52% to 80%. I see no trend in this figure, though interpretation is complicated by the inclusion of supplement sections in most issues. It is alarming, however, that without members' submissions there would have been no issue this year or last year. I hope that this both encourages members to continue contributing to the journal and demonstrates the need to attract more authors from further afield.

Publicising the journal and its contents is a potential strategy for stimulating wider interest. As it happens, during the first three months of 2026 the journal received unprecedented exposure in the print media: an article from the previous issue (Weddle, 2025) featured on the front page of *The Herald* and in *The National* (Hilley, 2026; Williams, 2026), and one from the present issue (Rawlins & Hammatt, 2026) was the subject of pieces in *The Dunoon Observer*, *The Scotsman* and *Scottish Field* (Anonymous, 2026; Hay, 2026; Forbes, 2026). The journal was named in all of these, and so it will be interesting to see if there is any evidence of an upturn in either the article submission rate for the 2027 issue or the number of online viewings of published articles on the journal website (as reported monthly to the Editor by *Crossref* – the organisation with which each article's DOI (Digital Object Identifier) is registered).

All the articles in this issue relate to localities in either the Clyde Sea Area or Glasgow and the Clyde catchment, a tighter geographical scope than usual but one that accords with the journal's explicit remit of focusing "on studies from the West of Scotland". Two of the papers concern the biodiversity of Glasgow Botanic Gardens (GBG). I am particularly pleased to see the account of the GBG vascular plants published at last (Philip, 2026). This is the final contribution in the series *On the Wildside Revisited: 200 Years of Wildlife in the Glasgow Botanic Gardens*, Parts 1, 2 and 3 of which were included in the 2019, 2021 and 2022 issues respectively. Its publication was delayed by a combination of factors not the least of which was the COVID-19 pandemic. It and the other GBG paper (Weddle, 2026) are typical products of the traditional approach to natural history in which the compilation of a species list depends on identifications based primarily on morphology, with habitat, geographical location and (in the case of animals) behaviour perhaps also being taken into account. By way of contrast, the species lists in the novel paper on the midge fauna of the Holy Loch Nature Reserve (Hammatt, 2026) were generated only by DNA barcoding, which may be a sign of things to come in natural history.

DNA barcoding is an example of a microgenomic identification process, i.e. it involves the sequencing of a small segment of an organism's genome and then searching for matches between this and sequences in a reference library derived from morphologically identified specimens. The standard barcode for animals is a fragment of the mitochondrial cytochrome *c* oxidase I (COI) gene, partly because this gene evolves rapidly enough to allow closely related species to be distinguished (Hebert *et al.*, 2003). This methodology has been increasingly exploited over the past 25 years and has been assisted by the development of the Barcode of Life Data System (BOLD), which is a continuously expanding public database of COI sequences (Ratnasingham & Hebert, 2007). As far as professional taxonomists are concerned, its main advantage is that, with the advent of high-throughput, low-cost sequencing technology, large numbers of specimens can be processed and ascribed identifications quickly. It may seem to be of remote relevance to amateur naturalists. However, palm-sized sequencers that can be used in the laboratory or in the field are already available (Seah *et al.*, 2020; Oxford Nanopore Technologies, 2026). With continuing progress in electronic miniaturisation and computerised information storage, it may not be long before we see hand-held identification devices realising "the promise of a schoolchild with a barcoder in hand learning to read wild biodiversity" (Consortium for the Barcode of Life, 2004; Hebert & Gregory, 2005). More realistically, such technology could make life a lot easier for committed naturalists dealing with groups that are taxonomically "difficult", for example due to the prevalence of morphologically indistinguishable cryptic species (an unfolding nightmare for amateur lichenologists).

The vision of the barcoding schoolchild illustrates another advantage claimed for barcoding methodology: that it will "democratise access", which means, in this context, enabling many more people, i.e. non-specialists, to discover the scientific names of the organisms they encounter (Consortium for the Barcode of Life, 2004; Srivathsan *et al.*, 2021). It will thus be a high-tech addition to the growing range of resources already serving this aim, most notably the wide choice of smartphone apps now available for identifying many groups of animals, plants and fungi (Truong & Van der Wal, 2024). This is a commendable aim and a good thing if it inspires deeper enquiry into natural history, although such resources by themselves do not turn their users into experts. They are potentially useful tools, but all have their limitations and pitfalls for the inexperienced (Cheng *et al.*, 2023; Sussex Wildlife Trust, 2023; Jones & Jones, 2025). They are not a substitute for the specialist expertise that is the keystone of natural history - knowledge acquired through years of studying and becoming acquainted intimately with a particular group of organisms. There is no shortcut to expertise.

This is my last year as Editor of the journal. I am very pleased that Mike Rutherford, Curator of Zoology and Anatomy at the Hunterian Museum, will be my successor. Mike has extensive experience of both authoring scientific articles and journal editing. I wish him every success during his tenure. For me, it has been a privilege to be able to contribute to the Society as journal Editor over the past eight years. As I have stated repeatedly, editing the journal is a team effort and for that reason I would like to express my gratitude to: Chris McInerny for his input as Assistant Editor from 2018 to 2024; Ruth Maclachlan for administrative support (which encompasses several important tasks), formatting the articles, assembling each print issue and, latterly, taking on the job of Assistant Editor; Richard Weddle for making articles available online and looking after the website; and Tony Payne for pre-editing book reviews. I also thank the book reviewers and, needless to say, all the authors who have chosen to submit their articles to the journal. Finally, I must acknowledge the contribution of the external reviewers who have provided critical evaluations of submitted manuscripts, which is indispensable for ensuring that the journal maintains the highest scientific standards. The external reviewers for this issue were (in alphabetical order): A. Acton, C.M. Bertelli, T. Ekrem, E.G. Hancock, D. Lang, V.A. Lemâitre, P.G. Moore, M. O'Reilly, N. Simpson, G. Smart, E. Stur, K.J. Watson, M.D. Webb and one other who preferred to remain anonymous.

REFERENCES

Anonymous (2026). Seagrass makes remarkable return to Holy Loch. *The Dunoon Observer* 9th January 2026.

Cheng, Z., Li, Q., Deng, J., Liu, Q. & Huang, X. (2023). The devil is in the details: problems in DNA barcoding practices indicated by systematic evaluation of insect barcodes. *Frontiers in Ecology and Evolution* 11, 1149839.

Consortium for the Barcode of Life (2004). Barcoding life: ten reasons. https://phe.rockefeller.edu/docs/TenReasonsBarcoding-1.pdf Accessed 3rd April 2026.

Forbes, E. (2026). Seagrass defies the odds by making spectacular comeback at Holy Loch. *Scottish Field* 6th January 2026.

Gray, R. (2025). Richmond Park East - 17th July, 2025. *GNHS Newsletter* November 2025, 7-11.

Hammatt, N. (2026). An initial snapshot of the dipteran superfamily Chironomoidea at Holy Loch Nature Reserve, Argyll, Scotland, as revealed by automated DNA barcoding. *The Glasgow Naturalist* 28(4), 20-31. https://doi.org/10.37208/tgn28408

Hay, K. (2026). 'Lungs of the sea' defies odds by making comeback at former US nuclear submarine base. *The Scotsman* 8th January 2026.

Hebert, P.D., Cywinska, A., Ball, S.L. & deWaard, J.R. (2003). Biological identifications through DNA barcodes. *Proceedings of the Royal Society B Biological Sciences* 270, 313-21. https://doi.org/10.1098/rspb.2002.2218

Hebert, P.D. & Gregory, T.R. (2005). The promise of DNA barcoding for taxonomy. *Systematic Biology* 54, 852–859. https://doi.org/10.1080/10635150500354886

Hilley, S. (2026). Rare ladybird and new bee species discovered in Maryhill. *The National* 4th March 2026.

Jones, H.G. & Jones, A.J. (2025). Application and pitfalls of the use of plant ID apps for urban flora and citizen science studies. *Plant Ecology and Diversity* 18, 287–295. https://doi.org/10.1080/17550874.2025.2476938

Moss, A. (2024). Auchlochan Estate, Lesmahagow – 13th July, 2024. *GNHS Newsletter* November 2024,

6-9.
Oxford Nanopore Technologies (2026). MinION™ Mk1D. https://nanoporetech.com/products/sequence/minion?utm Accessed 3rd April 2026.
Philip, M. (2026). The wild vascular plants of Glasgow Botanic Gardens, Scotland. *The Glasgow Naturalist* 28(4), 11-19. https://doi.org/10.37208/tgn28407
Ratnasingham, S. & Hebert, P.D.N. (2007). BOLD: The Barcode of Life Data System. *Molecular Ecology Notes* 7, 355–364. https://doi.org/10.1111/j.1471-8286.2007.01678.x
Rawlins, P. & Hammatt, N. (2026). Natural regeneration of the seagrass *Zostera noltii* in the Holy Loch, Argyll, Scotland. *The Glasgow Naturalist* 28(4), 45-47. https://doi.org/10.37208/tgn28402
Seah, A., Lim, M.C.W., McAloose, D., Prost, S. & Seimon, T.A. (2020). MinION-based DNA barcoding of preserved and non-invasively collected wildlife samples. *Genes* 11, 445. https://doi.org/10.3390/genes11040445
Srivathsan, A., Lee, L., Katoh, K., Hartop, E., Kutty, S.N., Wong, H. *et al.* (2021). ONTbarcoder and MinION barcodes aid biodiversity discovery and identification by everyone, for everyone. *BMC Biology* 19, 217. https://doi.org/10.1186/s12915-021-01141-x
Sussex Wildlife Trust (2023). The good, the bad and the middling - ID apps. https://sussexwildlifetrust.org.uk/news/the-good-the-bad-and-the-middling-id-apps Accessed 5th April 2026.
Truong, M.X.A. & Van der Wal, R. (2024). Exploring the landscape of automated species identification apps: development, promise, and user appraisal. *BioScience* 74, 601–613. https://doi.org/10.1093/biosci/biae077
Weddle, R.W. (2025). A first occurrence of Adonis' ladybird *Hippodamia variegata* (Coleoptera: Coccinellidae) in Glasgow, Scotland. *The Glasgow Naturalist* 28(3), 55. https://doi.org/10.37208/tgn28307
Weddle, R.W. (2026). Insects and other invertebrates in Glasgow Botanic Gardens, Scotland: 2025 update. *The Glasgow Naturalist* 28(4), 5-10. https://doi.org/10.37208/tgn28405
Williams, C. (2026). Rarely-spotted ladybird and new bee type make first appearance in city. *The Herald* 5th March 2026.

The Glasgow Naturalist (2026) Volume 28, Part 4, 5-10 https://doi.org/10.37208/tgn28405

FULL PAPERS

Insects and other invertebrates in Glasgow Botanic Gardens, Scotland: 2025 update

R.B. Weddle

89 Novar Drive, Glasgow G12 9SS

E-mail: richard@canto.plus.com

ABSTRACT

This paper is the latest in a series providing accounts of the status of the animals, plants and other organisms living wild in Glasgow Botanic Gardens, Scotland. It lists new species of invertebrates that have been found in the gardens over the past five years, together with earlier records that have come to light over the same period. The majority of these additions are insects, though also included are some records of spiders, mites, ticks and harvestmen (Arachnida), woodlice (Isopoda), millipedes (Diplopoda) and snails (Gastropoda).

INTRODUCTION

The first account of the invertebrates of Glasgow Botanic Gardens, Scotland (GBG) was provided by Hancock (1999). This was subsequently updated in a series of papers by Weddle (2019a,b; 2021a-d), Cathrine (2022) and Cathrine *et al.* (2022). In the last five years, around 240 additional species of invertebrates have been recorded in GBG and these are the subject of the present contribution. Most (167) of these new records are from the moth trap that is run in GBG as regularly as possible during the warmer months. The total includes some older records that came to light among records added retrospectively to online recording systems such as iRecord and iNaturalist. Any such records with a restricted licence have been excluded, as it would have been impracticable to acknowledge all the observers. However, this restriction has little effect on the list as a whole. Other records are the author's own field records.

Species that have been the topic of earlier short notes by the author in this journal are also included. Those found in the moth trap are marked with an asterisk in the list below. The common names of micro-moths are those given in Sterling (2023). Although this account is only an update, the full list of species found in GBG, including the Kelvin Walkway and wooded slopes to the north, can be found at www.gnhs.org.uk/biodiversity/GBG_splist.pdf, which shows the years when each species was first and last recorded. This list is updated regularly.

INSECTA

Ephemeroptera (mayflies)

Baetidae: **Procloeon bifidum* (pale evening dun), 05/12/2025, first Glasgow record; **P. pennulatum* (tiny sulphur dun), 18/08/2025, first Glasgow record.

Ephemeridae: **Ephemera danica* (green drake), 22/06/2023.

Heptageniidae: **Ecdyonurus dispar* (autumn dun), 23/07/2021, first Glasgow record; **Electrogena lateralis* (dark dun), 22/06/2023.

Plecoptera (stoneflies)

Nemouridae: **Nemoura cinerea*, 20/06/2025.

Perlodidae: **Isoperla grammatica* (common yellow sally), 20/06/2025.

Psocoptera (bark-lice)

Caeciliusidae: *Epicaecilius pilipennis*, 20/09/1998, first Glasgow record, though found shortly afterwards at Garscadden Wood; **Valenzuela flavidus*, 23/10/2024, third Glasgow record in 2024, the first two being joint first in "Clyde" since those at Cadder Wilderness (East Dunbartonshire) and other locations listed by King (1910).

Ectopsocidae: **Ectopsocus axillaris*, 15/10/2023; **E. briggsi/petersi/meridionalis* agg., 23/10/2024.

Elipsocidae: **Elipsocus hyalinus*, 06/05/2025, second Glasgow record, though also listed at Cadder Wilderness (East Dunbartonshire) by King (1910); **Reuterella helvimacula*, 13/08/2024.

Mesopsocidae: **Mesopsocus unipunctatus* s.l., 20/06/2025, first Glasgow record.

Stenopsocidae: **Graphopsocus cruciatus*, 19/05/2024, first Glasgow record.

Hemiptera (true-bugs)

Acanthosomatidae: *Elasmucha grisea* (parent bug), 22/09/2018, one of the commoner shieldbugs, present in this area since at least the 19th century (Weddle, 2026), so surprising that it had not been recorded in GBG earlier.

Lygaeidae: *Kleidocerys resedae* (birch catkin bug), 26/04/2023.

Miridae: **Blepharidopterus angulatus* (black-kneed apple capsid), 25/09/2023; **Camptozygum aequale*, 20/06/2025, first record for Clyde, though probably under-recorded; **Deraeocoris flavilinea*, 28/07/2024; *Heterocordylus tibialis*, 01/06/2021; **Phylus melanocephalus*, 28/07/2024, first Glasgow record;

**Phytocoris dimidiatus*, 25/09/2023, first Glasgow record; **Plagiognathus arbustorum*, 27/08/2021; **Psallus* sp., 25/09/2023; **Stenotus binotatus* (timothy grassbug), 09/07/2021.
Corixidae: **Corixa affinis*, 09/07/2025, first Glasgow record.
Aphididae: *Tetraneura ulmi* (fig gall), 06/06/2023, first Glasgow record; **Drepanosiphum platanoidis*, 10/10/2025, first Glasgow record.
Cicadellidae: *Aphrodes bicincta*, 23/09/2000, first Glasgow record; **Edwardsiana alnicola*, 12/08/2020, first Glasgow record, see Weddle (2021b); **Eupteryx decemnotata*, 05/06/2025, first record for south-west Scotland; **Eurhadina concinna*, 28/07/2024, first Glasgow record.
Pseudococcidae: *Pseudococcus calceolariae*, 29/08/2011, first record for south-west Scotland.

Neuroptera (lacewings and waxflies)
Chrysopidae (green lacewings): **Chrysoperla carnea* s.s., 31/03/2025; **Cunctochrysa albolineata*, 31/08/2022. Previously these had been recorded as "Chrysopidae sp.".
Coniopterygidae (waxflies): **Conwentzia* sp., 12/05/2025.
Hemerobiidae (brown lacewings): **Hemerobius humulinus*, 18/08/2025; **H. stigma*, 10/03/2024, first Glasgow record (see Weddle, 2025); **Wesmaelius nervosus*, 23/10/2024.

Trichoptera (caddis-flies)
As mentioned in Weddle (2021a), the caddis-flies often outnumber the moths in summer. The notes on Scottish status are from Wallace (2016).
Brachycentridae: **Brachycentrus subnubilus*, 31/05/2021.
Glossosomatidae: **Agapetus delicatulus*, 07/09/2021; **Glossosoma conformis*, 21/09/2024.
Hydropsychidae: **Hydropsyche contubernalis*, 20/09/2022, scarce in Scotland; **H. instabilis*, 08/03/2023.
Hydroptilidae: **Hydroptila vectis*, 19/06/2024; **H. tineoides*, 23/07/2025, first Glasgow record.
Leptoceridae: **Athripsodes cinereus*, 07/12/2023; **Ceraclea dissimilis*, 23/07/2021; **Leptocerus tineiformis*, 08/03/2023, absent from Scotland until recent years, regionally notable; **Mystacides azurea*, 07/09/2021; **Oecetis ochracea*, 28/07/2024; **O. testacea*, 09/07/2025, first modern Glasgow record.
Limnephilidae: **Halesus digitatus*, 15/10/2023; **Limnephilus binotatus*, 16/05/2024, nationally scarce, though of "least concern" on IUCN (International Union for Conservation of Nature) list; **L. hirsutus,* 23/07/2021, nationally scarce, though of "least concern" on IUCN list.
Phryganeidae: **Agrypnia pagetana*, 23/07/2021, locally common in southern Scotland.
Polycentropodidae: **Cyrnus trimaculatus*, 08/03/2023.
Psychomyiidae: **Tinodes waeneri*, 25/09/2023.
Sericostomatidae: **Sericostoma personatum*, 07/09/2021.

Coleoptera (beetles)
Cantharidae (soldier beetles): **Cantharis paludosa*, 20/06/2025, first Glasgow record, though there are a couple of records from the Milngavie area; **C. rufa*, 20/06/2025; **Rhagonycha lignosa*, 21/06/2022; **R. testacea*, 19/05/2022.
Cerambycidae (longhorn beetles): *Clytus arietis* (wasp beetle), 16/08/2015; *Grammoptera ruficornis*, 06/01/2021.
Coccinellidae (ladybirds): *Aphidecta obliterata* (larch ladybird), 26/04/2023; **Harmonia axyridis* (harlequin ladybird), 19/09/2021. It is perhaps surprising that it was 11 years from the first sighting of the harlequin ladybird in Glasgow before it was recorded in GBG. However, there had been only sporadic records in the interim. Though there has been a marked population expansion in the Glasgow area since 2021 (pers. obs.) and it is frequently seen around GBG, it has not yet displaced the other ladybird species, as has happened in some other parts of the U.K.
Curculionidae (weevils): **Otiorhynchus sulcatus* (vine weevil), 05/02/2021; a very common species, it is surprising that it had not been found in GBG previously.
Dermestidae: **Dermestes peruvianus* (Peruvian larder beetle), 23/07/2021; well known in Glasgow tenements.

Elateridae (click beetles): *Agriotes pallidulus*, 05/12/2023; **Athous bicolor*, 21/06/2022; *A. haemorrhoidalis*, 03/02/2020.
Kateretidae: **Brachypterus glaber*, 21/05/2025; a tiny pollen beetle typically found on nettles, often with *B. urticae,* though the latter has not yet been recorded in GBG.
Melandryidae: *Orchesia undulata*, 05/12/2023.
Nitidulidae: **Epuraea* sp., 07/09/2025.
Oedemeridae: *Oedemera lurida*, 14/07/2024. This species was first recorded in Glasgow by the_author in Ruchill Park in 2022, and now seems to be almost as common as *O. virescens,* which was first recorded in Glasgow in 2011 and was considered remarkable at the time as it was regarded as rare in the U.K., though it had by then become locally common in south-west Scotland (Philp, 2021). Both species are described as local in south-west Scotland (Duff, 2020).
Ptinidae: **Dryophilus pusillus*, 16/05/2024, first Glasgow record.
Scraptiidae: **Anaspis maculata*, 06/01/2021.
Staphylinidae (rove beetles): **Anotylus rugosus*, 20/06/2025; **Bisnius fimetarius*, 31/05/2021; **Bledius opacus*, 26/06/2025, first Glasgow record; **Carpelimus similis*, 26/06/2025, first Glasgow record; **Pseudomedon obscurellus*, 26/06/2025, first Glasgow record.

Lepidoptera (butterflies and moths)
Butterflies
Lycaenidae: *Favonius quercus* (purple hairstreak), 13/08/2022; probably locally common in Glasgow, though under-recorded due to its preference for frequenting the tops of oak trees. *Celastrina argiolus* (holly blue) has been recorded in the adjoining Kirklee allotments in July 2024, but not yet in GBG.
Nymphalidae: *Pararge aegeria* (speckled wood),

10/02/2024; first seen in the city in 2019, one of the most recent butterflies to have spread into the Glasgow area.

Moths

Glasgow Museums Biological Records Centre possesses a list of moths recorded "in Glasgow" in the last two decades of the 20th century. Some of these will have been from GBG, and others may be only from other vice-counties, as the city boundary straddles four vice-counties. This means that some of the "new" species listed below, while undoubtedly additions to the species list for GBG, may not actually be the first records, pending the outcome of ongoing research. Unless otherwise specified, the species were recorded as adults.

Bucculatricidae: **Bucculatrix thoracella* (lime tuft), 21/05/2025.

Cosmopterigidae: **Limnaecia phragmitella* (bulrush down moth), 07/09/2025.

Crambidae: **Anania coronata* (spotted magpie), 07/09/2021; **A. crocealis* (ochreous pearl), 23/07/2025, first VC77 and Glasgow record. **Catoptria falsella* (chequered grass-moth), 07/12/2022, first Glasgow record; **Evergestis pallidata* (chequered pearl), 28/07/2024.

Drepanidae: **Thyatira batis* (peach blossom), 07/09/2025.

Gelechiidae: **Bryotropha domestica* (house moss-moth), 28/07/2024; **Carpatolechia fugitivella* (elm grey), 14/07/2024.

Geometridae: **Chloroclystis v-ata* (v-pug), 07/12/2022; **Colotois pennaria* (feathered thorn) 09/09/2023; **Cyclophora linearia* (clay triple-lines), 19/06/2024, first Glasgow and VC77 record; **Eupithecia intricata* (Freyer's /Edinburgh pug), 06/05/2023; **E. subfuscata* (grey pug), 07/09/2025; **E. tenuiata* (slender pug), 14/07/2024; **Lobophora halterata* (seraphim), 21/05/2025; **Lomaspilis marginata* (clouded border), 07/09/2021; **Orthonama vittata* (oblique carpet), 18/08/2025; **Pasiphila chloerata* (sloe pug), 07/09/2021, first VC77 record; **Perizoma bifaciata* (barred rivulet), 30/07/2022; **Petrophora chlorosata* (brown silver-line), 19/05/2024.

Gracillariidae: *Cameraria ohridella* (horse-chestnut leaf-miner) leaf-mines, 09/10/2022, first record in VC77 and Glasgow, though it has been present in Scotland for at least ten years; **Phyllonorycter ulmifoliella* (common birch leaf-miner), 23/07/2025.

Lasiocampidae: **Euthrix potatoria* (drinker), 19/06/2024.

Momphidae: **Mompha raschkiella* (fireweed mompha), 18/08/2025.

Noctuidae: **Acronicta alni* (alder moth), 08/09/2022; *A. leporina* (miller), 15/08/2025; *A. psi* (grey dagger), 01/01/2024, larva; the larval form is readily distinguished from *A. tridens* (dark dagger), the lack of larval records of the latter supporting its presumed absence from Scotland (Leverton, 2024); **Agrotis puta* (shuttle-shaped dart), 12/05/2023, a species first found in west central Scotland only in 2019, having apparently spread from the east, though there were also records from the Solway coast; **Anorthoa munda* (twin-spotted quaker), 16/03/2025; **Apamea lithoxylaea* (light arches), 30/07/2022; **Ceramica pisi* (broom moth), 19/06/2024; **Colocasia coryli* (nut-tree tussock), 09/07/2025; *Cucullia chamomillae* (chamomile shark), 15/07/2022; **Lateroligia ophiogramma* (double lobed), 28/07/2024; **Lithophane leautieri* (Blair's shoulder-knot), 10/10/2022; **L. socia* (pale pinion), 21/05/2025; **Lycophotia porphyrea* (true lover's knot), 23/07/2021; **Mythimna ferrago* (clay), 28/07/2024; **Oligia latruncula* (tawny marbled minor), 14/07/2024; **Plusia putnami gracilis* (Lempke's gold spot), 28/07/2024; **Polia nebulosa* (grey arches), 20/06/2025; **Rusina ferruginea* (brown rustic), 21/06/2022; **Sunira circellaris* (brick), 10/10/2022; **Tiliacea citrago* (orange sallow), 31/08/2022.

Nolidae: **Pseudoips prasinana* (green silver-lines), 09/06/2022.

Notodontidae: **Furcula furcula* (sallow kitten), 01/06/2022; **Phalera bucephala* (buff-tip), 22/06/2023.

Parametriotidae: **Blastodacna hellerella* (hawthorn berry moth), 09/07/2025.

Praydidae: **Prays ruficeps* (cryptic ash bud moth), 18/08/2025, first VC77 record, though the second for Glasgow as there is a 2017 record from Cathcart (VC76).

Pterophoridae: **Platyptilia gonodactyla* (triangle plume), 31/05/2021.

Pyralidae: **Acrobasis advenella* (grey knot-horn), 12/07/2023.

Sphingidae: **Deilephila elpenor* (elephant hawk-moth), 09/06/2022; *Macroglossum stellatarum* (humming-bird hawk-moth), 01/08/2022. It seems only a matter of time before *Mimas tiliae* (lime hawk-moth) is recorded in GBG, as it has been present in the vicinity for several years (Weddle, 2023), and has since been spreading more widely.

Tortricidae: **Acleris bergmanniana* (yellow rose tortrix), 09/07/2021; **A. laterana* (dark-marked tortrix), 27/08/2025; **Clepsis consimilana* (rufous tortrix), 28/07/2024; **Cochylichroa atricapitana* (black-fronted straw), 18/08/2025; **Cydia fagiglandana* (beech mast piercer), 28/07/2024, first VC77 and Glasgow record, there being few other Scottish records; **Epinotia ramella* (black-marked tortrix), 31/08/2022; **E. tedella* (common spruce tortrix), 21/06/2022; **E. tenerana* (nut bud moth), 09/07/2025; **Eucosma campoliliana* (pied tortrix), 12/07/2022; **E. cana* (hoary tortrix), 22/06/2023; **Gypsonoma dealbana* (common cloaked tortrix), 09/07/2025; **Notocelia trimaculana* (hawthorn shoot moth), 22/06/2023; **N. uddmanniana* (bramble shoot moth), 14/07/2024.

Yponomeutidae: **Paraswammerdamia* sp., 14/07/2024.

Ypsolophidae: **Ypsolopha parenthesella* (white-shouldered ochre), 21/09/2024.

Diptera (true flies)

In this group few "first record" comments have been added as, with the exception of hoverflies, soldierflies and craneflies, this group is generally under-recorded in the Clyde area. In addition, many may well be the first modern records since Robert Henderson's surveys one hundred or more years ago (Henderson, 1899-1927).

Athericidae: *Atherix ibis* (yellow-legged water-snipefly), 28/05/2023.

Cecidomyiidae: *Dasineura urticae*, 19/06/2022; *Hartigiola annulipes*, 28/10/2024.
Ceratopogonidae: **Culicoides pulicaris*, 23/04/2021.
Chaoboridae: **Chaoborus flavicans*, 23/07/2025.
Chironomidae: **Psectrotanypus varius*, 13/08/2024; there are often large numbers of Chironomidae in the moth trap, and this is one of the few species that are readily identifiable.
Conopidae: *Conops quadrifasciatus* (four-banded bee-grabber), 05/08/2019; *Sicus ferrugineus* (ferruginous bee-grabber), 30/07/2022. Both these species pounce on bumblebee workers and inject an egg into the abdomen.
Culicidae: **Culiseta annulata* (banded mosquito), 16/10/2020.
Empididae: **Empis grisea*, 12/05/2025; **E. trigramma*, 16/05/2024; **Rhamphomyia pilifer*, 13/05/2021.
Fanniidae: **Fannia serena*, 18/08/2025.
Heleomyzidae: **Heteromyza rotundicornis*, 30/07/2022.
Lauxaniidae: **Pseudolyciella* sp., 23/10/2024; **Minettia inusta*, 10/10/2025.
Limoniidae: **Antocha vitripennis*, 27/08/2021; **Cheilotrichia cinerascens*, 23/04/2021; **Erioptera lutea*, 27/08/2021; **Orimarga virgo*, 09/07/2021, nationally rare, first Glasgow record; as the larvae are associated with seepages on steep slopes, particularly limestone, this specimen may be associated with the nearby exposures of the "limestone coal formation" in the Kelvin gorge (Whitbread, 2013).
Micropezidae: *Neria cibaria*, 24/05/2025.
Muscidae: *Phaonia subventa*, 23/03/2023.
Mycetophilidae: **Mycetophilidae* sp., 23/10/2024.
Pallopteridae: **Palloptera scutellata*, 03/10/2024.
Psychodidae: **Psychoda* sp., (moth flies) 23/04/2021; **Telmatoscopus* sp., 23/04/2021
Scathophagidae: **Scathophaga stercoraria* (yellow dung-fly), 19/05/2024.
Simuliidae: **Simulium ornatum* complex, 23/04/2021.
Stratiomyidae (soldierflies): **Beris fuscipes* (short-horned black legionnaire), 20/06/2025; *Chloromyia formosa*, broad centurion, 30/06/2024; *Chorisops nagatomii* (bright four-spined legionnaire), 13/08/2023; first Glasgow record of a recent arrival in south-west Scotland (Weddle, 2024).
Syrphidae (hoverflies): *Dasysyrphus albostriatus* (stripe-backed fleckwing), 11/09/2018; *Eristalis arbustorum* (plain-faced dronefly), 05/08/2019; *E. horticola* (stripe-winged dronefly), 05/08/2019; *Eupeodes latifasciatus* (meadow field syrph), 23/08/2018; *Meliscaeva cinctella* (banded meliscaeva), 11/09/2018; *Scaeva pyrastri* (pied hoverfly), 05/08/2019; *Sericomyia silentis* (yellow-barred peat hoverfly), 11/09/2018; *Sphaerophoria* sp., 05/08/2019; *Syritta pipiens* (thick-legged hoverfly), 05/08/2019; *Xylota sylvarum* (golden-tailed leafwalker), 08/06/2025.
Tachinidae: *Gymnocheta viridis*, 19/04/2020; **Phasia hemiptera*, 05/08/2019; *Tachina ursina*, 19/04/2020.
Tephritidae: *Anomoia purmunda*, 05/08/2019; *Chaetostomella cylindrica*, 30/07/2022; *Tephritis vespertina*, 30/07/2022.
Tipulidae (craneflies): **Nephrotoma quadrifaria*, 22/06/2023.

Hymenoptera (bees, wasps, ants, ichneumons and sawflies)

Bees
Andrenidae: *Andrena clarkella* (Clarke's mining bee), 24/02/2019, one of the more commonly recorded mining bees in Glasgow; *A. denticulata* (grey-banded mining bee), 08/05/2019, only the second Glasgow record, though probably under-recorded; *A. haemorrhoa* (orange-tailed mining bee), 29/05/2019, another of the more commonly recorded mining bees in Glasgow.
Apidae: *Anthophora furcata* (fork-tailed flower bee), 27/06/2019, at the time, only the third record in Glasgow; *A. plumipes* (hairy-footed flower bee), 29/02/2024, the first Glasgow record, there being a further 11 sightings in Glasgow the same year, two of them in GBG; *Bombus bohemicus* (gypsy cuckoo bee), 10/05/2024; *B. sylvestris* (forest cuckoo bee), 29/05/2019; *Nomada marshamella* (Marsham's nomad bee), 29/05/2019.
Halictidae: *Lasioglossum albipes* (bloomed furrow bee), 08/05/2019; *L. leucopus* (white-footed furrow bee), 08/05/2019; *L. smeathmanellum* (Smeathman's furrow bee), 27/04/2025.
Megachilidae: *Megachile centuncularis* (patchwork leafcutter bee), 29/05/2019; *M. willughbiella* (Willughby's leafcutter bee), 08/05/2019.

Wasps
Cynipidae: *Andricus kollari* (marble gall), galls, 08/10/2025.

Ants
Formicidae: *Linepithema iniquum*, 14/04/2010; *Plagiolepis alluaudi*, 10/01/2023. Both are non-native species found in the glasshouses.

Ichneumons
Braconidae: **Braconidae* sp., 18/08/2025.
Ichneumonidae: **Netelia inedita*, 10/03/2024; **Ophion slaviceki*, 14/07/2024.
Ichneumons are not uncommon in the moth-trap in summer and autumn, *N. inedita* and *O. slaviceki* being among the larger species found.

Sawflies
Tenthredinidae: *Euura proxima*, willow bean-galler, 06/05/2023; it is surprising that this very common gall had not been noted before.

ARACHNIDA
Acari (mites and ticks)
Eriophyidae: *Acalitus brevitarsus*, 29/05/2023, galls; *Aceria macrorhyncha*, galls, 28/04/2024; *A. pseudoplatani,* galls, 06/11/2022.
Cepheidae: *Unidentified sp. (thought to be *Cepheus dentatus*), 23/04/2021.
Ixodidae: *Ixodes ricinus* (castor bean tick), 28/04/2024.
*Unidentified oribatid sp., 23/04/2021.

Araneae (spiders)
Spiders, particularly relatively small species, are frequently found in the moth trap, though they are not

usually kept for identification, mainly because of the need to keep them apart from the collected insects.
Agelenidae: **Eratigena* sp., 16/05/2024; one of the large "house" spiders.
Clubionidae: *Clubiona comta*, 07/04/2023.
Salticidae: *Hasarius adansoni*, 02/10/2019; **Salticus scenicus*, 23/07/2025
Uloboridae: *Uloborus plumipes*, 04/12/2024.

Opiliones (harvestmen)
Phalangiidae: **Nelima gothica*, 07/09/2021. Strangely, *Nemastoma bimaculatum*, a common epigeal harvestman, has yet to be found in GBG.

CRUSTACEA
Isopoda (woodlice)
Armadillidiidae: *Reductoniscus costulatus*, 06/05/2013, in the Palm House, first record for Scotland.
Trichoniscidae: *Haplophthalmus danicus*, 17/04/2013, first recorded in Glasgow at locations including Springburn Park in 1906, and more recently at The Hidden Gardens, Pollokshields.

MYRIAPODA
Chilopoda (centipedes)
Mecistocephalidae: *Tygarrup javanicus*, 17/04/2013, in a glasshouse, first Scottish record.

Diplopoda (millipedes)
Blaniulidae: *Proteroiulus fuscus*, 17/04/2013, in a glasshouse, previously recorded in Glasgow at The Hidden Gardens in 2021.
Julidae: *Cylindroiulus caeruleocinctus*, 28/04/2024, in a glasshouse, first Glasgow record, though there is a 2008 record from Paisley Moss Local Nature Reserve.
Pyrgodesmidae: *Poratia digitata*, 17/04/2013, in a glasshouse, first Scottish record.

MOLLUSCA
Gastropoda (snails and slugs)
Clausiliidae: *Balea sarsii*, 18/03/2023, first Glasgow record, though there are records from Rouken Glen (East Renfrewshire), Mugdock Country Park (Stirlingshire) and other parts of the Clyde area. It is perhaps rather unexpected in Glasgow as it is very sensitive to pollution (A. Sumner, pers. comm.), and so perhaps its presence indicates improving pollution levels.

DISCUSSION

That so many new species have been found in the moth trap is due partly to the arrival of new moth species in the Glasgow area, possibly as a result of climate change. It may also reflect an increased effort to identify them, which has been greatly facilitated in recent years by easier access to identification keys, particularly online, and by recent field guides to the smaller moths (Micro-lepidoptera) such as Sterling (2023) and Langmaid *et al.* (2025).

Other additions to the GBG list will no doubt include smaller species that had been previously overlooked, although the most significant factor may be the availability of online recording systems such as iRecord and iNaturalist and the increasing number of "citizen scientists" who are now using these to record what they see in the field. There have also been several bioblitzes organised by RSPB in the years since the last major update (Weddle, 2021a), though, as mentioned in that paper, there still remains scope for recording and identifying more of the leaf-mines and galls, to which should be added the smaller Hemiptera, and Diptera large and small. The Ichneumonidae are also likely to be under-recorded; though some of the larger species can now potentially be identified using online resources such as dedicated Facebook groups, most of the smaller species are best tackled by rearing them from the larval stages that they parasitise, which would be a very worthwhile project for anyone inclined to tackle it.

The new species from the glasshouses are non-native and have been introduced on exotic plant material.

ACKNOWLEDGEMENTS

Thanks are due to Sharon Flint for identifying all the caddis-fly species, Geoff Hancock for identifying or confirming many of the Diptera and for helpful comments on the text, Richard Lyszkowski for identifying the smaller staphylinid beetles, Nigel Richards for identifying or confirming most of the micro-moths, and Iona Cunningham-Eurich for identifying the ichneumons. I am also grateful to all the observers who contributed records mentioned in this paper and who are too numerous to list individually, and to Andrew Sinclair, Manager at GBG, and his staff for assisting with the moth trap.

REFERENCES

Cathrine, C. (2022). The cockroaches (Dictyoptera) of Glasgow Botanic Gardens with a summary of the known distribution of *Periplaneta americana* (Linnaeus, 1758) and *P. australasiae* (Fabricius, 1775) in Scotland. *The Glasgow Naturalist* 27(4); 68-69. https://doi.org/10.37208/tgn27414
Cathrine, C., Godsman, K., Ahmed, J. & Currie, N. (2022). The arachnids of Glasgow Botanic Gardens. *The Glasgow Naturalist* 27(4), 53-59. https://doi.org/10.37208/tgn27413
Duff, A.G. (2020). *Beetles of Britain and Ireland. Vol 3: Geotrupidae to Scraptiidae*. A.G. Duff (Publishing), West Runton, Norfolk.
Henderson, R. (1899-1927). Field notebooks recording Diptera. Hunterian Museum Archive, RH/1/2 -5.
King, J.J.F.X. (1910). List of the "Clyde" Copeognatha, or Psocidae. *The Glasgow Naturalist* 2, 34-36.
Langmaid, J.R., Palmer, S.M., Young M.R. & Cubitt, M.G. (2025). *A Field Guide to the Smaller Moths of Great Britain and Ireland*. (4th edition-digital). The British Entomological and Natural History Society, Reading.
Leverton, R. & Cubitt, M. (2024). *The Larger Moths of Scotland*. Triphosa Publications.
Philp, B. (2021). False blister beetles of the genus *Oedemera* in Scotland. *The Glasgow Naturalist* 27(4), 3-6. https://doi.org/10.37208/tgn27404

Sterling, P., Parsons, M. & Lewington, R. (2023). *Field Guide to the Micromoths of Great Britain and Ireland*. (2nd edition). Bloomsbury Publishing, Dorset.

Wallace, I.D. (2016). *A Review of the Status of the Caddis Flies (Trichoptera) of Great Britain*. Natural England Commissioned Report NECR191.

Weddle, R.B. (2019a). The moths (Lepidoptera) of Glasgow Botanic Gardens. *The Glasgow Naturalist* 27(1), 53-56. https://doi.org/10.37208/tgn27110

Weddle, R.B. (2019b). The brown lacewing *Hemerobius atrifrons* (Neuroptera: Hemerobiidae) in Glasgow Botanic Gardens, Scotland. *The Glasgow Naturalist* 27(1), 68. https://doi.org/10.37208/tgn27112

Weddle, R.B. (2021a). Further insect and other invertebrate records from Glasgow Botanic Gardens, Scotland. *The Glasgow Naturalist* 27(3), 86-91. https://doi.org/10.37208/tgn27321

Weddle, R.B. (2021b). *Edwardsiana alnicola* (Hemiptera: Cicadellidae): a leaf-hopper new to Scotland, in Glasgow Botanic Gardens. *The Glasgow Naturalist* 27(3), 92. https://doi.org/10.37208/tgn27319

Weddle, R.B. (2021c). The land-hopper *Arcitalitrus dorrieni* (Crustacea: Amphipoda) in Glasgow Botanic Gardens, Scotland. *The Glasgow Naturalist* 27(3), 92-93. https://doi.org/10.37208/tgn27313

Weddle, R.B. (2021d). The molluscs and crustaceans of Glasgow Botanic Gardens, Scotland. *The Glasgow Naturalist* 27(3), 93-95. https://doi.org/10.37208/tgn27317

Weddle, R.B. (2023). Further evidence of breeding populations of lime hawk-moth (*Mimas tiliae*, Lepidoptera: Sphingidae) in Glasgow, Scotland. *The Glasgow Naturalist* 28(2) 23-24. https://doi.org/10.37208/tgn28209

Weddle, R.B. (2024). The four-spined legionnaires *Chorisops* spp. (Diptera: Stratiomyidae) in Glasgow and the west of Scotland. *The Glasgow Naturalist* 28(2), 37-39. https://doi.org/10.37208/tgn29211

Weddle, R.B. (2025). A brown lacewing *Hemerobius stigma* (Neuroptera: Hemerobiidae) in Glasgow Botanic Gardens, Scotland. *The Glasgow Naturalist* 28(3), 57. https://doi.org/10.37208/tgn28306

Weddle, R.B. (2026). The shieldbugs and allied species (Hemiptera: Pentatomoidea, Coreoidea & Pyrrhocoroidea) found in the Clyde area, Scotland. *The Glasgow Naturalist* 28(4), 32-38.

Whitbread, K. & Arkley, S. (2013). *A Geodiversity Audit of the City of Glasgow*. British Geological Survey, Geology and Landscape Scotland Programme, Commercial Report CR/13/022.

The Glasgow Naturalist (2026) Volume 28, Part 4, 11-19 https://doi.org/10.37208/tgn28407

The wild vascular plants of Glasgow Botanic Gardens, Scotland

M. Philip

Willow Cottage, 3 Marlage, Larkhall, Lanarkshire ML9 3DJ

E-mail: botany@opus44.co.uk

ABSTRACT
This paper presents the results of a survey of the wild vascular plants of Glasgow Botanic Gardens, Scotland conducted between 2017 and 2019, and a comparison of these with P. Macpherson's list published in 1998. A total of 308 taxa were recorded in the Gardens in 2017-19. Of these, 181 (58%) were reported in 1998 and 127 (42%) are additions. In the 2017-19 survey, 95 taxa (34% of those listed in 1998) were not refound. Notes are provided on some of the previously unrecorded species and the rate of species turnover in the Gardens is discussed.

INTRODUCTION
In 2017 it was suggested to the author that the article and catalogue of the wild plants of Glasgow Botanic Gardens, Scotland (GBG) compiled in 1998 by my predecessor as BSBI Recorder for VC77, the late Peter Macpherson (PM) (Macpherson, 1998), could be revisited and a comparative study undertaken to ascertain what may have changed over the intervening 20 years. In view of the broader task of gathering data for the Botanical Society of Britain and Ireland (BSBI) Atlas 2020 (BSBI, 2023), I chose to place a fresh study of Glasgow Botanic Gardens in that context and gather data across 2017, 2018 and 2019 rather than confine the effort solely to 2018. It should be remembered that PM's 1998 list was also a compilation of visits carried out from 1994 to 1997 (i.e. a comparable spread of time). As far as practicable, a similar methodology was followed: recording was of all plants considered growing "as wild" at the site where they were found, including natives and aliens that had arrived by natural dispersal or accidental introduction, or had spread from their original planting location in GBG (Macpherson, 1998; Macpherson *et al.*, 1996).

RESULTS
A complete list of plants recorded in 1994-97 and in 2017-19 is provided in Appendix 1. Species names of all plants added to the list in 2019 follow Stace (2019). Changes in PM's 1998 nomenclature are shown in Appendix 2. Also indicated in Appendix 1 is each plant's inferred status in GBG. Following Macpherson (1998), in cases where the status is uncertain, plants have been assigned to what is considered to be the most likely category to avoid including an additional "doubtful" category.

PM's 1998 list of plant species within GBG includes 276 taxa. Taking all 2017-19 records into account, 308 taxa have been recorded. Of these, 181 were noted in 1994-97 (58%) and 127 (42%) are additions. The 2017-19 survey did not refind 95 taxa (34%) listed in 1998. Fig. 1 summarises the changes that occurred between the two surveys.

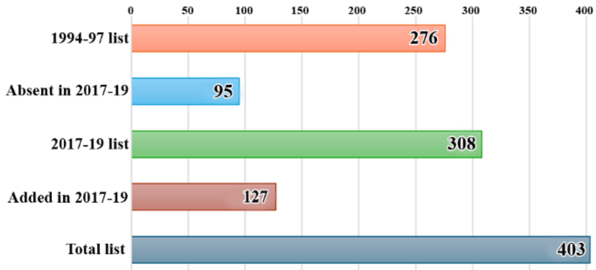


Fig. 1. Comparison of the numbers of vascular plant species recorded in Glasgow Botanic Gardens in 1994-97 and 2017-19.

It will thus be seen that the total number of species recorded growing "as wild" in GBG in 2017-19 is broadly similar to the number recorded in 1994-97. Further, the number of these species unique to their respective date class is also similar (something over one third).

DISCUSSION
The main observation derived following the 2017-19 survey is that much had changed over a 20-year period. Even allowing for outliers, one-off opportunist aliens, and the impossibility of replicating PM's survey exactly both across the ground and across the seasons, it is clear that a significant proportion of the plants recorded in 1994-97 were no longer to be found in GBG in 2017-19 and that their place had been taken by species not noted on the site previously.

Plant species still present in 2017-19
The statistics are, almost inevitably, misleading. For example, PM identified three different daffodil species in 1994-97: the 2017-19 survey made no attempt to repeat that. Other difficult genera such as *Taraxacum* (dandelion), *Salix* (willow), *Sorbus* (whitebeam), and *Rubus* (bramble) were certainly grappled with (with varying degrees of success) but efforts to identify every representative were neither exhaustive nor systematic. The same can be said of some of the grasses and the celebrated examples of *Cotoneaster* species in the "old

railway station" enclosure: it cannot be stated with certainty that all such species from the 1998 list have been accounted for – some of them had probably continued to survive, while others noted as "new" in the later survey may well have been present 20 years before.

The two lists probably overlap more than the above statistics suggest. What is beyond dispute is that many species that were present in GBG in 1994-97 were still to be found in 2017-19. A number of these are plants of semi-natural habitats, usually native, found in the marginal habitats notably by the mostly wooded or alluvial banks of the Kelvin. However, many common urban garden weeds find opportunity at GBG (as in any garden!). The sample list below also includes a wide range of slightly less familiar garden and wayside weeds, a range of grasses and ferns, hedgerow species, and suckering shrubs and trees:

Acer platanoides (Norway maple)
Ajuga reptans (bugle)
Alopecurus geniculatus (marsh foxtail)
Asplenium scolopendrium (hart's-tongue)
Blechnum spicant (hard fern)
Bromopsis ramosa (hairy brome)
Buddleja davidii (butterfly-bush)
Calystegia sepium (hedge bindweed)
Carex sylvatica (wood sedge)
Chrysosplenium oppositifolium (opposite-leaved golden-saxifrage)
Cymbalaria muralis (ivy-leaved toadflax)
Cynosurus cristatus (crested dog's-tail)
Epilobium ciliatum (American willowherb)
Eupatorium cannabinum (hemp-agrimony)
Ficaria verna (lesser celandine)
Geranium pyrenaicum (hedgerow crane's-bill)
Gnaphalium uliginosum (marsh cudweed)
Heracleum mantegazzianum (giant hogweed)
Impatiens glandulifera (Himalayan balsam)
Leucanthemum vulgare (ox-eye daisy)
Luzula campestris (field wood-rush)
Mercurialis perennis (dog's-mercury)
Pilosella aurantiaca ssp. *carpathicola* (fox-and-cubs)
Ribes uva-crispa (gooseberry)
Rubus cockburnianus (white-stemmed bramble)
Scrophularia nodosa (common figwort)
Soleirolla soleirolii (mind-your-own-business)
Spergula arvensis (corn spurrey)
Taxus baccata (yew)
Tellima grandiflora (fringe-cups)
Valeriana officinalis (common valerian)
Veronica officinalis (heath speedwell)

Among the more elusive denizens of GBG are:
Acaena ovalifolia (two-spined acaena)
Collomia linearis (tiny trumpet)
Epipactis helleborine (broad-leaved helleborine – locally known as "the Glasgow orchid")
Hypericum x *desetangsii* (Des Etang's St. John's-wort)
Impatiens parviflora (small balsam)
Lathraea clandestina (purple toothwort)
Linaria amethystea ssp. *multipunctata* (a small spotted toadflax with no common name)
Mycelis muralis (wall lettuce)
Reynoutria x *bohemica* (Bohemian knotweed)
Stachys arvensis (field woundwort) (Fig. 2)
Tanacetum macrophyllum (rayed tansy)

All the species listed above are among those which can be considered well-established on the site: in other words, they would appear to be "here to stay".

Fig. 2. *Stachys arvensis* (field woundwort) in Glasgow Botanic Gardens. (Photo: M. Philip)

Plant species not refound in 2017-19
It is never easy to bid old friends goodbye, but the great wheel of nature turns inexorably and the frantic competition for suitable places inevitably results in losers as well as winners. In our efforts to prioritise conservation, it is always worth bearing in mind the extreme brevity of human life, and the fact that we can too easily consider the "status quo" is that which is merely a random snapshot on a very long time-line. Although we may regret losing species from GBG, their ranks did contain many plants which were escapees, opportunists, thugs and chancers in the first place! Perhaps of some concern to conservationists are the apparent losses of some native species in the list below.

Species not refound in 2017-19 include:
Allium giganteum (giant onion)
Alstroemeria aurea (Peruvian lily)
Apium graveolens (wild celery)
Bellis perennis (cultivar "pom-pom daisy")
Campanula rapunculoides (creeping bellflower)
Chaerophyllum hirsutum (hairy chervil)
Cicerbita macrophylla (blue sow-thistle)
Dactylorhiza maculata (heath spotted-orchid)
Epilobium komarovianum (bronzy willowherb)
Epilobium roseum (pale willowherb)
Erythranthe x *robertsii* (hybrid monkey-flower)
Galium saxatile (heath bedstraw)
Hesperis matronalis (dame's violet)
Lamium maculatum (spotted dead-nettle)
Lathyrus pratensis (meadow vetchling)
Lunaria annua (honesty)
Matricaria chamomilla (scented mayweed)
Papaver somniferum (opium poppy)
Petrosedum rupestre (reflexed stonecrop)
Potentilla erecta (tormentil)

Saxifraga rotundifolia (round-leaved saxifrage)
Sonchus arvensis (perennial sow-thistle)
Stellaria nemorum (wood stitchwort)
Teucrium scorodonia (wood sage)
Tragopogon pratensis ssp. *minor* (goat's-beard)
Veronica agrestis (green field-speedwell)
The author would welcome new reports of any of these species found in GBG.

Previously unrecorded plant species
The most exciting part of carrying out such a survey is finding species that have not been recorded on the site before. In the case of GBG, some were, in all probability, overlooked in the past. There are a dozen or so very common plants that were not recorded in 1998: for instance, it seems unlikely that grasses such as *Agrostis stolonifera* (creeping bent), *Dactylis glomerata* (cock's-foot), *Holcus lanatus* (Yorkshire-fog) and *Lolium perenne* (perennial rye-grass), or herbs such as *Cirsium arvense* (creeping thistle), and *Plantago lanceolata* (ribwort plantain) were not on the 1998 list. Significant finds in the genera *Carex* (sedges), *Equisetum* (horsetails), *Geranium* (crane's-bills) and *Veronica* (speedwells) expanded the 2017-19 list. It is also possible that a number of aquatic plants appeared after 1998 times during reconstruction of the pond around 2004. Below are notes on some species not recorded in the Gardens before 2017-19.

Allium carinatum (keeled garlic) may have been new to GBG, but it is familiar in the Clyde Valley, for example on the riverbanks around Blantyre.

Asarina procumbens (trailing snapdragon) had been around for some time (Fig. 3), although initial rumours that this plant was introduced to GBG in the 1970s have been dismissed by the staff. Coincidentally, this species had also been recorded around the time of the 2017-19 survey on a wall in Larkhall, South Lanarkshire.

Cardamine amara (large bittercress) turned up on the water's edge on the River Kelvin. The dark anthers and large terminal lobe on the leaves make it unmistakable.

Chelidonium majus (greater celandine) appeared as a weed behind one of the buildings.

Cymbalaria hepaticifolia (Corsican toadflax) was established as a shy weed in a shrubbery. It is similar in appearance to the more familiar *Cymbalaria muralis* (ivy-leaved toadflax), but has white flowers.

Four *Equisetum* species were recorded in 2017-19 (there being none in PM's 1998 account). They are *E. arvense* (field horsetail), *E. fluviatile* (water horsetail), *E. palustre* (marsh horsetail), and *E. sylvaticum* (wood horsetail).

Glechoma hederacea (ground-ivy) may have been previously overlooked, but was recorded in both 2017 and 2018.

Hieracium dumosum (yellow-glandular hawkweed) was

Fig. 3. *Asarina procumbens* (trailing snapdragon) thriving on a sheltered brick wall, Glasgow Botanic Gardens. (Photo: M. Philip)

found on top of a wall and a specimen was sent to the referee for identification. Apparently, the GBG staff had been aware of it for many years. The herbarium specimen has been preserved by Glasgow Museums.

Juncus tenuis (slender rush) is frequent in rural Lanarkshire, especially on wet, trampled ground such as waterlogged paths.

Parietaria judaica (pellitory-of-the-wall) appeared as an occasional weed in the margin of the Herb Garden (Fig. 4). A procession of all sorts of annual weeds has probably been going on here largely unnoticed, except by the occasional field botanist.

Polystichum aculeatum (hard shield-fern) was frequent on the steep ground near the path above the River Kelvin.

Stellaria alsine (bog stitchwort) is another small and easily-overlooked plant of wet ground.

Verbascum virgatum (twiggy mullein) is another "weed" recorded in the cultivated Herb Garden area.

CONCLUSION
It is clear that the wild flora of GBG is an indication of a highly dynamic environment in which change appears to be extensive and rapid. Comparing the species totals of the 1994-97 and 2017-19 lists suggests that, on average, 1.0-1.5% of botanical species diversity was lost and replaced per year in GBG over 20 years. Given a

Fig. 4. *Parietaria judaica* (pellitory-of-the-wall), an opportunist weed in the Herb Garden, Glasgow Botanic Gardens. (Photo: M. Philip)

typical survey total of around 300 species, this "species churn" rate of over three species per year matches well with our figures. No doubt, should a similar project be carried out after another interval of 20 years, a further gradual shift in the inventory of wild plants at GBG will have occurred. It is likely that up to a third of the 2017-19 catalogue will have, by then, been supplanted by new arrivals. Recent observations at other sites suggest that such a "churn" rate may be typical - something that would merit further study and research.

ACKNOWLEDGEMENTS
Thanks are due to the helpful staff at Glasgow Botanic Gardens, to the RSPB for invitations to participate in "Bioblitz" activities, to Keith Watson at Glasgow Museums, and especially to all the keen, sharp-eyed amateur field botanists who were part of the 2017-19 survey work. One of these deserves particular mention: Malcolm Macneill's frequent visits and revisits, chatting to gardeners, hunting almost forensically for tiny plants, and following up to check on identifications, added significantly to the breadth of the record.

EDITOR'S NOTE
The first version of the manuscript of this paper was received by the Editor on 12th May 2020. After the manuscript underwent external peer review in July 2020, the subsequent stages of the publication process were interrupted by a number of circumstances, some related to the COVID-19 pandemic of 2020-23. I am indebted to Keith Watson for his major input into the final editing of the paper.

REFERENCES
BSBI (2023). *Plant Atlas 2020*. https://plantatlas2020.org

Macpherson, P. (1998). Plants growing in a wild state. *The Glasgow Naturalist* 23(3), 44-49.

Macpherson, P., Dickson, J.H., Ellis, R.G., Kent, D. & Stace, C.A. (1996). Plant status nomenclature. *BSBI News* 72, 13-16.

Stace, C. (2019). *New Flora of the British Isles* (4th edition). C&M Floristics, Ewloe, Wales.

APPENDIX 1

Alphabetical list of plants recorded in GBG in the 1994-97 survey of MacPherson (1998) and 2017-19 survey of the present author. The nomenclature complies with Stace (2019). Changes in the nomenclature used by Macpherson (1998) are shown in Appendix 2. Key: ☐ native on site; ☐ alien, naturally dispersed to site; ☐ alien, accidentally introduced to site; ☐ planted elsewhere in GBG but spread to site; ☐ not recorded.

Species	1994-97	2017-19
Acaena novae zelandiae		magenta
Acaena ovalifolia	magenta	magenta
Acer platanoides	blue	blue
Acer pseudoplatanus	blue	blue
Achillea millefolium	green	green
Adiantum capillus-veneris		magenta
Aegopodium podagraria	blue	blue
Aesculus hippocastanum	blue	blue
Agrostis canina	green	green
Agrostis capillaris		green
Agrostis stolonifera		green
Ajuga reptans	green	green
Alchemilla mollis	magenta	magenta
Alchemilla xanthochlora	green	
Alliaria petiolata	green	green
Allium carinatum		blue
Allium giganteum	magenta	
Allium paradoxum	magenta	magenta
Allium ursinum	green	green
Alnus glutinosa	green	
Alopecurus geniculatus	green	green
Alopecurus pratensis	green	green
Alstroemeria aurea	magenta	
Ammi majus		magenta
Anisantha sterilis	green	green
Anthriscus sylvestris	green	green
Aphanes arvensis agg.		green
Apium graveolens	magenta	
Aquilegia vulgaris	magenta	magenta
Arabidopsis thaliana	green	green
Arctium lappa		yellow
Arctium minus	green	green
Artemisia vulgaris	green	green
Aruncus dioicus	magenta	
Asarina procumbens		yellow
Asplenium adiantum-nigrum	green	
Asplenium ruta-muraria		green
Asplenium scolopendrium	green	green
Asplenium trichomanes		green
Athyrium filix-femina	green	green
Aucuba japonica		magenta
Avenella flexuosa	green	
Barbarea vulgaris	green	
Bellis perennis	green	green
Bellis perennis (cultivar)	magenta	
Betula pendula	green	green
Betula pubescens	green	green
Bistorta officinalis	green	green
Blechnum spicant	green	green
Brassica napus	blue	
Brassica rapa	blue	
Briza maxima	magenta	
Bromopsis ramosa	green	green
Buddleja davidii	blue	blue
Callitriche stagnalis	green	green
Caltha palustris		green
Calystegia sepium	green	green
Campanula latifolia	green	green
Campanula rapunculoides	magenta	
Campanula trachelium		magenta
Capsella bursa-pastoris	green	green
Cardamine amara		green
Cardamine flexuosa	green	green
Cardamine hirsuta	green	green
Cardamine pratensis		green
Carex nigra	green	green
Carex pendula		blue
Carex remota		green
Carex rostrata		green
Carex sylvatica	green	green
Castanea sativa		magenta
Centaurea montana	magenta	
Centaurea nigra		green
Cerastium fontanum	green	green
Cerastium glomeratum	green	green
Chaerophyllum hirsutum	magenta	
Chamaenerion angustifolium	green	green
Chelidonium majus		yellow
Chenopodium album		green
Chrysosplenium oppositifolium	green	green
Cicerbita macrophylla	blue	
Circaea lutetiana		green
Circaea x intermedia	green	green
Cirsium arvense		green
Cirsium vulgare	green	green
Claytonia perfoliata	yellow	yellow
Claytonia sibirica	blue	blue
Clematis vitalba		blue
Clinopodium vulgare	green	
Colchicum autumnale	magenta	magenta
Collomia linearis	magenta	magenta
Conopodium majus	green	

Species	1994-97	2017-19
Convallaria majalis		
Convolvulus arvensis		
Cotoneaster apiculatus		
Cotoneaster boisianus		
Cotoneaster bullatus		
Cotoneaster franchettii		
Cotoneaster frigidus		
Cotoneaster hjelmqvistii		
Cotoneaster horizontalis		
Cotoneaster lacteus		
Cotoneaster rehderi		
Cotoneaster salicifolius		
Cotoneaster simonsii		
Cotoneaster x watereri		
Crassula helmsii		
Crataegus monogyna		
Crocosmia x *crocosmiiflora*		
Cymbalaria hepaticifolia		
Cymbalaria muralis		
Cynosurus cristatus		
Cytisus scoparius		
Dactylis glomerata		
Dactylorhiza maculata		
Dasiphora fruticosa		
Daucus carota ssp. *carota*		
Digitalis purpurea		
Dryopteris affinis agg.		
Dryopteris affinis ssp. *cambrensis*		
Dryopteris dilatata		
Dryopteris filix-mas		
Elaeagnus umbellata		
Eleocharis acicularis		
Eleocharis palustris		
Elymus repens		
Epilobium brunnescens		
Epilobium ciliatum		
Epilobium komarovianum		
Epilobium montanum		
Epilobium obscurum		
Epilobium roseum		
Epipactis helleborine		
Equisetum arvense		
Equisetum fluviatile		
Equisetum palustre		
Equisetum sylvaticum		
Erodium cicutarium		
Erophila verna s.s.		
Erythranthe x *robertsii*		
Eupatorium cannabinum		
Euphorbia amygdaloides ssp. *robbiae*		
Euphorbia peplus		
Fagus sylvatica		
Festuca rubra agg.		
Ficaria verna		

Species	1994-97	2017-19
Filipendula ulmaria		
Foeniculum vulgare		
Fragaria ananassa		
Fragaria vesca		
Frangula alnus		
Fraxinus excelsior		
Galeopsis tetrahit		
Galium aparine		
Galium saxatile		
Geranium lucidum		
Geranium pratense		
Geranium pyrenaicum		
Geranium robertianum		
Geranium sylvaticum		
Geum urbanum		
Gilia inconspicua		
Glechoma hederacea		
Glyceria maxima		
Gnaphalium uliginosum		
Hedera colchica		
Hedera helix		
Hedera hibernica 'Hibernica'		
Heracleum mantegazzianum		
Heracleum sphondylium		
Hesperis matronalis		
Hieracium agg.		
Hieracium dumosum		
Hieracium sabaudum		
Hieracium triviale		
Hieracium virgultorum		
Holcus lanatus		
Holcus mollis		
Hyacinthoides hispanica		
Hyacinthoides non-scripta		
Hyacinthoides x *massartiana*		
Hydrocharis morsus-ranae		
Hypericum androsaemum		
Hypericum perforatum		
Hypericum tetrapterum		
Hypericum x *desetangsii*		
Hypochaeris radicata		
Ilex aquifolium		
Ilex x *altaclerensis*		
Impatiens glandulifera		
Impatiens parviflora		
Iris pseudacorus		
Jacobaea aquatica		
Jacobaea vulgaris		
Juncus articulatus		
Juncus bufonius		
Juncus effusus		
Juncus tenuis		
Knautia dipsacifolia		
Laburnum alpinum		

Species	1994-97	2017-19
Lactuca serriola f. *integrifolia*		
Lamiastrum galeobdolon ssp. *argentatum*		
Lamium maculatum		
Lamium purpureum		
Lapsana communis		
Larix decidua		
Lathraea clandestina		
Lathyrus pratensis		
Lemna minor		
Lemna trisulca		
Lepidium didymum		
Leucanthemum vulgare		
Ligustrum ovalifolium		
Limnanthes douglasii		
Linaria amethystea ssp. *multipunctata*		
Linaria repens		
Linaria vulgaris		
Lolium perenne		
Lonicera involucrata		
Lonicera periclymenum		
Lotus corniculatus		
Lotus pedunculatus		
Lunaria annua		
Luzula campestris		
Luzula multiflora		
Luzula sylvatica		
Lysimachia punctata		
Matricaria chamomilla		
Matricaria discoidea		
Medicago lupulina		
Melastomaceae sp.		
Melica uniflora		
Mentha aquatica		
Menyanthes trifoliata		
Mercurialis perennis		
Montia fontana		
Mycelis muralis		
Myosotis arvensis		
Myosotis scorpioides		
Myosotis sylvatica		
Myrrhis odorata		
Narcissus (Div. 1)		
Narcissus (Div. 2)		
Narcissus (Div. 3)		
Nepeta cf. *racemosa*		
Oenothera agg.		
Oxalis corniculata		
Oxalis corniculata var. *atropurpurea*		
Oxalis triangularis		
Papaver cambricum		
Papaver dubium s.l.		
Papaver rhoeas		
Papaver somniferum		
Parietaria judaica		

Species	1994-97	2017-19
Persicaria maculosa		
Petrosedum rupestre		
Phalaris arundinacea		
Phleum pratense		
Picea sitchensis		
Pilosella aurantiaca ssp. *carpathicola*		
Pilosella officinarum		
Plantago lanceolata		
Plantago major		
Poa annua		
Poa nemoralis		
Poa pratensis		
Poa trivialis		
Polygonatum x *hybridum*		
Polygonum arenastrum		
Polygonum aviculare		
Polypodium vulgare s.l.		
Polystichum aculeatum		
Polystichum setiferum		
Populus alba		
Populus tremula		
Potamogeton natans		
Potentilla anserina		
Potentilla erecta		
Primula japonica		
Primula vulgaris		
Prunella vulgaris		
Prunus lusitanica		
Prunus padus		
Pteridium aquilinum		
Quercus cerris		
Quercus petraea		
Quercus robur		
Quercus sp.		
Quercus x *(rosacea)*		
Ranunculus acris		
Ranunculus repens		
Reynoutria japonica		
Reynoutria sachalinensis		
Reynoutria x *bohemica*		
Rhododendron ponticum		
Ribes nigrum		
Ribes rubrum		
Ribes sanguineum		
Ribes uva-crispa		
Rosa canina agg.		
Rosa rugosa		
Rubus cockburnianus		
Rubus dasyphyllus		
Rubus fruticosus agg.		
Rubus idaeus		
Rubus laciniatus		
Rubus latifolius		
Rubus leptothyrsos		

Species	1994-97	2017-19
Rubus parviflorus		
Rubus radula		
Rubus spectabilis		
Rumex acetosa		
Rumex acetosella		
Rumex longifolius		
Rumex obtusifolius		
Rumex sanguineus		
Sagina apetala		
Sagina procumbens		
Salix alba		
Salix caprea		
Salix caprea x *cinerea*		
Salix cinerea ssp. *oleifolia*		
Sambucus nigra		
Sanicula europaea		
Saxifraga rotundifolia		
Saxifraga x *urbium*		
Schedonorus giganteus		
Schedonorus pratensis		
Scilla forbesii		
Scirpus sylvaticus		
Scorzonera hispanica		
Scrophularia nodosa		
Senecio sylvaticus		
Senecio vulgaris		
Sida hermaphrodita		
Silene dioica		
Silybum marianum		
Sinapis arvensis		
Sisymbrium officinale		
Solanum lycopersicum		
Solanum tuberosum		
Soleirolia soleirolii		
Sonchus arvensis		
Sonchus asper		
Sonchus oleraceus		
Sorbus aria		
Sorbus aucuparia		
Sorbus intermedia		
Sorbus latifolia		
Sparganium emersum		
Spergula arvensis		
Stachys arvensis		
Stachys palustris		
Stachys sylvatica		
Stellaria alsine		
Stellaria media		

Species	1994-97	2017-19
Stellaria nemorum		
Symphoricarpos albus		
Symphoricarpos x *chenaultii*		
Symphotrichum novi-belgii		
Symphytum officinale		
Symphytum tuberosum		
Symphytum x *uplandicum*		
Tanacetum macrophyllum		
Tanacetum parthenium		
Tanacetum vulgare		
Taraxacum agg.		
Taraxacum cordatum		
Taraxacum duplidentifrons		
Taraxacum exacutum		
Taxus baccata		
Tellima grandiflora		
Teucrium scorodonia		
Tilia x *europaea*		
Tolmiea menziesii		
Tragopogon pratensis ssp. minor		
Trifolium dubium		
Trifolium pratense		
Trifolium repens		
Tripleurospermum inodorum		
Tussilago farfara		
Typha latifolia		
Ulex europaeus		
Ulmus glabra		
Urtica dioica		
Valeriana officinalis		
Verbascum thapsus		
Verbascum virgatum		
Veronica agrestis		
Veronica arvensis		
Veronica chamaedrys		
Veronica hederifolia		
Veronica officinalis		
Veronica peregrina		
Veronica persica		
Veronica serpyllifoila		
Viburnum opulus		
Vicia sativa ssp. *nigra*		
Vicia sativa ssp. *segetalis*		
Vicia sepium		
Vinca minor		
Viola (cultivar)		
Viola riviniana		
Total	**276**	**308**

APPENDIX 2

Changes in the nomenclature used by Macpherson (1998).

Macpherson (1998)	Stace (2019)
Aster novi-belgii	*Symphotrichum novi-belgii*
Chamerion angustifolium	*Chamaenerion angustifolium*
Chionodoxa forbesii	*Scilla forbesii*
Deschampsia flexuosa	*Avenella flexuosa*
Elytrigia repens	*Elymus repens*
Fallopia japonica	*Reynoutria japonica*
Fallopia sachalinensis	*Reynoutria sachalinensis*
Fallopia x *bohemica*	*Reynoutria* x *bohemica*
Festuca gigantea	*Schedonorus giganteus*
Festuca pratensis	*Schedonorus pratensis*
Fragaria x *ananassa*	*Fragaria ananassa*
Hedera x 'Hibernica'	*Hedera hibernica* 'Hibernica'
Hieracium pseudorigens	*Hieracium virgultorum*
Hieracium vulgatum	*Hieracium triviale*
Lycopersicon esculentum	*Solanum lycopersicum*
Matricaria recutita	*Matricaria chamomilla*
Meconopsis cambrica	*Papaver cambricum*
Mimulus x *robertsii*	*Erythranthe* x *robertsii*
Persicaria bistorta	*Bistorta officinalis*
Phyllitis scolopendrium	*Asplenium scolopendrium*
Ranunculus verna	*Ficaria verna*
Sedum rupestre	*Petrosedum rupestre*
Senecio jacobaea	*Jacobaea vulgaris*

The Glasgow Naturalist (2026) Volume 28, Part 4, 20-31 https://doi.org/10.37208/tgn28408

An initial snapshot of the dipteran superfamily Chironomoidea at Holy Loch Nature Reserve, Argyll, Scotland, as revealed by automated DNA barcoding

N. Hammatt[1] & Wellcome Sanger Institute BIOSCAN Collective[2]

[1]Holy Loch Nature Reserve, Sandbank, Argyll PA23 8PD
[2]Wellcome Genome Campus, Hinxton, Cambridge CB10 1SA

[1]E-mail: holylochnaturereserve@gmail.com

ABSTRACT
This study utilises the UK BIOSCAN molecular pipeline at the Wellcome Sanger Institute to establish the first high-resolution, DNA-based taxonomic baseline for the large dipteran superfamily Chironomoidea at Holy Loch Nature Reserve, Argyll, Scotland. During 2024, sampling was conducted via Malaise trapping in carr woodland and a supralittoral saltmarsh habitat mosaic. The methodology employs DNA barcoding, specifically targeting the cytochrome *c* oxidase subunit I (COI) mitochondrial gene. This genetic marker serves as a diagnostic tool, allowing for species-level identification by comparing DNA sequences/barcodes against a global reference library. The audit revealed at least 134 species, including (when compared with records on the Global Biodiversity Information Facility, GBIF) ten new species (or near species) for Scotland and/or the U.K. The study extended standard UK BIOSCAN procedures to larvae and to marine specimens. Despite representing only a snapshot of chironomoid diversity at the Holy Loch, this study provides a foundational metadata anchor and reference library, essential for future biodiversity monitoring at the site.

INTRODUCTION
The world is currently experiencing an accelerating rate of species extinctions driven by human economic activity (IPBES, 2019). Biodiversity monitoring is central to both global conservation efforts and small community-led projects such as that involving the undisturbed, protected area of the Holy Loch Nature Reserve (HLNR) on the Cowal Peninsula, Argyll, Scotland. Such monitoring requires a comprehensive baseline audit of all resident taxa (Blaxter *et al.*, 2005). Given the central role of insects in providing ecosystem services for human well-being (Scudder, 2017), in a time of finite research resources it is clear that novel methods are required that are both at scale (to be relevant) and automated (to reduce costs).

For over two centuries, traditional taxonomy has relied on specialists working methodically on individual groups to publish morphological identification guides and dichotomous keys. However, applying these methods to insects requires an extensive and costly investment in human expertise. Due to a chronic lack of such a global strategic investment in taxonomists - the so-called "taxonomic impediment" (Engel *et al.*, 2021; Wheeler *et al.*, 2004) - humanity remains a long way from formally documenting every species via a Latin binomial, even at a single global site. Because many insect families remain difficult for non-specialists (and often experts) to identify during field-based surveys, compiling a comprehensive multi-class baseline at a community-led reserve like HLNR has historically been impossible. Consequently, many species may be lost to climate change and other environmental factors (Urban, 2024; Tedesco *et al.*, 2014) before they are ever described.

DNA barcoding (sequencing short DNA fragments from specific genes; Hebert *et al.*, 2003; Porter & Hajibabaei, 2018) offers a major step forward that enables rapid, species identification (Antil *et al.*, 2023). The Barcode of Life Database (BOLD), based in Guelph, Canada, maintains a growing library of DNA sequences from the cytochrome *c* oxidase subunit I (COI) mitochondrial gene, which have been deposited by taxonomists over recent decades. Additionally, specimens of insects and other organisms deposited in museum collections by taxonomists can also be sequenced and added to BOLD where they are clustered into statistically distinct sequence groups known as Biodiversity Index Numbers (BINs; Ratnasingham & Hebert, 2007, 2013). These BINs have a similarity threshold of ≥98% when they also tend to equate to species. Thus, even BINs without names, but which have unique DNA sequences, can be used as "proxy" species while taxonomic studies are carried out.

While earlier barcoding methods required the destruction of the specimen, the UK BIOSCAN project (coordinated by the Wellcome Sanger Institute, Hinxton, Cambridgeshire) utilises non-destructive DNA extraction methods (Park *et al.*, 2023). This is a critical advancement: where a barcode does not match an existing record on BOLD, the physical specimen remains intact, allowing taxonomists to conduct subsequent morphological studies to assign an existing name or describe a new species.

The UK BIOSCAN project aims to characterise the genetic diversity of flying insects from across the U.K.

(for an outline of the project, see Wellcome Sanger Institute (2026)). It employs robotic automation to generate high volumes of COI barcodes from invertebrates captured by standard Malaise traps deployed across multiple U.K. sites. Never before has such a vast dataset of barcodes been available for U.K. biodiversity and ecological research. This paper outlines a foundational method for monitoring taxonomic changes over time. The dipteran superfamily Chironomoidea (comprising four families) was selected for this study because available taxonomic resources for the group vary greatly: from the relatively recent identification keys for non-biting midges (Chironomidae) (Langton & Pinder, 2007), to web-based keys for biting midges (Ceratopogonidae), and somewhat dated resources for blackflies (Simuliidae) (Davies, 1966, 1968).

METHODS

Location

This study was carried out in 2024 and 2025 using insects trapped at the Holy Loch Nature Reserve (HLNR). This is located at the head of a sea loch, an inlet of the Firth of Clyde in Argyll, Scotland. This site has been relatively undisturbed for many decades in the ownership of Argyll and Bute Council and leased by Sandbank Community Development Trust. Light sheep grazing occurs in a small area of the saltmarsh from January to March annually. Otherwise, there is no other significant human activity.

Field sampling and specimen acquisition

The aim of this project was to provide a first snapshot of chironomoid diversity over the course of a year. Monthly invertebrate samples were obtained from standard two-metre Malaise traps deployed in two distinct ecological zones: (1) a complex, supralittoral habitat mosaic (Figs. 1 and 2; hereafter referred to as “marsh”), which comprises a beach with decomposing seaweeds and other organic debris, herbs (Fig. 3), gorse scrub and woodland on a sea-facing gravel ridge, *Festuca rubra*-dominated, herb-rich middle saltmarsh with water-containing depressions, and channels (Fig. 4), all within 40 m of the trap site; and (2) a stable carr woodland (Grid ref. 55.991205 N, -4.962823; what3words: soggy.fidgeting.squaring; Fig. 5) dominated by *Alnus glutinosa* (alder), *Betula pubescens* (downy birch) and *Salix caprea* (goat willow). There is evidence of an underground freshwater seep to the north of the marsh site which significantly alters the vegetation in this freshwater “lens”, and fills a sinuous channel. The marsh trap was deployed at the locations shown in Fig. 2.

Traps were deployed for 24 h concluding on the following dates in 2024: 27th January (carr only), 27th February, 31st March, 27th April, 22nd May, 30th June, 23rd July, 22nd August, 15th September, 21st October, and 26th November, and for seven days from 18th to 24th December. Calms days, ideally with sunshine, were chosen in order to sample during maximum invertebrate activity. The Malaise trapping bottle contained 100% ethanol. Individual specimens were then sorted (Fig. 6) and distributed into the wells of 96-well microtitre plate which are arranged in an eight-row by twelve-column grid format, with alphanumeric identification for easy sample tracking (e.g. A1, H12). Prior to that, Darwin Tree of Life metadata were collected for each specimen (Lawniczak *et al.*, 2022).

Supplemental sampling was performed from 1st to 15th September 2024 to completely fill the most recent plate prior to dispatch. This involved manual collection of larvae from submerged timber within a saltmarsh drainage ditch (Grid ref. 55.961783 N, -4.961925 E; what3words: notch.january.similar) and the deployment for 15 days of a moth pheromone trap baited with a solution of cider vinegar and *Rubus fruticosus* agg. (bramble) fruits in a hedge at the back of the saltmarsh (Grid ref: 55.963345 N, -4.961988 E; what3words: animator.lame.deputy). To prevent possible polymerase chain reaction (PCR: see below) inhibition by saline residues or acetic acid from the vinegar, all specimens retrieved from the saltmarsh or baited trap were washed in a phosphate buffer (pH 7.0) prior to preservation in 100% ethanol in the 96-well plates. Plates were stored in a freezer at at least -20ºC prior to dispatch to the Wellcome Sanger Institute by courier.

Molecular pipeline and DNA barcoding

Specimens were processed through the UK BIOSCAN high-throughput pipeline at the Wellcome Sanger Institute as described by Park *et al.* (2023). Following evaporation of the ethanol from each well, specimens were submerged in a lysis buffer, which allowed seepage of DNA-containing body fluids through the insects’ exoskeleton and preserved the structure of the "voucher" specimen for any subsequent taxonomic examination. The collection is curated at the Natural History Museum, London.

The PCR technique was then employed to produce multiple copies of a *ca.* 658 base pair fragment of the mitochondrial cytochrome *c* oxidase subunit I (COI) gene present in the DNA lysates (Mullis *et al.*, 1986). The amplified DNA strands were sequenced using the Illumina NovaSeq platform. The resulting raw sequence data were processed through a bioinformatics pipeline (mBRAVE; Ratnasingham, 2019) to isolate high-quality barcodes, with around 658 nucleotides, which were then uploaded to the Barcode of Life Data System (BOLD) under project HLNR.

Taxonomic assignment and the BIN system

Sequences were assigned to Biodiversity Index Numbers (BINs) using the BOLD Refined Single Linkage (RESL) algorithm (Ratnasingham & Hebert, 2013). This system clusters sequences into statistically distinct operational taxonomic units (OTUs) which serve as high-resolution species proxies. BIN sequences are then compared with named sequences in BOLD’s growing reference library.

Fig. 1. Aerial photograph of the "marsh" sampling site at Holy Loch Nature Reserve, Sandbank, Argyll, Scotland. (Photo: Phill Rawlins)

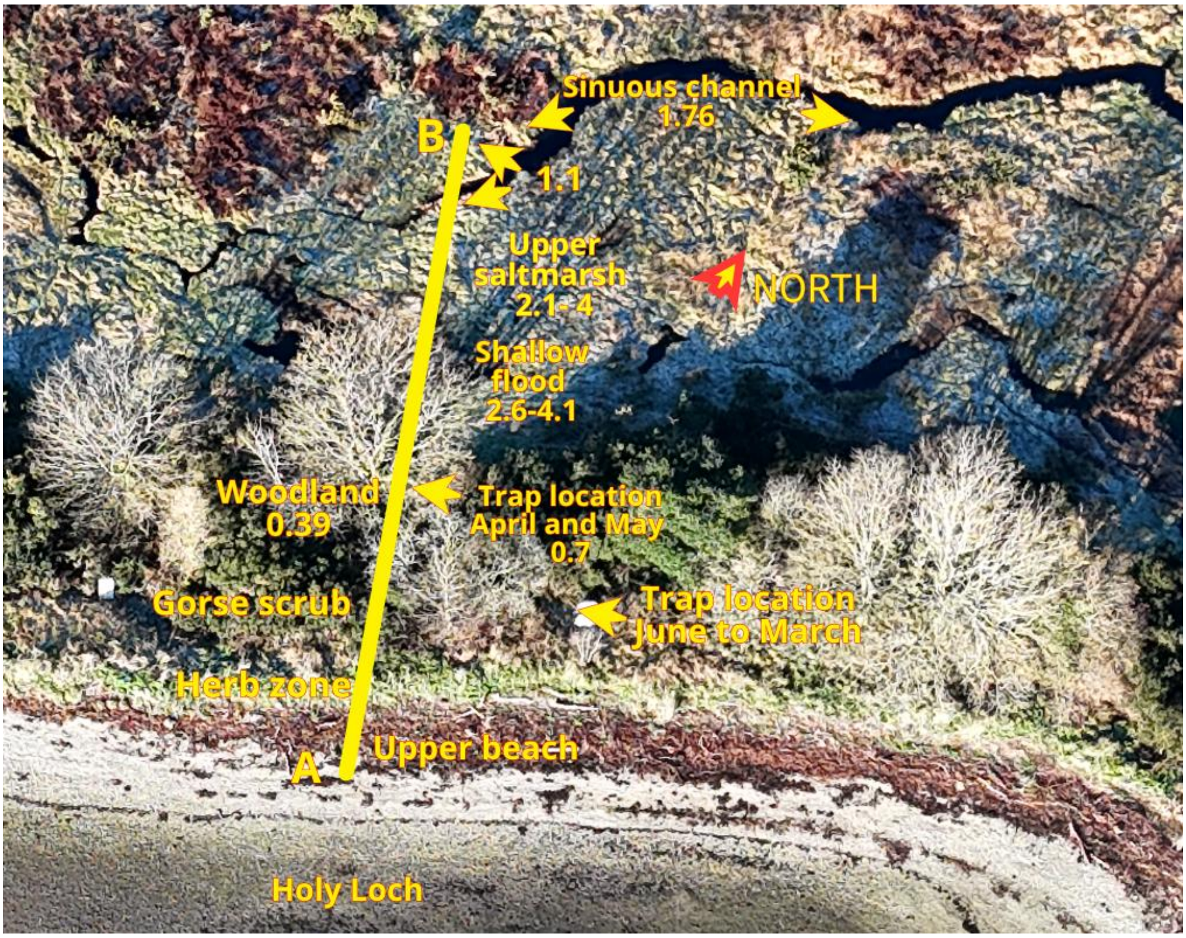


Fig. 2. Closer view of the boxed area in Fig. 1. A-B indicates the location of the 40 m linear transect. A: 55.9945 N, -4.9583; what3words: standard.sunflower.beginning. B: 55.9941 N, -4.9580; what3words: phantom.overgrown.junction. The values are soil conductivity measurements (mS cm^{-1}). (Photo: Phill Rawlins)

Fig. 3. The sinuous channel labelled in Fig. 2, located in flower-rich grassland (June 2024). (Photo: Neil Hammatt)

Fig. 4. A malaise trap at the June to March site (see Fig. 2). (Photo: Neil Hammatt)

Fig. 5. General view of the location of the carr woodland malaise trap, showing the dense, herbaceous understory. (Photo: Neil Hammatt)

Fig. 6. The "marsh" catch from June 2024. (Photo: Neil Hammatt)

At HLNR, taxonomic assignment of these BINs then followed a four-tier taxonomic confidence hierarchy (Table 1), depending on the amount of DNA and other supporting evidence.

In addition to the standard BOLD identification engine, all sequences that returned only a genus-level assignment were checked manually using BLAST (Basic Alignment Research Tool) searches on BOLD (https://id.boldsystems.org) and/or NCBI (https://blast.ncbi.nlm.nih.gov/Blast.cgi?PROGRAM=blastn&PAGE_TYPE=BlastSearch&LINK_LOC=blasthome). This step is necessary because the automatic BOLD pipeline is intentionally conservative and may stop at genus even when multiple high-quality species-level matches exist. Manual BLAST bypasses BIN-based restrictions and compares the sequence directly with all public reference records, allowing clear species-level identifications to be recognised when the evidence is unambiguous. Because BOLD is based on arthropod COI sequences and GenBank used by BLAST can contain any sequence from any taxon, results from BOLD were given more credence, but if BLAST added evidence, then that was also taken into consideration.

Primary data source

All sequences were downloaded to the publicly-available database on the Bioscan Report Card. This paper allots these sequences to the various trapping sites.

Abiotic Data Integration

Substrate pH and electrical conductivity (a proxy for total salinity) were recorded on 3rd November 2025, to provide a quantitative understanding of habitat heterogeneity at the two trapping sites within a relatively short flying distance between emerged adults and the traps. At the woodland site, four 5 m cardinal transects were established for substrate pH testing. Additionally, a 40 m longitudinal transect was established from the beach through successive "marsh" vegetation zones (Fig. 2). Measurements were taken at 1 m intervals along all transects using calibrated Hanna Instruments soil probes. These parameters are essential for mapping a single snapshot of physiological constraints of resident larvae, particularly in the dynamic saline conditions of the saltmarsh caused by spring tides of varying heights.

Considered evidence	Holy Loch Nature Reserve BIN taxonomic category			
	Confirmed identity	**Rare biosphere**	**Emerging identity**	**Barcode silence**
Molecular Sequence similarity to BOLD references	Close to 100% match to BOLD references; unambiguous species-level assignment	≥98% match to BOLD references; usually species-level, may require manual verification on BOLD or	Genus-level match only; multiple species in BOLD may exist; no confident species-level	No reliable match in BOLD; single or very few BLAST hits only; assignment not possible beyond
Number of reference sequences	≥3	<3	Any	No limit
Geographical range of reference BINs	≥2 countries	≥2 countries	Any	Any
Collector diversity for reference BINs	≥2 independent collectors	≥2 independent collectors	Any	Any
Longevity of BINs	>5 years	Can be newly formed	Can be newly formed	Can be newly formed
Recurrence (number of sequences per BIN at HLNR)	≥2 months	At least one month	Any	0 or very few (BLAST-only)
Ecological plausibility (if niche known)	Supporting evidence	Supporting evidence		
Entry to the UK Species Inventory (UKSI)	Supporting evidence	Supporting evidence		

Table 1. Confidence criteria used for BIN taxonomic conclusions at Holy Loch Nature Reserve, Sandbank, Argyll, Scotland.

RESULTS

Abiotic data

The substrate pH in the carr woodland remained relatively uniform throughout the study period, with values recorded between 6.6 and 6.9 (Table 2). In contrast, the saltmarsh habitat mosaic displayed a significant environmental gradient; pH values shifted from highly acidic (4.5) within the mature woodland atop the gravel ridge to 6.8 in the upper saltmarsh. Electrical conductivity on the saltmarsh largely reflected elevation, which determines the frequency and duration of tidal inundation during spring tides (Fig. 2).

Barcoding

Chironomoidea comprised the greatest number of individuals and BINs recorded at HLNR in 2024. Within the family Chironomidae, the genus *Limnophyes* was the most abundant, producing 842 barcodes, of which 348 were assigned to *L. natalensis*. Successful naming of BINs depended on the quality and completeness of the reference library; in several cases, such as BOLD:ACF9576, BINs may contain more than one species, specifically *Culicoides obsoletus* or *C. scoticus,* where morphological differences are not reflected in a 2% DNA sequence divergence. Conversely, some species, such as *Dasyhelea turficola*, spanned multiple BINs. This is a reminder that intraspecific genetic variation can be larger than the BIN algorithm can accommodate.

Within the Chironomidae, 23 BINs were assigned to “Confirmed identity” (Table 3), while thirty-two BINs occurred only once or a few times and were categorised as “Rare biosphere” (Table 4). Among 25 BINs with “Emerging identities” assignable only to genus (Table 5), manual BLAST analysis enabled the assignment of up to three possible species. Two relatively frequent BINs assigned to “Barcode silence” were identifiable only to the family level (Table 6). For Ceratopogonidae, at least seven species were identified confidently (Table 7), and fifteen rare BINs also had solid identifications. Among the 12 with emerging identities, BLAST analysis revealed that several could not be deciphered between two near-identical species.

Distance (m) from trap location 2	pH	Conductivity ($mS\ cm^{-1}$)	Habitat
−18	6.6		Beach
−16	6		**Trap location 1**
-11	6.5		Scrub ecotone
-8	4.4	0.39	Woodland
0	6.9	0.23	**Trap location 2**
1	6.6	0.47	Downslope scrub
2	6.5	0.7	Downslope scrub
3	6.6	0.93	Upper saltmarsh
4	6.8	1.48	Upper saltmarsh
5	6	1.54	Shallow flood edge
6	6.1	4	Shallow flood
7	6.5	2.6	Shallow flood
8	6.5	2.6	Shallow flood
9	5.3	2.6	Shallow flood
10	5.7	3.9	Shallow flood edge
11	6.1	4	Upper saltmarsh
12	6.3	2.8	Upper saltmarsh
13	6.2	2.6	Upper saltmarsh
14	6.5	3.5	Upper saltmarsh
15	6.1	2.4	Upper saltmarsh
16	6.6	2.1	Upper saltmarsh
17	6	2.7	Channel edge
18	5.7		Rushy shallow edge
19	6.4	1.76	Sinuous channel
20	5.8	2.6	Sinuous channel edge
21	6	3.5	Upper saltmarsh
22	6.7	1	Upper saltmarsh

Table 2. Variation in pH and soil conductivity and habitat description along a 40 m linear transect on vegetated gravel at Holy Loch Nature Reserve, Sandbank, Argyll, Scotland, on 2nd November 2025 (see Fig. 2). Both trap locations were in gorse and herb-rich vegetated gravel.

BIN	Assigned name	Wood		Marsh	
		Total	Months	Total	Months
BOLD:AAD7724	*Brillia bifida*	3	Feb, Dec	2	Jan
BOLD:ACF6903	*Chaetocladius perennis*	2	Feb	6	Jan, Jun, Aug, Sep
BOLD:AAF3277	*Chironomus aprilinus*	1	Aug	13	Apr, May
BOLD:AAN5317	*Chironomus salinarius*			15	Jun, Jul, Aug
BOLD:ACD4501	*Gymnometriocnemus brumalis*	5	Sep, Oct	14	Sep, Oct
BOLD:AAB8751	*Halocladius variabilis*			21	Mar,May, Jun, Jul, Aug
BOLD:AEF6833	*Halocladius varians*			6	Jul, Oct
BOLD:AAB9700	*Limnophyes edwardsi*	1	Dec	40	Mar, Apr, Jun, Aug
BOLD:AAJ2130	*Limnophyes habilis*	2	Feb, Jun	11	Jun, Jul, Aug, Sep
BOLD:AAB7359	*Limnophyes natalensis*	1	Jul	351	Apr, May, Jun, Jul, Aug
BOLD:AAE6392	*Limnophyes pentaplastus*	7	Feb, Mar, Jun, Dec	12	Jan, Jun, Jul, Aug
BOLD:ABU5525	*Limnophyes* sp. 14ES-unnamed	9	Feb, Mar, Jun, Jul, Dec	17	Jan, Apr, Jun, Aug, Dec
BOLD:ABW2734	*Limnophyes* sp. 14ES-unnamed	1	Jul	11	Jan, Feb, Apr, May, Jun, Jul, Dec
BOLD:AAB1806	*Limnophyes* sp. 3ES-unnamed	17	Aug, Nov, Dec	179	Jun, Jul, Aug, Oct, Nov, Dec
BOLD:AAC6643	*Metriocnemus albolineatus*			5	Jun, Aug
BOLD:AAI1573	*Metriocnemus fuscipes*	3	Feb, Oct	27	Feb,May,Jun,Jul,Aug
BOLD:AAI1572	*Metriocnemus picipes*	2	Apr, Aug	25	Apr, Jun, Aug, Sep
BOLD:AAC4200	*Paraphaenocladius impensus*	4	Jun, Oct, Dec	2	Apr
BOLD:ACN9514	*Paraphaenocladius impensus*			21	Mar, Apr, Jun, Jul, Aug
BOLD:ACG6805	*Pseudorthocladius* cf. *curtistylus*	3	Jun, Jul	10	Jun, Jul, Aug
BOLD:AAD9251	*Pseudorthocladius filiformis*			5	Aug
BOLD:ACP4407	*Pseudosmittia trilobata*			5	Apr, May
BOLD:ABW7981	*Smittia leucopogon*			5	Jun, Aug

Table 3. BOLD BINs with "Confirmed identity" from the family Chironomidae captured at the Holy Loch Nature Reserve, Sandbank, Argyll, Scotland, in 2024 from carr woodland (Wood) and the saltmarsh-based habitat mosaic (Marsh). This includes the total number caught as adults in 2024 and the months in which they were trapped.

Specific attention was given to the Simuliidae, where three larvae collected on 15th September from the saltmarsh field drain were assigned to two *Simulium* BINs, while a total of 12 adults collected in 2024 were allocated to three BINs (Table 8). Notably, BOLD:ACX9864 was captured both as a larva in September and as an adult on October 21st.

Comparison of the HLNR species found by UK BIOSCAN with the GBIF (Global Biodiversity Information Facility) distribution maps for Scotland and the U.K. on 9th December 2025, revealed many species not previously recorded in these jurisdictions. In Chironomidae, these include *Limnophyes pentaplastus*, *Pseudosmittia trilobata*, *Pseudorthocladius* cf. *curtistylus*, *Micropsectra apposita*, *M. klinki*, *Tanytarsus ejuncidus*, and *Xenopelopia nigricans*. In Ceratopogonidae, *Culicoides comosioculatus* appears to be new to the U.K., alongside *Dasyhelea arenivaga*, *Forcipomyia monilicornis*, and *Atrichopogon* cf. *hirtidorsum*.

DISCUSSION

In view of the trapping methodology employed – the use of a Malaise trap for short (mainly 24 h) monthly periods over the course of one year – the data generated in this investigation can provide only a snapshot of the chironomoid assemblage at HLNR. Also, taxonomic interpretations may be compromised by the fact that there are quite a few chironomid BINs with unclear or provisional taxonomy in BOLD, due to lack of revision or undescribed species. Despite these caveats, the molecular biodiversity audit presented here represents a transformative frontier for biological recording in the West of Scotland. Given the coastal setting and the diversity of aquatic and semi-aquatic environments present, including flooded carr, saltmarsh pans, brackish creeks, freshwater burns, and freshwater seeps, it is unsurprising that Chironomoidea, particularly Chironomidae (Armitage *et al.*, 1995), comprised the greatest number of individuals and BINs recorded at HLNR. DNA barcoding has similarly revealed substantial hidden chironomid diversity in other regions (Namayandeh *et al.*, 2024), highlighting the value of genomic approaches in complex wetland systems.

Substrate pH (Carstensen & Duarte, 2019) and salinity are the principal environmental factors structuring saltmarsh invertebrate assemblages. Tolerance to these variables, particularly soil salinity, determines the viability of species whose life cycles depend on wet substrates and decomposing organic matter. Both trap sites at HLNR were acidic: saltmarsh pH ranged from 4.5 to 6.8, whereas the carr woodland showed relatively uniform pH values, reflecting its homogeneous vegetation structure. As expected, conductivity on the saltmarsh largely reflected elevation, which determines the frequency and duration of tidal inundation during spring tides. These hydrological gradients influence plant community composition (Hammatt, unpublished data) and, consequently, the types of detrital resources available to invertebrates.

BIN	Assigned name	Wood		Marsh	
		Total	Months	Total	Months
BOLD:AAW1344	*Bryophaenocladius flavoscutellatus*	1	Jul	1	Jul
BOLD:AER6168	*Bryophaenocladius flexidens*			2	Oct
BOLD:AAM6273	*Bryophaenocladius ictericus*	1	Nov	1	Aug
BOLD:AAD4034	*Chaetocladius melaleucus*	1	Nov		
BOLD:AAJ4282	*Chironomus luridus*	1	Nov		
BOLD:AAD1162	*Corynoneura lobata*			1	Aug
BOLD:ACG3525	*Corynoneura* sp. 24ES			2	Jun
BOLD:AAP5927	*Cricotopus pulchripes*			1	Jun
BOLD:AAE4568	*Eukiefferiella claripennis*			1	Mar
BOLD:AAX3566	*Macropelopia nebulosa***			1**	Sep
BOLD:AAB8862	*Metriocnemus eurynotus*			1	Jun
BOLD:ACB9910	*Metriocnemus* sp. 1SW-unnamed			1	Aug
BOLD:AEJ0479	*Micropsectra apposita*	1	Feb		
BOLD:AAW0057	*Micropsectra klinki*	1	Feb	1	Jun
BOLD:AAD1527	*Micropsectra lindrothi*			1	Aug
BOLD:AEE6875	*Micropsectra pallidula*	1	Dec		
BOLD:AAC4200	*Paraphaenocladius impensus*			1	Mar
BOLD:ACF8295	*Paraphaenocladius pseudirritus*			1	Apr
BOLD:ACM5899	*Paratanytarsus austriacus*	1	Jul		
BOLD:AAF0341	*Polypedilum uncinatum*	1	Apr		
BOLD:AAG6458	*Pseudosmittia albipennis*	1	May	1	Jun
BOLD:AAD5902	*Rheocricotopus atripes*			1	Jan
BOLD:AEE5575	*Rheocricotopus* sp. 3ES			1***	Aug
BOLD:ACE0351	*Smittia* cf. *stercoraria*	1	Dec		
BOLD:AGO4959	*Smittia* cf. *stercoraria*			2	Aug, Dec
BOLD:ACK3746	*Smittia paranudipennis*			1	Jun
BOLD:ACM5388	*Smittia pratorum*			3	Jun, Oct
BOLD:AAP5616	*Tanytarsus brundini*			1	Jun
BOLD:AAW1102	*Tanytarsus ejuncidus*			1	Jun
BOLD:ACG9673	*Tanytarsus signatus*			1	Aug
BOLD:AAD5253	*Thienemanniella xena**			1	Aug
BOLD:ADA6313	*Xenopelopia nigricans*	1	Apr		
BOLD:AEV9540	*Limnophyes asquamatus*	2	Apr		

Table 4. BOLD BINs from the "Rare biosphere" of the family Chironomidae captured at the Holy Loch Nature Reserve, Sandbank, Argyll, Scotland, in 2024 from carr woodland (Wood) and the saltmarsh-based habitat mosaic (Marsh). This includes the total number caught as adults (and a single larva) in 2024 and the months in which they were trapped. *Identified by manual BLAST and the BOLD identification engine. **Larva from a seaweed pile on a beach. ***Swept.

BIN	Genus	BCY	Wood		Marsh	
			Total	Months	Total	Months
BOLD:ACR0319	*Bryophaenocladius*		1	Oct	1	Oct
BOLD:AAI7060	*Chaetocladius*				3	Dec
BOLD:AEQ8805	*Chaetocladius*				1	Jan
BOLD:ACD9509	*Georthocladius*				1	Mar
BOLD:AAI4193	*Gymnometriocnemus*				1	Apr
BOLD:AAU6603	*Hydrosmittia*				1	Aug
BOLD:AGL0475	*Krenopelopia* (nr. *binotata)**	2025			1	Jun
BOLD:AGO4493	*Krenopelopia* (nr. *binotata)**	2025			1	Aug
BOLD:AAI2213	*Krenopelopia* (nr. *binotata)**	2010			1	Aug
BOLD:ACO9143	*Limnophyes*				7	Feb, Jun, Aug
BOLD:ACR0830	*Limnophyes*		13	Dec	7	Feb, Mar, Apr, Jul
BOLD:ACT5780	*Limnophyes*				2	Apr, Oct
BOLD AGX5543	*Limnophyes*				116	Apr, May, Jun, Aug, Sep
BOLD:AAX4301	*Metriocnemus tristellus***	2011			2	Apr, Oct
BOLD:ACC1758	*Metriocnemus*	2012			1	Aug
BOLD:AEC4629	*Procladius*				1	Aug
BOLD:ACT1181	*Procladius*				1	Aug
BOLD:ACF9730	*Pseudorthocladius*				1	Apr
BOLD:AAM6263	*Pseudosmittia*		2	May		
BOLD:ACG7714	*Pseudosmittia*				4	Jul
BOLD:ADM2886	*Smittia*				1	Jun
BOLD:AEH1919	*Smittia*		1	May		
BOLD:ACF7218	*Smittia****				14	Jun, Aug
BOLD:ACU9413	*Smittia*		2	May, Jun		
BOLD:ACQ9002	*Thienemanniella* (nr. *vittata*)****				1	Jun

Table 5. BOLD BINs with "Emerging identity" from the family Chironomidae captured at the Holy Loch Nature Reserve, Sandbank, Argyll, Scotland, in 2024 from carr woodland (Wood) and the saltmarsh-based habitat mosaic (Marsh). This includes the total number caught as adults in 2024 and the months in which they were trapped. BCY = BIN creation year. *Each BIN has a few matches to sequences from *Krenopelopia binotata* in a BOLD manual algorithm run. These are all over 97% match. **Single match to *Metriocnemus tristellus* in a BLAST search. ***Single match on BLAST. ****Matched on BLAST. Nineteen barcodes were assigned to *Limnophyes* without first including them in a BIN.

BIN	Date BIN created	No. of specimens
BOLD:ACY5749	06/05/2019	4
BOLD:AEE3886	21/092020	2
BOLD:AEH2536	19/02/2021	27
BOLD:AGK6424	07/01/2025	1
BOLD:AGN3217	07/01/2025	13
BOLD:AGM4472	07/01/2025	3
BOLD:AGO3668	07/01/2025	2

Table 6. BOLD BINs with "Barcode silence" from the family Chironomidae captured at the Holy Loch Nature Reserve, Sandbank, Argyll, Scotland in 2024.

With basic descriptions of the trapping locations, habitat composition, and substrate variables, this paper serves as a metadata anchor for all subsequent UK BIOSCAN publications from HLNR. Given the potential number of distinct physiological niches, at a time when the concept of ecological niche itself is being critically re-examined (Ferrante, 2025), the substantially higher abundance of individuals and BINs on the saltmarsh compared with the structurally more uniform carr woodland is expected (Buche *et al.*, 2022). Both pH and salinity also influence dissolved oxygen concentrations, another fundamental determinant of invertebrate physiology (Banerjee *et al.*, 2019). Systematic measurements of dissolved oxygen across HLNR are scheduled to begin shortly to further refine these niche models.

At present, understanding of the specific, and potentially flexible, niches occupied by individual chironomid taxa remains limited. Consequently, devising targeted conservation measures for declining species, or even detecting climate-driven declines against a background of naturally variable population dynamics, remains challenging. However, the statistically robust volumes of BIN occurrence data now generated by UK BIOSCAN enable ecological modelling based on identifiable taxa rather than hypothetical species. Such models can incorporate variables such as habitat preference and flight period. In the present study, for example, *Limnophyes natalensis* was almost entirely restricted to the saltmarsh between April and August, whereas *Limnophyes* sp. 3ES was recorded more evenly throughout the year. While some taxa may be woodland specialists, it is notable that most BINs were recorded at both sites, suggesting a degree of landscape-scale connectivity.

Where chironomid niches have been investigated in detail, complex ecological relationships have emerged. These include the dependence of *Halocladius variabilis*, recorded at HLNR, on seaweeds (Tarakhovskaya & Garbary, 2009). In the context of projected climate change for western Scotland (Werrity & Sugden, 2012), it is notable that within the genus *Brillia*, temperature and moisture gradients are reported as key drivers of population divergence, with evidence of adaptive differentiation among species (Xu *et al.*, 2025). Food type has also been identified as a determinant of presence or absence in *B. bifida* (García & Pardo, 2015). Research on Ceratopogonidae has historically focused on their nuisance value to humans, particularly the Highland midge, *Culicoides impunctatus*, and their role as vectors of pathogens such as blue tongue virus (Blackwell *et al.*, 1992; Mullens *et al.*, 2015; King *et al.*, 2025).

By establishing a high-resolution genomic baseline at HLNR, investigations such as this bypass the "taxonomic impediment" that has historically stalled community-led conservation efforts (Engel *et al.*, 2021; Wheeler *et al.*, 2024). For over two centuries, the requirement for hyper-specialised morphological expertise has acted as a barrier, preventing small sites, such as Local Nature Reserves, from fully documenting their taxa. DNA barcoding democratises this process, allowing non-specialists to generate data of a calibre that matches or exceeds that of institutional surveys (Roslin *et al.*, 2022).

The identification of at least ten species new to the Scottish and/or U.K. lists – including *Culicoides comosioculatus*, *Limnophyes pentaplastus*, and *Xenopelopia nigricans* – signals that a significant volume of "hidden" biodiversity has been overlooked. Were any present, traditional morphological keys, which rely heavily on male genitalia (Langton & Pinder, 2007), could not resolve endemic genetic lineages. The use of non-destructive DNA extraction by the Sanger Institute is a critical technological advance (Park *et al.*, 2023); it ensures that the physical "voucher" remains intact, allowing specialists to revisit the exact specimens that produced a "new to science" barcode. This creates a vital bridge between 19th century morphological traditions and 21st century genomics.

This study validates HLNR as a vital site for long-term monitoring and provides the "genetic library" required for future environmental DNA (eDNA) metabarcoding. With the future integration of barcodes collected in 2025, 2026, and beyond, the resolution of our ecological map will continuously increase. This multi-year data stream will progress beyond simple inventorying into the analysis of seasonal shifts and population dynamics.

Ultimately, the phenological and distributional data captured in this inaugural year will serve as the permanent control against which all future ecological shifts will be measured.

ACKNOWLEDGEMENTS
This research was supported by Seachangers, William Grant Foundation, Flora and Fauna International, and the people of Cowal. We are grateful to Phill Rawlins for aerial photography and to two reviewers for their detailed feedback. COI barcode data used here were generated by the BIOSCAN project led by Mara Lawniczak's team at the Wellcome Sanger Institute. The BIOSCAN project and many of the people named in the Wellcome Sanger Institute BIOSCAN Collective author list are funded by the Wellcome Trust award 220540/Z/20/A.

BIN	Assigned name	Wood		Marsh	
		Total	Months	Total	Months
Confirmed identity					
BOLD:AAV9748	*Culicoides circumscriptus*			4	Jun
BOLD:ACG4335	*Culicoides impunctatus*	1	Jun	23	Jun, Jul
BOLD:ACX2603	*Culicoides punctatus*			11	Jun, Jul
BOLD:AAY9630	*Culicoides segnis*	3	May, Jun		
BOLD:ACX2767	*Dasyhelea arenivaga*			14	Jun, Jul, Aug
BOLD:AEH4464	*Dasyhelea turficola*			11	Jun, Jul, Aug
BOLD:ABW3987	*Forcipomyia tenuis*			6	Jun, Jul, Aug
Rare biosphere					
BOLD:ACP4327	*Ceratopogon grandiforceps*			1	Apr
BOLD:ADF6075	*Culicoides comosioculatus*			1	Aug
BOLD:AEC6694	*Culicoides newsteadi*			2	Jul, Aug
BOLD:AGT3278	*Dasyhelea modesta*			1	Jun
BOLD:AAV5098	*Dasyhelea turficola*			1	Jul
BOLD:AEH4801	*Dasyhelea turficola*			1	Jun
BOLD:AGR6137	*Dasyhelea turficola*			1	Jun
BOLD:AAN5148	*Forcipomyia bipunctata*			1	Jun
BOLD:ABW3942	*Forcipomyia nigra*	1	Jun		
BOLD:AEA8665	*Palpomyia flavipes*	1	Aug		
BOLD:ACX1684	*Palpomyia serripes* (using manual BLAST)			1	Aug
BOLD:ACL4093	*Schizohelea leucopeza*			1	Jun
BOLD:ACY6482	*Serromyia femorata*			1	Jun
BOLD:ACS7502	*Serromyia ledicola*			1	Jul
BOLD:ACG4212	*Stilobezzia ochracea*	1	Jul		
Emerging identitiy					
BOLD:AGL8522	*Atrichopogon*			5	May, Jun
BOLD:ABZ8851	*Atrichopogon* cf. *hirtidorsum*			2	Jul, Aug
BOLD:ACP8436	*Bezzia ornata*			1	Jun
BOLD:ACF9576	*Culicoides obsoletus* or *C. scoticus**			1	Jun
BOLD:ACF7867	*Culicoides obsoletus* or *C. scoticus**	2	Jun		
BOLD:ACS7831	*Dasyhelea* sp.			14	Jun, Jul, Aug
BOLD:ACX1316	*Dasyhelea* sp.			1	Jul
BOLD:ACN2557	*Forcipomyia monilicornis*			1	Jun
BOLD:ABW3952	*Forcipomyia sphagnophila* or *F. nigrans**	4	Mar, Jun	3	Jul
BOLD:ABW3964	*Forcipomyia sphagnophila* or *F. nigrans**			8	Jun, Jul, Aug
BOLD:ACX3286	*Palpomyia spinipes*	1	Aug		
Barcode silence					
BOLD:AFM9892	Ceratopogonidae	1	Aug	2	May, Jul
BOLD:AGN3401	Ceratopogonidae			1	Jun
BOLD:AGR1629	Ceratopogonidae			1	May
BOLD:AEH2536	Ceratopogonidae			10	Jun
BOLD:ADM5192	Ceratopogonidae			1	Jul
BOLD:AGL8523	Forcipomyiinae			1	May

Table 7. BOLD BINs from the family Ceratopogonidae captured at the Holy Loch Nature Reserve, Sandbank, Argyll, Scotland, in 2024 from carr woodland (Wood) and the saltmarsh-based habitat mosaic (Marsh), and assigned to four taxonomy confidence categories. This includes the total number caught as adults in 2024 and the months in which they were trapped. *These BINs had maximum similarity with at least two species. Identified by manual BLAST and BOLD.

BIN	Location	Catch details
BOLD:AAB8624	Saltmarsh field drain	2 larvae on 15th Sep
BOLD:ACX9864	Saltmarsh field drain	1 larva on 15th Sep
BOLD:ACX9864	Marsh	1 or 2 adults in Jan, Feb, Mar, Jun, Jul, Aug
BOLD:AFJ9886	Wood	1 adult in Mar
BOLD:AGO5113	Wood	1 adult in Jun

Table 8. Mixed category BINs from adult and larval *Simulium* species from carr woodland (Wood) and the saltmarsh-based habitat mosaic (Marsh) at Holy Loch Nature Reserve, Sandbank, Argyll, Scotland, in 2024, their trapping locations and dates.

REFERENCES

Antil S., Abraham, J.S., Sripoorna, S., Maurya, S., Dagar, J., Makhija, S. *et al.* (2023). DNA barcoding: an effective tool for species identification. *Molecular Biology Reports* 50, 761–775. https://doi.org/10.1007/s11033-022-08015-7

Armitage, P., Cranston, P.S. & Pinder, L.C.V. (1995). *The Chironomidae: Biology and Ecology of Non-Biting Midges*. Springer, Berlin. https://doi.org/10.1007/978-94-011-0715-0

Banerjee, A., Chakrabarty, M., Rakshit, N., Bhowmick, A.R. & Ray, S. (2019). Environmental factors as indicators of dissolved oxygen concentration and zooplankton abundance: deep learning versus traditional regression approach. *Ecological Indicators* 100, 99-117. https://doi.org/10.1016/j.ecolind.2018.09.051

Blackwell, A., Mordue, A.J., Young, M.R. & Mordue, W. (2009). Bivoltinism, survival rates and reproductive characteristics of the Scottish biting midge, *Culicoides impunctatus* (Diptera: Ceratopogonidae) in Scotland. *Bulletin of Entomological Research* 82, 299-306. https://doi.org/10.1017/S0007485300041055

Blaxter, M., Mann, J., Chapman, T., Thomas F., Whitton, C., Floyd, R. & Abebe, E. (2005). Defining operational taxonomic units using DNA barcode data. *Philosophical Transactions of the Royal Society B* 360, 1935-1943. https://doi.org/10.1098/rstb.2005.1725

Buche, L., Spaak, J.W., Jarillo, J. & De Laender, F. (2022). Niche differences, not fitness differences, explain predicted coexistence across ecological groups. *Journal of Ecology* 110, 2785–2796. https://doi.org/10.1111/1365-2745.13992

Carstensen, J. & Duarte, C.M. (2019). Drivers of pH variability in coastal ecosystems. *Environmental Science & Technology* 53, 4020-4029. https://doi.org/10.1021/acs.est.8b03655

Davies, L. (1966). The taxonomy of British blackflies (Diptera: Simuliidae). *Transactions of the Royal Entomological Society* 118, 413-506. https://doi.org/10.1111/j.1365-2311.1966.tb00832.x

Davies, L. (1968). *A Key to the British Species of Simuliidae (Diptera) in the Larval, Pupal and Adult Stages*. Scientific Publication No 24. Freshwater Biological Association, Milnthorpe.

Engel, M.S., Ceríaco, L.M.P., Daniel, G.M., Dellapé, P.M., Löbl, I., Marinov, M. *et al.* (2021). The taxonomic impediment: a shortage of taxonomists, not the lack of technical approaches. *Zoological Journal of the Linnean Society* 193, 381-387. https://doi.org/10.1093/zoolinnean/zlab072

Ferrante, M. (2025). The niche concept in a changing world. *Nature Reviews Biodiversity* 1, 419. https://doi.org/10.1038/s44358-025-00060-x

García, L. & Pardo, I. (2015). Food type and temperature constraints on the fitness of a dominant freshwater shredder. *International Journal of Limnology* 51, 227-235. https://doi.org/10.1051/limn/2015017

Hebert, P.D., Cywinska, A., Ball, S.L. & deWaard, J.R. (2003). Biological identifications through DNA barcodes. *Proceedings of the Royal Society B Biological Sciences* 270, 313-21. https://doi.org/10.1098/rspb.2002.2218

IPBES (2019). Summary for policymakers of the global assessment report on biodiversity and ecosystem services. Zenodo https://doi.org/10.5281/zenodo.3553458 Accessed 20th January 2026.

King, S., Nicholls, M., Scales, J., Gubbins, S., Pearce-Kelly, P., Saverimuttu, S. *et al.* (2025). The efficacy of vector-proof accommodation for the protection of livestock against *Culicoides* biting midges. Parasites & Vectors 18, 108. https://doi.org/10.1186/s13071-025-06736-9

Langton, P.H. & Pinder, L.C.V. (2007). *Keys to the Adult Male Chironomidae of Britain and Ireland*. Special Publication 64. Freshwater Biological Association, Ambleside, Cumbria.

Lawniczak, M.K.N., Davey, R.P., Rajan, J., Pereira da Conceição, L.L., Kilias, E., Hollingsworth, P.M. *et al.* (2022). Specimen and sample metadata standards for biodiversity genomics: a proposal from the Darwin Tree of Life project. *Wellcome Open Research* https://doi.org/10.12688/wellcomeopenres.17605.1

Mullens, B.A., McDermott, E.G. & Gerry, A.C. (2015). Progress and knowledge gaps in *Culicoides* ecology and control. *Veterinaria Italiana* 51, 313-323.

Mullis, K., Faloona, F., Scharf, S., Saiki, R., Horn, G. & Erlich, H. (1986). Specific enzymatic amplification of DNA in vitro: the polymerase chain reaction. *Cold Spring Harbor Symposia on Quantitative Biology* 51, 263-73. https://doi.org/10.1101/SQB.1986.051.01.032

Namayandeh, A., Guerra, S., Islam, N. & James, T. (2024). New species and a fascinating diversity of Chironomidae (Diptera, Insecta) in and around an overlooked urban vernal pool. *ZooKeys* 1208, 133-163. https://doi.org/10.3897/zookeys.1208.124495

Park, N., Dawson, E., Thurston, S., Tuameh, A., Mosca, M.M., Pereira da Conceição, L. *et al.* (2023). High-throughput DNA barcoding library construction and sequencing protocol for BIOSCAN using unpurified non-destructively extracted DNA from arthropods. *Protocols.io.* https://doi.org/10.17504/protocols.io.8epv5jzxdl1b/v1

Porter, T.M. & Hajibabaei, M. (2018). Scaling up: a guide to high-throughput genomic approaches for biodiversity analysis. *Molecular Ecology* 27, 313-338. https://doi.org/10.1111/mec.14478

Ratnasingham, S. (2019). mBRAVE: the multiplex barcode research and visualization environment. *Biodiversity Information Science and Standards* 3: e37986. https://doi.org/10.3897/biss.3.37986

Ratnasingham, S. & Hebert, P.D.N. (2007). BOLD: The Barcode of Life Data System. *Molecular Ecology Notes* 7, 355–364. https://doi.org/10.1111/j.1471-8286.2007.01678.x

Ratnasingham, S. & Hebert, P.D.N. (2013). A DNA-

based registry for all animal species: the Barcode Index Number (BIN) system *PLoS ONE* 8(7): e66213.
https://doi.org/10.1371/journal.pone.0066213

Roslin, T., Somervuo, P., Pentinsaari, M., Hebert, P.D.N., Agda, J., Ahlroth, P. *et al.* (2022). A molecular-based identification resource for the arthropods of Finland. *Molecular Ecology Resources* 22, 803–822.
https://doi.org/10.1111/1755-0998.13510

Scudder, G.G.E. (2017). The importance of insects. In: Foottit, R.G. & Adler, P.H. (Editors). *Insect Biodiversity: Science and Society Vol. 1* (2nd edition), pp.9-43. John Wiley & Sons, Hoboken, New Jersey.
https://doi.org/10.1002/9781118945568.ch2

Tarakhovskaya, E.R. & Garbary, D.J. (2009). *Halocladius variabilis* (Diptera: Chironomidae): a marine insect symbiotic with seaweeds from the White Sea, Russia. *Journal of the Marine Biological Association of the United Kingdom* 89, 1381-1385.
https://doi.org/10.1017/S0025315409000071

Tedesco, P.A., Bigorne, R., Bogan, A.E., Giam, X., Jézéquel, C. & Hugueny, B. (2014). Estimating how many undescribed species have gone extinct. *Conservation Biology* 28, 1360-1370.
https://doi.org/10.1111/cobi.12285

Urban, M.C. (2024). Climate change extinctions. *Science* 386, 1123-1128.
https://doi.org/10.1126/science.adp4461

Wellcome Sanger Institute (2026). BIOSCAN.
https://www.sanger.ac.uk/collaboration/bioscan/
Accessed 20th January 2026.

Werritty, A. & Sugden, D. (2012). Climate change and Scotland: recent trends and impacts. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh* 103, 133-147.
https://doi.org/10.1017/S1755691013000030

Wheeler, Q.D., Raven, P.H. & Wilson, E.O. (2004). Taxonomy: impediment or expedient? *Science* 303, 285.
https://doi.org/10.1126/science.303.5656.285

Xu, H.F., Lv, M.Y., Zhao, Y., Zhang, Z.C., Z., Liu, Z. & Lin, X.L. (2025). Cryptic diversity and climatic niche divergence of *Brillia* Kieffer (Diptera: Chironomidae): insights from a global DNA barcode dataset. *Insects* 16(7), 675.
https://doi.org/10.3390/insects16070675

The Glasgow Naturalist (2026) Volume 28, Part 4, 32-49

SHORT NOTES

https://doi.org/10.37208/tgn28404

Notes on the shieldbugs and allied species (Hemiptera: Coreoidea, Pentatomoidea and Pyrrhocoroidea) found in the Clyde area, Scotland

R.B. Weddle

89 Novar Drive, Glasgow G12 9SS

E-mail: richard@canto.plus.com

Only five shieldbugs are listed as having been recorded in the Clyde area prior to the 20th century (Murphy, 1901): cow-wheat shieldbug (*Sehirus biguttatus*, now *Adomerus biguttatus*), red-legged shieldbug (*Tropicoris rufipes*, now *Pentatoma rufipes)*, spiked shieldbug (*Picromerus bidens*), birch shieldbug (*Acanthosoma dentatum*, now *Elasmostethus interstinctus*), and parent bug (*Acanthosoma interstinctum*, now *Elasmucha grisea*).

There have been many new heteropteran species arriving in the area since then, particularly in the last 25 years, some of which may reflect range expansion due to climate change. Also, some longer established species have apparently increased in numbers, perhaps for the same or related reasons. This account focuses on those species found in the Clyde catchment area which are in the group covered by the U.K. national recording scheme for shieldbugs and allies.

In the following account, National Biodiversity Network is abbreviated as NBN, National Museum of Scotland as NMS, Biological Records Centre as BRC, United Kingdom Species Index as UKSI, and Scottish Insect Records Index as SIRI.

Occurrences in the Clyde area described below are based on records from Glasgow Museums BRC. Information from the NBN Atlas (NBN, 2025) was obtained in October 2025. To avoid the need for an excessive number of separate references to the Atlas, a link to it is supplied for each species. This link also enables access to at least one photograph of the species.

It should also be borne in mind that the NBN Atlas is a work in progress, and it is acknowledged that many extant biological records have still to be added. However, for this group, the Atlas seems to present a reasonably complete representation of both the species present in the Clyde area, and those in Scotland generally, as the U.K. recording scheme for this group seems to be unusually good at keeping the Atlas up to date with records submitted to them. Glasgow Museums BRC has uploaded all their shieldbug records up to 2024, and other Scottish BRCs and recording groups also seem to be reasonably up to date. NBN also gleans verified records from online recording applications such as iRecord and iNaturalist.

Superfamily Coreoidea

Coreidae

Western conifer seed bug, *Leptoglossus occidentalis* Heidemann, 1910
https://species.nbnatlas.org/species/NHMSYS0020476639

This is a non-native species which is included in the U.K. recording scheme for shieldbugs and allies. It is associated with pines, particularly Scots pine (*Pinus sylvestris*). The first U.K. record was in 2007, and it was first recorded in the Clyde area in 2020. There are records from Faifley (West Dunbartonshire), the Whitehills area of East Kilbride (South Lanarkshire) and Skelmorlie (North Ayrshire) (NBN, 2025). Glasgow Museums BRC also has a record from Biggar (South Lanarkshire). Despite the paucity of records from north of the border, Jones (2023) states that "it is currently vying with *P. rufipes* as Britain's most widespread shieldbug species" although this is based on geographical distribution, rather than frequency of sightings: it has been recorded in both Orkney and Shetland, whereas *P. rufipes* has been recorded only as far as the mainland north coast.

Rhopalidae

Cinnamon bug, *Corizus hyoscyami* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020309113

Though there is currently just one record in the Clyde area - from a garden in Dumbarton (West Dunbartonshire) in 2024 - this hides the fact that the species appears to be spreading rapidly northwards. The map in Bantock (2018) shows the most northerly U.K. records in South Lancashire and South Yorkshire, and Jones (2023) states that it had "just about" got into Scotland with records from Berwick and Dumfries. Now the NBN Atlas shows many records in the Scottish Borders and the Lothians, and two in Ayrshire dated 2022 and 2025, as well as the Dumbarton record already mentioned.

Historically, this was regarded as a species of dunes and coastal undercliffs, and many of the recent Scottish records are, indeed, coastal; the 2025 Ayrshire record is from Troon, and the Dumbarton record is from a domestic garden very close to a raised beach. However, as in England, the majority of the records are inland.

The adult has a striking red and black colouration, so is unlikely to be missed if present (though the nymphs are rather duller), so the spread is likely to be due to natural causes such as climate change rather than under-recording.

Superfamily Pentatomoidea
Acanthosomatidae
Hawthorn shieldbug, *Acanthosoma haemorrhoidale* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020308885
This species, which in 1892 seems to have been found no further north than Cannock Chase (Staffordshire) (Saunders, 1892), clearly spread northwards gradually over the subsequent 60 years, and though, in Southwood & Leston (1959), the northerly limit is still given as "Cumberland and Durham", the first Scottish record was in Kirkcudbright (Dumfries and Galloway) in 1946. By 1960, it had reached the Clyde area with records at Rothesay (Isle of Bute) in 1960, and the University of Glasgow Field Station at Rowardennan (East Loch Lomond) in 1969 (Hill, 1973). The subsequent spread, particularly from the 1990s onwards, is described, and records listed, by Ramsay (2014).

Bantock (2018) shows a general distribution over southern and central Scotland, extending up the north-east coast and the coast of the Moray Firth. The NBN Atlas adds records up the north of the mainland and in Shetland, though not apparently Orkney. Haddow (2024) points out that it is largely absent from upland areas in south-west Scotland, and the same is true in the Clyde area (NBN, 2025) though this may be partly due to recording being biased in favour of lowland areas.

Both Ramsay (2014) and Haddow (2024) point out that along with the range expansion, this species has diversified its range of host plants. In England, it has been found on some 27 tree species, though breeding only on Rosaceae. In Scotland, the number of associated plant species is considerably fewer, and breeding has been observed only on hawthorn (*Crataegus monogyna*) and *Cotoneaster* spp. (Ramsay, 2014).

It is also attracted to moth traps, including that at Glasgow Botanic Gardens.

Juniper shieldbug, *Cyphostethus tristriatus* (Fabricius, 1787)
https://species.nbnatlas.org/species/NHMSYS0020309134
Southwood & Leston (1959) stated that this species was confined to lowland and downland juniper woods (*Juniperus communis*), south of Lancashire, and was unknown in Scotland. However, the first record in Dumfries and Galloway was found on Leyland cypress (x *Cuprocyparis leylandii*) in 2008, and by 2024 it had reached Ochiltree cemetery, Ayrshire (Haddow, 2024). In the same year, a record in Biggar cemetery (South Lanarkshire) established the first record in the Clyde area (iRecord). There are also several records in more easterly and northerly areas of Scotland, particularly in upland areas.

In England, it has, since 1970, been spreading onto introduced cypresses and cedars, particularly Lawson's cypress (*Chamaecyparis lawsoniana*) in parks and gardens, and so it is now widespread in many parts of England (Bantock, 2018). Haddow (2024) also points out that the association with juniper will limit the number of records in the wild, while it may at the same time be under-recorded on cypresses in parks and gardens.

Birch shieldbug, *Elasmostethus interstinctus* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020309198
Records of this species in the Clyde area date back to the 19th century, and it is still plentiful, particularly, but not exclusively, on birch.

Murphy (1901) followed the arrangement and nomenclature used by Saunders (1892) and Saunders himself identified most of the species in Murphy's list. Thus, Murphy (1901) lists this species as "*Acanthosoma dentatum*", corresponding to the junior synonym *Elasmostethus dentatus* (De Geer) in UKSI. By the same token, the entry "*Acanthosoma interstinctum*" in Murphy's list confusingly represents *Elasmucha grisea* (see below).

It is common everywhere in the Clyde area, though apparently recorded rather patchily, given the ubiquity of birch across the area. It is also attracted to moth traps, including that at Glasgow Botanic Gardens.

Parent bug, *Elasmucha grisea* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020309200
This species is so-called because the females brood the eggs and young nymphs. It is listed as *Acanthosoma interstinctum* in Murphy (1901) and was swept from the same birch tree in Luss, Argyll, as the birch shieldbug listed as *A. dentatum*. As stated above, Murphy (1901) followed the nomenclature of Saunders (1892). This was different from that of the latest British list of Heteroptera; indeed, whereas Douglas & Scott (1865) had listed *Acanthosoma dentatum* and *A. griseum* (with *Cimex interstinctus* Linnaeus as a junior synonym), Saunders (1892) listed *Acanthosoma* (*A.*) *dentatum* and *A.* (*Elasmostethus*) *interstinctum* (with *griseum* auctt. nec Linnaeus as junior synonym). A better understanding of this confusion in the early British list of Heteroptera can be obtained from Dallas (1851), Reuter (1884) and Horváth (1899).

It is recorded less frequently than the birch shieldbug, but is widely distributed on birch and alder, and so may be under-recorded.

Cydnidae
Cow-wheat shieldbug, *Adomerus biguttatus* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020308901
A Nationally Scarce species, the only record in the Clyde area is from Garelochhead (Argyll) in the late

19th century (Murphy, 1901); there are also scattered records from elsewhere in Scotland (NBN, 2025) including late 19th century records from Perthshire (McGregor, 1893). It is a species of woodland rides and coppices, feeding on common cow-wheat (*Melampyrum pratense*) and has declined following abandonment of traditional woodland management (Bantock, 2018). Indeed Ramsay (2019) considered it extinct in Scotland, but, having cited that, Jones (2023) goes on to say that the discovery of an insect in Strathspey in the Cairngorms in early 2021 made the news headlines, thus highlighting the fact that as a ground-dwelling insect, it could easily be overlooked.

The Hemiptera catalogue of the Hunterian Museum in Glasgow includes a 1914 sighting from Nethy Bridge in Strathspey, collected by J.J.F.X. King; the 2021 records were from further downstream at Curr Wood near Dulnain Bridge (Grantown on Spey, Moray).

Pentatomidae
Subfamily Asopinae
The species in this subfamily differ from the other species in the superfamily Pentatomoidea by being carnivorous, at least in the adult and later instar stages. This is considered to be a late evolutionary development (Jones, 2023).

Spiked shieldbug, *Picromerus bidens* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020309660
The earliest record of this species in the Clyde area is from Dargavel (Bishopton, Renfrewshire) in 1899 (Murphy, 1901), though Saunders (1892) lists only southern English locations. Southwood & Leston (1959) described it as being widely distributed, though less common in the north, and this is still true (Jones, 2023). It is common in Gleniffer Braes Local Nature Reserve near Paisley, and has been recorded in the RSPB reserves at Lochwinnoch, Baron's Haugh, and Fannyside, as well as the Scottish Wildlife Trust reserves at Cathkin Marsh (South Lanarkshire), and Possil Marsh (Glasgow). The spread is from Inverkip, Inverclyde and Havoc, Dumbarton in the west, to Harthill, North Lanarkshire, and Tarbrax, South Lanarkshire in the east.

The adult pronotum has distinctive spine-like anterior angles. Another feature that is unusual for a shieldbug is that they overwinter as eggs. They prey on the larvae, and sometimes adults, of leaf-beetles, Lepidoptera, and sawflies.

Heather shieldbug, *Rhacognathus punctatus* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020309768
There are records of this species from Dumfriesshire (VC72) as far back as 1935, and there is a record from Rannoch in the 1860s (both SIRI). However, the earliest record in the Clyde area found so far is from Caldarvan, near Gartocharn (West Dunbartonshire) in 1983, and there has been a recent record from Ballagan, near Strathblane (Stirlingshire) in 2024 (M. Greve, pers. comm.).

Haddow (2024) describes it as one of the rarest shieldbugs in south-west Scotland (i.e. Dumfries and Galloway, as there are no known records from Ayrshire), but adds that it is easily overlooked as it seems to prefer less accessible habitats. Jones (2023) concurs, describing it as widely-scattered and local.

It feeds on adults and larvae of leaf-beetles such as the heather leaf-beetle *(Lochmaea suturalis*) (Jones, 2023).

Bronze (or banded) shieldbug, *Troilus luridus* (Fabricius, 1775)
https://species.nbnatlas.org/species/NHMSYS0020309921
The first Clyde specimen of this species was found by the author on a birch tree at the edge of Malls Mire Local Nature Reserve in Glasgow, in 2014. At that time, the only other Scottish records in the NBN Atlas were in the Lothians, though Haddow (2024) mentions that the majority of records in the south-west Scotland (south of the Clyde area) date from 2010 onwards, and NMS holds specimens from Dumfriesshire from the late 1970s.

It is now widespread across the Greater Glasgow area, from Havoc Meadow and RSPB Loch Lomond in West Dunbartonshire, and RSPB Baron's Haugh and Greenhead Moss in North Lanarkshire to RSPB Lochwinnoch in Renfrewshire, and Cathkin Marsh SWT reserve and Douglas Castle estate in South Lanarkshire. The main increase in the number of records here has occurred since 2022, and this arrival and spread are likely to be due mainly to natural causes such as climate change.

It is a predator of moth and sawfly caterpillars, beetle larvae and other small invertebrates (Jones, 2023).

Blue shieldbug, *Zicrona caerulea* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020109277
The earliest record of this relatively small, shining blue species in the Clyde area is from Aberfoyle (Stirlingshire) in 1897 (Evans, 1900), and McGregor (1893) lists a Perthshire location. However, no further Scottish records are evident until Crowson (1954-1996) found it at Mugdock Wood SSSI near Milngavie (East Dunbartonshire) in 1958, and again in 1980 (Crowson, 1954-1996). It seems not to have been found again until 2019 in South Haugh, Hamilton Low Parks (South Lanarkshire), and then sporadically at Overtoun Estate, Dumbarton, Little Sparta near Dunsyre in South Lanarkshire, and two locations in Renfrewshire - East Craigend and Bishopton. This last record is of nymphs in a tree nursery in 2025, and may be an example of breeding in a horticultural environment, though there seems no reason to suppose that any of the other records are other than naturally occurring. Bantock (2018) describes it as scarce in Scotland. Yet, though small (5-8 mm) by shieldbug standards, its metallic blue colour should make it noticeable in both the adult and

nymph stages (the latter also brightly marked with red). Nevertheless, Haddow (2024) points out that it is probably under-recorded as, apart from being small, it moves quickly.
It feeds on larvae, and sometimes adults of leaf beetles (Jones, 2023).

Subfamily Pentatominae

Hairy shieldbug, *Dolycoris baccarum* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020309177
Although Bantock (2018) shows this species in Scotland only in south-west and east-central coastal areas, there is a 19th century record from Perth (McGregor, 1893). However, since 2020 it has been recorded in numerous locations in Glasgow; in particular it seems to be thriving at Hamiltonhill Claypits Local Nature reserve. It has also been recorded in Bonhill, West Dunbartonshire, Bishopton in Renfrewshire, at RSPB Baron's Haugh and Carbarns in North Lanarkshire, and at Newton in South Lanarkshire. This spread seems likely to be mainly natural, though it may have been recently introduced on tree saplings at Hamiltonhill Claypits.

Green shieldbug, *Palomena prasina* (Linnaeus, 1761)
https://species.nbnatlas.org/species/NHMSYS0020109266
Nau (2003) reported that over the preceding decade this species had progressively colonised Bedfordshire, so that while previously scarce, it was by then a familiar and common species. By 2018, it had reached Northumberland and was described as still spreading (Bantock, 2018). It was first recorded in south-west Scotland near Lochmaben (Dumfries and Galloway) in 2010 (Haddow, 2024), reaching the Clyde area by 2021, where it has been recorded several times since 2021 in The Hidden Gardens, Pollokshields, Glasgow, and once in a garden near Strathaven (South Lanarkshire). Though, in these contexts, it could well have been introduced on plant material rather than by natural spread.

Southern green shieldbug, *Nezara viridula* Linnaeus, 1758
https://species.nbnatlas.org/species/NHMSYS0020309518
Southwood & Leston (1959) describe this as a "cosmopolitan insect", often imported in fruit and vegetables from Italy and the Canaries, and unlikely to become established. However, it was found breeding in south-east England in 2003 (Salisbury *et al*., 2009). The first Clyde record of this species was in 2007 from Clarkston, East Renfrewshire, found in a lettuce bought from a supermarket, so probably not of Scottish provenance. Another in 2018 was found in Irvine (North Ayrshire) inside a car rear light unit built in Romania. A third apparent record at Helensburgh on the NBN Atlas is marked as incorrect, and re-identified as hawthorn shieldbug (*A. haemorrhoidale*; see above).

However, there may be one Clyde record "in the wild", more accurately in a cultivated raised bed, at North Kelvin Meadow, Glasgow in 2017, though this has been rejected by the national scheme, as the lack of photographic evidence makes it unverifiable. In the present author's opinion, it is more likely to have been *P. prasina,* as the circumstances are similar to the 2021 above-mentioned record at The Hidden Gardens, and that species is now widespread in southern Scotland.

Now listed on UKSI as an established non-native, Jones (2023) states that this is a major pest of crops such as broad beans and peas and is widespread in south-east England, though currently the NBN Atlas shows records as far north as Newcastle upon Tyne, and of the Scottish records shown there, and not already mentioned here, only one, from Portsoy (Aberdeenshire), is not apparently associated with imported fruit or vegetables. Nevertheless, Jones also cites evidence that it can also be imported in horticultural material, and if it were to become established in the Clyde area, it would likely pose a severe problem for gardeners and allotment-holders.

Red-legged shieldbug (or forest bug), *Pentatoma rufipes* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020309624
Records of this species in the Clyde area date back to the 19th century. It is listed by Murphy (1901) as *Tropicoris rufipes,* and described as "not uncommon on birch", though only five locations are cited. There are curiously few 20th century records, mostly in the second half of the century, which may indicate under-recording at that time, as there is a plethora of 21st century records from all parts of the area, particularly since the advent of online recording systems such as iNaturalist.

It feeds on the sap and fruits of mostly broad-leaved tree species, though it has also been observed feeding on honeydew and insects such as aphids and moth caterpillars (Jones, 2023).

Gorse shieldbug, *Piezodorus lituratus* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020309665
Though not listed in Murphy's 1901 list for the Clyde area, SIRI includes several reports of this species' presence in Scotland since at least the late 19th century. The earliest record in the Clyde area is at Gartness, Stirlingshire, in 1939 (Hunterian Collection), but there are few subsequent records until the 21st century, in which there have been some 40 records, some even within the City of Glasgow, at Cathkin Braes and Hamiltonhill Claypits Local Nature Reserves. So, while the records from those two sites, along many others from other designated conservation sites, may well illustrate the success of local biodiversity initiatives, in view of Southwood & Leston's (1959) statement that the species occurs wherever gorse is present, it is likely that the species is generally under-recorded.

Cabbage (or brassica) shieldbug, *Eurydema oleracea* (Linnaeus, 1758)

https://species.nbnatlas.org/species/NHMSYS0020309225
This is found in much of southern England, but is commonest in the south-east. It feeds on a wide range of crucifers, but seems particularly associated with horseradish (*Armoracia rusticana*). The only occurrence in the Clyde area was in 2006, in Hyndland, Glasgow, in flowers from a florist which had probably been imported.

Eurydema liturifera (Walker, 1867)
As this species is not on UKSI, there is no NBN distribution map.
This east Asian species is included because of a single specimen found in grapes in Prestwick (South Ayrshire) in 1987, now in NMS collections under *Eurydema lituriferum*. Though found in Ayrshire, it is included here as it is within the wider "Clyde area" as understood by earlier naturalists such as Murphy (1901), and it is not mentioned in Haddow (2024).

Superfamily Pyrrhocoroidea
Pyrrhocoridae
Firebug, *Pyrrhocoris apterus* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020309752
This is the only U.K. species in this superfamily, and in the U.K. it is mainly confined to the south. There is only one Scottish record: a specimen was found in supermarket blueberries in the West End of Glasgow in 2019 and is now deposited in the Hunterian Museum.
Like the cinnamon bug, the adult has a striking red and black colouration, but the nymphs in this species are similarly coloured too.

Bantock (2018) states that it is unlikely to spread quickly through natural means, as fully winged specimens have not been recorded in the U.K. However, Jones (2023) reports that a large colony of long-winged forms was recorded in Essex in 2020 and is "possibly the prelude to a much wider spread", though as the English records currently represent the species' northern and western limit, it seems unlikely to appear in Scotland in the near future.

Possible future arrivals
There are no species from the other heteropteran families covered by the U.K. recording scheme that have been recorded in the Clyde area, although many shieldbugs that are not dependent on rare habitats such as breckland seem to be spreading northwards, possibly due to climate change, and the following species have either already appeared elsewhere in Scotland or may well appear here in the coming years. Of course, there may also be more vagrants introduced on fruit and vegetables or in horticultural material. These are by their nature unpredictable, although one or two of the latter may become established.

Evidence for a northward spread is detectable by comparing the distribution maps currently shown in the NBN Atlas with those in Bantock (2018) and looking for signs of movement northwards that reaches at least north Lancashire or north Yorkshire. Although, for the reasons outlined in the introduction, it is likely that Scottish records are reasonably up-to-date and reliable, the author is unable to evaluate how up-to-date the English records are. It seems, however, that the national recording scheme's records are complete to at least August 2025 and any change is more likely to be under-estimated than otherwise. It is also possible, however, that in these northern areas some of the apparent increase is due to previous under-recording.

Coreidae
Denticulate leatherbug (or trefoil bug), *Coriomeris denticulatus* (Scopoli, 1763)
https://species.nbnatlas.org/species/NHMSYS0020309108
Bantock (2018) shows records only as far north as the Tyne, but NBN currently has records in the Lothians, so it is possible that this bug may soon be found in the Clyde area too. The nymphs feed on leguminous plants, particularly black medic (*Medicago lupulina*) which is found widely here.

Rhopalidae
Marram bug, *Chorosoma schillingi* (Schilling, 1829)
https://species.nbnatlas.org/species/NHMSYS0020309082
Since 2018, records have been found on the south Cumbrian coast. Jones (2023) describes it as local, but not uncommon, and that it has been recorded inland included along the Thames as far as west London. If it colonises the south-westerly coasts of Scotland, it could therefore potentially reach well into the Clyde area. The food plants include, as the vernacular name suggests, marram grass (*Ammophila arenaria*), and other grasses not necessarily on dunes.

The insect is long and narrow, both at the adult and nymph stages, so could initially be mistaken for a damselbug (Nabidae).

Liorhyssus hyalinus (Fabricius, 1794)
https://species.nbnatlas.org/species/NHMSYS0020309367
Though noted by Bantock (2018) as "Nationally Scarce" and largely migratory, the NBN Atlas now shows this species is much more widespread, though both concur that the most northerly records are in Cumbria. Jones (2023) confirms it as more widespread, and "permanently, if erratically established". In view of its migratory capabilities, it is likely to reach Scotland if areas develop with suitably warm, dry soils. Jones also mentions that it is particularly common in brownfield sites such as those along the Thames estuary.

Myrmus miriformis (Fallén, 1807)
https://species.nbnatlas.org/species/NHMSYS0020309492
This is another long, narrow bug which, as its specific epithet suggests, could be mistaken for a mirid bug, but for the presence of ocelli. Since 2018, records have been found as far north as Easington on the Durham coast and Silloth on the south Solway coast. The latter record is

marked as "unconfirmed" in the NBN Atlas. However, as this refers to a specimen in the collection at Tullie in Carlisle that was collected by Stephen Hewitt, an experienced naturalist, there is little reason to doubt it, particularly as there are also records further south on the Cumbrian coast in the area of St. Bees Head. Jones (2023) describes it as local, though where it occurs it is common on dry grasslands.

Cydnidae

Pied shieldbug, *Tritomegas bicolor* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020309919

This is described as fairly common in southern England and Wales as far north as South Yorkshire (Bantock, 2018), though Crowson (1974) found two adults in leaf-litter in Glen Nant, Argyll. Therefore, it could potentially be found in the Clyde area as it feeds on common plants such as white dead-nettle (*Lamium album*). Given its bold black and white colouration, it seems unlikely that Crowson was mistaken. However, there are neither further Scottish records in the NBN Atlas nor specimens in the Hunterian and NMS collections.

Pentatomidae

Bishop's mitre, *Aelia acuminata* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020308903

This species has spread northwards from south of the Humber (Bantock, 2018) to the Tees (NBN, 2025). Within that range, it is common on warm open grasslands where it feeds on various grasses.

Ornate shieldbug *Eurydema ornata* (Linnaeus, 1758)
https://species.nbnatlas.org/species/NHMSYS0020309226

This handsome red and black bug was first recorded in the U.K. in 1997 and up to 2018 had only been recorded in the extreme south (Bantock, 2018). Since then it has spread north as far as Market Drayton in Shropshire, and Whitby in North Yorkshire. The food plants are various Brassicaceae (cabbage family).

Woundwort shieldbug, *Eysarcoris venustissimus* (Schrank, 1776)
https://species.nbnatlas.org/species/NHMSYS0020309235

This species has expanded northwards from South Yorkshire (Bantock, 2018) to North Yorkshire (NBN, 2025), though Bantock states that it seems to have an easterly preference. Therefore, if it eventually reaches Scotland, it may not spread to the Clyde area. It feeds on common Lamiaceae (mint and deadnettle family), which are common enough here.

Scutelleridae

Tortoise bug, *Eurygaster testudinaria* (Geoffroy, 1785)
https://species.nbnatlas.org/species/NHMSYS0020309231

Haddow (2024) mentions that this has seen a prolific expansion in range in England and Ireland in recent years, though it has not yet been recorded in south-west Scotland. Bantock (2018) shows the species present only in South Wales and England south of The Wash, but the NBN Atlas currently shows records as far north as Lancaster and Scarborough, evidencing some northerly spread.

ACKNOWLEDGEMENTS

Thanks are due to Malcolm Haddow for discussions and a copy of his booklet, to Jeanne Robinson (Hunterian Museum) and Robyn Haggard (Glasgow Museums) for access to specimens in those collections, and to Ashleigh Whiffin (NMS) for facilitating access to specimens and SIRI. I would also like to thank Valérie Lemaître and Mick Webb for helpful comments on the text.

REFERENCES

Bantock, T. (2018). Provisional atlas of shieldbugs and allies. www.britishbugs.org.uk/Provisional_atlas_of_shieldbugs_and_allies_2018.pdf Accessed October 2025.

Crowson, R.A. (1954-1996). *Field Diaries*. (Unpublished MS). Natural History Museum, London.

Dallas, W.S. (1851). XV. Note on the British species belonging to the genus *Acanthosoma*, Curt. *Transactions of the Entomological Society of London* 6(4), 109-114. https://doi.org/10.1111/j.1365-2311.1851.tb02490.x

Douglas, J.W. & Scott, J. (1865). *The British Hemiptera. Vol. 1. Hemiptera-Heteroptera*. Ray Society, London. https://doi.org/10.5962/bhl.title.7908

Evans, W. (1900). Some records of Scottish Coleoptera and Hemiptera. *Annals of Scottish Natural History* 9(33), 91-103.

Haddow, M. (2024). Shieldbugs in south-west Scotland. South West Scotland Environmental Information Centre, Kirkgunzeon, Dumfriesshire.

Hill, A.R. (1973). Short notes: hawthorn shieldbug. *The Glasgow Naturalist* 19(1), 59.

Horváth, G. (1899). Remarques synonymiques sur les hémiptères paléarctiques. *Revue d'Entomologie* 17(1898), 275-281.

Jones, R. (2023). *Shieldbugs*. William Collins, London.

McGregor, T.M. (1893). A list of the Hemiptera Heteroptera and Homoptera occurring in Perthshire. *Annals of Scottish Natural History* 2(8), 213-221.

Murphy, J.E. (1901). Order Hemiptera. Sub-Order Heteroptera. In: Scott Elliot, G.F., Laurie, M. & Murdoch, J.B. (Editors) *Fauna, Flora and Geology of the Clyde Area*, pp. 306-308. University of Glasgow Press, Glasgow.

Nau, B.S. (2003). On confusion between *Palomena prasina* (L.) and *Holcostethus vernalis* (Wolff) (Hem., Pentatomidae), with a correction. *Entomologist's Monthly Magazine* 139, 96.

NBN (2025). NBN Atlas. https://nbnatlas.org

Ramsay, A.J. (2014). The history and status of the hawthorn shieldbug *Acanthosoma haemorrhoidale* (Hemiptera: Acanthosomatidae) in Scotland, 1946-2008. *British Journal of Entomology and Natural History* 27(2), 81-91.

Ramsay, A.J. (2019). A review of Scottish records of

Adomerus biguttatus (L.) (Hemiptera: Cydnidae) and comments on distribution in Scotland. *British Journal of Entomology and Natural History* 32, 321–325.
Reuter, O.M. (1884). Synonymisches über Hemipteren. *Revue Mensuelle d'Entomologie Pure et Appliquée* 1, 131-135.
Salisbury, A., Barclay, M.V.L., Reid, S. & Halstead, A. (2009). The current status of the southern green shieldbug, *Nezara viridula* (Hemiptera: Pentatomidae), an introduced pest species recently established in south-east England. *British Journal of Entomology and Natural History* 22, 198-194.
Saunders, E. (1892). *The Hemiptera Heteroptera of the British Islands*. L. Reeve & Co, London.
Southwood, T.R.E. & Leston, D. (1959). *Land and Water Bugs of the British Isles*. Warne, London.

https://doi.org/10.37208/tgn28406

A fish trap at Millport, Great Cumbrae, Scotland

J. Parnell

14 Glasgow Street, Millport, Great Cumbrae, North Ayrshire KA28 0DJ

E-mail: J.Parnell@abdn.ac.uk

The consumption of fish was critical to the diet of settlements around the Firth of Clyde (Rorke, 2005). One method of catching fish was through the use of boulder enclosures, or yairs, which were designed to trap fish on receding tides in the intertidal zone. Such fish traps are recorded at numerous localities in south-west Scotland, i.e. the Clyde estuary, and in the adjacent part of Northern Ireland. Focused studies of fish traps have reported multiple traps on the North Ayrshire coast (Patterson, 1989) and the Isle of Bute (Ferrier, 1969). Patterson (1989) measured 35 boulder alignments interpreted as fish traps along 14 km of North Ayrshire coastline. Boulder fish traps are conjectured to date variably back to the Mesolithic, but in many cases the time of use is unknown. This report documents a boulder-based fish trap at Millport on the adjacent island of Great Cumbrae and constraints on the timing of its use.

A fish trap was built across the mouth of the bay known as Foul Port (National Grid Reference NS157545), about 300 m west of Millport Pier, and can be surmised from bay dimensions to be up to 80 m long (Fig. 1). It consisted of "a great dyke of huge boulders", when observed in the late 18th century (Lytteil, 1877, 1886). Today it is represented by a residue of smaller boulders and stones, which form a prominent row at higher tides (Fig. 2). Boulders were readily available at coastal sites in south-west Scotland. The region was in a southward pathway for debris during Quaternary glaciation, which

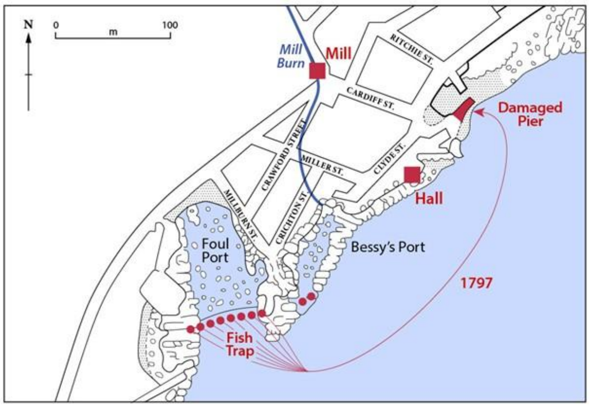


Fig. 1. Map of area west of Millport Pier, Great Cumbrae, Scotland, showing location of fish trap at Foul Port (red filled circles), which was dismantled to repair the pier in 1797. Barrier to create tidal pool at Bessy's Port also shown. "Hall" is site of Sheriff's Auld Ha', a probable site of administration. (Cartography: J. Bowie)

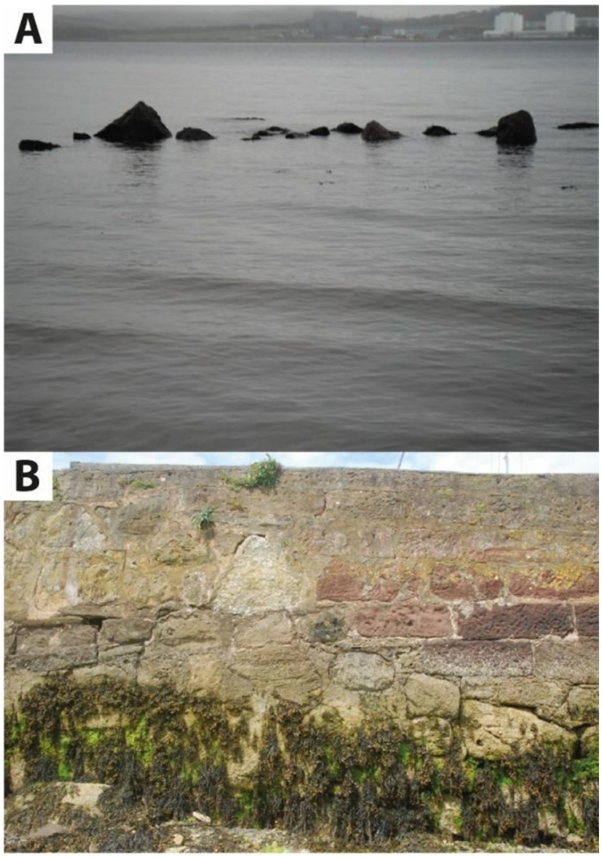


Fig. 2. Stonework at Millport, Great Cumbrae, Scotland. (A) Surviving row of small boulders and stones in sea at mouth of Foul Port, representing remains of fish trap. Background shows mainland shoreline at Hunterston, where fish traps have been discovered. (B) Outer (southern) wall of inner harbour at Millport Pier, showing boundary between (left) irregular residual boulders built up in 1797 from dismantled fish trap, and (right) red sandstone dressed slabs added subsequently. (Photo: I. Murray)

was a source of boulders for fish traps at least as far south as Wales (Bannerman & Jones, 1999). In the Firth of Clyde, the result is an abundance of rounded boulders (many >1 m), particularly including granites and gneisses derived from a basement of Precambrian rocks (Dalradian metasediments) and Caledonian granites which outcrop to the north. This part of the Firth of Clyde is characterised by large boulders perched on ice-plucked sandstone shelves (Patterson, 1989). On Great Cumbrae, an island which constitutes a hill above the sea floor, boulders accumulated on the lee (sheltered) side where the town of Millport was established, so the raw material for constructing fish traps was readily available. However, the boulders were both the origin of the Foul Port fish trap and the reason for its demise.

The Foul Port trap is reputably at a site of Viking settlement (Lytteil, 1877; Campbell, 2003). Carved stonework, the "Millport lintel", found nearby, may have a Viking origin, dating from about the 10th century (Buchanan, 2012). The Viking presence in western Scotland and Ireland lasted several centuries until the Battle of Largs in 1263 (Graham-Campbell & Batey, 1998). As most Vikings lived in coastal communities, fish would have been a key part of their diet. Salmon was especially valuable as a source of fat and protein, and had the additional advantage that it could be preserved by burial, as in the preparation of gravlax (gravadlax). Salmon consumption by Vikings is so far proven in Norway (Ramstad *et al.*, 2011). Fish would have been a major resource in the Firth of Clyde, including salmon, for which the Firth is a major pathway between breeding rivers and the open ocean (Mackay & Doughty, 1986; Lilly *et al.*, 2022). In pre-Viking Scotland the inhabitants presumably caught small fish from the shore, then Viking settlers increased the consumption of fish, including the application of fish traps (Barrett *et al.*, 2004; Williamson, 2004). A well-resourced Viking community would have contributed to the power-house that they established in Strathclyde (Clarkson, 2014). In the immediate vicinity, between Foul Port and the pier, a site on Clyde Street known as Sheriff's Auld Ha', a residence of the Sheriff of Bute, could have been a centre for hunting etc. (Lytteil, 1886). Several fish traps elsewhere are linked to administrative centres, i.e. they were "owned" or "controlled" by ecclesiastical or landowner institutions (e.g. Hale, 2004; Montgomery *et al.*, 2015). Two date constraints for use of the Foul Port trap are discussed below, related to the history of Millport Pier.

An early, 18th century phase of Millport Pier's history had involved the quarrying of freestone (sandstone slabs) for the stonework of Portpatrick Harbour, Dumfries and Galloway, at the same time extending the harbour space at Millport. The plans for Portpatrick Harbour are dated 1770 (Smeaton, 1812), and the completion of the work using Millport stone is reported in the Old Statistical Account (Graham, 1794), which constrains the date of the quarrying. The evidence given to the Tidal Harbours Commission of 1846 specifies that the only pre-1820 building of a pier at Portpatrick following Smeaton's planning was in the 1770s, although it was subsequently washed away (Graham, 2015). This must be the pier which used Millport stone. The date of completion is given as 1774 by Ayton & Daniell (1818), and the Tidal Harbours Commission (1847). Workmen quarrying stone at Millport for Portpatrick in the late 18th century apparently mended breaches in the boulder barrier at Foul Port and were able to catch salmon (Anonymous, 1856). Therefore, the 1770s quarrying dates the period when the fish trap was in place.

The barrier of "great boulders" was dismantled to repair nearby Millport Pier, in 1796/1797, under the direction of James Crawford, captain of the revenue cutter for south-west Scotland (Reid, 1864). The outer part of the harbour had partially collapsed, very probably due to abnormally stormy conditions which characterised the winter of 1796/1797 and extended from the British Isles to France. A Napoleonic invasion fleet sent to assault Ireland and Wales in 1796 was overwhelmed (Breen & Forsythe, 2007), and three of the largest stone slabs at Stonehenge including the lintel were toppled (Maton, 1800). London recorded a temperature of -21°C on Christmas Eve 1796 and the Thames froze. Conditions in Ayrshire were equally severe, and in between gales heaps of broken ice in the harbour at Ayr reached several metres above river level (Young & Close, 2022). The collapse of, and need to mend, Millport Pier with something substantial is not surprising. This was undertaken by 1797 according to an engraved pier abutment (Reid, 1864). The phase of pier building using irregular rounded boulders is evident on the southern (seaward) side of the inner harbour (Fig. 2) where the original stonework would have been most exposed to storms. The boulders in the pier include basalt, granite and schist, all occurring in surviving fish traps on the Ayrshire mainland coast (Patterson, 1989), which corroborates the use of the Foul Port fish trap to mend the pier. The granite and schist are derived from the glacial deposits transported from further north.

Millport developed where the Mill Burn, the main water course on the island, entered the sea (Fig. 1). At the western limit of Millport, Foul Port was a notable place to catch fish, especially salmon. Salmon could not have progressed upstream from there, as the Mill Burn, which currently enters Foul Port by an engineered conduit, entered the sea further east at the time of the fish trap. Salmon are still caught today in the Ettrick Burn on the adjacent Isle of Bute (Gibson & Stephen, 1976), and are known to run up very narrow streams; a salmon run up an earlier, more natural, Mill Burn is therefore not inconceivable. The Mill Burn formerly entered the sea at Bessy's Port, immediately east of Foul Port, where a tidal pool accommodating fish is created each day. The exit from the pool is a narrow gap (a few metres) in a hard band of rock (Fig. 1), which probably also functioned as a fish trap.

Many old fish traps elsewhere are found in remote locations, but this may be partially because the evidence for them has been removed at sites which became developed as population centres. Inevitably a river mouth site would attract both fish and habitation (Bathgate, 1948). In this case the growth of the town of Millport was intricately tied to the history of the fish trap at Foul Port. The trap is, notably, the only fish trap mentioned in literature about the island, which emphasises the importance of the locality. Beyond its initial attraction to the Viking population, the town grew as it became the base of the revenue cutter and its crew in the late eighteenth century. The harbour was expanded to accommodate the fishing boats which supported the growing population. Quarrying out space to enlarge the harbour yielded the stone to export to customers like Portpatrick in the 1770s, at the same time as the revenue men were chasing smugglers (Campbell, 1994). The quarrymen maintained the fish trap, which was metres from new houses that had been built for the revenue men (North Ayrshire Council, 2013). Then, when the pier of the enlarged harbour collapsed the fish trap supplied the means for mending it and ensured that the harbour could be further expanded into a steamer pier. At that time, the Mill Burn may still have supported fish, which would pass Foul Port and Bessy's Port. In several ways the Foul Port trap records the early history of the town of Millport.

Thanks are due to Jamie Bowie for cartography and Ian Murray for photography.

REFERENCES

Anonymous (1856). Jottings about Cumbrae. *Glasgow Herald* July 16th 1856.

Ayton, R. & Daniell, W. (1818). *A Voyage Round Great Britain, Undertaken in the Summer of 1813, Commencing with the Land's End, Cornwall, and with a Series of Views.* Vol. III. Longman, London.

Bannerman, N. & Jones, C. (1999). Fish-trap types: a component of the maritime cultural landscape. *The International Journal of Nautical Archaeology* 28, 70-84. https://doi.org/10.1111/j.1095-9270.1999.tb00823.x

Barrett, J.H., Locker, A.M. & Roberts, C.M. (2004). Dark Age economics revisited: the English fish bone evidence AD 600-1600. *Antiquity* 78, 618-636. https://doi.org/10.1017/S0003598X00113262

Bathgate, T.D. (1948). Ancient fish traps or yairs in Scotland. *Proceedings of the Society of Antiquaries of Scotland* 83, 98-102. https://doi.org/10.9750/PSAS.083.98.102

Breen, C. & Forsythe, W. (2007). The French shipwreck La Surveillante, lost in Bantry Bay, Ireland, in 1797. *Historical Archaeology* 41, 41–42. https://doi.org/10.1007/BF03377053

Buchanan, C.H. (2012). Scandinavians in Strathclyde: multiculturalism, material culture and manufactured identities in the Viking Age. In: Ritchie, A. (Editor). *Historic Bute: Land and People*, pp. 17-32. The Scottish Society for Northern Studies, University of Edinburgh, Edinburgh.

Campbell, J.R.D. (1994). *Clyde Coast Smuggling*. St. Maura Press, Millport.

Campbell, J.R.D. (2003). *Millport and the Cumbraes. A History and Guide*. North Ayrshire Council.

Clarkson, T. (2014). *Strathclyde and the Anglo-Saxons in the Viking Age*. Birlinn, Edinburgh.

Ferrier J. (1969). Tidal fish-traps in Bute. *Transactions of the Buteshire Natural History Society* 17, 31-35.

Gibson, J.A. & Stephen, A. (1976). The freshwater fishes of the Island of Bute. *Transactions of the Buteshire Natural History Society* 20, 71-75.

Graham, E.J. (2015). *A Maritime History of Scotland, 1650-1790*. Birlinn, Edinburgh.

Graham, H. (1794). Island and Parish of Cimbraes. *The Statistical Account of Scotland.* Vol. XI, Number XXX, pp. 391-397.

Graham-Campbell, J. & Batey, C.E. (1998) *Vikings in Scotland: An Archaeological Survey*. Edinburgh University Press, Edinburgh.

Hale, A.G.C. (2004). Fish-traps in Scotland: construction, supply, demand and destruction. In: Klápšte, J. (Editor). *Water Management in Medieval Rural Economy.* Ruralia 5. Památky archeologické, Supplementum 17, pp. 119-126. Institute of Archaeology, Prague.

Lilly, J., Honkanen, H.M., Bailey, D.M., Bean, C.W., Forrester, R., Rodger, J.R. & Adams, C.E. (2022). Investigating the behaviour of Atlantic salmon (*Salmo salar* L.) post-smolts during their early marine migration through the Clyde Marine Region. *Journal of Fish Biology* 101, 1285-1300. https://doi.org/10.1111/jfb.15200

Lytteil, W. (1877). *Landmarks of Scottish Life and Language*. J. Moodie Miller, Edinburgh.

Lytteil, W. (1886). *Guide-book to the Cumbraes, Firth of Clyde*. Menzies & Co., Carlisle and Edinburgh.

Mackay, D.W. & Doughty, C.R. (1986). Migratory salmonids of the Estuary and Firth of Clyde. *Proceedings of the Royal Society of Edinburgh Section B Biological Sciences* 90, 479-490. https://doi.org/10.1017/S0269727000005170

Maton, W.G. (1800). Account of the fall of some of the stones of Stonehenge, in a letter from William George Maton, M.B.F.A.S. to Aylmer Bourke Lambert, Esq. F.R.S. and F.A.S. *Archaeologia* 13, 103-106.

Montgomery, P., Forsythe, W. & Breen, C. (2015). Intertidal fish traps from Ireland: some recent discoveries in Lough Swilly, Co. Donegal. *Journal of Maritime Archaeology* 10, 117-139. https://doi.org/10.1007/s11457-015-9146-z

North Ayrshire Council (2013). *Millport Conservation Area Appraisal*. North Ayrshire Council, Irvine.

Patterson, E.M. (1989). Ancient fish traps on the North Ayrshire coast: Ardrossan to Hunterston. *Ayrshire Monographs, Ayrshire Archaeological & Natural History Society* September 1989, 29-42.

Ramstad, M., Halvorsen, L.S. & Olsen, A.B. (2011). Bjørkum: feasting, craft production and specialisation on a Viking Age rural site in Norway. *Antiquity* Project Gallery85 (328). https://antiquity.ac.uk/projgall/ramstad328 Accessed 23rd October 2025

Reid, J.E. (1864). *History of the County of Bute and Families Connected Therewith*. Thomas Murray & Son, Glasgow.

Rorke, M. (2005). The Scottish herring trade, 1470-1600. *The Scottish Historical Review* 84, 149-165.

Smeaton, J. (1812). *Reports of the Late John Smeaton F.R.S., Made on Various Occasions in the Course of*

his Employment as a Civil Engineer. Vol. 3. Longman, London.
Tidal Harbours Commission (1847). *Appendix C to Second Report of the Commissioners, with Supplement and Index*. William Clowes & Sons, London.
Williamson, J. (2024). Fishing through the Viking Age, a tale of survival, economy, and culture. *The Viking Herald* https://thevikingherald.com/article/fishing-through-the-viking-age-a-tale-of-survival-economy-and-culture/585 Accessed 20th August 2025
Young, A.F. & Close, R. (2022). *The Diary of Thomas McClelland: Ayr in the 1790s. Ayrshire Monographs No. 51*. Ayrshire Archaeological and Natural History Society, Ayr.

https://doi.org/10.37208/tgn28410

Going wild on woodchips: the alien wrinkled fieldcap mushroom *Agrocybe rivulosa* in Glasgow, Scotland

M. O'Reilly

Scottish Environment Protection Agency, Angus Smith Building, 6 Parklands Avenue, Maxim Park, Eurocentral, Holytown, North Lanarkshire ML1 4WQ

E-mail: myles.oreilly@sepa.org.uk

Unusual fungi from woodchipped beds have recently been highlighted in one of a series of notes on interesting fungi found around the Glasgow area (see O'Reilly, 2025, for full citations). Further information is provided here on unusual alien fungi, which, along with a few native species, appear to be taking advantage of the widespread use of woodchips and "going wild" in mulched beds in Scotland's parks and gardens.

The use of woodchip mulch has greatly increased within horticulture in recent decades in the U.K. Woodchips, a waste product of the forestry industry, have proved very useful as weed suppressants in shrubberies or flower beds. According to Shaw & Kibby (2001), woodchipped beds effectively present a qualitatively new habitat type for fungi, due to the physical structure of the woodchip layering in combination with whatever management or replenishment regime is practiced by the gardeners. This new habitat may be open to colonisation by both native fungi and exotic alien species.

The fungi from ornamental woodchipped beds in the U.K. have been investigated by Shaw & Kibby (2001) and Shaw *et al*. (2004) who found nearly 50 different species. They highlighted two alien agarics as epitomising woodchip fungal communities in south-east England: wavy cap, *Psilocybe cyanescens*, probably native to the U.S.A., and redlead roundhead, *Stropharia aurantiaca* (*sensu auct.*) which possibly came from Australia (Fig. 1). Both species may form dense aggregations, and the latter, with bright orange caps, is described as one "of the few fungi that can be identified from a moving car"! Note that there has been considerable nomenclatural confusion around this latter species, and it is now properly known as *Leratiomyces ceres* (see: Fortey, 2004; Bridge *et al*., 2008).

Fig. 1. Redlead roundhead (*Leratiomyces ceres*), Maxim Business Park, Eurocentral, North Lanarkshire, Scotland, October 2022. (Photo: M. O'Reilly)

Another alien woodchip mushroom highlighted by Shaw & Kibby (2001) is the mulch fieldcap, *Agrocybe putaminum,* which was originally described from a garden in France in 1913 and subsequently spread elsewhere in western Europe on mulched beds. It first turned up in the U.K. at Kew Gardens in 1986 (Pegler & Legon, 1998) and it has now been reported in 11 European countries (Halama, 2016).

In 1999 an unrecognised *Agrocybe* species was found in large numbers on a woodchip heap in Rotterdam and soon appeared elsewhere in the Netherlands and nearby in Luxembourg, also on woodchip heaps. It was subsequently determined as a species new to science, *Agrocybe rivulosa*, and a full description with a line-drawing figure was published (Nauta, 2003). The new species, *A. rivulosa*, was readily distinguished by the presence of a stipe ring, its relatively large spores, and the distinct radially rivulose wrinkles on its cap – hence its specific name. Surprisingly, Nauta (2003) did not speculate on the natural origin of *A. rivulosa* but did provide a key to six similar *Agrocybe* species then known from woodchips in north-western Europe.

Within a few years *A. rivulosa* had spread to Belgium, Denmark and England (Vellinga, 2008). It was first recorded in England on a woodchip pile in Staffordshire in 2004 (Lovett, 2006). As this woodchip pile had been produced on site from an overgrown hedge, Lovett suggested that *A. rivulosa* must have arrived in England by atmospheric circulation of spores (presumably from continental Europe), rather than commercial transport of woodchips. She also speculated that it was probably a thermophilic species utilising warm, decaying woodchips and that it may have originated from tropical or subtropical climes.

A. rivulosa is now widespread in the U.K., where the vernacular name, wrinkled fieldcap, has been adopted. It was first recorded in Scotland in 2006 (FRDBI, 2026) and reached Northern Ireland in the following year (Anderson, 2010). There are now a couple of hundred records throughout England and Wales, though still only around a couple of dozen sites for Scotland (FRDBI, 2026).

In August 2012, the author noticed a mass of mushrooms sprouting from a large pile of woodchips at the edge of the allotments in Eastwood Park, Giffnock, Glasgow (NS55445458697). There were around 200 fruiting bodies growing on the mound of woodchips ranging from fleshy erupting specimens, mature examples, and shrivelled decaying specimens (Fig. 2A). The mature specimens were up to about 10 cm tall with caps similarly wide of a yellow-brown colour in the middle but paler and wrinkled towards the rim, and initially with a distinct ring on the stipe (Fig. 2B). They were identified as *A. rivulosa* from the photographic guide to British mushrooms by Sterry & Hughes (2009), which included a short section on woodchip fungi. These authors suggested that *A. rivulosa* had already spread to “almost every county” since its arrival in the British Isles in 2004. A look at its distribution on the Fungal Records Database of Britain and Ireland (FRDBI, 2026) indicates this is somewhat exaggerated.

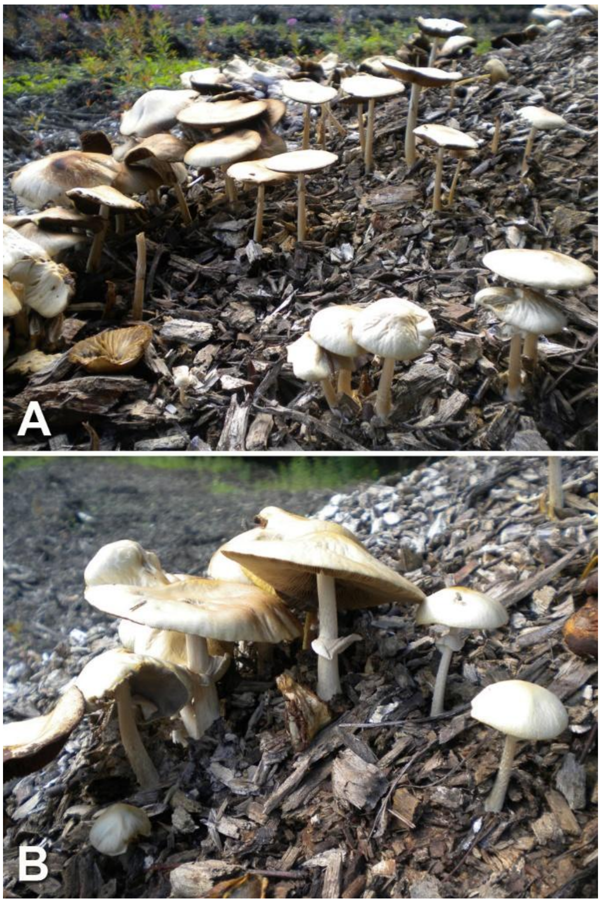


Fig. 2. Wrinkled fieldcap (*Agrocybe rivulosa*), Eastwood Park, Giffnock, Glasgow, Scotland, August 2012. (Photos: M. O’Reilly)

The Eastwood Park 2012 record of *A. rivulosa* was submitted to the FRDBI which now holds half a dozen other records of this alien species from the Glasgow area. The first record was from Hyndland in August 2011, and subsequent records were from Kelvingrove Park, May 2014; Milngavie, July 2016; Bull Wood, September 2018; Dalbeth, September 2019; and Bellahouston in June 2023 (FRDBI, 2026).

In August 2023 the author found other specimens of *A. rivulosa* growing on a large pile of woodchips on a vacant overgrown plot of land at the southern end of Belmont Drive, Giffnock, Glasgow (NS5586259055). The new find was not as spectacular as the previous Giffnock find in 2012 and initially comprised just six specimens found on 10th August (Fig. 3A,B). The woodchip pile was repeatedly visited right through into October, during which time new fruiting bodies constantly sprouted but were rapidly grazed away by slugs. They reached a peak of 52 fruiting bodies on 14th September, and the last 13 fruiting bodies were seen on 13th October.

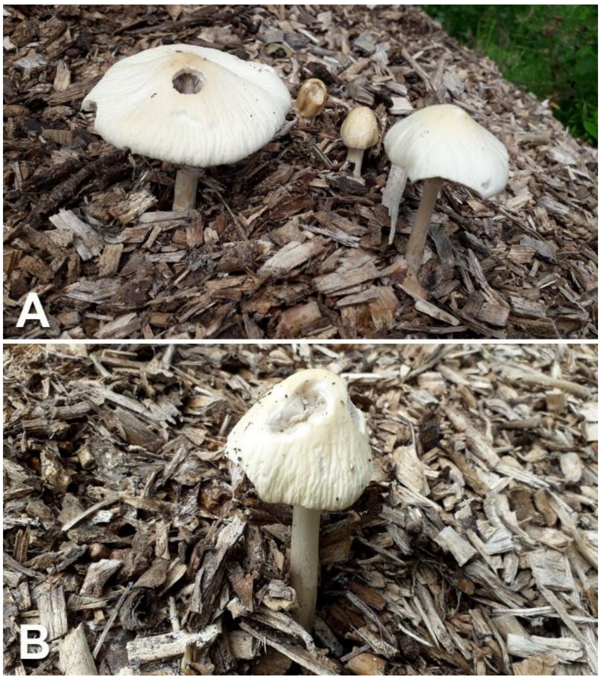


Fig. 3. Wrinkled fieldcap (*Agrocybe rivulosa*), Belmont Drive, Giffnock, Glasgow, Scotland, August 2023. (Photos: M. O’Reilly)

No other fungi appeared on the woodchips, but several large slime mould fruiting bodies were seen erupting and “going wild” on the woodchip mound, with one of the slime moulds partly engulfing an emerging

A. rivulosa specimen (Fig. 4A). The slime moulds were 20-30 cm in diameter and appeared to be varieties of the dog's vomit slime-mould, *Fuligo septica* (Fig. 4B,C). One of the slime moulds had a distinct yellow colouration suggesting *F. septica* var. *flava* (Fig. 5A,B). On maturing, the slime mould bodies blackened and clouds of spores could be seen wafting from them on the breeze. Although not fungi, a few common slime mould species are illustrated in Sterry & Hughes (2009). Nearly one hundred U.K. species are figured in recent guides by Holden (2021, 2025).

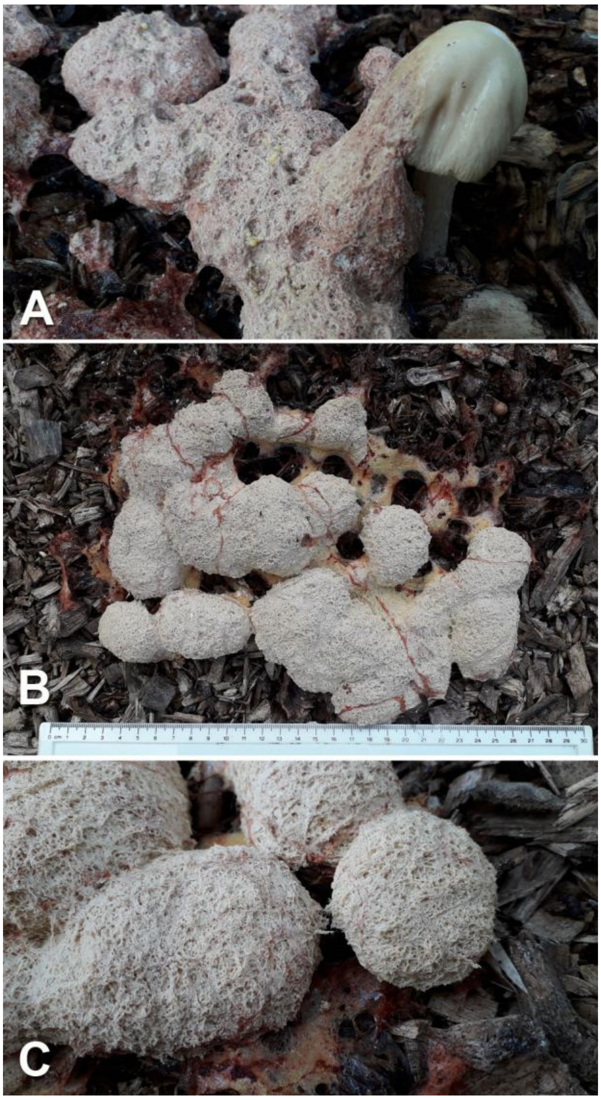


Fig. 4. Dog's vomit slime mould (*Fuligo septica*), Belmont Drive, Giffnock, Glasgow, Scotland, August 2023. (A) Spreading over a specimen of wrinkled fieldcap (*Agrocybe rivulosa*). (B) Another specimen of *F. septica*. (C) Closer view of *F. septica* specimen in (B). (Photos: M. O'Reilly)

Of the three alien fungi cited by Shaw & Kibby (2001) as typical wood chip colonisers in England, only the redlead roundhead, *Leratiomyces ceres*, is established in Scotland with about 20 records (FRDBI, 2026). Both the wavy cap (also called "blueleg brownie") *Psilocybe cyanesens* and the mulch fieldcap *Agrocybe putaminum* are now widespread in England, but have only rarely been recorded in Scotland. There are just two Scottish records of the former - from Glasgow, 2014 and Argyll,

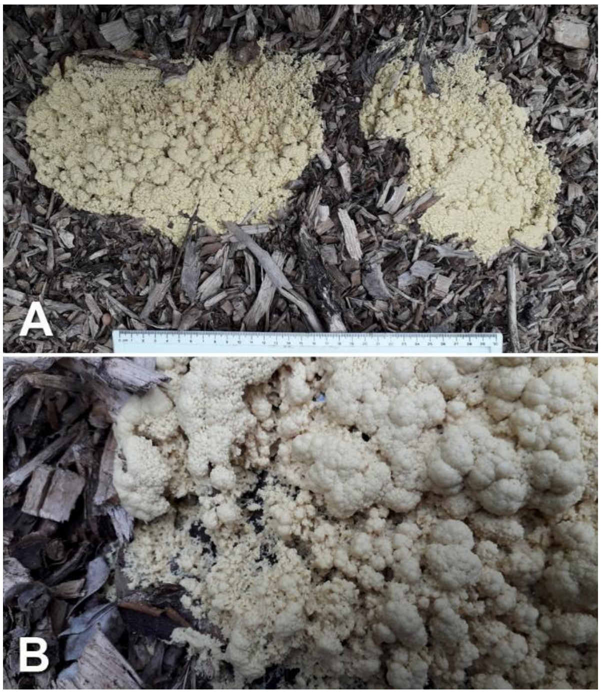


Fig. 5. Yellow dog's vomit slime mould (*Fuligo septica* var. *flava*), Belmont Drive, Giffnock, Glasgow, Scotland, August 2023. (A) General view. (B) Closer view of same specimen. (Photos: M. O'Reilly)

2017 - and a single record of the latter from Bishopton in 2022 (FRDBI, 2026).

The exact origin of these alien fungi found in the wild remains uncertain and these species are best regarded as cryptogenic (i.e. of obscure or uncertain origin). Although North America was suggested as the natural source of *A. putaminum* (Shaw & Kibby, 2001; Kibby, 2011), some doubt has been cast on this as the first confirmed records from that continent were from non-natural woodchip beds, and date from only the early 2000s (Vellinga, 2008; Halama, 2016). The natural origin of *A. rivulosa* is still completely unknown. Its first discovery in a major European port suggests the possibility that it came by ship to Europe, but where its voyage began is still unknown (Vellinga, 2008).

Woodchips are the fast food of the fungal world (Vellinga, 2008). It is evident that their prevalence presents new opportunities for fungi. This could include native species such as the cucumber cap *Macrocystidia cucumis* (Fig. 6), formerly rare but now extremely common on woodchip, including around Glasgow (Kibby, 2011). Other notable native colonisers of woodchip beds in or around the Glasgow area have included dense stands of upright coral fungi, *Ramaria stricta* (see O'Reilly, 2019), as well as yellow fieldcap *Bolbitius titubans* (Fig. 7) and two species of bird's nest fungi (O'Reilly, 2025).

It is the occurrence of previously scarce native fungi, alien fungi, and potentially completely new species of fungi that makes fungal forays in beds of mulch and woodchip so fascinating. An unpublished compilation of woodchip fungi at Kew Gardens now includes nearly

Fig. 6. Cucumber cap (*Macrocystidia cucumis*), Strathblane Parish Church graveyard, Stirlingshire, Scotland, October 2022. (Photo: M. O'Reilly)

Fig. 7. Yellow fieldcap (*Bolbitius titubans*), Maxim Business Park, Eurocentral, North Lanarkshire, Scotland, November 2021. (Photo: M. O'Reilly)

250 species (Bridge *et al*., 2008). Although the fungi of Glasgow's parks and public gardens were studied some time ago (Marshall, 1979), the new practices of mulching raise the prospect of new and interesting discoveries. It is hoped this note will encourage local naturalists to take a closer look at whatever fungal species are popping up and going wild on mulched border beds.

REFERENCES

Anderson, R. (2010). *Agrocybe rivulosa* Nauta, 2003 (Basidiomycotina; Agaricales), a woodchip fungus, new to Ireland. *Irish Naturalists' Journal* 31(2), 141.

Bridge, P.D., Spooner, B.M., Beever, R.E. & Park, D.C. (2008). Taxonomy of the fungus commonly known as *Stropharia aurantiaca*, with new combinations in *Leratiomyces*. *Mycotaxon* 103,109-121. https://doi.org/10.5962/p.414355

Fortey, R. (2004). *Psilocybe aurantiaca* and a case of mistaken identity. *Field Mycology* 5(2), 77-80. https://doi.org/10.1016/S1468-1641(10)60555-5

FRDBI (2026). Fungal Records Database of Britain and Ireland. https://www.frdbi.org.uk Accessed 9th March 2026.

Halama, M. (2016). *Agrocybe putaminum* (Agaricales, Basidiomycota) new for Poland. *Polish Botanical Journal* 61(2), 293-299. https://doi.org/10.1515/pbj-2016-0022

Holden, J. (2021). *A Provisional Census Catalogue of the Myxomycetes of the Forest of Dean. Their Status, Ecology, and Distribution*. The Gloucester Naturalist No. 35 (Special Issue).

Holden, J. (2025). *Myxomycetes of the Forest. An Exploration into the Hidden World of the Myxomycetes or Slime Moulds*. John Holden.

Kibby, G. (2011). ENHS meeting notes. Invasion of the aliens: climate change and invasive species in Britain, 14 September 2011. *Elmbridge Natural History Society Bulletin* 291.

Lovett, C. (2006). *Agrocybe rivulosa* new to the British list. *Field Mycology* 7, 47-48. https://doi.org/10.1016/S1468-1641(10)60366-0

Nauta, M.M. (2003). A new *Agrocybe* on woodchips in northwestern Europe. *Persoonia* 18, 271-274.

Marshall, M. (1979). *Fungi of the Glasgow Parks*. Glasgow District Council.

O'Reilly, M. (2019). New records of coral fungi: upright coral *Ramaria stricta* and greening coral *Ramaria abietina* from central Scotland. *The Glasgow Naturalist* 27(1), 95-96. https://doi.org/10.37208/tgn27130

O'Reilly, M. (2025). Woodchip wonders: bird's nest fungi in an office car park in central Scotland. *The Glasgow Naturalist* 28(3), 58-61. https://doi.org/10.37208/tgn28308

Pegler, D.N. & Legon, N.W. (1998). Profiles of fungi 92: *Agrocybe putaminum*. *Mycologist* 12(2), 60. https://doi.org/10.1016/S0269-915X(98)80045-1

Shaw, P.J.A. & Kibby, G.G. (2001). Aliens in the flowerbeds. *Field Mycology* 2(1), 6-11. https://doi.org/10.1016/S1468-1641(10)60081-3

Shaw, P.J.A., Butlin, J. & Kibby, G. (2004). Fungi of ornamental woodchips in Surrey. *Mycologist* 18, 12-15. https://doi.org/10.1017/S0269-915X(04)00103-X

Sterry, P. & Hughes, B. (2009). *Collins Complete Guide to British Mushrooms and Toadstools*. Harper Collins Publishers, London.

Vellinga, E.C. (2008). Wood chip fungi: *Agrocybe putaminum* in the San Francisco Bay Area. *Fungi* 1(4), 5 and 37-39.

https://doi.org/10.37208/tgn28402

Natural regeneration of the seagrass *Zostera noltii* in the Holy Loch, Argyll, Scotland

P. Rawlins & N. Hammatt*

Holy Loch Nature Reserve, Sandbank, Dunoon PA23 8PD

*E-mail: holylochnaturereserve@gmail.com

Seagrasses play a vital role in marine ecosystems by stabilising sediments, cycling nutrients, providing nursery habitat for fish and invertebrates, and capturing carbon (Nordlund *et al.*, 2016; Duarte, 2002). In the U.K., native seagrasses are mainly limited to *Zostera marina* and *Z. noltii*. These species have declined sharply over the past century due to coastal development, pollution, physical disturbance from anchoring and dredging, and disease outbreaks (Orth *et al.*, 2006; Jones & Unsworth, 2016).

Recent estimates suggest that over 90% of historic U.K. seagrass cover has been lost (Green *et al.*, 2021). The Holy Loch, a sea loch in Argyll, once a biodiverse marine habitat, was severely affected during the mid-to-late 20th century by the presence of a U.S. Navy submarine base. Activities associated with this facility, including dredging and chemical contamination particularly with copper, zinc and polychlorinated biphenyls (PCBs) (Miller *et al.*, 2000), plus agricultural and forestry run-off, are thought to have led to the local disappearance of seagrass beds.

Since the closure of the base in 1992, the loch has experienced gradual ecological improvement, though no active restoration of seagrass has been undertaken. This report details the findings of a 2025 survey that identified natural regeneration of *Z. noltii* within the Holy Loch. The first few stems were noticed in 2022. Since then, area expansion has occurred, and beds have become denser. Unlike most recent U.K. examples, which have relied on planting efforts (Gamble *et al.*, 2021), this regeneration appears to be spontaneous. The discovery contributes valuable insights into the conditions under which passive recovery may occur and underscores the importance of protecting such areas (Reynolds *et al.*, 2016).

Fieldwork was carried out between 12th and 17th May 2025, targeting the intertidal and shallow subtidal zones in the southeastern section of the Holy Loch. Approximately 20 ha of loch bed (Fig. 1) was surveyed by walking transects during low tide. Sediment type, vegetation cover, and visible signs of seagrass presence were recorded. *Z. noltii* was identified *in situ*, based on morphological features including narrow, linear leaves, a creeping rhizome system, and leaf sheath

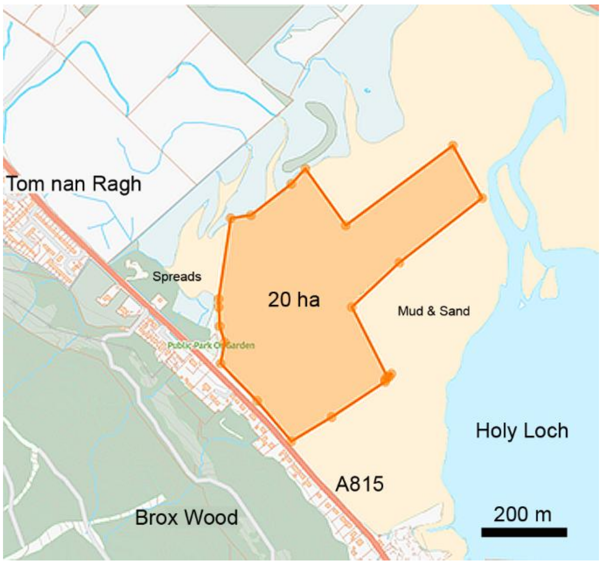


Fig. 1. Area of the Holy Loch seabed surveyed in May 2025. Field surveys focused on the southeastern intertidal and shallow subtidal zones. Approximate boundaries of the 20 ha search area are shown.

characteristics (Fig. 2). Observations were geo-referenced using handheld GPS devices (accuracy ±3 m), and photographic documentation was collected. No destructive sampling was performed. Spatial data were overlaid on aerial imagery using QGIS 3.34 to assess distribution and spatial coherence.

A continuous seagrass bed of approximately 3.6 ha was found southeast of the Holy Loch Nature Reserve (Figs. 3 and 4). Growth density varied, with the most robust patches observed in areas with minimal macroalgal competition and silty-sand substrates. Denser growth occurred in open patches free of other vegetation, while more fragmented patches were present in mixed-vegetation zones.

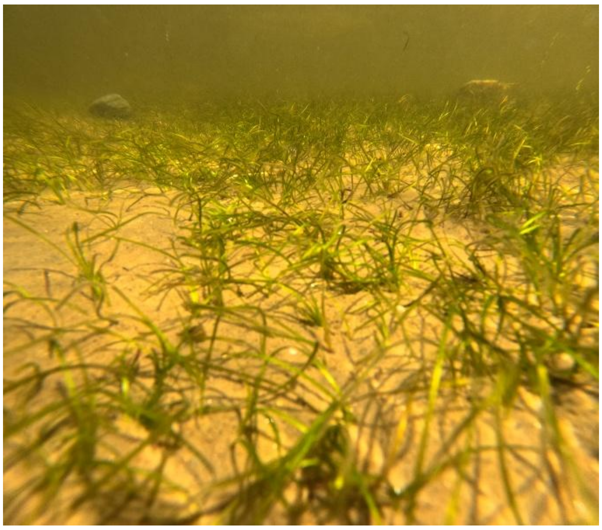


Fig. 2. Photograph of *Zostera noltii* on the bed of the Holy Loch, showing characteristic linear leaves. (Photo: N. Hammatt)

Fig. 3. Aerial image of the head of the Holy Loch (May 2025), showing the locations of regenerating *Zostera noltii*. Red-shaded polygons represent the main bed, while red dots mark smaller, recently established colonies. (Photo: P. Rawlins)

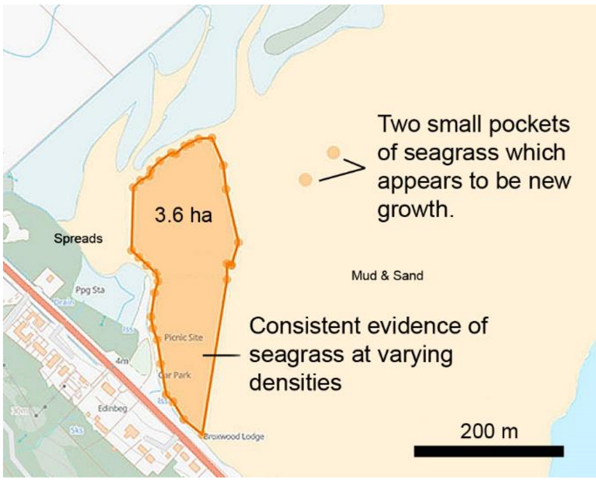


Fig. 4. Map showing *Zostera noltii* distribution at the head of the Holy Loch in May 2025. The main bed is highlighted in orange; smaller, newer colonies are marked as orange dots.

The eastern edge of the bed followed a depth gradient consistent with tidal exposure (Kendrick *et al.*, 2012). Two additional patches, each under 0.4 ha, were found northeast of the main bed (Fig. 4). These smaller patches exhibited signs of early-stage colonisation, including sparse rhizome spread and low shoot height (*ca.* 3-6 cm). All patch locations were recorded for future monitoring.

Water conductivity measurements have shown that this area of the seabed is subject to large fluctuations in salinity derived from varying volumes of rainwater run-off entering the loch during the year. Salinity measurements from the seagrass bed varied significantly from 9.5 PSU on 5th March 2025 to 42 PSU on 14th April 2025 after a relatively dry spell, which accords with the wide salinity tolerance of *Z. noltii* reported in the literature (see, e.g. d'Avack *et al.*, 2024).

The reappearance of *Z. noltii* in the Holy Loch represents a rare instance of natural seagrass recolonisation in a previously degraded coastal site. Given the loch's known history of industrial contamination and the absence of any planting activity, this finding is ecologically significant (Unsworth *et al.*, 2017). We hypothesise that dispersal from nearby lochs - such as Loch Long or Gare Loch - via tidal currents may have supplied viable propagules (Kendrick *et al.*, 2012). Additionally, a legacy sediment seed bank may have persisted in anaerobic conditions and responded to improved water and sediment quality (Jarvis *et al.*, 2014). Other, less likely, vectors include bird-mediated dispersal or long-distance drift from restoration sites such as Loch Craignish (Orth *et al.*, 2006).

The event highlights the resilience of *Z. noltii* and the potential for passive recovery in semi-enclosed lochs where hydrodynamic and environmental conditions are favourable (Reynolds *et al.*, 2016). The findings support the notion that some degraded systems retain latent ecological potential, which may be activated through environmental improvement alone. Continued monitoring is essential to determine persistence, expansion, and functional recovery of the meadow.

REFERENCES

d'Avack, E.A.S., Tyler-Walters, H., Wilding, C.M., Garrard, S.L. & Watson, A. (2024). *Zostera* (*Zosterella*) *noltei* beds in littoral muddy sand. In: Tyler-Walters, H. & Hiscock, K. (Editors). *Marine Life Information Network: Biology and Sensitivity Key Information Reviews*. Marine Biological

Association of the United Kingdom, Plymouth. https://www.marlin.ac.uk/habitats/detail/318/zostera_zosterella_noltei_beds_in_littoral_muddy_sand Accessed 3rd September 2025.
Duarte, C.M. (2002). The future of seagrass meadows. *Environmental Conservation* 29, 192-206. https://doi.org/10.1017/S0376892902000127
Gamble, C., Glover, A., Debney, A., Bertelli, C., Green, B., Hendy, I. *et al.* (2021). *Seagrass Restoration Handbook: UK & Ireland*. Zoological Society of London, London. https://cms.zsl.org/sites/default/files/2023-02/ZSL00168-Seagrass-Restoration-Handbook_20211108.pdf Accessed 3rd September 2025.
Green, A.E., Unsworth, R.K.F., Chadwick, M.A. & Jones, P.J.S. (2021). Historical analysis exposes catastrophic seagrass loss for the United Kingdom. *Frontiers in Plant Science* 12:629962. https://doi.org/10.3389/fpls.2021.629962
Jarvis, J.C., Moore, K.A. & Kenworthy, W.J. (2014). Persistence of *Zostera marina* L. (eelgrass) seeds in the sediment seed bank. *Journal of Experimental Marine Biology and Ecology* 459, 126-136. https://doi.org/10.1016/j.jembe.2014.05.024
Jones, B.L. & Unsworth, R.K.F. (2016). The perilous state of seagrass in the British Isles. *Royal Society Open Science* 3, 150596. https://doi.org/10.1098/rsos.150596
Kendrick, G.A., Waycott, M., Carruthers, T.J.B., Cambridge, M.L., Hovey, R., Krauss, S.L. *et al.* (2012). The central role of dispersal in the maintenance and persistence of seagrass populations. *BioScience* 62, 56-65. https://doi.org/10.1525/bio.2012.62.1.10
Miller, B.S., Pirie, D.J. & Redshaw, C.J. (2000). An assessment of the contamination and toxicity of marine sediments in the Holy Loch, Scotland. *Marine Pollution Bulletin* 40, 22-35. https://doi.org/10.1016/S0025-326X(99)00190-3
Nordlund, L.M., Koch, E.W., Barbier, E.B. & Creed, J.C. (2016). Seagrass ecosystem services and their variability across genera and geographical regions. *PLoS ONE* 11, e0163091. https://doi.org/10.1371/journal.pone.0163091
Orth, R.J., Carruthers, T.J.B., Dennison, W.C., Duarte, C.M., Fourqurean, J.W., Heck, K.L. *et al.* (2006). A global crisis for seagrass ecosystems. *BioScience* 56, 987-996. https://doi.org/10.1641/0006-3568(2006)56[987:AGCFSE]2.0.CO;2
Reynolds, L.K., Waycott, M., McGlathery, K.J. & Orth, R.J. (2016). Ecosystem services returned through seagrass restoration. *Restoration Ecology* 24, 583-588. https://doi.org/10.1111/rec.12360
Unsworth, R.K.F., Williams, B., Jones, B.L. & Cullen-Unsworth, L.C. (2017). Rocking the boat: damage to eelgrass by swinging boat moorings. *Frontiers in Plant Science* 8, 1309. https://doi.org/10.3389/fpls.2017.01309

https://doi.org/10.37208/tgn28403

Mass stranding of the scyphozoan jellyfish *Cyanea capillata* at Kames Bay, Isle of Cumbrae, Scotland

P.G. Moore

32 Marine Parade, Millport, Isle of Cumbrae KA28 0EF

E-mail: p.geoff.moore@gmail.com

Stranded jellyfish are well known to beach-combers on British beaches in summer. There are five common species in our inshore waters (Trewhella & Hatcher, 2015) but occasional incursions of oceanic waters may bring more exotic species to our shores (O'Reilly & Semler, 2020). Although jellyfish can actively swim, adverse weather can drive them ashore resulting in spectacular mass strandings.

This note records an unusual mass stranding of hundreds of lion's-mane jellyfish (*Cyanea capillata*; Cnidaria, Scyphozoa) of various sizes on the strandline at Kames Bay, Isle of Cumbrae, Scotland, which appeared overnight on 29th/30th August 2025 (Fig. 1). Having lived on the Isle of Cumbrae for over 50 years, I have never before witnessed such large numbers of this species being washed up on Kames Bay. A few milky white specimens of another scyphozoan - the barrel jellyfish *Rhizostoma octopus* - were also evident among the mass of red-brown *C. capillata* but represented under 1% of the strandings.

The Isle of Cumbrae is located in the Firth of Clyde. Substantial numbers of the early life-history stages (scyphistomae) of *C. capillata* have been observed on the submerged rock walls below the kelp zone near Furnace on the west side of Loch Fyne, Argyll (pers. obs.), which is one of the Clyde sea-lochs. The species is therefore a normal component of the Clyde Sea area marine fauna and regular strandings of usually small numbers of this mature jellyfish occur annually at this time of year. The jellyfish overwinters as the small polyp-like scyphistoma stage attached to rocks, and then buds an early swimming stage called an ephyra, which can be caught in plankton nets early in the year.

This mass stranding seems likely to have been a consequence of strong (40-50 m.p.h.) south-westerly winds brought about as a result of the residual impact of ex-hurricane Erin tracking across the Atlantic Ocean from America at the time, perhaps also being exacerbated as a result of higher sea temperatures due to the effects of climate change, and/or the possible ecosystem impacts of overfishing (Pauly *et al.*, 1998). On the receding tide early in the morning of 31st August, however, very few *C. capillata* were evident. The mass-stranded jellyfish had either been washed back into the

Fig. 1. *Cyanea capillata* stranded at Kames Bay, Isle of Cumbrae, Scotland, 30th August 2025. (A) View across the shore looking west. (B) View looking east. (Photos: Penny Healy)

still rough sea or been buried beneath shifted sand. The presence of several specimens half-buried in the sand, each surrounded by a scoured-out halo (observed on the morning receding tide of 1st September), is suggestive of the latter explanation.

It should be noted that it is the tentacles of *C. capillata* that sting, not the umbrella. Dog walkers (see Meadows, 2011) and parents are advised to stop dogs and children respectively touching *C. capillata* (though *R. octopus* is harmless). However, investigation of the underside of the umbrella of *C. capillata* (enabled by rubber gloves), may reveal the presence of the parasitic hyperiid amphipod *Hyperia galba,* with its startling lime-green eyes (see Moore, 1984).

Mass strandings offer the beachcomber a rare insight into the creatures inhabiting the pelagic realm of our coastal waters, and on rarer occasions may include oceanic creatures, such as by-the-wind sailor (*Velella velella*; Cnidaria, Hydrozoa, Porpitidae) or buoy barnacles (*Dosima fascicularis*; Arthropoda, Crustacea, Lepadidae), from much further offshore (The Herald, 2002; Scottish Government, 2011; O'Reilly *et al*., 2023). Nearshore seabed invertebrates, such as starfish (Echinodermata, Asteroidea), may also be subject to mass strandings on rare occasions (BBC, 2025).

I am grateful to my daughter Penny for taking the lion's mane jellyfish photographs, and I thank the anonymous reviewer for helpful comments that improved the manuscript.

REFERENCES

BBC (2025). Thousands of starfish wash up on Fife beach. https://www.bbc.co.uk/news/articles/c62l7el62j0o Accessed 19th September 2025.

Meadows, P.S. (2011). The dangers of lion's mane jellyfish, *Cyanea capillata* (Linnaeus) to domestic dogs (*Canis lupus familiaris*). *The Glasgow Naturalist* 25(3), 29–31.

Moore, P.G. (1984). *The Fauna of the Clyde Sea Area: Amphipoda*. Occasional Publication No. 2. University Marine Biological Station Millport, Isle of Cumbrae.

O'Reilly, M., Morris, A. & McKechnie, J. (2023). A mass stranding of buoy barnacles, *Dosima fascicularis*, on the Isles of Coll and Colonsay, Inner Hebrides, Scotland, in July 2020. *The Glasgow Naturalist,* 28(1), 35-37. https://doi.org/10.37208/tgn28108

O'Reilly. M. & Semler, P. (2020). The crystal jellyfish (*Aequorea vitrina*) in Loch Bracadale, Isle of Skye, Scotland. *The Glasgow Naturalist,* 27(2), 67-69. https://doi.org/10.37208/tgn27214

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R. & Torres, F. (1998). Fishing down marine food webs. *Science* 279, 860-863. https://doi.org/10.1126/science.279.5352.860

Scottish Government (2011). *Scotland's Marine Atlas: Information for the National Marine Plan. Scottish Occasional Visitors*. https://www.gov.scot/publications/scotlands-marine-atlas-information-national-marine-plan/pages/39/ Accessed 19th September 2025.

The Herald (2002). Experts puzzled by west coast invasion of millions of jellyfish. https://www.heraldscotland.com/news/11958244.Ex

perts_puzzled_by_west_coast_invasion_of_millions_of__jellyfish/ Accessed 19th September 2025.
Trewhella, S. & Hatcher, J. (2015). *The Essential guide to Beachcombing and the Strandline*. Wild Nature Press, Plymouth. https://doi.org/10.1515/9780691232423

Book Reviews

The Lives of Seaweeds: A Natural History of Our Planet's Seaweeds and Other Algae
Julie A. Phillips
Princeton University Press, Princeton, New Jersey, 2023, 288 pages, hardback with many colour plates and diagrams. ISBN 978069122855-6.
£30

If you are someone who found algae boring as a student and were much more attracted to flowering plants, be prepared to be surprised by this book. It is written by someone who clearly knows about the traditional botanical aspects of seaweeds but who works with algae as an environmental consultant and who brings the understanding of seaweeds to a wider audience. This is so important at the present time because of renewed interest in algae ranging from their role with blue carbon to their exploitation for food and chemicals.

Seaweeds are macroscopic marine algae but they are not the only algae in the sea and, despite the book's title, it does also contain a lot of information about other algal groups such as diatoms and dinoflagellates.

The presentation of the book makes it attractive to look through. There is a wealth of good quality, large, colour plates. These include 40 species of seaweed and other types of algae. Some are shown in macroscopic and some in microscopic form. There are also well-drawn, coloured and greyscale diagrams to explain, as the title says, the lives of seaweeds. This includes internal structure, growth patterns and the great diversity of life histories where quite dissimilar forms, once regarded as separate species, are now known to be different generations in the life of a single species.

The author explains what algae and seaweeds are and how they differ from other major groups of organisms without getting embroiled in what, to some specialists, is now a complex area based on molecular evidence. The evolutionary history of algae from 3.5 billion years ago is covered with the evolution of eukaryotic and prokaryotic cells and the early dominance of Cyanobacteria which, even in this reviewer's lifetime, had been called the blue-green algae. A great diversity of algal lines has now evolved in which seaweeds are only a small part in terms of the total number of species. While this is so, the seaweeds include the largest algae, some of the largest plant-like forms, such as the giant kelps of California, and are the algae probably most frequently seen and familiar to many people.

Along with attractive colour plates to explain the range of seaweed diversity and other algal forms, the book includes simple-to-understand but technically correct aspects of the lives of algae such as growth patterns, cell-types, life histories, the different generations, reproductive processes and resistant stages, and their ecology in various habitat types. This includes mudflats, rocky seashores, subtidal kelp forests and intertidal rock pools, with particular topics such as the Sargasso Sea, bioluminescence, algal blooms and climate change.

Following this good introduction to algal diversity and the place of seaweeds in this, which runs to over 200 pages, the book then devotes more than 50 pages to Algae and Humans. The main emphasis is on seaweeds but all types of algae are considered. This part of the book looks at the use of seaweeds for food, phycocolloids, pharmaceutical products and biofuels. Seaweed aquaculture is covered. This is not a new area worldwide, but it is particularly taking off in Britain now, so it is good that this area is covered. The downside of algae is also tackled by coverage of algal blooms.

At the end of the book there are some very useful pages which include a glossary of specialist terms and a simple, valuable table which summarises the differences between the eleven major algal groups in chemical, cellular and fine-structural features.

This is a very well-produced book which can give a good scientific explanation of seaweeds and other algae to the non-specialist in a beautifully illustrated and easy-to-read format. While the book has many exquisite colour plates of various seaweeds, they are a world-wide selection, so it is not an identification book for use with shore samples in any particular area. Nevertheless, it gives you much of the background information to seaweeds that the identification guides do not cover, and it makes it easier to use these guides.

Martin Wilkinson

Fossils: The Essential Guide
Paul D. Taylor
Natural History Museum, London, 2025. 256 pages, hardback illustrated. ISBN 9780565095635.
£20

Is there life on Mars? Perhaps not the correct question to ask when reviewing a book on terrestrial fossils. As Paul Taylor discusses in his preface, perhaps the question should be "Was there life on Mars and what should we expect it to look like?" To answer this question, looking closely at the earliest life-forms on Earth may provide some direction. The book does not stop with the primitive life-forms, though, and returns from Mars to the relative safety of our own planet. It continues by introducing all the major groups that are likely to be found as fossils. From bacteria to dinosaurs, Taylor takes us on a journey through time, looking at trilobites, ammonites, snails and bivalves, plants, sea urchins and fishes, amphibians, reptiles, birds and mammals and what they left behind - he even devotes some space to his favourite invertebrates – the Bryozoa.

In his first chapter, Taylor covers all the basics of palaeontology, from how fossils form, how they get their names, what rocks they are found in, plate tectonics, environmental changes, extinctions, how old they are, as well as a little on how likely organisms and their traces are to become fossils. This introduces the reader to what is going to happen next. Without it, fossils are just dead organisms in rocks – with it, fossils become powerful entities that teach us about our planet's faunal, floral, environmental, ecological and tectonic histories.

It is the job of every palaeontologist to reveal the history of life and its evolution through its fossil evidence. Fossils are a vital record of evolutionary change over the vastness of geological time. Our world is restless, and life on our fragile planet always has been at risk. It has survived through periods of warmer and colder climates, sea-level changes, acidification of the seas, methane degassing, environmental catastrophes as well as extraterrestrial impacts – some of these issues are currently crippling climate-sensitive societies. All these deep-time environmental changes can be inferred from the sediments and the fossils held within. This is why Taylor considers fossils key to developing contextual awareness as well as pertinent tools for introducing science to present and future generations.

One of the big issues with palaeontologists, as with many other scientists, is that it is impossible to have 100% agreement on anything. In palaeontology, understanding exactly when a fossil is a fossil, is just one niggling issue that has confounded many eminent committees. How much change must an organism have to endure through taphonomy (the decay processes involved in fossilisation) before it can be elevated to the dizzying heights of being classified as a fossil? Taylor simply places a year on the boundary – 10,000 years. Older than 10,000 years – a fossil; under 10,000 years – a sub-fossil. Is it that simple? Perhaps it should be. This is also the approximate boundary between the Pleistocene and the Holocene (which is about 11,700 years ago). This fossil/sub-fossil boundary may have to change in the future though as scientists are now able to revive nematodes from 46,000-year-old permafrost… and viruses from even further back – technically living sub-fossils. However, for the time being, this is as good a date as any.

The use of binomial latinised nomenclature for fossils is perhaps less controversial in the palaeontological literature than it seems to be becoming in the biological realm. There are few colloquial names for fossils unless they were of medicinal or decorative use. Examples include the "Dudley Locust" (a colloquial term for the trilobite *Calymene blumenbachii* from Dudley) or "bot-stones" (a term used on the Isle of Skye for belemnites that were used for medicinal purposes over 320 years ago). I agree with Taylor on this. Why artificially develop local indigenous names for fossils where none previously existed? If they did, however, they should be incorporated into the process of naming fossils wherever possible.

Personally, I would have preferred better coverage of some of the more significant discoveries of the last few decades, such as the tetrapods *Pederpes* from Dumbarton or "Ribbo" from the Scottish Borders, which have closed what had become known as "Romer's Gap" for over 70 years (the 15-million-year gap in our knowledge that covers terrestrialisation by vertebrates during the Early Carboniferous). Other fossils I would have included are the exceptionally rare and well preserved: "Bearsden Shark"; the shrimp *Tealliocaris weegie* with soft-tissue preservation; "Conan the Conodont" from Edinburgh; the proto-amniote *Westlothiana* from Bathgate; or the lovely Middle Jurassic pterosaur from Skye called *Dearc sgiathanach*. Of course, these all being Scottish, I may be accused of nationalist bias.

Although this is not a book to help with the identification of species for collectors, it is a book that elevates fossils to storytellers in order to share their own narrative. Those of us interested in listening to what fossils have to say will be delighted with this book.

It is exceptionally well illustrated with exemplary photographs and artworks supplementing and supporting the written words that tell the story of life on Earth. The reader is left astounded by the beauty and elegance of the past lives held hostage in the rocks as their story is unveiled by a professional and passionate palaeontologist.

Neil D.L. Clark

The Lives of Frogs: A Natural History
Jim Labisco & Richard Griffiths
Princeton University Press, Princeton, New Jersey, 2025. 288 pages, hardback with many colour photographs and figures. ISBN 9780691255019.
£30

Princeton University Press is well-known for its series of lavishly-illustrated WildGuides to the biodiversity of Britain and Europe. This book is not in that series, but is a similarly beautiful "introduction" to and "celebration" of the diversity and lives of frogs. The authors are Jim Labisco, a young lecturer at University College London and not-so-young Richard Griffiths, emeritus professor at the University of Kent and one of the U.K.'s most eminent herpetologists. In addition, the production team at Princeton University Press, acknowledged at the end, are responsible for much of the arrangement of the book, and such decisions as the use of American rather than British English, and the inclusion of imperial as well as metric measures.

The book is a 288-page hardback and listed at £30. What do you get for your money? First, a lot of beautiful colour photographs of frogs. As an example, the 12-page introductory chapter is more than 50% illustrations, including three full-page photographs. Following the introduction, which summarises frog diversity and tackles the age-old question (what is the difference between frogs and toads?), nine chapters cover different aspects of frog biology: evolutionary origins; life on land and in freshwater; communication and reproduction; development and parental care; activity; nutrition; defences against predators and disease; population fluctuations; and, finally, the frog population decline crisis and what is being done about it. At the end of each chapter, there is a set of five species accounts, with a full-page photograph and a page of text describing the species, its distribution and key features. The species are chosen to illustrate some aspect of the preceding chapter. For example, the Lesser Antillean frog *Eleutherodactylus johnstonei*, which likely originated on the Caribbean island of Montserrat and has now spread throughout the region (largely by anthropogenic means), is used to illustrate the chapter on frog movements. I have had some involvement in documenting its spread in Trinidad and Tobago. Each account includes a world map in grey, showing the frog's distribution in green (oddly missing for *E. johnstonei*). Following the topic chapters, there's a glossary defining some technical terms, a list of resources and an index.

The book has high production standards. Each photograph has a clear legend including an arrow pointing to the illustration (rather than a figure number). In addition to photographs, there are many other graphics: I particularly liked the two-page illustration of the frogs inhabiting an Amazonian floating meadow (pp. 56-7). Sources of original illustrations are given in the end acknowledgements section, but in a very concentrated format: I would personally have preferred them in the figure legends. Frog names are mostly given as capitalised common names and italicised scientific names, although scientific names are omitted from some of the graphics. I found very few typographical errors. One minor problem: the text includes frequent cross-references to pages where more information on a topic can be found; some of these are to chapter numbers, but the contents page does not number the chapters, and you need to work out for yourself that the introductory chapter is not counted as chapter one.

Who is the book aimed at? An "introduction" might seem to be for people who do not already know much about frogs, but who would like to find out, or for people who know about their local frogs, but not about any others. The book's coverage is very wide-ranging, quite detailed, pretty up-to-date and mostly uses non-technical language, so there is something here even for people who know quite a lot already. For example, the truly viviparous African frog *Nimbaphrynoides occidentalis* was new to me, as were the Brazilian frogs whose bony spines on the skull allow them to inject toxins into attackers, making them the only truly venomous frogs. I do, however, have some grumbles and reservations.

The description of North American frogs that survive extremely cold winters claims that their blood contains anti-freeze proteins. The research I have read denies this: rather, these frogs tolerate freezing by greatly increasing circulating levels of glucose which acts as a cryoprotectant, preventing damage to frozen cells.

About frogs that develop directly to froglets, without a tadpole stage in water, we read that "tadpoles complete their development within the egg capsule and hatch as fully metamorphosed froglets". There is a wide range of direct developing frogs but, at least in those I have looked at, it is misleading to think of the early stages as tadpoles, because they are so highly modified, with the tail bud developing into a hugely expanded respiratory organ.

There are some examples of what I call inappropriate "speciesist" writing, where a trait is said to have evolved in a particular species, but where it is actually characteristic of a whole group, genus or family. Examples are the occurrence of disc-shaped suckers in torrent-dwelling tadpoles (which is a feature of the multi-species genus *Amolops*, not of a single species); and the lack of a tongue in the Surinam Toad is, again, a feature of pipids in general.

It is claimed that cane toads locate tungara frogs (as prey) by detecting their calls. I would like to see the evidence for this. Michael Ryan's work showed that predatory bats locate tungara frogs by their calls, and that the frogs simplify their calls when bats are present, increasing their survival chances, but at the cost of reducing mating opportunities, because females prefer the complex calls.

I also felt that there are some odd omissions or example choices. Variable tadpole morphology in response to environmental factors (polyphenism) is exemplified by Mallorcan midwife toads, but not by David Pfennig's stunning description of the carnivore/omnivore morph system in spadefoot toads. Salt tolerance is mentioned in the American green treefrog, but the best known and most complete example of this - the crab-eating frog *Fejervarya cancrivora* - is surprisingly omitted. Similarly, there is a brief mention of one treefrog species reducing water loss by means of mucus skin secretions, but the fascinating skin-wiping behaviour - spreading a waxy secretion over the skin in phyllomedusine frogs - is absent. The farming of frogs as a source of human food is briefly mentioned, but the conditions under which these frogs live and are slaughtered is not discussed: the welfare of frogs remains a little-considered subject.

Next, a frustration. The text omits citations to sources, so how can you follow up on points of interest? The book list is a good resource (although, outrageously, the seminal book on tadpoles by McDiarmid and Altig (1999), is omitted), but only two of the books were published after 2015. You can find some of the examples in the "selected" list of research papers but, without clear citations, it is a labour, and for the general reader the book is aimed at, and who is not used to working through research papers, quite intimidating.

The final chapter appropriately covers the worldwide decline in amphibian populations, reviewing causes (I feel that herpetologists have yet to factor in the likely links with the parallel declines in insect populations) and progress towards solutions, both small-scale community-based work such as Toads on Roads campaigns, and large-scale efforts such as the Amphibian Ark, which focuses on the captive breeding of threatened species. I was surprised not to see any comment on such efforts to save Darwin's frog and the mountain chicken (both are covered under the parental care section, but with no comment on their dire state in the wild). The list of organisations at the end includes many of those involved in frog conservation, but oddly omits the charity Froglife (responsible for Toads on Roads in the U.K.) and Save the Frogs.

In conclusion, despite the reservations listed above, I thoroughly recommend this book. It truly is a celebration of frog diversity, and I endorse the message at the start that the main motivation behind conservation efforts should not be based on notions of services frogs may provide to us, but simply because they are wonderful.

REFERENCE

McDiarmid, R.W. & Altig, R. (1999). *Tadpoles: The Biology of Anuran Larvae*. University of Chicago Press, Chicago.

Roger Downie

Birds at Rest: The Behaviour and Ecology of Avian Sleep

Roger Pasquier

Princeton University Press, Princeton, New Jersey, 2025. 339 pages, hardback. ISBN 0691259968.
£30

Roger Pasquier is an eminent American ornithologist who has worked for The Audubon Society, WWF-US, Wildlife International and other natural history organisations. His previous publications include *Birds in Winter*, which was reviewed in *The Glasgow Naturalist* 27(2).

This present book includes considerations of "rest" (defined by others as wakeful immobility) as well as genuine "sleep". The very first chapter "Why do birds sleep?" is much broader than its title suggests, ranging across the whole of the animal kingdom and posing profound biological questions. At first sight, sleep appears utterly counter-productive; it makes you vulnerable to predation, and it prevents you doing other useful things, such as feeding. The argument that moving around at night might make you even more vulnerable to predation, and that other activities become less efficient in the dark, neglects the fact that both diurnal and nocturnal species "sleep" during their inactive period rather than simply "doing nothing". Sleep must be extremely important since every animal group with a nervous system appears to do it, and "lost sleep" often has to be made up later. Even though it appears essential, the benefits of sleep are difficult to pin down but may include the elimination of inactive metabolites, the repair of tissue damage, the boosting of the immune system, the consolidation of memory and the re-connection of synapses within the brain (see Anafi *et al.*, 2019). This is not to say that normal sleep patterns cannot be over-ridden; pectoral sandpipers (*Calidris melanotos*) show a huge reduction in sleep duration during the mating season, while white-crowned sparrows (*Zonotrichia leucophrys*) show a reduction during migration (see Joiner, 2016).

Like mammals, birds exhibit two forms of sleep – slow-wave sleep (SWS) and rapid eye movement (REM) sleep which is deeper. However, avian specialisms can be extraordinary. The chinstrap penguin (*Pygoscelis antarticus*) is said to have 10,000 sleep episodes a day - each of a few seconds but totalling 11 hours - and few birds show more than a few minutes' continuous sleep. Many birds also exhibit uni-hemispheric sleep where one hemisphere of the brain is asleep and the other is not; even more extraordinarily, one eye can be left open communicating with the "working" hemisphere which appears to show an activity state intermediate between SWS and full wakefulness.

The book consists of ten nugget-filled chapters whose topics include specialised roost sites, flock roosts, social behaviour, roosting times, travel to and from roost sites, and the effects of humans. Chapter 3 "Where to roost?" makes the point that roosting sites have to be actively chosen, sometimes on a daily basis - perhaps because the birds are on migration, perhaps because of diurnally changing factors such as tidal movements. Nesting sites may be chosen because of the surrounding abundance of food for the young, but successful roosting often requires greater concealment; thus, at least a third of male wood thrushes (*Hylocichla mustelina*) abandon their incubating female partners at night to hide in denser vegetation elsewhere. Conversely, it is difficult to conceive a closer linkage between feeding and roosting sites than in the insectivorous oxpeckers (*Buphagus* species), where the birds sleep on the back of the large ungulates whose irritants they consume during the day.

Communal roosting can provide further insurance against predation, but it still may not prevent up to 20% of a flock being eaten over a lengthy period of occupancy and it often needs to be allied to other deterrents. Owl pellet surveys can be instructive in highlighting this. Thus, where red-billed quelea (*Quelea quelea*) roost among reeds and grasses in West Africa, the birds make up the bulk of the skulls in regurgitated barn owl (*Tyto alba*) pellets; but if the quelea move into thorn trees which the owls dislike, the pellets only contain the skulls of small mammals. Burrows in earth and holes in trees would seem to be good roost sites, but they become death traps once snakes or other predators discover them.

All contemporary natural history books must end with a chapter on human impact. This one is quite short and, while there must undoubtedly be some serious effects, the examples given here seem mostly slight. Artificial light levels wake some urban insectivorous birds up early, but they do not stay up late – suggesting they have eaten their fill long before closing time; indeed, where that same light attracts insects, the birds may do better. Seed-eaters are not affected. Some of the more injurious effects on roosting urban birds come from our companions, the cats and rats. Artificial light may also bring breeding forwards, but often by a meagre one or two days.

This is not a mainstream ornithological topic but a fascinating one nevertheless – and unduly neglected. As you will gather from this review, it is full of fascinating examples which kindle the reader's interest. It is well-written and the examples chosen are from all round the globe. There are no photographs, but it is illustrated by a small number of charming pictures by Margaret la Farge. It is supported by nearly 30 pages of references.

REFERENCES

Anafi, R.C., Kayser, M.S. & Raizen, D.M. (2019). Exploring phylogeny to find the function of sleep. *Nature Neuroscience* 20, 109-116. https://doi.org/10.1038/s41583-018-0098-9

Joiner, W.J. (2016). Unravelling the evolutionary determinants of sleep. *Current Biology* 26, R1073-87. https://doi.org/10.1016/j.cub.2016.08.068

Tony Payne

Gleaners of Nature: 150 Years of the Dundee Naturalists' Society

Jim Cook, Colin McLeod & Anne Reid
Abertay Historical Society and Dundee Naturalists' Society, 2024. 157 pages, paperback. ISBN 97809000019661.
£7.50

This book has been a while in the making, since it was originally intended to celebrate the 125th anniversary of the Dundee Naturalists' Society (DNS), but the result is an intriguing history. The tale is redolent of the fortunes of so many local groupings of enthusiasts over long periods of time, with false starts, metamorphoses, ebbs, falls, great successes and even disbandments. The text is split into four main chapters of varying lengths which reflect chronological stages of this history.

The short first section "Origins" deals with the plethora of groups which arose periodically in Dundee from about 1708 until 1874 when the DNS was formed. These groups often coalesced around one or two men (there are few women at this stage); they rarely lasted long but they always gave themselves magnificent names such as the "Dundee Speculative Society" and the "Artificial and Scientific Society". In 1828, one of these groups called themselves "The Gleaners of Nature" from which this book's title is derived. Several features come through repeatedly. Expertise in natural history was classless - a widespread finding (see Allen,1976). At the time of its founding, the leader of the Gleaners was an apprentice umbrella-maker and many of these ad hoc societies formed around linen workers (some of whom found they could balance books on their looms) as well as gardeners, bootmakers or tailors. Nevertheless, members of the group often paid joining fees and annual fees far higher than other associations – and well out of proportion to their weekly wages. The definition of natural history was more akin to "natural science" than we would recognise today and would certainly include meteorology, geology, mineralogy and astronomy. Such early associations inevitably brought forth "characters", perhaps none so celebrated as the surgeon Patrick Blair who dissected an elephant that had died near Broughty Ferry; Blair later came to ruin through his support for the Old Pretender in 1715.

The second section "Heyday" narrates the flowering of the Society from its inception in 1874 to its temporary disappearance in the early 1900s. The founding fathers included an optician, a metalworker who made his own microscope, the local YMCA and a man who had a private astronomical observatory. Again, the definition of natural history is strained by the fevered pace of discovery and innovation in the Victorian Age; nobody could resist lectures and discussions on electric lamps, luminous paint, telephones and "the air quality in dwellings and schools", alongside more conventional biological topics such as the anatomy of the basking shark, snails on plants, or birds of the Tay. Public lectures gained a good audience when they were free but were poorly attended when charged for (it was the cheaper seats that were left vacant) and, in general, the Society struggled to make a profit from any attempt to gain a wider exposure in the town. Nevertheless, perhaps the most intriguing part of this section is an account of several elaborate *conversazioni* (containing short talks, musical interludes, demonstrations, exhibits, food and drink), which were held in large public buildings of the time and often attracted hundreds. The Society also thrived by virtue of its alliance with the new University College of Dundee and its programme of field-trips (though dredging at sea was more popular than the usual terrestrial activities). For reasons which are unclear, it all came to a sad and precipitate decline at the turn of the century.

The third and fourth parts "Revival and Wartime" and "Modern Times" are to some extent recapitulations of one another and demonstrate the inevitable cyclicity over time which is a feature of most clubs and societies. "Revival" begins with the reformation of the DNS in 1911, after a hiatus of nearly ten years, to coincide with the British Association's visit to Dundee. The DNS had to take out Zeppelin-insurance during the Great War but continued to operate throughout both upheavals. However, by the 1960s, interest was beginning to wane again until the Society decided in 1972 to fend off a possible takeover by a local museum group. Luckily, this period coincided with the rise in eco-awareness by the public and media, and the increased success of DNS mirrors, on a smaller scale, the expansion of larger national groupings such as RSPB.

Many practical questions arose during this period of 150 years. Should you attempt to organise both talks (indoors at a fixed venue) and field trips (outdoors at a variety of locations) – remembering that the period runs from the horse and cart at one end, through the growth (and subsequent demise) of both the railways and bus routes, to the current era of private transport? How much should you charge for membership? Should you produce a journal or newsletter (the earliest ones needed to be hand-written)? Should you establish "sections" within the society? Should you try to amass a collection of specimens and/or a library? How do you deal with changes of venue? Do you gain benefit from being allied to a local university or college? How do you interact with other local organisations? Some of these issues cropped up repeatedly and all are still highly relevant today.

The book ends with an appendix of short biographical notes of important persons from DNS history. There is a centre section of nearly 40 illustrations and a copious reference section to each chapter. This is a well-written and very worthwhile read.

REFERENCE

Allen, D.E. (1976). *The Naturalist in Britain: A Social History*. Allen Lane, London.

Tony Payne

The Lives of Octopuses and Their Relatives. A Natural History of Cephalopods

Danna Staaf
Princeton University Press, Princeton, New Jersey, 2023. 288 pages, hardback with many colour photographs. ISBN 9780691244303.
£30.00

This book is one of a series of "Lives of" volumes recently published by Princeton University Press covering the natural history of various ecological groups including frogs, bats, snakes, spiders, bees, lichens, butterflies, seaweeds, sharks, viruses, beetles, fungi, and moths. Like the other volumes, *The Lives of Octopuses and Their Relatives* is a hefty tome of nearly 300 pages, packed full of fascinating biological and ecological information and illustrated with numerous top quality colour photographs, many of which are full page size. The text is set at a level accessible to the general naturalist but bridging into the more scientific world of the specialist study of cephalopods.

There is a short introduction followed by a section explaining what a cephalopod is – they include many variants of octopuses, cirrate octopuses, squids, vampire squids, cuttlefish and nautiluses. Cephalopods are "lower" animals but with many advanced traits including intelligence and complex behaviour such as hunting and social signalling. They also have unusual morphologies - clawed suckers, beaks, bioluminescent photophores and amazing instantaneous mimicry. They show peculiar reproductive strategies, many being very short-lived with mass spawning events followed by mass mortalities. They include the largest known invertebrates such as the giant squid and colossal squid. They have a very long evolutionary history (with many spectacular shelled fossil species) which in some respects mirrors that of fish, although living cephalopods are far less speciose. It is not surprising that they have captured our imagination and this book explores the extant cephalopod world in considerable detail.

Following the introduction are sections on the cephalopods from seven different broad habitats: Beaches, Tide Pools, Sandflats and Mudflats; Seagrass Beds, Kelp Forests, and Rocky Reefs; Coral Reefs; Open Ocean; Midwater; Deep Sea; Antarctica and the Arctic, and finally a useful glossary and resource bibliography. The habitat sections are each prefaced by several pages describing the habitat features and the challenges they present to cephalopods. Hence readers are presented with a lot of oceanographic and marine biological knowledge which helps them fully appreciate how a diverse array of cephalopods has evolved to inhabit the entire marine realm. For each broad habitat around half a dozen cephalopod species are selected as representatives. Each of these receives a two-page spread – the first page describing the biology of the species and showing its world distribution, highlighting any peculiar features of its morphology or life history and the second page a beautiful colour photograph of a live specimen. The distribution maps are the only minor flaw I have noticed in this otherwise splendid volume. The maps all show the entire world in miniature so colour shading for those species of limited distribution is very small. There are also some inaccuracies – the Atlantic longarm octopus and the North Atlantic spoonarm octopus are both shown as occurring in the shelf seas around Britain, which is not the case (see Laptikhovsky & Ouréns, 2017). However, let us put the minor map errors to one side because there is so much about this volume that is excellent.

The cephalopods are a rather understudied group of marine organisms compared with their fishy relatives. This volume attempts to encompass the cephalopods of all the world's oceans, from shelf waters to open oceans and from the tropics to the poles. Around 50 species in total are selected to show-case the morphological and behavioural diversity of cephalopods, which currently number around 1,000 described species.

The Beaches, Tide Pools, Sandflats and Mudflats section briefly describes tides and their impacts; intertidal habitats; life in air and water; burying and burrowing behaviour; and the use of glue and suckers by cephalopods. Species highlighted include the tool-using coconut octopus which uses coconut halves to hide in – poking out two legs to walk along the seabed. The sand octopus is the only species to make a true burrow in sediment, meanwhile the wunderpus octopus, whose scientific name is *Wunderpus photogenicus*, has a striking (but fixed) banded colouration pattern resembling a poisonous sea krait snake or lion fish, a perfect example of Batesian mimicry. Surprisingly the world-famous mimic octopus, with its more dynamic mimicry of flounder, sea snakes etc. only gets a passing mention here. The southern bobtail squid has a light organ on its underside, powered by symbiotic bacteria, which provides countershading (against moonlight) at night and the southern bottletail squid produces copious slime to deter predators in the same manner as the famous hagfish.

The Seagrass, Kelp Forest, and Rocky Reef section describes: the origin of algae and algae ecosystems; the challenges of living in estuaries – only a very few cephalopods manage to cope with brackish waters; cephalopod gatherings to mate and spawn; and their targeting by human fisheries. Species highlighted include the southern pygmy squid, one of the smallest cephalopods, which glues itself to seagrass fronds – the females are 3 cm long and the males only 1.5 cm. Here too is the Pacific red octopus – 10 cm long but with a painful venomous bite and the Maori octopus nearly 1m long. The common Sydney octopus forms multi-generational congregations, now nicknamed "Octopolis", where much social squabbling occurs and there is mention of a recently described small Brazilian octopus whose typical hidey-hole is discarded beer cans!

The Coral Reef section describes the anatomy of corals; coral reproduction; algal partners of coral and coral bleaching. Coral reefs are discussed as evolutionary hotbeds including the famous Coral Triangle in the Indo-Pacific. Coral reefs are home, among others, to the night octopus – a nocturnal hunter of other octopuses; the poison ocellate octopus which drills mollusc shells to insert deadly venom; and the bellybutton nautilus, a prehistoric relic with a spiral shell and suckerless tentacles, which migrates daily from deep water to feed nearer the surface at night.

The Open Ocean plankton communities are exploited by pelagic cephalopods including both larval and adult stages. Some, like Humboldt squid, are large active hunters, other cephalopods lead a more sedate "jellyfish life-style" plucking zooplankton from the water column. Many midwater cephalopods undergo diel migration - coming to the surface at night to feed or hunt or spawn. They are heavily targeting by human fisheries. Post spawning cephalopods die and float and are a major food source for seabirds. Many cephalopods change depths as they grow – ontogenetic migration. The Open Ocean and Midwater habitats host a huge variety of octopus and squid including knobbed argonauts which produce an exterior protective shell; and the football octopus which has a swim-bladder, the female is up to 80 cm long, but the male is only about a tenth her size and with a large detachable reproductive arm. Here too we find purple-back flying squid, 2 m long, which can leap like a flying fish and large glass squid up to 2.7 m, both species with light producing photophores. The famous giant squid, with a total length of 13 m also lives here, hunted by sperm whales. It was first filmed alive in 2006. Just a little shorter, but heavier, is the colossal squid, without arm suckers but with strong swivel hooks. Most of the squid species feed on fish or crustaceans but the vampire squid survives on particulates from "marine snow".

Finally, the Deep Sea and the Antarctic/Arctic regions are described including global circulatory systems and the growth and impacts of ice-caps. A short history of both deep-sea and polar explorations is provided along with the discovery of undersea volcanoes and the spectacular deep-sea vent communities. The importance of sinking food such as "marine snow" and whale falls is discussed as well as visual communication in the dark via photophores. Deep and cold waters present many challenges and there is some interesting speculation on a polar evolutionary origin of cephalopods. Among the inhabitants are the Dumbo octopus with its webbed tentacles and flapping "ear" fins, which is the deepest known species from 7 km depth. In the dark zone there is the blind cirrate octopus with vestigial lens-less eyes covered in skin. It has umbrella arms and is possibly a plankton feeder. The deep-sea vent octopus crawls around the hot vents catching crabs and shrimps. It has eyes but they do not respond to light. The female seven-arm octopus is 4 m long but the males are only 20 cm long. Strangely, a broken arm of this poorly known deep-sea species washed up on Scottish shores in 2025! The Antarctic glass squid feeds on krill but is itself food for albatrosses and elephant seals. The Arctic octopus, the first cirrate octopus to be described, feeds mostly on worms. It lays hard-shelled eggs which take 32 months to hatch. The North Atlantic spoonarm octopus lives at depths over 400 m. The have an unusually long lifespan of 3-6 years and have been successfully bred in a laboratory, brooding their eggs for over a year.

Just a flavour of the enormous variety of lifestyles, and astounding adaptions of the cephalopods has been indicated in this review. You really must read this volume to fully appreciate the wondrous morphological and behavioural plasticity of cephalopods. Although I am already a "well-informed" marine biologist I found this volume absolutely fascinating, crammed full of facts and insights into an alternative "zootropolis of alien creatures" from our shallow coastal seas to the barely explored parts of our oceans. These, often bizarre, organisms are of great interest to evolutionary biologists and deserve to be much better known by natural historians.

REFERENCE

Laptikhovsky, V. & Ourens, R. (2017). *Identification Guide for Shelf Cephalopods in the UK Waters (North Sea, the English Channel, Celtic and Irish Seas).* Centre for the Environment, Fisheries and Aquaculture Science, U.K.

Myles O'Reilly

On the Trail of Sloths

Desmond Philip Gilmore, Carlos Peres da Costa and Denia Fittipaldi Duerte.
Goa 1556 Press, Saligão, Goa, India, 2025. 199 pages, paperback or ebook. ISBN (Print) 9789395795197, (Ebook) 9789395795586.
700 Rs

Sloths may appear harmless, and even cuddly, but they often receive a bad press. Oliver Goldsmith, writing in 1825, was unkind to them "One of the meanest and ill-famed of creatures that chews the cud" while a 20th century evaluation was that "they have no right to be living on earth, but they would be fitting inhabitants of Mars where the year is over 1,000 days long". Their very name is one of the deadly sins. Nevertheless, they represent a considerable proportion of the mammalian biomass of south and central American forests on both sides of the Andes, and they are remarkable in their adaptations to their chosen lifestyle.

This book by the late Des Gilmore from Physiology at the University of Glasgow and his colleagues at the University of Pernambuco, Recife, Brazil covers every angle of sloth biology. Taxonomically, sloths are lumped in with other new world curiosities – the armadillos and anteaters – and this Superorder was, until recently, termed the Edentata. This is misleading as only the anteaters lack teeth completely while the rest have premolars and molars; in sloths, there are no milk teeth and the adult teeth (which lack enamel) grow throughout life, being kept in check by grinding. The Superorder is now known as the Xenarthra (meaning "strange joints") which refers to the unusual articulation of the vertebrae. In fact, so much of sloth structure is strange, with one peculiarity being the number of cervical (neck) vertebrae. Every one of the 6,500-7,000 mammals alive today has seven cervical vertebrae except for manatees and sloths. However, the two-toed sloths have gone in for a reduction, while the three-toed species have elected for an increase. While the ability of sloths to rotate their heads while hanging upside down is remarkable, it appears to be the shape of the vertebrae, rather than their number, that matters. The reproductive system is primitive; males have internal testes, while females have no clear separation between the vagina and uterus. The main vein of the trunk (the vena cava) is paired in sloths, a perpetuation of the embryonic condition which is lost in other mammals.

Historically, sloths were found throughout north and south America (and even the Caribbean islands) and included both terrestrial and arboreal species. Some ground sloths weighed up to four tons and this group became extinct only within semi-historical times (10,000 years ago), even continuing to feature in some tribal oral traditions. The two living groups - the two-toed and three-toed sloths - diverged from one another 30-40 million years ago and are only distantly related. A dramatic case of convergent evolution?

This book explicitly builds on earlier major reviews and contains two dozen chapters. Some deal with specific body systems; the skeleton; the muscles; gut and feeding; lungs and respiration; liver, spleen and kidneys; heart and blood pressure; brain, spinal cord, special senses. Others deal with evolution; distribution and ecology; activity patterns; breeding; cytogenetics; thermoregulation. Finally, there are chapters on sloth diseases, parasites and commensals, and the problems of keeping sloths in captivity.

Probably the best-known attribute of sloths (they are very slow) explains many of their idiosyncrasies. Food usually takes a week to pass along the alimentary system and can take much longer on occasion. As the sloth normally descends to ground level to defaecate and urinate, it does so only every few days; this means that the stomach and bladder together can periodically constitute up to a third of body weight. Moreover, as the leaves which make up its diet are so poor a source of nutrition (fibre, but hardly any protein), a sloth could theoretically starve to death with a full stomach. The resting metabolic rate is so low that a sloth can cease to breathe for 20 minutes and still be revived.

The book forms a handy, compact review of sloths and their world. The writing is of a distinctly scientific tone, but clear and understandable, and editorial assistance (by Dr. John Shaw Dunn) is highlighted in the acknowledgements. There are few illustrations, which is a pity and may perhaps be due to the untimely death of the lead author. For compensation, the bibliography runs to an astonishing 40 pages.

Tony Payne

The Glasgow Naturalist (2026) Volume 28, Part 4, 58-62

PhotoSCENE 2025-26

PhotoSCENE Natural History Photographic Competition.
This year's event was held, for the first time, in the Kelvin Hall on Tuesday 10th February 2026 and was attended by roughly 50 members and friends. As always, the Society is very grateful to the University of Glasgow's School of Biodiversity, One Health and Veterinary Medicine (SBOHVM) for help with both the funding and the judging of the competition and to Lorna Kennedy for her help in receiving and compiling all the entries from Society members and students and staff of SBOHVM. The Society would also like to thank both Roy Petrie, former photographic editor for *The Herald*, and Professor Stephen Philips from SBOHVM for their help in judging the competition. This year there were 33 entrants resulting in a total of 144 photographs being submitted. Of these 144 entries, nine were awarded prizes totalling £750 by the judges. This year's overall winner of *The David Palmar Prize* was Scott Shanks, with his excellent photograph entitled "Strutting toad" (which won him £200). Second place was awarded to Kirsty Menzies, who received £150 for her image "Sawfly on oxeye daisy". The third-place prize of £100 was awarded to Clare Branston for her image of "Two sand martins". Additionally, there were six highly commended entries each receiving £50. This year there was a further rise in student entries to the competition with many (but not all) taken on University Exploration Society field trips or Ph.D. overseas research projects.

A. Colville Wilson

Overall winner:

Scott Shanks – Strutting toad (*Bufo bufo*), near Cardhu Distillery, Moray, Scotland, Spring 2025.

Second Prize winner:

Kirsty Menzies – Sawfly (*Tenthredo* sp.) on oxeye daisy (*Leucanthemum vulgare*), Boylestone Quarry, Barrhead, East Renfrewshire, Scotland, 7th July 2025.

Third Prize winner:

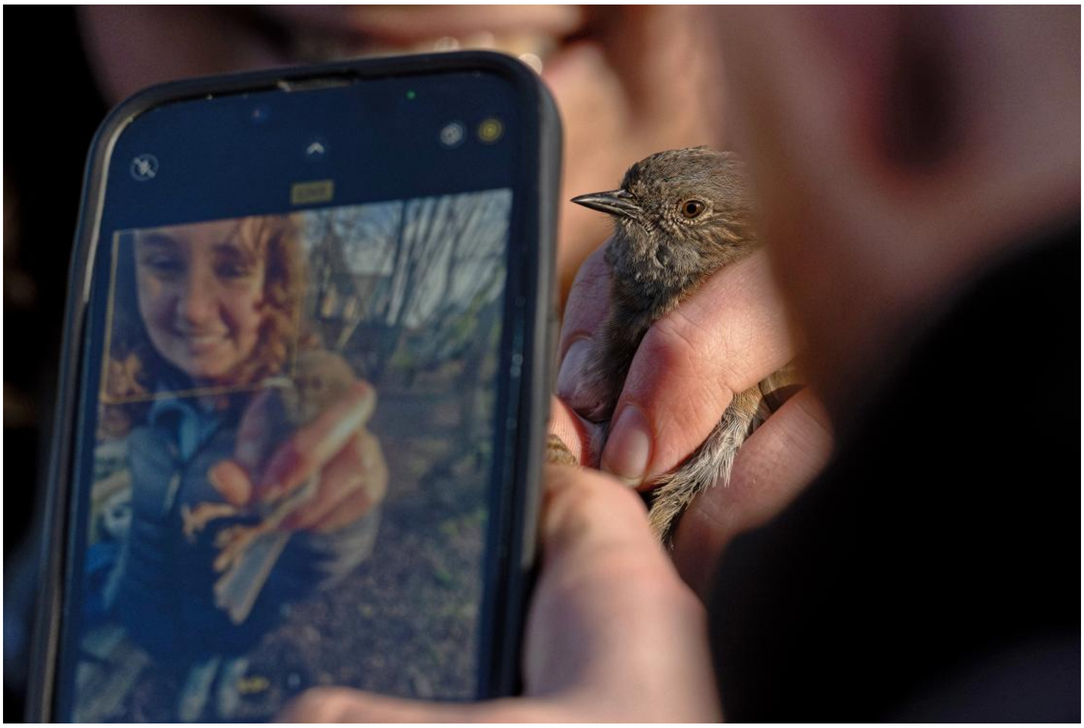
Clare Branston - Two sand martins (*Riparia riparia*) prospecting a cavity at an artificial nesting bank, Gailes Marsh Reserve near Irvine, North Ayrshire, Scotland, 12th April 2025.

Highly commended entries:

Alexander Levai - Longhorn beetle (Cerambycidae), University expedition to Tobago, 6th August 2025.

Rebecca MacArthur - Juvenile racoon (*Procyon lotor*), Alberta, Canada, 29th June 2025.

Mark Pitt – Common blue male (*Polyommatus icarus*), Hamiltonhill Claypits Nature Reserve, Glasgow, Scotland, August 2025.



Lionel Horn - Dunnock (*Prunella modularis*) ringing with Zoology students, Hamiltonhill Claypits Nature Reserve, Glasgow, Scotland, 1st April 2025.

Ewan Parry – Sawfly larva (*Nematus septentrionalis*) on a birch leaf (*Betula* sp.), walkway by the River Kelvin, Glasgow, Scotland, 31st August 2024.

Heather Snow – Puffin (*Fratercula arctica*) with sand-eels, Lunga, Treshnish Isles, Scotland, 2024.

BLB Grant Awards in 2025

Investment income earned from the Blodwen Lloyd Binns bequest enables GNHS to provide funding to support projects that have a direct benefit for natural history in Scotland, and to some extent further afield. After careful consideration of grant applications received in 2025, GNHS Council awarded funds towards the following projects:

Recipient	**Project**	**Award amount**
Chris McInerny	Nightjar survey in Scotland.	£2,038
Richard Levai *et al.*	University of Glasgow Tobago expedition 2025.	£1,000
Grace Jean Savage *et al.*	University of Glasgow Thailand expedition 2025.	£1,000
Leo Yokota *et al.*	University of Glasgow Egypt expedition 2025.	£1,000
Torridon Bradley-Mowat *et al.*	University of Glasgow Remote Scotland expedition 2025.	£1,000
Aubrey Small *et al.*	University of Glasgow Iceland expedition 2025.	£1,000
The Froglife Trust	Coalface to Wildspace Scotland.	£2,000
Katie Grieve	Student research on coral reef in Thailand.	£200
Jude Wilson	Conference attendance in South Africa to present PhD research findings on stressors affecting frog tadpoles.	£300

The Glasgow Naturalist (2026) Volume 28, Part 4, 64-65

PROCEEDINGS 2025

For each meeting lecturers' names and lecture titles are given, as is the location.

January 14th
Lecture: "Connecting communities through urban biodiversity: a pathway to sustainable engagement" from Professor Ria Dunkley. Kelvin Hall.

February 11th
Photographic night: Andy Wilson presented the results of the annual PhotoSCENE competition. Boyd Orr Building.

March 11th
Annual General Meeting preceded by Lecture: "Scotland's National Herpetological Strategy, 2025-2045" from Catherine Whatley. Boyd Orr Building.

March 13th
Expeditions Report Back, jointly with the University of Glasgow Expeditions Society. (Most expeditions are supported by the BLB Bequest). Graham Kerr Building.

April 8th
Lecture 1: "Saving Scotland's species-rich grasslands'" from Apithanny Bourne. Lecture 2: "Loch Lomond's oakwoods: an unnatural naturalness" from Cameron Easton. Kelvin Hall.

May 13th
Lecture: "Invasive species in a changing world" from Paul Walton. Kelvin Hall.

June 10th
Summer Social dinner held at Elenas Spanish Restaurant, preceded by a tour of wildlife areas in University of Glasgow campus at Gilmorehill led by Emily Robson.

September 9th
Lecture: "Glasgow Peregrine Project: good news in the city" from John Simpson. Kelvin Hall.

October 14th
Lecture 1: "Using genetics to support wildcat conservation in Scotland" from Jo Howard-McCombe. Lecture 2: "The Better Biodiversity Project'" from Neil Harris. Kelvin Hall. A National Biology Week meeting jointly with the Royal Society of Biology.

October 22nd
Blodwen Lloyd Binns Lecture: "A scientific overview of the conservation and ecology of the Serengeti" from Professor Grant Hopcraft jointly with staff and students from the University's School of Biodiversity, One Health & Veterinary Medicine. Graham Kerr Building with option of virtual attendance.

October 30th
Lecture: "Plant exploration in northern Vietnam" from Richard Baines jointly with Friends of Glasgow Botanic Gardens. Kelvin Hall.

November 11th
Lecture: "Plants of Bhutan" from David Long jointly with Glasgow Treelovers and Friends of Glasgow Botanic Gardens. Kelvin Hall.

December 2nd
Lecture: "Updating the taxonomy of the Zoology Museum" from Mike Rutherford jointly with University of Glasgow Zoology Society. Graham Kerr Building.

December 9th
Christmas Social dinner at Elena's Spanish Restaurant, preceded by tours of the zoological collections of the Hunterian Museum.

Excursions
There were ten excursions, some held jointly with either Paisley Natural History Society or the Clyde and Argyll Fungus Group.

Officers and Council elected at the 2025 AGM

President
Dominic McCafferty

Vice President
Nicole Digruber

General Secretary
Alison Park

Assistant Secretary
Eiryn Milligan

Treasurer
Susan Futter

Winter Syllabus
Roger Downie

Excursions
Alison Moss

Membership Secretary
Richard Weddle

Librarian
Myles O'Reilly

The Glasgow Naturalist Editor
Iain Wilkie

The Glasgow Naturalist Assistant Editor
Ruth Maclachlan

Newsletter Editor
Rachel Mosley

Section Convenors
Bio-recording: Richard Weddle
Botany: Alison Moss
Geology: Ann Ainsworth
Photography: Andy Wilson
Zoology: Jasmine Dickson

Social Secretary
Pat Thomson

Councillors
Robyn Haggard
Kirsty Kennedy-Wylie
Janet Palmar
Emma Plant
Jessica Young

BLB Executive
Chair: Chris McInerny
Secretary: Alison Park
Treasurer: Susan Futter
Scientific Advisor: Dominic McCafferty
Technical Advisor: Richard Weddle
Financial Liaison: Kirsty Kennedy-Wylie

The Glasgow Naturalist
Information for Contributors

1. *The Glasgow Naturalist* publishes full papers, short notes and book reviews. All articles are peer reviewed by a minimum of two reviewers. The subject matter of submissions should concern the natural history of Scotland in all its aspects, including historical treatments of natural historians. Details of the journal can be found at: www.gnhs.org.uk/gnat.html

2. Full papers should not normally exceed 20 printed pages. They should be headed by the title and author, postal and e-mail addresses. Any references cited should be listed in alphabetical order under the heading References. All papers must start with a short abstract of up to 200 words, which should summarise the work. The text should normally be divided into sections with sub-headings such as Introduction, Methods, Results, Discussion, Acknowledgements and References.

3. Short notes should not normally exceed two printed pages. They should be headed by the title and author's name, postal and e-mail address. Cited references should be listed in alphabetical order under the heading References. There should be no other sub-headings. Any acknowledgements should be given as a sentence before the references. Short notes may cover, for example, new locations for a species, rediscoveries of old records, ringed birds recovered, occurrences known to be rare or unusual, interesting localities not usually visited by naturalists, and preliminary observations designed to stimulate more general interest.

4. References should be given in full according to the following style:
Pennie, I.D. (1951). Distribution of capercaillie in Scotland. *Scottish Naturalist* 63, 4-17.
O'Reilly, M., Nowacki, S. & Gerrie, E. (2018). New records of the white-banded grapple-worm. *The Glasgow Naturalist* 26(4), 96-97.
Wheeler, A. (1975). *Fishes of the World*. Ferndale Editions, London.
Smith, C.W., Aptroot, A., Coppins, B.J., Fletcher, A., Gilbert, O.L., James, P.W. & Wolseley, P.A. (2009). *The Lichens of Great Britain and Ireland*. (2nd edition). The British Lichen Society, London.
Grist, N.R. & Bell, E.J. (1996). Enteroviruses. In: Weatherall, D.J. (Editor). *Oxford Textbook of Medicine*, pp. 381-390. Oxford University Press, Oxford.
References with more than six authors: name the first six authors, then add "*et al*."

5. References should be cited in the text as follows:
Single author: Pennie (1915)… (Pennie, 1915). Two authors: Grist & Bell (1996)… (Grist & Bell, 1996). More than two authors: Smith *et al.* (2009)… (Smith *et al.*, 2009). Multiple citations: (Pennie, 1915; Grist & Bell, 1996). Same author(s), publications in different years: (MacGillivray, 1840, 1855).

6. An organism's genus and species names should be given in italics when first mentioned. Thereafter only the common name is required. Please use lower case initial letters for all common names, e.g. wood avens, blackbird, unless the common name includes a normally capitalised proper name, e.g. Kemp's ridley turtle. The nomenclature of vascular plants should follow Stace, C.A. (2019). *The New Flora of the British Isles*. (4th edition). C&M Floristics, Stowmarket. Normal rules of zoological nomenclature apply. When stating distribution, it may be appropriate to give information by vice-county.

7. All articles must be prepared as a word-processed document in A4 format, double-spaced throughout, with margins of 25 mm, and 12point Times New Roman font. Tables and figure legends should be typed on separate pages at the end of the manuscript.

8. Tables are numbered in arabic numerals, e.g. Table 1. These should be double-spaced on separate pages with a title and short explanatory paragraph underneath.

9. Line drawings and photographs are numbered in sequence in arabic numerals, e.g. Fig. 1. If an illustration has more than one part, each should be identified as, e.g. 9A, B etc. They should be supplied as digital images (minimum resolution 300 dpi in tif or jpeg format) either in separate files or on separate pages at the end of the manuscript**: they should not be embedded in the text**. A metric scale must be inserted in photomicrographs etc. Legends for illustrations should be typed on a separate page.

10. Articles should be submitted by e-mail to the Editor: Mr Mike G. Rutherford (E-mail: Editor@gnhs.org.uk). When submitting an article, authors should assure the Editor explicitly that all illustrations, including maps, do not infringe copyright law. **Articles will not be considered for publication without this assurance.**

11. If an author has used an Artificial Intelligence Generated Content (AIGC) tool - e.g. ChatGPT - to create any part of the manuscript, its use must be detailed in the Methods or Acknowledgements section of a full paper or in the final paragraph of a short note. The author is fully responsible for the accuracy of any information provided by the tool, including cited references. Tools that are used to improve spelling or grammar are not included in the scope of these guidelines. **The final decision about whether use of an AIGC tool is permissible in the context of a submitted manuscript lies with the Editor**.

12. When the article is accepted for publication, the author should return the corrected manuscript to the Editor as soon as possible. Final proofs will be e-mailed to authors and should be returned by e-mail as soon as possible. **Alterations at this stage should be kept to the correction of typographical or formatting errors. Proposals for more extensive alterations, which should be forwarded directly to the Editor, will be approved only in exceptional circumstances.**

13. All submissions are liable to assessment by the Editor for ethical considerations, and publication may be refused on the recommendation of the Editorial Committee. A copy of the published article will be sent to the corresponding author as a pdf file. Offprints will not be supplied.

14. Authors must sign a publishing agreement giving the GNHS copyright for articles published in *The Glasgow Naturalist*. This is standard procedure for publishing in most scientific journals, and allows the article to be archived at the Biodiversity Heritage Library www.biodiversitylibrary.org/bibliography/38981#/summary