The Glasgow Naturalist (2024) Volume 28, Supplement, 144-146

https://doi.org/10.37208/tgn28S23

Research on fish at the University of Glasgow

N.B. Metcalfe

Graham Kerr Building, University of Glasgow, Glasgow G12 8QQ

E-mail: neil.metcalfe@glasgow.ac.uk

Although John Graham Kerr himself worked on lungfish, there was very little subsequent research on fish until the late 1970s. An exception was the 1963 PhD conducted by Peter Maitland on the ecology of the River Endrick (the main river flowing into Loch Lomond), which had a focus on five species of freshwater fish (Maitland, 1965), and some work on powan (*Coregonus clupeoides*) in the 1950s as part of Harry Slack's studies of the ecology of Loch Lomond. Peter went on to have a distinguished career with the Institute of Terrestrial Ecology, becoming one of the foremost fish ecologists in the U.K. and a pioneer in the conservation of rare species of fish.

Most of the research on aquatic organisms in the department in the 1970s was on invertebrates, although Peter Spencer Davies extended his main line of work on coelenterate metabolism to supervise Malcolm Jobling's PhD on the digestive physiology of plaice (*Pleuronectes platessa*) (Jobling & Davies, 1980). Malcolm went on to take up a position at the University of Tromsö in northern Norway, where he became internationally known for his work on the physiology of fish (in particular those associated with cold water fish farming, such as Arctic charr - *Salvelinus alpinus*, and Atlantic salmon – *Salmo salar*).

The arrival of Felicity Huntingford was the start of fish behaviour becoming a key area of departmental research (Huntingford *et al*., 2024). Her group initially studied the aggressive, anti-predator and breeding behaviour of three-spined sticklebacks (*Gasterosteus aculeatus*) (Giles & Huntingford, 1984). This species has a long history of being used for behavioural research, due to the ease with which it can be reared and induced to breed in the laboratory. A chance discussion between Felicity and John Thorpe from the Freshwater Fisheries Laboratory at Pitlochry led to a long-term and very fruitful collaboration between them both and with me; I was initially taken on in 1985 as Felicity's postdoctoral research assistant but later became an independent member of the academic staff. John had access to excellent salmon-rearing facilities (something the department lacked), which opened the way to many studies of the links between behaviour, growth and life histories in salmon (e.g. Metcalfe *et al.*, 1989). The facilities for holding salmon and related species such as Arctic charr and trout slowly increased - initially at the field station on Loch Lomond (Adams, 2024) but later in the Graham Kerr Building. However, it has never been possible to hold fish as large as adult salmon or trout in either of the Glasgow University locations, so all studies based on fish held in our facilities have been on small species or the juvenile stages of larger ones.

Felicity's research (together with Colin Adams, based at SCENE) gradually became focused on the welfare of farmed fish (Huntingford, 2024). Meanwhile I collaborated with Jan Lindström on the behavioural ecology of swordtails (Poeciliidae) and sticklebacks (Lindström *et al.*, 2009), and then began to specialise on the consequences of individual variation in metabolic rate and mitochondrial efficiency in a range of species of freshwater fishes. This work was initially focused on aquarium-based studies, but then extended to working in semi-natural stream tanks and finally full-scale field experiments in salmon streams in northern Scotland (Fig. 1), which showed that a fish's metabolic rate influenced its habitat choice and survival (Auer *et al.*, 2020). A theme of linking variation in metabolic rate to behavioural variation was strengthened by the arrival in 2009 of Shaun Killen, who brought expertise in measuring the swimming performance, shoaling and temperature preferences of fish (Killen *et al*., 2015).

Fig. 1. Researchers from the University of Glasgow using a backpack electrofishing kit to survey juvenile salmon populations in a highland stream. Studies of salmon and trout have formed a major focus of fish research in Glasgow. (Photo: N.B. Metcalfe)

In the 1990s Colin Adams started a major field-based study of the extensive variation in the morphology of Arctic charr populations living in the freshwater lochs of Scotland, documenting multiple examples of lochs that held separate populations of both pelagic and benthic morphs, differing in diet, appearance and life history (Adams *et al.*, 1998). The later arrival of the evolutionary biologists Kathryn Elmer and Kevin Parsons extended this study into analysis of the genetic basis and evolutionary history underlying the observed extreme morphological variation in this species (Mable *et al*., 2024). Over the last decade Kevin has also led a

large-scale study that has examined whether Icelandic populations of the three-spined stickleback living in ponds heated by geothermal sources are different from stickleback populations living in neighbouring unheated ponds, and whether any such differences are due to evolved changes or within- or between-generational phenotypic plasticity (Pilakouta *et al.*, 2023). This study system of a "natural experiment" provides an excellent model for how fish might respond to climate change.

While the majority of the research on fish in Glasgow has focused on species in fresh water, the arrival of David Bailey has led to work on marine fish, especially those living in deeper waters (Bailey *et al.*, 2009); marine biology in Glasgow is covered in more detail by Meadows (2024). Given the importance of salmon farming to the Scottish economy over the last 30-40 years, it is not surprising that there have also been links with the aquaculture industry. These have recently been given a boost by the work of Martin Llewellyn and Sofie Spatharis, who are developing a major collaborative research programme aimed at making Scottish aquaculture more sustainable through better disease control for farmed salmon and the development of more sustainable feeds.

The facilities in the Graham Kerr Building for holding and quantifying the behaviour and performance of fish have improved gradually over time, despite the building not having originally been designed for this purpose. Much credit for this goes to Graham Law, the manager of the animal facilities in the building, who lobbied hard to secure the funding and then designed and oversaw the renovation of the aquarium rooms. This involved much logistical juggling, as it was necessary to renovate rooms one at a time in order not to halt ongoing research projects, yet moving projects between rooms was difficult as the rooms had different capacities, types of tank (to suit particular species) and range of temperatures over which they could operate. Once completed, these improvements allowed the scope of projects to increase in both scale and duration: recent projects have included studies spanning multiple generations (e.g. to measure the evolutionary effect of contrasting selection pressures, or to test whether the effects of environmental change can be passed on to offspring through non-genetic means). The Graham Kerr Building and SCENE (Adams, 2024) have developed complementary facilities, with the Graham Kerr being more suited to studies involving many replicate fish tanks (e.g. breeding studies) while SCENE has two experimental stream tanks that allow research on the behaviour of fish in semi-natural conditions (for example, studies of shoaling or territorial behaviour).

Field studies on fish have continued since the pioneering work of Peter Maitland, but the nature of the work has changed in the last decade due to the development of acoustic tracking systems that allow recording of the movements of fish in their natural environment. This can be over a range of scales: Shaun Killen's group have used this technology to quantify the detailed space use of individual fish within a small freshwater loch (the Dubh Lochan at SCENE), while Colin Adams and collaborators have tracked the movement of salmon smolts over long distances down rivers and out into the Atlantic, shedding new light on their migration routes, speeds and survival rates at the start of the marine phase of their life cycle (Lilly *et al.*, 2024). It is also worth recording that for over 25 years there has been a mutually beneficial association between the University and the Clyde River Foundation (CRF), an independent charity that is dedicated to research and education on the aquatic environment of the River Clyde catchment. The University has provided a base for the CRF and affiliate University status for its staff, and in return members of the CRF have contributed to teaching students about freshwater biology and conservation, provided opportunities for field-based undergraduate and graduate student projects, and collaborated with the University's fish biologists.

As with any area of scientific research, the focus of fish research in Glasgow has changed over the years, because of changes in academic staff and their interests, technological developments opening new opportunities, and societal changes in the perceived areas of greatest importance affecting funding opportunities. Thus, while it is likely that research on fish will continue at the University for many years to come, it is difficult to predict its nature, although there is likely to be a continued interest in the responses of both wild and cultured fish to environmental change, and in sustainable aquaculture.

REFERENCES

Adams, C.E. (2024). The Field Station: from ex-army huts to SCENE. *The Glasgow Naturalist* 28, Supplement, 130-131. https://doi.org/10.37208/tgn28S06

Adams, C.E., Fraser, D., Huntingford, F.A., Greer, R.B., Askew, C.M. & Walker, A.F. (1998). Trophic polymorphism amongst Arctic charr from Loch Rannoch, Scotland. *Journal of Fish Biology* 52, 1259-1271. https://doi.org/10.1111/j.1095-8649.1998.tb00970.x

Auer, S.K., Bassar, R.D., Turek, D., Anderson, G.J., McKelvey, S., Armstrong, J.D. *et al.* (2020). Metabolic rate interacts with resource availability to determine individual variation in microhabitat use in the wild. *American Naturalist* 196, 132-144. https://doi.org/10.1086/709479

Bailey, D.M., Collins, M.A., Gordon, J.D.M., Zuur, A.F. & Priede, I.G. (2009). Long-term changes in deep-water fish populations in the northeast Atlantic: a deeper reaching effect of fisheries? *Proceedings of the Royal Society B - Biological Sciences* 276, 1965-1969. https://doi.org/10.1098/rspb.2009.0098

Giles, N. & Huntingford, F.A. (1984). Predation risk and inter-population variation in antipredator behavior in the 3-spined stickleback, *Gasterosteus aculeatus* L. *Animal Behaviour* 32, 264-275. https://doi.org/10.1016/S0003-3472(84)80346-2

Huntingford, F.A., Nager, R.G., McKeegan, D.E., McCafferty, D.J. & Hansell, M.H. (2024). A century

of research and teaching in animal behaviour and welfare in the Graham Kerr building. *The Glasgow Naturalist* 28, Supplement, 147-149. https://doi.org/10.37208/tgn28S14

Jobling, M. & Davies, P.S. (1980). Effects of feeding on metabolic rate, and the specific dynamic action in plaice, *Pleuronectes platessa* L. *Journal of Fish Biology* 16, 629-638. https://doi.org/10.1111/j.1095-8649.1980.tb03742.x

Killen, S.S., Nati, J.J.H. & Suski, C.D. (2015). Vulnerability of individual fish to capture by trawling is influenced by capacity for anaerobic metabolism. *Proceedings of the Royal Society B - Biological Sciences* 282, 20150603. https://doi.org/10.1098/rspb.2015.0603

Lilly, J., Honkanen, H.H., Rodger, J.R., del Villar, D., Boylan, P., Green, A. *et al.* (2024). Migration patterns and navigation cues of Atlantic salmon post-smolts migrating from 12 rivers through the coastal zones around the Irish Sea. *Journal of Fish Biology* 104, 265-283. https://doi.org/10.1111/jfb.15591

Lindström, J., Pike, T.W., Blount, J.D. & Metcalfe, N.B. (2009). Optimisation of resource allocation can explain the temporal dynamics and honesty of sexual signals. *American Naturalist* 174, 515-525. https://doi.org/10.1086/606008

Mable, B.K., Griffiiths, R. & Griffiths, K. (2024). History of molecular biology work in the Graham Kerr building (1996-2024). *The Glasgow Naturalist* 28, Supplement, 160-164. https://doi.org/10.37208/tgn28S18

Maitland, P.S. (1965). The feeding relationships of salmon, trout, minnows, stoneloach and three-spined sticklebacks in the River Endrick, Scotland. *Journal of Animal Ecology* 34, 109-133. https://doi.org/10.2307/2372

Meadows, A. (2024). Marine biology research for the last 50 years. *The Glasgow Naturalist* 28, Supplement, 168-170. https://doi.org/10.37208/tgn28S15

Metcalfe, N.B., Huntingford, F.A., Graham, W.D. & Thorpe, J.E. (1989). Early social status and the development of life-history strategies in Atlantic salmon. *Proceedings of the Royal Society B - Biological Sciences* 236, 7-19. https://doi.org/10.1098/rspb.1989.0009

Pilakouta, N., O'Donnell, P.J., Crespel, A., Levet, M., Claireaux, M., Humble, J.L. *et al.* (2023). A warmer environment can reduce sociability in an ectotherm. *Global Change Biology* 29, 206-214. https://doi.org/10.1111/gcb.16451