range of dentate-gyrus neurons did not rescue long-term memory. This finding is intriguing, because it suggests that simultaneous reactivation of multiple neuronal ensembles in the dentate gyrus cancels out the effects of reactivating a specific engram. Consequently, treatments such as electrical stimulation of deep brain regions, which are used to treat human neurological disorders but cannot discriminate between engram and non-engram cells, may not improve memory in patients.

Notably, a previous study[9] showed that electrical stimulation of the perforant path increases levels of amyloid-β in the interstitial fluid around hippocampal cells. Further work is needed to determine whether Roy and colleagues' engram intervention increases amyloid-β levels, and whether the strategy can ameliorate memory impairments in late-stage Alzheimer's disease if combined with techniques[10] to reduce amyloid-β levels and aggregation of tau.

To both tag and manipulate engrams in mice, Roy *et al.* introduced genetic constructs in two viruses — a strategy that comes with caveats. One construct contained a short, 1-kilobase promoter region, which drives gene expression in active neurons. In its natural state in the genome, the promoter drives *c-Fos* expression, but in the viral construct it promotes expression of an 'activator' gene that, in turn, drives expression of a second construct that encodes the ion channel. However, this promoter naturally acts in concert with enhancer elements that span the 50 kilobases of DNA surrounding it[11]. Excluding these gene-regulatory elements from the viral construct results in an incomplete engram, because some neurons that are activated by the aversive experience less strongly than others will not be tagged. The engram could be labelled with greater specificity by incorporating the activator into the genomic position of *c-Fos*, such that all the gene-regulatory elements can act in concert to tag neuronal ensembles in response to aversive experience.

In addition, regardless of promoter expression, the construct containing the ion channel can be activated only when an antibiotic called doxycycline is removed from the animals' diet. Roy and colleagues tagged engram cells for 24 hours from the start of contextual fear conditioning. This design lacks precision, so some nonspecific neurons are probably included in the tagged ensemble. Engram labelling could be optimized by decreasing the time for which doxycycline is removed from the diet, or by using an alternative engram-tagging strategy that allows a shorter time window for labelling[12].

Nonetheless, the potential to rescue long-term memory in dementia is exciting. In the future, Roy and colleagues' findings might help to guide engram-based strategies that rescue memory deficits in patients with early-stage Alzheimer's disease. ■

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ANIMAL MIGRATION

Dispersion explains declines

Migratory birds are declining globally. A broad study of European migratory birds finds that species that disperse widely during the non-breeding season are less likely to be in decline than are species with more restricted dispersion.

RICHARD A. FULLER

Migratory birds undertake some of the most extraordinary journeys of any animal, but many of these birds are in catastrophic decline[1]. The very mobility of these species makes it extremely difficult to diagnose causes of the declines, and painstaking ecological studies are needed to unpick them on a case-by-case basis[1]. Writing in *Ecology Letters*, Gilroy *et al.*[2] present data hinting at a much-needed general explanation for why some migratory species are more vulnerable than others. In an analysis of 340 migratory bird species, they show that species that disperse widely during the non-breeding season, relative to their breeding distribution, are much less likely to be declining than are species that have relatively more-restricted distributions outside the breeding season.

The distances travelled by some migratory birds are astounding. The blackpoll warbler (*Setophaga striata*), a forest songbird weighing only 12 grams, flies more than 2,500 kilometres

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Figure 1 | Wood warbler (*Phylloscopus sibilatrix*). Although this declining bird species has extensive breeding grounds across Europe, it spends the non-breeding season in a relatively small area in west and central Africa. Gilroy *et al.*[2] find that such low migratory dispersion is associated with population decline.

50 Years Ago

The American Institute of Physics is uncommonly well informed about the jobs its members do, and about the salaries they are paid. The latest batch of figures, made public in *Physics Today* for January, will as usual comfort those struggling for a Ph.D. with the knowledge that their efforts (if successful) are likely to add something like 5,000 dollars to an annual salary in industrial research and development. In 1964 the median starting salary for Ph.D. physicists in industry appears to have been 12,600 dollars, compared with 8,800 dollars for those starting with a master's degree and 7,500 dollars straight after graduation. The initial value of a Ph.D. seems to be equivalent to ten years of plodding up the promotion ladder … By contrast, academic life offers a lower starting salary but faster promotion … The profession of physics has something in common with professional football, where a man must reckon that his earning power will disappear altogether at forty.
From *Nature* 26 March 1966

100 Years Ago

The *Museums Journal* for March very properly reprints the recent discussion in the House of Lords on the closing of museums … For we have in this the measure of the value our rulers set upon the scientific work of the country. We talk much of the education of the "masses," but it is now abundantly evident that the "educated" have still much to learn. Many of the speakers during the debate seemed to be under the impression that the mental equipment attained at Eton suffices to meet all the demands of later life. Though some of the speakers were actually trustees of the British Museum, yet they displayed neither knowledge of the nature of the work of that institution, nor of museums in general.
From *Nature* 23 March 1916

non-stop over open ocean in its make-or-break migration from the boreal forests of the Northern Hemisphere to northern South America[3]. The bar-tailed godwit (*Limosa lapponica*) flies 12,000 km non-stop over the Pacific Ocean from Alaska to New Zealand[4], and the Arctic tern (*Sterna paradisaea*) covers the distance to the Moon and back three times during its lifetime[5].

But these remarkable journeys depend on the availability of suitable destinations. The slender-billed curlew (*Numenius tenuirostris*), which may now be extinct, migrated from breeding grounds in Siberia to tiny areas in southern Europe and North Africa, where suitable wintering habitat has rapidly declined through the conversion of wetlands to farmland[6]. Its case is potentially the first extinction of a European bird since the demise[6] of the great auk (*Pinguinus impennis*) in the mid-nineteenth century.

There are more than 1,200 migratory bird species in the world, and many may wane to rarity or extinction before we have worked out why they are in trouble. Despite this scientific uncertainty, immediate conservation action is crucial[7]. But little progress has been made in identifying general explanations for the enormous declines in migratory animals, which severely hampers effective conservation planning.

Analysing a database of Europe-wide population trends for 340 bird species, Gilroy *et al.* tested several hypotheses for why some 36% of Europe's migratory bird species are in decline. About 40% of the species studied have non-breeding ranges that are larger than their breeding ranges, which the authors term a high migratory dispersion. The researchers found that these species were less likely to be in population decline than were others, when factors such as the effects of migration distance, habitat use and climatic niche width were controlled for.

For example, the wood warbler (*Phylloscopus sibilatrix*; Fig. 1) breeds across a large swathe of Europe, from Britain to Ukraine, but spends the non-breeding season in a relatively small area in west and central Africa. This species is in rapid decline. By contrast, the Eurasian reed warbler (*Acrocephalus scirpaceus*), which has a similar breeding distribution to the wood warbler but occurs across the whole of sub-Saharan Africa in the non-breeding season, has a stable or increasing population. This kind of difference in migration strategy is a surprisingly good predictor of population declines, and is consistent with increasing concern that desertification, habitat loss and degradation in the wintering grounds of Europe's migratory birds are driving a new wave of population collapse[7].

Some species do not exhibit the full to-and-fro migration seen in the warblers that decamp wholesale to Africa, but instead are present year-round in some areas of their breeding distribution. Gilroy *et al.* found that these partial migrants were notably less likely to be declining than were full migrants, suggesting a clear advantage to this strategy.

Gilroy and colleagues' wide-ranging study also pinpointed several other influences on migratory-bird populations. They found that declines were especially pronounced among habitat specialists (particularly, farmland species), small-bodied species and, intriguingly, those that have not advanced their annual arrival date in Europe between 1960 and 2006 to start breeding in response to the earlier onsets of spring. This latter effect could result from climate-adaptable species being more resilient to decline[8], although it is also possible that species that are not declining for other reasons have greater population variability in arrival date, on which selection can operate.

Studies of other geographic regions and taxa are needed to establish the generality of these results, but for now the findings are a major step forward in predicting the possible need for conservation action among the world's migratory bird species, simply on the basis of maps of their seasonal distributions. New technology, such as the network of 300 automated telemetry towers across North America as part of the Motus project[9], is transforming our knowledge of migratory routes, and innovative analysis of threats across the annual cycle of migratory species[10] is opening up ways of planning effective conservation action.

But more data alone will not save migratory species. Ambitious global and regional conservation agreements and initiatives, such as the Convention on the Conservation of Migratory Species of Wild Animals, the African-Eurasian Migratory Landbirds Action Plan and the East Asian-Australasian Flyway Partnership, are beginning to bear fruit and achieve joined-up conservation. Because of the extreme reliance of many migrants on small areas at some point in their migratory cycle, smartly targeted conservation action may be effective in reversing population declines. ■

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