species — be it our anatomy, behaviour or genetics — would bring me the sort of academic wealth I have always coveted.

Do you have a favourite paper or science book? I really love Michael Rosenzweig's 1995 book *Species Diversity in Space and Time*. It is written in such an inquisitive, non-authoritative style. The author takes the reader on a quest through the scientific literature, looking for answers about macroecology, and he is very honest along the way in stating that he also does not know if these answers will be found at the end of the book and whether his approach is best. It is a rare gem of child-like, joyful scientific inquisitiveness. It is not an easy book, but the egalitarian way in which it is written simply pulls you in. It was one of my favourite reads during the time I spent working in a university in Malaysian Borneo, where I was surrounded by exactly the kind of ecological patterns and problems that Rosenzweig grapples with in this book.

What is the best advice that you've been given? Greg Hurst, with whom I once shared an office, said to me, "you should write a book". So I did. And I have kept on writing ever since.

Speaking of books, how do you go about conceiving and writing one? First, after finishing a book, it takes me a few years to shake off the conviction that I am never going to write another book ever again. Then, some idea starts brewing in my head on a topic that I like and that I think the general public will also find intriguing. For instance, at the moment I am working on a book for MIT Press provisionally entitled *How to Be an Urban Naturalist*. I develop an idea into a full-fledged 25-page proposal and my agent then sends it to publishers. Only when we have a deal with a publisher do I start writing. I like to have a fixed day in the week on which I work on my book, although I can also write on trains, in cafés and even in dentist waiting rooms. I try to have a pragmatic approach. There's no point waiting for inspiration: just get a thousand words per day on paper and a year later you'll have a book. I try to write even when I don't feel like it at all, and often I find that, when I read those uninspired texts later, their problems are nothing that a bit of editing and embellishment cannot solve. I write in English, so if there is also going to be a Dutch edition I have to translate my own English text into my own Dutch text, which is a weird process.

Do your books also help your academic career? Surprisingly, they do. Even though they are trade books, not peer-reviewed and meant for a general audience, some get cited quite often in the scientific literature. But, more importantly, the research that goes into writing a book gives me a lot of ideas for research projects for myself and my students.

You are very active in community science. Why is this? I think the time is right for it. Back in the 19th century, science was dominated by independent thinkers and experimenters who had curiosity, money and time. Then came the 20th century with its large scientific institutions, and it was no longer possible to make progress in science as an individual; 'amateur' became a dirty word. But today, with everything that institutionalised science monopolised in the past — literature, data, knowledge, tools — now freely available online to anybody, there are new options for the untrained amateur. I help community scientists get to grips with biodiversity science so that they can initiate and carry out scientific research projects in their surroundings. This empowers them to push back against authorities that threaten urban green spaces or the environmental quality. The open science revolution has made that possible, and I love helping groups of amateurs create their own scientific approach for dealing with the world. Moreover, people who do science for the first time are so infectiously enthusiastic that I always find myself falling in love with my own field all over again.

DECLARATION OF INTERESTS

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Quick guide

Australian magpies

Robin D. Johnsson[1], Farley Connelly[2], John A. Lesku[3,*], and Timothy C. Roth II[1]

What are Australian magpies? Australian magpies (*Gymnorhina tibicen*) are songbirds native to Australia and Papua New Guinea, and have been introduced to New Zealand (Figure 1). They can be found in both rural and urban habitats and are amongst the most common birds. While Australian magpies superficially resemble Eurasian magpies (*Pica pica*), crows (*Corvus* spp.), and other corvids, they are not corvids. Instead, Australian magpies belong to the taxonomic family Artamidae, a group that includes butcherbirds (*Melloria quoyi* and *Cracticus* spp.), currawongs (*Strepera* spp.), peltops (*Peltops* spp.), and woodswallows (*Artamus* spp.). Artamidae is in turn part of the superfamily Corvoidea which consists of almost 800 oscine passerines (including corvids) originating from the Papuan archipelago about 30 million years ago.

What's special about them? Australian magpies can live up to 30 years and form long-lasting pair bonds (although extra-pair copulations are common) and establish territories that they fiercely defend together. One can often see groups of magpies engaged in territorial disputes or chasing off other bird species. Aside from aggressive displays, magpies are very social birds that live in family groups year-round. Once in an established territory, magpies put a lot of resources into their young by engaging in extended parental care and some groups even engage in cooperative breeding. During the breeding season, magpies become highly protective of their nestlings and are infamous for swooping pedestrians and cyclists. As a deterrent, cyclists will attach cable ties to their helmets giving them a spikey-headed appearance, often making international news headlines. Magpies have an extended juvenile phase and only reach maturity after one year, at which point they either leave their natal territory or stay, as helpers (females only), for the next breeding season. Magpies, especially juveniles, have been observed engaging in play. Play,

Figure 1. An adult Australian magpie.
Photo: Robin D. Johnsson.

sociality, and long life-span, together with a long developmental period, are a suite of traits often associated with complex behaviours and cognition. These traits in addition to magpies being inquisitive, habituating readily to humans, and being extremely food-motivated, make Australian magpies amenable to scientific study. From a comparative perspective, magpies provide an excellent opportunity to explore the evolution of bird cognition as they occupy a similar niche to corvids, display signs of complex cognition, and live in multifaceted social structures, yet are not so closely related to the better-studied crows and ravens.

How do they sound? Australian magpies are known for their loud, melodious songs; vocalizations that sound like no other bird and are a common feature of the Australian soundscape (https://youtu.be/m_BjnP5EEy4). The magpie actually got its scientific name from its song: tibicen meaning 'piper' or 'flutist'. One common song is the 'carol' which is used for defending territories. Magpies recognize other (individual) magpies based, in part, on their vocalizations — they can even distinguish between familiar and unfamiliar human voices. Magpies have a large vocal repertoire that remains flexible throughout life, including a wide range of vocalizations such as songs, calls, grunts and mimicry. Alarm calls can indicate the type of predator (e.g., aerial vs terrestrial) and the degree of danger, with more calls indicating a nearby threat. Magpies also respond appropriately to the alarm calls of another Australian species, the noisy miner (*Manorina melanocephala*), even to the extent that they differentiate airborne and ground-based predators. Not unlike human language, Australian magpies can combine calls to create new meaningful calls.

How clever are they? Australian magpies show signs of complex cognition, including physical cognition and perhaps even some understanding of causality. Wild Australian magpies can learn to solve a common task that involves pulling on one or more strings to reel in a reward. Magpies perform well on different configurations of this string-pulling, and some magpies even learn to discriminate between intact (functional) strings and cut (non-functional) strings; however, it is unclear whether trial-and-error learning or an understanding of causality underpins this outcome. Australian magpies also show how sociality can shape cognitive development and evolution. When tested on a series of cognitive tasks, including associative and reversal learning, inhibitory control and spatial memory tests (Figure 2), wild Australian magpies from larger groups display higher performance than magpies from smaller ones. Magpies living in larger groups are also able to find an innovative solution to a foraging task faster, and information spreads more rapidly to other group members, compared to magpies living in smaller groups. This positive effect of group size on cognitive performance arises at an early stage before fledging. In female magpies, cognitive performance also provides a selective advantage in that females who perform better on a battery of cognitive tests have more hatchlings, fledglings and fledglings surviving to independence per year. Large groups may therefore provide animals with unique problems and thus drive the evolution towards more complex cognition.

What can we learn from snoozing magpies? Like humans, magpies sleep at night, and, like some humans, magpies also enjoy a midday nap. Unlike humans, magpies have hundreds of sleep bouts per night with episodes of non-REM sleep typically 30 seconds long and bouts of REM sleep usually shorter than 10 seconds. When tested on a reversal learning task, in which a learned rule was violated leading to the birds learning a new rule (Figure 2), tired magpies showed reduced performance. Magpies made more mistakes following a sleepless night, and were slower to interact with the test when most tired. Thus, like humans, sleep loss in magpies is associated with impaired motivation, attention, and performance. Sleep homeostasis was recently studied in captive Australian magpies. After an extended period of enforced wakefulness, magpies recovered lost non-REM sleep by sleeping more, with greater sleep consolidation, and increased non-REM sleep intensity. And following 12 hours of nighttime sleep loss, magpies napped more during the day and showed

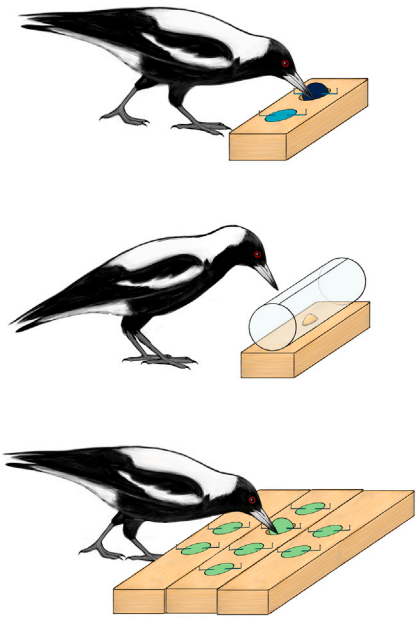

Figure 2. Cognition in Australian magpies.
Cognitive tests for associative and reversal learning (top), inhibitory control (middle) and spatial memory (bottom). In the associative learning task, magpies learn under which coloured lid they can find food. Once they have learnt this association, the rewarded colour is switched in the reversal learning task to the previously unrewarded colour. For the inhibitory control task, magpies have to inhibit their response to peck at a transparent barrier and instead make a detour to get the food reward. The spatial memory task requires magpies to remember in which wells (covered by lids) an experimenter has hidden food (modified from Connelly *et al*. (2022); illustrations by Laura X. Tan).

reduced non-REM sleep intensity on the next night. Oddly, however, magpies never recovered lost REM sleep.

Does urbanization affect magpies? One hallmark of urban environments is artificial light at night. When exposed to simulated streetlights for 4-h at night, magpies lost three-quarters of their normal amount of non-REM sleep. Even under amber light, which is often promised to preserve the integrity of circadian rhythms in humans, magpies lost half their non-REM sleep. While amber light was less disruptive than white light, the birds lost substantial amounts of sleep. Thus, city planners should think carefully about how and when night lights are used around wildlife. Urban noise, as with artificial light at night, disrupts sleep in magpies. Despite the sleep-suppressing effects of light and noise pollution, Australian magpies thrive in urban environments and are a common fixture of many Australian cities. Magpies from urban and rural environments showed no difference in their ability to complete cognitive tasks despite the increasing noise levels associated with urbanized habitats. However, wild Australian magpies perform worse on cognitive tasks when heat stressed, an early warning that a warming world may threaten the behaviour and physiology of birds.

Where can I find out more?

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DECLARATION OF INTERESTS

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Primer

Placoderms

John A. Long[1,*] and Kate Trinajstic[2]

For over 70 million years, during the Paleozoic, the placoderms (Greek for 'plated skin'), an extinct group of armoured fishes, were the most abundant and diverse vertebrates on our planet. Some of the first placoderm fossils discovered — such as *Bothriolepis* with its bone-covered pectoral fins — seemed so bizarre that they were thought to represent turtles or ancient beetles. All placoderms bear thick overlapping dermal plates around the head (called the 'head shield') and an area of the body covered in similar overlapping plates enveloping the pectoral to anal region (called the 'trunk-shield'). Placoderm fossils (Figure 1) are known from every continent on Earth ranging from the early Silurian (~438 million years ago) to the end Devonian (~359 million years ago) when they became extinct.

Placoderms were once thought to be a dead-end lineage with no relevance to modern biology, but in the past 15 years there has been a renaissance of new research that has changed our views on the relationships of these fishes. Placoderms are now placed on the ancestral line leading to all other jawed vertebrates, as the sister group to sharks, bony fishes and tetrapods. Placoderms were first made popular through the writings of Hugh Miller in the 19th century. In recent years, placoderms have featured in museum displays around the world, many featuring bones or reconstructed models of the giant predator *Dunkleosteus*. They have also infiltrated pop culture, such as in the Hayao Miyazaki film *Ponyo* (2008).

A potted placoderm history

The Swiss palaeontologist Louis Agassiz (1833) was the first to recognise them as a distinct group of fishes, but he thought they were jawless fishes, much like the ostracoderms. Starting in the 1920s, Erik Stensiö Stensio applied a method of grinding fossil skulls away slowly