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EDITORIAL

Contact chemoreception, magnetic maps, thermoregulation by a superorganism, and, thanks to Einstein, an all-time record: the Editors' and Readers' Choice Awards 2023

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Abstract
During the 99 years of its history, the *Journal of Comparative Physiology A* has published many of the most influential papers in comparative physiology and related disciplines. To celebrate this achievement of the journal's authors, annual Editors' Choice Awards and Readers' Choice Awards are presented. The winners of the 2023 Editors' Choice Awards are 'Contact chemoreception in multi-modal sensing of prey by *Octopus*' by Buresch et al. (J Comp Physiol A 208:435–442, 2022) in the Original Paper category; and 'Magnetic maps in animal navigation' by Lohmann et al. (J Comp Physiol A 208:41–67, 2022) in the Review/Review-History Article category. The winners of the 2023 Readers' Choice Awards are 'Coping with the cold and fighting the heat: thermal homeostasis of a superorganism, the honeybee colony' by Stabentheiner et al. (J Comp Physiol A 207:337–351; 2021) in the Original Paper category; and 'Einstein, von Frisch and the honeybee: a historical letter comes to light' by Dyer et al. (J Comp Physiol A 207:449–456, 2021) in the Review/Review-History category.

Keywords Journal of Comparative Physiology A · Editors' Choice Awards · Readers' Choice Awards · Karl von Frisch · Albert Einstein

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Showcasing authors' excellence

Over the 99 years of its existence, the *Journal of Comparative Physiology A* has earned its reputation of publishing some of the finest and most influential papers in comparative physiology and related disciplines. This has become possible only because many of our authors entrust us with their very best pieces of research. To show our appreciation for their trust, and to celebrate their achievements, we established four awards in 2022—the Editors' Choice Award and the Readers' Choice Award, each in the categories Original Paper and Review/Review-History Article (Zupanc et al. 2022). Like last year, our announcement of this year's four winning pieces is combined with a discussion of their significance in the broader scientific context.

The Editors' Choice Awards 2023

For the Editors' Choice Award 2023, any article published in Volume 208 (2022) was eligible, except papers (co-) authored by a member of the Editorial Board. The selection

of the winners was based on independent votes cast by each member. First and second choices were indicated by 2 points or 1 point, respectively.

The winner in the Original Paper category is 'Contact chemoreception in multi-modal sensing of prey by *Octopus*' by K.C. Buresch, K. Sklar, J.Y. Chen, S.R. Madden, A.S. Mongil, G.V. Wise, J. G. Boal, and R.T. Hanlon (2022). It received 7 points. The runner-up is the article 'Opsin knockdown specifically slows phototransduction in broadband and UV-sensitive photoreceptors in *Periplaneta americana*' by Roman V. Frolov, Irina Severina, Ekaterina Novikova, Irina I. Ignatova, Hongxia Liu, Marianna Zhukovskaya, Päivi H. Torkkeli, and Andrew S. French (2022) with 4 points.

Buresch et al. (2022) investigated whether octopuses (*Octopus bimaculoides*) can discriminate prey from non-prey objects solely based on contact chemoreception. Octopuses have keen vision but usually forage blindly by inserting their arms into crevices searching for hidden prey. Whether they discriminate prey by mechano- or chemosensors on their arm suckers was previously unknown. In an ingenious behavioral assay, the authors presented agarose discs containing extracts of prey and non-prey within an artificial rock dome that the octopus could explore blindly by extending its arms inside through small openings. Fresh preparation of the discs ensured that no diffusion of chemicals into the seawater had occurred. Prey discs received significantly more touches and arm curls than non-prey discs, indicating that contact chemosensory cues suffice for prey identification. While under natural conditions a combination of mechanical and chemical cues, and perhaps even a dermal light sense, likely contributes to prey identification, this investigation highlights the importance of contact chemoreception for prey detection. The study, therefore, impressively illustrates the different sensory world of octopuses as compared to the one we perceive in our daily life.

The winner in the category Review/Review-History Article is 'Magnetic maps in animal navigation' by Kenneth J. Lohmann, Kayla M. Goforth, Alayna G. Mackiewicz, Dana S. Lim, and Catherine M. F. Lohmann (2022). It was nominated by 7 out of 8 editors, who awarded a total of 11 points. The article in second place is 'Organization of the parallel antennal-lobe tracts in the moth' by Jonas Hansen Kymre, Xi Chu, Elena Ian, and Bente Gunnveig Berg (2022), with a score of 5.

In their comprehensive and lavishly illustrated review, Lohmann et al. (2022) enlighten us on our current understanding of one of the most fascinating sensory adaptations used by animals for long-distance navigation—the ability to discern the local intensity and inclination angle of the earth's magnetic field and to use them to determine the current location relative to a distant goal. The inclination angle is the angle that the magnetic field lines make with the surface of the earth, and this changes systematically from 0° at the magnetic equator to 90° at the poles, thus being correlated with latitude. The field strength also changes systematically, albeit not as predictably, but in large parts of the world field strength and inclination angle vary almost orthogonally to create a grid-like "map" (as we humans might imagine it) where each spatial location is represented by a unique combination of these two magnetic parameters.

Even though the idea of animals tapping into such a map to find their way first arose 140 years ago (Viguier 1882), it was not until Ken and Catherine Lohmann harnessed hatchling sea turtles in the middle of a set of magnetic coils that the idea was finally shown to be true (Lohmann and Lohmann 1994, 1996). By studying the swimming orientations of sea turtles exposed to magnetic fields typical of various far-flung locations within their vast North Atlantic oceanic home, Ken and Catherine Lohmann showed that sea turtles indeed seem to rely on positional information from the earth's magnetic map to remain in safer, warmer ocean waters. In the 25 years that have elapsed since those first remarkable discoveries, the Lohmanns and many others have discovered that this "magnetic map sense" exists in a large range of taxonomically diverse animals, including amphibians, fish, birds and even arthropods. Magnetic maps are now known to be used for travelling to a distant goal (such as a breeding area), returning home (even after many years away) or determining the necessity for fueling up before a possibly arduous long-distance migration. All this and more—as well as where research on magnetic maps is heading—can be found in this magnificent and much recommended review.

The Readers' Choice Awards 2023

The winners of the Readers' Choice Awards in the categories Original Paper and Review Article were determined by the number of online accesses (HTLM or PDF versions) of pieces that appeared in Volume 207 (2021). These accesses are used as a proxy of 'popularity' of a paper. The year 2021, instead of 2022, was chosen to ensure that each article published had been available online for at least 12 months before a decision was made on December 5, 2022.

The winner in the Original Paper category is 'Coping with the cold and fighting the heat: thermal homeostasis of a superorganism, the honeybee colony' by Anton Stabentheiner, Helmut Kovac, Monika Mandl, and Helmut Käfer (2021) with 4673 accesses, followed by the article of Madeline Williamson, Alexandra Mitchell, and Barry Condron (2021) with 2453 accesses.

In their study, Stabentheiner et al. (2021) present a comprehensive analysis of thermoregulatory mechanisms in honeybee (*Apis mellifera*) colonies. Honeybees maintain 'tropical conditions' in their brood nest during periods of

cold and heat. Precise thermal homeostasis is most important for brood development, and adult bees suffer from behavioral and neuronal deficits when their brood develops outside an optimal temperature range of 34–36 °C (Groh et al. 2004; Jones et al. 2005). Thermoregulatory control in breeding honeybee colonies needs to be examined at the level of a superorganism with thousands of cooperating individuals (Moritz and Southwick 1992; Heinrich 1993).

Stabentheiner et al. (2021) used state-of-the-art technology, such as large arrays of thermocouple probes and temperature/humidity sensors combined with high-resolution thermal imaging camera recordings, to analyze individual body- and brood-comb temperatures under different environmental conditions. The bees' regulatory behaviors include individual endothermic (wing muscle) heat production, water droplet deposition, and wing fanning, as well as group-level changes in bee densities. The most important outcome of their study is that the starting or set points for the various thermoregulatory mechanisms underlying colony heating and cooling overlap across relatively broad temperature ranges. Together with passive effects, this results in a remarkable thermal constancy of 34.8–35.9 °C in the central brood nest. This enormous precision is comparable to the constancy of core body temperatures in mammals. Whereas in mammals this is controlled by a set point at the level of the central nervous system, the obviously large variation in behavioral set points across thousands of individual bees is required to guarantee smooth stabilization of the brood nest temperature in a decentralized colony-level system. The study by Stabentheiner et al. (2021) is a big step forward towards understanding the many facets underlying thermoregulatory precision in breeding honeybee colonies.

The winner of the Readers' Choice Award in the Review/Review-History Article category is 'Einstein, von Frisch and the honeybee: a historical letter comes to light' by Adrian G. Dyer, Andrew D. Greentree, Jair E. Garcia, Elinya L. Dyer, Scarlett R. Howard, and Friedrich G. Barth (2021). It was downloaded an amazing 322,878 times. This is nearly 253 times the average number of accesses of any of the other review or review-history articles published in 2021—an all-time record!

What is it that has triggered this enormous interest far beyond the regular readership of the *Journal of Comparative Physiology A*? The soundest explanation appears to be that it was the name of Albert Einstein. Even 68 years after his death, interest in Einstein's life and work remains unwaning. Approximately one million searches per month are carried out on Google using the term 'Albert Einstein', whereas over the same time typically about 2000 searches are conducted related to 'Karl von Frisch' (data based on an analysis performed by using Google Trends Supercharged—Glimpse on December 6, 2022). Springer Nature had informed the media about the Dyer et al. (2021) paper shortly before its publication in the *Journal of Comparative Physiology A*. This press release resulted in global reporting by dozens of news outlets, and the mentions in hundreds of tweets and blogs, of the discovery of a previously unknown letter written by Albert Einstein—a story that prompted, in turn, widespread access of the article published in the *Journal of Comparative Physiology A*.

The letter was written by Einstein on October 18, 1949, from Princeton (United States) to Glyn Davys in Bournemouth (England). At that time, Davys studied acting, but previously he had served in the British Royal Navy as an engineer working on radar. It seems that his work with the then rather new and exciting technology, and the reporting earlier that year by English newspapers of Karl von Frisch's discovery of how polarization patterns in the sky may affect the dances and orientations toward food sources of honeybees (von Frisch 1949), motivated him to write a letter to Einstein. Although this letter has not yet been found, it can be inferred from Einstein's response that Davys had mentioned von Frisch's studies and asked him how the results of these investigations could be utilized in physics.

Albert Einstein confirmed in his letter that he was well familiar with the work of Karl von Frisch (the two met during von Frisch's visit to Princeton in the spring of 1949; von Frisch 1957), but that he could not "see a possibility to utilize these results in the investigation concerning the basis of physics." However, he continued: "Such could only be the case if a new kind of sensory perception, resp. of their stimuli, would be revealed through the behavior of the bees. It is thinkable that the investigation of the behavior of migratory birds and carrier pigeons may some day lead to the understanding of some physical process which is not yet known." Although the letter was rather brief, it has demonstrated Einstein's openness to the possibility of discovery of sensory modalities in animals alien to humans, and his (correct) prediction that such new insights might result in a close interaction between biology and physics.

Congratulations to the recipients of the 2023 Editors' and Readers' Choice Awards!

Author contributions Selection of candidate articles for awards: KA, CHF, UH, PMN, WR, AMS, EJW, GKHZ; drafting of manuscript: GKHZ, WR, EJW, UH; review and editing of manuscript: KA, CHF, UH, PMN, WR, AMS, EJW, GKHZ.

Data availability The datasets generated and analyzed for determining the winners of the Editors' Choice Awards and the Readers' Choice Awards are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare no conflict of interest.

References

Buresch KC, Sklar K, Chen JY, Madden SR, Mongil AS, Wise GV, Boal JG, Hanlon RT (2022) Contact chemoreception in multimodal sensing of prey by *Octopus*. J Comp Physiol A 208:435–442. https://doi.org/10.1007/s00359-022-01549-y

Dyer AG, Greentree AD, Garcia JE, Dyer EL, Howard SR, Barth FG (2021) Einstein, von Frisch and the honeybee: a historical letter comes to light. J Comp Physiol A 207:449–456. https://doi.org/10.1007/s00359-021-01490-6

Frolov RV, Severina I, Novikova E, Ignatova II, Liu H, Zhukovskaya M, Torkkeli PH, French AS (2022) Opsin knockdown specifically slows phototransduction in broadband and UV-sensitive photoreceptors in *Periplaneta americana*. J Comp Physiol A 208:591–604. https://doi.org/10.1007/s00359-022-01580-z

Groh C, Tautz J, Rössler W (2004) Synaptic organization in the adult honey bee brain is influenced by brood-temperature control during pupal development. Proc Natl Acad Sci USA 101:4268–4273. https://doi.org/10.1073/pnas.0400773101

Heinrich B (1993) The hot-blooded insects: strategies and mechanisms of thermoregulation. Springer-Verlag, Berlin

Jones JC, Helliwell P, Beekman M, Maleszka R, Oldroyd BP (2005) The effects of rearing temperature on developmental stability and learning and memory in the honey bee, *Apis mellifera*. J Comp Physiol A 191:1121–1129. https://doi.org/10.1007/s00359-005-0035-z

Kymre JH, Chu X, Ian E, Berg BG (2022) Organization of the parallel antennal-lobe tracts in the moth. J Comp Physiol A 208:707–721. https://doi.org/10.1007/s00359-022-01566-x

Lohmann KJ, Lohmann CMF (1994) Detection of magnetic inclination angle by sea turtles: a possible mechanism for determining latitude. J Exp Biol 194:23–32. https://doi.org/10.1242/jeb.194.1.23

Lohmann KJ, Lohmann CMF (1996) Detection of magnetic field intensity by sea turtles. Nature 380:59–61. https://doi.org/10.1038/380059a0

Lohmann KJ, Goforth KM, Mackiewicz AG, Lim DS, Lohmann CMF (2022) Magnetic maps in animal navigation. J Comp Physiol A 208:41–67. https://doi.org/10.1007/s00359-021-01529-8

Moritz RFA, Southwick EE (1992) Bees as superorganisms: an evolutionary reality. Springer-Verlag, Berlin

Stabentheiner A, Kovac H, Mandl M, Käfer H (2021) Coping with the cold and fighting the heat: thermal homeostasis of a superorganism, the honeybee colony. J Comp Physiol A 207:337–351. https://doi.org/10.1007/s00359-021-01464-8

Viguier C (1882) Le sense de l'orientation et ses organes chez les animaux et chez l'homme. Rev Philos Fr Etrang 14:1–36

von Frisch K (1949) Die Polarisation des Himmelslichtes als orientierender Faktor bei den Tänzen der Bienen. Experientia 5:142–148. https://doi.org/10.1007/BF02174424

von Frisch K (1957) Erinnerungen eines Biologen. Springer-Verlag, Berlin

Williamson M, Mitchell A, Condron B (2021) Birth temperature followed by a visual critical period determines cooperative group membership. J Comp Physiol A 207:739–746. https://doi.org/10.1007/s00359-021-01512-3

Zupanc GKH, Arikawa K, Helfrich-Förster C, Homberg U, Narins PM, Rössler W, Simmons AM, Warrant EJ (2022) It's all about seeing and hearing: the Editors' and Readers' Choice Awards 2022. J Comp Physiol A 208:351–353. https://doi.org/10.1007/s00359-022-01541-6