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EDITORIAL

Centennial issue

Günther K.H. Zupanc[1]

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Abstract
The Journal of Comparative Physiology A, also known as JCPA, was founded by Karl von Frisch and Alfred Kühn in 1924, then under its German title *Zeitschrift für vergleichende Physiologie*. During the 100 years of its history, it became the leading international journal in comparative physiology and its daughter discipline, neuroethology. As such, it had a major impact on the development of these disciplines. In celebration of this achievement and the nearly 10,000 articles that appeared during the last 100 years, this Centennial Issue is published. Its authors reflect on the history of JCPA and the early pioneers, including women scientists, of comparative physiology; share the impact that the Journal had on their careers; discuss the benefit of the enormous taxonomic diversity of model systems used in studies published in JCPA; contrast this philosophy with the strategy of a limited number of standard biomedical model systems; review popular and trending research topics covered in JCPA; and, by interrogating the past, take a peek into the future of neuroethology.

Keywords Zeitschrift für vergleichende Physiologie · Journal of Comparative Physiology A · Comparative physiology · Neuroethology · Model systems · Karl von Frisch

Introduction

This year marks the 100th anniversary of the founding of the Journal of Comparative Physiology A by Karl von Frisch and Alfred Kühn. The first issue of its predecessor, the *Zeitschrift für vergleichende Physiologie*, appeared in March 1924. Comparative physiology was then still in its infancy; hence, the number of potential contributions was rather limited. Although the first collection of articles was combined into a double issue, it contained a mere six papers. The next collection, again a double issue, appeared in September 1924, with just seven articles. However, the *Zeitschrift* quickly gained reputation, largely owing to von Frisch, who served as its Editor-in-Chief for the next 36 years.[1] One year later, it attracted 28 contributions, including the first of nine articles that von Frisch published in the Journal. By the end of 2023, a combined 9445 articles have appeared in the *Zeitschrift für vergleichende Physiologie* and its successors, the Journal of Comparative Physiology and the 'A' branch of the latter, now known as JCPA. Many of the landmark discoveries in comparative physiology and neuroethology have been reported in the Journal, and virtually every leading scientist in these disciplines has published in JCPA. What has evolved over the 100 years of JCPA's history is a notable symbiosis of the Journal and the community of its authors and readers. Without JCPA, it is unlikely that neuroethology would have become as successful as it is today.

To celebrate the 100th anniversary of JCPA, and the contributions of its numerous authors, we offer this special issue. In this Centennial Issue, we first take a closer look at the history of the Journal, its co-founder Karl von Frisch, and two women pioneers whose works were made available to the community of comparative physiologists through their publications in the *Zeitschrift für vergleichende Physiologie*. Following these contributions, two internationally accomplished JCPA authors share in personal essays how the Journal has impacted their careers. In the third issue section, after examining the 'model systems' in studies published in JCPA over the last 100 years, 21 leading experts review a broad range of topics, popular and

[1] In contrast to Karl von Frisch, Alfred Kühn, apart from being co-founder of the *Zeitschrift für vergleichende Physiologie*, never played any major role for the journal. As author, he published just two articles (Kühn 1927, 1950).

✉ Günther K.H. Zupanc
g.zupanc@northeastern.edu

[1] Department of Biology, Northeastern University, Boston, MA 02115, USA

trending, in areas covered by the Journal. Each of these articles contributes ideas about potential future work—including some hypotheses that may cause debate. This glimpse into the future continues in the final Perspectives piece of the Centennial Issue. By interrogating the past, the author ventures some predictions about potential trends in neuroethology.

In celebration of JCPA

A look back at the history of comparative physiology and its premier journal

Throughout the 100 years of JCPA's history, the relationship between the Journal and its authors is perhaps best characterized as mutualistic. Through their publications in JCPA, authors have gained recognition as leading scientists in comparative physiology and related disciplines, and their publications in JCPA have been instrumental in establishing the Journal as the premier platform for reporting high-quality research.

This mutualism becomes evident as a recurrent theme in the article *One hundred years of excellence: the top one hundred authors of the Journal of Comparative Physiology A*. To select out of nearly 10,000 authors of the last 100 years the top 100, Zupanc et al. (2024) developed three performance criteria. Then, they collated a large set of biographical data to compile short biographies of each of the 100 selected authors. Notably, by revealing the numerous interconnections between these individual investigators, they highlight how mentor/mentee relationships and collaborations between the top 100 authors have served as engines to drive the development of comparative physiology in general and neuroethology in particular.

The only Top 100 Author who published all his papers in the first half of JCPA's 100 years of history is Karl von Frisch. As the discoverer of the dance language of bees and an awardee of the Nobel Prize (1973), he is, without doubt, more widely known than any other author of JCPA. Yet, despite his popularity, significant aspects of his career have resisted explanation. For example, how was it possible that, at a time during the Nazi era, when he faced the threat of forced early retirement because of his partial Jewish ancestry, his research flourished more than at any other period of his life? For their article *"Resistance leads to self-destruction": how an (a)political strategy helped Karl von Frisch succeed during the Nazi era*, Zupanc and Wanninger (2024) reviewed hundreds of documents in various archives in Munich and Berlin to answer this question. What emerges from this historical research is a complex picture of a scholar who not only ignored the political reality around himself but also was willing to demonstrate loyalty to Adolf Hitler's government and to mobilize the help of influential Nazis to advance his scientific agenda.

The complex picture of Karl von Frisch also expands to his relationship with female scientists. In 1924, when he co-founded the *Zeitschrift für vergleichende Physiologie*, science was dominated by males. Given this situation, it is all the more remarkable that the very first article in the Journal was authored by a woman, Ruth Beutler, who had received her PhD under his mentorship. Hardly known today, she dedicated her life and career to supporting von Frisch's work, as shown in the article *Ruth Beutler: the woman behind Karl von Frisch* by Zupanc (2024). Perhaps most significantly, it was one of her observations that prompted him to revisit, and revise, his earlier (incorrect) model of how honeybees communicate, through their dances, the direction and distance of a food source from the hive. On the other hand, Beutler was also an accomplished scientist by her own rights, who had pioneered the application of methods from physiological chemistry to the study of zoological phenomena. Nevertheless, despite her full qualification for appointment to a professorial position, for many years she was employed by von Frisch as a technician only.

The next contribution to this special issue also portrays a woman scientist who, like Ruth Beutler, earned her PhD under the guidance of Karl von Frisch and published her thesis research in the *Zeitschrift für vergleichende Physiologie*. In their article, *Ingeborg Beling and the time memory in honeybees: almost one hundred years of research*, Beer et al. (2024) review how Beling succeeded in the late 1920s in demonstrating time memory in honeybees, a capability that these insects use for optimizing foraging when they visit flowers. Beling's description of the fundamental characteristics of the circadian clock that underlies the honeybee's time memory made her an early pioneer in chronobiology. However, after a few years of highly productive research, her scientific career (like that of many other women scientists of her time) abruptly ended, probably due to family reasons and/or political pressure to reduce the number of women in the workforce.

Comparative physiology and JCPA: personal stories

In this issue section, two world leaders in neuroethology—each a Top 100 Author—reflect on their scientific careers, the joy of doing research in their chosen fields, and the impact that JCPA had on their work and life.

In the first essay titled *A formative journal for a formative career: a personal recollection of how JCPA has inspired and guided my research life*, Warrant (2024) takes us back to the early years of his life when he made the fateful decision to create his own study program, leading to a double major in physics and entomology; and, after completion of

his undergraduate education, when he followed the advice of David Sandeman to join the laboratory of George Adrian Horridge at the Australian National University in Canberra for pursuing a PhD. There, he became fascinated by the question of how insect superposition eyes work—a problem he attacked by combining theoretical modeling of the optics of such eyes in different species with electrophysiological recordings from photoreceptors in the retina. Throughout these formative years, JCPA was *the* formative journal—a true treasure trove of information in the field of insect vision, published by what Warrant calls his "JCPA heroes." Not surprisingly, all five papers resulting from his PhD research were published in JCPA. Many more followed, totaling 24 publications in the Journal by the end of 2023.

Like Eric Warrant, the author of the next essay, Horst Bleckmann, shares with the readership his deep affection for JCPA. With 42 articles published in JCPA, he is one of the most prolific authors of the Journal of the last 100 years. Not surprisingly, these articles also include his very first scientific paper published. In his essay, *The incomparable fascination of comparative physiology: 40 years with animals in the field and laboratory*, Bleckmann (2024) reflects not only on the impact that JCPA had on his career but also on the truly comparative framework that has defined his research. Whereas in most neuroethologists, the 'comparative' aspect of their work is restricted to the study of non-traditional model systems, Bleckmann, together with his students, postdoctoral researchers, and collaborators, worked, during the 40 years of his career as an active researcher on a broad range of taxa, including: teleosts, sharks, marine and freshwater rays, fishing spiders, seals, water rats, amphibians, venomous snakes, pistol shrimps, cephalopods, insects, chameleons, geckos, lizards, and birds of prey. Despite this diversity of taxa, the choice of a new species added was not random. At the beginning of his career, he investigated the sensory basis of lateral line-mediated prey capture behavior in two surface feeding fish species and showed that, although these species are only distantly related, they carry out essentially the same stimulus analysis for prey detection and prey localization. Subsequently, he added to the study of the hydrodynamic sense investigations of fishing spiders, which respond to capillary surface waves caused by prey; electrophysiological recordings from central lateral line units in thornback guitarfish and hornsharks; recordings of microphonic potentials from epidermal lines (structures analogous to the mechanoreceptive lateral line of fishes) on the head and arms of cephalopods; and determination of behavioral sensitivity of juvenile crocodiles and caimans to insect-generated water-surface waves. At the end of his vivid essay, Bleckmann cites one of his mentors, Theodore Holmes Bullock: "There are two types of biologists. One who knows everything about nothing and one who knows a little bit about everything." Clearly, Bleckmann belongs to the latter type.

One hundred years of comparative physiology: popular and trending model systems and topics

At the outset of this issue section, Wagner et al. (2024) consider whether JCPA has lived up to the 'comparative' promise in its name. The answer is provided in their article *Model organisms and systems in neuroethology: one hundred years of history and a look into the future*. The analysis is not only of immediate relevance to readers and authors of the Journal but also to the community of comparative physiologists and neuroethologists in general. The authors' comprehensive analysis reveals that, during the last 100 years, research involving more than 1500 (!) different taxa has been published in the nearly 9500 articles. They contrast these figures with the 13 so-called standard model systems identified by the National Institutes of Health (NIH) for prioritizing funding. The three authors—accomplished neuroethologists with far over 100 years of combined research experience—enthusiastically advocate for an alternative strategy to NIH's selection of a highly limited number of organisms. They argue that many important insights cannot be gained through restriction to NIH's generalist model systems but instead require the study of specialists—species with specific adaptations. Wagner et al. (2024) present compelling evidence in support of their argument by describing past major contributions of work on specialists and by providing detailed accounts of their own research on motion vision in insects, sound localization in owls, and electroreception in weakly electric fish. In concluding their review, they express their hope "that future neuroethologists find the amazing solutions developed by animals in the course of evolution attractive enough to continue working with non-standard species." Surely, JCPA will continue to provide *the* platform for publication of such studies.

The next two articles review specific aspects of insect-plant interactions. In the first article titled *Chemosensory detection of glucosinolates as token stimuli for specialist insects on brassicaceous plants: discovery and impact*, Wang and van Loon (2024) first take us back to the discovery, more than 100 years ago, that glucosinolates are used as token stimuli by larvae of *Pieris* butterflies, which specialize in feeding on plants of the family Brassicaceae. Then, the authors discuss how, during evolution, these substances have emerged as defense mechanisms in plants against phytophagous insects, while insects, in turn, developed defense mechanisms against their toxic effects. Finally, based on more recent findings of taste neurons highly sensitive to glucosinolates in *Pieris brassicae* and of the molecular foundation of this sensory capability, Wang and van Loon present

a model of how the evolution of these gustatory receptors tuned to these token stimuli could be explained.

A second contribution to the Centennial Issue also addresses an often-overlooked aspect of the intricate relationship between plants and insects—mechanical interactions. In their article *Mechanoecology: biomechanical aspects of insect-plant interactions*, Salerno et al. (2024) review, from a mechanical point of view, fascinating details of this relationship, by focusing on the adaptations of insects to attach to plants and on the plant-surface adaptations that prevent insect attachment. The latter aspect has significant translational potential in agriculture. As has already been demonstrated, the attachment ability of insect pests to surfaces can be reduced by various kinds of nanomaterials. Such environmentally friendly methods might be a promising alternative to the use of harmful chemicals, such as insecticides, to control insect infestation.

In the article *Crickets in the spotlight: exploring the impact of light on circadian behavior*, Levy et al. (2024) present a stimulating review of research over the last century on crickets as model insects in chronobiology. The focus of their contribution is on the study of light as a *Zeitgeber* for entrainment of the circadian pacemaker(s) that control rhythmic behavior, such as stridulation and locomotor activity. The authors review evidence for the location of the main circadian pacemaker in the optic lobes, and how entrainment of its oscillatory neural activity by photic stimuli is thought to be mediated at the molecular level. Largely based on their own work, they discuss how crickets can be used for exploring the detrimental effects of artificial light in urban habitats on the behavior and physiology—an application of neuroethological research for which there is likely an increased need in the years to come.

Communication has been one of the most popular phenomena addressed in JCPA. As just one example, duetting as part of acoustic communication in animals has fascinated many human observers, perhaps because a similar coordinated exchange of vocal signals occurs in humans. Despite the popularity of duetting behavior, surprisingly little is known about its evolution and function. To formulate empirically testable predictions for future experimental research, De Gregorio et al. (2024) carried out a comprehensive review of the literature, which they present in the article *Who you live with and what you duet for: a review of the function of primate duets in relation to their social organization*. Grounded on this review, the authors hypothesize that in primates and birds mate defense and mate guarding are critical functions of duetting, and that, in the course of evolution, this behavior has emerged when social organizations shifted from pair living to promiscuity.

Another highly popular topic in JCPA is orientation and navigation. Several mechanisms underlying these abilities in migrating and homing animals have been suggested, including the use of a magnetic compass based on inclination of the Earth's geomagnetic field. The information extracted from this parameter enables animals to distinguish between 'pole-ward' and 'equator-ward.' By contrast, the notion that animals can also extract bicoordinate map information from the geomagnetic field is, though at first sight attractive, highly controversial. In his article *Avian navigation: the geomagnetic field provides compass cues but not a bicoordinate 'map' plus a brief discussion of the alternative infrasound directionfinding hypothesis*, Hagstrum (2024) reviews how data collected through magnetic surveys and other physical studies align with the premises of the magnetic map hypothesis. He concludes that the notion of a bicoordinate magnetic map as a critical component of animal navigation systems is no longer tenable, as is the idea of a map based on two parameters in general. Along the same lines, he advocates for complementing studies of the organism's behavior with rigorous investigations of the physical environment to finally solve the open questions in animal navigation.

In the final paper in this section, titled *Roles for cerebellum and subsumption architecture in central pattern generation*, Montgomery (2024) addresses a question of broad importance: what is the function of the cerebellum, particularly in the context of rhythmic behaviors driven by central pattern generators? By employing a comparative approach and frequently drawing from control-architecture concepts in autonomous robotics, he presents some intriguing ideas about the possible function of this vertebrate brain structure. He argues that moderation of rhythmic pattern generation by sensory input already existed early in vertebrate evolution, prior to the development of the cerebellum. The evolution of the cerebellum enhanced the functionality of the underlying pre-existing neural network by adding a subsumption architecture, a control architecture used in the field of robotics in which the complete behavior is decomposed into sub-behaviors that are organized into a hierarchy of layers; higher layers can influence data flow of lower layers to create the more complex behavioral goal. Montgomery suggests that one of the functions added by the adaptive filter capabilities of the cerebellum involves error learning to appropriately repurpose the output of a central pattern generator. Such adaptive learning is, for example, used to stabilize the body from perturbations caused by active movement.

A peek into the future

In the last article of this special issue, *A perspective on neuroethology: what the past teaches us about the future of neuroethology*, Beetz (2024) offers his predictions about the future of neuroethology. These predications are based

on a solid analysis (what else would a reader expect from a contribution to JCPA?) of past and present trends. And who but a young scientist (Beetz was born in 1988) would have had the courage to accept the challenge to write this article? For this Perspectives piece, Beetz reviewed all abstracts of the last six International Congresses of Neuroethology and categorized them according to sensory modalities, experimental model species, and research topic. What emerges from this analysis is not only a useful inventory of research foci in the recent past but also an interesting projection of potential trends over the next 10–20 years.

While I must admit that the margin of error of Beetz's predictions is not within the range that one usually expects in a scientific publication, something that transpires very clearly from his paper is the enthusiasm that drives his research and the research of so many other neuroethologists. It is not difficult to predict, with high confidence, that this attitude will remain a core pillar of comparative physiology research in the next 100 years, just like it did during the last 100 years.

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References

Beer K, Zupanc GKH, Helfrich-Förster C (2024) Ingeborg Beling and the time memory in honeybees: almost one hundred years of research. J Comp Physiol A. https://doi.org/10.1007/s00359-024-01691-9

Beetz MJ (2024) A perspective on neuroethology: what the past teaches us about the future of neuroethology. J Comp Physiol A. https://doi.org/10.1007/s00359-024-01695-5

Bleckmann H (2024) The incomparable fascination of comparative physiology: 40 years with animals in the field and laboratory. J Comp Physiol A. https://doi.org/10.1007/s00359-023-01681-3

De Gregorio C, Valente D, Ferrario V, Carugati F, Cristiano W, Raimondi T, Torti V, Giacoma C, Gamba M (2024) Who you live with and what you duet for: a review of the function of primate duets in relation to their social organization. J Comp Physiol A. https://doi.org/10.1007/s00359-023-01689-9

Hagstrum JT (2024) Avian navigation: the geomagnetic field provides compass cues but not a bicoordinate map plus a brief discussion of the alternative infrasound direction-finding hypothesis. J Comp Physiol A. https://doi.org/10.1007/s00359-023-01627-9

Kühn A (1927) Über den Farbensinn der Bienen. Z vergl Physiol 5, 762–800. https://doi.org/10.1007/BF00302277

Kühn A (1950) Über Farbwechsel und Farbensinn von Cephalopoden. Z vergl Physiol 32, 572–598. https://doi.org/10.1007/BF00340410

Levy K, Barnea A, Tauber E, Ayali A (2024) Crickets in the spotlight: exploring the impact of light on circadian behavior. J Comp Physiol A. https://doi.org/10.1007/s00359-023-01686-y

Montgomery JC (2024) Roles for cerebellum and subsumption architecture in central pattern generation. J Comp Physiol A. https://doi.org/10.1007/s00359-023-01634-w

Salerno G, Rebora M, Gorb E, Gorb S (2024) Mechanoecology: biomechanical aspects of insect-plant interactions. J Comp Physiol A. https://doi.org/10.1007/s00359-024-01698-2

Wagner H, Egelhaaf M, Carr C (2024) Model organisms and systems in neuroethology: one hundred years of history and a look into the future. J Comp Physiol A. https://doi.org/10.1007/s00359-023-01685-z

Wang CZ, van Loon JJA (2024) Chemosensory detection of glucosinolates as token stimuli for specialist insects on brassicaceous plants: discovery and impact. J Comp Physiol A. https://doi.org/10.1007/s00359-023-01684-0

Warrant EJ (2024) A formative journal for a formative career: a personal recollection of how JCPA has inspired and guided my research life. J Comp Physiol A. https://doi.org/10.1007/s00359-023-01683-1

Zupanc GKH (2024) Ruth Beutler: the woman behind Karl von Frisch. J Comp Physiol A. https://doi.org/10.1007/s00359-023-01622-0

Zupanc GKH, Wanninger S (2024) "Resistance leads to self-destruction": how an (a)political strategy helped Karl von Frisch succeed during the Nazi era. J Comp Physiol A. https://doi.org/10.1007/s00359-024-01697-3

Zupanc GKH, Homberg U, Helfrich-Förster C, Warrant EJ, Simmons AM (2024) One hundred years of excellence: the top one hundred authors of the Journal of Comparative Physiology A. J Comp Physiol A. https://doi.org/10.1007/s00359-024-01699-1