Karl von Frisch

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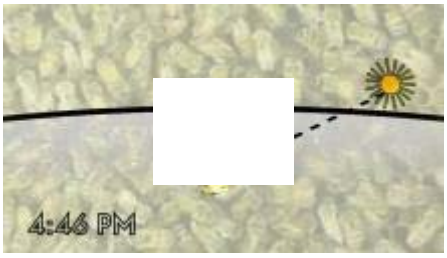
Karl Ritter von Frisch ForMemRS[1] (20 November 1886 – 12 June 1982) was an Austrian ethologist who received the Nobel Prize in Physiology or Medicine in 1973, along with Nikolaas Tinbergen and Konrad Lorenz.[2][3]

His work centered on investigations of the sensory perceptions of the honey bee and he was one of the first to translate the meaning of the waggle dance. His theory was disputed by other scientists and greeted with skepticism at the time. Only recently was it definitively proved to be an accurate theoretical analysis.[4]

Karl von Frisch

Born	20 November 1886 Vienna, Austria
Died	12 June 1982 (aged 95) Munich, Germany
Nationality	Austria
Fields	Ethology
Known for	bees
Notable awards	Nobel Prize in Physiology or Medicine in 1973 Balzan Prize for Biology in 1962



The Waggle Dance of the Honeybee

Contents

Life

Karl von Frisch was the son of the surgeon and urologist Anton Ritter von Frisch (1849-1917) and his wife Marie, née Exner. He was the youngest of four sons, all of whom became university professors. He studied in Vienna under Hans Leo Przibram and in Munich under Richard von Hertwig, initially in the field of medicine but later turning to the natural sciences. He received his doctorate in 1910 and in the same year started work as an assistant in the zoology department of Munich University. In 1912 he became a lecturer in zoology and comparative anatomy there; and in 1919 was promoted to a professorship. His research on honeybees was continued by his student Ingeborg Beling. In 1921 he went to Rostock University as a professor of zoology and director of an institute. In 1923 he accepted the offer of a chair at Breslau University, returning in 1925 to Munich University, where he became the head of the institute of zoology. After that institute was destroyed in World War II, he went to the University of Graz in 1946, remaining

there until 1950 when he returned to the Munich institute after it was reopened. He retired in 1958 but continued his research. Karl von Frisch married Margarete, née Mohr. Their son, Otto von Frisch, was director of the Braunschweig natural history museum between 1977 and 1995.

Research

Karl von Frisch studied the European honey bee (*Apis mellifera carnica*).

Bee perception

Carnica bee on a goldenrod flower head

Sense of smell: Frisch discovered that bees can distinguish various blossoming plants by their scent, and that each bee is "flower constant".[5] Surprisingly, their sensitivity to a "sweet" taste is only slightly stronger than in humans. He thought it possible that a bee's spatial sense of smell arises from the firm coupling of its olfactory sense with its tactile sense.

Optical perception: Frisch was the first to demonstrate that honey bees had color vision, which he accomplished by using classical conditioning. He trained bees to feed on a dish of sugar water set on a colored card. He then set the colored card in the middle of a set of gray-toned cards. If the bees see the colored card as a shade of gray, then they will confuse the blue card with at least one of the gray-toned cards; bees arriving to feed will visit more than one card in the array. On the other hand, if they have color vision, then the bees visit only the blue card, as it is visually distinct from the other cards. A bee's color perception is comparable to that of humans, but with a shift away from the red toward the ultraviolet part of the spectrum. For that reason bees cannot distinguish red from black (colorless), but they can distinguish the colors white, yellow, blue and violet. Color pigments which reflect UV radiation expand the spectrum of colors which can be differentiated. For example, several blossoms which may appear to humans to be of the same yellow color will appear to bees as having different colors (multicolored patterns) because of their different proportions of ultraviolet.

Powers of orientation: Frisch's investigation of a bee's powers of orientation were significant. He discovered that bees can recognize the desired compass direction in three different ways: by the sun, by the polarization pattern of the blue sky, and by the earth's magnetic field, whereby the sun is used as the main compass, with the alternatives reserved for the conditions arising under cloudy skies or within a dark beehive.[6]

Polarization pattern: Light scattered in a blue sky forms a characteristic pattern of partially polarized light which is dependent on the position of the sun and invisible to human eyes. With a UV receptor in each of the lens units of a compound eye, and a UV filter oriented differently in each of these units, a bee is able to detect this polarization pattern. A small piece of blue sky is enough for a bee to recognize the pattern changes occurring over the course of a day. This provides not only directional but also temporal information.

Variations in the daytime position of the sun: Karl von Frisch proved that variations in the position of the sun over the course of a day provided bees with an orientation tool. They use this capability to obtain information about the progression of the day deep inside a dark beehive comparable to what is known from the position of the sun. This makes it possible for the bees to convey always up-to-date directional information during their waggle dance, without having to make a comparison with the sun during long dance phases. This provides them not only with alternative directional information, but also with additional temporal information.

Internal clock: Bees have an internal clock with three different synchronization or timekeeping mechanisms. If a bee knows the direction to a feeding place found during a morning excursion, it can also

find the same location, as well as the precise time at which this source provides food, in the afternoon, based on the position of the sun.[7]

Horizontal orientation of the honeycomb: Based on the magnetic field, the alignment of the plane of a honeycomb under construction (e.g., the new honeycomb of a swarm) will be the same as that of the home hive of the swarm, according to Karl von Frisch. By experiment, even deformed combs bent into a circle can be produced.

Sensing the vertical: The vertical alignment of the honeycomb is attributed by Karl von Frisch to the ability of bees to identify what is vertical with the help of their head used as a pendulum together with a ring of sensory cells in the neck.

Dances as language

Knowledge about feeding places can be relayed from bee to bee. The means of communication is a special dance of which there are two forms:

Round dance

The “round dance” provides the information that there is a feeding place in the vicinity of the beehive at a distance between 50 and 100 meters, without the particular direction being given. By means of close contact among the bees it also supplies information about the type of food (blossom scent).

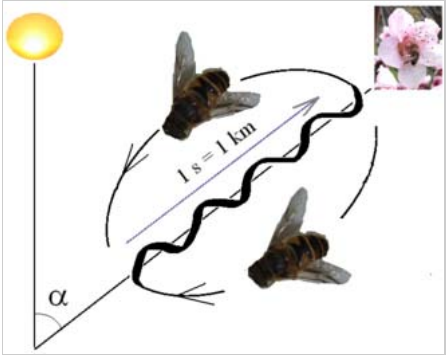
> The foraging bee...begins to perform a kind of “round dance”. On the part of the comb where she is sitting she starts whirling around in a narrow circle, constantly changing her direction, turning now right, now left, dancing clockwise and anti-clockwise, in quick succession, describing between one and two circles in each direction. This dance is performed among the thickest bustle of the hive. What makes it so particularly striking and attractive is the way it infects the surrounding bees; those sitting next to the dancer start tripping after her, always trying to keep their outstretched feelers on close contact with the tip of her abdomen....They take part in each of her manoeuvrings so that the dancer herself, in her mad wheeling movements, appears to carry behind her a perpetual comet’s tail of bees.[8]

Waggle dance

The waggle dance

The "waggle dance" is used to relay information about more distant food sources. In order to do this, the dancing bee moves forward a certain distance on the vertically hanging honeycomb in the hive, then traces a half circle to return to her starting point, whereupon the dance begins again. On the straight stretch, the bee “waggles” with her posterior. The direction of the straight stretch contains the information about the direction of the food source, the angle between the straight stretch and the vertical being precisely the angle which the direction of flight has to the position of the sun. The distance to the food source is relayed by the speed of the dance, in other words, by the number of times the straight stretch is traversed per unit of time. The other bees take in the information by keeping in close contact with the dancing bee and reconstructing its movements. They also receive information via their sense of smell about what is to be found at the food source (type of food, pollen, propolis, water) as well as its specific characteristics. The orientation functions so well that the bees can find a food source with the help of the waggle dance even if there are hindrances they must detour around like an intervening mountain.

As to a sense of hearing, Karl von Frisch could not identify this perceptive faculty, but it was assumed that vibrations could be sensed and used for communication during the waggle dance. Confirmation was later provided by Dr. Jürgen Tautz, a bee researcher at Würzburg University's Biocenter.[9]



Interpretation of the waggle dance

"Dialects"

The linguistic findings described above were based on Karl von Frisch's work primarily with the Carnica variety of bees. Investigations with other varieties led to the discovery that language elements were variety-specific, so that how distance and direction information is relayed varies greatly.

Other work

Frisch's honey bee work included the study of the pheromones that are emitted by the queen bee and her daughters, which maintain the hive's very complex social order. Outside the hive, the pheromones cause the male bees, or drones, to become attracted to a queen and mate with it. Inside the hive, the drones are not affected by the odor.

Eugenics

Frisch advocated the use of eugenics as far as preventing, through sterilisation, people with hereditary diseases from reproducing (giving as examples deafness, blindness, haemophilia and crippled limbs). However, he cautioned that:

"such action certainly represents a great restriction of personal liberty and it demands the highest ethical integrity of those men who are responsible for its application."

He hoped that this could be introduced through voluntary schemes and education about family planning.[10]

Honors and decorations

This article incorporates information from the equivalent article on the German Wikipedia.

- Lieben Prize (1921)
- Pour le Mérite (1952)
- Foreign Honorary Member of the American Academy of Arts and Sciences (1952)[11]
- Foreign Member of the Royal Society (1954)
- Honorary ring of Vienna (1956)
- Kalinga Prize for the Popularization of Science (1958)
- Bavarian Order of Merit (1959)
- Austrian Medal for Science and Art (1960)
- Balzan Prize for Biology "For having consecrated his entire life to experimenting on thousands of bees, thus discovering a true language of gestures for communication and opening new insights into the knowledge of insect behaviour" (motivation of the Balzan General Prize Committee). (1962)
- Nobel Prize for Physiology or Medicine, with Konrad Lorenz and Nikolaas Tinbergen for his achievements in comparative behavioral physiology and pioneering work in communication between insects. (1973)
- Grand Merit Cross with Star and Sash of the Federal Republic of Germany (*Großes Verdienstkreuz mit Stern und Schulterband*) (1974)
- Bavarian Maximilian Order for Science and Art (1981)

- In his honor, the Karl Ritter von Frisch Medal of the German Zoological Society (*Deutschen Zoologischen Gesellschaft*, DZG), is awarded every two years to scientists whose work is distinguished by extraordinary zoological achievements which represent an integration of insights from several different biological disciplines. It is Germany's most important science prize in zoology and includes prize money of 10,000 euros.
- Member of the German Academy of Sciences Leopoldina - National Academy of Sciences
- Honorary doctorates from a number of universities, honorary membership of numerous academies and scientific societies

Publications

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- *Der Farben- und Formensinn der Bienen.* In: Zoologische Jahrbücher (Physiologie) 35, 1–188, (1914–15)
- *Über den Geruchssinn der Bienen und seine blütenbiologische Bedeutung.* In: Zoologische Jahrbücher (Physiologie) 37, 1–238 (1919)
- *Über die ‚Sprache' der Bienen. Eine tierpsychologische Untersuchung.* In: Zoologische Jahrbücher (Physiologie) 40, 1–186 (1923)
- *Aus dem Leben der Bienen.* Springer Verlag Berlin (1927)
- *Untersuchung über den Sitz des Gehörsinnes bei der Elritze.* In: Zeitschrift für vergleichende Physiologie 17, 686–801 (1932), it R. Stetter
- *Über den Geschmacksinn der Bienen.* In: Zeitschrift für vergleichende Physiologie 21, 1–156 (1934)
- *Du und das Leben – Eine moderne Biologie für Jedermann.* (1936) [literally, *You and Life: A Modern Biology for Everyman*]
- *Über einen Schreckstoff der Fischhaut und seine biologische Bedeutung.* In: Zeitschrift für vergleichende Physiologie 29, 46–145 (1941)
- *Die Tänze der Bienen.* In: Österreichische Zoologische Zeitschrift 1, 1–48 (1946)
- *Die Polarisation des Himmelslichtes als orientierender Faktor bei den Tänzen der Bienen.* In: Experientia (Basel) 5, 142–148 (1949)
- *Die Sonne als Kompaß im Leben der Bienen.* In: Experientia (Basel) 6, 210–221 (1950)
- *Das kleine Insektenbuch.* Insel Verlag (1961)
- *Tanzsprache und Orientierung der Bienen.* Springer-Verlag Berlin/Heidelberg/New York (1965)
- *Aus dem Leben der Bienen.* Springer-Verlag Berlin/Heidelberg/New York (9. Auflage 1977), ISBN 3-540-08212-3
- *Erinnerungen eines Biologen.* Springer-Verlag, Berlin/Göttingen/Heidelberg 1957 (Autobiographie)
- *Die Tanzsprache der Bienen. Originaltonaufnahmen 1953–1962*, hrsg. v. Klaus Sander. 2-CD-Set. supposé, Köln 2005. ISBN 978-3-932513-56-5
- " Tiere als Baumeister. Frankfurt a.M., Ullstein, 1974. 309 Seiten. 105 Zeichnungen & 114 Photographien. ISBN 3-550-07028-4

In English

- The dancing bees - an account of the life and senses of the honey bee, Harvest Books New York (1953), a translation of *Aus dem Leben der Bienen*, 5th revised edition, Springer Verlag
- About Biology, Oliver & Boyd (1962), a translation of *Du Und Das Leben*
- Animal Architecture (Originally published as *Tiere Als Baumeister*.) New York, Helen and Kurt Wolff. (ISBN 0-15-107251-5) (1974 1st edition)

See also

- List of Austrian scientists
- List of Austrians

- Apiology

See also: Frisch

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2. ^ Michelsen, A. (2003). "Karl von Frisch lecture. Signals and flexibility in the dance communication of honeybees". *Journal of comparative physiology. A, Neuroethology, sensory, neural, and behavioral physiology* **189** (3): 165–174. doi:10.1007/s00359-003-0398-y (http://dx.doi.org/10.1007%2Fs00359-003-0398-y). PMID 12664092 (//www.ncbi.nlm.nih.gov/pubmed/12664092).
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5. ^ von Frisch, pp. 45-51.
6. ^ von Frisch, pp. 93-96.
7. ^ von Frisch, pp. 137-147.
8. ^ von Frisch, p. 102 ff.
9. ^ Rohrseitz, K.; Tautz, J. (1999). "Honey bee dance communication: Waggle run direction coded in antennal contacts?". *Journal of Comparative Physiology A: Sensory, Neural, and Behavioral Physiology* **184** (4): 463. doi:10.1007/s003590050346 (http://dx.doi.org/10.1007%2Fs003590050346).
10. ^ Karl von Frisch, *About Biology*, Oliver & Boyd, Edinburgh, 1962, pp. 268-273. (Translated from *Du Und Das Leben*, Im Verlag Ullstein, Berlin, 1959)
11. ^ "Book of Members, 1780-2010: Chapter F" (http://www.amacad.org/publications/BookofMembers/ChapterF.pdf). American Academy of Arts and Sciences. Retrieved 15 April 2011.

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- von Frisch, Karl *The Dancing Bees*, Harcourt, Brace & World, Inc. 1953

Ritter

Regarding personal names: *Ritter* is a title, translated approximately as *Knight*, not a first or middle name. There is no equivalent female form.

External links

- Karl Von Frisch, *The Dance Language and Orientation of Bees* (http://www.hup.harvard.edu/catalog.php?isbn=9780674190511), (1967) Harvard University Press
- Dance and communication of honey bees (http://www.polarization.com/bees/bees.html)
- Karl von Frisch, *Decoding the Language of the Bee*, Nobel Lecture, December 12, 1973 (http://nobelprize.org/medicine/laureates/1973/frisch-lecture.html)
- Biography and bibliography (http://vlp.mpiwg-berlin.mpg.de/people/data?id=per308) in the Virtual Laboratory of the Max Planck Institute for the History of Science
- Autobiography (http://nobelprize.org/nobel_prizes/medicine/laureates/1973/frisch-autobio.html)

Categories: 1886 births | 1982 deaths | People from Vienna | Beekeepers | Ethologists | University of Vienna alumni | Ludwig Maximilian University of Munich alumni | Foreign Members of the Royal Society | Ludwig Maximilian University of Munich faculty | University of Rostock faculty | University of Breslau faculty | University of Graz faculty | Austrian knights | Fellows of the American Academy of Arts and Sciences | Members of the Bavarian Maximilian Order for Science and Art | Nobel laureates in Physiology or Medicine | Austrian Nobel laureates | Kalinga Prize recipients | Recipients of the Pour le Mérite (civil class) | Recipients of the Bavarian Order of Merit | Recipients of the Austrian Decoration for Science and Art | Grand Crosses with Star and Sash of the Order of Merit of the Federal Republic of Germany | Fellows of the German Academy of Sciences Leopoldina

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