Non-Visual Orientation in *Talitrus saltator*

The orientation of the sandhopper, *Talitrus saltator*, has been intensively studied by PAPI, PARDI and co-workers[1-6]. Most of their researches were dedicated to sun or moon orientation. The animals were disorientated when the sky was totally overcast and no indication of the sun's position was detectable[2]. Likewise, at night, no orientation was observed when the moon was absent or invisible[5]. Covering the eyes with black paint also prevented orientated escape reactions[1,7].

Repeating the experiments of PAPI and PARDI, we found indications of a non-visual orientation, directing the animals seaward or landward[8]. The experiments mentioned here were performed on the Mediterranean shore near Banyuls (France), on the Dutch North Sea island of Terschelling, at Utrecht, and on the coast of South Wales[9].

In so far as our work repeated the experiments of PAPI and PARDI on solar orientation, our findings are fully comparable. Some examples are given in Figure 1. The results were checked on their deviation from random by the method given by SCHMIDT-KOENIG[10].

Our control experiments, however, in which the dry bowl was darkened by a black rubberized cloth, showed in many cases a distinct aggregation of the animals in a seaward direction. In Banyuls the distribution of the animals was repeatedly photographed after a 10 min period in total darkness; in all cases the bowl was vigorously shaken while under the black cloth at the start of this period. Examination of the negatives showed a seaward distribution (Figure 2A) which was not altered by transferring the animals to the top of a hill 1 km distant from the shore (see Figure 2B). On Terschelling also a significant orientation in the dark could be demonstrated (Figure 2C). Transferring the animals behind the dunes (distance from the sea 750 m) did not change this orientation pattern (Figure 2F). The orientation could be reversed to a landward direction by wetting the inner side of the bowl with sea water (Figure 2E). In Wales, orientation in the dark could be demonstrated again: 7 out of 27 photographs showed a non-random distribution pattern with all the mean directions seaward (Figure 2F). When the sky was visible to the animals, orientation was apparent in 19 out of 24 experiments, the mean directions having about the same scattering (Figure 2G). We believe that the lower number of successful experiments in total darkness can be attributed to a decreased motivation of the animals to move seaward.

Orientation in the dark being possible, it would be interesting to know whether the animals use this mechanism at night when the moon is absent. During one night on Terschelling the animals undoubtedly showed an orientation (Figure 3A). In Wales, some night observations revealed a distinct orientation too (Figure 3B, C). Obscuring the visible stars by a black cloth did not prevent direction finding (Figure 3D).

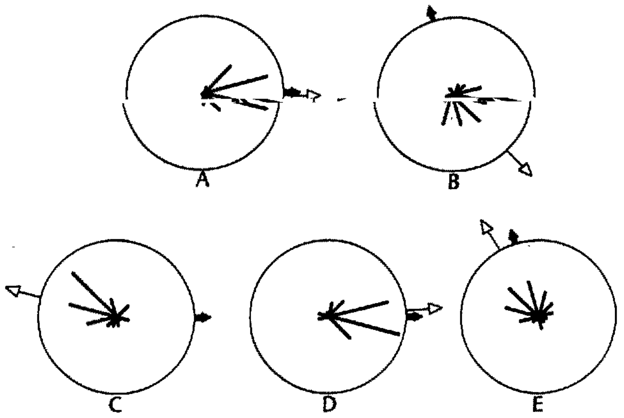

Fig. 1. Orientation by means of optical clues. The number of animals in each of 12 segments is given as a percentage, the radius of the circle representing 35%. Black arrow = the direction towards the sea; open arrow = the mean direction of the animals; n = number of animals in the figure; P = probability of a random distribution. (A) Skyline, sun and polarization pattern present, the bowl being dry. $n = 214$, $P < 0.0001$. (B) Skyline, sun and polarization pattern present, the bowl has been wetted with sea water (landward migration). $n = 351$, $P < 0.0001$. (C) Sun and skyline screened off; the sun is shown in a mirror from the opposite direction (bowl dry). $n = 42$, $P < 0.0001$. (D) Animals transferred to a shore with a coastline at right angles to that of the place of origin, no screening. $n = 44$, $P < 0.0001$. (E) Animals transferred behind the dunes (750 m), no screening. $n = 862$, $P < 0.0001$.

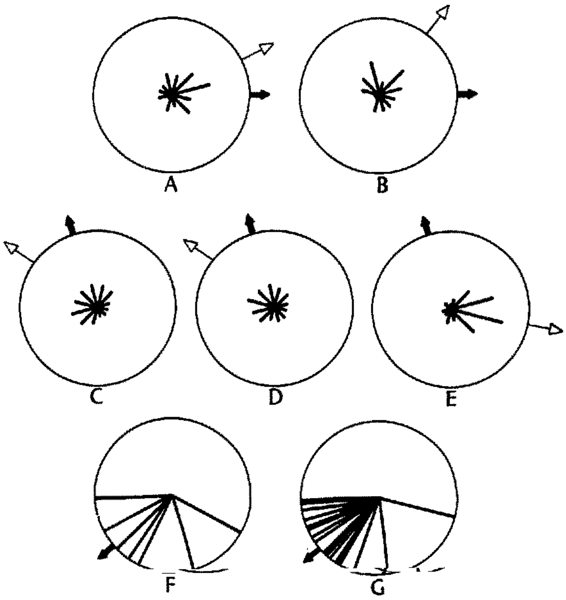

Fig. 2. Orientation in the dark during daytime. See text. (A) $n = 147$, $P < 0.0001$. (B) $n = 191$, $P < 0.0001$. (C) $n = 678$, $P < 0.0001$. (D) $n = 598$, $P < 0.0001$. (E) $n = 270$, $P < 0.0001$. (F) $n = 50$, $P < 0.05$ at least, in each experiment. (G) $n = 50$, $P < 0.05$ at least, in each experiment.

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[1] L. PARDI and F. PAPI, Naturwissenschaften *39*, 262 (1952).

[2] L. PARDI and F. PAPI, Z. vergl. Physiol. *35*, 459 (1953).

[3] E. T. DEBENEDETTI, Naturwissenschaften *50*, 25 (1963).

[4] F. PAPI, Cold Spring Harb. Symp. quant. Biol. *25*, 475 (1960).

[5] F. PAPI and L. PARDI, Z. vergl. Physiol. *35*, 490 (1953).

[6] F. PAPI and L. PARDI, Biol. Bull. mar. biol. Lab. Woods Hole *124*, 97 (1963).

[7] D. I. WILLIAMSON, J. mar. biol. Ass. U.K. *30*, 91 (1952).

[8] As far as we know only one observation in the literature might point to a non-visual orientation in *Talitrus*, WILLIAMSON[7] reported that animals made directed escape reactions in a dense fog.

[9] We wish to thank the Directors of the Laboratoire Arago at Banyuls, of the Biologisch Station Schellingerland, of the Dale Fort Field Centre, Wales and of the Palaeomagnetisch Instituut of Utrecht for their hospitality and for providing us with advice and instruments.

[10] K. SCHMIDT-KOENIG, Z. Tierpsychol. *18*, 221 (1961).

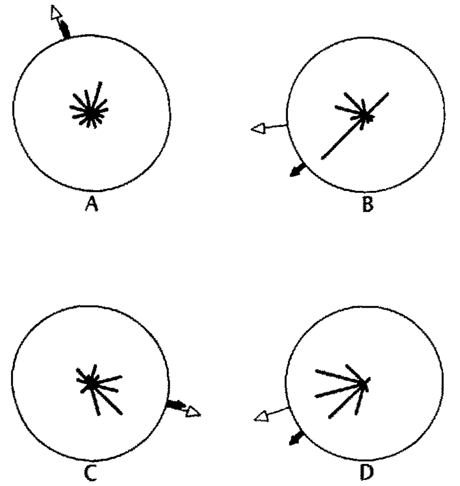

Fig. 3. Orientation at night when the moon is absent. (A) Sky visible, partially covered with clouds. Animals transferred behind the dunes. $n = 486$, $P < 0.0001$. (B) Sky visible, no clouds. Animals transferred to the top of a hill. $n = 29$, $P < 0.05$. (C) The same experiment with animals from another shore. $n = 56$, $P < 0.01$. (D) Sky screened. $n = 27$, $P < 0.01$.

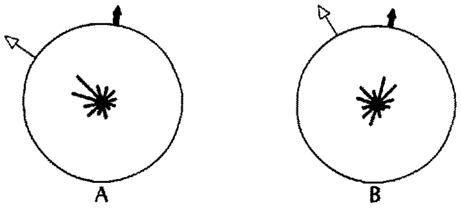

Fig. 4. Orientation and the earth's magnetic field. See text. (A) $n = 410$, $P < 0.0001$. (B) $n = 414$, $P < 0.0001$.

Stimulated by the experiments of SCHNEIDER[11], BECKER[12] and others on the influence of magnetism on orientation, we have compensated the earth's magnetic field down to 50 γ (normal horizontal strength being 0.18 gauss) by means of Helmholtz coils. This was done in the Palaeomagnetic Institute at Utrecht some metres below the earth's surface. The animals used in these experiments were stored in the laboratory for several days, using a tilted aquarium with a layer of sand and some sea water. The results show that the animals have a tendency to orientate in total darkness when the natural magnetic influence is present (Figure 4A). This tendency remains when the earth's magnetic field is almost eliminated (Figure 4B). The orientation being only weak, the large number of observations brings about a high level of significance. Further studies on this subject will be undertaken in the near future.

Zusammenfassung. Die Versuche von PAPI und PARDI[1–6] wurden mit *Talitrus saltator* wiederholt. Auch unter völligem Lichtabschluss zeigten die Tiere ein noch ähnlich orientiertes Verhalten. Ausschaltung des erdmagnetischen Feldes bis auf 50 γ konnte die Orientierung im Dunkeln nicht aufheben.

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[11] F. SCHNEIDER, Ergebn. Biol. *26*, 147 (1963).

[12] G. BECKER, Naturwissenschaften *50*, 664 (1963).

Response of *Pisum sativum* Linn. to Gibberellic Acid

Earlier workers[1–3] have reported that spraying various crop plants with gibberellic acid (GA) at their various growth stages invariably resulted in the increased vegetative growth of aerial parts but did not increase the total yield. Some of them[2,3] have reported that treatment with GA in fact depressed the yields. A trial conducted at a sewage farm on *Pisum sativum* has produced interesting results. Spraying with increasing concentrations of GA on 4-week-old (pre-flowering) and 8-week-old (flowering stage) plants resulted in increasing and decreasing total green pod yields, respectively.

P. sativum, variety Bonneville, was grown during the winter season on a sewage farm. Randomized block design with all possible combinations of the 2 ages (4 and 8 weeks old) and 5 GA concentrations (0, 75, 150, 225 and 300 ppm) with 4 replications was used. 10 plants at 45 · 23 cm spacing formed a plot. The crop was maintained on sewage water depending on the condition of soil and crop plants. The analysis of sewage water contained 22.13 ppm nitrogen (NO_3), 0.075 ppm phosphorus (P_2O_5), and 26.2 ppm potassium (K_2O). Apart from various growth characteristics (data to be published), the green marketable pods were picked every 3 days starting from the 11th week after sowing, and the separate yields and the mean total yield were obtained (Table).

There were no significant differences between the mean green pod yields due to different GA concentrations, whereas significantly different yields were obtained when GA was sprayed at the 2 different growth stages. A significant differential response to concentrations when sprayed at the 2 growth stages was observed. The interesting point is that when plants were sprayed at the pre-flowering stage, corresponding increase in the yield was recorded with higher concentrations of GA.

The results of spraying GA at the flowering stage are in conformity with the findings of earlier workers[1–3]

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[1] E. F. ALDER, C. LEBEN, and A. CHICHUK, J. Am. Soc. Agron. *51*, 307 (1959).

[2] D. G. MORGAN and G. C. MEES, Nature, Lond. *178*, 50, 1356 (1956).

[3] D. G. MORGAN and G. C. MEES, J. agric. Sci., Camb. *50*, 49 (1958).