second messenger (*13*). Furthermore, studies with insoluble NGF derivatives and ^{125}I-labeled NGF indicate that, like insulin (*14*), NGF exerts its action on responsive neurons by first combining with a surface membrane receptor (*15*) and that the properties of this interaction are quite similar to those of insulin (*16*).

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Odor-Following and Anemotaxis

In the study of Farkas and Shorey (*1*), male pink bollworm moths, *Pectinophora gossypiella*, flew through a "response" plane near the source of an odor plume of female sex pheromone. In both still air and moving air large majorities of those moths which crossed the response plane flew within the odor plume toward its source. Farkas and Shorey concluded that (i) these moths can stay within an odor plume in the absence of an air current, (ii) these moths can sense the direction of the source of an odor plume in the absence of an air current, and (iii) for these moths anemotaxis (orientation to an air current) is not necessary for locating the source of an airborne odor. The results of Farkas and Shorey support the first but not the last two conclusions.

In the still-air trials, replicates were "abandoned" in which moths did not cross the response plane within 20 seconds. Thus, moths which remained stationary in the odor plume short of the response plane would not be counted. Also not counted would be moths flying in the plume but turning away from its source. In short, data which might have supported the need for anemotaxis were discounted. Furthermore, since moths were released at the end of the odor plume away from the source, they were not given an equal opportunity to fly in the "wrong" direction. In a critical test, one would release moths at the longitudinal midpoint of the odor plume in both still air and moving air and compare the percentages (of all moths released) moving toward or away from the source of the plume. A nonsignificant difference would support the last two conclusions.

The results of Farkas and Shorey thus show that moths can follow an airborne odor trail in still air. However, their results cannot be interpreted as a rejection of the generally held hypothesis that animals must orient to an air current (anemotaxis) to find the source of an airborne odor.

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References and Notes

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In our report (*1*) we asserted that the mechanism by which pink bollworm male moths steer toward a source of female sex pheromone does not require a sensing of wind direction. Grubb has raised two questions with regard to our tabulation of data and our experimental procedure that could cast doubt on the validity of this assertion.

First, he pointed out that we abandoned those replicates in the still-air trials in which the moths did not cross the response plane (the cross-sectional area of the tunnel located 30 cm "downwind" from the pheromone source) within the arbitrary 20-second interval during which we considered the plume still remained intact. Thus, moths which remained stationary in the odor plume short of the plane and moths turning away from the odor source would not be counted. We regret that we omitted the following important information. In each of 27 replicates conducted with a plume suspended in still air, a single male moth left the release cage and entered the plume. Seven of these moths either left the plume or remained in the plume but did not pass the response plane in the 20-second interval. The remaining 20 moths proceeded about 1.5 m from the release cage and passed through the response plane. Sixteen of these remained within the central portion of the flight tunnel occupied by the pheromone plume and four flew outside this area. Thus, approximately 60 percent of the moths that initially entered the plume exhibited odor trail-following over a short (1.5 m) distance.

We agree with Grubb's second point. Our experiment did not conclusively demonstrate that the odor trail possessed an inherent polarization, indicating to the moths the direction along the axis of the trail toward the odor source. Although we could not detect an anemotactic reaction, we did not perform the critical experiment that would allow us to say without doubt that such a reaction is not needed to provide the directional cues to the trail.

We did not intend to disclaim the existence of anemotaxis as one of the mechanisms that may be used by some species of insects during their in-flight orientation to a distant odor source. However, we continue to question the universal application of this phenomenon, which is generally accepted as a truism although it has received almost no experimental validation, to all cases of olfactory orientation. Our demonstration that pink bollworm moths follow an airborne odor trail in still air, even if the trial is not polarized, provides an additional mechanism for aerial approach to an odor source.

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