**Main idea of paper**: Measure influence of shimmering on hornets and conversely, measure influence of hornets on shimmering.

**Definitions:**

* W (wave strength): number of surface bees per frame that were actively shaking/lifting their abdomen
* Two types of shimmers (small-scale and large-scale):
  + Small-scale: composed of local wave-like shimmers made by tens of bees
  + Large-scale: waves that spread out over entire nest and compose of 100s of bees
* Estimate for the shimmering strength, the number of bees participating in the first 600 ms after the start of a shimmer is defined by the integral of W(600 ms)/f\_corr where f\_corr is a correction factor which accounts for an individual bee’s shaking lasting approximately 160 ms.

**Parameters of Hornets:**

* 2 dimensional position coordinates
* Angular flight direction
* Turning angle per time (40ms): calculated as difference in flight directions between two successive frames
* Non-directional flight velocity
* 5 classes of pre-wave distances of hornets (Table 1, page 5). If multiple hornets were present, then the category of the hornet closest to the nest was considered.
* 8 classes of pre-wave flight velocities of hornets was also used (Table 2, page 5). If multiple hornets were present, then a flight velocity was calculated and used (weights the hornets closer to the nest more heavily).
* Shimmering waves and flight patterns of hornets were monitored from 100 ms before shimmering to 1000 ms after onset of shimmering.
* Want to know if W is dependent on flight parameters of hornets

**Results:**

**Impact of hornets on shimmering**

* Wave strength in pre-wave period of small-scale shimmers was low due to non-repetition of signals. Low-scale shimmers peaked after 200 – 250 ms.
* Big-scale waves reached their maximum activity (W) typically after 400 ms and were repetitive.
* Shimmering was found even without the presence of predators, but large-scale shimmering was only observed under the presence of hornets.
* When the wasps were in the category of closest proximity to the nest, pre-wave, the provoked wave was maximal and included around 70 bees over 600 ms. When the wasps began further away, much smaller waves were observed and fewer bees participated.
* Hornets with a speed less than 20 cm/s provoked only a single weak wave with less than 40 bees involved. If hornets flew at a rate greater than 30 cm/s, then larger waves were triggered (More than 80% of the maximal wave strength achieved over the course of the experiment)
* Arousal rate of bee colony also represented by repetitiveness of shimmering, increasing exponentially with proximity of hornets to the nest. Complex relationship between flight velocity and repetitiveness of shimmering (follows an “optimum distribution”: maybe don’t consider this). Repetitiveness of shimmering is primarily a function of proximity
* Most hornets flew at the mean hovering distance (52.1cm +- 0.53 cm (Se)) and slower than 50 cm/s when shimmering was provoked.

**Impact of shimmering on hornets**

* For hornets closer than the mean hovering distance mentioned above, they not only invoked larger waves, but also withdrew further from the nest at the onset of shimmering. However, if they began further than the mean hovering distance from the nest, then they drew closer to the nest upon shimmering.
* To quantify response of a hornet to shimmering, change in distance one second after onset of shimmering was calculated
* At mean hovering distance, hornets were not affected by shimmering; they stayed neutral.
* Figure 8 reveals that hornets are influenced by both phases of shimmering: hornets are driven away from the nest not only as the wave starts, but also until the wave ends
* According to Figure 9, both large and small - scale shimmering waves impacted the flight trajectories of hornets. In particular, the hornets did not typically decelerate but instead altered their flight trajectory away from the nest. Interestingly, large-scale waves had less affect on the hornet. On the other hand, large scale waves caused the hornet to accelerate for about 400 ms.