Black soldier fly larvae feed by forming a fountain around food

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1 Supplementary videos

1. Black soldier fly larvae eat a 40-cm diameter pizza in two hours. Once larvae break through the crust, they consume the softer cheese rather than eating the rest of the crust. This indicates that the collective motion of larvae allows them to access food that is easier for them to chew. Video courtesy of Grubbly Farms.

2. Larvae in petri dishes eating chicken feed, sped up 256 times. Some larvae do not eat, while others ate for 44% of the time they are around food. The times larvae interact with food are recorded to determine that larvae eat for 5 minutes at a time, with a standard deviation of 8 minutes.

3. The motion of a larva's mouth, filmed at 500 fps and slowed down 4 times. A piece of orange is touched to the mouth and then removed to make it possible to observe the larva's mouth as it eats. The larva first raises one maxilla, then the other, and brings both back down at the same time. This motion suggests that larvae shear food rather than holding on to it.

4. Larvae filmed from bottom of container, sped up 128 times. The unedited video is used for PIV analysis. A region of larvae crawling towards and around the food forms, and larvae also crowd in the corners of the container.

5. Larvae filmed from top of container, sped up 128 times. The unedited video is used for PIV analysis. Mean motion of larvae shows that larvae are pushed away from the food on top of the layer. A similar effect is seen in the corners.

6. Groups of larvae, from 1 to 500 larvae, eating orange slices, sped up 128 times. One larva cannot be seen underneath the piece of food it is consuming. 500 larvae eat very quickly. The orange is quickly buried underneath the larvae.

2 Supplementary Figures
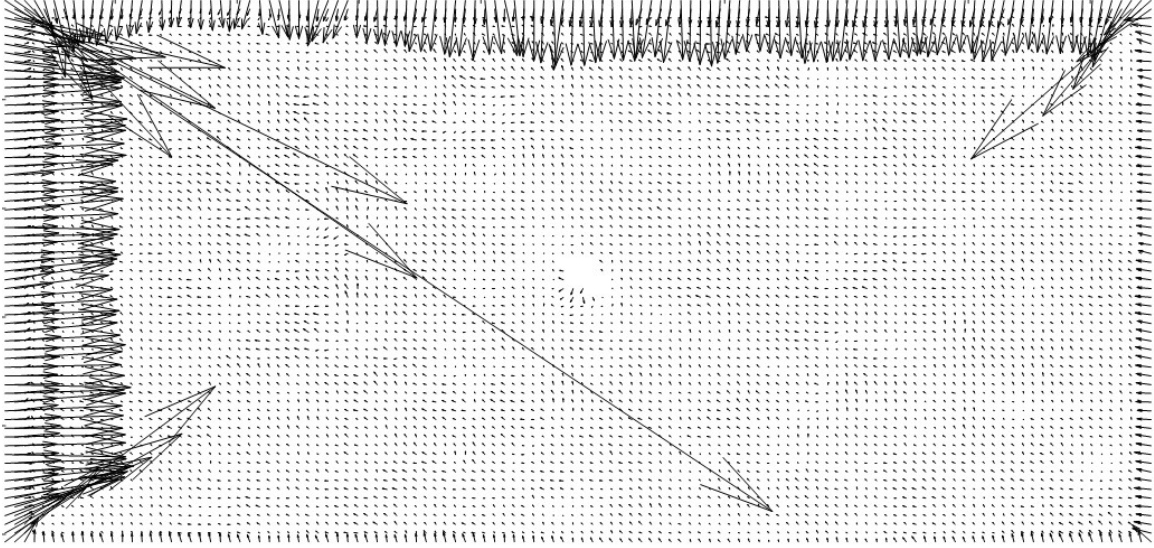
Figure S1: When vector fields used for averaging in the top view in the top and bottom view PIV experiment are reshuffled in time, their average no longer shows a mixing region. This indicates that the mixing region found through PIV analysis is valid.

3   Supplementary tables

Table 1: Larva composition determined by EDS

Element	Mouth concentration (Weight %)	Head concentration (Weight %)
C	69.42	56.59
N	3.87	14.93
O	25.19	27.7
Mg	Not detected	0.09
P	0.1	0.31
S	0.27	0.11
K	0.61	0.22
Ca	0.49	Not detected
Zn	0.04	0.05

Table 2: Larva flow properties derived from PIV

Property	Top	Bottom
$\overline{\mathbf{u}}$, Average speed (mm/s)	0.09	0.07
$\nabla \times \mathbf{u}$, Vorticity (1/s $\times 10^{-3}$)	0.9	-0.6
$\nabla \cdot \mathbf{u}$, Divergence (1/s $\times 10^{-3}$)	1.4	-1.7
Area (cm^2)	80	60