

1 **ELECTRONIC SUPPLEMENTARY MATERIALS (ESM)**

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3 Collective foraging decision in a gregarious insect

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16 **Files in this Data Supplement:**

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18 Text ESM 1

19 Figures ESM 1

20 Tables ESM 1

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22 **Text ESM1 - Estimation of the parameters of the model**

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24 Parameters of the model were estimated from data recorded for cockroaches tested
25 individually in the arena in the presence of two food sources for 45 minutes (Fig. 1a).

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27 Probability to Leave the Shelter

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29 Probability α to leave the shelter was estimated from the following observations: (i) the
30 distribution of the latencies of cockroaches tested individually to leave the shelter was an
31 exponential function (Chi-square test: $\chi^2 = 3.64$, $df = 3$, $p = 0.3025$), and (ii) 55% of the
32 cockroaches tested in groups left their shelter, whatever the group size (Fig. 2a). Probability α
33 was estimated by fitting theoretical percentages of individuals remaining in the shelter during

34 the courses of experiments to the experimental values of the for each group size (nonlinear
35 regression: for $\alpha = 0.0022$; fitting group of 50, $r^2 = 0.9743$, $p < 0.0001$; fitting group of 100, r^2
36 $= 0.9935$, $p < 0.0001$; fitting group of 200, $r^2 = 0.9972$, $p < 0.0001$) (figure ESM1). α is
37 constant per unit of time and similar for the three group sizes (Table ESM1).

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39 Probability to join and to leave sources

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41 Probabilities β_j to join sources and δ_{ij} to leave sources were estimated from experimental
42 values characterizing all visits of individually tested cockroaches.

43 The latency to reach a food source was significantly higher for the first visit than for
44 all the subsequent visits (Kruskal-Wallis test: $H = 68.71$; $df = 15$, 228; $p < 0.0001$; for all
45 comparisons between visit 1 and subsequent visits: $z > 3.00$; $p < 0.0500$). Latencies for all
46 subsequent visits (visits 2 to 16) did not differ significantly (Kruskal-Wallis test: $H = 14.96$;
47 $df = 14$, 186; $p = 0.0590$). Therefore, in the model we considered a long latency for visit 1
48 (mean latency of visit 1) and a short latency for the following visits (mean latency of all
49 subsequent visits). The distributions of latencies for the first visit and for all subsequent visits
50 were exponential functions (Chi-square test: visit 1, $\chi^2 = 3.55$, $df = 3$, $p = 0.1692$; subsequent
51 visits, $\chi^2 = 6.00$, $df = 3$, $p = 0.1116$) implying that the probability to leave the source is
52 independent of time. The probability β_j to join a source at a visit j is the inverse of the mean
53 latency to join a source for a visit j (Table ESM1). β_1 is the probability to join a source for the
54 first visit, and β_2 is the probability to join a source for all subsequent visits.

55 Similarly, time spent feeding at a source for the first visit was significantly higher than
56 time spent feeding at a source for all the subsequent visits (Kruskal-Wallis test: $H = 28.36$; df
57 $= 15$, 228; $p < 0.0001$; for all comparisons between visit 1 and subsequent visits; $z > 3.00$; $p <$
58 0.0500). Feeding durations of all subsequent visits (2 to 16) did not differ significantly
59 (Kruskal-Wallis test: $H = 11.03$; $df = 14$, 186; $p = 0.2730$). Therefore in the model we
60 considered a long feeding bout for the first visit (mean feeding duration of visit 1) and a short
61 feeding bout for the subsequent visits (mean feeding duration of all subsequent visits).
62 Feeding durations at a source for the first visit and for all subsequent visits were well fitted by
63 an exponential distribution (Chi-square test: visit 1, $\chi^2 = 1.52$, $df = 3$, $p = 0.6766$; subsequent
64 visits, $\chi^2 = 3.56$, $df = 3$, $p = 0.3135$). Probability δ_{ij} of leaving a source i at visit j is estimated
65 by:

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$$\delta_{ij} = d_j + \frac{K}{1 + e^{\eta(N-T)}} \quad i = 1, 2 \quad j = 1, 2$$

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69 $d_j + K$ is equal to the probability of individually tested cockroaches to leave source i at visit j
70 estimated by the inverse of the duration of feeding bouts for visit j (table ESM1). Values $K =$
71 0.0035 , $\eta = 2$ and $T = 22$ were estimated by fitting equation (2) to experimental data. When δ_{ij}
72 is constant (null hypothesis of non-interacting individuals), N was estimated by the mean
73 number of cockroaches at a source during the whole experiments, which was always
74 approximately 5% for the three group sizes (groups of 50: $6.5 \pm 0.49\%$, $N = 27$; group of 100:
75 $4.99 \pm 0.40\%$, $N = 25$; and groups of 200: 4.52 ± 0.41 , $N = 19$). δ_{ij} is constant for each group
76 size (group of 50: $\delta_{i,1} = 0.0480$, $\delta_{i,2} = 0.0085$; groups of 100: $\delta_{i,1} = 0.0470$, $\delta_{i,2} = 0.0083$;
77 groups of 200: $\delta_{i,1} = 0.0430$, $\delta_{i,2} = 0.0080$). When δ_{ij} is not constant (hypothesis of a retention
78 effect) N was equal to X_i , the total number of feeding individuals on source i (see “Model:
79 Decision-making mechanism”). $\delta_{i,1}$ is the probability to leave source i after the first visit, and
80 $\delta_{i,2}$ is the probability to leave source i after all subsequent visits.

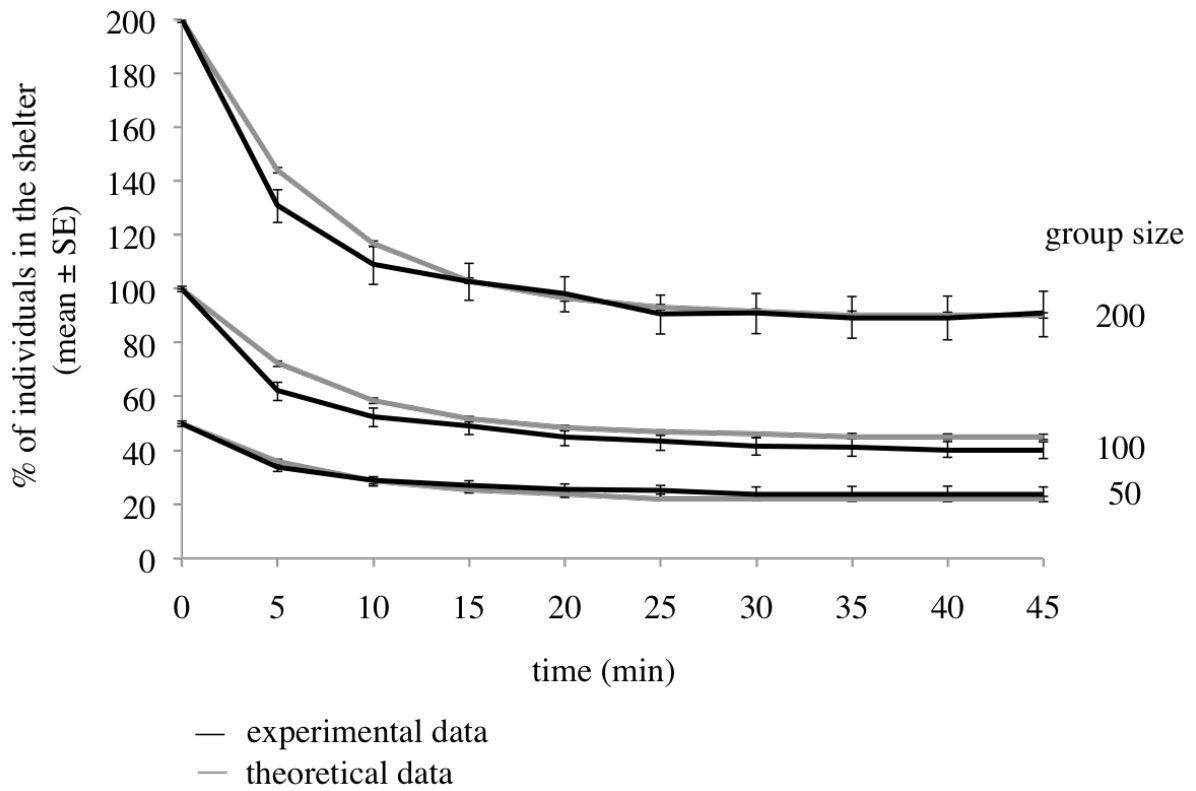
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82 Probability of being satiated

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84 The architecture of the model (equation system (1), Fig. 4) was based on the observations that
85 after a visit to a source, approximately 20% ($17.04 \pm 0.02\%$, $N = 96$) of cockroaches were
86 satiated and never returned to one of the two sources. During experiments, cockroaches were
87 never observed returning to their shelter after the exploration phase. In the model, we
88 therefore considered that satiated individuals always remained inactive in the arena (state O)
89 with no possibility to return to the shelter (state S).

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91 **Fig. ESM1** Estimation of probability to leave the shelter. Value of α was estimated by fitting
 92 the theoretical percentages of individuals remaining in the shelter (grey lines) to the
 93 experimental data of cockroaches tested individually in the arena (black lines). Fitting was
 94 made on experimental data for groups of 50, 100 and 200 cockroaches. α is constant per unit
 95 of time and similar for the three group sizes ($\alpha = 0.0022$). Simulations were run 1000 times
 96 each.

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