

1 **Detailed Methods**

2 *Breeding and non-breeding seasons*

3 Many animals have distinct stages in their annual cycle ('seasons') that correspond with
4 environmental variation, principally food availability. Here, we consider a system with two
5 seasons defined by whether an animal is breeding or not breeding (Betini *et al.* 2013a,b),
6 although the principles could be extended to more complex seasonality. Our system mimics
7 several key elements of seasonality in the wild: (1) the breeding season is shorter than the non-
8 breeding season; (2) flies are not food-restricted during the non-breeding season, but females
9 have no source of protein and no laying medium, and therefore do not lay eggs; and (3) fecundity
10 declines with time during the breeding season (Betini *et al.* 2015; Elliott *et al.* 2016).

11 We simulated seasonality by creating distinct breeding and non-breeding 'seasons',
12 following the protocol in Betini *et al.* (2013a,b, 2015; Fig. S1). During the 'non-breeding
13 season', adults were placed in an empty vial with access to 0.2 ml of 5% water-sugar solution,
14 for 4 d, which prevented females from producing eggs. During the 'breeding season', flies were
15 placed for 24 hrs into 10 mL of a dead yeast-agar-sugar medium (1000 mL H₂O, 100 g sucrose,
16 50 g Fleischmann's yeast, 16 g agar, 8 g C₄H₄KNaO₆, 1g KH₂PO₄, 0.5 g NaCl, 0.5 g MgCl₂, 0.5
17 g CaCl₂, 0.5 g Fe₂(SO₄)₃), then adults were discarded, and larvae were allowed to mature to
18 adults. Flies were kept at 25 °C, 12 L:12 D cycles, and humidity was between 30-50%. The same
19 sized vial (28 x 95 mm) was used for both seasons.

20 *Fear experiments*

21 We used Chinese praying mantids, *Tenodera aridifolia sinensis* (hereafter 'mantids') as
22 predators. We tested *Drosophila* with single first instar mantids that had been feeding on adult
23 *Drosophila* for their entire lives prior to the start of the experiment. To control for age and body

24 size, we only used individual adult *Drosophila* between 1-3 d old from parents bred at low
25 density. To obtain these offspring, we selected males and females and placed 4, 16, 80 or 160
26 individuals (50:50 sex ratio) in separate 28 x 95 mm vials with 10 ml of fresh food for 24 hrs (d
27 0). It takes a minimum of 8 d for offspring to develop. On d 9, we discarded all offspring and
28 used only individuals that emerged between d 10 and 12. We then combined these offspring and
29 randomly grouped equal ratios of males and females into one of three treatments: 'control' ($n =$
30 15), 'non-breeding mantid' ($n = 15$) and 'breeding mantid' ($n = 15$).

31 All treatments began at the start of the non-breeding season and finished at the end of the
32 breeding season. After 4 d in the non-breeding season, we moved the survivors to the breeding
33 season, but controlled density by combining all survivors from each treatment at the end of the
34 non-breeding period and then placed the same density of flies (50:50 sex ratio) as was present in
35 the non-breeding season in each breeding vial.

36 For the '*non-breeding mantid*' treatment, immediately prior to the commencement of the
37 non-breeding season, we placed a first instar mantid at the bottom of the non-breeding season
38 vial and placed a sponge between the mantid and the flies (Fig. S1). This prevented the mantid
39 from ascending the vial and the flies from seeing the mantid. After four days, the mantid and
40 flies were removed and placed into the breeding season. The breeding season was identical
41 between the non-breeding mantid and '*control*' treatments (Fig. S1).

42 For the '*breeding mantid*' treatment, the non-breeding season was identical to the control.
43 After four days, the flies were transferred into the breeding season. For the breeding mantid
44 treatment, a sponge was placed in an empty non-breeding vial and the mantid was added in the
45 breeding season vial with fresh fly food 24 hrs before the survivors from the non-breeding
46 season were transferred to the breeding period (Fig. S1).

47 The breeding season was shorter than the non-breeding season as we attempted to create an
48 ecologically relevant experimental system and breeding seasons are shorter than non-breeding
49 seasons for many wild animals. Consequently, the flies in the breeding season were exposed to
50 the predator for a shorter period than the flies in the non-breeding season, which could also be
51 true for wild animals with longer non-breeding seasons than breeding seasons. A longer breeding
52 season would be unlikely to change the impact of the predator on fecundity as ~80% of eggs are
53 laid within 6 hrs after the females are exposed to the medium and larvae hatch after 24 hrs and,
54 as they grow, consume eggs that are subsequently laid. The 'control' followed the same protocols
55 as the two treatments (see also next section) but did not have a mantid added in either season
56 (Fig. S1).

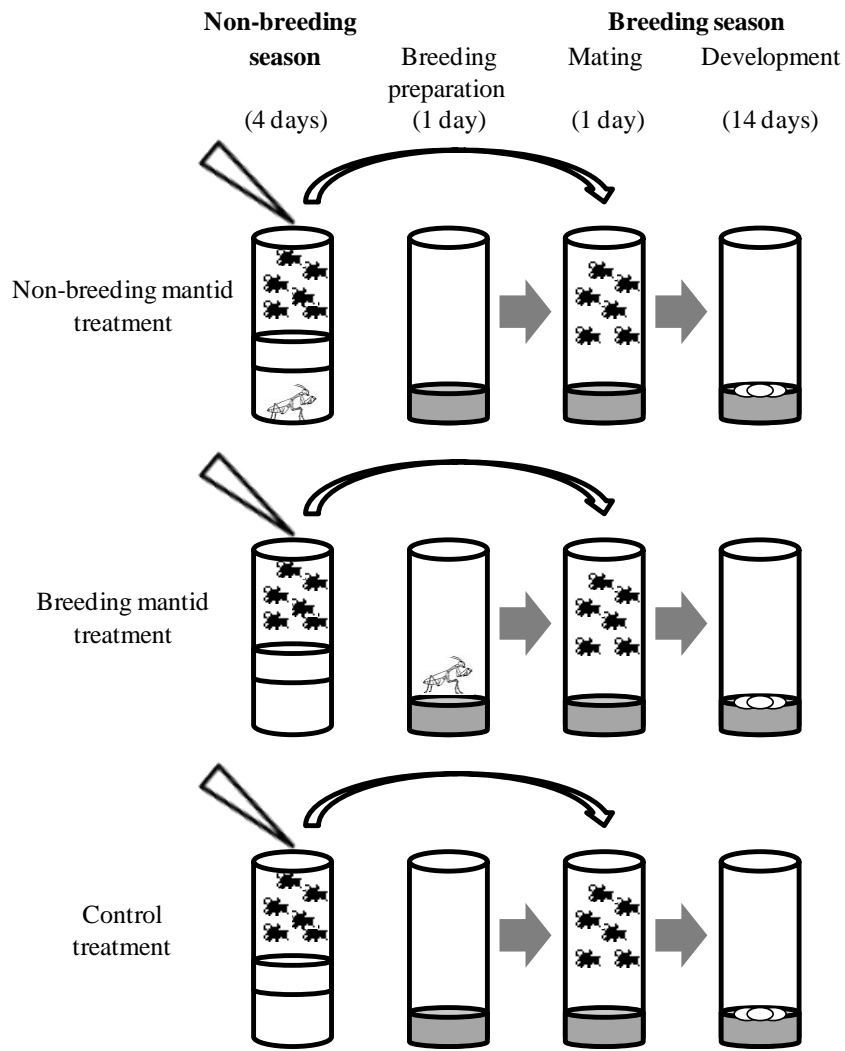
57 To investigate the effects of the treatment on reproductive output, we counted the total
58 number of offspring emerged, which we termed '*fecundity*'. Over 90% of eggs hatch, and
59 consequently the number of offspring emerged is very similar, and highly correlated with, the
60 number of eggs laid (Elliott et al. 2016). We also measured '*female offspring mass*', which was
61 the average mass of female offspring on the day juvenile flies emerged.

62 The form of mantid cue was different between non-breeding and breeding seasons, with
63 the mantid present continually during the non-breeding season and only the remaining scent in
64 the breeding season. However, the response in both cases was similar along a gradient of mantid
65 sizes and presumably chemical cues associated with the mantids, meaning that the response to
66 the cue was likely some form of threshold function (Elliott et al. 2016). In that case, we must
67 have been near the maximum threshold response in both cases, and the responses were therefore
68 similar.

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70 **References**

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91 *melanogaster*. *Evolution* **49**, 649-659.



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95 **Fig. S1.** Schematic diagram of the two treatments and control used in the study. All flies

96 began in the non-breeding season (the slanted triangle at the top of the vial shows the

97 sugar-water solution used to feed the flies during this period) and, after 4 d, were move to

98 the breeding season (the dark gray at the bottom of the vial represents the dead yeast–

99 agar–sugar medium). The breeding season consisted of 24 hrs for mating and then 14 d

100 for development of larvae. For the ‘non-breeding mantid treatment’, mantids were placed

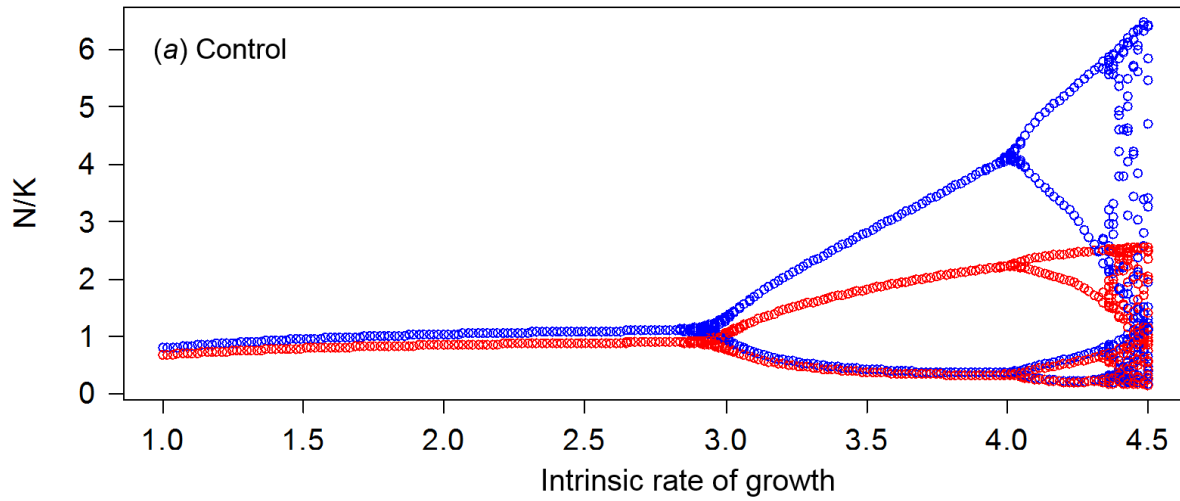
101 at the bottom of the vial during the non-breeding season and, for the ‘breeding mantid

102 treatment', mantids were placed in breeding vials one day prior to the start of the
103 breeding season and removed prior to addition of flies. Larvae emerged between d 8-15,
104 with > 99% occurring between d 9-13 (breeding season days numbered to include 1 d as
105 eggs).

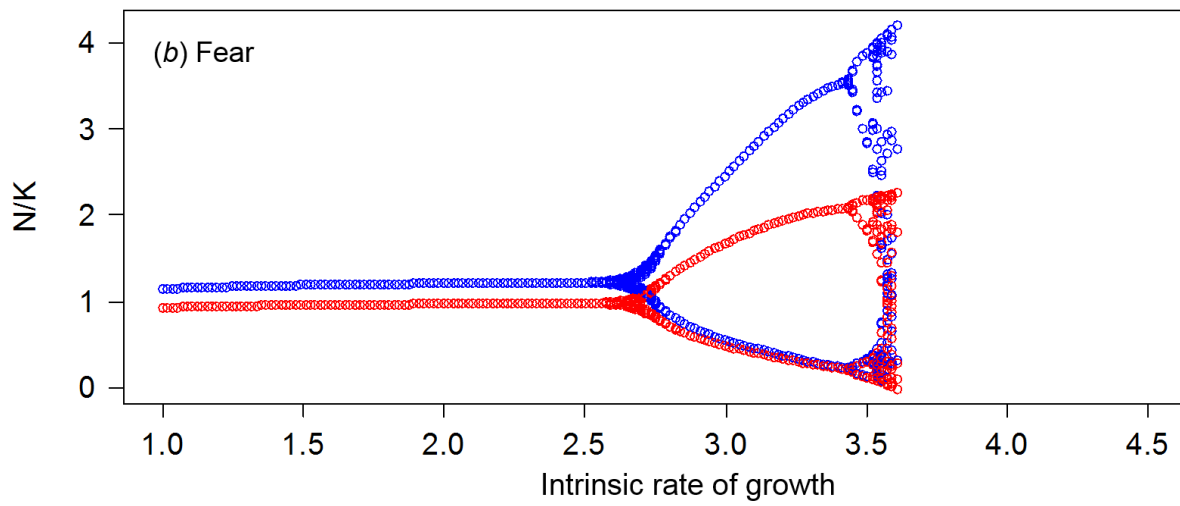
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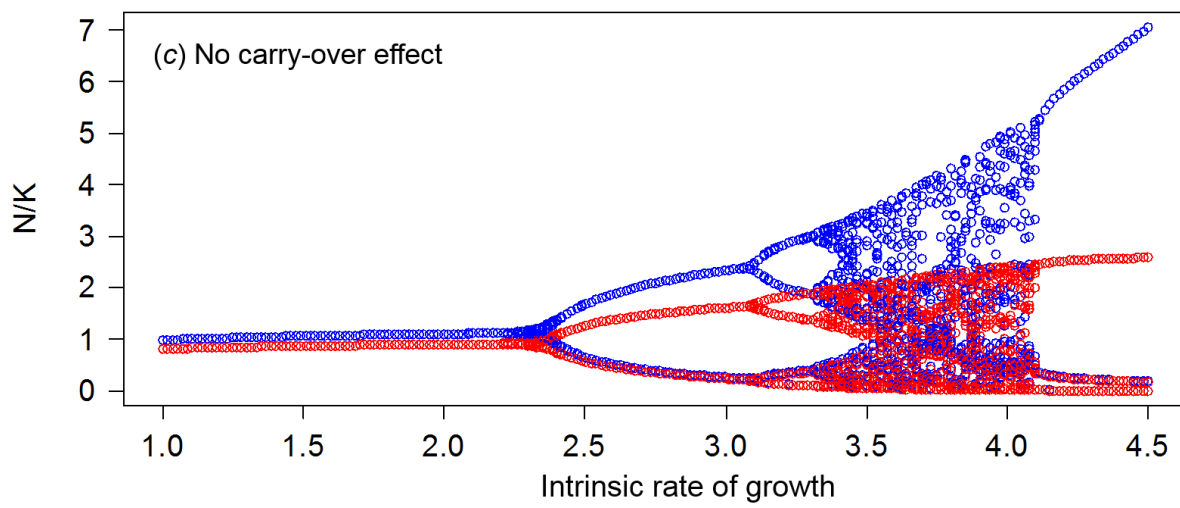
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112 **Fig. S2.** Bifurcation diagram of (a) bi-seasonal Ricker model with carry-over effect (from Betini
113 et al. 2013a), (b) bi-seasonal Ricker model with carry-over effects in the presence of fear and (c)
114 bi-seasonal Ricker model without carry-over effects. Model is parameterized using the data
115 presented in our paper. Both the non-breeding (red) and breeding (blue) seasons are shown.
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118 **Table S1.** Data used to calculate fecundity in the paper.

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Treatment	Density	Fecundity
control	4	3.75
control	4	4.5
control	4	4.5
control	4	3.5
control	4	5.25
control	4	5.5
control	4	4.5
control	4	3.5
control	4	5
control	16	1.6875
control	16	2.0625
control	16	2.0625
control	16	2.6875
control	16	2.8125
control	16	2.9375
control	16	2.9375
control	16	3
control	16	3.125
control	16	3.25
control	16	3.3125
control	16	3.5
control	16	3.5
control	16	3.5625
control	16	3.625
control	16	3.75
control	16	3.75
control	16	3.8125
control	16	3.8125
control	16	3.875
control	16	3.9375
control	16	4
control	16	4
control	16	4.25
control	16	4.4375
control	16	4.5625
control	16	4.5625
control	16	4.625
control	16	4.625

control	16	4.9375
control	16	5.0625
control	16	5.0625
control	16	5.1875
control	16	5.3125
control	16	5.4375
control	16	5.625
control	16	5.6875
control	16	6.5
control	80	1
control	80	1
control	80	0.8375
control	80	1.0625
control	80	1.3875
control	80	0.975
control	80	0.9875
control	80	1
control	80	1.25
control	80	1.2375
control	80	1.175
control	80	1.025
control	160	0.70625
control	160	0.8625
control	160	0.5
control	160	0.5375
control	160	0.525
control	160	0.6125
control	160	0.475
control	160	0.70625
control	160	0.63125
control	160	0.425
control	160	0.45625
control	160	0.58125
control	160	0.58125
control	4	3.25
breeding mantid	4	4.5
breeding mantid	4	3
breeding mantid	4	4.25
breeding mantid	4	2.75
breeding mantid	4	4.5
breeding mantid	4	4.25
breeding mantid	4	3
breeding mantid	4	4.25

breeding mantid	4	4.25
breeding mantid	4	2.75
breeding mantid	16	1
breeding mantid	16	1.375
breeding mantid	16	1.9375
breeding mantid	16	1.9375
breeding mantid	16	2.0625
breeding mantid	16	2.0625
breeding mantid	16	2.8125
breeding mantid	16	2.8125
breeding mantid	16	2.875
breeding mantid	16	2.9375
breeding mantid	16	3
breeding mantid	16	3
breeding mantid	16	3.0625
breeding mantid	16	3.0625
breeding mantid	16	3.3125
breeding mantid	16	3.375
breeding mantid	16	3.625
breeding mantid	16	3.625
breeding mantid	16	3.8125
breeding mantid	16	4
breeding mantid	16	4.125
breeding mantid	16	4.1875
breeding mantid	16	4.25
breeding mantid	16	4.25
breeding mantid	16	4.25
breeding mantid	16	4.4375
breeding mantid	16	4.5
breeding mantid	16	4.75
breeding mantid	16	4.75
breeding mantid	16	5.125
breeding mantid	16	5.4375
breeding mantid	16	5.625
breeding mantid	16	6
breeding mantid	16	6.9375
breeding mantid	80	0.975
breeding mantid	80	1.2
breeding mantid	80	1.35
breeding mantid	80	1.375
breeding mantid	80	1.475
breeding mantid	80	1.125
breeding mantid	80	0.975

breeding mantid	80	1
breeding mantid	80	1.5
breeding mantid	80	0.95
breeding mantid	80	0.9875
breeding mantid	80	1
breeding mantid	160	0.5875
breeding mantid	160	0.475
breeding mantid	160	0.7625
breeding mantid	160	0.675
breeding mantid	160	0.68125
breeding mantid	160	0.65
breeding mantid	160	0.4625
breeding mantid	160	0.70625
breeding mantid	160	0.45625
breeding mantid	160	0.7125
breeding mantid	160	0.40625
breeding mantid	160	0.53125
breeding mantid	160	0.75625
non-breeding mantid	4	3.25
non-breeding mantid	4	1.5
non-breeding mantid	4	4.5
non-breeding mantid	4	2.75
non-breeding mantid	4	3
non-breeding mantid	4	0.5
non-breeding mantid	4	2.5
non-breeding mantid	4	3
non-breeding mantid	4	0.75
non-breeding mantid	4	3.5
non-breeding mantid	16	1.875
non-breeding mantid	16	1.9375
non-breeding mantid	16	2.125
non-breeding mantid	16	2.1875
non-breeding mantid	16	2.25
non-breeding mantid	16	2.25
non-breeding mantid	16	2.3125
non-breeding mantid	16	2.4375
non-breeding mantid	16	2.6875
non-breeding mantid	16	2.8125
non-breeding mantid	16	2.8125
non-breeding mantid	16	2.875
non-breeding mantid	16	2.875
non-breeding mantid	16	2.875
non-breeding mantid	16	3

non-breeding mantid	16	3.0625
non-breeding mantid	16	3.1875
non-breeding mantid	16	3.1875
non-breeding mantid	16	3.25
non-breeding mantid	16	3.3125
non-breeding mantid	16	3.375
non-breeding mantid	16	3.375
non-breeding mantid	16	3.4375
non-breeding mantid	16	3.4375
non-breeding mantid	16	3.4375
non-breeding mantid	16	3.5625
non-breeding mantid	16	3.875
non-breeding mantid	16	3.875
non-breeding mantid	16	3.9375
non-breeding mantid	16	4
non-breeding mantid	16	4.125
non-breeding mantid	16	4.25
non-breeding mantid	16	4.3125
non-breeding mantid	16	4.375
non-breeding mantid	16	4.375
non-breeding mantid	16	5
non-breeding mantid	16	5.125
non-breeding mantid	80	1.35
non-breeding mantid	80	1.2
non-breeding mantid	80	1.275
non-breeding mantid	80	0.8
non-breeding mantid	80	1.0125
non-breeding mantid	80	1.2
non-breeding mantid	80	1.1875
non-breeding mantid	80	1.025
non-breeding mantid	80	1.3375
non-breeding mantid	80	0.825
non-breeding mantid	80	1.2125
non-breeding mantid	80	0.7625
non-breeding mantid	160	0.55
non-breeding mantid	160	0.69375
non-breeding mantid	160	0.7375
non-breeding mantid	160	0.5875
non-breeding mantid	160	0.4875
non-breeding mantid	160	0.4625
non-breeding mantid	160	0.61875
non-breeding mantid	160	0.68125
non-breeding mantid	160	0.61875

non-breeding mantid	160	0.64375
non-breeding mantid	160	0.5875
non-breeding mantid	160	0.4375
non-breeding mantid	160	0.4375