

## Supporting Information

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**Table S1. Test temperatures, the total number of aphids and the number of exposure times used to assess heat and cold stress tolerance in three aphid species.** For each species and temperature, the numbers indicate the total number of individuals assessed, with the number of tested durations indicated in parenthesis. For each temperature x duration combination, there are 2-4 replicates, each consisting of a pool of 7-12 individuals.

Species	Age (days)	High temperature (°C)								Low temperature (°C)							
		34	35	36	37	38	39	40	-11	-10	-9	-8	-7	-6	-5	-4	-3
<i>M. dirhodum</i>	2	218(8)	263(9)	266(9)	252(8)	236(8)	210(7)	183(6)	-	182(7)	216(8)	252(9)	259(10)	274(9)	215(7)	-	-
<i>M. dirhodum</i>	6	273(9)	173(6)	191(6)	264(9)	266(8)	260(8)	240(8)	137(5)	245(9)	222(10)	382(16)	255(10)	205(7)	279(10)	-	-
<i>M. dirhodum</i>	12	383(14)	252(8)	287(9)	231(8)	275(9)	225(7)	280(8)	-	235(8)	294(11)	382(15)	222(8)	225(9)	-	-	-
<i>S. avenae</i>	2	208(5)	148(5)	193(5)	216(6)	200(5)	289(6)	229(5)	279(10)	364(13)	356(12)	271(10)	294(11)	218(7)	180(6)	-	-
<i>S. avenae</i>	6	255(7)	266(6)	298(8)	210(6)	195(6)	176(5)	239(6)	207(8)	280(10)	467(15)	232(8)	374(15)	232(9)	255(8)	-	-
<i>S. avenae</i>	12	201(6)	203(7)	194(6)	292(8)	241(9)	261(10)	209(8)	240(8)	259(8)	236(10)	317(14)	352(12)	200(7)	204(7)	-	-
<i>R. padi</i>	2	298(10)	291(10)	216(8)	175(6)	204(7)	190(7)	192(6)	-	-	-	-	266(12)	185(8)	237(8)	287(11)	286(11)
<i>R. padi</i>	6	272(9)	257(9)	345(11)	229(7)	196(6)	172(5)	212(8)	164(8)	150(7)	204(9)	325(12)	296(12)	410(16)	238(9)	276(10)	-
<i>R. padi</i>	12	284(9)	343(12)	226(9)	204(6)	217(7)	300(10)	206(7)	-	-	123(5)	146(6)	144(7)	196(8)	265(9)	210(7)	167(6)

**Table S2. McFadden's pseudo-R<sup>2</sup> for estimating the goodness of fit of logistic model at each temperature for each species and group**

Species	Age(days)	High temperature (°C)								Low temperature (°C)							
		34	35	36	37	38	39	40	-11	-10	-9	-8	-7	-6	-5	-4	-3
<i>M. dirhodum</i>	2	0.88	0.94	0.88	0.88	0.78	0.95	0.83	-	0.78	0.65	0.71	0.74	0.81	0.82	-	-
<i>M. dirhodum</i>	6	0.85	0.90	0.95	0.90	0.83	0.70	0.88	0.73	0.28	0.79	0.49	0.82	0.71	0.74	-	-
<i>M. dirhodum</i>	12	0.78	0.94	0.84	0.93	0.84	0.80	0.58	-	0.72	0.36	0.66	0.81	0.78	-	-	-
<i>S. avenae</i>	2	0.86	0.87	0.93	0.91	0.91	0.78	0.80	0.57	0.49	0.75	0.92	0.90	0.82	0.77	-	-
<i>S. avenae</i>	6	0.69	0.91	0.52	0.96	0.93	0.88	0.77	0.84	0.17	0.27	0.77	0.85	0.80	0.81	-	-
<i>S. avenae</i>	12	0.94	0.93	0.95	0.89	0.93	0.85	0.91	0.49	0.37	0.67	0.53	0.60	0.79	0.91	-	-
<i>R. padi</i>	2	0.85	0.85	0.91	0.91	0.95	0.92	0.95	-	-	-	-	0.49	0.41	0.81	0.75	0.81
<i>R. padi</i>	6	0.91	0.81	0.87	0.85	0.88	0.86	0.84	0.51	0.68	0.44	0.41	0.51	0.65	0.66	0.62	
<i>R. padi</i>	12	0.84	0.58	0.84	0.82	0.68	0.74	0.87	-	-	0.83	0.76	0.66	0.37	0.39	0.77	0.73

**Table S3 Three-way ANCOVA for thermal death time curves from three cereal aphid species of three ages under high temperatures.  $p$ -values < 0.05 are marked in bold italics in the table.**

Variable	<i>df</i>	F-value	<i>p</i> -value
Test temperature	1	2614.58	<b>&lt;0.001</b>
Age	2	8.88	<b>&lt;0.001</b>
Species	2	84.52	<b>&lt;0.001</b>
Age × Species	4	2.77	<b>0.004</b>
Test temperature × Age	2	2.03	0.144
Test temperature × Species	2	13.95	<b>&lt;0.001</b>
Test temperature × Age × Species	4	1.84	0.137

**Table S4 Three-way ANCOVA for thermal death time curves from three cereal aphid species of three ages under low temperatures. *p*-values < 0.05 are marked in bold italics in the table.**

Variable	<i>df</i>	F-value	<i>p</i> -value
Test temperature	1	607.76	<b>&lt;0.001</b>
Age	2	16.44	<b>&lt;0.001</b>
Species	2	136.03	<b>&lt;0.001</b>
Age × Species	4	13.60	<b>&lt;0.001</b>
Test temperature × Age	2	0.23	0.80
Test temperature × Species	2	8.70	<b>&lt;0.001</b>
Test temperature × Age × Species	4	2.80	<b>0.04</b>

**Table S5. Comparison of  $\log_{10}(Lt_{50})$  at 37 °C between species and ages.** Pairwise  $p$ -values from *emmeans* () examining differences in  $\log_{10}(Lt_{50})$  at 37 °C between three aphid species from three ages (2, 6 and 12 days).  $p$ -values < 0.05 are marked in bold. Light grey cells mark the comparisons between three species with the same age while coloured cells mark the comparisons testing the effect of ages within species.

Age		2 days			6 days			12 days		
Age	Species	<i>M. dirhodum</i>	<i>S. avenae</i>	<i>R. padi</i>	<i>M. dirhodum</i>	<i>S. avenae</i>	<i>R. padi</i>	<i>M. dirhodum</i>	<i>S. avenae</i>	<i>R. padi</i>
2 days	<i>M. dirhodum</i>		<b>0.0019</b>	<.0001	0.7424			<.0001		
	<i>S. avenae</i>			<b>0.0056</b>		0.1471			0.0945	
	<i>R. padi</i>						<b>0.0436</b>			0.5296
6 days	<i>M. dirhodum</i>					<b>0.0002</b>	<.0001	<b>0.0001</b>		
	<i>S. avenae</i>						<b>0.0009</b>		0.9649	
	<i>R. padi</i>									0.2879
12 days	<i>M. dirhodum</i>								<b>0.0288</b>	<b>0.0005</b>
	<i>S. avenae</i>									0.1449
	<i>R. padi</i>									

	Species	<i>M. dirhodum</i>	<i>S. avenae</i>	<i>R. padi</i>	<i>M. dirhodum</i>	<i>S. avenae</i>	<i>R. padi</i>	<i>M. dirhodum</i>	<i>S. avenae</i>	<i>R. padi</i>
2 days	<i>M. dirhodum</i>		0.0803	<b>0.0007</b>	0.6085			<b>0.0015</b>		
	<i>S. avenae</i>			0.0688		0.4568			0.075	
	<i>R. padi</i>						0.7032			0.7118
6 days	<i>M. dirhodum</i>					<b>0.0252</b>	<b>0.0414</b>	<b>0.0105</b>		
	<i>S. avenae</i>						0.9644		0.4974	
	<i>R. padi</i>									0.9999
12 days	<i>M. dirhodum</i>								0.0651	0.4964
	<i>S. avenae</i>									0.4161
	<i>R. padi</i>									

**Table S6. Comparison of slope at high temperatures between species and ages.** Pairwise  $p$ -values from *emmtrends ()* examining differences in  $z$  ( $-1/\text{slope}$ ) between three aphid species from three ages (2, 6 and 12 days).  $p$ -values  $< 0.05$  are marked in bold. Light grey cells mark the comparisons between three species at the same age while coloured cells mark the comparisons testing the effect of ages within species.

**Table S7. Comparison of  $\log_{10}(Lt_{50})$  at  $-7^{\circ}\text{C}$  between species and ages.** Pairwise  $p$ -values from *emmeans* () examining differences in  $\log_{10}(Lt_{50})$  at  $-7^{\circ}\text{C}$  between three aphid species from three ages (2, 6 and 12 days).  $p$ -values  $< 0.05$  are marked in bold. Light grey cells mark the comparisons between three species at the same age while coloured cells mark the comparisons testing the effect of ages within species.

Age	Species	2 days			6 days			12 days		
		<i>M. dirhodum</i>	<i>S. avenae</i>	<i>R. padi</i>	<i>M. dirhodum</i>	<i>S. avenae</i>	<i>R. padi</i>	<i>M. dirhodum</i>	<i>S. avenae</i>	<i>R. padi</i>
2 days	<i>M. dirhodum</i>		0.1852	<b>0.0001</b>	0.7806			0.2645		
	<i>S. avenae</i>			<b>0.0006</b>		0.1776			0.3898	
	<i>R. padi</i>						0.263			<b>0.0044</b>
6 days	<i>M. dirhodum</i>					0.7185	<b>&lt;.0001</b>	0.5529		
	<i>S. avenae</i>						<b>&lt;.0001</b>		0.8571	
	<i>R. padi</i>									<b>&lt;.0001</b>
12 days	<i>M. dirhodum</i>								0.2066	<b>&lt;.0001</b>
	<i>S. avenae</i>									<b>&lt;.0001</b>
	<i>R. padi</i>									



**Table S8. Comparison of slope at low temperatures between species and ages.** Pairwise  $p$ -values from *emmtrends()* examining differences in  $z$  ( $-1/\text{slope}$ ) between three aphid species from three ages (2, 6 and 12 days).  $p$ -values  $< 0.05$  are marked in bold. Light grey cells mark the comparisons between three species while coloured cells mark the comparisons testing the effect of ages within species.

Age	Species	2 days			6 days			12 days		
		<i>M. dirhodum</i>	<i>S. avenae</i>	<i>R. padi</i>	<i>M. dirhodum</i>	<i>S. avenae</i>	<i>R. padi</i>	<i>M. dirhodum</i>	<i>S. avenae</i>	<i>R. padi</i>
2 days	<i>M. dirhodum</i>		0.1278	0.8663	0.9417			0.3801		
	<i>S. avenae</i>			0.476		0.5397			0.2013	
	<i>R. padi</i>						0.3745			0.0982
6 days	<i>M. dirhodum</i>					0.8262	0.0912	0.2237		
	<i>S. avenae</i>						0.2698		0.7529	
	<i>R. padi</i>									0.3729
12 days	<i>M. dirhodum</i>							0.2713		<b>0.0127</b>
	<i>S. avenae</i>									0.0735
	<i>R. padi</i>									

**Table S9 The statistics of temperature in three sites (Beijing, Xinxiang and Wuhan) in summer months and winter months**

**(2016/2017).**  $T_{max}$ ,  $T_{min}$  and  $T_{av}$  are the maximal, minimal and average hourly temperature in the summer/winter months, respectively.

$t \geq 30^{\circ}\text{C}$  is the duration when temperature is above  $30^{\circ}\text{C}$  in the summer months.  $t \leq 0^{\circ}\text{C}$  is the duration when temperature is lower than  $0^{\circ}\text{C}$  in the winter months.

		Beijing	Xinxiang	Wuhan
summer	$T_{max}$	37.0°C	39.5°C	38.0°C
	$T_{min}$	7.0°C	10.4°C	13.4°C
	$T_{av}$	25.2°C	26.1°C	26.5°C
	$t \geq 30^{\circ}\text{C}$	611 h	736 h	868 h
winter	$T_{max}$	16.0°C	24.1°C	25.0°C
	$T_{min}$	-13.0°C	-6.2°C	-2.2°C
	$T_{av}$	0.7°C	4.2°C	8.7°C
	$t \leq 0^{\circ}\text{C}$	1473 h	771 h	67 h

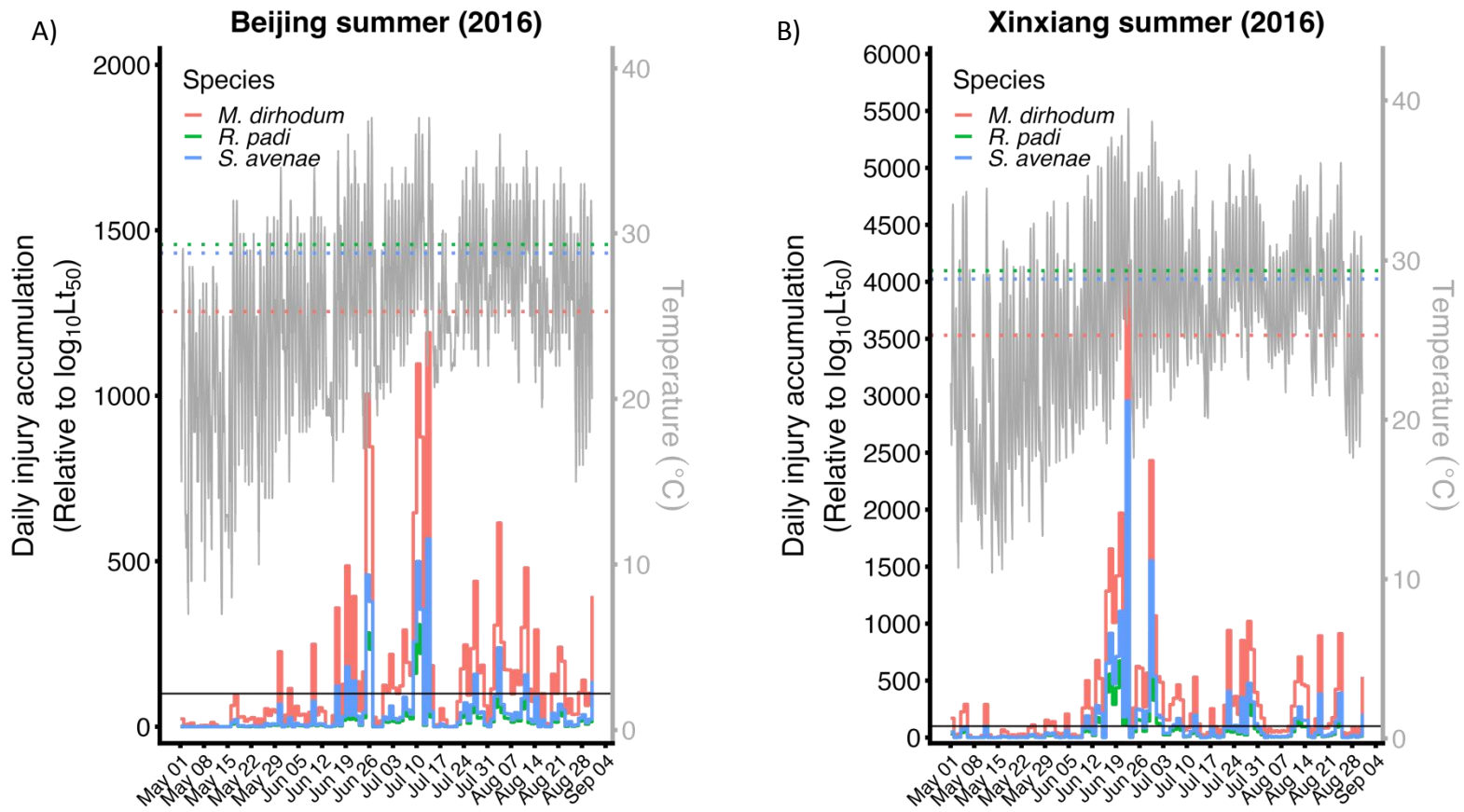


Figure S1. Predicted daily injury accumulation based on the TDT parameters for the three species of cereal aphids (*M. dirhodum*, *S. avenae*, *R. padi*) (age 6days) under natural temperature fluctuations found in Beijing (A) and Xinxiang (B) in the summer months (May-August) of 2016.

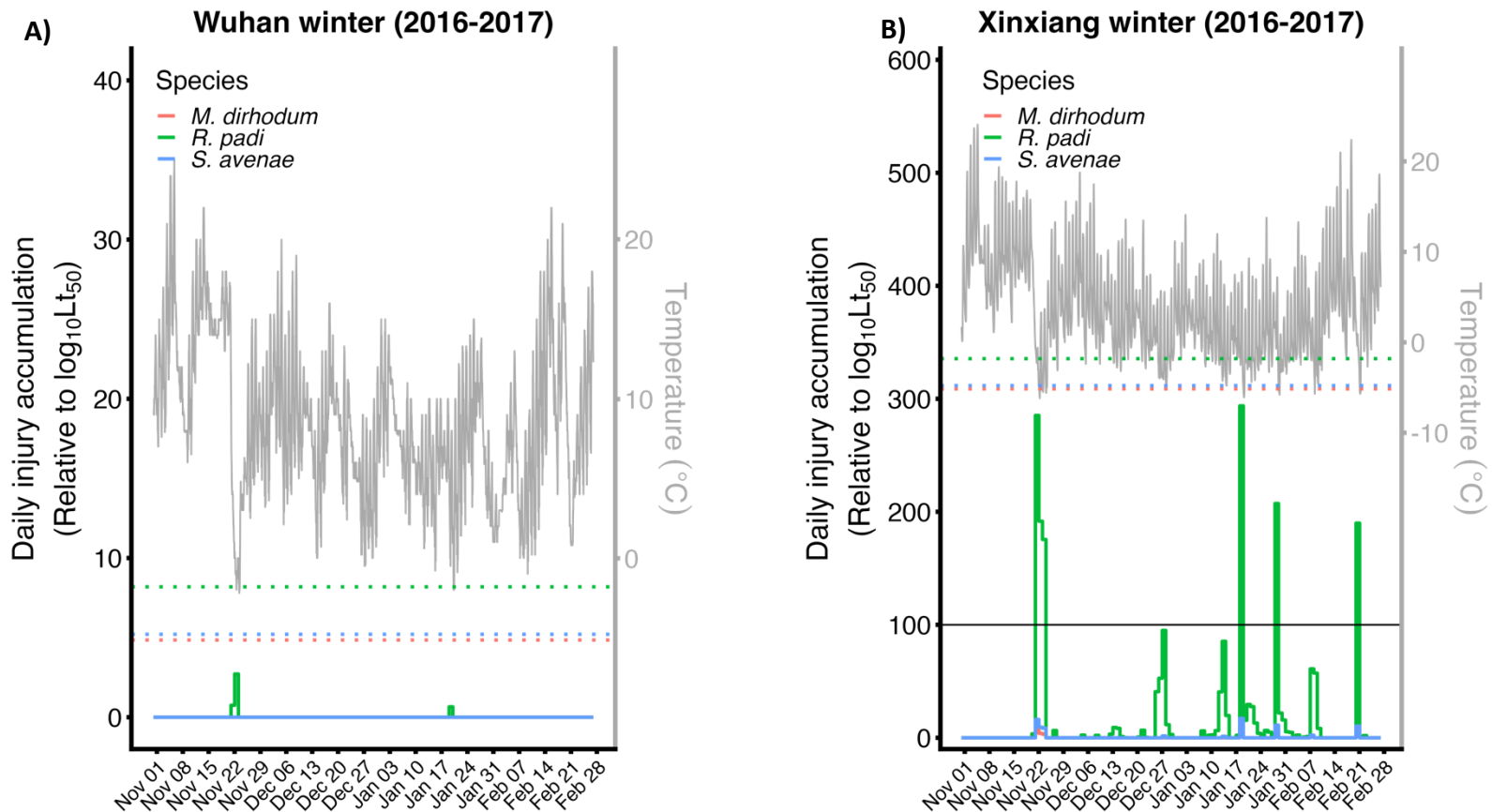
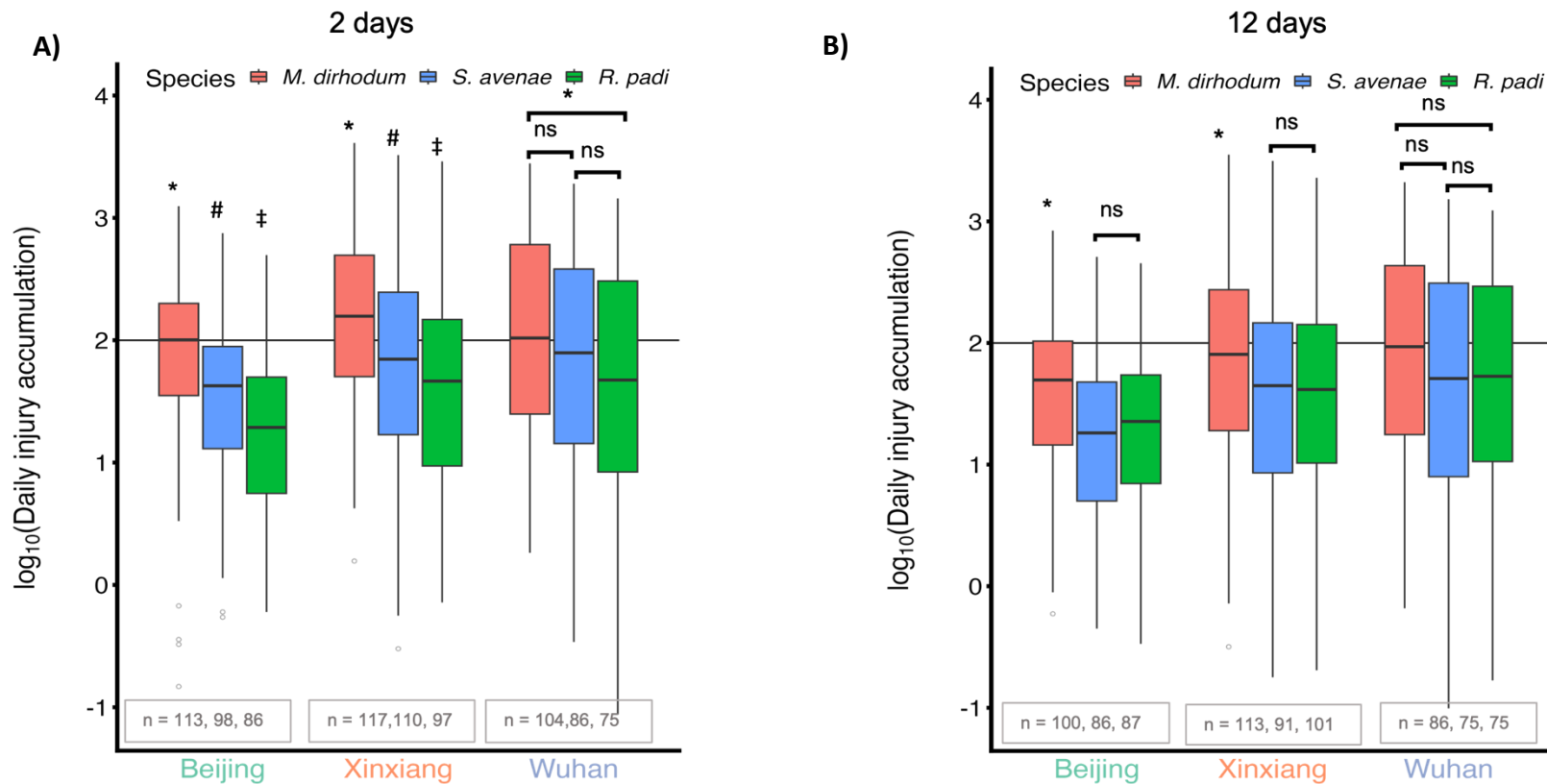
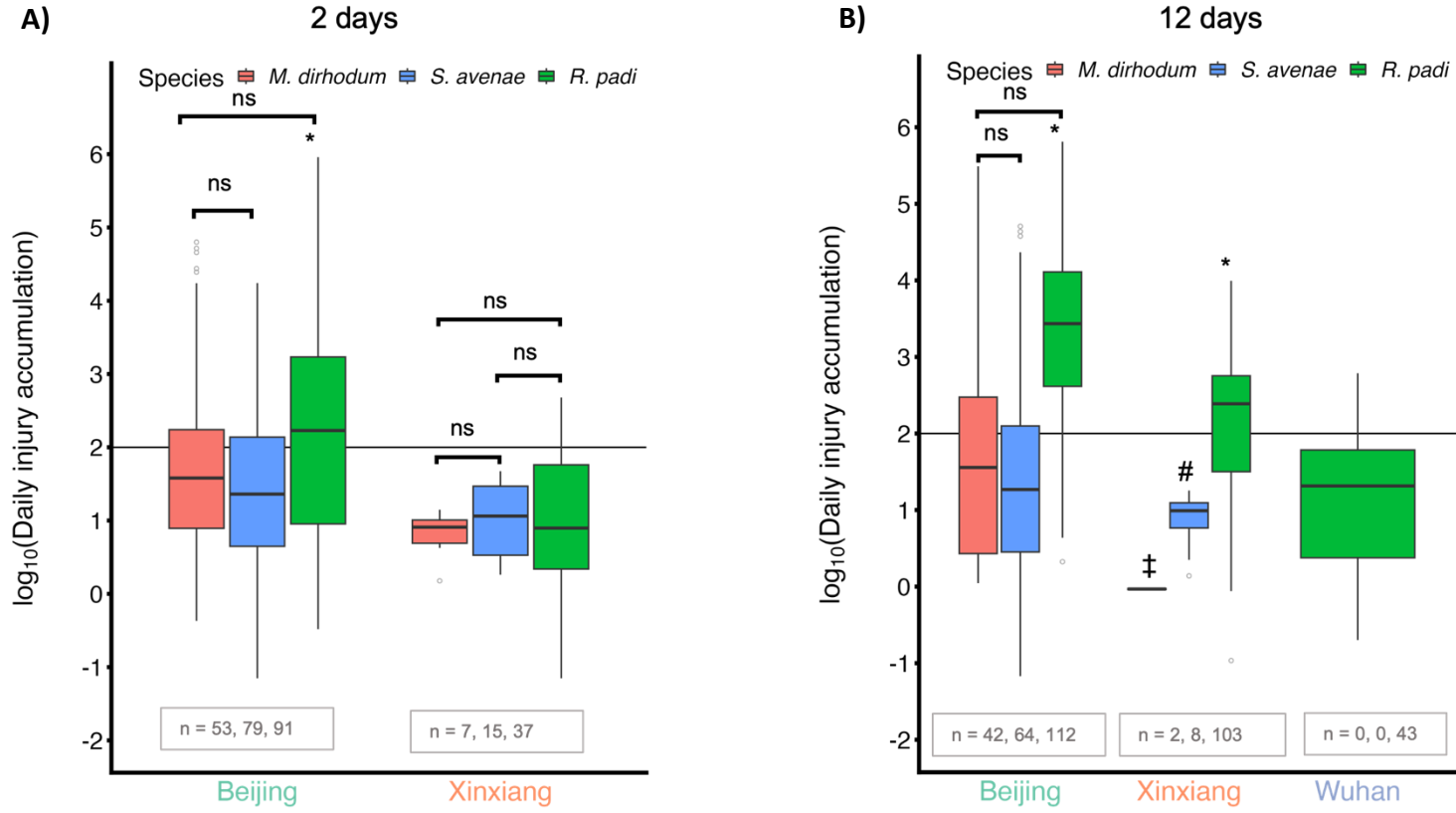


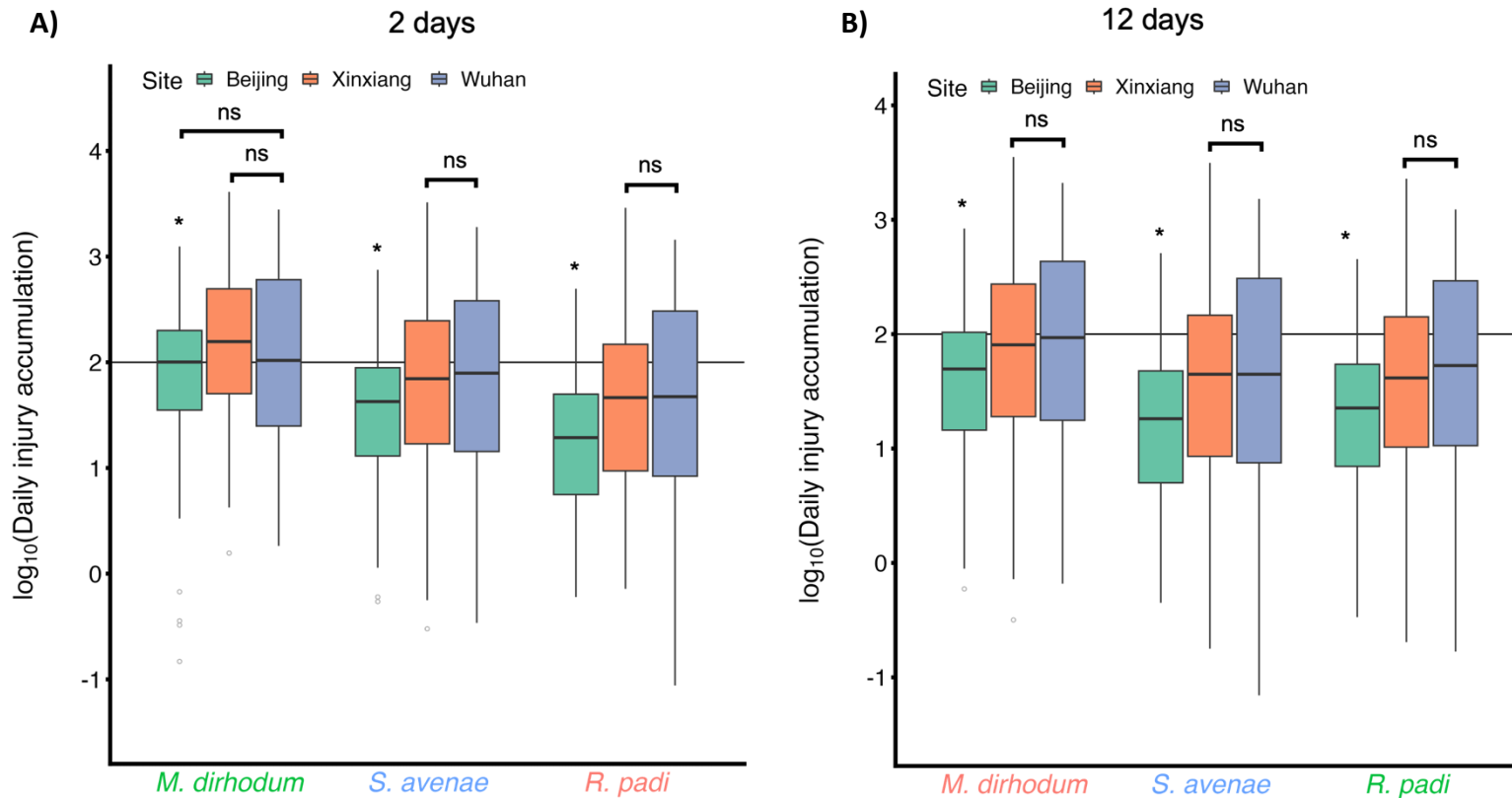
Figure S2. Predicted daily injury accumulation based on the TDT parameters for the three species of cereal aphids (*M. dirhodum*, *S. avenae*, *R. padi*) (age 6days) under natural temperature fluctuations found in Wuhan (A) and Xinxiang (B) in the winter months (November-February), 2016-2017.



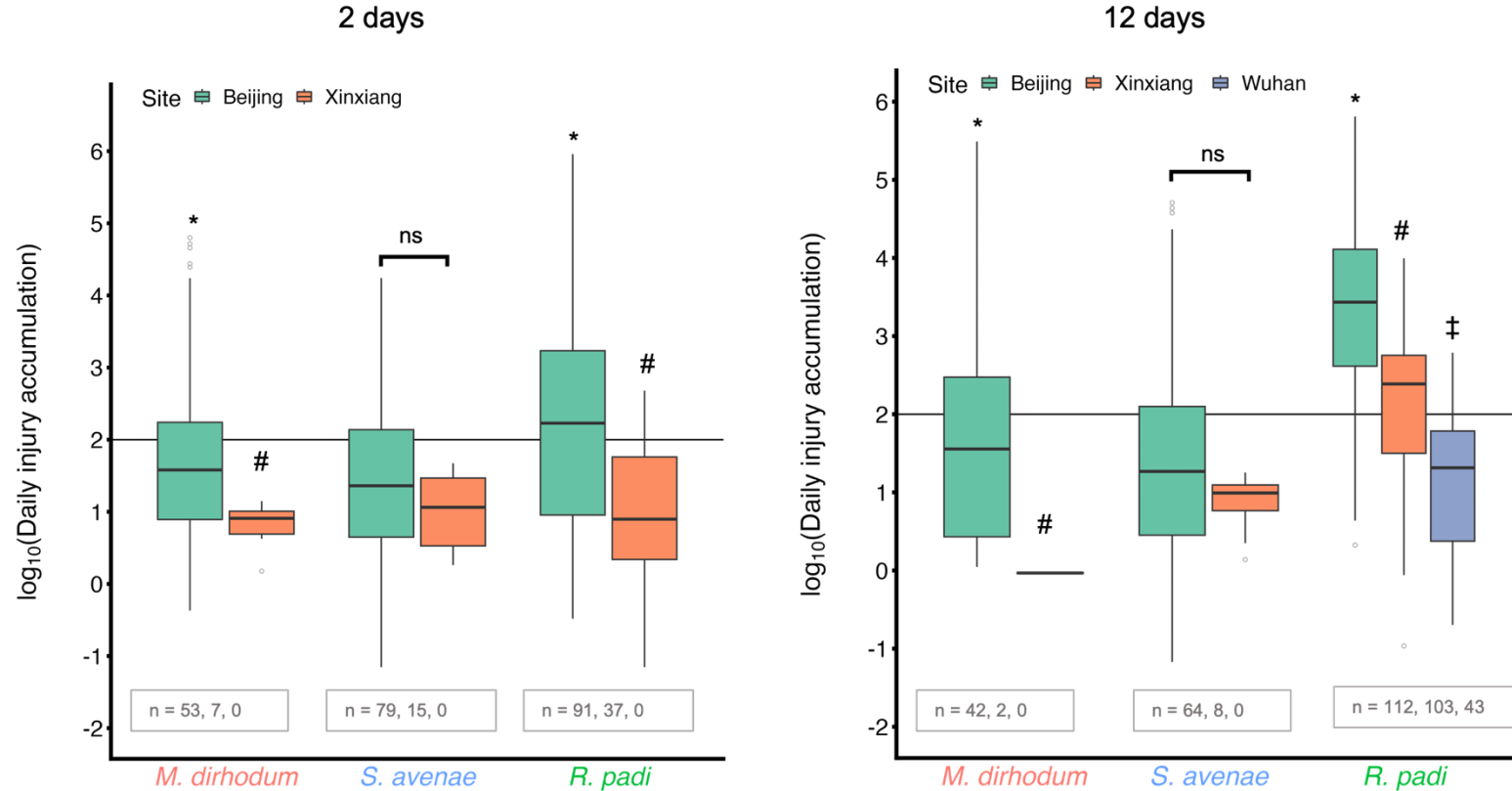
**Figure S3. Predicted daily injury accumulation based on the TDT parameters for 2-d-old (A) and 12-d-old (B) cereal aphids (*M. dirhodum*, *S. avenae*, *R. padi*) under natural temperature fluctuations in the summer (May-August) of 2016. The y-axis was  $\log_{10}$ -transformed and the calculated injury accumulation resulting in median lethal (100) was marked by the line at  $\log_{10}(\text{Daily injury accumulation}) = 2$ . To avoid comparing a lot of days without any injury accumulation, only days with injury accumulation (indicated as n in the graph) were summarized in this plot. Comparisons between species within sites were examined using Kruskal-Wallis Rank Sum Tests followed by Pairwise Wilcoxon Rank Sum Tests with a Benjamini-Hochberg correction. \*, #, and ‡ mark significant difference ( $p < 0.05$ ) among species.**



**Figure S4. Predicted daily injury accumulation based on the TDT parameters for 2-d-old (A) and 12-d-old (B) cereal aphids (*M. dirhodum*, *S. avenae*, *R. padi*) under natural temperature fluctuations in the winter (November-February) of 2016-2017.** The y-axis was  $\log_{10}$ -transformed and the calculated injury accumulation resulting in Median lethal (100) was marked by the line at  $\log_{10}(\text{Daily injury accumulation}) = 2$ . To avoid comparing a lot of days without any injury accumulation, only days with injury accumulation (indicated as n in the graph) were summarized in this plot. Comparisons between species within sites were examined using Kruskal-Wallis Rank Sum Tests followed by Pairwise Wilcoxon Rank Sum Tests with a Benjamini-Hochberg correction. \*, #, and ‡ mark significant difference ( $p < 0.05$ ) among species.



**Figure S5. Predicted of daily injury accumulation based on the TDT parameters for 2-d-old (A) and 12-d-old (B) cereal aphids (*M. dirhodum*, *S. avenae*, *R. padi*) under natural temperature fluctuations in three sites during the summer months (May-August) of 2016.** To avoid comparing a lot of days without any injury accumulation, only days with injury accumulation (indicated as n in the graph) were summarized in this plot. Comparison of  $\log_{10}$ (daily injury accumulation) between sites within species during summer months were conducted using Kruskal-Wallis Rank Sum Tests followed by Pairwise Wilcoxon Rank Sum Tests with a Benjamini-Hochberg correction. \*, #, and ‡ mark significant difference ( $p < 0.05$ ) among species.



**Figure S6. Predicted of daily injury accumulation based on the TDT parameters for 2-d-old (A) and 12-d-old (B) cereal aphids (*M. dirhodum*, *S. avenae*, *R. padi*) under natural temperature fluctuations in three sites during winter months (November-February, 2016-2017). To avoid comparing a lot of days without any injury accumulation, only days with injury accumulation (indicated as n in the graph) were summarized in this plot. Comparison of log<sub>10</sub>(daily injury accumulation) between sites within species during summer months were conducted using Kruskal-Wallis Rank Sum Tests followed by Pairwise Wilcoxon Rank Sum Tests with a Benjamini-Hochberg correction. \*, #, and ‡ mark significant difference ( $p < 0.05$ ) among species.**