# Palaearctic egg parasitoids interaction to three grapevine exotic pests in northwestern Italy: a new association involving *Metcalfa pruinosa*

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*Insects*

## Supplementary material

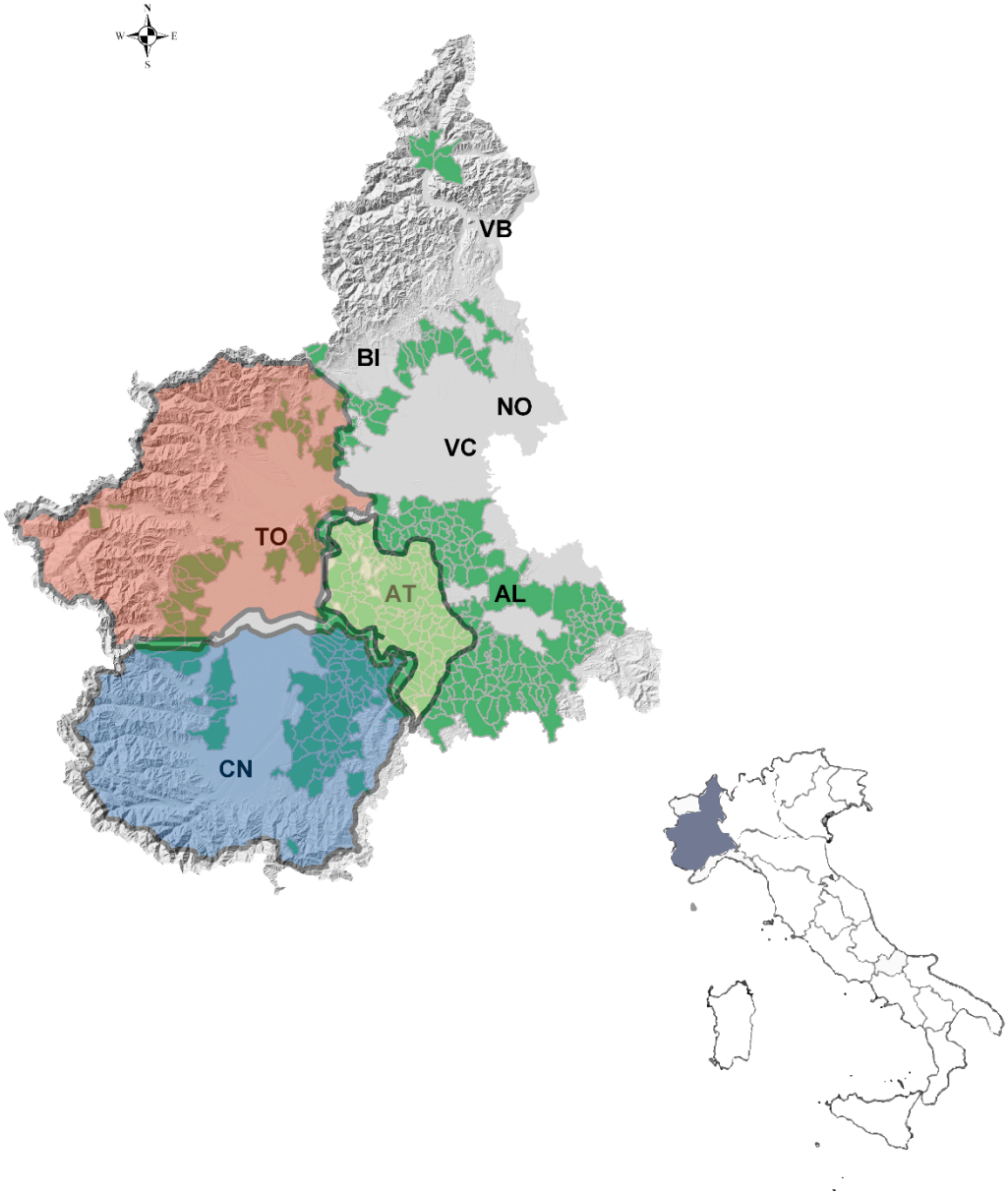


**Figure S1.** Map of the surveyed areas in Piedmont. Blue surface (Cuneo province), and yellow surface (Asti province) referred to the study on the parasitization rate of *Oligosita* cf *collina*. Red surface (Turin province) refers to the comparison between the parasitization rate of *Neodryinus typhlocybae* and *Oligosita* cf *collina* group on *Metcalfa pruinosa.* The green plots on the map represent the wine-growing municipalities in Piedmont region.

17 **Table S1.** Study on the parasitization rate of *Oligoista* cf *collina* during 2017 and 2018: coordinates of the collection sites.

| Area | Year | Site | Coordinates |
|---|---|---|---|
| Asti Province | 2017 | | |
| | | 1 | 44°49'15.4"N 8°18'04.5"E |
| | | 2 | 44°47'32.5"N 8°17'44.9"E |
| | | 3 | 45°03'07.2"N 8°01'59.4"E |
| | | 4 | 44°45'39.4"N 8°24'31.8"E |
| | | 5 | 44°52'04.4"N 8°18'51.6"E |
| | 2018 | | |
| | | 6 | 44°57'43.5"N 8°15'28.6"E |
| | | 7 | 44°59'36.6"N 8°09'44.3"E |
| | | 8 | 44°57'42.9"N 8°17'09.5"E |
| | | 9 | 45°02'11.1"N 8°04'57.2"E |
| | | 10 | 44°49'17.3"N 8°01'08.7"E |
| Cuneo Province | 2017 | | |
| | | 1 | 44°36′37.9′′N 8°12′24.7′′E |
| | | 2 | 44°36'50.6"N 8°11'51.4"E |
| | | 3 | 44°36'37.9"N 8°12'24.7"E |

| | | | |
|---|---|---|---|
| | | 4 | 44°48'26.6"N 7°58'55.1"E |
| | | 5 | 44°47'30.4"N 7°58'01.4"E |
| | 2018 | | |
| | | 6 | 44°30'42.9"N 7°56'47.6"E |
| | | 7 | 44°32'53.2"N 7°59'10.1"E |
| | | 8 | 44°41'31.8"N 8°14'35.2"E |
| | | 9 | 44°48'28.2"N 7°57'41.6"E |
| | | 10 | 44°42'29.4"N 8°19'22.6"E |

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**Table S2.** Survey on the comparison between *Oligosita* cf *collina* and *Neodryinus typhlocybae*: coordinates for the collection sites relative to the comparison.

| Area | Year | Site | Coordinates |
|---|---|---|---|
| Turin Province | 2018/2019 | | |
| | | 1 | 45°23'48.3"N 7°40'03.1"E |
| | | 2 | 45°18'41.6"N 7°54'16.5"E |
| | | 3 | 45°20'30.8"N 7°49'16.1"E |
| | | 4 | 45°17'27.5"N 7°56'30.1"E |
| | | 5 | 45°20'00.1"N 7°49'53.8"E |
| | | 6 | 45°19'34.4"N 7°51'18.2"E |
| | | 7 | 45°16'43.3"N 7°37'56.9"E |
| | | 8 | 45°25'59.4"N 7°57'22.4"E |

**Table S3.** Results of the selected generalized linear mixed effects model (GLMM) testing the effects on the parasitization rate of Plant Species, Host Egg Density, Plant Cover and the interaction between Host Egg Density and Plant Cover.

| Parameter | Estimate | SE | z | P |
|---|---|---|---|---|
| (Intercept) | -1.08589 | 0.08678 | -12.512 | *** |
| *Corylus avellana*. | -0.28625 | 0.09458 | -3.026 | ** |
| *Vitis* spp. | 0.26396 | 0.06839 | 3.859 | *** |
| Host Egg Density | 0.52363 | 0.06935 | 7.550 | *** |
| Plant Cover | 0.28382 | 0.05300 | 5.355 | *** |
| Host Egg Density: Plant Cover | 0.10732 | 0.05420 | 1.980 | 0.047704 |

SE standard error of parameter estimates. z z-score testing whether the parameter estimate is significantly different from zero. Pr(|z|) probability of the observed z-score being greater than the critical value. Significant at ≤ 0.05 (*). ≤ 0.01 (**). ≤ 0.001(***). not significant (NS).

**Table S4**. Candidate GLMM predicting the *Metcalfa pruinosa* egg parasitization (dependent variable corresponds to success or failure of parasitization). Best subset selection approach was used; results shown only the top 10 candidate models. Group Site nested within Area was included as random effect in all models to take into accounts the dependences among measures in each Area (1| area/site)".

| | **Response variable: number of eggs ejected from communal nest** | | | **Overall model significance** | |
|---|---|---|---|---|---|
| | **Fixed effects** | **AIC$_i$** | **ΔAIC$_i$** | **Wald's $X^2$** | ***P*** |
| [1.] | ~plant species+plant cover+plant species:host eggs density+host eggs density:plant cover | 410.626317189967 | 0.000000 | 725.3 | <0.0001 |
| [2.] | ~plant species+host eggs density+plant cover+plant species:host eggs density+host eggs density:plant cover | 410.626320914904 | 0.000004 | 725.3 | <0.0001 |
| [3.] | ~plant species+plant cover+plant species:host eggs density | 411.497259738122 | 0.870943 | 722.43 | <0.0001 |
| [4.] | ~plant species+host eggs density+plant cover+plant species:host eggs density | 411.497259870215 | 0.870943 | 722.43 | <0.0001 |
| [5.] | ~plant species+host eggs density+plant cover+host eggs density:plant cover | 411.695475559671 | 1.069158 | 720.23 | <0.0001 |
| [6.] | ~plant species+host eggs density+plant cover+plant species:host eggs density+plant cover:plant species+host eggs density:plant cover | 411.720921207443 | 1.094604 | 728.21 | <0.0001 |
| [7.] | ~plant species+plant cover+plant species:host eggs density+plant cover:plant species+host eggs density:plant cover | 411.720921876676 | 1.094605 | 728.21 | <0.0001 |
| [8.] | ~plant species+host eggs density+plant species:host eggs density+plant cover:plant species+host eggs density:plant cover | 411.720922147976 | 1.094605 | 728.21 | <0.0001 |

| | | | | | |
|---|---|---|---|---|---|
| [9.] | ~plant species+plant species:host eggs density+plant cover:plant species+host eggs density:plant cover | 411.720923594172 | 1.094606 | 728.21 | <0.0001 |
| [10.] | ~plant species+plant cover+plant species:host eggs density+plant cover:plant species | 412.065634384171 | 1.439317 | 725.86 | <0.0001 |

**Table S5.** Results of the selected generalized linear mixed effects model (GLMM) testing the effects on the oviposition rate of Plant Species and Plant Cover.

| **Parameter** | **Estimate** | **SE** | **z** | **P** |
|---|---|---|---|---|
| (Intercept) | 2.20649 | 0.07570 | 29.147 | *** |
| *Corylus avellana* | -0.36801 | 0.10752 | -3.423 | *** |
| *Vitis* spp. | 0.27576 | 0.10049 | 2.744 | ** |
| Plant Cover | 0.22721 | 0.04606 | 4.933 | *** |

SE standard error of parameter estimates. z z-score testing whether the parameter estimate is significantly different from zero. Pr(|z|) probability of the observed z-score being greater than the critical value. Significant at ≤ 0.05 (*). ≤ 0.01 (**). ≤ 0.001(***). not significant (NS).

**Table S6**. Candidate GLMM predicting the *Metcalfa pruinosa* oviposition (dependent variable corresponds to the count of laid eggs of *Metcalfa pruinosa*). Best subset selection approach was used; results shown only the top 10 candidate models. Group Site nested within Area was included as random effect in all models to take into accounts the dependences among measures in each Area (1| area/site)".

| | **Response variable: number of eggs ejected from communal nest** | | | **Overall model significance** | |
|---|---|---|---|---|---|
| | **Fixed effects** | **AIC$_i$** | **ΔAIC$_i$** | **Wald's $X^2$** | ***P*** |
| [1.] | ~plant species+plant cover+ offset(log(plant)) | 605.161772115018 | 0.000000 | 591.16 | <0.0001 |
| [2.] | ~plant species+plant cover:plant species+ offset(log(plant)) | 605.794000229603 | 0.632228 | 587.79 | <0.0001 |
| [3.] | ~plant species+plant cover+plant cover:plant species+ offset(log(plant))" | 605.794000232042 | 0.632228 | 587.79 | <0.0001 |
| [4.] | ~plant species+plant cover+year+ offset(log(plant)) | 606.818019074198 | 1.656247 | 590.82 | <0.0001 |
| [5.] | ~plant species+year+plant cover:plant species+ offset(log(plant)) | 607.543683592333 | 2.381911 | 587.54 | <0.0001 |
| [6.] | ~plant species+plant cover+year+plant cover:plant species+ offset(log(plant)) | 607.543683601835 | 2.381911 | 587.54 | <0.0001 |
| [7.] | ~plant cover+plant species:year+ offset(log(plant) | 607.924954709873 | 2.763183 | 587.92 | <0.0001 |
| [8.] | ~plant cover+year+plant species:year+ offset(log(plant)) | 607.924954710409 | 2.763183 | 587.92 | <0.0001 |
| [9.] | ~plant species+plant cover+plant species:year+ offset(log(plant)) | 607.924954713611 | 2.763183 | 587.92 | <0.0001 |
| [10.] | ~plant species+plant cover+year+plant species:year+ offset(log(plant)) | 607.924954714603 | 2.763183 | 587.92 | <0.0001 |

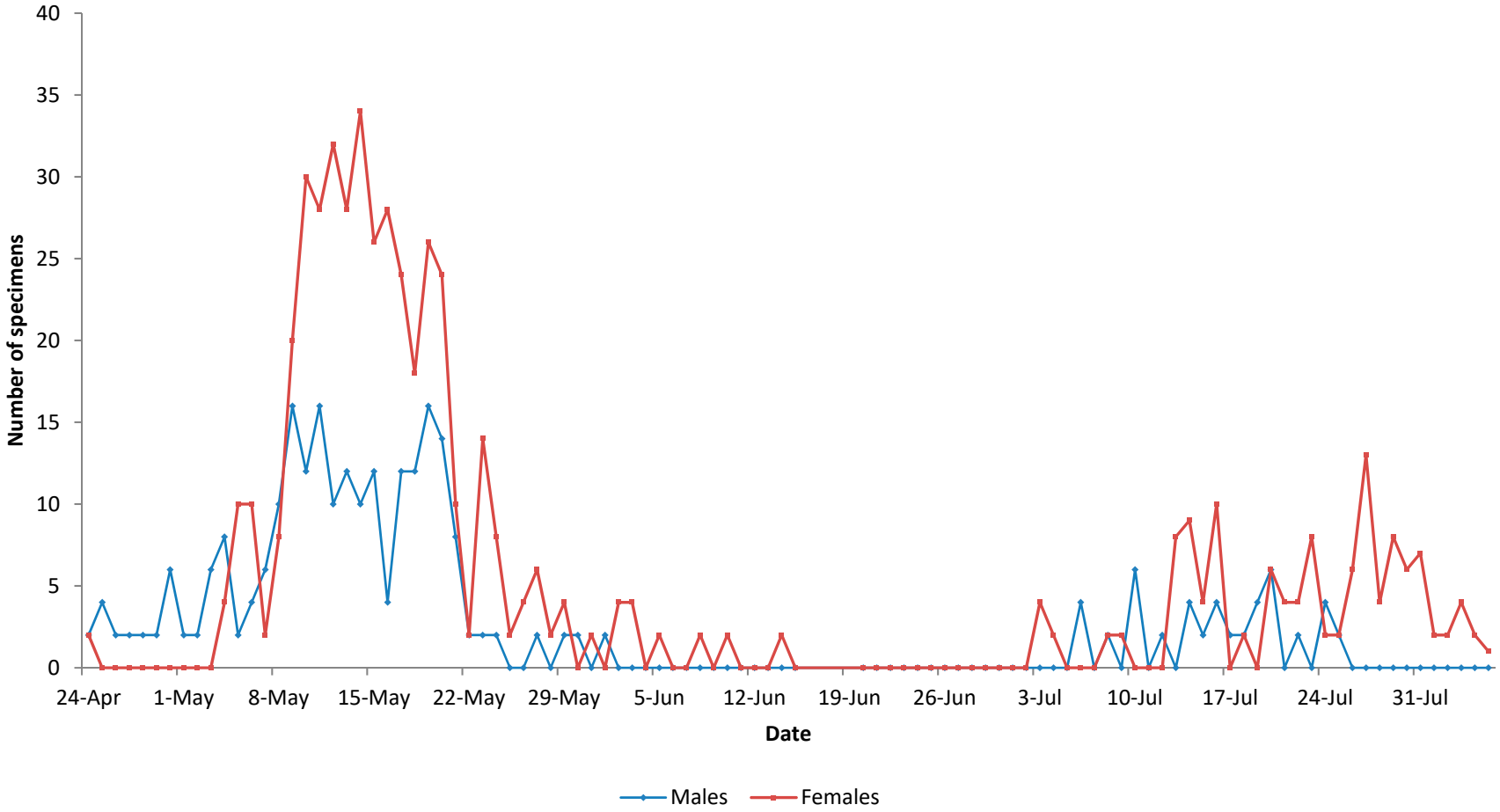
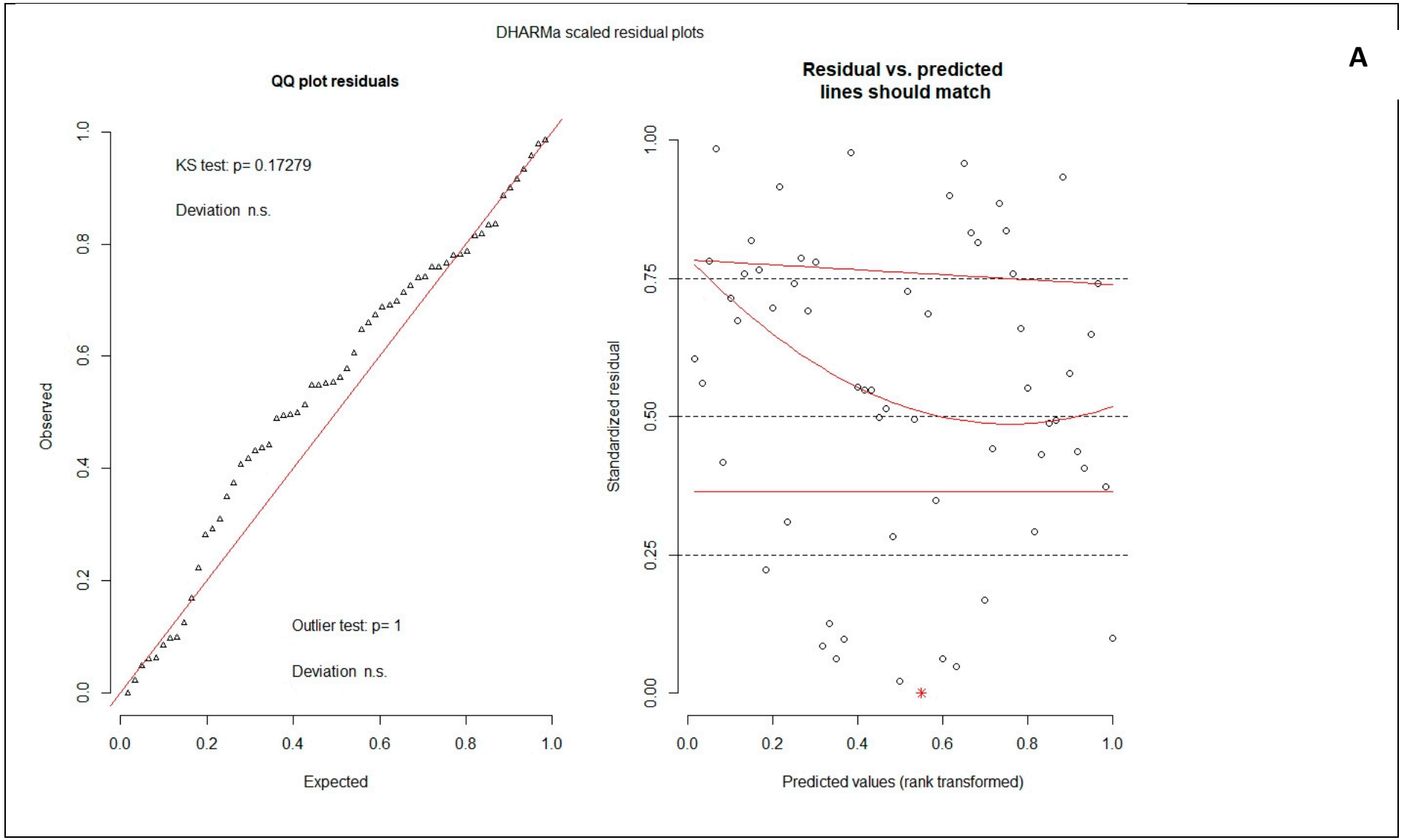


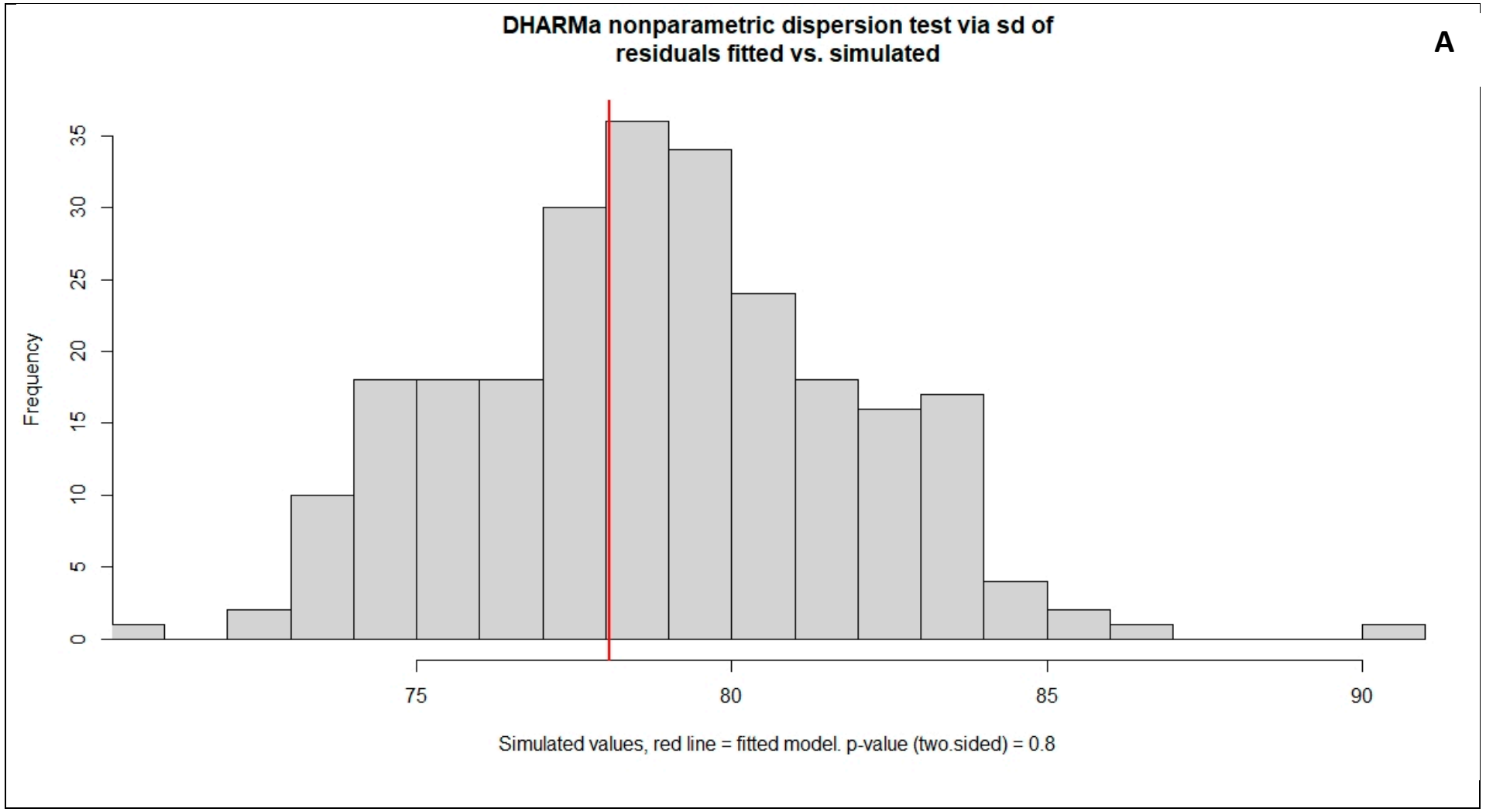

**Figure S2.** Daily emergence of *Oligosita* cf *collina* from field collected parasitized eggs.

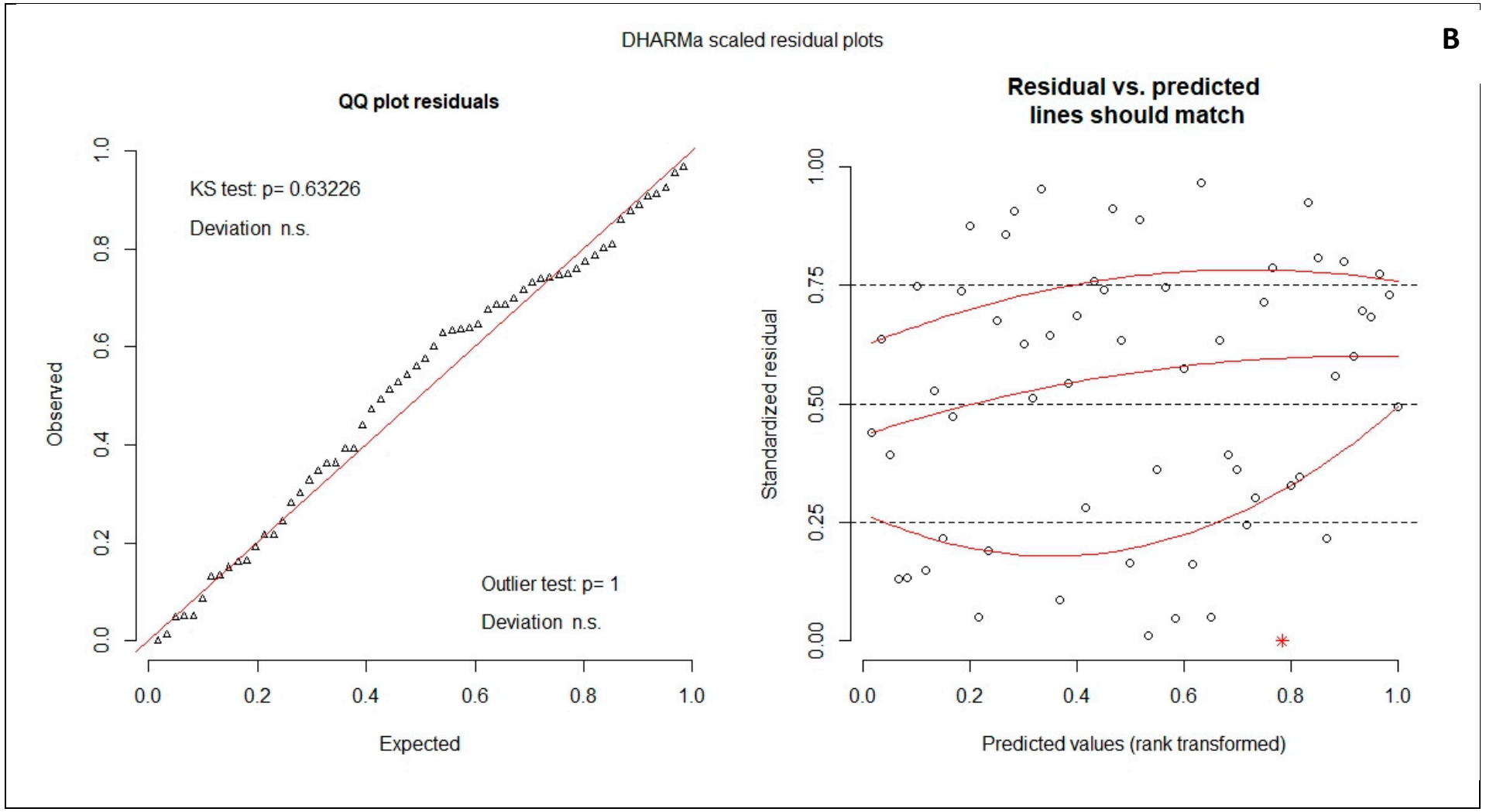
**Table S7.** Parasitization rate of *Oligosita* cf *collina* and *Neodryinus typhlocybae* in each site.

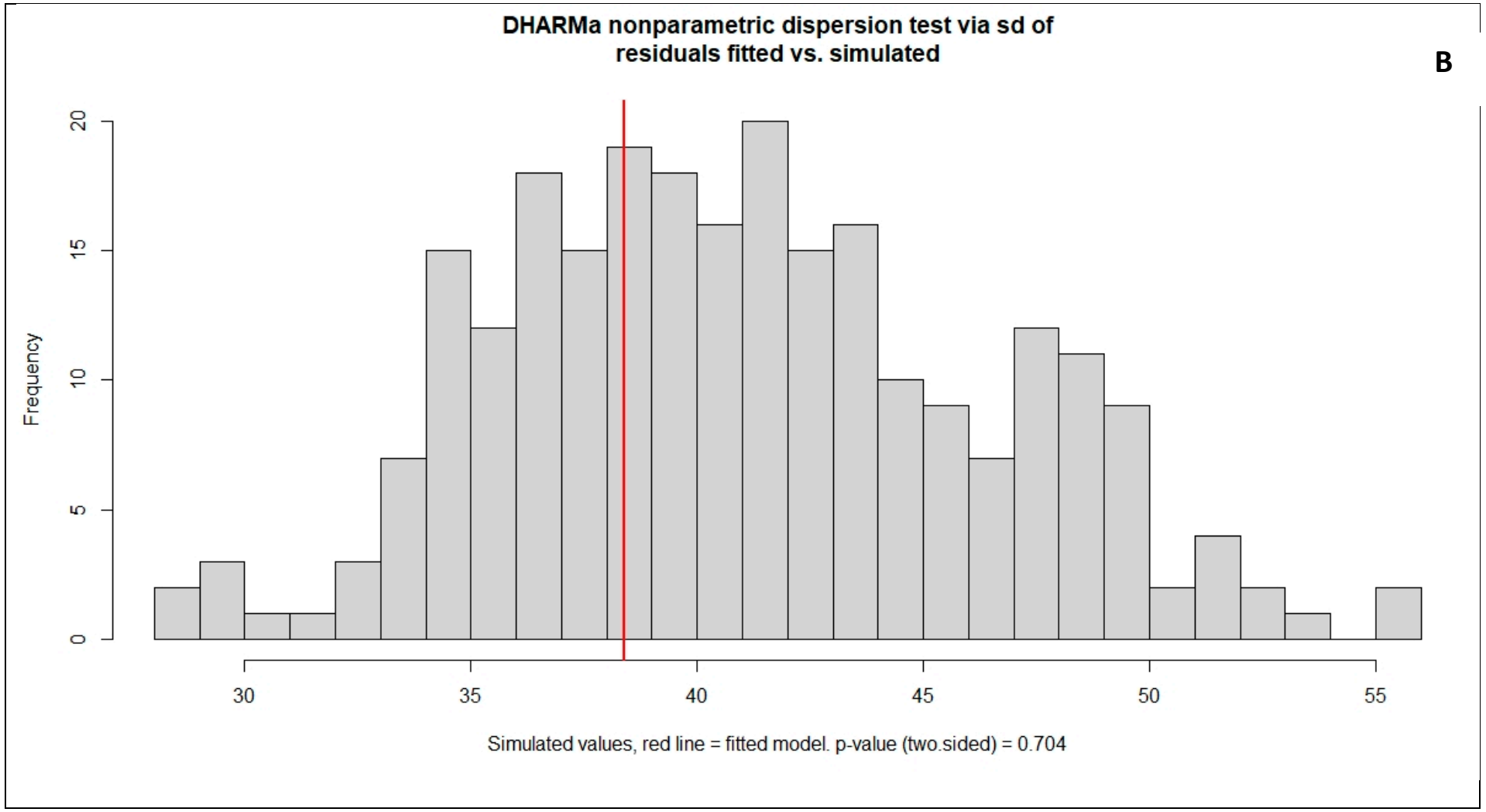
| **Site** | **Parasitization rate of *Oligosita* cf *collina*** | **Parasitization rate of *Neodryinus typhlocybae*** |
|---|---|---|
| 1 | 0.34 | 0.30 |
| 2 | 0.44 | 0.25 |
| 3 | 0.47 | 0.18 |
| 4 | 0.36 | 0.20 |
| 5 | 0.45 | 0.32 |
| 6 | 0.41 | 0.26 |
| 7 | 0.39 | 0.29 |
| 8 | 0.46 | 0.27 |

**Figure S3**. Graphs of the residual diagnostic for the selected models concerning the probability of parasitization **(A)**, and *Metcalfa pruinosa* oviposition rate **(B)**.




DHARMa nonparametric dispersion test via sd of residuals fitted vs. simulated
A
Frequency
0
5
10
15
20
25
30
35
75
80
85
90
Simulated values, red line = fitted model. p-value (two.sided) = 0.8


DHARMa scaled residual plots
B
QQ plot residuals
KS test: p= 0.63226
Deviation n.s.
Outlier test: p= 1
Deviation n.s.
Observed
Expected
0.0
0.2
0.4
0.6
0.8
1.0
Residual vs. predicted
lines should match
Standardized residual
Predicted values (rank transformed)
0.00
0.25
0.50
0.75
1.00


DHARMa nonparametric dispersion test via sd of
residuals fitted vs. simulated
B
Frequency
0
5
10
15
20
30
35
40
45
50
55
Simulated values, red line = fitted model. p-value (two.sided) = 0.704