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# MASTERARBEIT

Titel der Masterarbeit

## Mating success and ectoparasitic load in the red soldier beetle *Rhagonycha fulva* (Coleoptera, Cantharidae)


verfasst von

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# 1. Introduction

## 1.1. *Rhagonycha fulva* and *Trombidium* sp. – portraits of host and parasite

The red soldier beetle *Rhagonycha fulva*, a member of the cantharid family, is one of Austria's most common beetles. The yellowish-red imagines range from 7 to 10 mm in size and are active from May to August. During this time they can frequently be found on Apiaceae such as chervil or caraway, where they prey on smaller arthropods, feed on pollen and mate for remarkably long periods of time (Harde & Severa, 2000). Despite their conspicuous appearance and striking abundance in Central Europe, however, very little research has been previously conducted on the species' biology, life-cycle and mating behaviour.

Observations of a population of *R. fulva* in Oberpiesting (Lower Austria) in 1999 revealed an infestation of the adult soldier beetles with ectoparasitic larval mites of the genus *Trombidium* (Trombidiidae). The larval stages of these members of the suborder Parasitengona have been found to occur on a large number of arthropod hosts including Lepidoptera, Coleoptera, Diptera, Orthoptera, Hemiptera and Homoptera, Hymenoptera, Araneae, Pseudoscorpiones and Opiliones (Zhang, 1998; Conradt et al., 2002). Though the species of both hosts and parasites are widely distributed, exact host-parasite relationships as well as questions concerning host specificity are still rare.

Trombidiid larvae emerge from eggs laid into the soil in synchrony with the activity of their hosts, usually during spring and summer in temperate regions. Hosts are presumably found through positive phototactic and / or negative geotactic movement on the soil surface and on plants, though the exact mechanisms are unknown. After acquisition of an arthropod host, an ectoparasitic larva can remain attached for up to two weeks before it moves into the soil to complete its development (Zhang, 1998). The attachment process is accompanied by formation of a feeding tube, the stylostome, at the site of cheliceral penetration where the host's hemolymph is extracted by the parasite (Mohamed & Hogg 2004). Depending on the volume of hemolymph extracted from the host, the larvae increase in size over time (Peterson et al., 1992).

The parasitic larval stage is followed by a calyptostatic protonymph, a predatory deutonymph, a calyptostatic tritonymph and free-living, predatory adult (Zhang, 1998).

## 1.2. Assortative Mating

Assortative mating - meaning a type of non-random mating in which the mated partners show greater phenotypic or genotypic similarities than would be expected in a random mating situation – has been observed across a variety of taxa including humans, beetles and other arthropods (Alcock & Hardley, 1987; Crespi, 1989; Harari et al. 1999; Alvarez & Jaffe, 2004; McLain, 2005).

For arthropods in particular, Crespi (1989) postulates three main causes for assortative mating: Mate choice, mate availability and mating constraints. Which of these best explains the observed assortativity of mated couples differs between taxa. As an example, Harari et al. (1999) found support of the mating constraints hypothesis and an overall preference for larger mates in the curculionid beetle *Diaprepes abbreviatus.* However, most studies focus on assortative mating by size alone which is not sufficient to explain many mating systems among the Coleoptera (Alcock & Hardley, 1987).

In the Cantharid beetle *Rhagonycha fulva* a special case of assortative mating has been postulated and termed "correlative mating" (Parzer, 2006): The study found a complex pattern of correlations between mated pairs including various assortative and disassortative character states of legs, antennae and elytra.

A second study conducted on *R. fulva* showed size and shape differences between the genitalia of mated and unmated males (Bellersen, 2005). Whether these are a result of male-male competition, female choice or assortative mating, however, remains an open question along with various other aspects of this species' biology and mating-behaviour which are in need of further research.

## 1.3. Parasitism and sexual selection

Perhaps the most widely known hypothesis attempting to link parasitic infestation and sexual selection is that of William Donald Hamilton and Marlene Zuk formulated in 1982. The Hamilton-Zuk hypothesis of parasite-mediated sexual selection suggests that a male's traits (e.g. bright colours) can serve as a signal indicating resistance to diseases and parasites, thereby allowing females to choose the most resistant mates (Hamilton & Zuk, 1982).

However, while further examination did show a significant negative effect of parasites on males' showy characters, the effect's magnitude varied greatly across host and parasite taxa,

thus yielding highly ambiguous results that indicate the immense complexity of sexual selection and male advertising (Hamilton & Poulin, 1997). Therefore a wide array of studies has been performed since the Hamilton-Zuk hypothesis was initially published, leading to the postulation of many other possible connections between parasitism and mate-choice.

Among the most important aspects of this topic was the question addressed by Folstad and Karter in 1992, who stated that in some species a negative feedback loop between signal intensity of male sexual characters and resistance to parasites may take effect. This is supposedly due to the fact that hormones such as testosterone, while enhancing the formation of showy male sexual characters, may have negative effects on immunocompetence, thus making the showiest males also the ones most susceptible to infection (Folstad & Karter, 1992). Since the development of showy sexual characters can be detrimental to the immune-system, these characters can function as costly and honest signals similar to those postulated in Zahavi's "Handicap Principle" (Zahavi, 1975), which lead the authors to call this mechanism the immunocompetence handicap. However, quite like the various studies seeking to test the Hamilton-Zuk hypothesis, further examinations concerning the immunocompetence handicap yielded results that found the correlations between parasite burden and sexual characters to be positive, negative or absent (Folstad & Karter, 1992; Getty, 2002), thus only allowing conclusions for the respective species in question.

### 1.4. Aim and research questions

Based on the ambiguous results of previous research and the competing theories aiming to explain possible correlations between an individual's resistance to parasitic infections and its mating success, the goal of this study is to explore the relationship of ectoparasitic load and mate-choice in *Rhagonycha fulva*. The aim is to clarify if and how the presence, abundance and location of ectoparasites influences mate-choice in this particular species and whether parasitic load correlates with other traits such as sex and body-size.

Microscopic assessments of parasitic load, size and distribution on the host's body as well as measurement of a size parameter on specimens of the cantharid beetle *Rhagonycha fulva* will be used to examine the following questions:

- Is there sexual dimorphism regarding the abundance, location or size of ectoparasites?

- Does parasitic load and distribution differ significantly between mated and unmated individuals?
- Is there evidence for size assortative mating?
- Does body-size influence infestation with ectoparasitic mites?
- What is the relationship of ectoparasitic loads within mated pairs?
- Can ectoparasites be considered to play a role in mate-choice and mating success?

## 2. Material and methods

### 2.1. Sample

This study was conducted on specimens of *R. fulva* collected by Dr. Hans Leo Nemeschkal in July of 1999 in Oberpiesting, Lower Austria (47° 52' 21" N, 16° 6' 30" E). Mated pairs were collected in copula; unmated specimens were not observed to be engaged in mating and were all collected from the direct vicinity of copulating couples. All animals were killed and conserved in 70% ethanol immediately after collection and identified using the identification key after Freude et al. (1979).

The material used for experimentation consists of 34 unmated males and 11 unmated females as well as 198 pairs of mated beetles.

In addition to the sample above, three mated pairs of *R. fulva* were captured alive by myself in July of 2013 in Loretto, Burgenland (47° 55' 7" N, 16° 31' 6.9" E) and stored in 70% ethanol following their natural death. This extra sample was merely scanned for the presence of larval ectoparasitic mites to be used for genetic analysis. All other measurements and statistical test were conducted using only the material from the original sample.

Ectoparasitic larval mites were identified by Ao. Univ.-Prof. Mag. Dr. Manfred G. Walzl (Department of Integrative Zoology, Vienna).

### 2.2. Parasitic load assessment

The determination of parasitic loads was conducted by observing each individual under a binocular microscope (Olympus SZ 30) to assess the location and size of each larval mite attached to the specimen.

Each larval mite present was assigned to one of five regions on the host's body (thorax, abdomen, leg-bases, dorsal subelytral space and the interstice between elytron and ala; see figure 1) as well as to one of three size-categories (<0.3mm (S), 0.3-0.6mm (M), >0.6mm (L)) in order to facilitate recording size and location of each observed larval *Trombidium*.

Figure 1: Schematic illustration of the hosts' five body-regions to which ectoparasitic larval mites were assigned: thorax (red), abdomen (blue), leg-bases (green), subelytral space (purple), interstice between elytron and ala (yellow).

### 2.3. Femur measurements

The right metathoracic femur of each individual was measured in length using a measuring microscope (Nikon MM-40) in order to obtain a size-parameter for each specimen. Measurements were conducted without removing the legs, by recording the distance between the proximal and distal dorsal edges of the femur (see figure 2).

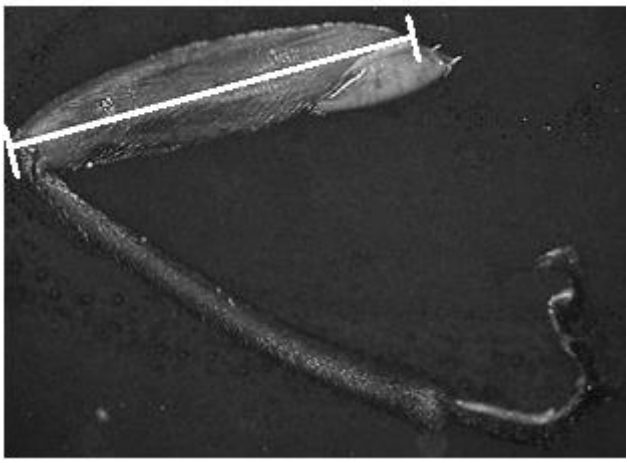

Figure 2: White markings denote the measured distance between proximal and distal dorsal borders of the right femur on the metathorax of each specimen.

### 2.4. Genetic analysis

As an attempt to confirm the identification of the larval mites by morphological characters with molecular methods, five large mites from five different specimens out of both the 1999 and 2013 samples (table 1) were chosen for PCR and sequencing at the Institute of Parasitology at the Veterinary University of Vienna.

Table 1: Collection date, sex, number and mating status of the host as well as size and location of the larval mites for all specimens chosen for genetic analysis.

| **Collected in** | **Host sex** | **Host nr.** | **Mating status** | **Size** | **Location** |
|---|---|---|---|---|---|
| 2013 | M | 1 (LO) | mated | L | subelytral |
| 2013 | F | 2 (LO) | mated | L | subelytral |
| 1999 | F | 165 | mated | L | leg-base |
| 1999 | F | 171 | mated | L | ala |
| 1999 | M | 177 | mated | L | thorax |

DNA extraction followed the directions provided by the Qiagen DNeasy Blood & Tissue Kit (Qiagen, Hilden, Germany). For homogenization a 3mm Tungsten Carabide Bead (Qiagen, Hilden, Germany) was added to the samples before placing them in a TissueLyser II (Qiagen, Hilden, Germany). The PCR-protocol was designed by Josef Harl, using a modified COI-

barcoding protocol with primers (table 2) amplifying a 652-658bp fragment of the COI (cytochrome oxidase I) gene.

Table 2: Master mix for standard PCR of Acari specimens.

| **Master mix** | **1 tube** |
|---|---|
| H2O | 10.375 µl |
| 5X Green Reaction Buffer | 5 µl |
| dNTP´s (10mM) | 0.5 µl |
| TaqPolymerase (GoTaq) 5u/µl | 0.125 µl |
| Forward Primer: 10 pmol/µl COI_Acari_Fw<br>5´-TCTACAAATCATAAAGACATTGGAAC -3´ | 2 µl |
| Reverse Primer : 10 pmol/µl COI_Acari_rv2<br>5'- TAAACTTCTGGATGCCCAAAAAACCA -3' | 2 µl |
| Template | 5 µl |
| Total | 25 µl |

PCR was conducted on an Eppendorf Mastercycler proS (Eppendorf AG, Hamburg, Germany), where the following settings were used:

| | | |
|---|---|---|
| 95 °C | 2 min | initial denaturation |
| 95 °C | 1 min | |
| 48 °C | 1 min | 35 x |
| 72 °C | 1 min | |
| 72 °C | 5 min | final extension |
| 15 °C | storage | ∞ |

The resulting amplified PCR products were analyzed via gel electrophoresis on a 1.8% agarose gel stained with 0.5µl ethidium bromide.

Positive PCR products were purified with illustra ExoStar 1-Step® (GE Healthcare, Buckinghamshire, UK) and sequenced using the BigDye Sequencing Kit and an automatic 310 ABI PRISM sequencer (PE Applied Biosystems, Weiterstadt, Germany). The resulting

sequences were aligned and analyzed with Chromas and GeneDoc and compared to preexisting sequence entries using BOLD (http://www.boldsystems.org/).

### 2.5. Statistical analysis

To test for significant differences between the observed groups of *R. fulva* hosts (male, female, paired, unpaired) in the distribution of larval mites regarding their size and location, a G-test (goodness of fit test) was performed. The G-test as well as all means and standard deviations were calculated in MS Excel (Windows 7).

To calculate linear regression coefficients with bootstrap randomizations (N=5000), the program MUREG (Nemeschkal, 1999) was used. For this purpose, all length measurements were logarithmized (ln) and the raw numbers of larval mites present were prepared by a square-root transformation. This method was applied to determine if and how mating status, sex, size and parasitic load of the specimens influence one another and also whether the data indicate assortativity within pairs regarding size and parasite-infestation. In all cases where binary facts were of interest (i.e. mated/unmated, male/female, parasites present/absent), dummy-coded variables (1/0) were used.

To construct a path diagram illustrating the respective influences of male (x1) and female (x2) femur length on the total parasitic load of the mated couple (y), a multiple linear regression analysis was conducted in MUREG. The obtained regression coefficients and the standard deviations of the variables were then used to calculate the path coefficients using the following formula:

$$PC_{xi} = b_{xi} * (s_{xi} / s_y)$$

To determine whether mating between paired *R. fulva* couples was assortative regarding size, the correlation coefficient (Pearson's r) of logarithmized femur-lengths was calculated in MS Excel.

P-values and their corresponding levels of significance for a one-sided test were set as follows:

| | |
|---|---|
| P > 0.1 | no significance (n.s.) |
| 0.1 >= P > 0.05 | no significance but a trend (n.s./tr.) |
| 0.05 >= P > 0.01 | significant (*) |
| 0.01 >= P > 0.001 | very significant (**) |
| P =< 0.001 | highly significant (***) |

## 3. Results

### 3.1. Larval mites – size assessment

Microscopic assessment of the larval mites yielded the following results (see table 3) in respect to ectoparasite size in the four groups of host-beetles: A total of 122 mites were found on mated male hosts; distribution between the three size-categories (small, medium and large larval mites) was relatively even (figure 3, top). Mated females were infested with 183 mites in total; here the small larval mites presented as the largest group (49%), followed by the large and lastly the medium-sized ectoparasites (figure 3, bottom). Within the unmated specimens of *R. fulva*, the males were mainly infested with small mites (60%), the number of medium and large parasites was equal (figure 4, top). Unmated females were only infested with two mites in total, both of them small (figure 4, bottom).

Table 3: Absolute and relative amounts of ectoparasitic larval mites found on mated and unmated male and female specimens of *Rhagonycha fulva*, assigned to three size categories: S (small, <0.3mm), M (medium, 0.3-0.6mm) and L (large, >0.6mm).

| | **S** | **M** | **L** | **Sum** |
|---|---|---|---|---|
| **Male mated (N=198)** | 36.07% (44) | 25.41% (31) | 38.52% (47) | 122 |
| **Female mated (N=198)** | 48.63% (89) | 20.76% (38) | 30.60% (56) | 183 |
| **Male unmated (N=34)** | 60% (15) | 20% (5) | 20% (5) | 25 |
| **Female unmated (N=11)** | 100% (2) | 0% | 0% | 2 |

The results of the G-test of homogeneity of mated males versus mated females and of mated males versus unmated males showed non-significant trends of differences between the respective groups (d.f.= 2, G-value= 4.74636, p= 0.09318 as well as d.f= 2, G-value= 5.23016, p= 0.07316). Due to small sample-size, unmated females were excluded from the calculation.

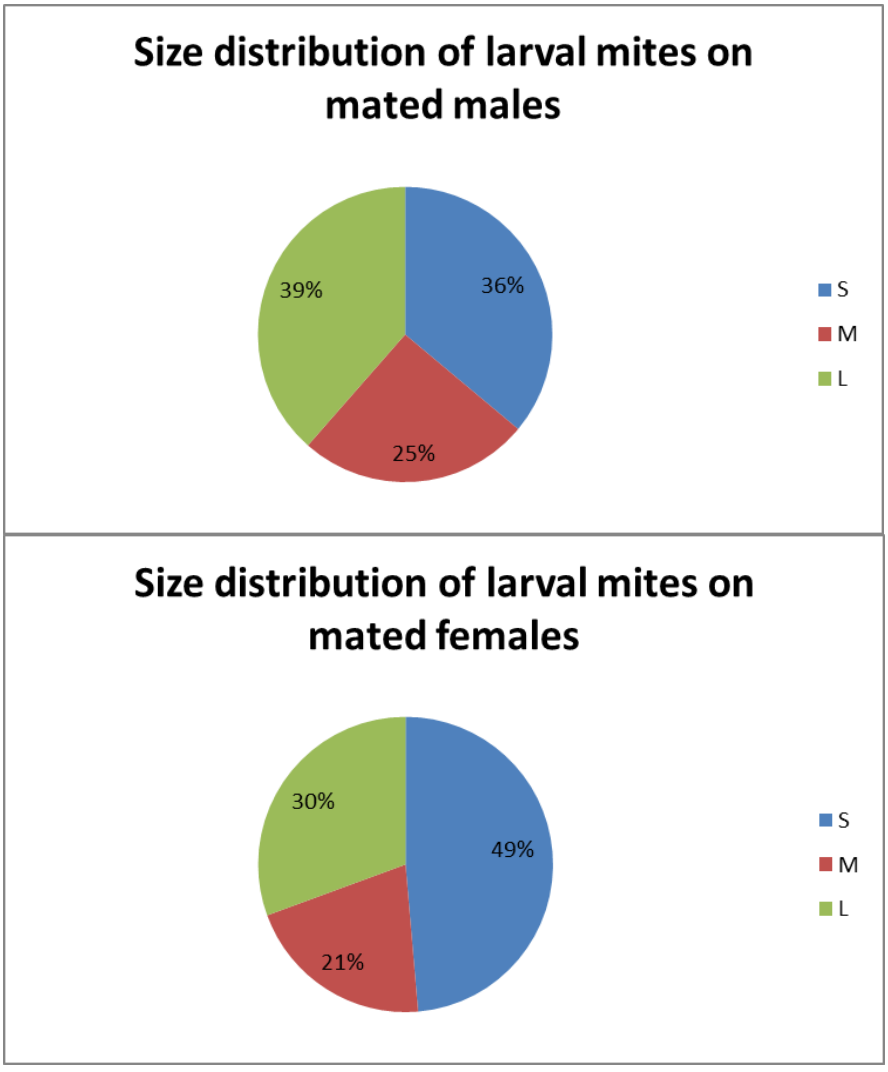


Figure 3: Relative amounts of ectoparasitic larval mites found on mated male (top) and female (bottom) specimens of *Rhagonycha fulva*, assigned to three size categories: S (small, <0.3mm), M (medium, 0.3-0.6mm) and L (large, >0.6mm).

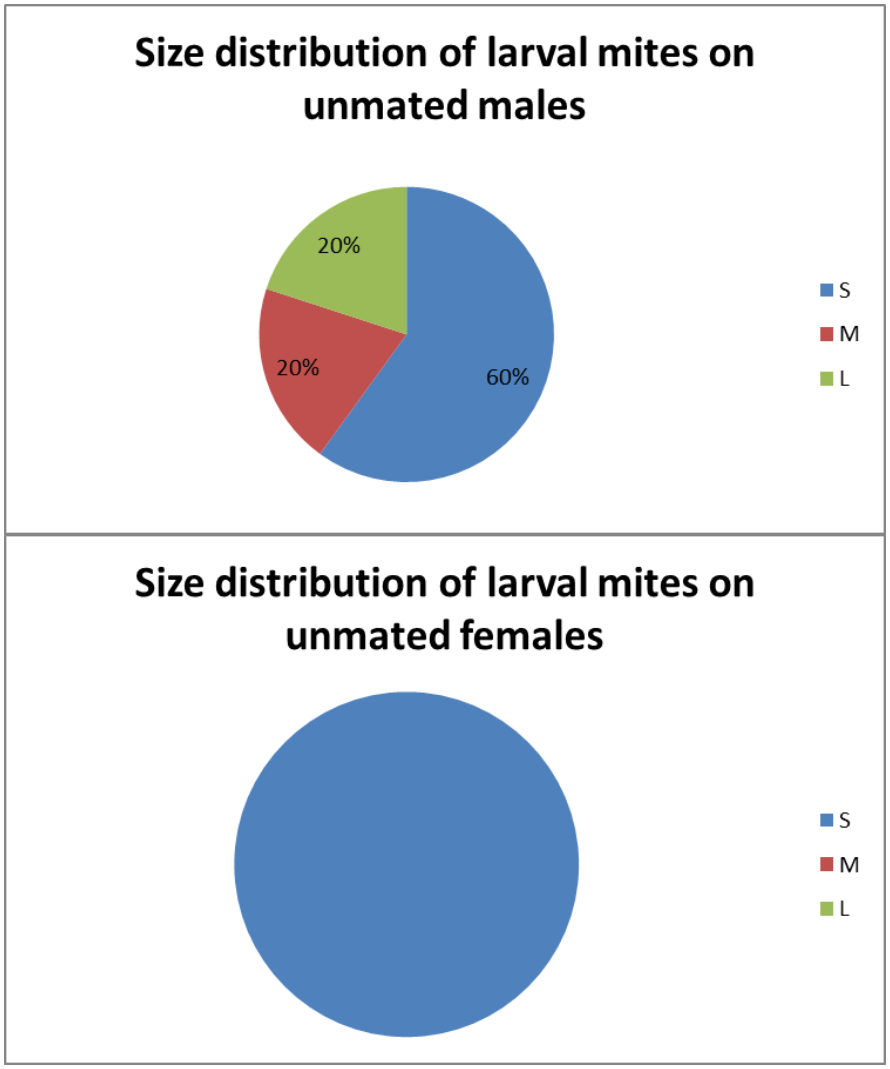


Figure 4: Relative amounts of ectoparasitic larval mites found on unmated male (top) and female (bottom) specimens of *Rhagonycha fulva*, assigned to three size categories: S (small, <0.3mm), M (medium, 0.3-0.6mm) and L (large, >0.6mm).

### 3.2. Location of ectoparasites

Microscopic assessment of the mites' location on the host-body revealed characteristic distribution-patterns for the observed groups. In all male beetles as well as in the unmated females, the highest number of ectoparasites was found in the dorsal subelytral space, followed by the base of the legs (table 4). However, while mated and unmated males had roughly half of their ectoparasites located under the elytra (56% and 48% respectively, see figures 5 and 6, top) the percentage of subelytral parasites was even higher in mated females at 77% (figure 5, bottom). Thorax, abdomen and the interstice between elytron and ala each

held 2-12% of the observed parasites in all males and mated females. In unmated females only two parasites were found, one located on the thorax, one at the leg-base (figure 6, bottom).

The results of the G-test revealed significant differences in the distribution of ectoparasites between mated males and mated females (d.f.= 4, G-value= 16.44327, p= 0.00248) and no difference between mated and unmated males (d.f.= 4, G-value= 4.19562, p= 0.38018). Due to small sample size, unmated females were again exempt from statistical testing.

Table 4: Distribution of ectoparasitic larval mites along five body-regions of mated and unmated male and female specimens of *R. fulva*; absolute and relative amounts**.**

| | **Thorax** | **abdomen** | **leg-base** | **ala** | **subelytral** | **sum** |
|---|---|---|---|---|---|---|
| **Male mated (N=198)** | 8.33% (10) | 5% (6) | 25.83% (31) | 5% (6) | 55,83% (67) | 120 |
| **Female mated (N=198)** | 3.31% (6) | 2.21% (4) | 15.47% (28) | 1.66% (3) | 77.35% (140) | 181 |
| **Male unmated (N=34)** | 12% (3) | 12% (3) | 28% (7) | 0% | 48% (12) | 25 |
| **Female unmated (N=11)** | 0% | 50% (1) | 50% (1) | 0% | 0% | 2 |

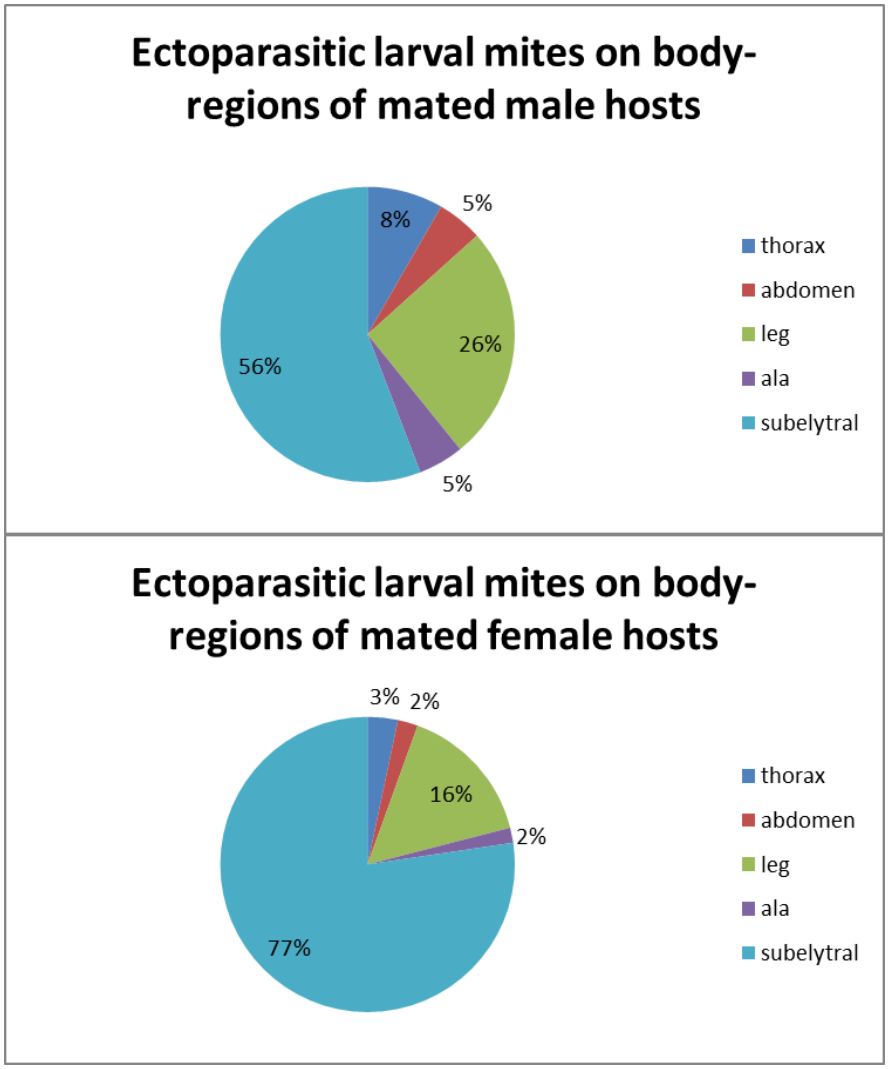


Figure 5**:** Relative amounts of ectoparasitic larval mites found on mated male (top) and female (bottom) specimens of *Rhagonycha fulva*, assigned to five body-regions of the host: thorax, abdomen, leg-base, ala and subelytral space.

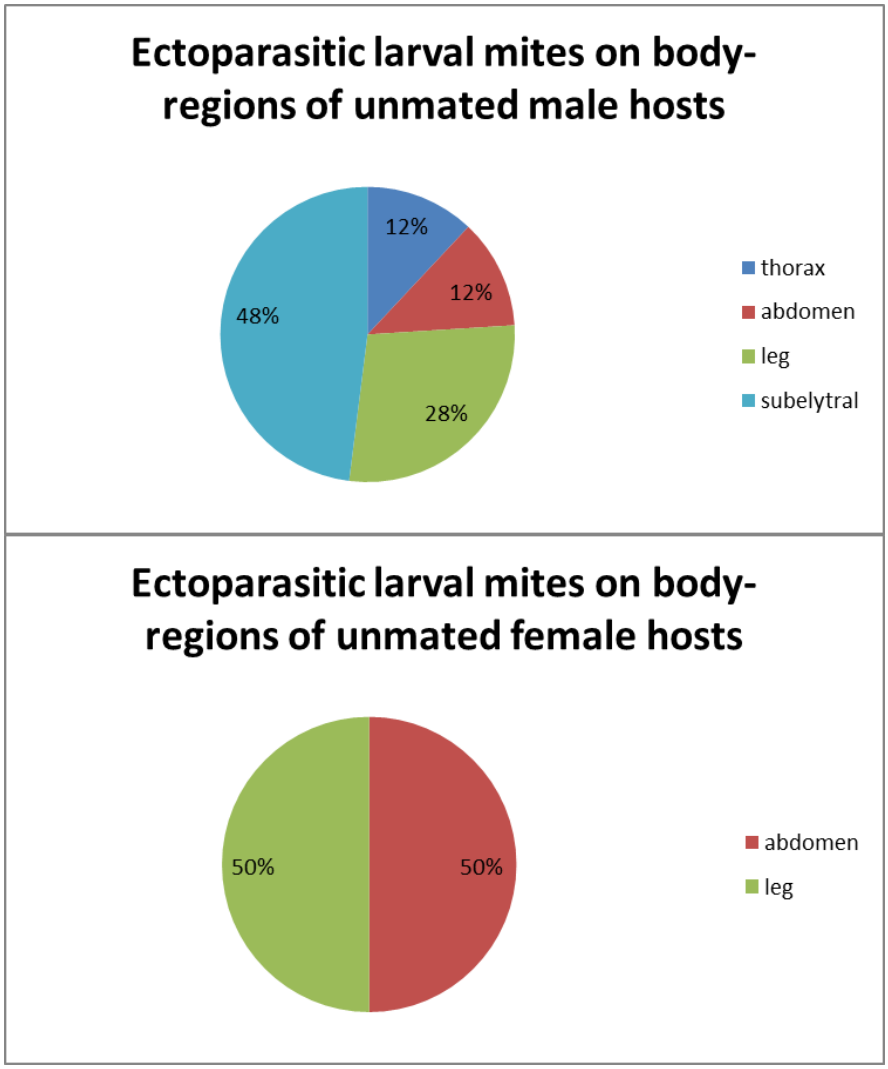


Figure 6**:** Relative amounts of ectoparasitic larval mites found on unmated male (top) and female (bottom) specimens of *Rhagonycha fulva*, assigned to five body-regions of the host: thorax, abdomen, leg-base, ala and subelytral space.

Figure 7 shows an example of a larval mite as found on one of the observed specimens.

Figure 7: Mated female nr. 42, the black circle marks a larval mite of medium size (ca. 0.5mm), located in the subelytral space, dorsolateral between metathorax and first abdominal tergite.

### 3.3. Parasitic loads

For the total parasitic loads of each of the four groups, mean and standard deviation of the number of parasites found within the respective group were calculated for the entire group including parasitized as well as non-parasitizes individuals. Additionally, mean ectoparasitic loads of the individuals infested with at least one ectoparasite were assessed separately by calculating only with the individuals of that group infested by one or more larval mites. Rates of infestation denote the percentage of individuals in each of the four groups infested with a minimum of one larval *Trombidium* (table 5).

The highest mean ectoparasitic load was found on mated females (0.924±1.574 in total, 2.033±1.789 in the infested group only), the lowest average number of mites per individual was observed in unmated females (0.182±0.405 total, 1.0±0 among infested individuals) with mated and unmated males ranging in between. The highest observed total count was at 13 mites per individual (mated female nr. 74). Rates of parasitism ranged from 18.2% for unmated females to 47.1% for unmated males. The percentage of infested mated females was found to be only slightly lower than that of the unmated males (45.5%), the rate of parasitism for mated males was at 39.4%.

Table 5: Means, standard deviations (SD) of parasitic infestation by ectoparasitic larval mites on mated and unmated males and females of *Rhagonycha fulva* for total sample and for parasitized individuals, as well as rates of parasitism.

| | **Male mated** | **Female mated** | **Male unmated** | **Female unmated** |
|---|---|---|---|---|
| **Mean (total)** | 0.616 | 0.924 | 0.735 | 0.182 |
| **SD (total)** | 0.994 | 1.574 | 1.024 | 0.405 |
| **Mean (parasitized)** | 1.013 | 2.033 | 1.563 | 1.000 |
| **SD (parasitized)** | 1.014 | 1.789 | 0.964 | 0.000 |
| **Rate** | 39.4% | 45.5% | 47.1% | 18.2% |

### 3.4. Femur length

Table 6 shows the results of the measurements of the right metathoracic femur in each specimen in the form of mean and standard deviation of the raw data as well as of the logarithmically transformed (ln) data for each of the four groups.

Table 6: Mean and standard deviation (SD) of average measured femur lengths (in mm) as well as of logarithmized data for mated and unmated males and females of *Rhagonycha fulva*.

| | **Male mated** | **Female mated** | **Male unmated** | **Female unmated** |
|---|---|---|---|---|
| **Mean (mm)** | 2.350 | 2.388 | 2.380 | 2.329 |
| **SD** | 0.145 | 0.142 | 0.123 | 0.166 |
| **Mean (ln)** | 0.853 | 0.869 | 0.866 | 0.843 |
| **SD (ln)** | 0.063 | 0.061 | 0.052 | 0.072 |

These results show that within the observed sample mated females possessed the longest femurs and unmated females were shown to have the shortest. All measured femurs ranged between 1.9 and 2.7 mm in length. Further statistical tests were conducted using only the logarithmized data.

### 3.5. Linear regression analyses

All results of the linear regression with bootstrapping (i.e. regression coefficients, coefficients of determination as well as P-values) are listed in table 7. Dependent and independent variables for each of the 18 linear regressions (hypotheses A1-C4) as well as the research questions leading to each particular combination of variables are described in the text.

In all cases where dummy coding was applied, the following coding-scheme was used:

| | | | |
|---|---|---|---|
| mated: | 1 | unmated: | 0 |
| parasitized: | 1 | non-parasitized: | 0 |
| male: | 1 | female: | 0 |

Table7: Linear regression results including regression coefficients (b), coefficients of determination ($r^2$) and P-values as well as significances.

| **Hypothesis** | **b** | **$r^2$** | **P-Value** | **significance** |
|---|---|---|---|---|
| A1 | -0.039778 | 0.003049 | 0.139 | n.s. |
| A2 | -0.029232 | 0.002697 | 0.130 | n.s. |
| A3 | 0.055184 | 0.015050 | 0.007 | sig. ** |
| A4 | 0.039570 | 0.016951 | 0.001 | sig. *** |
| A5 | -0.062030 | 0.003759 | 0.030 | sig. * |
| A6 | -0.070981 | 0.009587 | 0.001 | sig. *** |
| A7 | 0.222222 | 0.064171 | 0.020 | sig.* |
| A8 | 0.189355 | 0.073017 | 0.008 | sig. ** |
| A9 | -0.111111 | 0.012821 | 0.007 | sig. ** |
| A10 | -0.052432 | 0.003886 | 0.094 | n.s./tr. |
| B1 | -0.428600 | 0.005606 | 0.024 | sig. * |
| B2 | 0.341152 | 0.008788 | 0.037 | sig. * |
| B3 | -1.032319 | 0.016619 | <0.001 | sig. *** |
| B4 | 0.087924 | 0.007133 | 0.058 | n.s./tr. |
| C1 | -0.009954 | 0.009700 | 0.033 | sig. * |
| C2 | -0.023018 | 0.000003 | 0.482 | n.s. |
| C3 | -0.004251 | 0.002711 | 0.197 | n.s. |
| C4 | 1.781270 | 0.099632 | 0.068 | n.s./tr. |

a) Parasitic loads:

Hypothesis A1:

Dependent variable: Mated versus unmated males (dummy variable)

Independent variable: Parasitized versus non-parasitized (dummy variable)

Question: Do mated and unmated males differ significantly concerning the presence of ectoparasites on the host-animals?

Result: No significant difference between mated and unmated males could be detected concerning the presence of ectoparasites.

Hypothesis A2:

Dependent variable: Mated versus unmated males (dummy variable)

Independent variable: Number of ectoparasites on each male specimen (square-root transformed counting data)

Question: Do parasitic loads differ significantly between mated and unmated male beetles?

Result: No significant difference in the number of ectoparasites was detected when comparing mated to unmated male specimens.

Hypothesis A3:

Dependent variable: Mated versus unmated females (dummy variable)

Independent variable: Parasitized versus non-parasitized (dummy variable)

Question: Do mated and unmated females differ significantly regarding the presence of ectoparasites on the host-animals?

Result: The test revealed that mated females are parasitized significantly more often than unmated ones (P= 0.007).

Hypothesis A4:

Dependent variable: Mated versus unmated females (dummy variable)

Independent variable: Number of ectoparasites on each female specimen (square-root transformed counting data)

Question: Do parasitic loads differ significantly between mated and unmated female beetles?

Result: Mated females are infested with significantly more larval mites than unmated females (P= 0.001).

Hypothesis A5:

Dependent variable: Mated males versus mated females (dummy variable)

Independent variable: Parasitized versus non-parasitized (dummy variable)

Question: Does the presence or absence of parasites differ significantly between mated male and mated female beetles?

Result: The test revealed mated females to have a significantly higher parasite-presence than mated males (P= 0.03).

Hypothesis A6:

Dependent variable: Mated males versus mated females (dummy variable)

Independent variable: Number of ectoparasites on each mated male and mated female specimen (square-root transformed counting data)
Question: Do parasitic loads differ significantly between mated male and mated female beetles?
Result: Mated females were found to have significantly higher parasitic loads than mated males (P= 0.01).

Hypothesis A7:
Dependent variable: Unmated males versus unmated females (dummy variable)
Independent variable: Parasitized versus non-parasitized (dummy variable)
Question: Do unmated male and unmated female beetles differ significantly concerning the presence or absence of parasites?
Result: The results of this test indicate that unmated males were parasitized significantly more often than unmated females (P= 0.02).

Hypothesis A8:
Dependent variable: Unmated males versus unmated females (dummy variable)
Independent variable: Number of ectoparasites on each unmated male and unmated female specimen (square-root transformed counting data)
Question: Do parasitic loads differ significantly between unmated male and unmated female beetles?
Result: The analysis revealed that unmated males have significantly higher ectoparasitic loads than unmated female specimens (P= 0.008).

Hypothesis A9:
Dependent variable: Parasitized mated males versus non-parasitized mated males (dummy variable)
Independent variable: Parasitized mated females versus non-parasitized mated females (dummy variable).
Question: What is the relationship of parasite presence within mated couples?
Result: The negative regression coefficient (b= -0.111111) indicates a disassortativity of parasite presence on mated individuals. In this disassortative relationship concerning the

presence of parasites on mated partners the females have significantly more cases of parasitic infestation than the males they mate with (P= 0.007).

Hypothesis A10:

Dependent variable: Number of ectoparasites on each mated male (square-root transformed counting-data)

Independent variable: Number of ectoparasites on each mated female (square-root transformed counting-data)

Question: What is the relationship of ectoparasitic loads within mated couples?

Result: A non-significant trend towards disassortativity within the mated couples regarding the number of ectoparasites was shown (P= 0.094), with the females infested by more parasites than their male partners.

b) Femur measurements:

Hypothesis B1:

Dependent variable: Mated males versus unmated males (dummy variable)

Independent variable: Femur length of mated and unmated male specimens (right metathoracic femur, logarithmized data)

Question: Do mated and unmated males differ significantly with respect to the lengths of their femora?

Result: The analysis revealed that unmated males possess significantly longer femora than mated males (P= 0.024).

Hypothesis B2:

Dependent variable: Mated females versus unmated females (dummy variable)

Independent variable: Femur length of mated and unmated female specimens (right metathoracic femur, logarithmized data)

Question: Do mated and unmated females differ significantly with respect to the lengths of their femora?

Result: In females the mated specimens have significantly longer legs than the unmated females (P= 0.037).

Hypothesis B3:

Dependent variable: Mated males versus mated females (dummy variable)

Independent variable: Femur length of mated male and mated female specimens (right metathoracic femur, logarithmized data)

Question: Do mated males and mated females differ significantly with respect to the lengths of their femora?

Result: When comparing mated males and mated females, the females were shown to possess significantly longer femora ($P < 0.001$).

Hypothesis B4:

Dependent variable: Femur length of mated male specimens (right metathoracic femur, logarithmized data)

Independent variable: Femur length of mated female specimens (right metathoracic femur, logarithmized data)

Question: Does the relationship of femur lengths within mated couples indicate significant positive or negative assortativity?

Result: Within the mated pairs there was a slight non-significant trend toward positive assortativity with respect to femur length ($P = 0.058$).

c) Parasites and size:

Hypothesis C1:

Dependent variable: Femur length of mated male specimens (right metathoracic femur, logarithmized data)

Independent variable: Number of parasites found on each mated male specimen (square-root transformed counting data)

Question: How do size (represented by femur length) and parasitic load concide in mated males?

Result: In mated males the negative regression coefficient ($b = -0.00995442$) indicates a significant negative relationship of femur length and parasitic load, revealing that larger males have fewer ectoparasites ($P = 0.033$).

Hypothesis C2:

Dependent variable: Femur length of unmated male specimens (right metathoracic femur, logarithmized data)

Independent variable: Number of parasites found on each unmated male specimen (square-root transformed counting data)

Question: How do size (represented by femur length) and parasitic load coincide in unmated males?

Result: In unmated males no significant correlation between femur length and parasitic load was found.

Hypothesis C3:

Dependent variable: Femur length of mated female specimens (right metathoracic femur, logarithmized data)

Independent variable: Number of parasites found on each mated female specimen (square-root transformed counting data)

Question: How do size (represented by femur length) and parasitic load coincide in mated females?

Result: In mated females the results did not indicate any significant correlation between femur length and parasitic load.

Hypothesis C4:

Dependent variable: Femur length of unmated female specimens (right metathoracic femur, logarithmized data)

Independent variable: Number of parasites found on each unmated female specimen (square-root transformed counting data)

Question: How do size (represented by femur length) and parasitic load coincide in unmated females?

Result: In unmated females no significant correlation between femur length and parasitic load was found.

### 3.6. Path analysis

Figure 8 illustrates the results of the path analysis showing the effects of male (x1) and female (x2) body-size on the total parasitic load of the mated couple (y) and the correlation of body-sizes within the mated pairs.

Similar to the results of the regression analysis, a non-significant weak positive correlation (Pearson's r= 0.084) between the femur lengths of mated males and females was observed.

The influence of the male's body-size (represented by femur length) on the total parasitic load of the mated pair was shown to be non-significant (P= 0.157). In contrast, the path analysis showed a significant negative effect of increasing female body-size on the cumulative ectoparasitic load of the mated couple (Pathcoeff. x2= -0.13; P= 0.002).

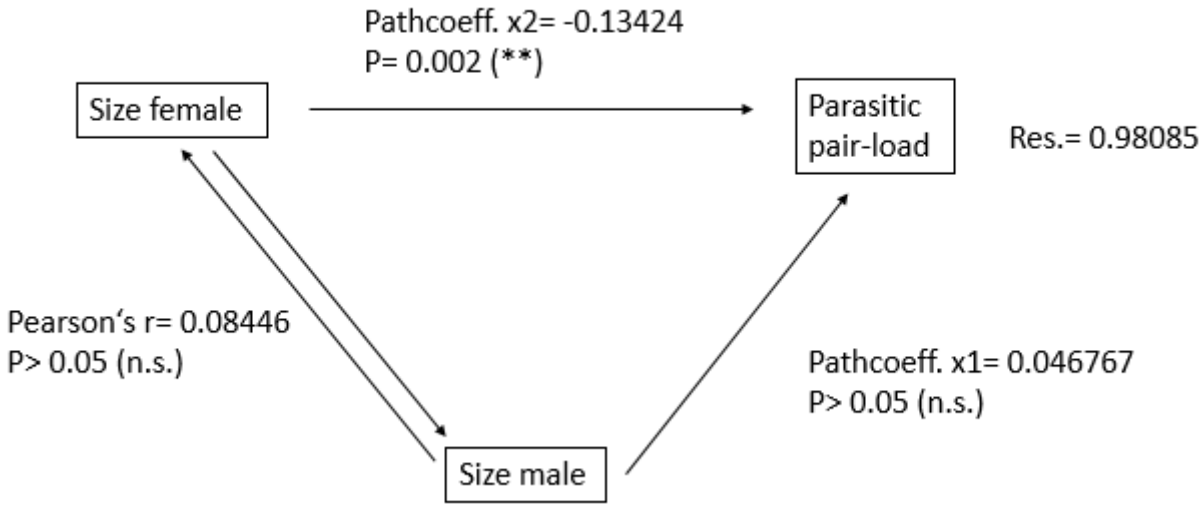


Figure 8: Path-diagram illustrating the effects of male and female body size on the total parasitic pair-load. Path coefficients for x1 (male femur length) and x2 (female femur length) are shown, as well as correlation (Pearson's r) between paired male and female femur lengths, significances and residuum.

### 3.7. Genetic analysis

After amplification of the COI barcoding-region via PCR, detection of the amplified product by gel-electrophoresis showed a sufficient amount of PCR-product to be used for sequencing in two of the five analysed specimens (mites from mated males 2(LO) and 177). Sequencing showed a difference of one base-pair between the two specimens. With the barcoding region having a total length of 655 bp this amounts to a difference of 0.15% (see appendix for full barcoding sequences).

The comparison of the obtained sequences with pre-existing sequence data in the BOLD-database showed the highest similarity (84.37%) with the COI barcoding region of members of the family Trombidiidae.
Determination of genus or species was not possible due to lack of comparable sequences within the database.

## 4. Discussion

Parasite location and distribution

Whereas larval mites of small, medium and large sizes occurred in similar quantities on mated males, unmated males and mated females were mainly parasitized by ectoparasites of the small size-category, though this trend was not significant. As engorgement of the mites usually increases with time due to the amount of hemolymph extracted from the host, one can only assume that these observed differences are merely the effect of different attachment-times of the parasites. An alternative explanation may be that the different groups of *R. fulva* are differently well-suited as hosts for the larvae in question, allowing them to extract little or no hemolymph from certain hosts (Peterson et al., 1992). To thoroughly interpret these results, further research should be directed at the biology of host and parasite and the topic of host-specificity to gain a clearer understanding of the mechanisms involved.
The assessments of the distribution of parasites among the host-animals' body-regions show the highest parasitic load is in the subelytral space for the three largest out of the four host-groups (mated males and females, unmated males). Similarly, other studies investigating the parasitism in Coleoptera by trombidiid larvae (Peterson et al. 1999; Mohamed & Hogg, 2004) have shown that the subelytral dorsal abdominal tergites are the most suitable place for mite-attachment because the intersegmental membranes are soft and therefore easy to penetrate and the forewings provide protection against detachment (e.g. by the host's cleaning behaviour). In *R. fulva* the base of the legs also seems to be a relatively safe and easily accessible place for the parasites, since it proved to be the second most frequently occupied region in all groups of the studied sample. The distribution of ectoparasites was shown to be significantly different between mated males and females with the most striking difference being the infestation of the subelytral cavity that held 56% of the mites in males, but 77% in females. This dissimilarity in the infestation of the subelytral space may be explained by behavioural differences between male and female soldier beetles (pers. observation). While females tend

to be rather sessile, males perform fast and frequent flights, which may lead to difficulties for the parasites in remaining attached near the moving wings. This could lead to the parasite being more evenly distributed along the male hosts' body than on their female conspecifics.

Overall loads

In this study average ectoparasitic loads for *Rhagonycha fulva* were found to be between 2.03 ± 1.79 (mated females) and 1.0 (unmated females) larval mites per infested individual. Even considering that the average load for unmated females may not be representative due to very small sample size of the group (N= 11), these numbers are relatively low compared to the findings of other studies. Peterson et al. (1992) found a similar average number of 1.88-2.88 *Trombidium* larvae per individual of the bean-leaf beetle *Cerotoma trifurcata*. However, larger arthropods such as Lepidoptera were observed to be infested by up to 15 larval mites (Robaux, 1974) and female grasshoppers even with up to 175 ectoparasites per individual (Severin, 1944).

Excessive parasitism by trombidiid larvae is thought to be detrimental to the host's survival and reproduction (Conradt et al., 2002) with the severity of the effect depending on the relative size of host and parasite in addition to the total parasitic load (Zhang, 1998). Taking into account the host animal's overall body-size of 7-11mm and the average parasitic loads on arthropods of comparable or smaller sizes (e.g. *C. trifurcata*) I therefore assume that the detrimental effect due to exsanguination of the host by the average observed number of larval mites is considerably low in the studied specimens of *R. fulva*.

The rates of parasitism observed in this study ranged from 47-18%. This percentage is high compared to the findings of Peterson et al. (1992), who found infestation rates of 1-5% on *C. trifurcata*, but seem consistent with the results of other studies (for a complete review, see Zhang, 1998): Parasitism rates ranged from 90% in the buzzing grasshopper *Sphingonotus savignyi* parasitized by *Allothrombidium sp*. (Chandra, 1984) to 0-3% in cereal leaf beetles (*Oulema* spp.) infested by *Eutrombidium trigonum* (Heyer, 1992). In Lepidoptera, Conradt et al. (2002) found 11-50% parasitized individuals within the studied populations.

Rates of parasitism by trombidiid larvae can fluctuate greatly between years or seasons (Zhang, 1998; Peterson, 1992), therefore without comparable data from other years, the results obtained in this study can merely be considered a snapshot of the observed population for a specific time and place.

Differences between groups

When attempting to interpret the results of the linear regression analysis concerning the parasitic loads of the observed host-groups, the significantly lower load of unmated females in comparison to unmated males as well as to mated females may be a result of the small sample size and cannot be safely interpreted. What seems to be noteworthy, however, is the significantly higher rate of parasitism in mated females in relation to mated males. Taking into account the assumptions of the immunocompetence-handicap, one would assume the male specimens - especially those with high mating success - to be more susceptible to parasitic infections due to the trade-off between showy male characters and an optimally functioning immune-system (Folstad & Karter, 1992). Fittingly, Conratd et al. (2002) found male butterflies showing higher rates of infestation than females. This does not seem to be the case for the observed population of *R. fulva*. However, Peterson et al. (1992) also found significantly higher rates of parasitism in female specimens and point out that ecological and behavioural factors, such as sex-dependent differences in intracanopy and soil-surface distribution patterns may account for the differences in infestation. A similar explanation seems likely for the species in question: As female soldier-beetles tend to be larger in overall body-size and much less mobile than their male conspecifics, it may be easier for larval mites to access and latch on to female hosts.

Due to the prolonged mating time the assumption seems logical that the larval mites may switch from one host to another during copula. However, Trombidiidae tend to avoid leaving a healthy and suitable host once they are attached and have formed a stylostome (Zhang, 1998). While other mites – mainly of the family Podapolipidae – are prone to change hosts during mating (Hurst et al. 1995), trombidiid larvae are currently not known to be sexually transmitted between arthropod hosts (Knell & Webberey, 2004).

Another interesting finding in this respect is the fact that no significant difference in parasitic load could be found between mated and unmated males. According to the Hamilton-Zuk hypothesis, a female should be able to choose the most parasite-resistant mate based on phenotypic characters, such as showy colouration. The size of this effect, however, varies depending on the type of parasite involved, with endoparasites having a greater effect on male showiness than ectoparasites (Hamilton & Poulin, 1997). Furthermore, some studies have even shown higher mating-success for individuals with parasitic infections (Folstad & Karter, 1992; Getty, 2002; Kerstes et al, 2013). Explanations for these phenomena include

behavioural manipulation by the parasite itself (De Crespigny et al., 2006; McLachlan, 1999) and adaptive behaviour such as augmented mating-eagerness in the hosts (Kerstes et al., 2013). Additionally, most biological mating-systems seem to depend on a far more complex array of characters than immunocompetence and showiness alone. Getty (2002) stresses the need to distinguish between traits connected to viability and those linked to the susceptibility to parasitic infection:

> "Immunity and parasites might play a fundamental role in many biological signalling systems, but viability-indicating traits are not necessarily parasite-load-indicating traits. Theory allows for the possibility that high-quality big signallers have greater health and more parasites than low-quality small signallers (and the data suggest that in many systems they do)." (Getty, 2002)

He also points out that big - and therefore high-quality – signallers may be hosts to more parasites with less impact to their viability. In a system in which fitness is more sensitive to predators than to parasites, this could lead to sexual selection for larger body-size, higher steroid levels, and – in accordance with the immunocompetence handicap – lower anti-parasite competence in desirable males (Getty, 2002).

Assortativity – parasites and size

In the studied sample the mean body-size (represented by femur-length) of the female specimens was significantly greater than that of the males. As in a previous study on this species (Parzer, 2006) no significant evidence for size assortative mating could be found. However, within the mated pairs a significant disassortativity regarding the presence of parasites was detected: Mated couples frequently presented with one individual heavily infested and the other nearly or completely parasite-free, most commonly with the female being the more heavily parasitized mate.

The analysis of the influence body-size has on parasite infestation revealed that while mated male specimens are on average smaller in size than unmated ones, the larger of the mated males tend to have fewer ectoparasitic mites. The mating status of males as well as the size of mated females alone does not seem to have a significant effect on parasitic load. However, when interpreting the results of the path analysis, it becomes evident that increasing size of

the female partner contributes negatively to the total parasitic load of mated couples, while male size plays no significant role in that matter.

Since the exact mechanisms of mate choice, courtship and sexual selection in *R. fulva* are not well enough studied at this point, only tentative interpretations can be made about the complex connections discovered in this study: Assuming a system with female choice and persistent courtship by males as in the related cantharid species *ChauIiognathus pennsylvanicus* (McLain, 2005), one could draw the conclusion that parasite-infested female beetles tend to choose a male partner with few or no parasites, as shown by the disassortativity of parasitic loads. The negative effect of increasing female body-size on total parasitic pair-load may be caused by the fact that while there was no significant correlation of size within the mated pairs, a slight trend toward positive size assortative mating was discovered. Since the larger mated males were shown to have fewer parasites, by choosing a relatively large mate, a large female would indirectly lower the ectoparasitic load of the mated pair, though its own size does not correlate with the number of parasites it carries. It is not known whether members of the studied species can directly assess the parasitic load of their prospective partners (e.g. via chemical cues) or whether size, colouration or other traits serve as optical indicators but the evidence strongly suggests a form of mate choice that involves disassortative mating regarding ectoparasitic load. With a residuum of over 98% for the variance of total ectoparasitic load of a mated pair, the results of the path analysis can only serve to explain a small portion of what contributes to the cumulative amount of parasites within a couple. While the size of the female partner certainly plays a significant role, many other – so far unknown – factors undoubtedly have influence on that matter.

Among arthropods in general the most common form of assortative mating is assortativity regarding size, often with the largest individuals of both sexes being the ones with the highest mating-success (Crespi, 1989). This also holds true for many species of the Coleoptera in particular (McLain, 1981; Harari et al. 1999; Bernstein & Bernstein, 1998). Possible advantages that suggest the adaptive value of this “self seeks like” mechanism of mate choice are the reduction of excessive genetic variance, a stabilizing effect on population genetics and the possibility to simultaneously choose for good genes and minimize inbreeding, thus making assortative mating itself evolutionarily beneficial and therefor widespread across various species (Alvarez & Jaffe, 2004).

However, in many species other factors seem to play more important roles in mate choice: Amount and quality of nuptial gifts, operational sex ratio of the population (Alcock & Hardley, 1987) as well as the local frequency of selectively favoured phenotypes (McLain, 2005) are just a few of many possible factors that can influence mate choice independent of mere body size. In biological systems involving parasites with a detrimental effect on viability or fecundity individuals face additional challenges when it comes to choosing a mate: Due to their physiological dissimilarities, males and females often respond differently to parasitic infections with males often being the more susceptible sex (Kerstes et al., 2013; Folstad & Karter, 1992). However, infected individuals of both sexes do not necessarily have a lower chance of finding a mate in populations that have coevolved with parasites. In certain species of Coleoptera, parasitized animals were shown to display a higher willingness to mate and experience no trouble finding a partner. This is thought to increase the offspring's genetic diversity and thereby its fitness in an environment with a constant threat of parasitism (Kerstes et al., 2013).

A similar mechanism might be at work in the studied case of *Rhagonycha fulva*, however further research regarding the biology of host and parasite and the details of sexual selection and mating behaviour in the red soldier beetle is necessary in order to fully understand the role trombidiid parasites play in the process of mate choice in this common but poorly studied species.

Genetic analysis

The results of the barcoding analysis confirm the initial identification of the ectoparasites as trombidiid mites. Interestingly, though the two analysed specimens were collected in different years and stemmed from different populations, the obtained sequences were almost identical. Hebert et al. (2003) found genetic divergences in the COI barcoding-region of other arthropod taxa to average at 0.25% within species, 6.8% within genera and above 10% within families. With a difference of 0.15% it is therefore safe to assume that the two larval mites collected in 1999 in Lower Austria and in 2013 in Burgenland, respectively, are members of one and the same species.

Though exact identification of the larval mites was not possible in the course of this study due to lack of comparable sequences in the used databases, further investigation of this subject may yield results that could help address the open questions of host-specificity and determine

whether specimens of *Rhagonycha fulva* show infestation of one host by multiple species of ectoparasites, as observed in other species of Coleoptera (Peterson et al., 1992).

## Summary

The cantharid *Rhagonycha fulva* is one of Austria's most common beetles. Despite its abundance in Central Europe, very little research has been previously done about the species' biology and mating behaviour.

Observations of a population of *R. fulva* in Oberpiesting (Lower Austria) in 1999 revealed an infestation with ectoparasitic larval mites of the genus *Trombidium* (Trombidiidae). In previous studies aiming to find links between mating success and parasitism, correlation between parasite burden and the ability to find a mate was found to be either significantly positive or negative or not significant depending on the species in question. Taking into account previously published theories about sexual selection in connection with parasitism, the aim of this study was to determine if and how the presence, abundance and location of ectoparasites on the host's body influence mating success in this particular host and to determine further if parasitic load correlates with additional characters like sex and body-size.

Microscopic assessment of the number, size and location on the host's body of larval mites as well as measurements of the right metathoracic femur as a size parameter were conducted on 34 unmated males and 11 unmated females as well as 198 mated pairs of the beetle species. Additionally, mites from five different hosts were chosen for genetic analysis via DNA barcoding.

The study revealed significant differences in the distribution and abundance of ectoparasites on mated male and female hosts. While no significant evidence for size assortative mating could be determined, a disassortative relationship regarding the presence of parasites within mated couples was found. Large mated males were observed to carry significantly fewer parasites than smaller mated males and parasitism could not be shown to be detrimental to the males' mating success. While female size alone does not influence parasitic load directly, the cumulative number of larval mites in a mated couple decreases significantly with increasing female size, suggesting a mechanism of female choice for disassortative ectoparasitic loads. The genetic analysis yielded positive results for two of the analysed larval mites which were identified as Trombidiidae by means of DNA-barcoding.

These findings and their putative biological implications for the species in question are discussed in the light of current theories linking parasitism and sexual selection – such as the Hamilton-Zuk hypothesis and the concept of the immunocompetence handicap.

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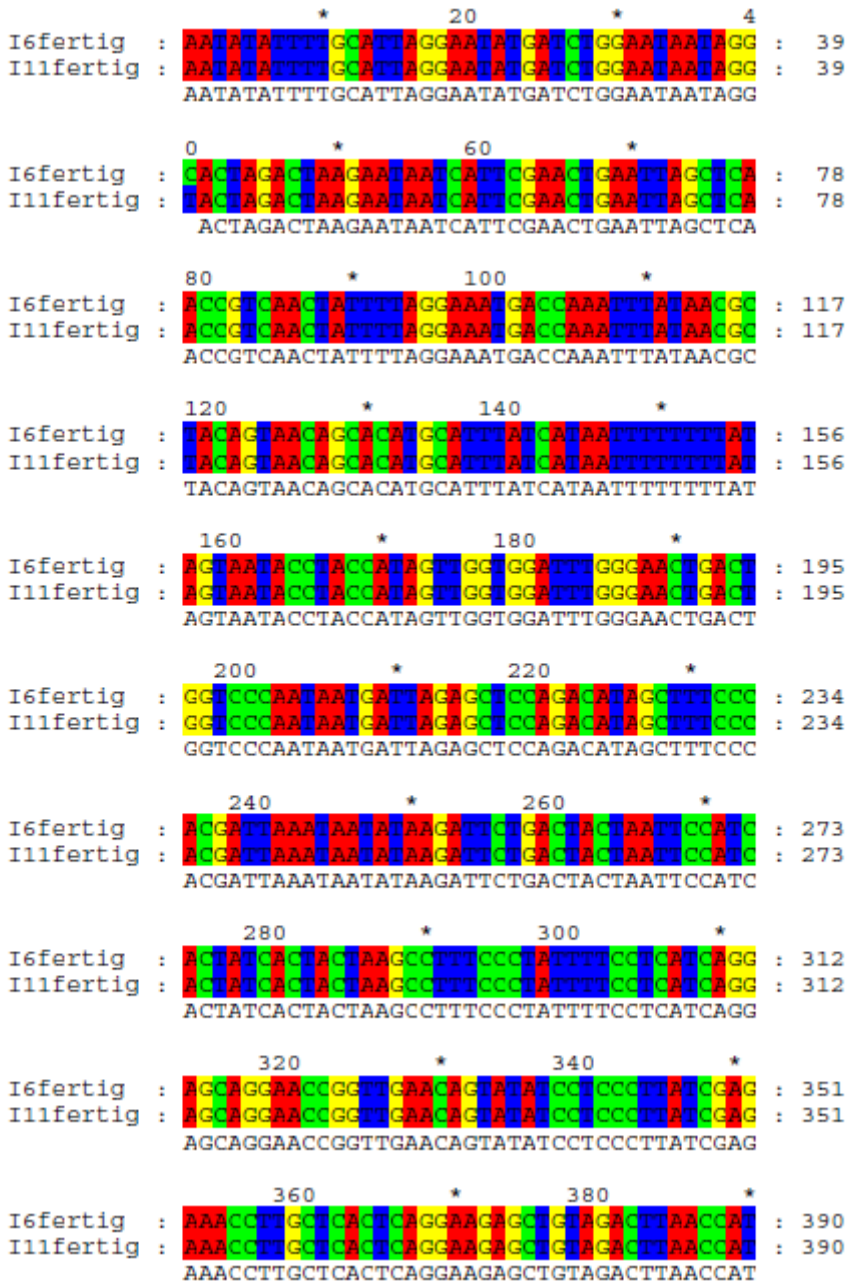
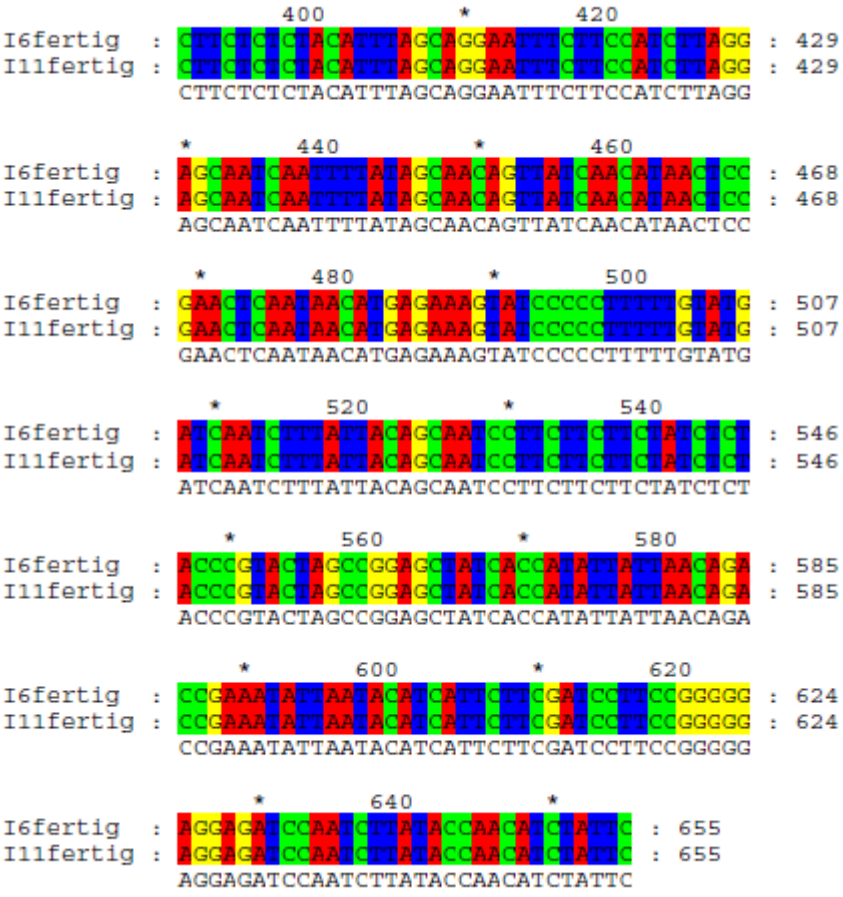
## Appendix

Results of the DNA-barcoding analysis: Aligned sequences of mites from male host specimens 2(LO) (I6fertig) and 177 (I11fertig).




400 * 420
I6fertig : CTTCTCTCTACATTTAGCAGGAATTTCTTCCATCTTAGG : 429
I11fertig : CTTCTCTCTACATTTAGCAGGAATTTCTTCCATCTTAGG : 429
CTTCTCTCTACATTTAGCAGGAATTTCTTCCATCTTAGG
* 440 * 460
I6fertig : AGCAATCAATTTTATAGCAACAGTTATCAACATAACTCC : 468
I11fertig : AGCAATCAATTTTATAGCAACAGTTATCAACATAACTCC : 468
AGCAATCAATTTTATAGCAACAGTTATCAACATAACTCC
* 480 * 500
I6fertig : GAACTCAATAACATGAGAAAGTATCCCCCTTTTTGTATG : 507
I11fertig : GAACTCAATAACATGAGAAAGTATCCCCCTTTTTGTATG : 507
GAACTCAATAACATGAGAAAGTATCCCCCTTTTTGTATG
* 520 * 540
I6fertig : ATCAATCTTTATTACAGCAATCCTTCTTCTTCTATCTCT : 546
I11fertig : ATCAATCTTTATTACAGCAATCCTTCTTCTTCTATCTCT : 546
ATCAATCTTTATTACAGCAATCCTTCTTCTTCTATCTCT
* 560 * 580
I6fertig : ACCCGTACTAGCCGGAGCTATCACCATATTATTAACAGA : 585
I11fertig : ACCCGTACTAGCCGGAGCTATCACCATATTATTAACAGA : 585
ACCCGTACTAGCCGGAGCTATCACCATATTATTAACAGA
* 600 * 620
I6fertig : CCGAAATATTAATACATCATTCTTCGATCCTTCCGGGGG : 624
I11fertig : CCGAAATATTAATACATCATTCTTCGATCCTTCCGGGGG : 624
CCGAAATATTAATACATCATTCTTCGATCCTTCCGGGGG
* 640 *
I6fertig : AGGAGATCCAATCTTATACCAACATCTATTC : 655
I11fertig : AGGAGATCCAATCTTATACCAACATCTATTC : 655
AGGAGATCCAATCTTATACCAACATCTATTC

**Zusammenfassung**

Der Rote Weichkäfer, *Rhagonycha fulva* (Cantharidae) ist einer der häufigsten Käfer Österreichs. Trotz seines massenhaften Vorkommens in Mitteleuropa sind viele Aspekte der Biologie inklusive des Sexualverhaltens dieser Art weitgehend unerforscht.

Untersuchungen einer Population von *R. fulva* in Oberpiesting (Niederösterreich) im Jahre 1999 ergaben einen Befall zahlreicher Individuen mit ektoparasitischen Milbenlarven der Gattung *Trombidium* (Trombidiidae). In vorangegangenen Studien, die darauf abzielten Zusammenhänge zwischen Parasitenbefall und Paarungserfolg zu untersuchen, wurde festgestellt, dass die Korrelation zwischen Parasitenbefall und erfolgreicher Partnersuche je nach Spezies signifikant positiv oder negativ oder auch nicht signifikant sein kann. Unter Berücksichtigung der gängigen Theorien über sexuelle Selektion im Zusammenhang mit Parasitismus war das Hauptziel der hier durchgeführten Untersuchungen, festzustellen, ob und wie Vorhandensein, Größe und Platzierung der Ektoparasiten auf den Wirtstieren den Paarungserfolg der untersuchten Wirtsart beeinflussen, und ob Parasitenbefall mit anderen Merkmalen, wie etwa dem Geschlecht und der Körpergröße, in Verbindung gebracht werden kann.

An 34 unverpaarten Männchen, 11 unverpaarten Weibchen und 198 Paaren der Käferart wurden mikroskopische Analysen von Anzahl, Größe und Verteilung der Milbenlarven sowie Längenmessungen am rechten Femur des Metathorax durchgeführt. Zudem wurden Milben von fünf Wirtstieren mittels DNA-barcoding genetisch analysiert.

Die Untersuchungen ergaben signifikante Unterschiede nach der Verteilung und Anzahl der Ektoparasiten auf verpaarten Männchen und Weibchen der Wirte. Während kein signifikanter Hinweis auf größenassortative Paarung gefunden werden konnte, wurde eine disassortative Beziehung der Parasitenzahlen innerhalb der Käferpaare festgestellt. Große verpaarte Männchen haben signifikant weniger Parasiten als kleine verpaarte Männchen und Parasitierung scheint nicht mit dem Verpaarungsstatus der männlichen Käfer zusammenzuhängen. Obwohl die Größe des Weibchens keinen direkten Einfluss auf die Parasitenmenge hat, verringert sich die kumulative Parasitenanzahl eines Paares signifikant mit zunehmender Größe des weiblichen Partners. Dies lässt auf einen Mechanismus schließen, bei dem disassortative Parasitenladung als Partnerwahlkriterium für Weibchen dienen kann. Die genetische Analyse ergab positive Resultate für zwei der untersuchten Milbenlarven, die mittels DNA-barcoding als Trombidiidae bestimmt werden konnten.

Diese Ergebnisse und ihre möglichen biologischen Implikationen für die untersuchte Art werden im Lichte bereits bestehender Theorien – wie der Hamilton-Zuk Hypothese oder des Immunokompetenz-Handicaps – diskutiert.

# Lebenslauf

Persönliche Daten

Name: Alice Laciny

Geburtsdatum: 18.05.1989

Geburtsort: Wiener Neustadt

Staatsbürgerschaft: Österreich

Schulbildung

1995-1998: Friedrich Eymann Waldorfschule mit Öffentlichkeitsrecht

1998-1999: San Francisco Waldorf School

1999-2002: Friedrich Eymann Waldorfschule mit Öffentlichkeitsrecht

2002-2007: Bundesgymnasium und Bundesrealgymnasium Albertgasse

4.6.2007: Reifeprüfung, Schwerpunkt Biologie (Fachbereichsarbeit „Methoden der forensischen Entomologie“) mit ausgezeichnetem Erfolg bestanden

Akademische Bildung

2007-2011: Bachelorstudium Biologie mit Schwerpunkt Zoologie, Universität Wien

31.3.2011: Abschluss des Bachelorstudiums Biologie mit ausgezeichnetem Erfolg

März 2011 – April 2014: Masterstudium Zoologie, Universität Wien.

Oktober 2012 - April 2014: Master Student am Department für theoretische Biologie, Universität Wien. Forschung zum Thema Paarungserfolg und Ektoparasitenbefall bei *Rhagonycha fulva* (Cantharidae).

2011-2014: Fachtutorin für StEOP-Zoologie, Universität Wien. Leitung persönlicher Fragestunden, Onlinebetreuung der StudentInnen.

Januar-März 2014: Praktikum im Umfang von 240h am Institut für Parasitologie, Veterinärmedizinische Universität Wien. Erlernen und Durchführung molekularer Diagnoseverfahren.

Stipendien

2008, 2009, 2011, 2012: Leistungsstipendium der Universität Wien