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HONEY BEE POPULATIONS, THEIR PARASITES, AND LANDSCAPE STRUCTURE: A CASE STUDY FROM SLOVAKIA

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Abstract.
The loss of bees is a relatively well-known worldwide phenomenon. Many papers have examined the direct influence of various factors on global bee losses. However, a look at this problem in regard to host-parasite-environment interactions is rare. This paper attempts to demonstrate the possible connections between bees, their parasites and the landscape structure. During research at 27 selected sites across Slovakia, Nosema *spp. spores were detected in two samples (7.41% of the examined apiaries) and* Varroa destructor *in a total of 41% of the samples (mean prevalence of 0.57). Significant differences were found in the mites infestation at elevations up to 500 m and over 500 m, and at sites with different ecological stabilities (ES). Considering the landscape structure,* Varroa *mites infestation was significantly influenced positively by the presence of discontinuous urban fabrics.*

Key words: *host-parasite-environment interactions, bees,* Varroa destructor, Nosema *spp., secondary landscape structure*

Introduction

Bees are essential plant pollinators of major food crops (Klein et al. 2007; Brown & Paxton 2009). Animal-mediated pollination is one of the ecosystem services of high economic interest (Gallai et al. 2009; Lautenbach et al. 2012; Klatt et al. 2014; Papanikolaou et al. 2017) which is strongly affected by changes in land use (Weiner et al. 2014). Most land use change is associated with the expansion of croplands, habitat loss and fragmentation and biodiversity declines (Green et al. 2005; Tilman et al. 2011; Grau et al. 2013; Lambin et al. 2013; Cely-Santos & Philpott 2019). These changes may exacerbate the impacts of land use conversion on biodiversity (Tscharntke et al. 2005; Flynn et al. 2009; Mogren et al. 2016).

Bees are highly sensitive to environmental changes, and while their diversity declines in simplified habitats distant from undisturbed areas, bees respond to agricultural practices and habitat configuration at different scales (Cely-Santos & Philpott 2019). After habitat loss, invasive species, parasites and disease also appear to be the most widespread and documented threats to bee populations (Brown & Paxton 2009). However, there are also theories (see Fedoriak et al. 2021) that do not support the hypothesis that intensive agriculture per se negatively affects honeybees. Beekeeping can be viewed as a social "glue" that strengthens the opportunity for landscape stewardship for the provision of multiple ecosystem services in particular, and rural development in general (Fedoriak et al. 2021).

Agricultural landscapes in different regions vary greatly in forage and land management, indicating a need for additional information on the relationship between honeybee health and landscape cultivation. Furthermore, it has been demonstrated that high rates of *Varroa destructor* Anderson & Trueman, 2000 mite infestation in honeybees can lead to negation of the potential benefits of high quality forage and land use conditions, underscoring the importance of this parasite in influencing colony health and survival outcomes (Dolezal et al. 2016). A recent study showed that *Varroa* mites selectively feed primarily on body fat, thus contributing to compromised nutritional and immune systems of honeybees (Ramsey et al. 2019).

Therefore, the main goal of this study is to try to find possible relationships between bees, bee metapopulations, their parasites and land use in selected localities in Slovakia.

Material and Methods

The sampling was conducted throughout Slovakia during the winter period 2019/2020. In total, 27 beekeepers were selected for our research (see Fig. 1, Supplement 1). *Varroa* mites and *Nosema* spp. were checked for in all colonies according to the beekeeper's management regimes. Every beekeeper collected bees from the screened bottom board of three randomly selected hives per apiary during the period 21.2.- 15.3.2020, packed them and sent them to the laboratory for further processing.

Laboratory analysis

Parasite analysis

In the laboratory, 10 bees were randomly selected from each sampling site for *Nosema* spp. analysis. The rest of the bee samples were weighed and used to determine the *V. destructor* infestation.

***Nosema* spp. analysis**

To determine the *Nosema* spp. infection from pooled samples of ten randomly selected bees, a simple microscopy method was used. A positive sample was numbered 1 and a negative sample was numbered 0 (Fries et al. 2013).

***Varroa destructor* analysis**

The *Varroa destructor* infestation was examined by a modified washing method as described by Rin-

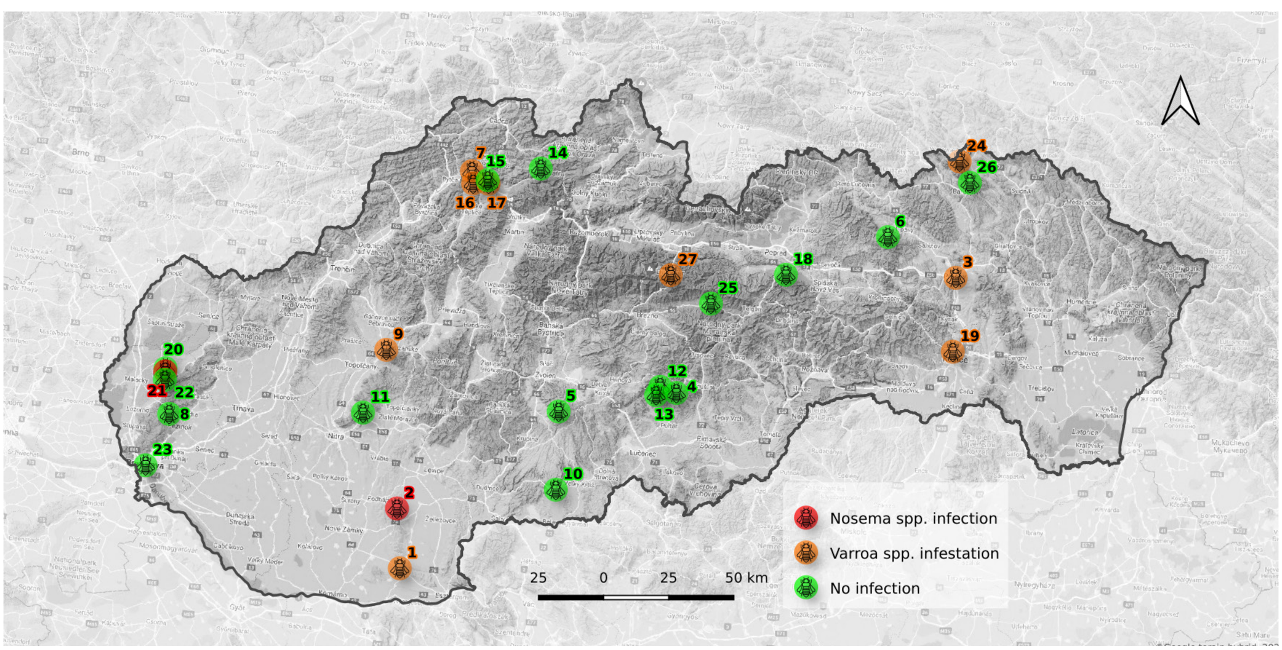

Figure 1. Distribution of 27 beekeepers (apiaries) within Slovakia.

derer et al. (2004). A weighted sample of bees was placed in a plastic container and flooded with water with a drop of detergent. The sample thus prepared was mixed and shaken for 15 minutes. Subsequently, the sample was poured through a sieve system (the upper sieve retained the bees and the lower the *Varroa* mites and small impurities) and thus washed with a stream of water for 1 minute. The content of the bottom sieve was examined under a stereomicroscope and the total number of captured individuals of *V. destructor* mites was counted. The content of the top sieve was then returned to the container and the washing procedure was repeated until no mites were detected on the bottom sieve. All recorded mites from one sample of all washes were counted together. The *V. destructor* infestation per 100 g of bees was calculated from the dry weight of the bees and the number of mites recorded.

Data analysis

The density of hives at the sites from which the samples were obtained came from the central evidence of livestock register (https://www.pssr.sk; accessed 28.6.2020).

Landscape analysis

At the sampling sites, the secondary landscape structure and its influence on the evaluated characteristics (*Varroa destructor* and *Nosema* spp. infestation) was also determined. For research purposes, the flight distance for the bees was set at 2 km from the hive. Within this radius, the percentage of the following classes of the land cover structure elements were determined by CLC (2018) – see Supplement 2. CORINE Land Cover (CLC 2018) is coordinated by the European Environment Agency (EEA) in the scope of the EU Copernicus programme and implemented by national teams under the management and quality control of the EEA. It consists of an inventory of land cover in 44 classes in nomenclature, where the minimum mapping unit is 25 hectares and the minimum mapping width is 100 metres. Based on this vector data, we have clipped a 2 km radius on each locality and using the geographic information system QGIS, we have counted the share of each class in the focused area. The 2 km radius was selected because honeybees have been estimated to mainly forage for pollen (around 90% of their visitation) within a 1.6 km radius of their hives in agricultural landscapes (Couvillon et al. 2014; Danner et al. 2014).

Landscape coefficients analysis

Ecological stability

Three landscape indices/coefficients were calculated using EXCEL software. The coefficient of ecological stability (Miklós 1986) was calculated as follows:

$$ES = \frac{\Sigma(P_a * K_{pn})}{P}$$

where P_a is an area (ha) of individual forms of land use (forest, arable land, etc.), K_{pn} is the coefficient of ecological significance (arable land – 0.14; grasslands – 0.65; forest – 1.00; water bodies/areas – 0.79; built-up areas – 0.00, other forms – 0.14) and P is total area of the evaluated sampling site. The results of the ecological stability index are divided into five categories according to the ecological stability of the evaluated area: ES<0.2 – significantly destabilized landscape; 0.20>ES>0.40 – destabilized landscape; 0.40<ES<60 – partially stabilized landscape; 0.60<ES<0.80 – stabilized landscape; ES>80 – significantly stabilized landscape.

Anthropogenic pressure

The coefficient of anthropogenic pressure (*AP*; Kupková 2001) was calculated as follows:

$$AP = \frac{H}{L}$$

where H is the sum of areas with a higher intensity of use (arable land, built-up areas, industrial areas etc.) and L is the sum of areas with a lower intensity of use (forest, grasslands, water bodies). A higher value of the *AP* index means the greater anthropogenic impact on the sampling site. We used a non-parametric Kruskal-Wallis test to determine differences in *V. destructor* infestation between sampling sites with a low ($AP<2$), medium ($2<AP<6$) and high ($AP>6$) anthropogenic pressure coefficient.

Originality of the cultural landscape

The coefficient of the originality of the cultural landscape (*OCL*; Žigrai 2001) was calculated as follows:

$$OCL = \frac{\text{area of forest + area of grasslands}}{\text{area of arable land}}$$

A higher value of the index indicates that more of the original landscape has been preserved at the sampling site.

Spearman's correlation analysis was used to determine the correlation relationship between variables. The non-parametric Mann–Whitney U test was used to find out significant differences of the evaluated variables depending on the presence/absence of a specific element of the secondary landscape structure. The Kruskal-Wallis test, like the Spearman's correlation coefficient, was considered statistically significant if the P-value was less than 0.05 and 0.01. Statistical analyses were performed using R studio (R Studio Team, Boston) and JASP computer software (Version 0.14.1).

Results

In total, 27 sampling sites in Slovakia were selected for our analysis. The majority of them (more

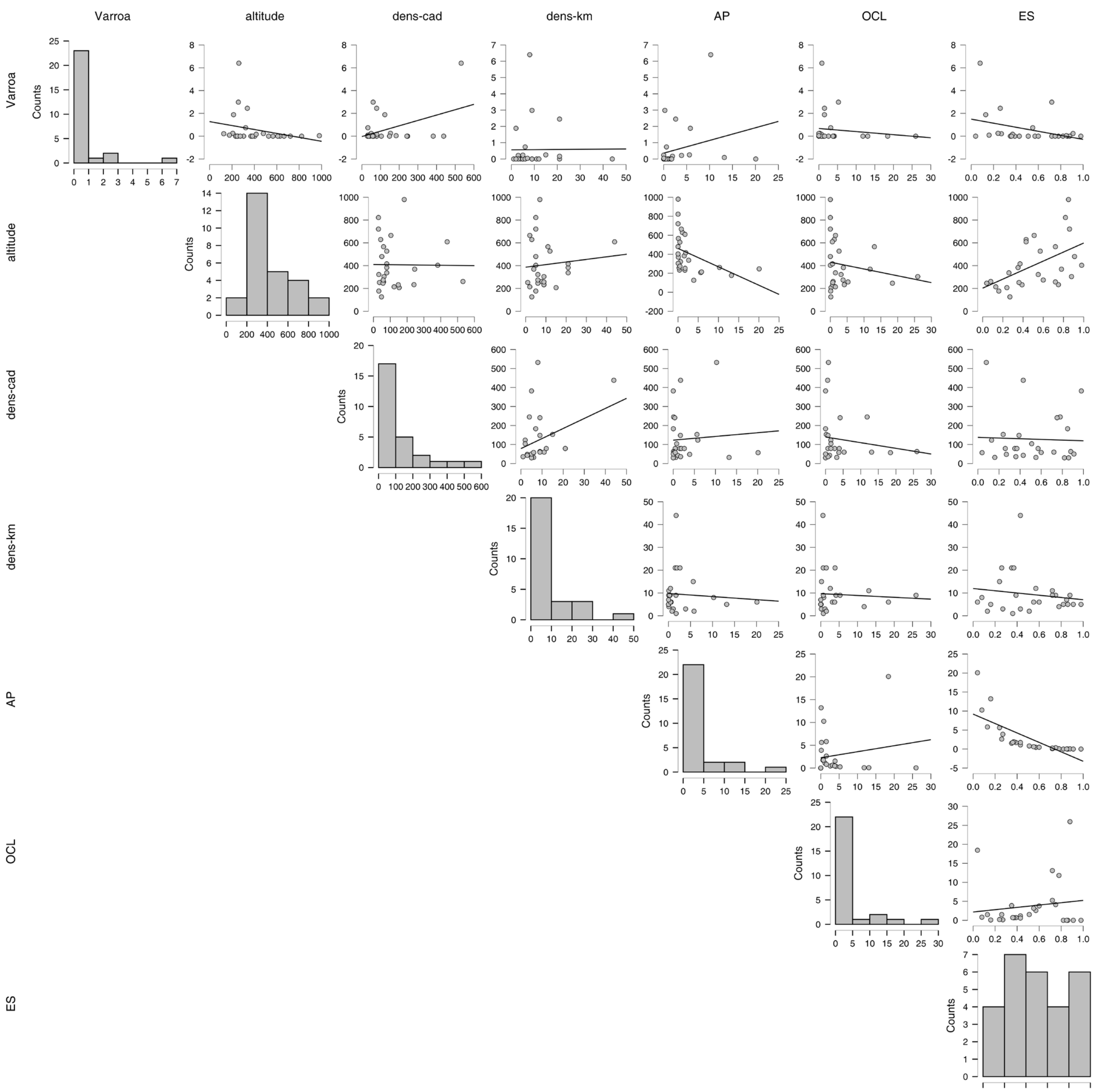

Figure 2. Density and correlation plots of *Varroa destructor* and selected sampling site characteristics (density – hives density per km^2; AP – Coefficient of anthropogenic pressure; OCL – Coefficient of the originality of the cultural landscape; ES – Coefficient of ecological stability) with confidence intervals 95%.

than 70%) were located at elevations up to 500 m a.s.l., with the highest positioned apiary at 980 m a.s.l. A wide range of hives densities and coefficients reflecting the landscape were covered in our research. The *AP* and *ES* strongly correlated with elevation (*AP* negatively, *ES* positively), and *ES* correlated strongly negatively with *AP* (Fig. 2).

Nosema spp. spores were detected in only two samples, those originating from apiaries 2 and 21 (both less than 300 m a.s.l.), which means only 7.41% of the examined apiaries, while *V. destructor* infestation was observed in 41% of the samples, with a mean prevalence of 0.57. The highest infestation was 6.4 mites per 100 g of bees at apiary 3.

No significant correlation nor regression was observed between mites infestation and sampling site characteristics. On the other hand, it is clear that *V. destructor* occurred only at sites lower than 500 m a.s.l., and 8 sites at which *V. destructor* occurred (out of 9 total sites with *V. destructor* mites) were located at an elevation of less than 400 m. a.s.l. A similar pattern was observed in the ES coefficient, where most *Varroa*-negative sites had a higher ES (see Fig. 2). This finding was not surprising, as ES correlates with elevation (Spearman's $\rho = 0.569$, $p < 0.01$).

Based on these results, categories were made and analysed. There were significant differences (Kruskal-Wallis test, $p<0.05$) in mites infestation in groups of sites with different elevations (up to 500 m and over 500 m; Fig. 3) and different *ES* (Kruskal-Wallis test, $p<0.03$; group 1: <0.35, group 2: ≥0.35 and <0.6, gr. 3: ≥0.6; Fig. 3).

Only one significant positive correlation (Spearman's $\rho = 0.458$; $p<0.03$) was found between *V. destructor* infestation and landscape structure 1.1.2 (discontinuous urban fabric). This landscape structure also correlated negatively with *ES* and elevation (Spearman's $\rho = -0.892$, $p<0.01$ and -0.468, $p<0.03$, respectively) and positively with *AP* (Spearman's $\rho = 0.867$, $p<0.01$).

Discussion

In our study, we analysed the characteristics of the research sites and detected the relationship between elevation, anthropogenic pressure and ecological stability. The *AP* and *ES* correlations with elevation are not surprising and are related to the distribution of the land cover structure elements at different elevations, and even less surprising is the negative correlation between *AP* and *ES*. We were much more interested in the relationships between the above-mentioned and other characteristics of the sampling sites, on the one hand, and bee parasites on the other.

As *Nosema* spp. was confirmed from only two of the apiaries examined, it is not possible to statistically evaluate the results, draw general conclusions or confirm findings from other authors (e.g. Kralj & Fuchs 2010; Li et al. 2013; Forfert et al. 2015). From them, the most important are the findings of Forfert et al. (2015) pointing out that inter-colony transmission of *Nosema* spp. occurs typically through honeybee workers not returning to their home colony but entering a foreign colony (so-called drifting). Honeybee pathogens and pests need to be transferred from one colony to another if they are to maintain themselves in a host population. Foragers infected with *Nosema* spp., parasitized by *V. destructor* mites or infected with viruses are more likely to drift to neighbours' colonies compared to healthy honeybees (Kralj & Fuchs 2010; Li et al. 2013). Moreover, colonies with high *Varroa* infestation had a significantly

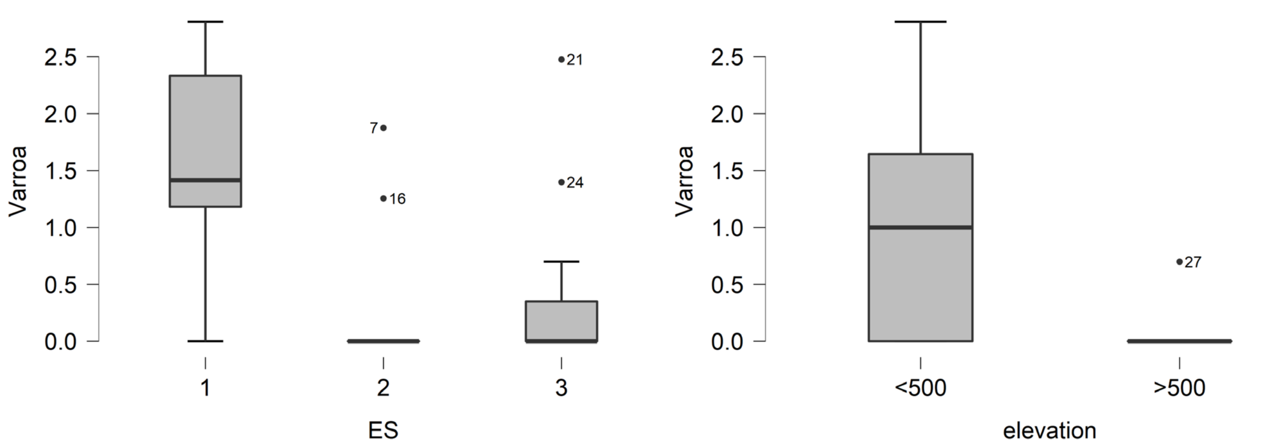

Figure 3. Infestation of *Varroa destructor* at elevations (m a.s.l.) up to and over 500 m (left) and in different *ES* groups (right; gr. 1: <0.35, gr. 2: ≥0.35 and <0.6, gr. 3: ≥0.6) – boxplots (outliers labelled).

enhanced acceptance of drifters, although they did not send out more drifting workers (Forfert et al. 2015). The proportion of *Varroa*-infested drones at the drone congregation areas (DCAs) was positively correlated to the distance to the apiary, and this trend was observed toward higher mite loads in the DCAs (Galindo-Cardona et al. 2020).

The results related to *V. destructor* mites are much more interesting than those regarding *Nosema* spp. The infestation of *V. destructor* seems to be influenced by several characteristics of sites that correlate with each other. This may mean that only one of them is of ecological significance in terms of prevalence and infestation of mites, with which the others correlate to, or that several (or all of them) have a certain significance (influence) on the occurrence of these parasites. We are rather prone to believe the latter option and assume that mite infestation is affected by a combination of several variables. This is basically confirmed by the findings of other authors, who found the connection of various factors with the condition and parasites of bees.

Our results also show that landscape forms of anthropogenic origin have a positive effect on *V. destructor* infestation. On the other hand, mites infestation was significantly lower at elevations above 500 m and with higher ecological stability (expressed as the *ES* index). In connection with landscape forms of anthropogenic origin, Clermont et al. (2015) observed that bee colony losses were positively correlated with the size of the biggest field or land cover class (e.g. large industrial facilities), although they did not take into account the influence of parasites, only the direct influence of the landscape and bees. We assume that the discontinuous urban fabric and industrial and commercial units offer only a minimum of suitable food sources for bees and can also cause temperature shocks or produce stressors (e.g. heavy metals or other pollutants) which cumulatively can reduce bee immunity, support the infestation of parasites and ultimately, as Clermont et al. (2015) predict, bee colony losses. Honeybees kept in areas of lower cultivation were also found to exhibit higher lipid levels than those kept in areas of high cultivation, but this effect was observed only in colonies that were free of *V. destructor* mites (Dolezal et al. 2016). The infestation of *V. destructor* mites in bees collected directly before winter was associated with lower lipid levels and higher titres of deformed wing virus (DWV). Moreover, *V. destructor* infestation interacts with the landscape, obscuring the effects of the landscape alone and suggesting that the benefits of an improved foraging landscape could be lost without adequate control of mite infestations (Dolezal et al. 2016). Honeybee colonies in regions composed predominantly of semi-natural areas, coniferous forests and pastures had the lowest loss probability in four out of six years, and loss probabilities within these regions were significantly lower in five out of six years compared to those within regions composed predominantly of artificial surfaces, broad-leaved and coniferous forest (Kuchling et al. 2018).

Decourtye et al. (2019) observed that the decline in plant abundance and the diversity (which is characteristic of monoculture plantations) on which bees rely is contributing to the rapid decline in honeybee colony losses. Our results also show that landscape forms of anthropogenic origin have a positive effect on *V. destructor* infestation, which can potentially contribute to the decline of bees. The use of agrochemicals can also result in potential disruptions of bee immunity (e.g. Henry et al. 2012; Sanchez-Bayo & Goka 2014). Cely-Santos and Philpott (2019) also observed the influence of elevation, vertical structure of the vegetation and landscape structure on bee community structure.

Regarding the lower mites infestation at higher elevations, our results are in line with findings from East Africa, where the detected numbers of *V. destructor* mites positively correlated with elevation, suggesting that environmental factors may play a role in honeybee host-parasite interactions (Muli et al. 2014).

Despite our efforts to record and evaluate as many factors as possible that could affect the infestation and prevalence of bee parasites, it seems that there is another factor (or combination of factors) that we have not analysed which affects the presence and prevalence of *V. destructor*.

Conclusion and Suggestions

The health of honeybee colonies should be understood together with the landscapes in which they live. That is why a detailed analysis of the landscape structure can be helpful in the management of bees and their parasites. With its appropriate implementation in nationwide bee management, it is possible to influence the infestation of bee parasites and thus the vitality and productivity of the whole colony.

The important factor that correlated negatively with *V. destructor* infestation is ecological stability. *Varroa* prevalence positively correlated with discontinuous urban landscape structures. We therefore recommend reducing bee density in such landscapes.

Urban, industrial, and agricultural developments are three of widespread forms of human land use. Their respective effects on honeybee health still remain poorly understood, which is why future research is needed in this field.

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Supplement 1: Details about selected apiaries, density of hives in respective cadaster, *Nosema* spp. and *Varroa destructor* infestation.

Locality	**Coordinates**	**Number of hives per km²**	**Number of hives per cadaster**	**Altitude** (m a.s.l.)	***Nosema* spp. infection ***	***Varroa destructor* infestation** Nr. of mites per 100 g of bees
1	47°52'17.2"N 18°27'39.9"E	3	48	126	0	0.27
2	48°03'48.6"N 18°25'03.7"E	15	153	207	1	0.25
3	48°59'47.3"N 21°14'41.7"E	8	532	261	0	6.40
4	48°32'44.7"N 19°49'12.8"E	4	245	369	0	0
5	48°27'00.0"N 19°12'36.0"E	11	60	566	0	0
6	49°07'31.2"N 20°52'41.9"E	12	79	527	0	0
7	49°15'27.4"N 18°40'02.8"E	6	32	322	0	0.74
8	48°19'45.1"N 17°12'14.6"E	5	382	403	0	0
9	48°37'07.6"N 18°17'49.4"E	5	32	177	0	0.09
10	48°11'02.1"N 19°13'53.5"E	9	148	232	0	0
11	48°23'45.2"N 18°12'15.8"E	9	241	233	0	0
12	48°33'47.0"N 19°44'03.8"E	5	30	822	0	0
13	48°32'02.5"N 19°42'58.8"E	5	30	721	0	0
14	49°17'06.3"N 19°01'42.5"E	3	43	629	0	0
15	49°13'50.9"N 18°45'13.3"E	21	79	383	0	0
16	49°12'55.7"N 18°40'43.5"E	21	79	416	0	0.17
17	49°13'09.2"N 18°45'37.3"E	21	79	337	0	2.45
18	48°58'34.4"N 20°21'14.9"E	44	438	609	0	0

Supplement 1, continued: Details about selected apiaries, density of hives in respective cadaster, *Nosema* spp. and *Varroa destructor* infestation.

19	48°44'28.7"N 21°14'52.5"E	2	123	214	0	1.88
20	48°48'46.0"N 17°16'15.0"E	9	63	304	0	0
21	48°47'40.5"N 17°16'20.8"E	9	60	257	1	2.98
22	48°44'49.3"N 17°16'45.9"E	1	36	252	0	0
23	48°09'18.5"N 17°05'56.1"E	6	57	246	0	0
24	49°23'53.5"N 21°14'12.6"E	5	50	480	0	0.24
25	48°51'51.8"N 19°58'25.3"E	2	104	665	0	0
26	49°19'34.2"N 21°17'46.9"E	6	58	274	0	0
27	48°57'00.7"N 19°45'02.8"E	7	183	980	0	0.04

* The positive sample = 1 and the negative sample = 0.

Supplement 2: The percentage of the classes of the land cover structure elements* determined by CLC (2018).

Site	111	112	121	122	123	131	132	133	141	142	211	221	222	231	242	243	311	312	313	321	324	411	511	512	Grand Total
1	0.0%	9.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	56.1%	9.8%	0.0%	0.0%	4.6%	1.8%	7.9%	0.0%	0.0%	0.0%	0.0%	10.8%	0.0%	0.0%	100.0%
2	0.0%	10.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	72.6%	0.0%	2.1%	0.0%	0.0%	1.8%	13.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
3	3.7%	60.6%	15.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	8.7%	0.0%	0.0%	0.0%	2.2%	7.6%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.8%	0.0%	0.0%	19.4%	0.0%	21.4%	37.7%	0.0%	11.8%	0.0%	1.8%	0.0%	0.0%	0.0%	100.0%
5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.1%	0.0%	0.0%	0.5%	0.0%	59.5%	22.2%	0.0%	7.1%	0.0%	3.6%	0.0%	0.0%	0.0%	100.0%
6	0.0%	4.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	26.6%	0.0%	0.0%	26.0%	0.1%	17.8%	0.0%	13.4%	11.9%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
7	0.0%	14.8%	4.2%	3.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.3%	0.0%	0.0%	0.7%	0.0%	14.1%	2.4%	20.0%	7.8%	0.0%	3.9%	0.0%	6.9%	6.3%	100.0%
8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	94.3%	0.0%	0.0%	0.0%	5.7%	0.0%	0.0%	0.0%	100.0%
9	0.0%	11.4%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	80.0%	0.0%	0.0%	0.0%	0.0%	6.7%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
10	0.0%	9.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	35.4%	17.6%	0.0%	3.2%	0.0%	12.5%	21.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
11	0.0%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.0%	11.9%	3.1%	0.0%	0.0%	2.8%	3.7%	69.2%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	100.0%
12	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	34.8%	0.0%	14.2%	43.8%	0.0%	4.6%	0.0%	2.5%	0.0%	0.0%	0.0%	100.0%
13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	30.0%	0.0%	3.8%	57.9%	0.0%	1.2%	0.0%	7.1%	0.0%	0.0%	0.0%	100.0%
14	0.0%	10.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	38.6%	0.0%	0.0%	15.9%	3.0%	14.5%	1.5%	4.3%	11.9%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
15	3.5%	35.1%	11.7%	1.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.6%	0.0%	0.0%	7.8%	2.3%	6.8%	3.8%	8.5%	7.7%	0.0%	0.0%	0.0%	4.9%	0.0%	100.0%
16	0.0%	11.6%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	0.0%	0.0%	51.5%	0.0%	0.0%	8.5%	0.0%	4.0%	0.0%	13.8%	6.5%	0.0%	1.4%	0.0%	0.0%	0.0%	100.0%
17	3.5%	43.8%	10.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.1%	0.0%	0.0%	1.3%	2.3%	6.6%	3.5%	3.7%	6.7%	0.0%	0.0%	0.0%	4.6%	1.3%	100.0%
18	0.0%	1.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	61.6%	0.0%	0.0%	2.7%	0.0%	4.1%	0.0%	29.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
19	3.0%	56.0%	10.5%	0.8%	0.0%	4.9%	0.0%	0.0%	0.4%	0.0%	3.4%	0.0%	0.0%	0.0%	6.4%	8.2%	2.1%	0.0%	4.3%	0.0%	0.1%	0.0%	0.0%	0.0%	100.0%
20	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.7%	0.0%	0.0%	0.0%	0.0%	0.0%	4.4%	63.3%	3.6%	8.3%	16.6%	0.0%	0.0%	0.0%	100.0%
21	0.0%	5.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	15.1%	0.0%	0.0%	0.0%	0.0%	3.0%	3.0%	50.3%	0.0%	6.1%	16.9%	0.0%	0.0%	0.0%	100.0%
22	0.0%	11.0%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	51.6%	0.0%	0.0%	6.6%	0.0%	15.3%	14.3%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	100.0%
23	20.6%	68.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	4.0%	0.0%	100.0%
24	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.6%	0.0%	12.0%	57.7%	2.1%	14.5%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
25	0.0%	8.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	29.0%	0.0%	0.0%	10.8%	7.2%	17.0%	0.0%	10.9%	16.6%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
26	0.0%	7.4%	3.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.1%	18.0%	0.0%	0.0%	16.5%	0.0%	13.6%	1.4%	12.9%	23.6%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
27	0.0%	2.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.1%	0.0%	1.9%	0.0%	61.7%	0.0%	0.1%	21.2%	0.0%	0.0%	0.0%	100.0%

* The land cover structure elements: (111) continuous urban fabric, (112) discontinuous urban fabric, (121) industrial or commercial units, (122) road and rail networks and associated land, (123) port areas, (131) mineral extraction sites, (132) dump sites, (133) construction sites, (141) green urban areas, (142) sport and leisure facilities, (211) non-irrigated arable land, (221) vineyards, (222) fruit trees and berry plantations, (231) pastures, (242) complex cultivation patterns, (243) agriculture with significant areas of natural veg., (311) broad-leaved forest, (312) coniferous forest, (313) mixed forest, (321) natural grasslands, (324) transitional woodland-shrub, (411) inland marshes, (511) water courses, (512) water bodies.