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# Preliminary analysis of loss rates of honey bee colonies during winter 2015/16 from the COLOSS survey

Keywords: Apis mellifera; apiculture, colony loss; monitoring; winter survival; beekeeping; survey; citizen science

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Honey bees face several biotic and abiotic threats. In temperate climates, the overwintering period with no available forage is a critical phase for colony survival. In most countries there is a lack of data for colony losses, or it is not accompanied by other information, for example on hive management, that allows epidemiological risk analysis. In the past decade, research initiatives started to investigate winter losses of honey bee colonies. One of the efforts, including many European and some non-European countries (van der Zee et al., 2012, 2014) is organized through COLOSS (prevention of honey bee COlony LOSSes, currently a non-profit organization). Making use of standardized methods for surveys of beekeepers (van der Zee et al., 2013), this investigation provides a quick, but well accepted, measure of colony loss rates, and aims to identify regions with increased risk as well as to identify best practice hive management. In a previous study, inappropriate treatment against the parasitic mite Varroa destructor, access of foraging honey bees to certain crops, queen problems in summer and queen age have been demonstrated to significantly affect winter mortality (van der Zee et al., 2014).

In our most recent COLOSS survey starting in spring 2016, we asked beekeepers for the number of colonies wintered and how many of these colonies after winter (a) were alive but had unsolvable queen problems (like drone-laying queens or no queen at all) and (b) were dead or reduced to a few hundred bees. By the end of June 2016, 29 countries contributed data to our study. These data were collected centrally, processed and used for preliminary analysis for this short note. Data files were checked for consistency of loss data (i.e. number of colonies at start of winter should not be missing and should be greater than zero, number of colonies dead or lost due to queen problems should not be missing and should be greater than or equal to zero, number of dead colonies plus number of colonies lost due to queen problems should not be greater than number of colonies at start of winter). Altogether, we received valid answers from 19,952 beekeepers. These beekeepers collectively wintered 421,238 colonies, and reported 18,587 colonies with unsolvable queen problems and 32,048 dead colonies after winter. This gives an overall loss rate of 12.0% (95% confidence interval 11.8%-12.2%) during winter 2015/16, with marked differences among countries (Table 1). The highest loss rate was found in Ireland and Northern Ireland, followed by Wales and also Spain, whereas it was lowest in the Czech Republic and central Europe in general. Note that from Wales and Spain, but also some other countries, only a low number of responses, sometimes from certain regions only, were available this year. Relative risk calculations at regional level (regional loss rates divided by the overall loss rate; Figure 1) also highlight raised risk of loss in Scotland, Denmark, parts of Sweden and France and some areas in Eastern Europe.

The overall loss rate of colonies over the winter of 2015/16 is methodologically comparable to previous studies, for example the winter of 2012/13 with an overall loss rate of 16.1%, but of course with different coverage of participating countries and regions (van der Zee et al., 2014). For the same winter, a pan-European surveillance program, implemented in 17 countries, ascertained winter mortality based on field inspections to range from 4.7% to 30.6% in different countries (Chauzat et al., 2016). They found that clinically detected diseases (varroosis, American foulbrood and nosemosis) before winter significantly contribute to winter mortality. The calculation of loss rates presented in this note is methodologically not entirely comparable to those in the USA, but established surveys report for example a total loss rate of 22.3% for the winter of 2014/15 in the USA and even higher in some previous years (Seitz et al., 2016).

The loss rates presented in our previous publications likewise included both dead colonies (or empty hives) and colonies with queen problems, but as the sum of these two cases of loss (van der Zee et al., 2012, 2014). Beekeepers in the present study differentiated these two cases, and assessed 7.6% (95% CI 7.4%-7.8%) of their colonies as dead or empty, and 4.4% (95% CI 4.3%-4.5%) having unsolvable queen problems after winter. This underlines and, for the first time in Europe, quantifies often experienced but poorly studied symptoms associated with unknown pathogenesis or apparently spontaneous colony mortality (Tarpy et al., 2013). Again, winter losses related to queen problems (including a missing queen, laying workers, or a drone egg laying queen) varied between 1.3% in Algeria and 2.2% in the Czech Republic to 12.6% in Ireland and 13.9% in Northern Ireland (Table 1) and further surveillance of this phenomenon and the investigation of possible causes are recommended. More detailed studies are needed to investigate whether apicultural management, such as annual or biennial re-queening, can mitigate this problem.

The full COLOSS survey dataset allows for a number of possible risk factors for colony loss to be analysed. In this note we focus on an often investigated factor, operation size. We grouped beekeeping operations into small (S, 1 to 50 colonies; by far the most common in the countries represented here), medium (M, 51 to 150 colonies) and large (L, 151 colonies or more) operations, and found that in most countries, and also overall, class S had a significantly higher loss rate than class L and/or class M. This is comparable to previous findings (van der Zee et al., 2014; Seitz et al., 2016; Chauzat et al., 2016).

In this short note we present comparable loss rates of honey bee colonies during winter 2015/16 from 29 countries. Whereas the COLOSS monitoring of colony losses in some countries is well established and covers an appreciable proportion of beekeepers (Table 1), the response from some other countries is limited in number or is mostly confined to some regions only (Figure 1). We therefore aim to strengthen and extend this joint effort to gain more insight into colony losses. A more detailed statistical analysis of risk of losses, and other variables, including several years of data, is planned for separate publication.

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**Table 1**. Number of respondents, number of colonies going into winter, mortality rate (including 95% confidence interval, CI), loss rate of colonies due to queen problems, overall loss rate, response rate per country (expressed as percentage of responses per estimated number of beekeepers, though a few surveys were random and invited only selected beekeepers to participate) and effect of operation size. Mortality and loss rates were calculated as colonies lost as a percentage of colonies wintered, CIs were calculated using the quasi-binomial generalized linear modelling (GzLM) approach in van der Zee et al. (2013), and effect of operation size was tested using a single factor quasi-binomial GzLM to model probability of loss, see text for classification of operation sizes S, M, L. Significance codes for p-values: *** p<= 0.001 ; ** 0.001<p<=0.01; * 0.01<p<= 0.05; ns=non-significant (p>0.05).

| Country | No. of respon-dents | No. of colonies going into winter | % Mortality Rate (95% CI) | % Rate of loss of colonies due to queen problems (95% CI) | Overall winter loss rate (95% CI) | Estimated % of beekeepers represented | Effect of operation size |
|---|---|---|---|---|---|---|---|
| Austria | 1289 | 23418 | 4.5 (4.0-5.2) | 3.6 (3.3-3.9) | 8.1 (7.4-8.8) | 5 | ***M,L<S |
| Belgium | 451 | 4064 | 6.9 (5.8-8.3) | 5.2 (4.1-6.6) | 12.2 (10.5-14.0) | 5 | ns, few in class M/L |
| Czech Republic | 968 | 17350 | 4.1 (3.6-4.7) | 2.2 (2.0-2.5) | 6.4 (5.8-7.1) | 2 | ns, few in class L |
| Denmark | 1186 | 12359 | 6.9 (6.2-7.6) | 8.6 (8.0-9.3) | 15.5 (14.4-16.7) | 19 | ***L<S,M |
| Estonia | 71 | 5115 | 11.2 (8.5-14.7) | 4.3 (2.9-6.2) | 15.5 (12.2-19.5) | 1 | **L<S |
| Finland | 339 | 9222 | 10.8 (9.5-12.1) | 4.7 (4.0-5.4) | 15.4 (13.9-17.0) | 11 | *L<S |
| France | 488 | 36734 | 9.6 (8.5-10.8) | 3.8 (3.4-4.3) | 13.4 (12.2-14.7) | 1 | ns |
| Germany | 5952 | 75419 | 8.3 (7.9-8.6) | 3.5 (3.3-3.6) | 11.7 (11.4-12.1) | 5 | *L<S,M |
| Ireland | 427 | 4059 | 16.9 (15.2-18.9) | 12.6 (11.1-14.2) | 29.5 (27.4-31.7) | 14 | *M>S; no class L |
| Israel | 49 | 32165 | 5.3 (3.7-7.5) | 5.2 (4.1-6.5) | 10.5 (8.2-13.2) | 10 | ns |
| Latvia | 472 | 16367 | 7.4 (6.5-8.5) | 7.6 (6.1-9.5) | 15.0 (13.1-17.2) | 11 | *L>S,M |
| Macedonia | 296 | 17288 | 5.0 (4.4-5.7 | 3.0 (2.6-3.5) | 8.0 (7.1-8.9) | 10 | ns, but M<S |
| Netherlands | 1425 | 11815 | 7.4 (6.7-8.2) | 3.4 (3.0-3.8) | 10.8 (9.9-11.7) | 20 | ns, no class L |
| Northern Ireland | 93 | 574 | 14.3 (10.8-18.6) | 13.9 (10.3-18.6) | 28.2 (22.6-34.6) | 9 | n/a; only class S |
| Norway | 743 | 13249 | 8.0 (7.0-9.1) | 4.1 (3.7-4.7) | 12.1 (11.0-13.3) | 21 | ***M,L<S |
| Poland | 492 | 17822 | 6.0 (5.1-7.1) | 5.2 (4.7-5.9) | 11.3 (10.2-12.5) | 1 | **M<S; few in class L |
| Scotland | 154 | 701 | 12.8 (10.1-16.2) | 5.1 (3.4-7.6) | 18.0 (14.6-21.9) | 11 | n/a; only class S |
| Slovakia | 276 | 6783 | 4.0 (3.0-5.2) | 4.2 (3.4-5.2) | 8.2 (6.8-9.7) | 2 | ns, few in class L |
| Slovenia | 267 | 7910 | 11.1 (8.9-13.7) | 3.2 (2.6-3.8) | 14.2 (11.8-17.1) | 3 | ns |
| Sweden | 2092 | 25403 | 10.0 (9.3-10.7) | 5.9 (5.5-6.4) | 15.9 (15.1-16.8) | 15 | ***M,L<S |
| Switzerland | 1259 | 17813 | 4.8 (4.3-5.4) | 5.1 (4.7-5.5) | 9.9 (9.2-10.7) | 7 | *M<S; no class L |
| Ukraine | 399 | 13850 | 6.3 (5.3-7.5) | 3.6 (2.9-4.5) | 9.9 (8.5-11.4) | <1 | ***L<M<S |
| Countries with a data set mostly for a limited number of regions | | | | | | | |
| Algeria | 59 | 5729 | 11.9 (9.9-14.3) | 1.3 (0.9-1.9) | 13.2 (11.0-15.9) | <1 | ns |
| Italy | 309 | 6815 | 6.7 (5.6-8.1) | 5.8 (4.8-7.2) | 12.5 (10.9-14.5) | 1 | *L<S |
| Spain | 113 | 10786 | 15.4 (12.6-18.7) | 6.7 (5.0-9.1) | 22.1 (18.7-26.0) | <1 | *L<S,M |
| Turkey | 139 | 22160 | 4.9 (3.6-6.7) | 2.8 (1.9-4.0) | 7.7 (5.7-10.2) | <1 | ***L<S,M |
| Countries with limited data at this time | | | | | | | |
| Croatia | 62 | 4303 | 13.8 (9.2-20.1) | 2.6 (1.8-3.8) | 16.4 (11.6-22.7) | <1 | *, but no sig. diffs, few in class L |
| Lithuania | 43 | 1733 | 14.1 (10.7-18.4) | 4.6 (2.8-7.4) | 18.7 (14.4-24.0) | n/a | ***L<S,M, but only 1 in class L |
| Wales | 39 | 232 | 12.1 (7.2-19.6) | 10.3 (6.9-15.3) | 22.4 (16.0-30.4) | 1 | n/a; only class S |
| Overall | 19952 | 421238 | 7.6 (7.4-7.8) | 4.4 (4.3-4.5) | 12.0 (11.8-12.2) | n/a | ***M,L<S |

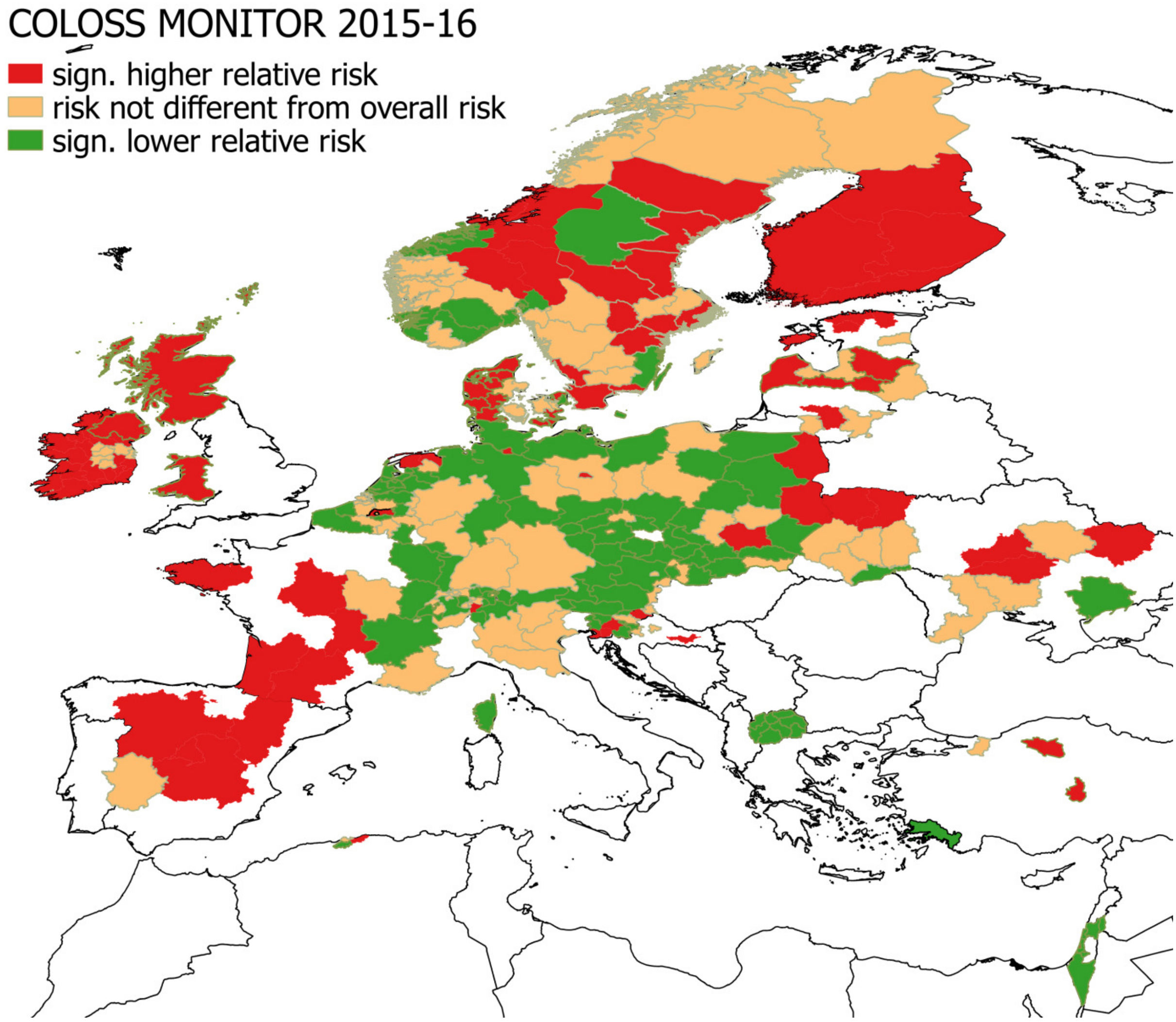


**Figure 1**. Map showing relative risk of overwinter loss at regional level (where sufficient beekeepers were represented in a region, taken as 6 or more beekeepers here). Regions with a loss rate significantly higher/lower than the overall loss rate are shown in red/green respectively.