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NOTES AND COMMENTS

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

Robert Brodschneidera,b,1, Alison Grayb,†, Romée van der Zeea,c,‡, Noureddine Adjlane,§, Valters Brusbardis,‡, Jean-Daniel Charrièreb,†, Robert Chleboń, Mary F Coffey, Karl Crailsheim, Bjørn Dahlé, Jiří Daníhlík, Ellen Danneels, Dirk C de Graaf,†, Marica Maja Dražić, Mariia Fedorik,§, Ivan Forsythe,‡, Miroljub Golubovski,‡, Ales Gregorc,§, Urszula Grzędz,a, Ian Hubbk, Raşşan Ivgın Tunca, Lassi Kaumo, Ole Kilpinena,‡, Justinas Kretavičia,†, Preben Kristiansen,†, Maritta Martikkala, Maritä Martikkalaa, Raquel Martíñ-Hernández,‡, Franco Mutinelli,‡, Magnus Peterson,§, Christoph Otten,§, Asli Ozkirima, Aivar Raudmet,‡, Noa Simon-Delso,§, Justinas Kretavičia,‡, Grazyna Topolska,‡, Julien Vallon,‡, Fleming Vejsnæs,§ and Saskia Woehl,aa

aInstitute of Zoology, University of Graz, Graz, Austria; bDepartment of Mathematics and Statistics, University of Strathclyde, Glasgow, UK; cNederlands Centrum Bijenonderzoek (NCB), Tersoal, Netherlands; dDepartment of Biotechnology, University M'hamed Bougara, Boumerde, Algeria; eLatvian Beekeepers Association, Jelgava, Latvia; fAgroscope, Swiss Bee Research Center, Bern, Switzerland; gDepartment of Poultry Science and Small Farm Animals, Slovak University of Agriculture, Nitra, Slovakia; hDepartment of Life Sciences, University of Limerick, Limerick, Ireland; iNorwegian Beekeepers Association, Kliifta, Norway; jFaculty of Science, Palacky University Olomouc, Olomouc, Czech Republic; kHoney Bee Apiculture Program, Mugla Sıtkı Kocman University, Mugla, Turkey; lCroatian Agricultural Agency, Zagreb, Croatia; mInstitute of Biology, Chemistry and Bioresources, Yuriy Fedkovych Chernivtsi National University, Chernivtsi, Ukraine; nThe Agri-Food and Biosciences Institute, Belfast, UK; oAssociation for Conservation of Macedonian Local Honey Bee (Apis mellifera macedonica) – MacBee, Negorci, Macedonia; pAgricultural Institute of Slovenia, Slovenia; qFaculty of Veterinary Medicine, Department of Pathology and Veterinary Diagnostics, Warsaw University of Life Sciences, Warsaw, Poland; rWelsh Beekeepers Association, Welshpool, UK; sDepartment of Plant and Animal Breeding, Apiculture Program, Mugla Sıtkı Kocman University, Mugla, Turkey; tFinnish Beekeepers Association, Helsinki, Finland; uDanish Beekeepers Association, Søren, Denmark; vInstitute of Environment and Ecology, Aleksandras Stulginskis University, Vilius, Lithuania; wSwedish Beekeepers Association, Malmö, Sweden; xConsejería de Agricultura de la Junta de Comunidades de Castilla-La Mancha (CIAPA, IRIAF), Marchamalo, Spain; yIstituto Zooprofilattico Sperimentale delle Venezie, Italy; zDLR Fachzentrum für Bienen und Imkerei, Mayen, Germany; aaHacettepe University, Ankara, Turkey; bbEstonian Beekeepers Association, Tallinn, Estonia; cBeekemapping and Information Centre, Louvain la Neuve, Belgium; dAgricultural Research Organization, The Volcani Center, Bet Dagan, Israel; eeITSA-Institut de l’abeille, Avignon, France

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In this short note we present comparable loss rates of honey bee colonies during winter 2015/16 from 29 countries, obtained with the COLOSS questionnaire. 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. Beekeepers in the present study 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%) as having unsolvable queen problems after winter. The overall analysis showed that small operations suffered higher losses than larger ones. A table with detailed results and a map showing response and relative risks at regional level are presented.

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

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

Corresponding author. E-mail: Robert.Brodschneider@uni-graz.at

1Robert Brodschneider conceived the idea for the paper and wrote a first draft.

2Did data processing and editing, all statistical analysis for the table, and contributed to the text.

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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 had 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 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 modeling (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.

| Country        | No. of respondents | 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               | 23,418                           | 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                | 17,350                           | 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               | 12,359                           | 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)                | 11                                   | **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                | 36,734                           | 9.6 (8.5–10.8)           | 3.8 (3.4–4.3)                                            | 13.4 (12.2–14.7)                | 1                                    | Ns                   |
| Germany        | 5952               | 75,419                           | 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                                   | **L > M, S           |
| Israel         | 49                 | 32,165                           | 5.3 (3.7–7.5)            | 5.2 (4.1–6.5)                                            | 10.5 (8.2–13.2)                 | 10                                   | Ns                   |
| Latvia         | 472                | 16,367                           | 7.4 (6.5–8.5)            | 7.6 (6.1–9.5)                                            | 15.0 (13.1–17.2)                | 11                                   | Ns                   |
| Macedonia      | 296                | 17,288                           | 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               | 11,815                           | 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                | 13,249                           | 8.0 (7.0–9.1)            | 4.1 (3.7–4.7)                                            | 12.1 (11.0–13.3)                | 21                                   | **M, L < S          |
| Poland         | 492                | 17,822                           | 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               | 25,403                           | 10.0 (9.3–10.7)          | 5.9 (5.3–6.4)                                            | 15.9 (15.1–16.8)                | 15                                   | **M, L < S          |
| Switzerland    | 1259               | 17,813                           | 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                | 13,850                           | 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                | 10,786                          | 15.4 (12.6–18.7)         | 6.7 (5.0–9.1)                                            | 22.1 (18.7–26.0)                | <1                                   | **L < S, M           |
Turkey          139                | 22,160                          | 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. diff. 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           |
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        19,952             | 421,238                         | 7.6 (7.4–7.8)            | 4.4 (4.3–4.5)                                            | 12.0 (11.8–12.2)                | N/a                                  | **M, L < S          |

Notes: Significance codes for p-values: ***p < 0.001; **0.001 < p <= 0.01; *0.01 < p <= 0.05; Ns = non-significant (p > 0.05).
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., 2015).

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, Lengerich, & Pettis, 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 data-set allows for a number of possible risk factors for colony loss to be analyzed. In this note we focus on an often investigated factor, operation size. We grouped beekeeping operations into small (S, 1–50 colonies; by far the most common in the countries represented here), medium (M, 51–150 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 (Chauzat et al., 2016; Seitz et al., 2015; van der Zee et al., 2014).

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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ORCID
Robert Brodschneider http://orcid.org/0000-0002-2535-0280
Alison Gray http://orcid.org/0000-0002-6273-0637
Jean-Daniel Charrière http://orcid.org/0000-0003-3732-4917
Robert Chlebo http://orcid.org/0000-0001-8715-0578
Dirk C. de Graaf http://orcid.org/0000-0001-8817-0781
María Fedoriak http://orcid.org/0000-0002-6200-1012
Ivan Forsythe http://orcid.org/0000-0002-8642-102X
Lassi Kauko http://orcid.org/0000-0001-7836-6553
Ole Kilpínen http://orcid.org/0000-0001-6972-1648
Preben Kristiansen http://orcid.org/0000-0001-6718-2214
Maritta Martikkala http://orcid.org/0000-0001-5761-8627
Raquel Martín-Hernández http://orcid.org/0000-0002-1730-9368
Franco Mutinelli http://orcid.org/0000-0003-2903-9390
Christoph Otten http://orcid.org/0000-0001-5324-2255
Aslı Ozkirim http://orcid.org/0000-0002-8930-2587
Noa Simon-Delso http://orcid.org/0000-0003-1729-890X