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ORIGINAL RESEARCH ARTICLE

# Declines of managed honey bees and beekeepers in Europe

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## Summary

Growing evidence indicates that European managed honey bees are in decline, but information for Europe remains patchy and localized. Here we compile data from 18 European countries to assess trends in the number of honey bee colonies and beekeepers between 1965 and 2005. We found consistent declines in colony numbers in central European countries and some increases in Mediterranean countries. Beekeeper numbers have declined in all of the European countries examined. Our data support the view that honey bees are in decline at least in some regions, which is probably closely linked to the decreasing number of beekeepers. Our data on colony numbers and beekeepers must, however, be interpreted with caution due to different approaches and socioeconomic factors in the various countries, thereby limiting their comparability. We therefore make specific recommendations for standardized methodologies to be adopted at the national and global level to assist in the future monitoring of honey bees.

# Pérdidas de abejas manejadas y apicultores en Europa

## Resumen

Cada vez hay más pruebas que indican que las abejas europeas manejadas están en declive, pero la información para Europa sigue desigual y localizada. Aquí compilamos datos a partir de 18 países europeos para evaluar las tendencias respecto al número de colonias de la abeja de la miel y de apicultores entre 1965 y 2005. Encontramos constantes disminuciones en cuanto al número de colonias en países centroeuropeos y algún aumento en países mediterráneos. El número de apicultores ha disminuido en todos los países europeos examinados. Nuestros datos apoyan la visión de que las abejas de la miel están disminuyendo por lo menos en algunas regiones, lo que está probablemente ligado a la disminución de apicultores. Nuestros datos sobre el número de colonias y de apicultores deben, sin embargo, ser interpretados con precaución debido a diversos enfoques y a los factores socioeconómicos en los diversos países, limitando por tanto su comparación. Por lo tanto hacemos recomendaciones específicas para que sean adoptadas metodologías estandarizadas al nivel nacional y global para ayudar en la futura supervisión de las abejas de la miel.

**Keywords:** *Apis mellifera*, honey bee declines, colonies, colony losses, beekeeping, pollinator decline

# Introduction

Honey bees have been managed in Europe for several millennia (Crane, 1999) and have contributed to human diets directly through honey, and indirectly by providing pollination services to a wide range crops and wild plants. It is estimated that 84% of the European Union's crops depend, at least in part, on insect pollination (Williams, 1994) and honey bees are the easiest to manage, and thus appear to be the most important crop pollinators (McGregor, 1976; Delaplane and Mayer 2000). In light of the importance of honey bees for pollination and human nutrition, recent major losses of honey bee colonies demand urgent scientific clarification. While it is well established that the ectoparasitic mite *Varroa destructor* is a major contributor following its arrival in Europe in the 1970s, the drivers of more recent losses remain unclear (Stokstad, 2007). It is obvious that any understanding of the underlying factors and causes for these major colony losses requires a detailed knowledge of the number of live and dead colonies, ideally at a global scale.

Whilst a 'global pollinator crisis' was questioned by Ghazoul (2005), there have been an increasing number of local reports over past decades suggesting that the numbers of honey bee colonies are declining. In the USA, the statistics show declines in honey bee colonies in 1947-1972, 1989-1996, a recent drop in 2005 (National Research Council, 2006), as well as major losses in the past two years (vanEngelsdorp *et al.*, 2008). For Europe, however, the evidence is patchy and often poorly documented despite clear and severe cases of honey bee losses in a number of regions (e.g. Rosenkranz and Wallner, 2008). Moreover, the numbers of beekeepers have not been assessed at a European scale, which is probably crucial because density of colonies closely matches the density of beekeepers (Moritz *et al.*, 2007). Furthermore, wild or feral honey bee colonies are also declining in the USA and in Europe (Kraus and Page, 1995; Moritz *et al.,* 2007; Jaffé *et al.,* 2009) most probably due to *V. destructor*, leaving behind only those colonies kept by beekeepers. In conclusion, there has as yet been no large-scale assessment of the extent of the problem in Europe. It is therefore prudent to bring together and critically assess the available information for Europe. Here we aim to quantify the extent of changes in honey bee colony numbers and beekeepers across Europe over past decades.

# Materials and methods

We selected a number of European countries for the purposes of data mining. The choice of country was based on the availability of suitable data and geographic spread. The 18 countries included were: Austria (AT); Belgium (BE); Czech Republic (CZ); Denmark (DK); England (EN); Finland (SF); Germany (DE); Greece (GR); Italy (IT); Luxembourg (LU); Netherlands (NL); Norway (NO); Poland (PL); Portugal (PT); Scotland (SC); Slovakia (SK); Sweden (SE) and Wales (WA).

Using national beekeeping journals, national beekeeping organizations and government reports, we collected information on the total number of colonies and beekeepers (Table 1). In order to assess changes through time, we targeted data in five-year increments from 1965 to 2005. Not all countries were able to provide data for all dates. For two countries, we were able to access additional detailed annual statistics for colony and beekeeper numbers: Sweden, 1920-2005 and England, 1953-2008 (Table 1). Information on the arrival date for *V. destructor* in each country was obtained, where possible, from journal publications or national beekeeping organizations or equivalent (Table 1).

Tabulations of total numbers of colonies and beekeepers were made for each country through time and data gaps identified. Two comparison periods were selected, based on good data coverage and historical relevance: net percentage change between 1965 and 1985 and net percentage change between 1985 and 2005.

To examine for regional differences, countries were assigned using climatic characteristics as central European (AT, BE, CZ, DE, DK, EN, LU, NL, PL, SC, SK and WA), Scandinavia (NO, SF and SE), or Mediterranean (GR, IT, and PT). Mean net changes for colony numbers and beekeeper numbers for all countries and regions were compared to zero (no change) using a t-test. All datasets were tested for normality and transformed where appropriate.

# Results

Data on colony numbers were available for 14 European countries for 1965 to 1985, and for 18 countries for 1985 to 2005. In both cases there were mixed changes among countries, with some countries showing a net increase in colonies and others showing a net decrease (Table 2 and Figs 1a and 1b). There was no overall trend in colony numbers when countries were pooled, i.e. the net trend was not significantly different from zero, for 1965-1985 ($t=1.76$, $n=14$, $p=0.102$), but for 1985-2005 there was a significant overall decline of 16% ($t=3.22$, $n=17$, $p=0.005$). There were also distinct regional variations for both time period comparisons. For 1965-1985, the Scandinavian and Mediterranean regions showed net increases in colony numbers (61%: $t=10.1$, $n=3$, $p=0.010$ and 37%: $t=11.48$, $n=2$, $p=0.055$ respectively, Table 2), and while there was no overall change in central Europe, there were consistent decreases in western central Europe (Fig. 1a: AT, BE, DE, DK, EN, LU, WA) compared to eastern central Europe (CZ, SK). However, between 1985 and 2005, the trends within Europe had changed with a significant 25% decrease in colonies in central Europe (Fig. 1b: $t=5.34$, $n=11$, $p<0.001$), but no net change in either Scandinavia or the Mediterranean (Table 2).

***Table 1***. Countries assessed in this study with data sources, regional categorization and estimated date of *Varroa* arrival.

| **Country** | **Code** | **Data sources** | **Region** | **Estimated date of *Varroa* arrival** |
|---|---|---|---|---|
| Austria | AT | Journal: *Bienen Vater* (1960 to 2005)*; Österreichischer Imkerbund; http://aeiou.iicm.tugraz.at/aeiou.encyclop.b/b457627.htm;internal&action= _setlanguage.action?LANGUAGE=en; ww.apiservices.com. | Central | 1980-1986 |
| Belgium | BE | Journal: *La Belgique Apicole, Revue Belge d' Apiculture, Maandblat Koninklijke Vlaamse Imkersbund* (1960 to 2005)*; Letzebuerger Beien-Zeitung (1989) Hundert Jahre Letzebuerger Beienzeitung. 100: 52; Nivaille, J (1993) 100 ans d'apiculture en Belgique de 1890 a nos jours. Carnets du CARI, 36: 36-39; Schulz, A (1987) Hat unsere traditionelle Imkerei noch eine Zukunft? *Biene* (1987) 123: 11-16; Prof. Dr O Van Laere (pers. comm.), ex-director, Merelbeke Institute, Ghent University; www.apiservices.com. | Central | 1980-1981 |
| Czech Republic | CZ | Journal: *Včelařtví* (1960 to 2005)*; Dr. V Vesely (pers. comm.), Czech Beekeeping Institute, Dol; Samsinak K, Haragsim O (1972) The mite *Varroa jacobsoni* imported into Europe. *Vcelarstvi*. 25: 268-269; www.apiservices.com. | Central | 1972-1984 |
| Denmark | DK | Flemming Vejsnæs (pers. comm.), Danish Beekeepers Association. | Central | |
| Europe | EU | European Community, COPA/COGECA. Beekeeping in the European Community; problems and needs, Pr (89) 26, P (89) 28. Brussels, Belgium; Comite des Organisations Professionnelles Agricoles de la C.E. (1989) 70 pp; Jones, H R (2004) European beekeeping in the 21st Century. *Bee World* 85: 77. | N/A | N/A |
| England | EN | Survey of Bee Health & Beekeeping in England & Wales, (1955-1971), MAFF; Beekeeping Statistics, (1972-1979), MAFF; Beekeeping and Bee Health Statistics (1980-1992), MAFF; National Bee Unit database. | Central | 1992 |
| Finland | SF | Journal: *Bienen Mehiläinen* (1970 to 2005)*; Dr K Fakhimzadeh (pers. comm.), University of Helsinki, and Mr K Koivalehto, Finnish honey packers Association; www.apiservices.com. | Scandi-navia | 1980 |
| Germany | DE | Journal: *Deutsches Bienen* (1965 to 2005)*; Deutscher Berufs und Erwerbs Imker Bund E.V.; Silke Beckedorf (pers. comm.), Editor, *Deutsches Bienen* Journal, and Dr Werner von der Ohe (pers. comm.), Chairman, International Honey Commission, Bienen Institute, Celle, Germany; Ruttner F. 1977. Interim report on the cause of V*arroa* infection. *Die Biene* 13: 353-354; www.apiservices.com. | Central | 1977 |
| Greece | GR | Santas, L A (1979) Problems of honey bee colonies in Greece. *Apiacta* 14: 127-313; Dr. Fani Hatjina (pers. comm.), Hellenic Institute for Apiculture, Moudania, Greece; www.apiservices.com. | Mediter-ranean | 1979-1981 |
| Ireland | IE | Journal: *An Beachaire* (1960 to 2005)*; Jim Ryan (pers. comm.), editor of *An Beachaire*. | Central | 1998 |
| Italy | IT | Journal: *Apicoltore D' Italia* (1960 – 1973)*; Journal: *L'Ape Nostra Amica* (1979 – 1995)*; Dr Anna-Gloria Sabatini (pers. comm.), CRA-API, Direttore Incaricato, Via di Salicento 80, Bologna, Italy. | Mediter-ranean | 1981 |
| Luxembourg | LU | Journal: *Letzebuerger Bienen Zeitung* (1960 to 2005)*; Bormann, J (1992) Bienenhaltung in Luxemburg. *Neue Bienen Zeitung* 3: 37-39. | Central | |
| Netherlands | NL | Journal: *Onze Bijen* (1979 – 1990)*; Journal: *Bijenteelt* (1965 – 1991)*; Journal: *Maandschrift voor Bijenteelt* (1960 – 1989)*; Jan Charpentier (pers. comm.), Beekeeping Advisor to NMCP, Bezuidenhoutsweg,12, The Hague; www.apiservices.com. | Central | 1980-1981 |
| Norway | NO | Bjørn Dahle (pers. comm.), Norwegian Beekeepers Association. | Scandi-navia | |

*Archive copies from International Bee Research Association library.

***Table 1 Cont.*** Countries assessed in this study with data sources, regional categorization and estimated date of *Varroa* arrival.

| Country | Code | Data sources | Region | Estimated date of *Varroa* arrival |
|---|---|---|---|---|
| Poland | PL | Journal: *Pszczelnicze Zeszyty Naukowe* (1957 –1995)*; Journal: *Pszczelarstwo* (1990 –2005)*; Dr Grazyna Topolska (pers. comm.), School of Veterinary Medicine, University of Warsaw, and Prof. Dr J Woyke (pers. comm.), Bee division, Agricultural University, Warsaw; Koivulehto K. (1976) *Varroa jacobsoni*, a new mite infesting honey bees in Europe. *British Bee Journal* 104: 16-17; www.apiservices.com. | Central | 1976 |
| Portugal | PT | Dr Antonio Murilhas (pers. comm.), Instituto de Cien Agrarias Mediterranicas, Evora University, Portugal; www.apiservices.com. | Mediter-ranean | |
| Scotland | SC | Beekeeping and Honey Statistics (1984-1989), MAFF; Murray M. and Simcox H. (2003) Use of wild living resources in the UK – a review. UK Committee for IUCN. | Central | 1992 |
| Slovakia | SK | Journal: *Vcelar* (1959 to 1994)*; Slovakian Ministry of Agriculture; Prof. Dr J Šimúth (pers. comm.), Slovak Academy of Sciences, Bratislava, and Róbert Chlebo (pers. comm.), National Agricultural University, Nitra, Slovakia; www.apiservices.com. | Central | |
| Sweden | SE | Journal: *Bitidingen* (1960 to 2000)*; Sveriges Biodlares Riksförbund; Prof. Dr. Ingemar Fries (pers. comm.), Agricultural University, Uppsala, Sweden, Janne Mårtensson (pers. comm.), and Lotta Fabricius (pers. comm.). | Scandi-navia | 1980-1981 |
| Wales | WA | Survey of Bee Health & Beekeeping in England & Wales, (1955-1971), MAFF; Beekeeping Statistics, (1972-1979), MAFF; Beekeeping and Bee Health Statistics (1980-1992), MAFF. | Central | 1992 |

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***Table 2.*** Net proportional changes (%) in the numbers of honey bee colonies and beekeepers between 1965 and 1985 and 1985 and 2005 by region. Values are means ± SE (n = number of countries where data was available). Symbols indicate the probability of the mean being significantly different from zero; where *** = p<0.001, ** = p<0.01* = p<0.05, and $^{(*)}$ = p<0.08.

| Comparison | Region | Net % change in | |
|---|---|---|---|
| | | Colony numbers | Beekeeper numbers |
| 1965 - 1985 | All Europe: | 16.2 ± 9.2 (14) | 0.0 ± 14.3 (11) |
| | Central Europe | -3.6 ± 8.1 (9) | -26.0 ± 12.4 (7) $^{(*)}$ |
| | Mediterranean | 37.4 ± 3.3 (2) $^{(*)}$ | 41.7 ± 0.0 (1) |
| | Scandinavia | 61.2 ± 6.1 (3) ** | 46.7 ± 22.8 (3) |
| 1985 - 2005 | All Europe: | -16.1 ± 5.0 (17) ** | -31.4 ± 4.5 (15) *** |
| | Central Europe | -24.7 ± 4.6 (11) *** | -37.9 ± 4.8 (10) *** |
| | Mediterranean | 13.3 ± 3.3 (3) $^{(*)}$ | -2.5 ± 3.3 (2) |
| | Scandinavia | -14.1 ± 13.1 (3) | -29.2 ± 0.4 (3) *** |

For the 1965 comparison with 1985, there was no significant overall change in European in beekeeper numbers (Fig. 1c), however, in central Europe there was a 26% decrease in beekeepers (t=2.10, n=7, p=0.080). In contrast, between 1985 and 2005 there was a significant 31% reduction in the number of beekeepers in Europe as a whole (Fig. 1d: t=7.06, n=15, p<0.001), which was driven by a 38% decline in central Europe (t=7.97, n=10, p<0.001) and a 29% decline in Scandinavia (t=67.17, n=3, p<0.001).

A detailed time series for Sweden (1920-2005) revealed two peaks in colony and beekeeper numbers; the first was a major peak in 1940-1955 followed by a sharp decline, and the second was a smaller peak from the mid 1980s to mid 1990s, again followed by a decline (Fig. 2a). In England, data from 1953 to 2008 were available, though there were gaps for 1954 and 1993-2007. Steady declines were apparent in the 1950s and 1960s (Fig. 2b), followed by fluctuations up until 1993, and then lower numbers in 2008.

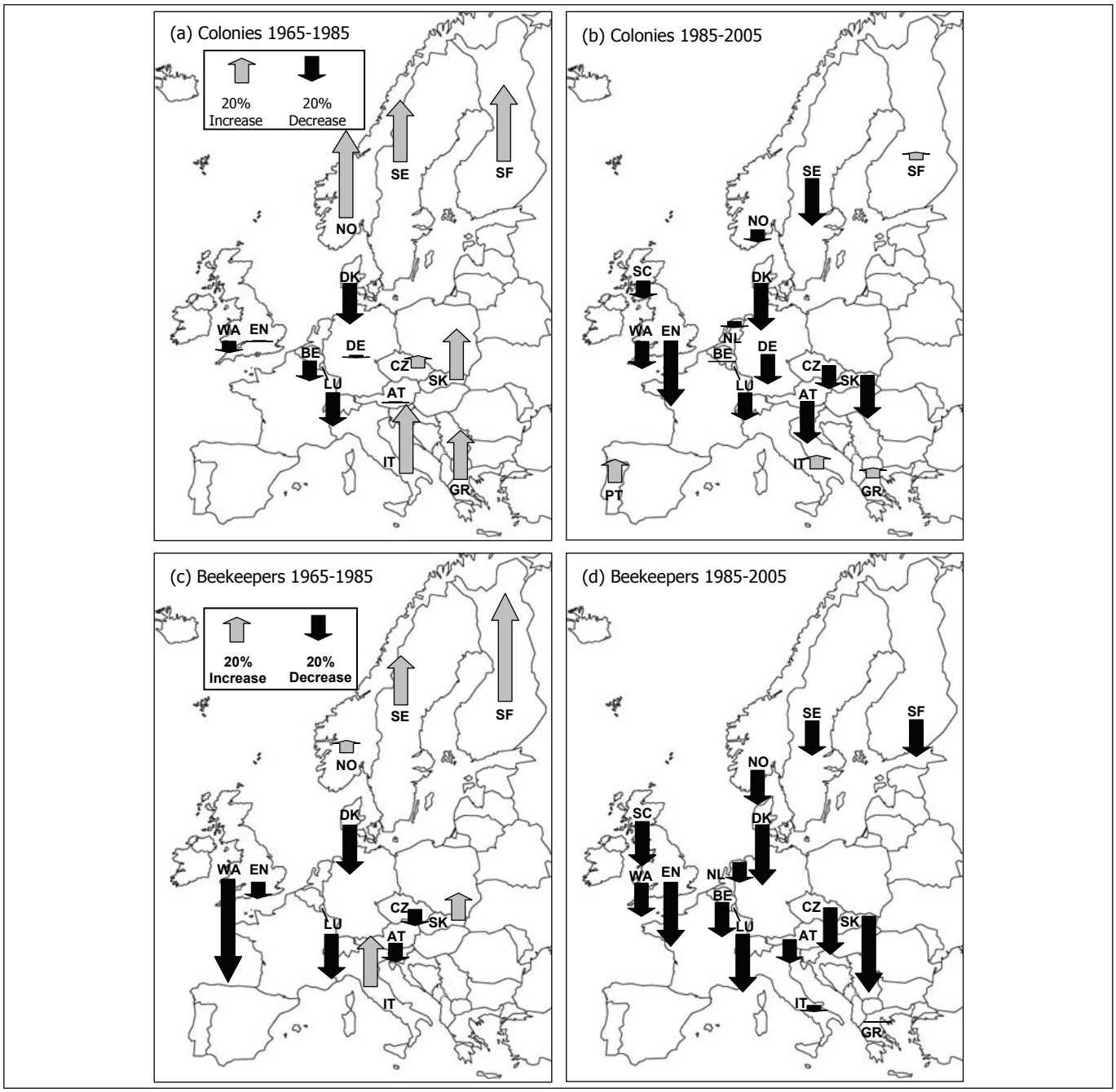


***Fig. 1.*** Graphical summary of the net proportional changes (%) in: total numbers of honey bee colonies between 1965 and 1985 (a), and 1985 and 2005 (b); total numbers of beekeepers between 1965 and 1985 (c), and 1985 and 2005 (d). Black arrows indicate decreases, grey arrows indicate increases, and the height of the arrow is proportional to the percentage change with reference arrows provided in legends. Country codes are given in Table 1.


***Fig. 2.*** Total numbers of colonies and beekeepers through time in (a) Sweden, and (b) England.

# Discussion

Our data suggest consistent declines in honey bee colony numbers in central European countries but some increases in Mediterranean countries. Furthermore, beekeeper numbers have declined in all European countries examined.

Based on FAO data (FAO, 2009), it is reported that honey bee hives have globally increased by ~45% during the last 50 years, though this has probably been driven by economic globalization (such as the increasing demand for agricultural pollination services) rather than any biological factor (Aizen and Harder, 2009). Given the concurrent declines in Europe (this study) and the USA (National Research Council, 2006), yet overall global increase, this suggests that increases in managed honey bees outside of Europe and the USA must be even greater than 45%, highlighting the stark contrast in trends from different regions of the globe. It should be noted that the FAO data only give an estimate of the current number of hives for a particular year and do not include any record of losses, so some caution in interpretation is needed, as local declines may be masked by aggregated data.

Marked changes in the numbers of managed honey bee colonies have occurred across Europe since 1965, but the pattern is heterogeneous. There has been a general trend for a decline in central Europe (Austria, Belgium, Denmark, England, Germany, Luxembourg, Netherlands, Poland, Scotland and Wales) since 1965, with declines also reported in other countries (Czech Republic, Norway, Slovakia and Sweden) since 1985. In contrast, Mediterranean countries (Greece, Italy and Portugal) have shown a consistent increase between 1965 and 2005. In Scandinavia (Finland, Norway and Sweden) a general increase in colony numbers between 1965 and 1985 has switched to decreases in Sweden and Norway, and a much smaller rate of increase in Finland between 1985 and 2005. The possible drivers for these patterns are numerous and fall into two general categories. The patterns could be an artefact of the way data have been collected, or alternatively the observed patterns may represent actual changes in the honey bees and beekeeping in the study countries. Here we will assess both possibilities and suggest how future monitoring of honey bees can be improved.

We are interested in general patterns through time, and while data were collected by different national bodies over several decades with each country operating its own census, we could find no evidence that the method of collection changed at any point in time across countries. Given the consistency of trends across countries and regions, and the lack of any obvious mechanism that could distort records consistently in one direction, we conclude that the direction of observed trends is reliable. We do however, note that the magnitude of trends may be less reliable and this is discussed below.

Several drivers of honey bee loss have been proposed (Stokstad, 2007; vanEngelsdorp *et al.*, 2009), but to date there is little consensus on which driver, or combination of drivers, are responsible for observed declines in Europe except for the mite *V. destructor*, which clearly plays a central role, because it infests virtually every honey bee colony in Europe. Since other important European pollinators, such as solitary bees, bumble bees and hoverflies have also been reported to have severely declined since 1980 in the UK and the Netherlands (Biesmeijer *et al.*, 2006), it seems as if at least some of the drivers are the same for honey bees and other pollinators. In any case, the potential causes and factors for losses cannot be adequately addressed based on the presented data. While general patterns are apparent, we urge caution in any interpretation of the magnitude of such changes. For instance, we present national means that may mask stark regional differences. Historical data collection methods vary between countries and there has been little standardization across Europe. Data published in journals are net figures that estimate of the number of colonies surveyed at one point in time, and do not, for instance, give a measure of the number of hives imported or exported. It is difficult to compare data from countries with no registration of colonies with data from countries in which beekeepers are subsidized per colony, data from countries where beekeepers get paid for lost colonies or both of the latter. Moreover, in some countries beekeepers even have to pay a tax per hive. Increases and decreases are, however, only considered within countries, thereby limiting the effect of these factors. On the other hand, policy might have changed in some countries within the evaluation period, which further limits data interpretation. In conclusion, we found trends, which should, however, be carefully interpreted.

The overall trend for changes in the number of beekeepers in each country is largely consistent with the pattern for colonies, thereby confirming earlier studies (Moritz *et al.*, 2007). We found consistent marked declines in central Europe between 1965 and 2005; there were some increases in Scandinavia and the Mediterranean for 1965-1985, but this was then followed by a decline since 1985. Declines in beekeeper numbers across Europe is a trend related to several potential factors, besides the above mentioned socioeconomic factors for colony numbers. In recent decades, rising incomes in rural areas have meant that production of honey for 'own use' is less important as alternative sugar and honey products are more readily affordable. Manpower requirements for agriculture have also decreased with higher proportions of rural populations working in urban areas and hobby beekeeping becoming less popular. The price of treating bee diseases has increased to the extent that the cost of treatments may equal or exceed the income from a colony for an entire year, thus making it uneconomic to keep bees on a small scale (Hoopingarner and Sanford, 1991). Moreover, the effort for treating disease, in particular *V. destructor*, has probably also reduced the attractiveness of beekeeping as a hobby. These socio-economic factors are the probable overall drivers for the reduction of beekeeper

numbers, although there may be strong regional differences in the type and strength of individual pressures acting. For example, increases in colonies and beekeeper numbers in recent times in some countries (Fig. 1) may have resulted from the higher demand for hives to be exported. For example, due to obviously much milder and shorter winters, Mediterranean countries are able to supply mated queens and nucleus colonies earlier than more northerly European countries. With greater winter mortality there may be an increased demand for bees and queens earlier and earlier in the year.

We recommend the following general actions at the local, national, European and possibly global levels, which will facilitate a better understanding of the changes in honey bees and assist in quantifying and identifying the drivers of changes:

1. Adoption of a standardized methodology for surveys, with data reported at the local and national levels and then compiled in a central and web-based database. Data should be partitioned to also include the number of colonies imported and exported annually and to account for migratory beekeeping.
2. Collation of information on colony mortality at the local and national levels using standardized criteria and protocols to assign actual or probable cause of loss.
3. Development of a globally coordinated research programme to quantify the relative contributions of the various potential factors such diseases, habitat changes (including agro-chemical use), socio-economics, etc.
4. Creation of a research organization to ensure pollination, which will take advantage of a global network to co-ordinate disease reporting, research and introduce methodologies for treatment programs, as well as acting as a permanent home to the IBRA library and other libraries that are currently distributed across Europe. Such a facility could act as a clearing house for research outputs, coordinate the publication of relevant findings and assist in the targeting of research funds to specific problems.

Our recommendations are consistent with several recent EU initiatives with the shared aim of monitoring bee mortality and colony losses, including standardization of monitoring protocols, harmonization of diagnoses and analyses, and centralization of data collections. The COLOSS network (= Prevention of honey bee COlony LOSSes) is at present supported by COST (European COoperation in Science and Technology) via the Action FA0803. It is one the largest honey bee networks in history, currently consisting of over 150 partners in 41 countries (most of Europe, Australia, Canada, Chile, Israel, Jordan, Peru, PR China, South Korea, Republic of South Africa, USA). COLOSS comprises the three main groups of stakeholders (scientists, beekeepers and industry) with the goal to complement and not duplicate national efforts. The main objective of COLOSS is to improve knowledge and prevent large scale losses of honey bee colonies, and while COLOSS does not directly support scientific research it aims to harmonize and integrate national activities across Europe and worldwide. As part of the process, international standards will be developed for both monitoring and research activities in the form of a "Bee Book" (analogous to the Red Book for *Drosophila*, Lindsley and Zimm, 1992). The Bee Book will be used as a framework to integrate various COLOSS working groups and thus enable joint large-scale international efforts to identify the underlying drivers for colony losses. It is crucial to work internationally, because attempts by individual countries to identify the drivers of colony losses and develop sustainable management are likely to fail due to the high number of interacting factors driving losses and inter-regional differences. We urge policy makers and practitioners to support these initiatives and our recommendations so that further losses of honey bees can be detected, quantified and understood, and appropriate mitigation strategies developed.

In conclusion, our study suggests that there is a decline in honey bee colonies in central Europe and in beekeeper numbers across Europe. Since other pollinators such as some wild bees and hoverflies, are also in decline (Biesmeijer *et al.*, 2006), this presents a potential threat to pollination services both to crops and to wild flowers. Our data must, however, be cautiously interpreted due to the various potential factors interfering with data collection. With the limited evidence available it is neither possible to identify the actual driver of honey bee losses in Europe nor to give a complete answer on the trends for colonies and beekeepers. This obviously creates an urgent demand for a standardization of evaluation methods, especially on colony numbers. Such harmonized reliable methods will be the obvious backbone for any research to understand and mitigate honey bee colony losses.

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# References


AIZEN, M A; HARDER L D (2009) The global stock of domesticated honey bees is growing slower than agricultural demand for pollination. *Current Biology* 19: 915-918.

BIESMEIJER, J C; ROBERTS, S P M; REEMER, M; OHLEMÜLLER, R; EDWARDS, M; PEETERS, T; SCHAFFERS, A P; POTTS, S G; KLEUKERS, R; THOMAS, C D; SETTELE, J; KUNIN, W E (2006) Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science* 313: 351-354.

CRANE, E (1999) Recent research on the world history of beekeeping. *Bee World* 80: 174-186.

DELAPLANE, K S; MAYER, D F (2000). *Crop Pollination by Bees*. CABI Publishing; UK.

FAO (2009) FAOSTAT/Production/ Live Animals. http://faostat.fao.org

HOOPINGARNER, R; SANFORD, M T (1991) The costs of beekeeping. II: Survey of Sideline Beekeepers. *American Bee Journal* 131: 114-115.

JAFFÉ, R.; DIETEMANN, V.; ALLSOPP, M H; COSTA, C; CREWE, R M; DALL' OLIO, R; DE LA RUA, P; EL-NIWEIRI, M A A; FRIES, I; KEZIC, N; MEUSEL, M S; PAXTON, R J; SHAIBI, T; STOLLE, E; MORITZ, R F A (2009) Estimating the density of honey bee colonies across their natural range to fill the gap in pollinator decline censuses. *Conservation Biology* DOI: 10.1111/j.1523-1739.2009.01331.x

KRAUS, B ; PAGE, R E (1995) Effect of *Varroa jacobsoni* (Mesostigmata: Varroidae) on feral *Apis mellifera* (Hymenoptera: Apidae) in California. *Environmental Entomology* 24: 1473–1480.

LINDSLEY D L; ZIMM, G G (1992) The great red book. The genome of *Drosophila melanogaster* (1992). Academic Press; San Diego, USA.

MCGREGOR, S E (1976) *Insect Pollination of Cultivated Crop Plants*. U.S. Department of Agriculture - Agricultural Research Service; Washington DC, USA.

MORITZ, R F A; KRAUS B; KRYGER P; CREWE R M (2007) The size of wild honey bee populations (*Apis mellifera*) and its implications for the conservation of honey bees. *Journal of Insect Conservation* 11: 391–397.

NATIONAL RESEARCH COUNCIL (2006) *Status of pollinators in North America.* National Academic Press; Washington DC, USA.

ROSENKRANZ, P; WALLNER, K (2008) The chronology of honey bee losses in the Rhine Valley during spring 2008: an example of a worst case scenario. In *Proceedings of the 3rd European Conference of Apidology; Belfast, UK*, p. 94-95.

STOKSTAD, E (2007) The case of the empty hives. *Science* 316: 970-972.

VANENGELSDORP, D; HAYES, J; UNDERWOOD, R M; PETTIS, J (2008) A survey of honey bee colony losses in the U.S., Fall 2007 to Spring 2008. *PLoS ONE*, 3(12) e4071.

WILLIAMS, I H (1994) The dependence of crop production within the European Union on pollination by honey bees. *Agricultural Zoology Reviews* 6: 229-257.