The survey of wild bees (Hymenoptera, Apoidea) in Belgium and France

by

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Summary

The Mons and Gembloux laboratories study the wild bees of Belgium and France more than 30 years, beside special contributions for other countries. A first report, published as early as 1980, listed 13 threathened wild bees species in Belgium and N. France. In 1991, this research team published a comprehensive report about the faunistic drift in Apoidea of Belgium by comparing the relative numbers of species before 1950 and since then. The change in the abundance was estimated by the Stroot & Depiereux statistical method. Of 360 species, 91 are decreasing (25.2%), 145 are stable (40.2%), 39 are expanding (10.8%), and 85 have an indeterminable status (rare species: 23.5%). The authors compared different hypotheses that could explain this global regression. As the regression mostly affected long-tongued species, it is likely due to the fall in availability of plants with long corollae (e.g. Lamiaceae, Fabaceae, Scrophulariaceae). The strong relative regression of cleptoparasites could be seen as the result of an absolute numerical decrease of all Apoidea. The relative regression of species nesting under ground could be explained by the lessened availability or suitability of open areas due to afforestation, urbanisation or agricultural intensification. The strong regression of long-tongued species seriously threatens the maintain of an appropriate pollination level of wild and cultivated plants.

The present situation of the survey indicates that numerous species are strongly regressing, not only in the cultivated plains of Belgium and surrounding countries but also at the continental level (typical examples are *Bombus cullumanus*, *Bombus confusus*, *Bombus sylvarum*, *Megachile parietina*). Everywhere, the species associated with Leguminous plants seem to be at highest risk. On the other hand, some species are stable, despite of their extreme localisation (a good example is *Xylocopa cantabrita*). A few species are also known to be expanding (a typical case is *Bombus semenoviellus*).

Introduction

The Mons and Gembloux laboratories study the wild bees of Belgium and France more than 30 years. The first report, published as early as 1980 (Leclercq *et al.* 1980), listed 13 threathened Apoidea species in Belgium and in North of France.

In 1988, we published a report concerning the faunistic drift of Belgian bumblebees (Rasmont & Mersch 1988). This report has been updated and completed in 1993 (Rasmont *et al.* 1993), with the inclusion of a general report about the whole wild bee fauna of Belgium, including all the solitary species. This last comprehensive report for Belgium is summarised in the next part.

Since this time, the research team of Mons and Gembloux devoted most of their time to a much more extended region, including France (Pauly 1999; Rasmont *et al.* 1995; Rasmont & Adamski 1995; Rasmont & Gaspar 2002), but also Morocco (Rasmont & Barbier 2003), Turkey (Rasmont & Flagothier 1996) and even Madagascar (Pauly *et al.* 2001). For some dedicated groups, we are preparing biogeographical, faunistic and taxonomic revisions at the continental level (Andrenidae: Patiny 1998, Patiny & Gaspar 2000; Xylocopidae: Terzo & Rasmont 2003, Terzo & Ortiz 2004; Melittidae: Michez *et al.* 2004a, b, *in press*, *submited*; Bombinae: Rasmont & Terzo *in preparation*).

The present report will include a summary of the report about the faunistic drift of Apoidea in Belgium, published in 1993. Thereafter, we will point out some other significant cases concerning other surveyed countries.

The Faunistic drift of Apoidea in Belgium

Summarised from Rasmont *et al.* (1993)

Leclercq *et al.* (1980) included 13 Apoidea species in their "first red list of threatened insects in the Belgian fauna". However, the method used then to determine the status of the populations of these species did not include the abundance criterion ; it was based on the evolution of the geographical range of the taxa. A species was included in this "first red list" only if the number of 10 km UTM squares it occupied had regressed by at least 10 units since 1950. This criterion allowed the useful determination of the 13 most threatened species. Nonetheless, the examination of old documents and the comparison of entomologists' recollections indicate that the Apoidea fauna has been much more deeply modified. Very often, the regression of a species is not marked by a remarkable shrinking of its distribution but by a decrease in its relative frequency.

However, the fact that a great part of the fauna is decreasing while another is expanding can be seen as quite normal. Both regression and expansion could be just the expression of a random variation of the fauna.

Therefore, it is very important to study not only the geographical distribution of the species but also ~~the~~ their numerical variations i. e. : the faunistic drift.

By "faunistic drift" we mean any modification of the relative specific composition of local faunae along time. This change is, in general but not always, linked to variations in the geographical distribution of species. "Faunistic drift" is a locution which has the advantage of being presumptively neutral, unlike the words "expansion" or "regression". Moreover, it reminds, by analogy with "genetic drift", that a great part of the changes in population estimates can be stochastic or result from a sampling bias.

Thanks to an update of the Gembloux and Mons faunistic data bank made in 1991, an estimation of the faunistic drift of Apoidea in Belgium can be provided.

Material and methods

The Gembloux faunistic data bank has encoded all the data concerning Apoidea of Belgium, Luxembourg, the North of France and neighbouring areas till 1988. Since then, the University of Mons-Hainaut is also taking part in this collection of information.

The data are managed by the Data Fauna Flora (Barbier *et al.* 2000) software.

For Belgium alone, 48,654 data on 79,765 solitary bee specimens of the 1900-1991 period are now available. The main authors of these data are: J.Leclercq, A.Jacob-Remacle, A.Pauly, V.Lefeber, P.Mathot, J.Petit, K.Janssens, C.Thirion, L.Verleysen and P.Rasmont. The other authors are (in decreasing order of contribution) K.Warncke, Liongo li Enkulu, M.Schwarz, A.Ruwet, G.Vander Zanden, L. & C.Verlinden, H.M.Warlet, H.Wiering, D.Gryffroy, J.J.Pasteels, Y.Barbier, C.Verstraeten, G.Pagliano, J.Decelle, J.Van Schepdael, C.Burgeon, C.Luyts, P.M.F.Verhoeff, J.Beaulieu and C.Gaspar.

Only data including at least the year and the province are taken into account.

Table I. Solitary Apoidea studied

Origin of data	Before 1900 or without date	Before 1950	Since 1950
Field	9	3	1,214
Litterature	1,583	1,495	728
Collection	6,210	12,573	63,752
Total number of specimens	7,802	14,071	65,694
Data of the present study			

All distribution maps of solitary bees of Belgium have been published from 1971 to 1982 (Jacob-Remacle 1982; Leclercq & Rasmont 1985; Leclercq 1971, 1972a, b, 1982; Liongo li Enkulu 1982; Mathot 1982; Pauly 1978,1982a, b, c; all these references are included in Leclercq *et al.* 1972-1985). Those of Apidae Bombinae were published by Rasmont (1988).

We use the Stroot & Depiereux (1989) method to estimate the faunistic drift. This method is very attractive as it puts forward an objective estimation criterion which takes into account differences of sampling effort during the different periods.

For bumblebees (Apidae Bombinae), the data of Rasmont & Mersch (1988) are reinterpreted thanks to the Stroot & Depiereux (1989) method (table III). However, the estimation criterion for this family is the number of specimens in collection and not the number of occurrences.

Table II. Apidae Bombinae Data from Rasmont & Mersch, 1988		
Origin of data	Before 150	Since 1950
Field	20	2,284
Litterature	914	324
Collection	78,003*	12,282
Total number of specimens	78,937	14,892
*all specimens are not yet encoded but they have been all identified and counted		

Apis mellifera (L.) has not at all been considered here as it lives in Belgium as a domestic insect only. Therefore, Apidae include here bumblebees (Bombinae) only. The data cover is detailed in the tables I and II.

For each species, the status calculated by the Stroot & Depiereux (1989) method is compared with the distribution map of the species. This led first to the correction of the status of most species determined as "significantly" (*) or "highly significantly decreasing" (**) then, to the conclusion that they are "more or less stable". Are particularly concerned the species which are very confined and those for which the number of occupied UTM squares did neither decrease nor increase by more than 25% (apparently stable distribution). The explanation of this systematic bias is that because of the sharp increase in the total number of occurrences for the second period, such stability has been computed as a relative regression. In the opposite, all species in significant (*) or highly significant (**) expansion actually indicate a distinct increase in the number of occupied UTM squares (more than 25% increase). Undisputably, all the species computed as very highly significantly decreasing or increasing (***) present respectively a sharp regression or expansion (at least 25% of difference in the observed UTM squares number).

Table III. Estimating faunistic drift
using the Stroot & Depiereux (1989) method

	Observed estimator			Expected estimator		Chi²	Trend
	Before 1950	Since 1950	Total	Before 1950	Since 1950		
Species 1	p_{11}	P_{12}	T_1	e_{11}	e_{12}	I_1	(-)
Species 2	p_{21}	P_{22}	T_2	e_{21}	e_{22}	I_2	+
Species 3	p_{31}	P_{32}	T_3	e_{31}	e_{33}	I_3	=
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.
Species i	p_{i1}	p_{i2}	T_i	e_{i1}	e_{i2}	I_i	.
Total	$T_{.1}$	$T_{.2}$	T	$T_{.1}$	$T_{.2}$		

population estimator can be:

- number of specimens in collections
- number of lines in data bank
- number of grid squares
- number of sample units
- number of occurrences (1 occurrence = at least one observation of the taxa in a given grid square during a given year).

Expected estimator

$$E_{ij} = \frac{T_{i.} * T_{.j}}{T}$$

$$I_i = \sum_{j=1}^{2} \frac{(p_{ij} - e_{ij})^2}{e_{ij}}$$

The value Ii is compared with the value of chi2 distribution (1 degree of freedom).

- : species in relative regression

= : species in relative status quo

+ : species in relative expansion

() : species with an expected estimator < 5 for the "since" period.

For the present study, the population estimators are

- occurrences by UTM (10km) * year, for the solitary Apoidea;
- number of specimens, for the bumblebees.

Results

330 species of solitary Apoidea have been observed in Belgium during the 1900-1992 period. For the same period, Rasmont & Mersch (1988) list 30 species of bumblebees.

On the 360 Apoid species known in Belgium for the period studied, 91 are decreasing (25.2%), 145 are more or less stable (40.2%), 39 are expanding (10.8%), and 85 are in an undetermined situation (rare species: 23.5%) (fig. 1).

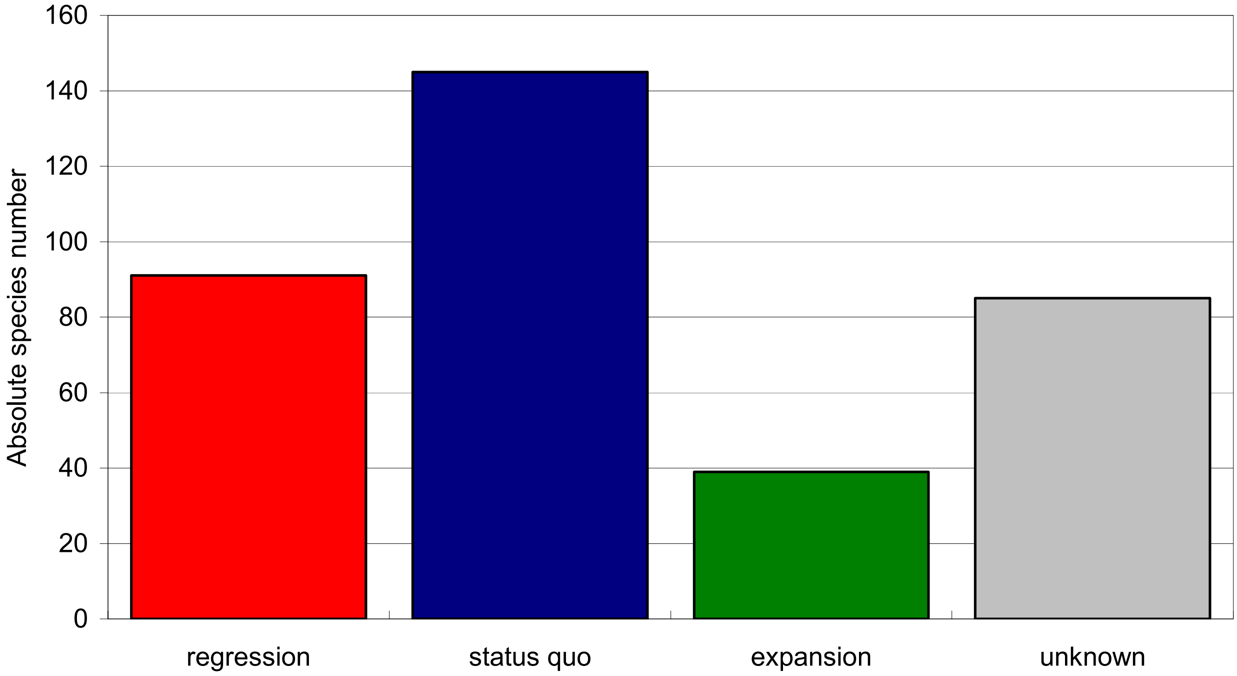


Figure 1. Status of Belgian Apoidea: all species.

Discussion

The present study confirms the status of the 13 species regarded as decreasing by Leclercq *et al.* (1980).

For solitary bees, the relative regression of species cannot be explained by a shortage in the observations (14,071 specimens before 1950 and 65,694 since 1950).

Besides, the regression rate of bumblebees is probably a bit overestimated (19 taxa in regression on 28 studied: 68%). According to Rasmont (1988) and Rasmont & Mersch (1988), the regression is less pronounced than according to the present criteria (14 taxa in regression on 28: 50%).

The regression is not equal for the different taxa (fig. 2).

The regression is sharp for Apidae and Anthophoridae (species with a long tongue preferring zygomorphic flowers with a long corolla): the number of decreasing species is far greater than the number of stable or expanding ones. The regression is also sharp for Megachilidae (medium to long tongue): almost 25% of species are decreasing. However, almost 50% of the species are stable.

For Halictidae (short tongue), the regression is sharper than the expansion. However, the majority of species are stable.

For Andrenidae and Colletidae (very short to short tongue), many species are stable and the number of increasing species is greater than the number of decreasing ones. In Melittidae (7 taxa with short tongue), species are stable, except *Macropis europaea* which is distinctly decreasing (this had already been noticed by Leclercq *et al.*, 1980).

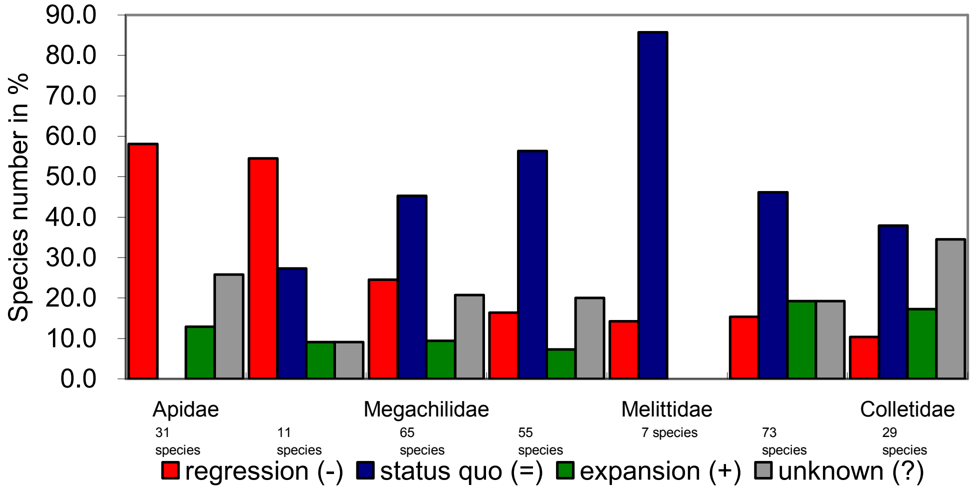


Figure 2. Status of Belgian Apoidea: foraging species of the seven families.

It seems that the foraging taxa with a long tongue show a relative decrease particularly in comparison with species with a short one. The latter seem to be more or less stable or even in small relative increase. The number of decreasing species is smaller than the number of increasing ones but most important is the fact that a clear majority of the species are stable. This appears clearly in fig. 3 where taxa have been gathered in three categories: species with a medium to long tongue, species with a very short to short tongue, and cleptoparasitic species.

This makes us believe that the Apoidea regression is due first of all to the loss of floral resources which would be particularly marked for plants with long corollae (Fabaceae, Lamiaceae, Scophulariaceae, Boraginaceae). Rasmont (1988) and Rasmont & Mersch (1988) have already noticed that the decrease of legume crops (Fabaceae) seems enough to explain the regression of most bumblebees species in Belgium (table V). The study of the data on the other wild Apoidea confirms this hypothesis. An additional reason may be the excessive mowing of embankments, road sides and public areas, which are privileged locations for Lamiaceae (e.g. *Lamium* spp., *Ballota nigra*) and Boraginaceae (e.g. *Echium vulgare*, *Symphytum officinale*).

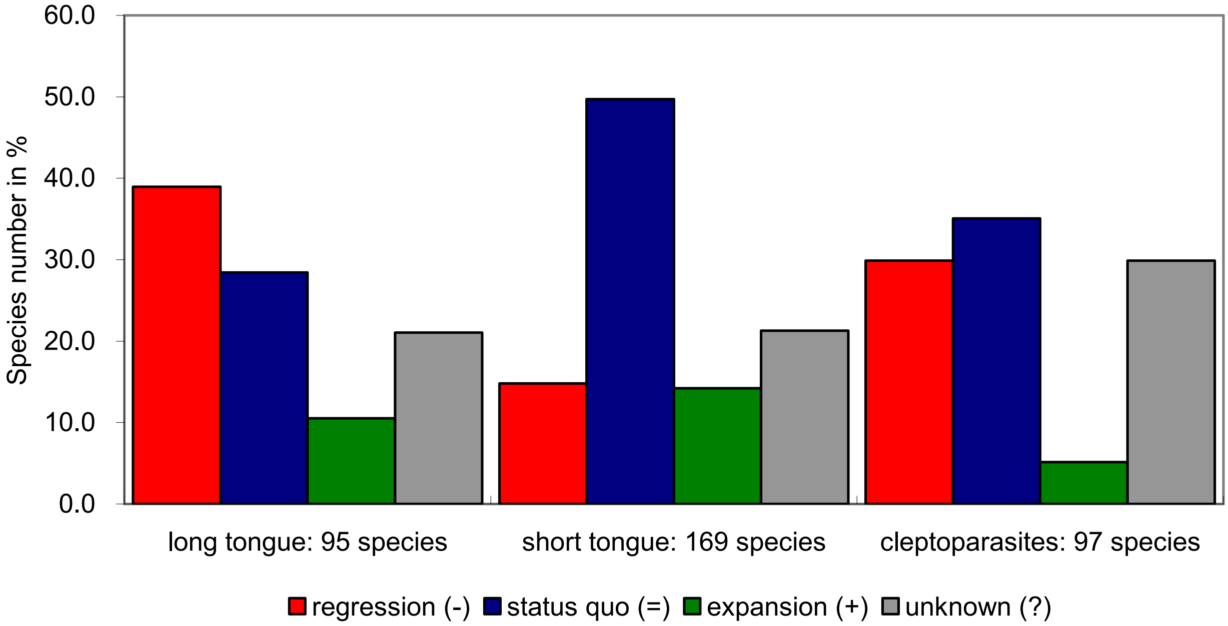


Figure 3. Status of Belgian Apoidea: main guilds.

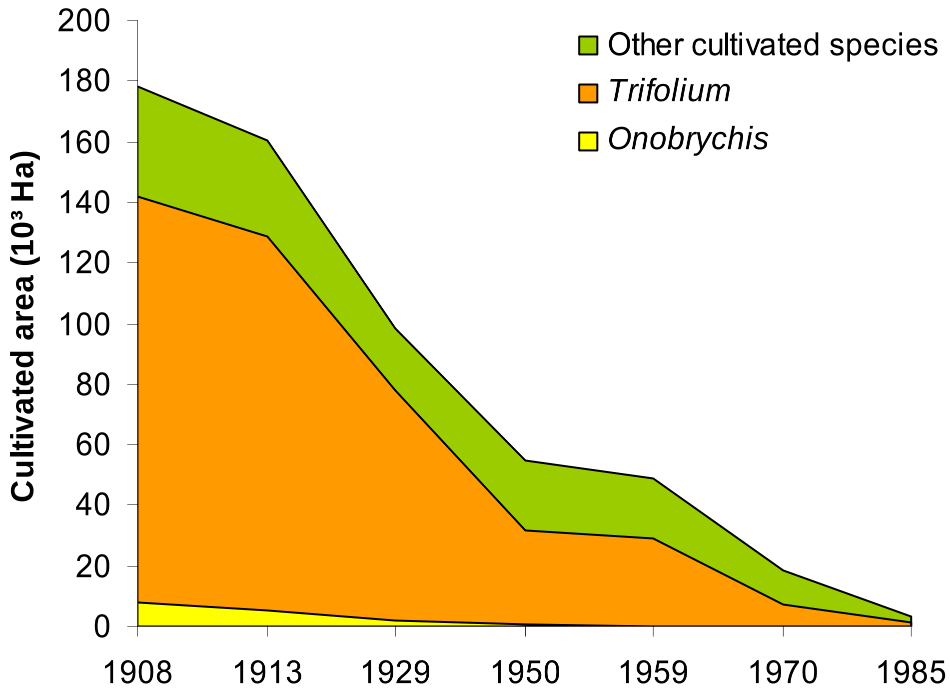


Figure 4. Cultivated area of leguminous plants in Belgium (modified from Rasmont & Mersch 1988 and Patiny 1998).

A very sharp regression of most of cleptoparasitic species (fig. 5) is noticed too, especially in Megachilidae and Anthophoridae. This is curious since Anthophoridae parasite especially Andrenidae and Colletidae, taxa with short tongues, stable or in relative increase. The only hypothesis that could be put forward to explain this cleptoparasite regression is that it probably expresses an absolute numerical decrease of the hosts. Indeed, the survival of a cleptoparasitic species needs that the populations of its host are numerous. In case of a numerical regression of the host, even if its geographical distribution is not affected, its cleptoparasitic species would undergo a more than proportional decrease. Besides the relative regression of the long-tongued species, an absolute regression of the whole Apoidea superfamily must therefore be feared.

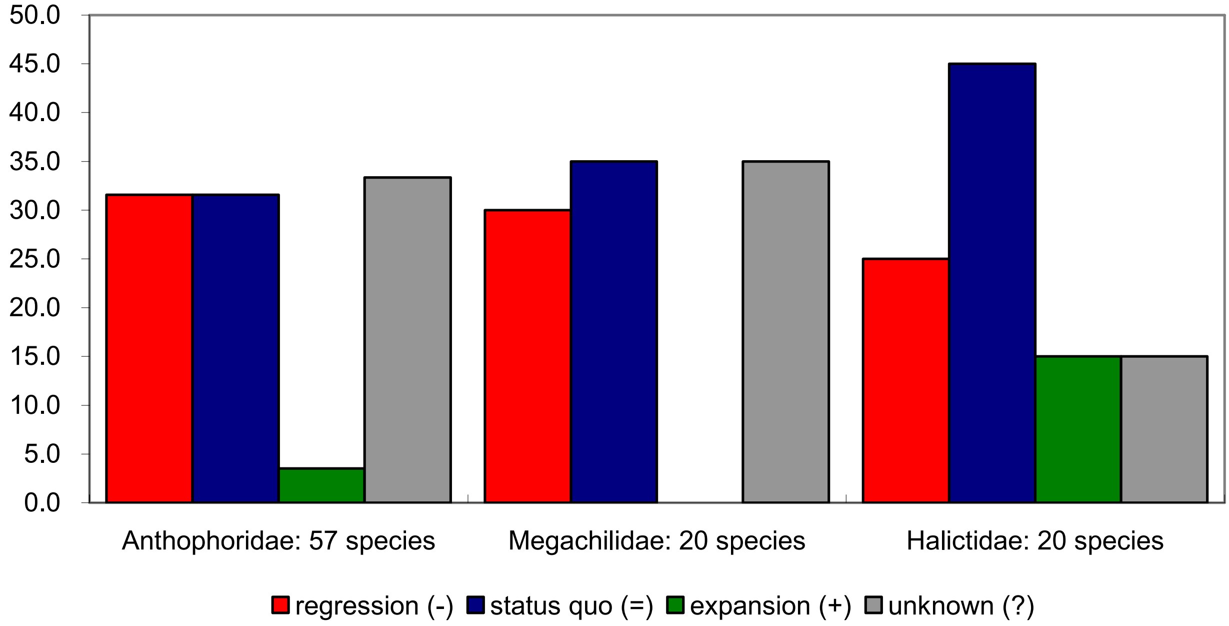


Figure 5. Status of Belgian Apoidea: cleptoparasitic species.

Some nesting habits (listed by Westrich, 1990) seem to be correlated with the regression (fig. 6). The few Belgian species nesting in snail shells are not worth discussing here as their number is too small. Species with nests in ground holes seem to be more threatened than the ones nesting in wood or plant stems, what had already been noticed by Westrich (1989). Michener (1979) points out that nesting in ground holes would be an adaptation to open or xeric areas. In the opposite, species which are nesting in wood or in plant stems are rather adapted to woody or wet environments, as nesting above the ground avoids a great part of the mortality due to cryptogamic diseases in wet conditions. This relative regression of ground nesting species could be caused by an increasing shortage of suitable open areas. Several mechanisms may contribute to this shortage: afforestation, which was very important in some areas of Belgium (particularly in the province of Namur, where the greatest part of chalky dry grassland, formerly used for cattle is now planted with pine woods); weeding of crops; conversion of lands into housing areas.

Among the factors whose role is difficult to estimate, the case of insecticides, herbicides and fungicides seems to be particularly problematic. The acute poisoning does not seem to have played a big role except in local and limited cases. However, nearly nothing is known about the chronic intoxication and the influence of sublethal doses. The latter could have brought selective pressure variations in different ways. As generations of wild bees are short, small interspecific differences in the selective pressure could have led in a few years to the replacement of sensitive species by others.

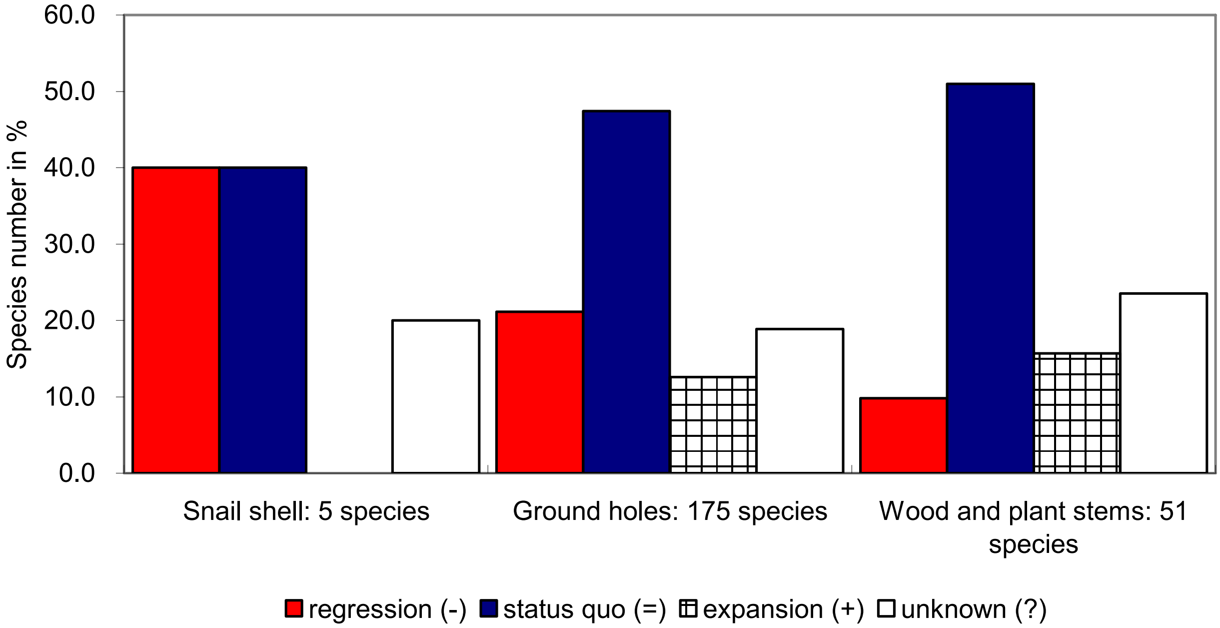


Figure 6. Status of Belgian Apoidea: nesting habits of the foraging species.

The conclusions of this study strongly remind those of Corbet *et al.* (1991), Osborne *et al.* (1991) and Williams *et al.* (1991), whereas these authors studied especially the case of the honey bee and bumblebees (Apidae). It seems that the regression of Apidae affects all kinds of wild bees too. Even short-tongued species seem to undergo a regression despite their relative number increases. The whole regression phenomenon affects more strongly species with a long tongue. This should be considered as a serious problem as they are the most efficient and specialised pollinators. In an untouched wild bee fauna, the isolated regression of a long-tongued species could probably be ecologically compensated for by the spontaneous substitution of competing species. However, in the present situation, it is the whole guild that is threatened. Therefore, we may fear that the linked regression of all species will not allow a spontaneous replacement. It is likely that the density and the diversity of these pollinators fall under the population level needed to insure the pollination requirement of many agricultural and horticultural productions. Moreover, the regression of key species would lead to the disappearance of great parts of the wild flora.

Very few European countries have a long tradition in collecting and studying Apoidea. It is therefore unlikely that a long and constant survey - as in Belgium - could become widespread in whole Europe. However, the progressive dying out of legume crops, the intensification of breeding, the afforestation of economically marginal agricultural areas and urbanisation are general in Europe. Therefore, this faunistic drift of the Apoidea fauna may be feared to be widespread.

To conclude about the faunistic drift of wild bees in Belgium, on 360 species observed in the country since 1900, 25% are decreasing and only 11% are expanding. This regression especially affects long-tongued species, which are precious specialised pollinators, auxiliaries of agriculture and horticulture. This can be seen as the result of the dying out of legume crops and of the destruction of wild long corolla flowers like labiate, borage and figwort families.

The strong relative regression of cleptoparasites can be seen as the outcome of an absolute numerical decrease of the whole Apoidea superfamily.

The relative regression of the species nesting in ground holes can be interpreted as a consequence of an increasing shortage in suitable open areas through afforestation, urbanisation and agriculture intensification.

The general wild bees regression, which strongly affects long-tongued species, seriously threatens the maintain of an adequate pollinating level of wild and cultivated plants.

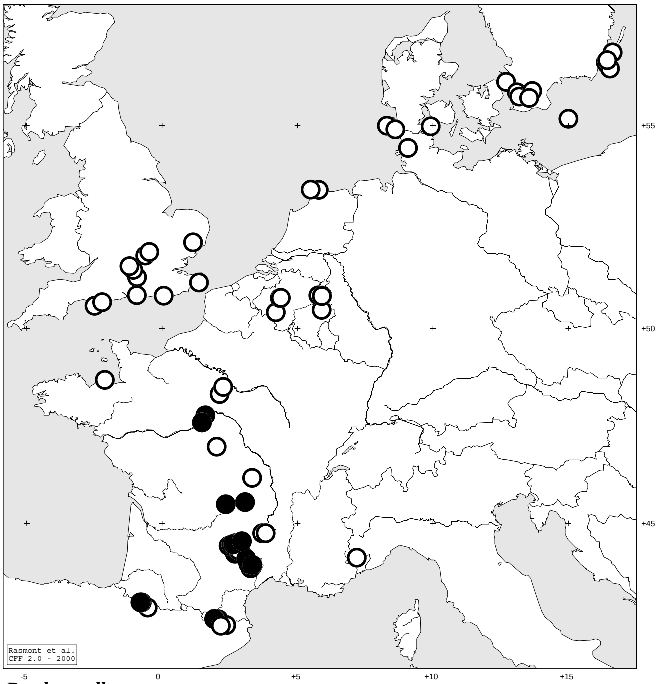
Is such kind of faunistic drift of wild bees observed elsewhere by the Mons and Gembloux research team?

For several countries, faunistic data are too few to support any conclusion. This is the case in Madagascar (Pauly *et al.* 2001), in Morocco (Rasmont & Barbier 2003), in Turkestan (Terzo & Rasmont 2003). Unfortunately, even in Europe, the lack of such historical data prevents any discussion about faunistic drift. It is the case for the bumblebees of Corsica (Rasmont & Adamski, 1995) and for small carpenter bees (Ceratinini) of Spain (Terzo & Ortiz 2004). It is also the case for most small or unconspicuous species from France, like Panurginae or Mellitidae (Patiny & Gaspar 1992; Michez *et al.* 2004a, b, *in press*, *submitted*).

Our research team is nevertheless able to point out some remarkable cases in different groups. A negative faunistic drift (regression) can be observed in several bumblebee species at the continental level.

The most dramatic case is without doubt the *Bombus cullumanus* (Kirby) one (fig. 7). This species was observed in the beginning of the 20th Century as far north as S. Sweden. It was observed in abundance in some localities of N. Germany, the Netherlands and England. It has been observed in the neighbourhood of big cities like Brussels and Paris. Since 1950, the species has considerably regressed, totally disappearing from the whole northern part of its area. Now, it can be found only in a dozen of localities in West and East Pyrenees, and in the west of Massif Central. Even in these places, it is extremely rare. We would guess that the whole population~~s~~ of the species does not amount to more than a few dozens of surviving queens! As this species is known as a Leguminosae visitor, this strong regression is coherent with the general explanations hypothesised by Rasmont *et al.* (1993) for Belgium.

Other bumblebee species associated with leguminous plants are regressing (*Bombus distinguendus* Morawitz, *Bombus sylvarum* (L.) (fig. 8), *Bombus confusus* Schenck, and other) but their case is not as extreme as for *Bombus cullumanus*.



Bombus cullumanus
161 specimens
○ Before 1960 : 116 specimens
● Since 1960 : 45 specimens

Figure 7. Distribution of *Bombus cullumanus* (Kirby) sensu stricto (from Rasmont & Terzo, *in preparation*).

Figure 8. *Bombus sylvarum* (L.), foraging on *Rhinanthus mediterraneus* (Sterneck) Sennen (photo P. Rasmont).

Another case observed by our team is the considerable regression of *Megachile parietina* (Goeffroy) (=*Chalicodoma muraria* (Retzius)) in France (Rasmont *et al.* 2003). This species was very widespread in most of France. It was even regarded as a pest, as it built large and heavy constructions on many human buildings. Jean-Henri Fabre took the large colonies of this species as a favorite subject of observation. In the present time, Megachile parietina has become a rare species (fig. 9). Here again, the flower preferences of this regressing bee go to leguminous plants (fig. 10).

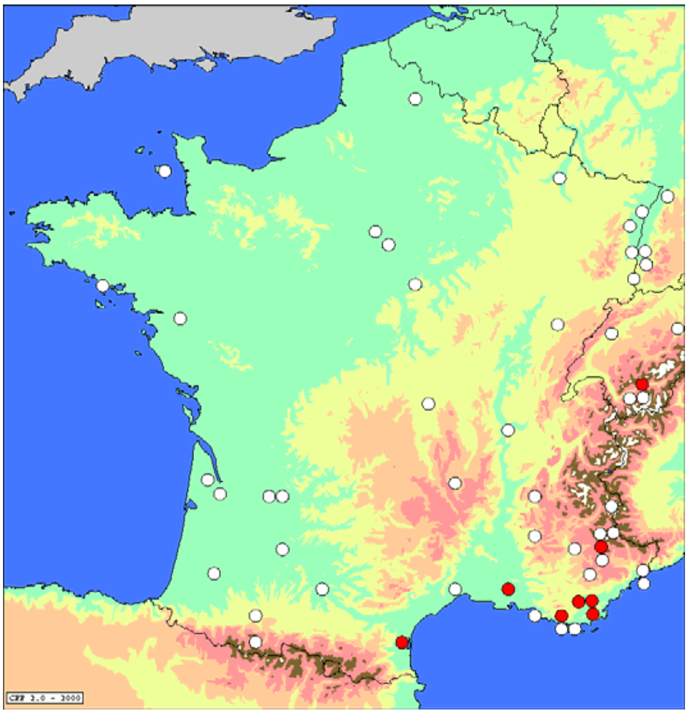


Figure 9. Distribution of *Megachile parietina* (Goeffroy) in France and Belgium (from Rasmont *et al.* 2003).

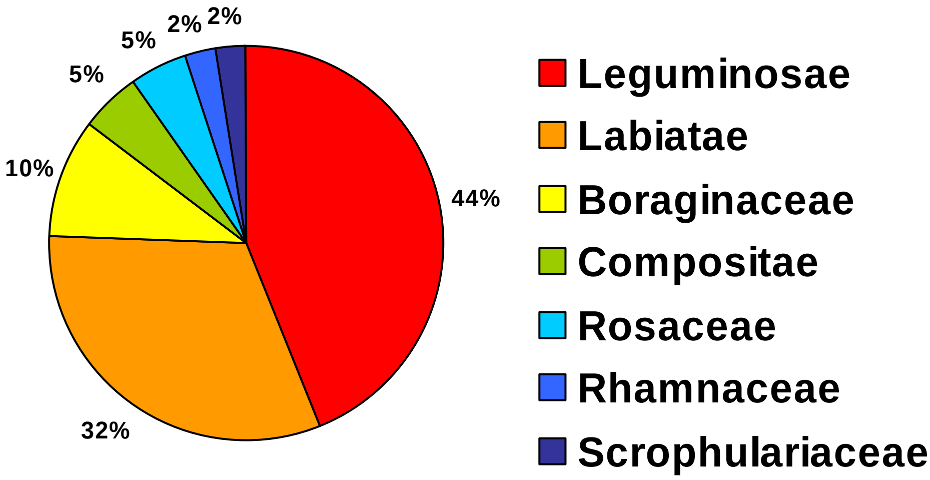


Figure 10. . Flower choices of *Megachile parietina* (Goeffroy) (original data, n = 41).

Such a decline of numerous wild bee species, most of them associated to Leguminous plants, shows that something serious occurs with this plant family. As these plants play a very important role in the ecosystems as a main entry of nitrogen in biosphere, we may suspect or at least fear some risk of disruption of this main biocycle.

May we not conclude this report on a too pessimistic note. Our research team also shows that some wild bees are stable, even if they are extremely localised. It is the case of *Xylocopa cantabrita* Lepeletier (fig. 11). This species is known in Europe from a very small number of places in France and Spain. We spent season after season searching this species in one of the two localities where it was observed in France, the very famous Montagne de la Sainte-Baume. Eventually, we succeeded. In fact, the indications given by the last century's authors where so imprecise that we spent long time searching in bad places. Now we discovered the biotopes and flower choices of the species. And we observed that the Sainte-Baume population is large and in a good health (Terzo & Rasmont 2003).

Figure 11. *Xylocopa cantabrita* Lepeletier, landing to its prefered flower *Asphodelus ramosus* L. (photo P. Rasmont).

Some species are even in expansion. This is the case of *Bombus semenoviellus* (Skorikov) (fig. 12). This species was known originally from the surroundings of Moscow. It is expanding to the west, reaching now the north of Germany (van der Smissen & Rasmont 2000). We may expect it to reach the Netherlands and Belgium in the next years.

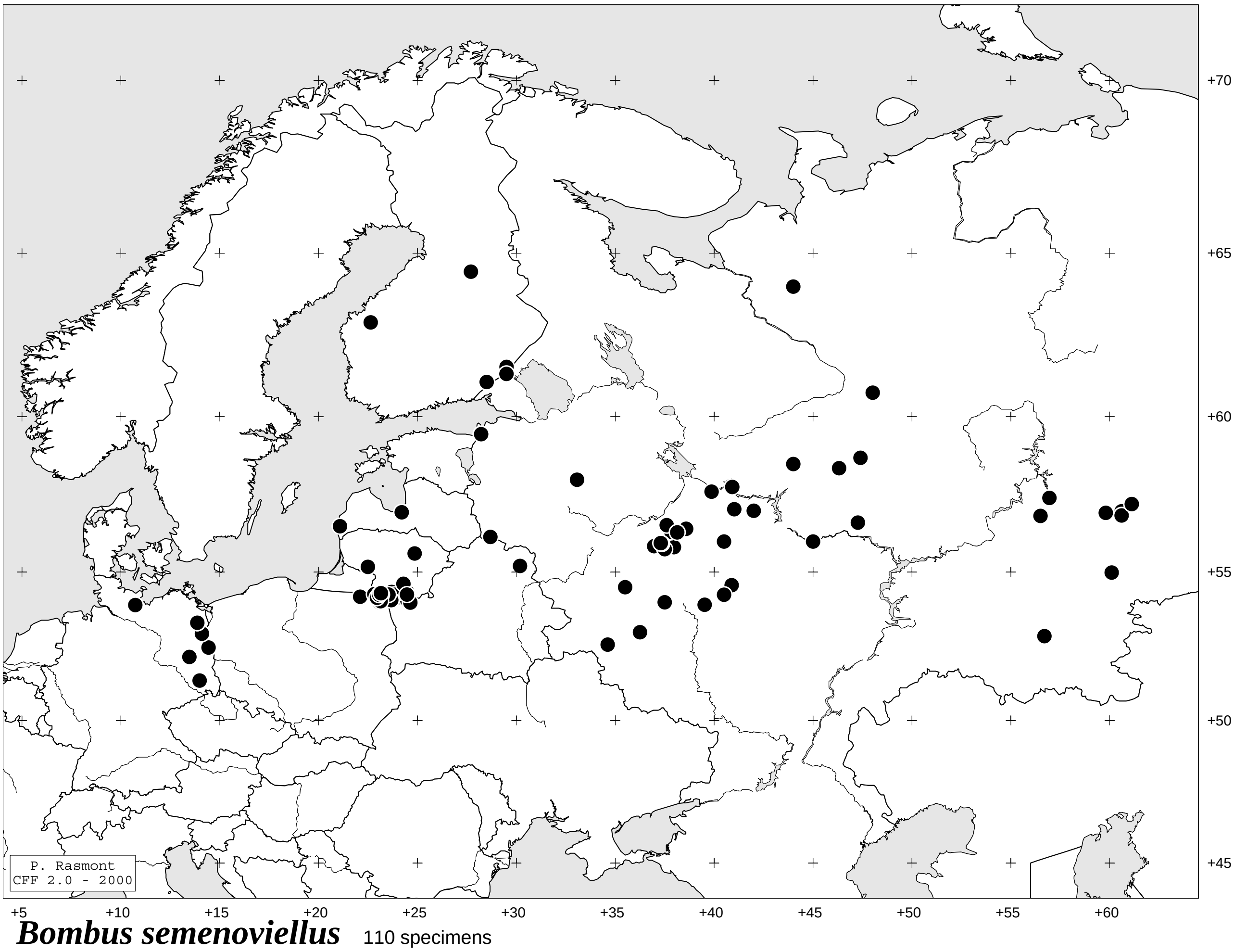


Figure 12. Distribution of *Bombus semenoviellus* (Skorikov) (modified from van der Smissen & Rasmont 2000). All the stations out of Russia are recent for the species (since 1965).

General conclusions

The Mons and Gembloux research team survey a large part of the wild bee fauna from Belgium and France with special contributions for other countries.

This survey indicates that numerous species are strongly regressing, not only in the cultivated plains of Belgium and surrounding countries but also at the continental level.

The species associated with Leguminous plants seems to be at the highest risk.

On the other hand, some species are stable, despite of their extreme localisation. A few cases of expanding species are also known.

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