Chapter

Commercial Pollination of Apple Orchards: Val di Non Case Study

Luciano Pilati, Paolo Fontana and Gino Angeli

Abstract

This chapter presents the results of a survey conducted in spring 2019 within the beekeepers who rent their colonies for the pollination of apple orchards in Val di Non, an alpine area in North Italy. The commercial pollination of apple orchards in this area is managed in an associated form by their cooperatives. The survey, carried out in collaboration with the local farmer cooperatives, submitted to the beekeepers a questionnaire containing questions on the economic and apidological aspects of their migratory beekeeping. The answers, referring to 43 questionnaires, show that beekeepers mostly: plan the migration itinerary at the beginning of the year; proceed to balance the colonies of honey bees before the pollination of the apple orchards; believe that the strength of the colonies must affect the pollination fee paid by the farmers and that the concentration of the colonies for the pollination of crops is not a relevant factor in the spread of bee diseases. The winter losses of honey bee colonies suffered by the responding beekeepers are on average 11.9%. The average cost of feeding the honey bee colony amounts to 19.1 €/colony. Finally, there is a wide interest in beekeepers to ensure the honey bee colonies.

Keywords: commercial pollination service, apple orchards, Val di Non, cooperative management of pollination service, survey, economic and apidological results, sustainability

1. Introduction

The use of managed western honey bee (*Apis mellifera* Linnaeus, 1758) colonies for commercial pollination of crops is redesigning modern beekeeping. Farmers must use managed honey bee colonies for generalized loss or reduction of not managed pollinator biodiversity in intensively cultivated areas [1, 2] and to support crop yield and/or to improve crop quality [3, 4]. Conversely, beekeepers are interested in hiring their bee colonies to farmers to cash colony rental fees and in addition, if the pollinated crop produces valuable nectar, to obtain honey productions. The matching between the demand of farmers and the supply of beekeepers has given rise to markets in the world of commercial pollination services [5–9] with very heterogeneous economic and apidological characteristics. The possibility of sequentially integrating the production of honey and commercial pollination services during the year has led beekeepers to undertake the migration management of honey bee colonies. The movements of the honey bee colonies follow privileged itineraries [10–13], and according to some authors [14], these itineraries are designed by the beekeepers before the start of the migration itinerary. The commercial pollination of crops is posing some new economic issues. Traditionally, the pollination fee per hive was contracted by the beekeeper without taking into account the robustness of the honey bee colony [15]. However, some research has shown that robustness significantly affects the productivity of the bees [16–19]. Consequently, farmers should choose the stocking density on the basis of their robustness to obtain the optimal pollination. In reality, the inhomogeneity of colony-to-colony robustness reflects the effects on the pollination of the crop. For this reason, balancing of honey bee colonies before the start of pollination service is to be counted among the good beekeeping practices [20]. The migratory management of modern beekeeping offers advantages but also involves risks: the concentration of numerous honey bee colonies coming from the most disparate places in a restricted area to be pollinated can facilitate the spread of honey bee diseases [21, 22]; displacement of honey bee colonies over long distances can affect their health [23, 24] and also the percentage of winter losses [25]. Moreover, when the supply of the commercial pollination service involves the movement of bees of a subspecies of not managed *Apis mellifera* within the natural range of another subspecies, or when honey bees belonging to the so-called commercial hybrids are handled, damage can be created both to the not managed populations of *Apis mellifera* of the other local subspecies and to honey bees managed by local beekeepers [26].

Even the intensive cultivation of the apple trees shows some problems from the point of view of pollination [27]. The intensification of cultivation has made the survival of local not managed pollinators difficult, especially where the cultivations reach great extents, while at the edge of the cultivated area, near the natural vegetation (woods or grasslands), not managed pollinators can easily satisfy the residual pollination needs. To support the pollination provided by wild pollinators in areas where these do not constitute stable and conspicuous populations, apple producers use the pollination service provided in general by the managed honey bee colonies. We used honey bee colony and beehive as synonyms even if this latter is formed by the colony of honey bees and the hive (box) that contains it.

Commercial pollination is a consolidated practice in Val di Non (North Italy), an alpine area specialized in intensive apple cultivation. In this area the pollination contract with the beekeepers is stipulated by the cooperatives to which the farmers confer apples for storage, processing, and marketing. The combined management of the pollination service allows to overcome the technical-economic limit deriving from the typical pulverization of the land structure of the local farms. In order to gather information about beekeepers who support the pollination of the apple orchards in Val di Non, a survey was conducted through a questionnaire. The survey was filled anonymously. Participants were asked questions about some technical-economic and apidological questions concerning mainly migratory beekeeping. The objective of the survey is twofold: on the one hand to verify if there are differences between the answers provided by small- and large-scale beekeeping operations on quantitative aspects, such as the level of bee colony losses in winter and the number of kilometers traveled annually, but also on qualitative aspects such as balancing of bee colonies and the propensity to ensure bee colonies, and on the other hand, to compare the results obtained with those of other surveys on beekeeping. Unfortunately, this comparison will remain confined to a few aspects because many questions we submit to beekeepers are lacking terms of comparison.

The structure of this chapter is the following. After the presentation in Section 2 of the materials and methods of investigation, in Section 3 five economic and five apidological aspects considered worthy of attention will be briefly discussed, not all those considered in the questionnaire, to avoid that the analysis becomes too dispersive. The results obtained will be shown and briefly discussed in Section 4. Section 5 will present some proposals for the future of migratory beekeeping in Val di Non (but not only).

2. Materials and methods

The exploratory survey on beekeepers supporting apple pollination in Val di Non was conducted during the spring 2019 using a special questionnaire. Submitting questionnaires to the beekeepers to collect business information is a fairly common practice. The winter losses of bee colonies [28, 29], the pollination fees [30, 31], and the movement of bee colonies during the year [32, 33] have been surveyed with this instrument.

The associated management of the pollination service in Val di Non facilitated the investigation; in fact, the cooperative managers contacted beekeepers to interview, distribute, and collect questionnaires. Beekeepers filled in a questionnaire with 20 questions: in some cases, the interviewee was asked to provide a dichotomous answer (yes/no) as shown in **Table 1**, Section 1; in other cases, the questions

	Number of honey bee colonies					
	1–80		>80		All	
Section 1						
	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
Plans honey bee colony movements?	93.1	6.9	100. 0	0.0	95.2	4.8
Interest in ensuring honey bee colonies?	63.3	36. 7	92.3	7.7	72.1	27.9
Balance honey bee colonies?	93.3	6.7	100.0	0.0	95.3	4.7
Section 2						
Disease spread risk			%			
Irrelevant	34.5		46.2		38.1	
Low	41.4		46.2		42.9	
Significant	24.1		7.7		19.0	
Honey bee colony losses in summer			%			
<5%	92.8		74.6		90.3	
5–10%	3.6		15.4		7.3	
>10%	3.6		0.0		2.4	
Honey bee robustness vs pollination fee			%			
No	10.0		8.3		9.5	
Low	30.0		25.0		28.6	
High	60.0		66.7		61.9	
Commercial hybrids are an opportunity?			%			
No	43.3		38.5		41.9	
Yes	10.0		30.7		16.3	
Do not know	47.7		30.8		41.8	
Section 3						
Cost of feeding honey bees (€/colony)	21.1		14.7		19.1	
Kilometers traveled per year	3538		13,592		6650	
Winter honey bee colony losses (%)	12.5		10.3		11.9	

Table 1.
Beekeepers replies to the questionnaire.

were multiple choice and the interviewee could choose between several pre-coded answers (**Table 1**, Section 2); in other cases, the answer was in an open form where the interviewee entered numeric data (**Table 1**, Section 3).

A total of 43 completed questionnaires were returned by the beekeepers. However, the number of valid answers varies from question to question. As a whole, the respondent beekeepers, given the stocking density average locally applied to apple orchards, provide almost half of the commercial pollination needs in the area under investigation.

The commercial pollination of the apple orchards in Val di Non is always practiced at the beginning of the migration itinerary of the beekeepers of Northern Italy. In this period of the year, beekeepers are not able to provide data on the loss of honey bee colonies in summer and winter, on the average feeding cost of the honey bee colony. For these aspects, the questionnaire asked the beekeeper to refer to the situation of the previous year (2018) or the last two years or to indicate the expected value under normal conditions. The averages of the continuous variables and the percentages of the answers to the pre-coded questions were calculated. The statistical analyzes of the data collected with the questionnaire are placed, for the peculiarity of the questions set out and for the lack of information on the distribution of the variables, in the context of non-parametric statistics. To process the collected data, the R program, an open source programming language designed specifically for statistical analysis [34], was used. In order to ascertain the effect of the company size, beekeepers were divided into two groups based on the number of bee colonies they managed: a) up to 80 honey bee colonies; and b) more than 80 honey bee colonies.

3. Technical-economic and apidological aspects of apple pollination

3.1 Technical-economic aspects

Most apple cultivars require cross-pollination with a compatible pollinizer to increase apple tree yield and fruit quality. Some exceptions to this are the diploid varieties as Golden Delicious, the more cultivated in Val di Non. Although this variety is partially self-fruitful, it will produce better apples with cross-pollination by means of honey bees. This has been observed in Val di Non where, despite being close to vast areas of meadow and wood, the pollination action carried out by wild pollinators is sometimes limited due to the low temperatures of the flowering period. To get the maximum quality of apple production, it is necessary that pollination takes place at the first flowering phase, when 2–4% of the flowers of apple are open (first king flowers). The commercial pollination of the apple tree does not occur in Val di Non simultaneously because the local flowering periods of the apple orchards depend on the altitude and exposure and on the different varieties cultivated. Depending on the altitudinal level, at the same variety, the flowering window is about 14–18 days, while it's between 5 and 8 days the period of beginning of flowering among the varieties grown on the same altitudinal plane. The honey bee colonies are distributed in orchards to be pollinated in small batches according to precise stocking density, which in the case of apple intensive cultivation is placed in the range 8 ± 4 honey bee colonies per batch. The optimal stocking density varies according to some parameters, in particular the varieties of apples locally grown (few varieties or multi-varieties). Even if one colony per hectare could generally be enough, it is advisable to distribute honey bee colonies at a rate of 1.5 per hectare. The permanence of honey bee colonies for pollination of apple orchards has a theoretical duration of 18 ± 2 days, generally included between the first week of April and May; operatively this period is greatly influenced by the weather pattern [35].

If the first phase of full flowering takes place with very favorable weather for the flight of honey bees, the hives can be transferred to the next site already after 7–10 days.

The problem of the use of pesticides assumes in the case of the Val di Non and, more generally in the alpine territory, a particular connotation due to the blossoming of apple orchards that is strictly correlated to the variation of the elevation. In fact, it may happen that active honey bees on a site where apple orchards are in bloom and therefore pesticide treatments are not yet performed can reach apple orchards located at a lower elevation where the bloom is already over (or is considered such by growers), and therefore the treatments with pesticides have already started. The problem is aggravated by the presence of new apple plants which, especially in the first year of plantation, usually bloom 3–4 weeks later than the others. These young apple trees are often nearby or mixed (in rows) with productive ones and can after that receive pesticides while blooming.

The apple growers of the Val di Non confer (with few exceptions) their production for the subsequent conservation, processing, and marketing to 16 cooperatives associated in turn in a Consortium. The area cultivated with apple trees from the 4000 producers associated with the cooperatives of the Val di Non extends over 6400 ha located at an altitude between 450 and 900 m above sea level (https://www.melinda.it/il-consorzio/il-consorzio.html). In the Val di Non, the average size of the apple orchards owned by single farmers is only 1.6 ha, and the land parcels are so small that they evoke the image of "patches of land." The management of the pollination service at the farm level would be almost impossible, given that the flight of the honey bee exceeds 1 km and does not respect the boundaries of the land parcels. In these conditions, some farmers may behave as free riders, i.e., wait for others to implement their apple orchard pollination service and then benefit from it free of charge. Acting in this way would get the service without paying the fee; lastly, however, they would compromise, due to the reaction of those who paid for the service, the commercial pollination on the whole area (or almost) reaching a socially inefficient situation. The problem of the free rider found a solution in Val di Non thanks to the coordination function carried out by the farmer cooperatives. The latter, acting as territorial authority, organize the pollination service on behalf of their members: they decide the stocking density to be applied to the apple orchards, settle the payments to beekeepers who have provided honey bee colonies for hire, and divide the cost of the service among the producers in proportion to the pollinated surface. In some areas of the Val di Non, the commercial pollination service is managed by the land improvement consortium to replace the cooperative.

The associated management of the pollination service generates a further economic advantage as it allows to contain the transaction costs [36]. The pollination contract is in fact stipulated by the cooperative without the direct involvement of thousands of farmers.

The most significant economic aspects among those submitted to beekeepers with the questionnaire are the following:

a. If they plan the movements of honey bee colonies before the start of the migration route. This hypothesis, however plausible it may be, remains to this day unproven.

b. If they consider the robustness of the honey bee colonies to be relevant in determining the pollination fee of the apple orchards. The effectiveness of the pollination service depends critically to know if the beekeepers who support the pollination of the apple orchards in Val di Non are aware of the need to consider this factor in the calculation of the pollination fee of the commercial pollination service.

c. What is the average cost borne by the beekeeper for feeding the honey bee colony in order to obtain strong colonies early in the season. The data on the costs of big beekeeping operations for the year 2018 reported by Sumner and Champetier [37] show that the cost of the food purchased suffered a very strong increase compared to 1976.

d. How many kilometers the beekeeper travels to manage the movements of his bee colonies; this is a significant aspect for measuring the migratory footprint of the beekeeper.

e. Whether the beekeeper is interested in securing his honey bee colonies. This is an economic aspect of primary importance. In the last few decades, the role of insurance has grown enormously in many productive sectors of alpine agriculture, especially in those afflicted by adverse climatic conditions or plant diseases. Surprisingly, in apiculture the insurance instrument has not found wide applications (at least in Italy) although the effects of climatic adversities have become increasingly evident in the last few years.

3.2 Apidological aspects

The intensification of apple cultivation, even in the Val di Non, has made the survival of local not managed pollinators difficult due to the drastic reduction of the flora capable of supplying pollen and nectar, for the reduction of nesting and overwintering sites for some bees and even more for the use of agrochemicals. The presence of not managed Apoidea is generally very scarce in intensively cultivated areas. Stable populations of Apoidea and other wild pollinators are present only in areas adjacent to meadows, pastures, and forests [38]. However, these populations provide a limited contribution because they have normally reduced mobility, not exceeding 80–100 m of home range. Since the cultivation of the apple tree in Val di Non follows linearly the path of the Noce river forming on the two sides of the river strips of variable width often fragmented by areas of natural vegetation, the presence of not managed pollinators in apple orchards is closely related to their ability to reach them from adjacent areas that depends on the width of these strips. The immediate implication of the peculiar apple orchard cultivation configuration in Val di Non, in relation to the management of the commercial pollination service, is that the stocking density to be applied is not uniform but varies according to the need for integration of "natural" pollination. The choice of stocking density to be applied in order to optimize the pollination of the apple orchards must carefully consider the level of robustness of the honey bee colonies. In fact, the pollination potential of the honey bee colonies depends both on the number of foraging bees as well as on their health status. Each bee is able to make 3–10 daily flights, during which it can visit up to 3000 flowers [39]. Since the health status is difficult to estimate quickly and economically, the pollination contract is limited to prescribing, if provided, the minimum strength (population) of the colonies quantified on the basis of the number of "inhabited" frames/combs.

At the beginning of the spring season, i.e., at the end of the wintering period, honey bee colonies have a poor robustness, and beekeepers must reinforce them with artificial preventive nutrition or enter the market to buy colonies or brood combs. Among the apidological aspects submitted to beekeepers in the questionnaire, the following are the most relevant:

a. If they proceed to balance the colonies of honey bees before the pollination of the apple orchards.

b. What is the percentage of losses of bee colonies found in the winter rest period 2017/2018 and 2018/2019.

c. What is the percentage of losses of bee colonies found in the summer period 2017/2018 and 2018/2019, classifying it as follows: less than 5%, between 5 and 10%, and over 10%.

d. If they consider that the concentration of bee colonies in the area to be pollinated facilitates the spread of diseases and parasites among bees.

e. If the use of commercial hybrids (i.e., the so-called Buckfast bees) constitutes an opportunity. Commercial hybrids offer opportunities for their great vigor, for the production of abundant broods, and for the consequent formation of populous honey bee colonies, but they carry with them the risk of not reaching the robustness of the colonies themselves at the beginning of the productive season. Commercial hybrids, strongly selected for the production of honey, find hard to develop their colonies in the early stages of the production season when they are used for pollination of crops.

4. Results

The responding beekeepers manage on average 93.3 honey bee colonies. Thirty beekeepers have less than 80 honey bee colonies with an average of 27.9. The remaining 13 beekeepers with more than 80 honey bee colonies have an average of 244.2. All beekeepers with less than 80 honey bee colonies have their headquarters in the local area, specifically in the Trentino-Alto Adige region, while the remaining 13 come from other Italian regions. It follows that the size classes and the classes of origin coincide. Overall, the responding beekeepers have in total 4011 honey bee colonies; those from outside the region have only 3175 colonies that are almost 80% of the total number. The "local" beekeepers therefore prevail numerically over the others, but they are minority in terms of colonies of honey bees possessed.

With regard to the economic aspects (see **Table 1**, Section 1), a clear majority percentage (95.2%) of the responding beekeepers declares that they plan the migration itinerary ex ante. The percentage reaches 100% for the beekeeper with over 80 honey colonies. This result supports the basic assumption of the model of the migratory beekeeper on the planning of the movement sequence at the beginning of the year.

Most beekeepers (61.9%) believe that the strength of the honey bee colony should affect highly the pollination fee paid for pollination of the apple tree (see **Table 1**, Section 2). This percentage is low compared to the importance attributed to balancing the honey bee colonies; it could be distorted due to the convenience of beekeepers with less robust honey bee colonies to declare the parameter irrelevant.

The distance traveled by beekeepers takes into account not only the movements of bee colonies but also the visits to apiaries located at various sites during the season. Responding beekeepers traveled (see **Table 1**, Section 3) an average of 6650 km during 2018 (both for pollination services and honey production). The distance traveled by beekeepers with less than 80 honey bee colonies is much lower, being on average 3538 km. Beekeeper with more than 80 colonies traveled an average of 13,592 km during 2018. The greater distance traveled by beekeepers belonging to the latter size class finds an easy explanation in their origin from outside the region and in their farm size. The reduced number of kilometers traveled by beekeepers with less than 80 honey bee colonies shows that these beekeepers have a weak migration footprint.

The average annual cost for the honey bee colony feeding stands at 19.1 €/colony, being higher for beekeepers with less than 80 colonies (21.1 €/colony) and minor (14.7 €/colony) for those with a higher number. It is surprising that the big beekeeping operations have a lower average cost for feeding the colony than the small ones. The first possible explanation of the difference is the amount of food provided to honey bees, and the second one is that beekeepers with less than 80 colony pay a higher price because they buy smaller quantities.

In total 72.1% of beekeepers declare an interest in securing honey bee colonies being the 92.3% within the beekeepers belonging to the class with more than 80 colonies. This high percentage is a good starting point to implement an insurance strategy suitable on the needs of beekeepers.

Regarding the apidolological aspects, almost all (95.3%) the responding beekeepers balance their honey bee colonies before the apple pollination service. The percentage reaches 100% for beekeepers with more than 80 colonies.

The losses of honey bee colonies suffered in the winter period in the 2-year period 2017/2018 and 2017/2019 amounted to the average of 11.9% (see **Table 1**, Section 3). This is a lower percentage than that documented by the Coloss survey [29] for European beekeepers, which reached an average of 16.4% during winter 2017/2018 with variations from 2.0 to 32.8% between countries. Beekeepers with a number of colonies greater than 80 undergo winter losses that are lower in percentage (10.3%) than in those with a lower number of colonies (12.5%). This result is aligned with that of the Coloss survey.

The losses of honey bee colonies suffered by beekeepers during the productive, summertime period, with few exceptions, are less than 5% in the area under investigation (see **Table 1**, Section 2). The overall average loss of honey bee colonies during the 2-year period considered therefore remains less than 16.9%.

Only 19% of interviewed beekeepers consider the risk of spread of honey bee diseases as significant due to the movement and the subsequent concentration of honey bee colonies. This risk is considered irrelevant or low by 92.4% of beekeepers with more than 80 honey bee colonies.

To the question of whether commercial hybrids represent an opportunity, the answers "do not" and "don't know" are on a par with 41.9 and 41.8%. Only 16.3% of beekeepers believe that commercial hybrids are an opportunity. However, the answers to this question are very different in the two size classes. 30.7% of beekeepers with more than 80 honey bee colonies compared to a meager 10.3% of beekeepers of the other size class believe that commercial hybrids are an opportunity. 47.7% of beekeepers with less than 80 bee colonies and 30.8% of the other size class do not know how to answer this question, demonstrating their lack of knowledge of the subject.

4.1 Discussion

The survey carried out using the questionnaire highlighted some interesting differences between migratory beekeeping implemented in the Val di Non for pollination of apple orchards and the pollination service conducted in other beekeeping contexts such as the USA. The major differences concern the average annual cost for the honey bee colony feeding, the risk of spread of honey bee diseases, and the losses of honey bee colonies suffered in the winter period. These differences derive both from the specific morphological and climatic conditions of the Val di Non and from the main address and the size of the beekeeping operations involved in the pollination service. The Val di Non is a typical alpine valley where the apple orchards are of small extension and the altitudinal variability generates a straightness of blooms. It is therefore necessary to move the honey bee colonies from one site to the next one in rapid succession, and this obviously favors small- and medium-sized, more flexible, and dynamic beekeeping operations.

The average annual cost for the honey bee colony feeding stands in Val di Non at 19.1 €/hive, a value much lower than that reported by Sumner and Champetier [37], equal to 50.21 $/hive, referred, however, to large-scale commercial migratory beekeepers (1000 hive operation) from California. The differences between the two contexts make the data for the cost for the honey bee colony feeding difficult to compare even if they refer to the same year (2018). The small size of beekeeping operations that support the commercial pollination of apple orchards in Val di Non probably favors greater efficiency in the management of honey bee colonies, and, on the other hand, the main production address (honey production) does not allow the use of large artificial feeds before the production season, in order not to contaminate the honey product with noncompliant sugars and not to stimulate swarming.

Almost all the beekeepers that support the commercial pollination of the apple orchards in Val di Non balance their honey bee colonies before the apple pollination. Beekeeping in North America, in particular that aimed at the large-scale pollination service, does not provide for colony balancing, but on the contrary, these, kept in hives of different conception, are divided before the migration. The most common hives used by North American beekeepers are multi-nest body Langstroth hives, while in Italy the most common ones are the Dadant-Blatt hives with single nest body. With these hives the balancing and moderate feeding of the honey bee colonies before their displacement in cultivated agricultural areas are normal in Italy in order to anticipate their demographic development and after that to better perform pollination and honey production.

The risk of spread of honey bee diseases due to the concentration of honey bee colonies is considered irrelevant by beekeepers interviewed above all by those who have more than 80 honey bee colonies. It is a result in contrast with the resonance that this problem has aroused in the USA and Australia. Most likely, the concentration of a few thousand bee colonies in an area of about 6000 ha that develops linearly along the two sides of the Val di Non is not perceived by the responding beekeepers as a real risk of spread of honey bee diseases.

The losses of honey bee colonies suffered in the winter period in the 2-year period 2017/2018 and 2017/2019 assumes a lower average value than that documented by the Coloss survey [33] for European beekeepers. Winter losses are lower in percentage for the large-scale beekeeping operations than in those with a higher number of colonies. The greater distance traveled annually by large beekeeping operations for the transfer of honey bee colonies between forage sites therefore does not exercise the feared negative effect in the opinion of beekeepers who support pollination of the apple orchards in Val di Non.

5. Conclusions

The pollination of the apple orchards in Val di Non has peculiar characteristics that make it a case of study: the orography and landscape structure could favor the integration between "natural" pollination and "managed pollination"; pollination of apple orchards is managed in a cooperative manner and not by each farmer; and the pollination of the apple tree is also supported by the honey bee colonies managed by small local beekeepers not contractually involved in the pollination service.

Among the economic and apidological aspects covered by the survey on beekeepers who operate the apple pollination service in Val di Non, two deserve to be highlighted for their immediate operational implications:

- The robustness of the honey bee colonies is considered, by the majority of interviewed beekeepers, a parameter that must have a large impact on pollination fee, and therefore apple tree pollination service contracts should include clauses that subordinate the level of pollination fee to the robustness of honey bee colonies.
- The high propensity of the responding beekeepers to ensure their honey bee colonies are the prerequisite for pushing insurance companies to place on the market "cutoff" policies on the needs of beekeepers, in particular for the coverage of risks of honey bee colony losses and of honey production reduction.

Regarding the future of apple orchard pollination in Val di Non (and not only), it is to be hoped that the value of unmanaged pollinators will be enhanced by means of an integrated crop pollination strategy [40] that includes the protection of plant biodiversity also in agroecosystems and the protection of sensitive sites in view of the reproduction of wild pollinators.

Conflict of interest

No conflict of interest.

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