RAIZO
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BULLETIN ZOOSANITAIRE

REPORT ON SUSPECTED BEE POISONINGS BY PESTICIDES IN QUÉBEC BETWEEN 2015 AND 2018

BACKGROUND

Each year since 2007 several cases of suspected poisoning have been reported by Québec beekeepers to the MAPAQ. The role of pesticides in mortalities could only be confirmed in a few of these cases[1]. In some cases, the quality and quantity of samples submitted, or sampling methodology were inadequate to confirm the role of pesticides in mortalities. It is difficult to know the extent of pesticide poisoning of honeybees in the Québec bee population because many instances are likely not reported by beekeepers to the MAPAQ.

Between 2015 and 2018, the Ministry has continued its commitment to conduct investigations when beekeepers suspect an episode of pesticide poisoning in their hives. Awerness efforts each spring encourage beekeepers to react quickly in cases of abnormal mortality in their hives. Regular observations as well as the quick collecting and freezing of the dead bees is advised to ensure the quality of the samples. In total, **35 beekeepers** have reported one or more incidents to MAPAQ's bee team between 2015 and 2018. The reports were spread out throughout the season, April to October, but the majority occurred in the spring of each year. In the great majority of cases, a MAPAQ inspector completed an inquiry questionnaire with the beekeeper. The purpose of the questionnaire was not to find a culprit or to detect flaws in the practices of an agricultural producer, but rather to clarify and document the circumstances surrounding the incident (including factors like colonization and culture sites in proximity to the hive). The sampled bees were then analysed in the MAPAQ's Laboratory of Food Expertise and Analysis. When the beekeepers agreed to it, their information was shared with the Pest Management Regulatory Agency so that the agency could further investigate through pollen analyses. The data gathered by the MAPAQ and the Agency was used to produce a national report.

[1] The concentration of the pesticides detected in the laboratory was compared to the lethal dose 50 (LD50), as it is given on the SAgE pesticides internet site (http://www.sagepesticides.qc.ca). The LD50 corresponds to the dose of a substance that can cause the death of 50 % of an animal population under precise experimental conditions, which is an acute exposure to a single pesticide at a time.

REPORT FOR 2018

For the 2018 bee season, there were 12 incidents reported that led to an investigation by the MAPAQ's staff. In total, samples were taken in 22 hives belonging to 11 beekeepers. In four cases, the concentrations of pesticides in the bee samples were high enough to explain, at least in part, the mortality observed. One of these four incidents was reported in summer and involved a pesticide in the neonicotinoid family, imidacloprid (0.004 µg/bee[2], being equivalent to LD50[3]), in combination with permethrin (0.014 µg/bee, being 28% of the LD50), an insecticide in the pyrethroid family. Three other incidents, arising in summer, were associated with the presence of an insecticide, extremely toxic for bees, spinosad, found in very high concentrations (from 0.099 to 0.41 µg/bee, being from 34 to 141 times the LD50). This bio-pesticide is used in conventional and organic crops (notably for cranberry). Moreover, two of the three hives affected were situated near a cranberry growing operation at the time of poisoning. Spinosad is undoubtedly the cause of the bees' death in these three cases.

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2 The results of the analyses are given in mg/kg and are transposed to µg/bee to compare them to LD50 data for SAgE pesticides. To do this, it is roughly considered that 10 bees weigh about 1 gram. This estimation is based on the works of Walorczyk and Gnusowski.

3 The LD50 varies for the same pesticide depending on the method of exposure (oral or by contact). Since it is difficult to determine the way in which the bees had been exposed, the lowest LD50 was used for comparison with the detected dose.

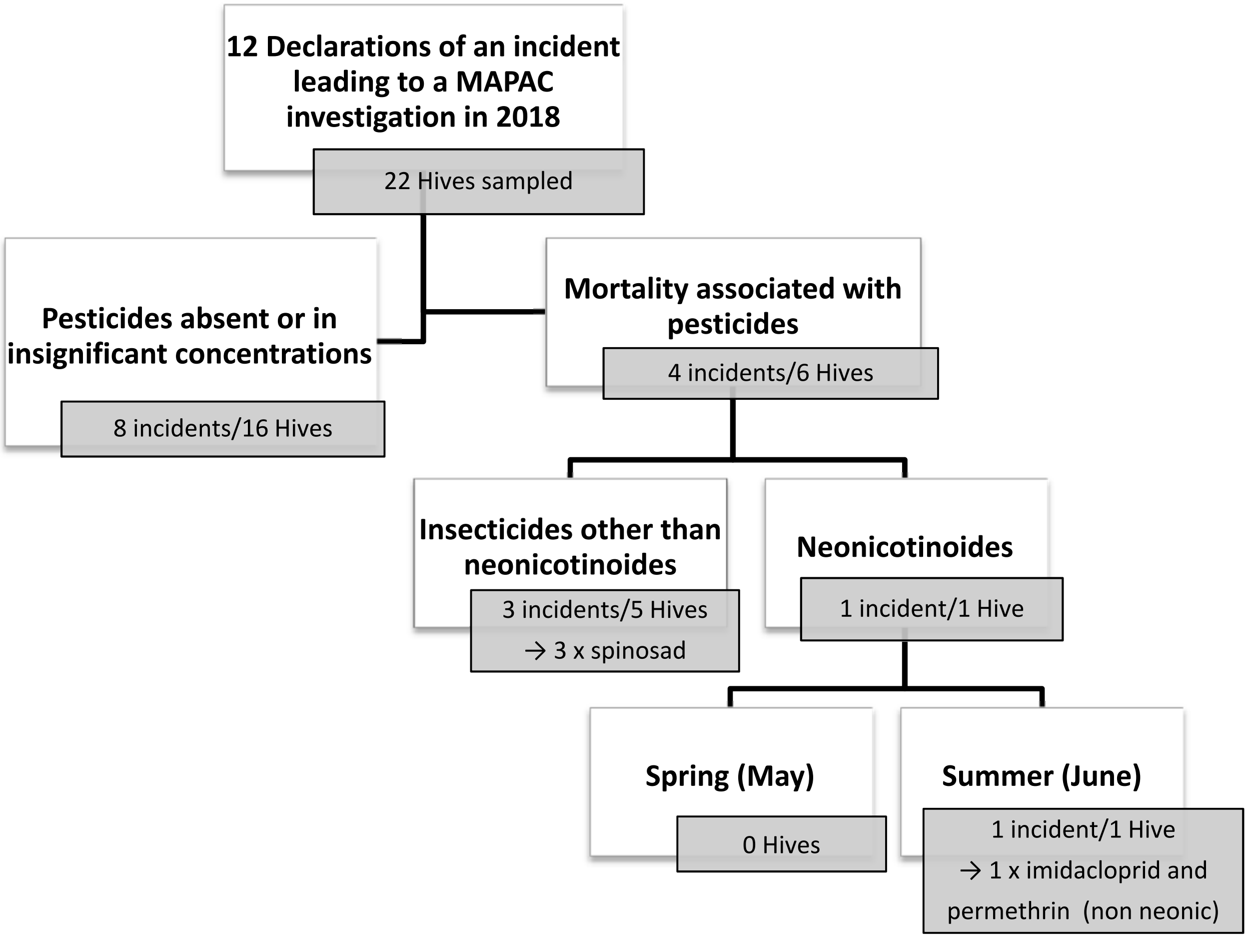

Figure 1.

Summary of suspected poisonings leading to a MAPAQ investigation in 2018

REPORT FOR 2017

For the 2017 bee season, there were eight incidents reported, of which seven led to an investigation by the MAPAQ's staff. In total, samples were taken in 11 hives belonging to seven beekeepers. In four cases, the concentrations of pesticides in the bee samples were high enough to explain, at least in part, the mortality observed. Two of these four incidents were reported in the spring and involved a pesticide of the neonicotinoid family, clothianidin, alone or in combination with coumaphos, an organophosphate insecticide and miticide. The concentrations of these pesticides in the dead bees was variable from one sample to another. They fell between 0.002 µg/bee (being 50% of the LD50) for clothianidin and 0.28 µg/bee (9% of the LD50) for coumaphos. While coumaphos is sometimes used to treat bee colonies for varroa mite, the beekeeper affected by this last incident did not report the use of coumaphos in his hives over the previous year. The other two incidents, occurring in summer, were associated with the presence of spinosad, detected in concentrations of 0.15 and 0.70 µg/bee, which is 52 and 242 times the LD50. All of the affected hives were situated in a cranberry field at the time of poisoning. Spinosad is certainly involved in the mortality of bees in those cases.

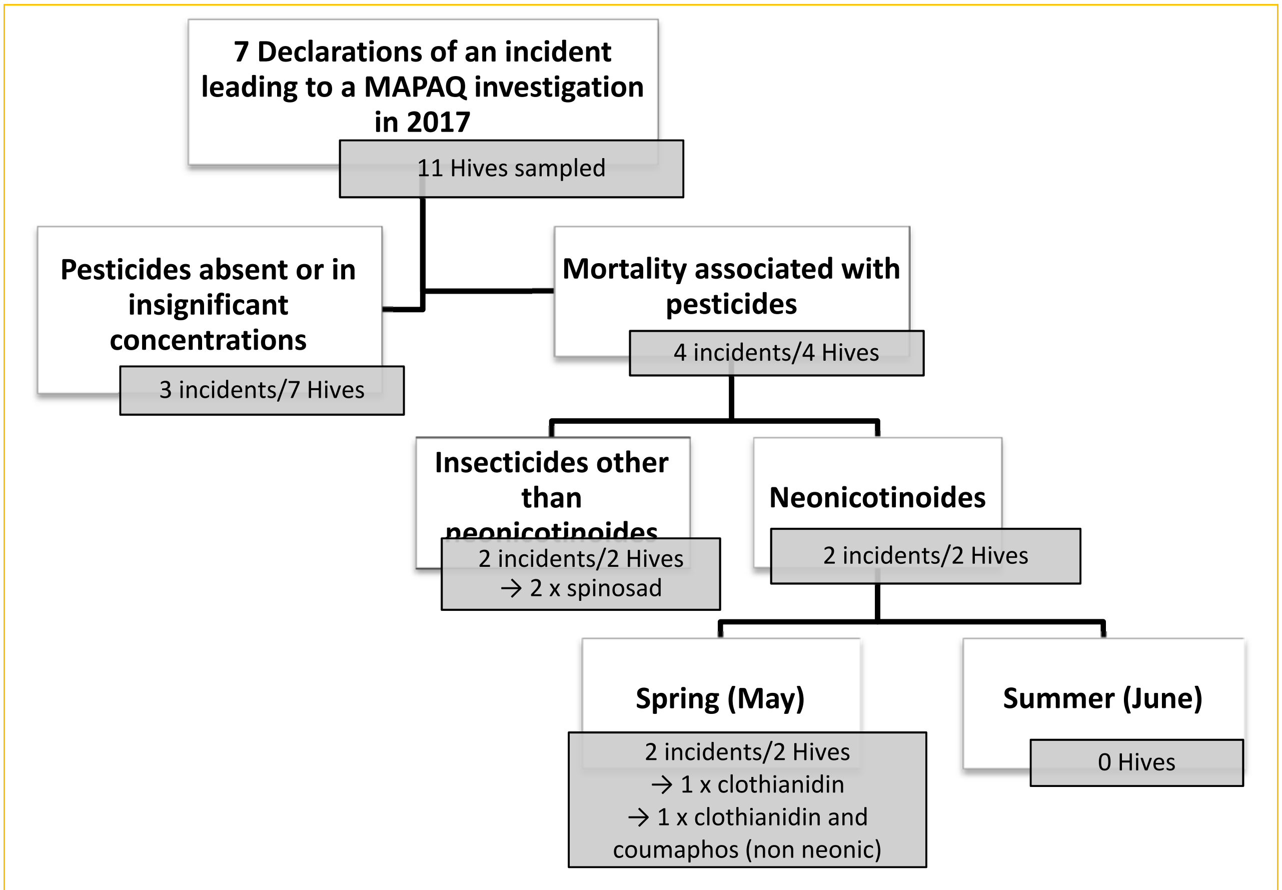

Figure 2.

Summary of suspected poisonings leading to a MAPAQ investigation in 2017

REPORT FOR 2016

For the 2016 bee season, 16 incidents were reported that led to investigations by the MAPAQ's staff. In total, samples were taken in 31 hives belonging to 15 beekeepers. In eight cases, the concentrations of pesticides detected in the bee samples were high enough to explain the mortality observed. Seven of these eight incidents involved pesticides of the neonicotinoid family (six in the spring and one in the summer). The two neonicotinoids identified were thiamethoxam and clothianidin, sometimes alone (clothianidin present in the sample) sometimes in combination. The concentrations of pesticides in the dead bees was quite variable from one sample to the next. The concentration of thiamethoxam reached 0.0001 µg/bee (being 2% of the LD50) while that of the clothianidin fell between 0.0001 and 0.0007 µg/bee (that is 3% to 18% of the LD50). Another incident was associated with the presence of an insecticide not belonging to the family of neonicotinoids, dichlorvos. It is an organophosphate miticide.

The investigation revealed that at least four of the nine hives in which neonicotinoids were found in the dead bees were situated in proximity to cornfields, while another hive was located not far from strawberry fields. These types of pesticides can be used in both crops.

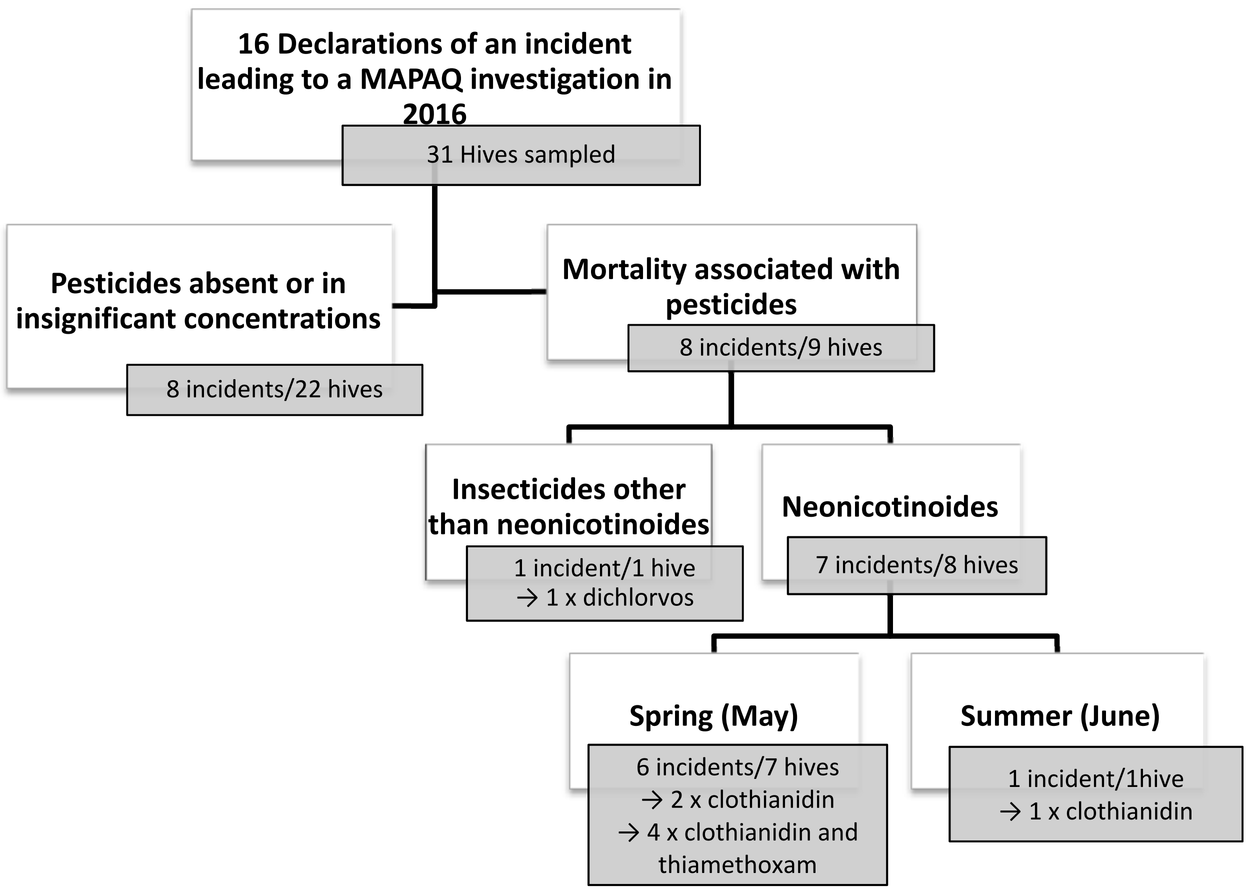

Figure 3.

Summary of suspected poisonings leading to a MAPAQ investigation in 2016

REPORT FOR 2015

For the 2015 bee season there were 17 incidents reported that led to investigations by the MAPAQ's staff. In total, samples were taken in 25 hives belonging to 13 beekeepers. In five cases the concentration of pesticides in the bee samples were high enough to explain, at least in part, the mortality observed. One of these five incidents, occurring in May, involved pesticides of the neonicotinoid family, being a combination of thiamethoxam and clothianidin. Among the four incidents associated with the presence of insecticides not belonging to the neonicotinoid family, two have been associated with a combination of spinosad and spinetoram. Spinetoram is an insecticide used in conventional crops. With concentrations of 0.22 to 0.79 µg/bee for spinosad (being 27 to 75 times the LD50) and of 0.0013 to 0.0035 µg/bee for spinetoram (being 5 to 15%

of the LD50), it is possible to conclude that, in these latter cases, the pesticides are the cause of the bee deaths. Another case of suspicion could be associated with the presence of high concentrations of permethrin (0.33 μg/bee, or more than 2.5 times the LD50) and of tetramethrin (0.24 μg/bee, or more than 1.5 times the LD50), two chemical insecticides of the pyrethroid family. In another case, the presence of phosmet (0.064 μg/bee, being 6% of the LD50), an insecticide and miticide of the organophosphate family, could have been the cause. All incidents associated with insecticides not belonging to the neonicotinoid family have been reported during the summer of 2015 (in July or in August).

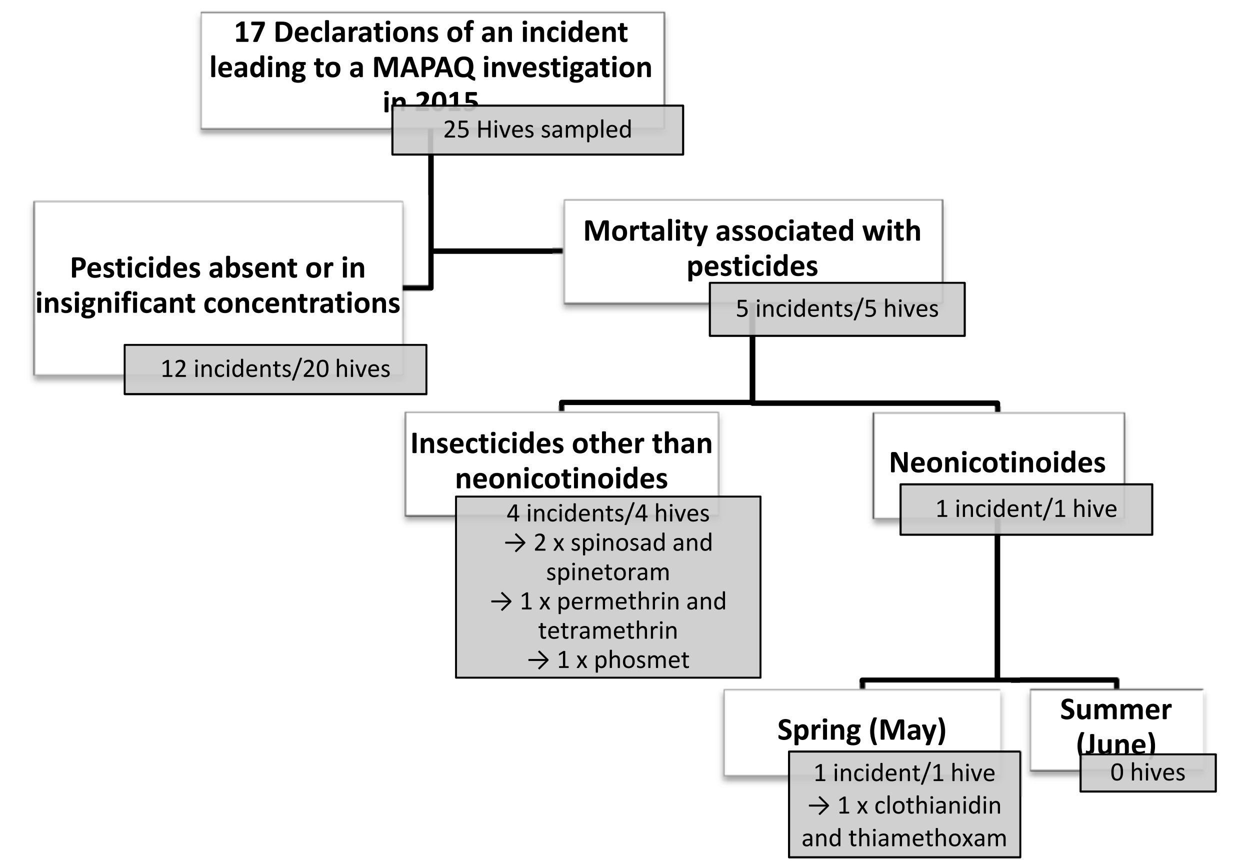

Figure 4.

Summary of suspected poisonings leading to a MAPAQ investigation in 2015

Summary Table – Mortality Associated with Pesticides

Table 1.

Description of episodes of acute poisoning of bees by pesticides in Québec between 2015 and 2018

	Principal Pesticides Detected in Sample	Level of Toxicity for the Bee	Concentration Detected	Number of hives involved
2018	Imidacloprid and permethrin	High	Imidacloprid: 100% of the LD50 (oral) and 9% of the LD50 (contact) Permethrin: 8% of the LD50 (oral) and 28% of the LD50 (contact)	1
	Spinosad	High	From 34 to 141 times the LD50	5
2017	Clothianidin and coumaphos	Clothianidin: High Coumaphos: moderate	Clothianidin: between 5% and 50% of the LD50 Coumaphos: 9% of the LD50	1
	Clothianidin	High	Between 3% and 33% of the LD50	1
	Spinosad	High	242 times the LD50	1
2016	Thiamethoxam and clothianidin[4]	High	Thiamethoxam: between 2% and 14% of the LD50 Clothianidin: between 2% and 22% of the LD50	4
	Clothianidin	High	Between 2% and 40% of the LD50	4
	Dichlorvos	High	30% of the LD50	1
2015	Spinosad and spinetoram	High	Spinosad : between 27 and 75 times LD50 Spinetoram: between 5% and 15% of the LD50	2
	Permethrin and tetramethrin	High	Permethrin: 3 times the LD50 Tetramethrin: 2 times the LD50	1
	Thiamethoxam and clothianidin[1]	High	Thiamethoxam: 2% of the LD50 Clothianidin: 5% of the LD50	1
	Phosmet	High	6% of the LD50	1

4. While the Concentration of clothianidin detected in the sample could represent a direct exposure to this insecticide, it could also translate to a higher exposure to thiamethoxam, since clothianidin is the principal metabolite of thiamethoxam.

CONCLUSION

The number of suspect poisoning cases reported to the MAPAQ by Québec beekeepers can vary greatly from one year to the next. In 2017, for example, the number of reported incidents was almost 3 times less than in 2016 and 2015 and two times less than in 2018. Over the course of these three years **21 incidents involving 24 hives of 14 different businesses** were suspected to be associated with a **pesticide poisoning**. Eleven of these cases (12 hives) involved insecticides of the neonicotinoid class, while the others were associated with the presence of other insecticides. The concentrations detected in the dead bees were variable, but were sometimes extremely elevated, running as high as 242 times the LD50.

In some cases, it is rather easy to establish a relationship between the insecticide involved in the bee poisoning episodes and the agricultural crops situated in proximity to the affected hives (for example, pollination sites). That is especially the case for poisonings with **spinosad** and **spinetoram** which occur at the time of cranberry pollination. Poisonings with **neonicotinoids** seem to be most often associated with the presence of corn and soya crops in proximity, according to information collected during investigations. However, this does not prove conclusively that they are the source of contamination.

It should be noted that in the majority of the bee samples analysed, several different pesticides were detected: herbicides, fungicides, and of course insecticides that are the most likely to be toxic to bees. More than 20 different pesticides were detected in some samples. Simultaneous exposure to a large number of pesticides, including miticides used in hives (for example, coumaphos), can certainly have a cumulative effect and perhaps even synergy (Johnson, 2009; Johnson, 2010) which it is difficult to evaluate with the help of the LD50 unique to each pesticide. The list of all the pesticides detected (including those that are present in trace forms, thus not significant) in the samples of bees analysed between 2015 and 2018, is presented in the appendix.

APPENDIX – All Pesticides Detected in the Samples of Bees Analysed between 2015 and 2018

Table 2

Pesticides detected in the 116 samples of bees in MAPAC's Laboratory of Food Expertise and Analysis, between 2015 and 2018.

Pesticide	Type	Family	Toxicity for Bees	Concentration (% of the LD50)	Years	Number of Positive Samples
2,4-D (Clacyfos)	Herbicide	Phenoxy	Weak	Traces	2015, 2016	3
2,4,5-T	Herbicide	Chlorophenoxy	Weak	Traces	2016	1
5-Hydroxythiabendazole	Metabolite of thiabendazol	–	–	–	2016	1
Allethrin	Insecticide	Synthetic pyrethroid	Moderate	Traces	2015, 2016	5
Amitraz	Insecticide	Triazapentadine	Weak	Traces to 0.021%	2015, 2016, 2017, 2018	18
Atrazine	Insecticide	Synthetic pyrethroid	Moderate	Traces	2016	2
Azinphos-methyl	Insecticide	Organophosphate	High	Traces	2015	1
Bentazone	Herbicide	Benzothiadiazole	Weak	0.001%	2016	1
Bifenazate	Insecticide	Bifenazate	Moderate	Traces	2015	1
Boscalid	Fungicide	Carboxamides	Weak	Traces	2015, 2016	3
Piperonyl butoxide	Insecticide	---	Weak	Traces	2015, 2016, 2018	4
Carbendazim	Fungicide	Benzimidazole	Weak	Traces	2015, 2016	13
Chlorantraniliprole	Insecticide	Diamide	Weak	Traces to 0.12%	2015, 2017, 2018	8
Chlorfenvinphos	Insecticide	Organophosphate	–	Traces	2015	1
Chlorpropham	Herbicide	Carbamate	Weak	Traces	2015, 2016	6
Chlorthiophos	Insecticide	Organophosphate	–	–	2016	1
Clothianidin	Insecticide	Neonicotinoids	High	Traces to 50%	2015, 2016, 2017, 2018	16
Coumaphos	Insecticide	Organophosphate	Moderate	Traces à 9%	2015, 2016, 2017, 2018	27
Cypermethrin	Insecticide	Synthetic pyrethroid	High	3 %	2015	1
Cyprodinil	Fungicide	Anilinopyrimidine	Weak	Traces	2015, 2016	3
Deltamethrin	Insecticide	Synthetic pyrethroid	High	2%	2015	1
Dichlorvos	Insecticide	Organophosphate	High	30%	2016	1
Diphenylamine	Fungicide	–	–	Traces	2016	3
Diuron	Herbicide	Urea	Weak	Traces	2015, 2016	6
2,4,5-TP (Fenoprop)	Herbicide	–	–	Traces	2016	2
Fenpyroximate	Insecticide	Pyridazinone	Weak	Traces	2016	2
Fludioxonil	Fungicide	Phenylpyrrole	Weak	Traces 0.01%	2015, 2016, 2018	5
Flufenacet	Herbicide	Oxyacetamide	Weak	Traces	2015	7
Fluopyram	Fungicide	Pyridine	Weak	Traces	2016	2

Flutriafol	Fungicide	Triazole	Moderate	Traces	2015	1
Tau-Fluvalinate	Insecticide	Synthetic pyrethroid	High	3%	2017	1
Hexazinone	Herbicide	Triazinon	Weak	Traces	2015	1
Imidacloprid	Insecticide	Neonicotinoids	High	100% (oral) or 9% (contact)	2018	1
Ipconazole	Herbicide	Triazole	Weak	Traces	2016, 2017	2
Mecoprop (MCPP)	Herbicide	Phenoxy	Weak	Traces	2015, 2016	2
Mecarbam	Insecticide	Organophosphorus	–	Traces	2015	1
Methoxyfenozide	Insecticide	Diacylhydrazine	Weak	Traces to 0.0024%	2015, 2016, 2017, 2018	8
Metolachlor	Herbicide	Chloroacetamide	Weak	Traces	2016	4
Metribuzine	Herbicide	Triazinon	Weak	Traces	2016	1
Myclobutanil	Fungicide	Triazole	Weak	Traces	2015	1
Octhilinon	Bactericide and fungicide	–	–	–	2017	1
Pendimethalin	Herbicide	Dinitroanilin	Weak	Traces to 0.01%	2015, 2016	2
Permethrin	Insecticide	Synthetic pyrethroid	High	From 1 to 250%	2015, 2018	3
Phenothrin	Insecticide	Synthetic pyrethroid	High	Traces	2015	1
Phorate sulfone	Insecticide	Organophosphate	High	Traces	2015	1
Phosmet	Insecticide	Organophosphate	High	6%	2015	1
Propiconazole	Fungicide	Triazole	Weak	Traces	2015, 2016	2
Pyraclostrobin	Fungicide	Strobilurin	Weak	Traces to 0.01%	2015, 2016	3
Quinoxyfen	Fungicide	Quinolone	Weak	Traces	2015	1
Quizalofop	Herbicide	Aryloxyphenoxy propionate	Weak	Traces	2015	1
Resmethrin	Insecticide	Synthetic pyrethroid	High	0.2%	2015	1
Spinetoram	Insecticide	Spinosyn	High	From 5 to 15%	2015	2
Spinosad	Insecticide	Spinosyn	High	From < 72% to 24 241%	2015, 2017, 2018	10
Spiromesifen	Insecticide	Derivative of tetronic acid	Weak	Traces	2015, 2016	2
Tetramethrin	Insecticide	Synthetic pyrethroid	High	157%	2015	1
Thiabendazol	Fungicide	Benzimidazole	Moderate	Traces to 0.3%	2015, 2016, 2017, 2018	15
Thiamethoxam	Insecticide	Neonicotinoids	High	From 2% to 14%	2015, 2016	5
Trifloxystrobin	Fungicide	Strobilurin	Weak	Traces	2015, 2016, 2017	8

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