OXALIC ACID TREATMENTS FOR VARROA CONTROL (A REVIEW)

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Introduction

Oxalic acid (OA) is one of the most common natural acaricides used against varroa throughout Europe. Its activity is well known since the middle 1980s at least, due to experiments performed mainly in Eastern-Europe and Asia on the spraying and sublimation administration techniques (OKADA and NEKANE, 1987; POPOV et al., 1989).

However, only one decade later OA became increasingly popular in West-European beekeeping community due to massive trials performed in Germany (RADETZKI et al., 1994) and further experiments (NANETTI et al., 1995; IMDORF et al., 1995) showing high efficacy of weak solutions sprayed onto the bees of broodless colonies. Although many beekeepers used (and still use) to treat their colonies with the spraying technique, this complicate and time consuming method limited OA adoption to relatively small scale beekeeping farms. Many attempts had been made during time to find more practical and less invasive treatment methods and considerable progresses were achieved when the trickling technique was set-up in Italy (NANETTI and STRADI, 1997). In that case, a concentrate sugar syrup (60%) added with 4.2% OA was trickled by the means of a syringe (5 ml per Dadant-Blatt comb occupied by the bees) onto the comb top bars of broodless colonies. The efficacy averaged 96.8% and a weaker OA concentration resulted in significantly lower acaricidal effect. Further experiments showed steady performances even when the treatments were made in cold middle winter period. Several hobbyists and professional beekeepers successfully embraced the new technique, especially in Italy, but further trials were needed to corroborate its use in other European climates and technical circumstances.

The general lack of knowledge about OA needed a special interest of the *European Group for Integrated Varroa Control*, that decided to create a working group to investigate on the substance. Part of the involved researchers focused on setting-up the trickling method, in order to verify the possibility to extend this application method also in other areas. The needed experiments were performed according to agreed protocols in order to compare the results. This paper summarises the main achievements resulting by this corporate research.

Partnership and experiment outline

The following scientists participated to the experiments on OA trickling in their respective countries.

- **Finland** — *Seppo Korpela* (Agricultural Research Center of Finland, Institute of Plant Protection, Jokioinen)
- **Germany** — *Ralph Büchler* (Hessische Dienstleistungszentrum für Landwirtschaft, Gartenbau und Tierschutz, Bieneninstitut, Kirchhain)
- **Italy** — *Antonio Nanetti* (Istituto Nazionale di Apicoltura, Bologna)
- **Norway** — Stine Helland (Norwegian Beekeepers Association, Billingstad)
- **Sweden** — *Ingemar Fries* (Swedish University of Agricultural Sciences, Department of Entomology, Uppsala); *Preben Kristiansen* (Swedish Beekeepers Association, Mantorp)
- **Switzerland** — *Jean-Daniel Charriere & Anton Imdorf* (Swiss Bee Research Centre, Liebefeld, Bern)

The set of experiments covered a two year period and involved about 1100 colonies in different countries. As a first approach, a screening on various solutions was made in autumn 1998 in Nordic countries, where an earlier broodless condition was expected. This allowed a beforehand selection of some promising solutions, that had to be submitted to more extensive investigations during the same autumn season in Germany, Italy and Switzerland. Some of these solutions were tested also in 1999, but in this year other concentrations were considered too.

The original dose (5 ml per Dadant-Blatt comb occupied by the bees) was taken as a reference in most cases. However, it was proportionally reduced when smaller comb sizes were used.

As a general rule, controls were provided for in the apiaries where the treatments were made. They were treated with water or non-OA syrup applied by the same technique. Fallen mites were counted for an adequate period after the treatments. Further acaricide treatments were subsequently performed in order to kill the surviving mites and calculate the efficacy of OA treatment. Poorly infested colonies were not taken into account in this respect.

Treatment tolerance for the bees was inferred by the results of colony checks performed according to the Liebefeld method (GERIG, 1983) before the treatments and at the end of cold season. The success in overwintering was considered too, being outwintered, queenless, drone-laying and very weak colonies considered as killed by the treatment, unless other reasons (e.g. starvation, ant attacks, other diseases) could be recognized (Table I).

Table I

Colonies found dead during the winter following the treatment period in controls and treated colonies (pooled)

	Control	Treated
Screening in 1998 (Finland, Norway, Sweden)	9.6%	10.1%
Further investigations in 1998 (Germany, Italy, Switzerland)	5.4%	3.0%
Investigations in 1999 (Finland, Germany, Norway, Sweden, Switzerland)	2.3%	8.0%

Screening in Nordic countries (1998)

Solutions resulting from the combination between three OA concentrations (0, 2.1 and 4.2%) and three sugar concentrations (0, 30 and 60%) were screened in Finland, Norway and Sweden on approximately 300 colonies. The solutions were trickled by a syringe into the colonies, after cover removal, between September 11 and October 14, 1998.

The dose varied according to the comb size: approximately 0.4 ml per dm^2. The colonies were treated with variable amounts, depending on the number of combs occupied by the bees. However, Finnish experiments were made applying the above amount to combs fully populated by bees and, therefore, lower doses were trickled into the colonies in this case. Three weeks after the OA trickling, standard Perizin administrations were given to the colonies as a control treatment. Colony checks were made before OA administrations and at the end of April – beginning of May 1999.

The results of the screening are summarised in Figures 1 and 2 and in Table I.

In Finland, where underdosed treatments were applied if compared to Norway and Sweden, a reduced acaricidal effect was usually recorded. When 4.2% OA, 60% sugar solution was used in these two countries, the efficacy was in line with previously mentioned findings (NANETTI and STRADI, 1997).

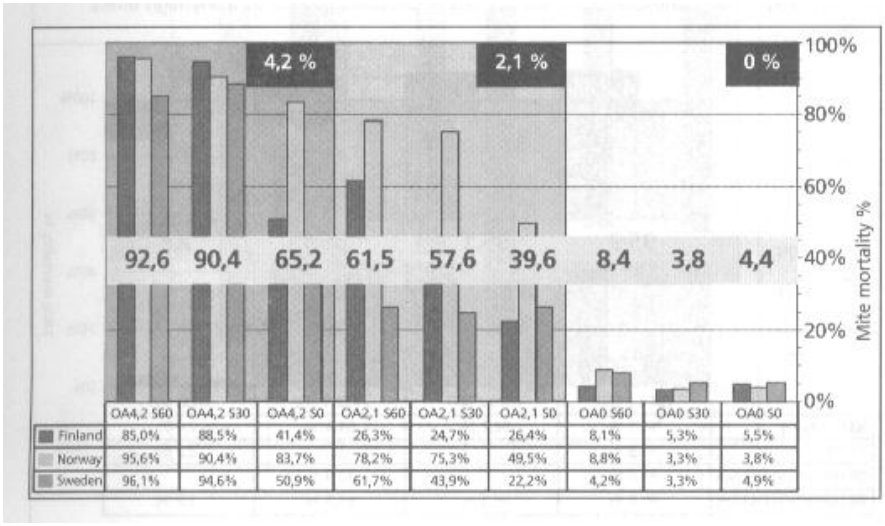
Reduced OA (2.1%) and non-sugar solutions resulted in noticeably decreased acaricidal effect. For a given OA concentration, 30% sugar option usually yielded slightly worse efficacy if compared to 60% one. The kind of treatment did not seem to have affected the winter decrease of colony strength, although 2.1% OA treated colonies underwent to a slightly better overwintering than 4.2% OA treated and control ones. Failures in colony overwintering ranged around 10% either in controls or in treated groups.

Further investigations in 1998

Basing on the screening results, the investigations performed later in 1998 mainly focused on 60% sugar solutions. 2.1, 3.2 and 4.2% OA concentrations were considered. About 220 colonies were used altogether in Germany, Italy and Switzerland. In the last country, either Dadant-Blatt or Swiss type of hive were taken into account.

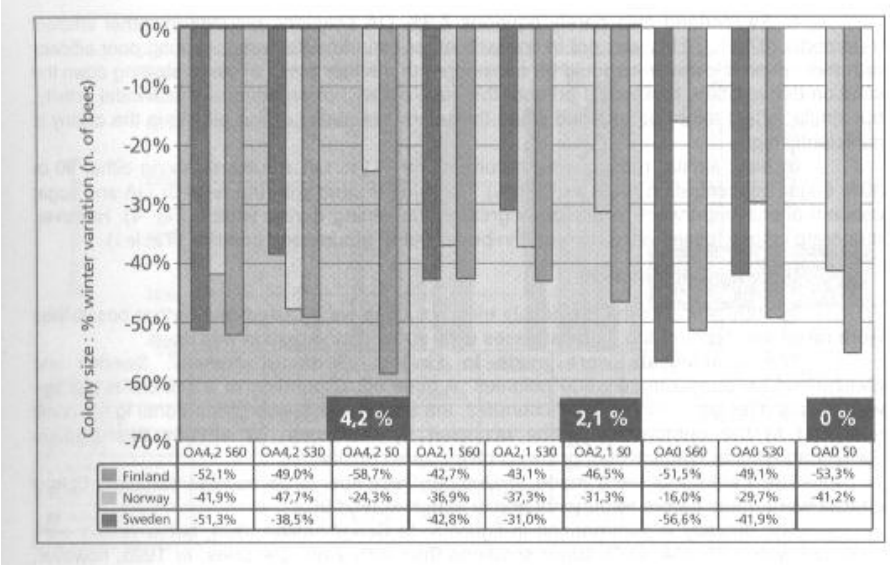
The treatments were applied in November-December, as soon as the screening results on acaricidal effect were available and the broodless condition was attained in each country. In Germany the dose was calculated according to the method previously used in Norway and Sweden, whereas in Italy and Switzerland about 5 ml per comb occupied by the bees were applied. The colonies were checked before treatments and on the following spring.

Consistently to other experiments 2.1% OA sugar solutions yielded the lowest efficacy (Fig. 3) but, unexpectedly, 3.2 and 4.2% OA ones gave a similarly high effect.



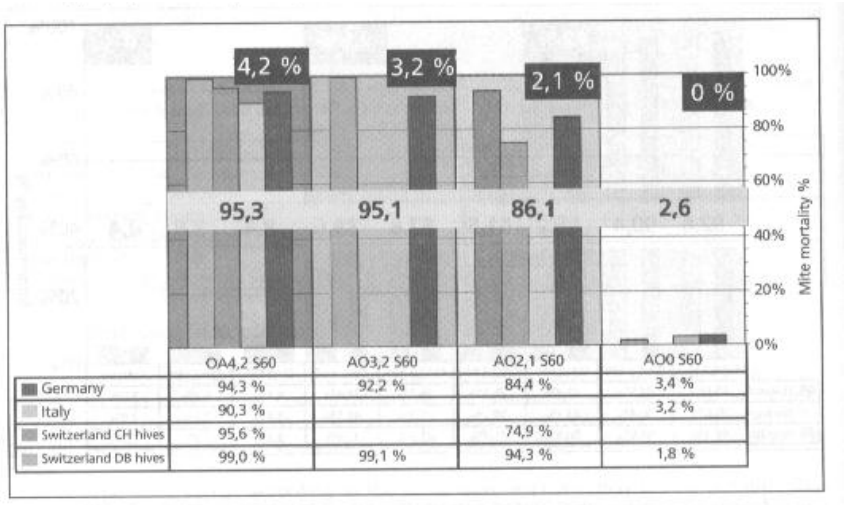
	OA4,2 S60	OA4,2 S30	OA4,2 S0	OA2,1 S60	OA2,1 S30	OA2,1 S0	OA0 S60	OA0 S30	OA0 S0
Finland	85,0%	88,5%	41,4%	26,3%	24,7%	26,4%	8,1%	5,3%	5,5%
Norway	95,6%	90,4%	83,7%	78,2%	75,3%	49,5%	8,8%	3,3%	3,8%
Sweden	96,1%	94,6%	50,9%	61,7%	43,9%	22,2%	4,2%	3,3%	4,9%

Figure 1 – Screening in Nordic countries. Average efficacy in colonies treated by trickling with different oxalic acid (OA) and sugar (S) concentrations.



	OA4,2 S60	OA4,2 S30	OA4,2 S0	OA2,1 S60	OA2,1 S30	OA2,1 S0	OA0 S60	OA0 S30	OA0 S0
Finland	-52,1%	-49,0%	-58,7%	-42,7%	-43,1%	-46,5%	-51,5%	-49,1%	-53,3%
Norway	-41,9%	-47,7%	-24,3%	-36,9%	-37,3%	-31,3%	-16,0%	-29,7%	-41,2%
Sweden	-51,3%	-38,5%		-42,8%	-31,0%		-56,6%	-41,9%	

Figure 2 – Screening in Nordic countries. Average variation of colony size during winter 1998/1999.



	OA4,2 S60	AO3,2 S60	AO2,1 S60	AO0 S60
Germany	94,3 %	92,2 %	84,4 %	3,4 %
Italy	90,3 %			3,2 %
Switzerland CH hives	95,6 %		74,9 %	
Switzerland DB hives	99,0 %	99,1 %	94,3 %	1,8 %

Figure 3 – Investigations in 1998. Average efficacy in colonies treated by trickling with different oxalic acid (OA) and sugar (S) concentrations.

In Switzerland also barely aqueous 4.2% OA solutions resulted in rather efficient treatments (87.8%). This was not in line with other experiments demonstrating poor efficacy with this option. However it should be considered that sugar plays a role in slowing down the solution dehydration, that would prevent the development of an adequate acaricidal activity, but similar effect might be attained when the relative humidity of the air within the colony is sufficiently high.

In Italy, similar results were recorded with 4.2% OA solutions having either 60 or 30% sugar concentration (90.3 vs 89.6%). Colonies treated with the highest OA and sugar concentrations underwent to a slightly greater weakening during winter (Fig. 4). However, moderate colony losses were recorded in both treated groups and controls (Table I).

Investigations in 1999

In 1999 some of the previously tried solutions were tested, but further possibilities were taken into account too. In most cases 60% sugar concentration was used.

The experiments were made in Finland, Germany, Norway, Sweden and Switzerland on approximately 600 colonies. A dose corresponding to 3 microlitres per bee was used in Germany. In the other countries, the applied dose was proportional to the comb size and to the number of combs occupied by the bees, as already described. In Switzerland, either Dadant-Blatt or Swiss hives were considered.

The treatments were made in October-December on broodless colonies. Colony checks were made before treatments and in March-May 2000.

The efficacy is summarized in figure 5. In Scandinavian trials, better results were recorded with 3.2% OA, 60% sugar solutions than with 2.6% OA ones. In 1998, however, even better efficacy was recorded in 4.2% OA treated colonies. In Switzerland, OA ranging between 2.1 and 3.2% resulted in high efficacy, provided the sugar concentration was 60%. Noticeable decrease was recorded with 30% sugar option.

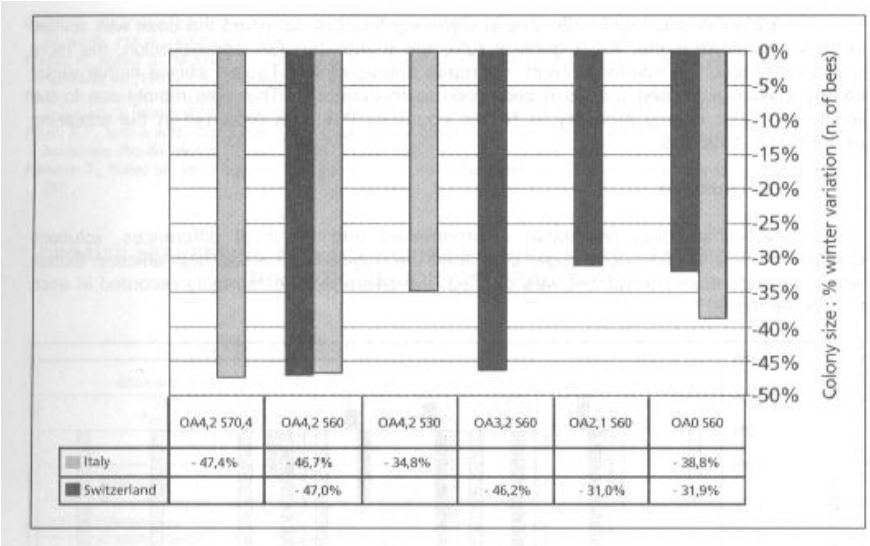


Figure 4 – Investigations in 1998. Average variation of colony size during winter 1998/1999.

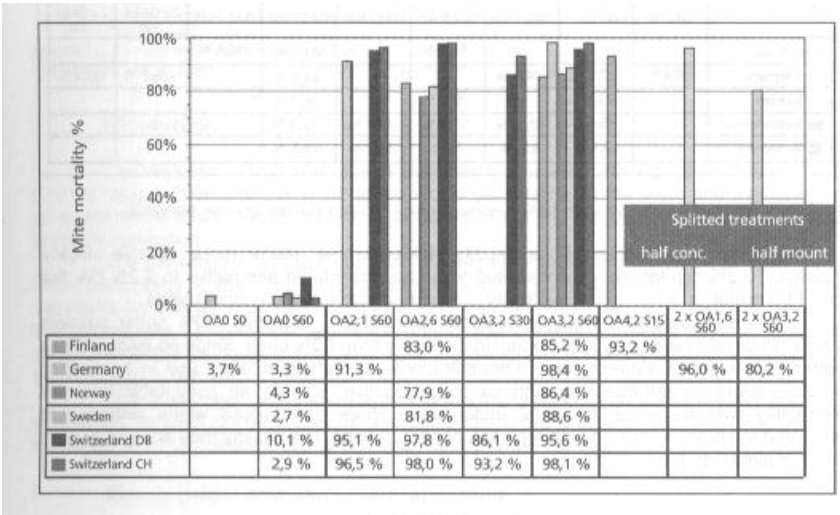
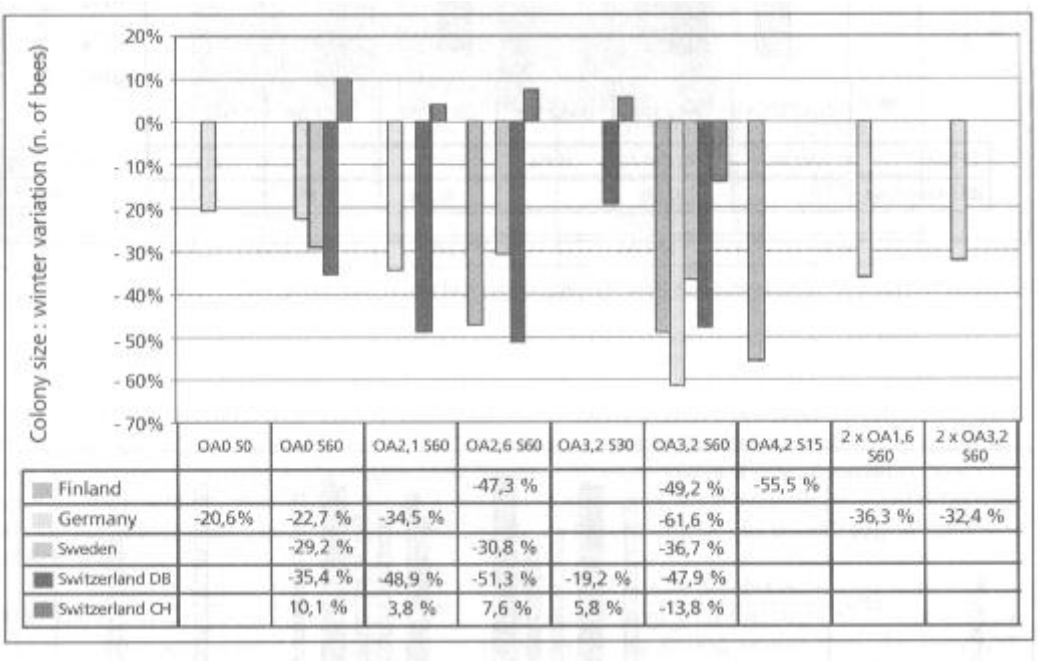


Figure 5 – Investigations in 1999. Average efficacy in colonies treated by trickling with different oxalic acid (OA) and sugar (S) concentrations.

3.2% OA was highly effective in Germany too, but not when the dose was splitted into two administrations. As a general rule, the higher the OA concentration, the more pronounced was the colony strength decrease during winter. Table I shows higher winter colony losses in treated groups if compared to the controls. This was mainly due to the relatively higher colony mortality in Nordic countries that was recorded in the screening performed in 1998 too.

Conclusions

Notwithstanding noticeable environmental and technical differences, solutions containing 4.2% OA and 60% sugar confirmed the originally recorded high efficacy. Except when an underdosed treatment was applied, the average mite mortality recorded in each trial exceeded 90%.



	OA0 S0	OA0 S60	OA2,1 S60	OA2,6 S60	OA3,2 S30	OA3,2 S60	OA4,2 S15	2 x OA1,6 S60	2 x OA3,2 S60
Finland				-47,3 %		-49,2 %	-55,5 %		
Germany	-20,6%	-22,7 %	-34,5 %			-61,6 %		-36,3 %	-32,4 %
Sweden		-29,2 %		-30,8 %		-36,7 %			
Switzerland DB		-35,4 %	-48,9 %	-51,3 %	-19,2 %	-47,9 %			
Switzerland CH		10,1 %	3,8 %	7,6 %	5,8 %	-13,8 %			

Figure 6 – Investigations in 1999. Average variation of colony size during winter 1999/2000.

Lower OA concentrations usually yielded worse and/or more variable efficacy. However, 3.2% repeatedly demonstrated to be an acceptable alternative to 4.2% OA, that might be preferred when poor tolerability is recorded with the last concentration.

In most cases non-sugar solutions were poorly effective. 30% sugar solutions tended to develop a slightly lower acaricidal efficacy than 60% ones. Since no evidence for a better tolerability of weaker sugar concentrations was attained, their use in beekeeping practice might be unnecessary and counterproductive. Usually an acceptable treatment tolerability was recorded. In some instances a more pronounced winter distress was observed in colonies treated with high OA concentrations, but usually they showed a winter survival similar to the controls.

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