



HAL
open science

First report of *Varroa destructor* resistance to pyrethroids in the UK

Helen Thompson, Michael Brown, Richard Ball, Medwin Bew

► **To cite this version:**

Helen Thompson, Michael Brown, Richard Ball, Medwin Bew. First report of *Varroa destructor* resistance to pyrethroids in the UK. *Apidologie*, 2002, 33 (4), pp.357-366. 10.1051/apido:2002027 . hal-00891907

HAL Id: hal-00891907

<https://hal.science/hal-00891907>

Submitted on 11 May 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

First report of *Varroa destructor* resistance to pyrethroids in the UK

Helen M. THOMPSON*, Michael A. BROWN, Richard F. BALL, Medwin H. BEW

National Bee Unit, Central Science Laboratory, Sand Hutton, York, YO41 1LZ, UK

(Received 8 November 2001; revised 2 January 2002; accepted 14 January 2002)

Abstract – *Varroa destructor* resistance to pyrethroids has been reported in mainland Europe since the early 1990's. *V. destructor* was first detected in the UK in 1992 and since then there has been widespread use of the only two authorised pyrethroid treatments. A routine national screening programme for resistance to pyrethroids was established in 2000 and in August 2001 resistance was detected in southwest England. The resistance outbreak was limited to 25 apiaries, was associated with product misuse, and the resistance factors to fluvalinate and flumethrin were approximately 10 fold when compared to susceptible mites. There was no cross-resistance with amitraz, coumaphos or cymiazole. This level of resistance is far lower than that detected following widespread colony collapse in Italy and highlights the importance of the correct use of varroacides and of early detection of resistance to enable its control.

Varroa destructor / resistance / pyrethroid / monitoring

1. INTRODUCTION

Varroa destructor Anderson and Trueman (Anderson and Trueman, 2000) a major pest of the European honeybee (*Apis mellifera* L.) was first reported in western Europe in the late 1970's/early 1980's. If untreated, infested colonies generally die within 2–3 years. The pyrethroid acaracides (e.g. Apistan (fluvalinate) and Bayvarol (flumethrin)) were introduced in the 1980's and proved very effective in the mite control, relatively non-toxic to the bees and easy to use. However, *V. destructor* resistance to these pyrethroid acaracides, detected due to high levels of colony losses, was first reported in Europe in 1992 (Watkins, 1997). Trouiller (1998) monitored the spread of resistance to pyrethroids throughout Europe and his data supported the theory that the resistant strain originated in Italy in the early 1990s

and spread to Slovenia, Switzerland, France, Belgium and Austria. In 1998 the detection of fluvalinate resistant mites in the United States was reported associated with lack of control of the mites with Apistan (Baxter et al., 1998; Elzen et al., 1998). Many cases of resistance in Europe were associated with the use of agricultural formulations of the pyrethroids (Watkins, 1997) or the high use of varroacide strips which significantly increase the selection pressure for resistant mites (Milani, 1999). Resistance is usually associated with decreased fitness leading to a decrease in the frequency of the resistance allele (reversion). Reversion of fluvalinate resistance of approx. 50% per year has been reported in Italy following withdrawal of the active ingredient (Trouiller, 2001). Resistance is not limited to the pyrethroid varroacides, it has also been reported for coumaphos in Italy (Abed and Ducos

* Correspondence and reprints
E-mail: H.Thompson@csl.gov.uk

de Lahitte, 1993; Milani and Della Vedoiva, 1996; Spreafico et al., 2001) and amitraz in the former Yugoslavia after only 4 years of use (Dujin et al., 1991 as cited by Milani, 1999). The basis of *V. destructor* resistance and its management is reviewed by Milani (1999).

Varroa destructor was first reported in the UK in 1992 in Devon, since when it has spread throughout England and Wales and into many parts of Scotland. There are only two registered treatments in the UK, both pyrethroids. This paper reports the first case of resistance to pyrethroids to be detected in the UK. This is also the first case to have been detected as part of a routine national screening programme rather than in response to reported lack of mite control by beekeepers (Milani, 1999). Early detection is crucial in reducing economic damage (Milani, 1999). The detection of resistance to Apistan required assessment of cross-resistance with the only other registered treatment (Bayvarol) and with other treatments, Apivar (amitraz), Apitol (cymiazole) and CheckMite (coumaphos) which could be authorised for use under "Special Treatment Authorisation" issued by the UK Veterinary Medicines Directorate to control the outbreak.

Several methods have been used to define pyrethroid resistance in the field and laboratory. We used those developed by Trouiller (1998) and Milani (1995) so as to ensure comparability with data collected elsewhere in Europe.

2. MATERIALS AND METHODS

2.1. Chemicals

Tau-fluvalinate (94%), flumethrin (97.7%) and coumaphos (95%) were obtained from Sigma Chemical Company, Poole, Dorset. Amitraz was obtained as Apivar strips (3.2%) from Laboratoires Biove, France. Cymiazole as Apitol (17.5%) and Apistan package bee strips (2.5% tau-fluvalinate) were a gift from Vita (Europe) Ltd, UK.

2.2. Field trials

From early 2000 country-wide field trials were conducted by CSL Appointed Bee Inspectors with field test kits using Apistan package bee strips. A minimum of two colonies were tested in each apiary.

The kits were based on those developed by Vita (Europe) Ltd (Trouiller, pers. comm.) in which bees from test colonies were exposed to the Apistan package bee strips for 4 hours to determine the number of susceptible mites dropping onto a sticky surface on the floor of the cage. The number of mites remaining on bees was determined by washing in detergent. The efficacy was calculated by expressing the number knocked off bees by exposure to the Apistan package bee strips as a percentage of the total. When efficacy was detected at 60% or less mites were submitted to the laboratory for confirmatory tests. In addition, data were submitted by beekeepers using the field kit or the equivalent Beltsville test method (Pettis et al., 1998).

2.3. Laboratory studies

2.3.1. Sources of mites

Mites for dose-mortality assessments were sampled from two susceptible colonies (95–100% efficacy using field test kits) from a single apiary site at CSL, York, and from three resistant colonies from a single apiary identified by the field test in Devon (showing 2–5% efficacy using field test kits). Mites from each colony were kept separate and included as a replicate in each assay thus allowing any differences in sensitivity between colonies to be identified. Mites from the country-wide survey were sent to the laboratory for confirmation of resistance whenever field test kits showed less than 60% efficacy.

Infested combs were brought in to the laboratory from the CSL apiary, or sent by courier overnight from the apiary. Combs were sampled as soon as possible after arrival and never more than 3 days after collection (combs were stored at 30–32 °C and 60–80% relative humidity in the dark). Mites were extracted from combs and any which were contaminated with larval fluid, damaged or not fully pigmented were rejected. Mites were put into petri dishes with damp filter paper and honeybee larvae from just capped cells within 24 hours prior to assay. The assays were carried out between 28 August and 22 September 2001.

2.3.2. Bioassays

Laboratory studies were undertaken to confirm resistance in colonies identified in field tests and to determine the susceptibility of mites to a number of varroacides. Full dose-response curves were developed for five different varroacides. These dose-response curves were also used to identify a suitable

dose of fluvalinate for use in laboratory confirmation studies of resistance.

The response of *V. destructor* mites to fluvalinate, flumethrin and coumaphos was determined using the methods developed by Milani (1995) and Milani and Della Vedova (1996). The active ingredients were dissolved in hexane (fluvalinate and flumethrin) or acetone (coumaphos) and then incorporated into paraffin wax (melting point 46–48 °C) and the solvent allowed to evaporate. The concentration levels in wax for fluvalinate were 23, 46, 90, 185, 500 and 2000 mg/kg, for flumethrin were 0.2, 0.5, 2.0, 5.0, 20 and 50 mg/kg and for coumaphos were 5.0, 10, 25 and 75 mg/kg. Control paraffin was prepared with the same volume of solvent as the treated paraffin. Glass discs and steel rings (supplied by Vita (Europe) Ltd) were coated with the treated paraffin, the remaining solvent allowed to evaporate off overnight and the discs placed together to form capsule and stored at 30–32 °C and 60–80% relative humidity in the dark before use.

Mites were placed in the treated capsule for 6 hours for fluvalinate and flumethrin and 4 hours for coumaphos before transfer onto untreated larvae in glass petri dishes. Three replicates of ten mites were used per treatment. The mortality was observed at transfer, 24 and 48 hours. The assay was repeated if control mortality was greater than 15%.

The efficacy of amitraz was assayed using the method of Faucon et al. (1996). A piece of Apivar strip (0.4–0.5 g) was placed in a petri dish cage with five bees in the absence of *V. destructor* mites for 2 hours (30–32 °C, 60–80% relative humidity) before the introduction of five mites. Five replicates were set up for each assay, i.e. 25 mites per assay. The time for mites to drop off the bees was determined and compared to that of control bees in which no Apivar strip was present (there was no control mortality).

The efficacy of cymiazole was determined by direct application of Apitol dissolved in water (0.2 µl) to the ventral side of *V. destructor* mites placed on their dorsal side on sticky tape. Doses of 0.5, 0.9, 1.8 and 3.7 µg cymiazole per mite were applied to 30 mites per dose and mortality observed at 24 hours. Control mites were dosed with water containing the same level of sucrose as the highest Apitol dose.

The CSL Probit 1 programme was used to calculate an LC₅₀ for fluvalinate, flumethrin, coumaphos and cymiazole and an LT50 (time to 50% mortality) for amitraz. This program takes into account control mortality (there was no control mortality in the

amitraz assay) and calculates 95% confidence limits and slope (Finney, 1971).

2.3.3. Laboratory confirmation of field test resistance

When field test kits showed 60% efficacy or less comb samples were sent to the laboratory for confirmation. Mites were sampled from the submitted combs as above and confirmation of resistance was undertaken using the bioassay with a single concentration of 200 mg/kg fluvalinate (3 replicates of 10 mites) and control capsules (3 replicates of 5 mites). The mortality was determined after 48 h and resistance confirmed if the efficacy was 70% or less and control mortality was 15% or less. The data were also compared with those of the field test kits to determine the comparability of field and laboratory data.

3. RESULTS

3.1. Field trials

In 2000 and 2001 a total of over 450 colonies were tested in nearly 300 apiaries in England and Wales. Resistance was detected for the first time in Devon and Cornwall in August 2001. Further targeted testing in the area showed 38 colonies with resistance in 25 apiaries but no resistance was detected outside this area (see Fig. 1). Of the 415 reports received

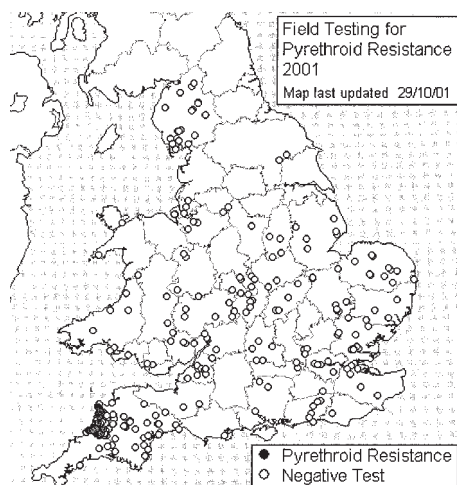


Figure 1. Distribution of pyrethroid resistance field test results (positive field tests confirmed by laboratory testing) in England and Wales 2001.

from resistance tests 47% had a total of less than 5 mites (56% of these had no mites detected), suggesting that resistance is not a problem in these colonies due to the low total numbers of mites present. Of the colonies showing resistance the mean number of mites knocked down was 4.7 (SD 7.8) and the mean number washed off was 18 (SD 19) giving a mean efficacy of 19% (SD 17%). Fifteen colonies (39%) gave less than 10% efficacy in the field test.

3.2. Laboratory studies

The dose-response curves for the mites from CSL, York and the resistant apiary in Devon are shown in Figures 2–6.

3.2.1. Fluvalinate

The susceptibility of mites from colonies at York (LC_{50} 42.7 mg/kg, 95% confidence limits (CL) 25.4–59.6 mg/kg, slope 1.9) and those from the resistant apiary identified in Devon (LC_{50} 477 mg/kg, 95% CL 300–906 mg/kg, slope 1.4) showed an 11 fold difference in the LC_{50} for fluvalinate. The LC_{95} for the York colonies (326 mg/kg) was 20 fold lower than that estimated for the Devon colonies (6957 mg/kg)

showing the curves deviated from parallel at levels which would affect efficacy of Apistan in the Devon colonies. The 200 mg/kg discriminatory concentration used in the laboratory confirmation studies following field detection of resistance according to the reference curves resulted in a mean of 85% mortality of susceptible mites and 30% mortality of resistant mites.

3.2.2. Flumethrin

Figure 3 shows that mites from both sources were far more sensitive to flumethrin than to fluvalinate but showed a similar order of difference in susceptibility. The mites from the York colonies (LC_{50} 0.47 mg/kg, 95% CL 0.25–0.73 mg/kg, slope 1.4, LC_{95} 6.4 mg/kg) showed a 13 fold lower LC_{50} and LC_{95} than the mites from the Devon colonies (LC_{50} 6.3 mg/kg, 95% CL 3.9–10 mg/kg, slope 1.5, LC_{95} 81 mg/kg).

3.2.3. Coumaphos

The sensitivity of the mites from York and those from Devon to coumaphos is shown in Figure 4. The curves are very similar and there is no difference in the LC_{50} between the mites from the two sources (York LC_{50} 14 mg/kg,

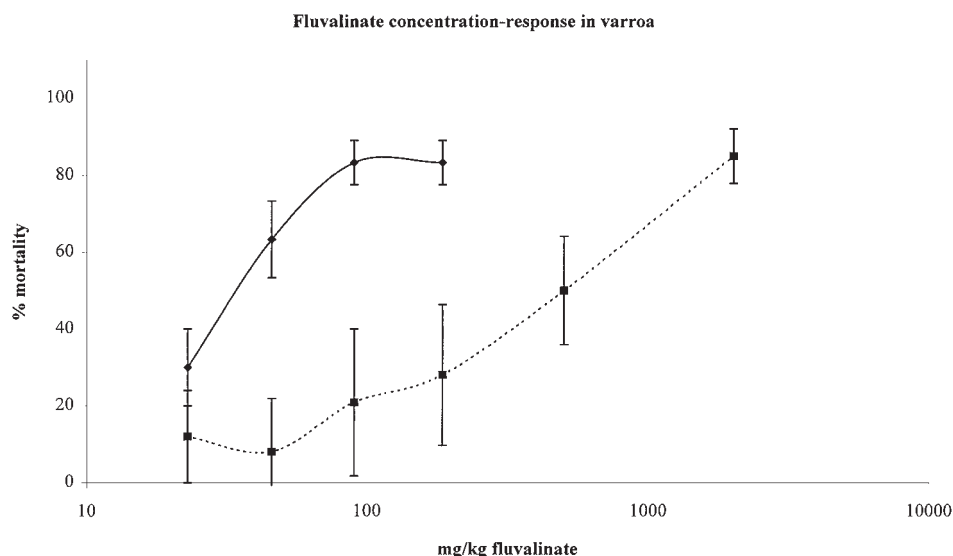


Figure 2. Proportion of dead *V. destructor* mites in fluvalinate assays (\pm SD) carried out with mites from colonies at CSL, York (solid line) and in Devon (dotted line) (30 mites per point).

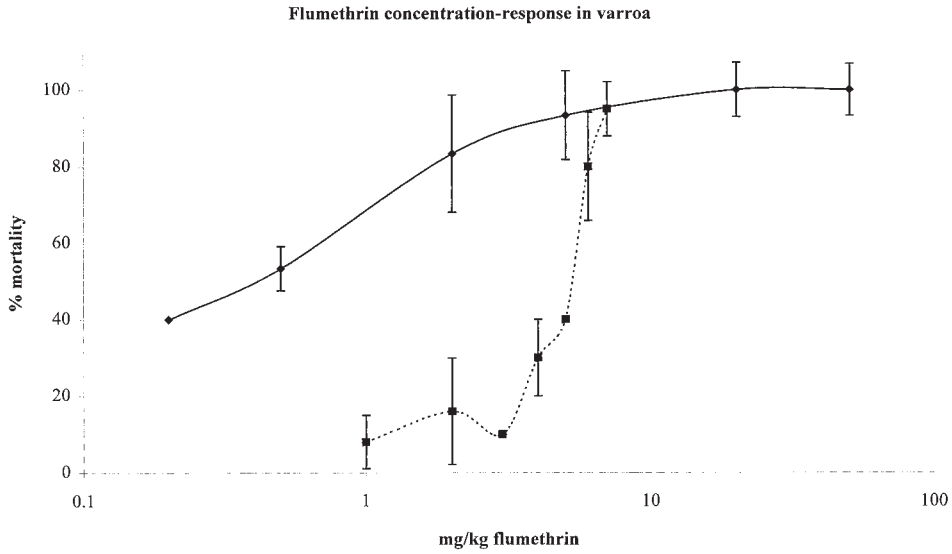


Figure 3. Proportion of dead *V. destructor* mites in flumethrin assays (\pm SD) carried out with mites from colonies at CSL, York (solid line) and in Devon (dotted line) (30 mites per point).

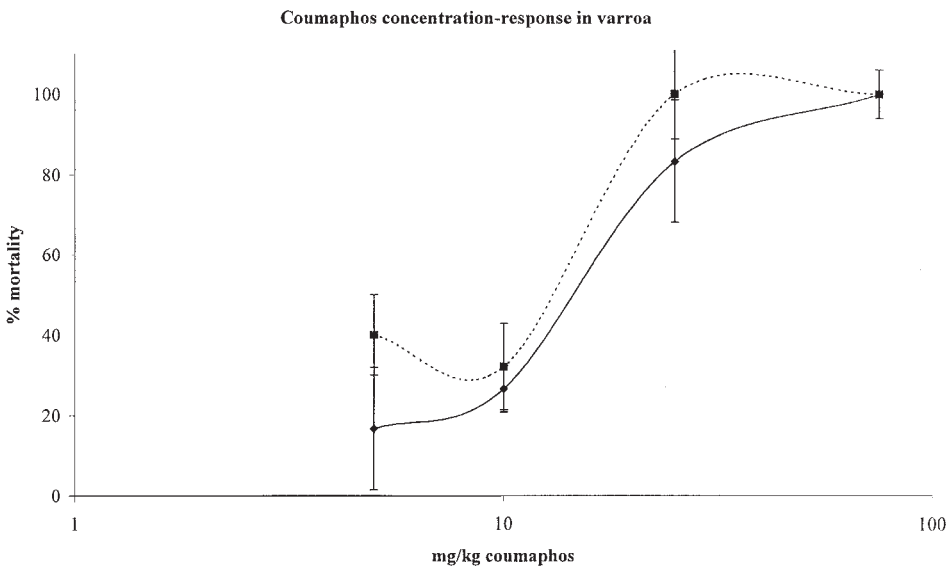


Figure 4. Proportion of dead *V. destructor* mites in coumaphos assays (\pm SD) carried out with mites from colonies at CSL, York (solid line) and in Devon (dotted line) (30 mites per point).

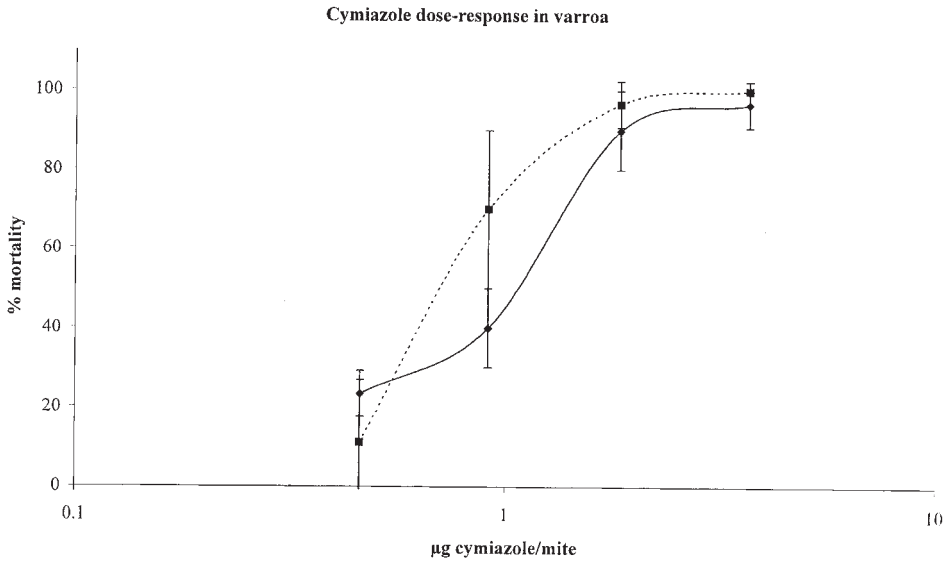


Figure 5. Proportion of dead *V. destructor* mites in cymiazole assays (\pm SD) carried out with mites from colonies at CSL, York (solid line) and in Devon (dotted line) (30 mites per point).

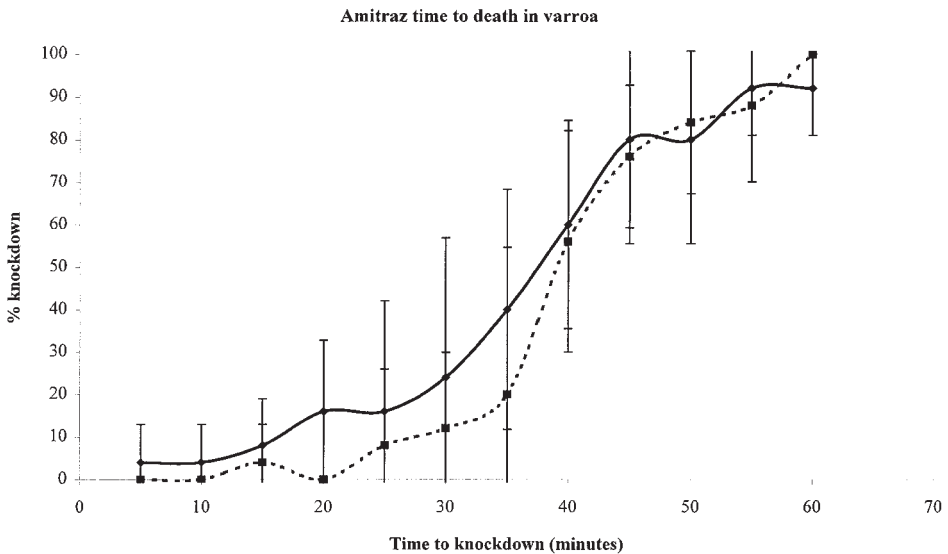


Figure 6. Time to knockdown for *V. destructor* mites in amitraz assays (\pm SD) carried out with mites from colonies at CSL, York (solid line) and in Devon (dotted line) (25 mites).

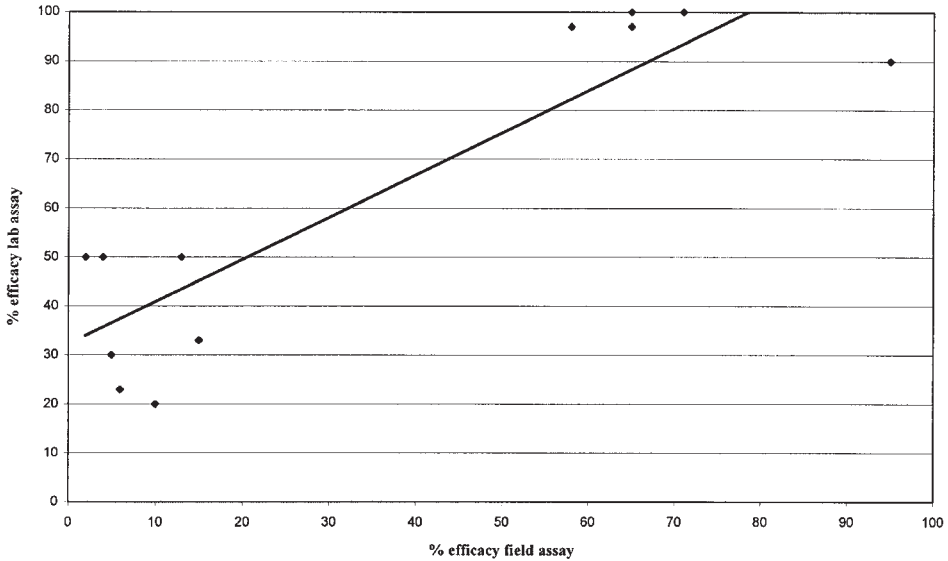


Figure 7. Comparison of field and laboratory assessments of fluvalinate efficacy in colonies sampled in 2001.

95% CL 11–17 mg/kg, slope 3.3; Devon LC₅₀ 11 mg/kg, 95% CL 7.7–14 mg/kg, slope 2.7).

3.2.4. Cymiazole

The sensitivity of the mites from York and those from Devon to cymiazole is shown in Figure 5. Again the curves are very similar and there is no difference in the LC₅₀ between the mites from the two sources (York LD₅₀ 0.9 µg/mite, 95% CL 0.73–1.1 µg/mite, slope 3.3; Devon LD₅₀ 0.8 µg/mite, 95% CL 0.62–0.91 µg/mite, slope 5.4).

3.2.5. Amitraz

The sensitivity of the mites from York and those from Devon to amitraz is shown in Figure 6. The time to knockdown is very similar and there is no difference in the LT₅₀ between the mites from the two sources (York LT₅₀ 35 min, 95% CL 31–39 min, slope 5.9; Devon LT₅₀ 39 min, 95% CL 38–41 min, slope 9.2).

3.3. Laboratory confirmation of field test resistance

A comparison of the results from laboratory and field resistance test results for the same colonies is shown in Figure 7. Although the data is

limited, due the small number of colonies in which resistance has been detected, there was a correlation between the laboratory and field data ($r = 0.89$). This shows that the field kit can reliably detect resistance when a threshold of 60% efficacy is used, although false positives are shown by the field kit near the threshold. For the 7 samples from colonies confirmed as resistant in the laboratory the field efficacy using the 2.5% Apistan package bee strip was 8% (SD 5%) and the laboratory efficacy using fluvalinate at 200 mg/kg was 37% (SD 13%).

4. DISCUSSION

This is the first reported incidence of *V. destructor* resistance to pyrethroids in the UK and the first in Europe detected prior to reports of colony losses by beekeepers. Devon was also site of the first reported case of *V. destructor* in the UK in 1992 and therefore use of pyrethroid treatments may have been occurring for up to ten years. In this case, the beekeeper was well known by the local regional bee inspector to misuse Apistan strips, through long-term continual use of strips throughout the year and overdosing, despite repeated advice to the contrary. Many other cases in Europe have been the

result of migratory beekeeping and importation of resistant mites rather than new outbreaks (Watkins, 1997; Trouiller, 1998). However, the localised nature of this outbreak, with no importation of bees by the beekeeper or by those affected in the locality, makes the development of resistance within the area more probable than the importation of resistant mites.

The toxicity of fluvalinate to the susceptible mites from CSL, York was slightly higher than that reported by Milani (1995) (LC_{50} 13–19 mg/kg) suggesting generally lower susceptibility than mites in Italy but similar to that reported by Mozes-Koch et al. (2000) in Israel (41.5 mg/kg) and Trouiller (1998) (25 mg/kg). The LC_{50} in resistant mites was similar to that reported in Tirano, Italy (385 mg/kg) but lower than that reported in Como (857 mg/kg) or reported by Trouiller (1998) in Italy (9 234 mg/kg). When comparing the mites tested under the same conditions the 11 fold resistance factor in LC_{50} shown by the mites from the Devon apiary is far lower than the 440 fold resistance in Italy reported by Milani (1995) or 369 reported in Italy by Trouiller (1998) but higher than the 2 fold resistance factor reported for Israel by Mozes-Koch et al. (2000). The 200 mg/kg discriminatory concentration for detecting resistant mites is the same as that identified by Trouiller (1998).

The toxicity of flumethrin is similar to that reported by Milani (1995) (0.28–0.36 mg/kg) in susceptible mites and but slightly lower than the 11.4–20.4 mg/kg in resistant mites in Italy. These data clearly demonstrate the cross-resistance to fluvalinate and flumethrin.

The toxicity of coumaphos was similar to that reported by Milani and Della Vedova (1996) and Spreafico et al. (2001) for susceptible mites in Italy (9.8–12.2 mg/kg) and well below the LC_{50} reported for resistant mites (21.5–554 mg/kg) (Spreafico et al., 2001). This confirmed that there was no cross-resistance or multi-resistance to coumaphos in the mites from the fluvalinate resistant colonies. The toxicity of amitraz as Apivar strips was determined as a LT_{50} due to the instability of amitraz and showed similar results in the CSL, York and Devon colonies to those reported by Faucon et al. (1995) (13–47 minutes) who also showed that there was no cross-resistance between

fluvalinate and amitraz. The toxicity of cymiazole to mites from the CSL, York and Devon was also similar to that recorded for susceptible mite populations (Watkins, pers. comm.).

Comparable data for a range of varroacides in mites from the same colonies are not possible due to resistance being detected by poor *V. destructor* control and collapsing colonies (Milani, 1995). As the resistance was detected in the early stages this is the first time that truly comparable data have been generated for five different varroacides in mites from the same colonies. These laboratory data have allowed cymiazole, amitraz and coumaphos to be identified as control measures for the fluvalinate resistant mite.

The use of the field kits as a strategy to detect resistance at an early stage has allowed the situation to be managed before it became widespread or resulted in colony collapse. The laboratory confirmation tests have shown that the field kits can reliably detect resistance when a threshold of 60% is used, although false positives may occur around this value underlining the need for laboratory confirmation of apparent new outbreaks. The mean efficacy detected in the outbreak in the southwest of England ($18\% \pm 16\%$) was slightly greater than that detected in Florida, USA, using the same package bee strips ($7.1 \pm 7.9\%$) (Elzen et al., 1998), and similar to that reported in colonies elsewhere in Europe since 1995, e.g. Switzerland 0–26% efficacy (Trouiller, 1998). The kits and laboratory confirmation will be continued to be used in monitoring the situation in England and Wales and in encouraging beekeepers to monitor their own colonies to ensure outbreaks are detected at an early stage and information can be provided on appropriate management strategies.

ACKNOWLEDGEMENTS

This research was funded by the Horticulture and Potatoes Division, DEFRA and by NAWAD. The authors are grateful for the assistance of the CSL bee inspectors in carrying out the field tests and technical advice from Vita (Europe) Ltd.

Résumé – Résistance de *Varroa destructor* aux pyréthri-noïdes en Grande-Bretagne : premier cas signalé.

La résistance de l'acarien *Varroa destructor* aux pyréthri-noïdes est signalée en Europe continentale depuis le début des années 90. L'acarien a été détecté pour la première fois au Royaume-Uni en 1992 et depuis cette date l'usage des deux seuls traitements autorisés aux pyréthri-noïdes s'est largement répandu. Un programme national de dépistage appliqué en routine a démarré en 2000 et, en août 2001, la résistance a été détectée dans le sud ouest de l'Angleterre. Le foyer de résistance était limité à 25 ruchers et associé à une mauvaise utilisation du produit. La toxicité de cinq varroacides (fluvalinate, fluméthrine, coumaphos, amitraze et cymiazole) a été comparée sur des acariens provenant de deux sources : (i) des colonies apparemment sensibles situées au CSL, York et (ii) des colonies du sud-ouest de l'Angleterre identifiées comme étant résistantes. La toxicité du fluvalinate pour les acariens sensibles du CSL, York était légèrement supérieure à celle mentionnée par Milani (1995) (concentration létale 50, CL₅₀, de 13 à 19 mg/kg) suggérant une sensibilité généralement plus faible que celle des acariens d'Italie, mais semblable à celle mentionnée par Mozes-Koch et al. (2000) en Israël (41,5 mg/kg) et par Trouiller (1998) (25 mg/kg). La CL₅₀ pour les acariens résistants était semblable à celle signalée à Tirano, Italie (385 mg/kg), mais inférieure à celle signalée à Come (857 mg/kg) ou à celle mentionnée par Trouiller (1998) en Italie (9234 mg/kg).

Lorsque l'on compare les acariens testés dans les mêmes conditions, la résistance pour la CL₅₀ présentée par les acariens du rucher du Devon (facteur de 11) est beaucoup plus basse que la résistance en Italie mentionnée par Milani (1995, facteur de 440) ou celle mentionnée en Italie par Trouiller 1998, facteur de 369), mais plus forte que la résistance mentionnée en Israël par Mozes-Koch et al. (2000, facteur de 2). La dose discriminante de 200 mg/kg pour détecter les acariens résistants était la même que celle identifiée par Trouiller (1998).

La toxicité de la fluméthrine était semblable à celle mentionnée par Milani (1995) en Italie pour les acariens sensibles (0,28–0,36 mg/kg) mais légèrement inférieure à la toxicité pour les acariens résistants (11,4–20,4). Ces données prouvent clairement la résistance croisée au fluvalinate et à la fluméthrine. La toxicité du coumaphos était semblable à celle mentionnée par Milani et Della Vedova (1996) et par Sprafico et al. (2001) pour les acariens sensibles en Italie (9,8 à 12,2 mg/kg) et bien inférieure à la CL₅₀ mentionnée pour les acariens résistants (21,5 à 554 mg/kg) (Sprafico et al., 2001). Ceci confirme l'absence de résistance croisée et de multi-résistance au coumaphos chez les acariens des colonies résistantes au fluvalinate. En raison de l'instabilité de

l'amitraze, on a utilisé la toxicité létale 50 (TL₅₀) pour évaluer la toxicité de l'amitraze sous forme de bandelettes Apivar®. Les résultats au CSL, York et dans les colonies du Devon étaient semblables à ceux mentionnés par Faucon et al. (1995) (13 à 47 min), qui ont montré eux aussi qu'il n'y avait pas de résistance croisée entre le fluvalinate et l'amitraze. La toxicité du cymiazole pour les acariens du CSL, York et du Devon était semblable à celle enregistrée pour des populations sensibles d'acariens (Watkins, données non publiées).

Comme la résistance a été détectée à un stade précoce, c'est la première fois que des données vraiment comparables ont pu être obtenues pour cinq varroacides différents pour des acariens issus des mêmes colonies. Ces données de laboratoire ont permis d'identifier le cymiazole, l'amitraze et le coumaphos comme témoins dans les tests de résistance au fluvalinate. L'utilisation de kits de terrain comme stratégie pour détecter la résistance à un stade précoce a permis de gérer la situation avant qu'elle ne soit largement répandue ou qu'elle ne provoque la mort des colonies.

Varroa destructor / résistance / pyréthri-noïde / surveillance

Zusammenfassung – Erster Bericht über die Resistenz von *Varroa destructor* gegen Pyrethroide in England.

Über eine Resistenz von *Varroa destructor* gegen Pyrethroide auf dem europäischen Festland wurde seit den frühen neunziger Jahren berichtet. Der erste Fund der Milbe in England erfolgte 1992 und seitdem war die Anwendung der beiden einzigen zugelassenen Pyrethroide weitverbreitet. Eine routinemäßige, nationale Rasterprüfung zur Resistenz gegen Pyrethroide wurde seit dem Jahr 2000 durchgeführt und im August 2001 wurde die Resistenz in Südwest-England nachgewiesen. Das Vorkommen der Resistenz war auf 25 Bienenstände begrenzt und hing mit einer falschen Anwendung der Mittel zusammen.

Die Toxizität mehrerer Varroazide wurde bei Milben aus 2 Herkünften verglichen: aus offensichtlich nicht resistenten Beständen in CSL, York und aus den resistenten Beständen im Südwesten Englands. Die Giftwirkung von Fluvalinat auf die nicht resistenten Milben aus CSL, York war etwas stärker als die von Milani (1995) beschriebene (LC₅₀ 13–19 mg/kg), wohl ein Zeichen für eine allgemein geringere Empfindlichkeit als bei Milben in Italien, aber ähnlich wie die von Mozes-Koch et al. (2000) in Israel und von Trouiller (1998) gefundenen Werte (25 mg/kg). Die LC₅₀ bei resistenten Milben war ähnlich wie in Tirano, Italien (385 mg/kg), aber niedriger als in Como (857 mg/kg) oder als die Werte von Trouiller (1998) in Italien (9 234 mg/kg).

Beim Vergleich von Milben, die unter den gleichen Bedingungen getestet waren, erwies sich der 11fache Resistenzfaktor bei der LC_{50} der Milben aus dem Bienenstand Devon als viel niedriger als die 440fache Resistenz in Italien, beschrieben von Milani (1995) oder 369 in Italien (Trouiller, 1998). Er war aber höher als der 2fache Resistenzfaktor in Israel (Mozes-Koch et al., 2000). Die 200 mg/kg Dosis zur Auffindung von resistenten Milben war dieselbe wie die von Trouiller (1998) bestimmte.

Die Giftwirkung von Flumethrin war vergleichbar zu der von Milani (1995) beschriebenen (0,28–0,36 mg/kg) Wirkung, aber etwas geringer als die 11,4–20,4 mg/kg bei resistenten Milben in Italien. Diese Ergebnisse zeigen eine Kreuz-Resistenz zwischen Fluvalinate und Flumethrin.

Die Toxizität von Coumaphos entsprach den Ergebnissen von Milani und Della Vedova (1996) und Spreafico et al. (2001) für anfällige Milben in Italien (9,8–12,2 mg/kg) und lag weit unter der LC_{50} , die für resistente Milben gefunden wurde (21,5–554 mg/kg) (Spreafico et al., 2001). Das ist ein Nachweis, dass es keine Kreuz-Resistenz oder Mehrfachresistenz gegen Coumaphos bei den Milben aus Fluvalinat resistenten Völkern gab.

Die Toxizität von Amitraz in Apivar Streifen wurde wegen der Instabilität von Amitraz als LT_{50} bestimmt und die Ergebnisse waren ähnlich wie in CSL, York und Devon in Völkern, die von Faucon et al. (1995) (13–47 Minuten) untersucht wurden. Er zeigte auch, dass es keine Kreuz-Resistenz zwischen Fluvalinate und Amitraz gab. Die Toxizität von Cymiazole bei Milben von CSL, York and Devon ähnelte ebenfalls den Ergebnissen für die nicht resistenten Milbenpopulationen (Watkins, pers. comm.).

Da die Resistenz in einem frühen Stadium entdeckt wurde, konnten hier zum ersten Mal wirklich vergleichbare Daten für 5 verschiedene Varroazide von Milben aus denselben Völkern erhoben werden. Diese Labordaten ermöglichten, dass Cymiazole, Amitraz and Coumaphos als wirksames Mittel gegen Fluvalinat resistente Milben identifiziert werden konnte. Die Nutzung von genormten Felduntersuchungen als Strategie zur Entdeckung von Resistenzen in einem frühen Stadium hat ermöglicht, mit der Situation fertig zu werden bevor sie sich weit verbreitet oder gar zum Zusammenbruch von Völkern führt.

***Varroa destructor* / Resistenz / Pyrethroide / Überprüfung oder Überblick / Rasterprüfung**

REFERENCES

- Abed T., Ducos de Lahitte J. (1993) Détermination de la DL_{50} de l'amitraz et du coumaphos sur *Varroa jacobsoni* Oud. au moyen des acaricides Anti-varroa (Schering) et Perizin (Bayer), *Apidologie* 24, 121–128.
- Anderson D.L., Trueman J.W.H. (2000) *Varroa jacobsoni* (Acari: Varroidae) is more than one species, *Exp. Appl. Acarol.* 24, 165–189.
- Baxter J., Eischen F., Pettis J., Wilson W.T., Shimanuki H. (1998) Detection of fluvalinate resistant varroa mites in US honey bees, *Am. Bee J.* 138, 291.
- Dujin T., Jovanic V., Šukakov D., Milkovic Z. (1991) Effects of extended utilisation of amitraz-based preparations on the formation of resistant strains of *Varroa jacobsoni*, *Vet. Glas.* 45, 851–855 (in Croatian (latin script) with Serbian spelling).
- Elzen P.J., Eischen F.A., Baxter J.R., Pettis J., Elzen G.W., Wilson W.T. (1998) Fluvalinate resistance in *Varroa jacobsoni* from several geographic locations, *Am. Bee J.* 138, 674–676.
- Faucon J.P., Drajnudel P., Fléché C. (1996) Varroose : mise en évidence de la résistance du parasite aux acaricides par la méthode de détermination du temps létal moyen, *Apidologie* 27, 105–110.
- Finney D.J. (1971) *Probit Analysis*, 3rd ed., Cambridge University Press, Cambridge.
- Milani N. (1995) The resistance of *Varroa jacobsoni* Oud. to pyrethroids: a laboratory assay, *Apidologie* 26, 415–429.
- Milani N. (1999) The resistance of *Varroa jacobsoni* Oud. to acaricides, *Apidologie* 30, 229–234.
- Milani N., Della Vedova G. (1996) Determination of the LC_{50} in the mite *Varroa jacobsoni* of the active substances in Perizin and Cekafox, *Apidologie* 27, 175–184.
- Mozes-Koch R., Slabezki Y., Efrat H., Kalev H., Kamer Y., Yakobson B.A., Dag A. (2000) First detection in Israel of fluvalinate resistance in the varroa mite using bioassay and biochemical methods, *Exp. Appl. Acarol.* 24, 35–43.
- Pettis J.S., Shimanuki H., Feldlaufer M.F. (1998) Detecting fluvalinate resistant varroa mites, *Am. Bee J.* 138, 535–537.
- Spreafico M., Eordegh F.R., Bernardinelli I., Colombo M. (2001) First detection of strains of *Varroa destructor* resistant to coumaphos. Results of laboratory tests and field trials, *Apidologie* 32, 49–55.
- Trouiller J. (1998) Monitoring *Varroa jacobsoni* resistance to pyrethroids in western Europe, *Apidologie* 29, 537–546.
- Trouiller J. (2001) Monitoring Varroa resistance to pyrethroids (1994–2001), *Bee Craft*, 15–17.
- Watkins M. (1997) Resistance and its relevance to beekeeping, *Bee World* 78, 15–22.