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Ecology and control of saddle gall midge, *Haplodiplosis marginata* von Roser (Diptera; Cecidomyiidae)

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CONTENTS

1. ABSTRACT

The saddle gall midge, *Haplodiplosis marginata*, is a sporadic pest in the UK and central and northern Europe.

Adults emerge from overwintering sites in the soil to mate and lay eggs on cereals (primarily wheat and barley, rarely oats) and grasses, especially couch grass, *Agropyron repens,* at the stem extension stage (GS31-39). Eggs hatch and larvae crawl down the stem to feed under the leaf sheath, where their feeding causes characteristic saddle-shaped galls. These galls restrict movement of nutrients to the ears, resulting in weak stems and small or blind ears. This causes yield losses when there are more than 5-7 galls per tiller. Damage is locally important on heavy soil types where wheat and/or barley are grown in continuous rotation.

Cultural control is best achieved by including a non-cereal crop, such as sugar beet or oilseed rape, in the rotation, as the adults do not fly far from their emergence locations.

There are no label recommendations for chemical control of saddle gall midge but some control can be obtained by one or two applications of insecticides applied to control other pests. Pyrethroids, such as alpha-cypermethrin, deltamethrin, esfenvalerate and lambda-cyhalothrin, and organophosphorous products, such as dimethoate, may give good control when the timing of applications is targeted at the moment eggs hatch and larvae migrate down the stem.

2. INTRODUCTION

Localised epidemics of the saddle gall midge, *Haplodiplosis marginata* (von Roser) (1840) (syn. *H. equestris* Wagner 1871) have been recorded in the last two years in central England, especially Buckinghamshire, Bedfordshire, Warwickshire, Worcestershire and Suffolk (Allison, 2010; Case, 2011; http://farmingforum.co.uk/forums/showthread.php?t=35126; http://www.syngenta-crop.co.uk/sm/blogview.aspx?blogid=25&groupid=11). This pest is very sporadic in the UK; previous epidemics have been reported in 1968 and 1969 (Golightly and Woodville, 1974; Woodville, 1968, 1970, 1973), but until now this pest has remained below economically damaging levels. The recent epidemics have raised its profile once again, stimulating renewed interest in its ecology and methods of control. Because of its sporadic nature, few ecological studies have been conducted, and, of those, most have been done in continental Europe. This paper reviews the evidence available in the literature.

3. DESCRIPTION AND LIFE HISTORY

The saddle gall midge was first recorded as a pest in 1692 and 1693 in north east Bavaria, Germany (Weidner, 1985), but was not recorded in England until 1889 in Lincolnshire (Golightly & Woodville, 1974). As its name suggests, the saddle gall midge is a fly, not unlike the orange wheat blossom midge in appearance (Figure 1), about 5 mm long (range: 2 to 5.5 mm for females).

Figure. 1. Adult female saddle gall midge

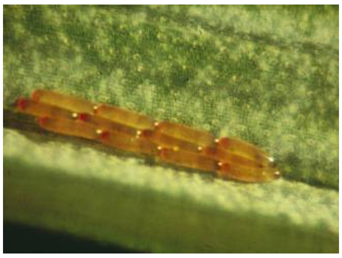

Figure 2. Saddle gall midge eggs

Figure 3. Saddle gall midge larva

The adults emerge from their pupation sites in the soil from late May onwards (Gratwick, 1992; Skuhravy et al., 1983), although, if spring weather is unusually warm, they can appear as early as late April (as reported by growers in 2011). Males tend to emerge first, followed by females 3-5 days later; the latter predominate towards the end of the migration period (Skuhravy et al., 1983). Emergence is influenced by temperature and moisture conditions, with warmer temperatures stimulating earlier migration, and dry conditions prohibiting it. After mating, the larger females lay their blood-red eggs (Figure 2) in a long thin raft on the upper or lower surfaces of cereal or grass leaves when the plants are at the stem extension stage (GS31-39; Zadoks et al., 1974). Each female has about 100 eggs in her ovariole, depending on size (range: 14-250). The eggs hatch within 1-2 weeks and the young larvae move down the leaf to feed on the stem under the protection of the leaf sheath. The larvae are initially whitish green but turn orangy-red as they grow larger (Figure 3).

Their feeding activity on the stem results in the formation of galls by the plant that resemble saddle-shaped depressions swollen at either end (Figure 4), hence the descriptive name given to the pest. These galls occur mainly on the top three internodes, but may occur on lower internodes in backward crops. The galls, however, are not as visible as depicted in Figure 4; they are usually covered by the leaf sheath and outward visible symptoms are more subtle (Figure 5).

Figure 4. Saddle-shaped galls on wheat

Figure 5. Outward symptoms of infestation

The larvae achieve full size by mid-July, when they fall to the ground in search of shelter, sometimes reaching densities as high as 6,400 /m^2 (Popov et al., 1998). They spend the rest of the year, and overwinter, as larvae in diapause in small hollows in the soil. The larvae pupate the following spring and emerge again as adults in May. If weather conditions are dry, about 75% of larvae can remain in diapause for another year, emerging when conditions may be better. However, even where weather is suitable, about 20% of larvae may remain in the soil in diapause (Popov et al., 1998).

4. DISTRIBUTION AND ABUNDANCE

In addition to central England, the saddle gall midge is widely distributed throughout central and northern Europe (Figure 6). Infestations were recorded in Bulgaria, Denmark, north-west Germany, Holland, Serbia, southern Sweden and Switzerland in the 1950s and 60s (reviewed in Woodville, 1968), but also in Austria, Belgium, Czechoslovakia (now Czech Republic and Slovakia), northern France, Hungary, Netherlands (although it is regarded as rare in this country (Daamen & Stol, 1993)), Poland, Romania and the former Yugoslavia, some epidemics in later years (reviewed by Skuhravy et al., 1983, Basedow, 1986, and Popov et al., 1998). More recently, outbreaks have been recorded in France in 2010 (Anon, 2011), Germany in 2004 (Mölck, 2006) and Greece in

2009-10 (Deligeorgidis et al., 2012). These outbreaks were attributed to the increase in the practice of growing continuous cereals. On the other hand, damage tended to be low or absent during periods of low soil temperature (<15°C) and dry weather, especially between mid April and mid May, which affected the emergence of the adults (Skuhravy et al., 1983; Popov et al., 1998). Interestingly, in the latter study, cultivation of soil to allow planting of maize in spring encouraged emergence of adults by dissipating the crust on the soil surface, even in dry weather.

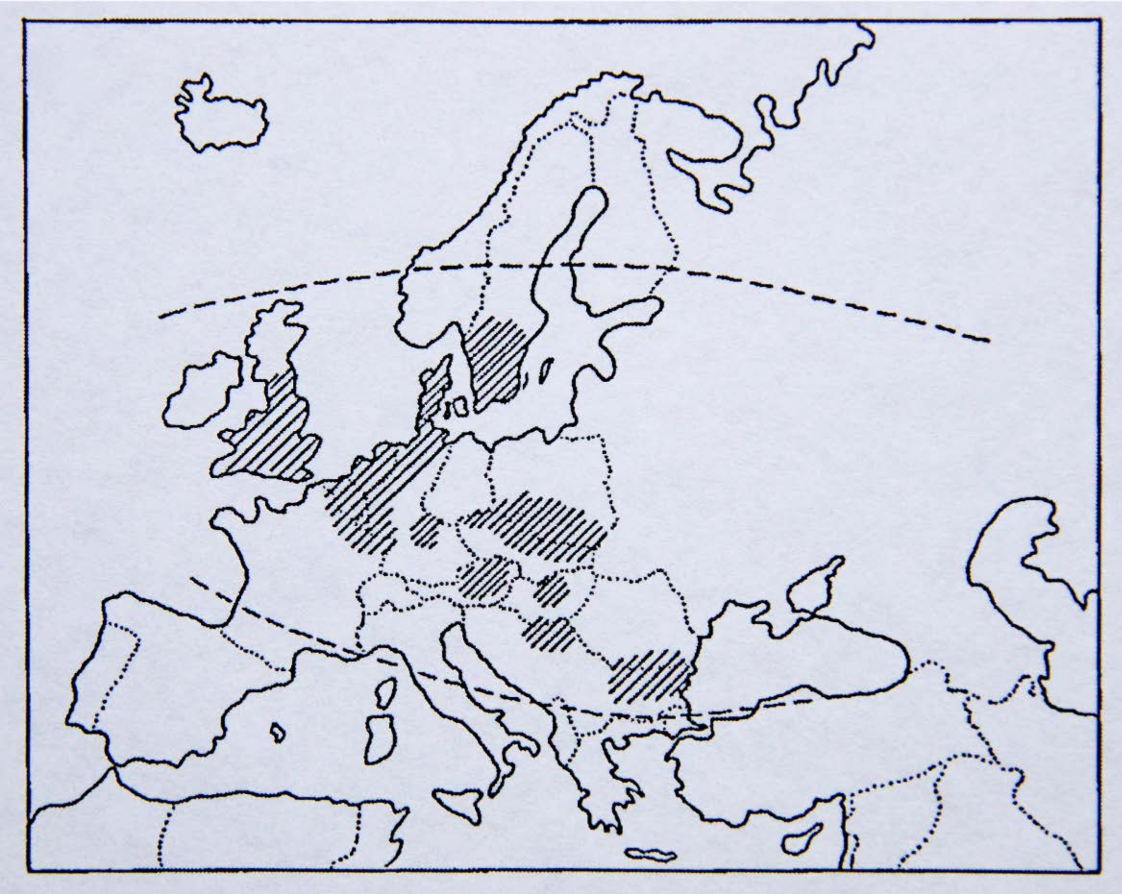

Figure 6. Distribution of saddle gall midge in Europe. (adapted from Skuhravy et al., 1983). Shaded areas are where crop damage has been recorded at least once from 1956-1983.

5. HOST PLANT PREFERENCES

Before man's development of graminaceous crops, saddle gall midge must have evolved in association with wild grasses. Of 48 species examined by Schütte (1964), couch grass, *Agropyron repens*, was the most heavily infested, followed by false barley, *Hordeum murinum* and darnel, *Lolium temulentum.* All other grass species examined including the Phalaridae, Agrostidae, Aveneae either had no larvae at all, or were only slightly infested. Within cultivated crops examined, wheat, *Triticum aestivum*, barley, *Hordeum vulgare,* and rye, *Secale cereale,* were all attacked equally, but the Einkorn wheat, *Triticum monococcum*, and oats, *Avena sativa*, remained undamaged.

Egg-laying behaviour follows these observations of plant species attacked when those host plants are available at the time of egg laying, but in their absence, females will lay eggs on many species of grass, and some non-graminaceous species such as potato, *Solanum tuberosum,* and even directly on the soil (Skuhravy et al., 1983). Skuhravy et al. (1983) suggested that oats could be used as a trap crop to reduce the infestation pressure in neighbouring fields, without causing undue yield losses. However, in the study by Woodville, 24% of spring sown oats in Bedfordshire, UK from 1967-71, and 33% (one of three fields surveyed) in 1972 were infested, so perhaps there were differences in the varieties, or the state of maturity of the plants at the time of egg hatch that determined whether oats was a suitable host plant or not (Woodville, 1973). Despite these observations, Woodville concluded that oats were a less favoured host plant than wheat or barley.

6. FORECASTING AND MONITORING

Due to its sporadic nature, it is very difficult to acquire sufficient data to construct meaningful models of population dynamics for this insect species. Even where epidemics occur more often, for example in Germany, attempts to do so have not been successful (Basedow, 1986). In a continuous winter wheat plot in Germany, two peaks of abundance were observed in a 10 year monitoring programme (1976 and 1983), but in other years, numbers remained low despite good emergence conditions in some years. Some anecdotal links to levels of rainfall in April and May have been made but with not much accuracy from a modelling point of view. There was a good positive correlation between rainfall in July and abundance of adults the following year in 8 out of ten years (1975-1985) (Basedow, 1986). High rainfall in July may have allowed easier penetration of the soil to find overwintering sites.

Monitoring of adult activity during their emergence phase can give some forewarnings of impending risk. Of the methods available, water traps were considered to be more efficient at trapping adults than sweep nets or sticky traps (Popov et al., 1998). However, major influences of weather on further development of the various life-history stages make forecasting unpredictable (Golightly & Woodville, 1974).

7. CROP DAMAGE

7.1. Cropping practices

Anecdotal evidence from the UK suggests that fields growing continuous wheat or barley are more at risk than those practicing rotations with different crops. This was confirmed in Czech studies where first year barley was reported to have 12% infestation of tillers, but this rose sharply to 37 and 62% when successive barley crops were grown, and there were more galls per infested tiller (Skuhravy et al., 1983). Similar observations were made on successively-grown wheat. In addition, later sown crops (October) had more damage than those sown in September. The latter effect was attributed to the early sown plants being at an unfavourable growth stage when the larvae hatched.

Very heavy infestations of cereals were recorded in Romania where the preceding crop was wheat (66%) or barley (44%), compared to those following maize (11%), sunflower (11%), flax (8%), beans (7%) or peas (3%) (Popov et al. 1998). These lower infestations were due to immigration from neighbouring fields. Within wheat varieties there was no sign of any resistance, but barley, rye and triticale had considerably fewer larvae per stem (less than a third) than all the wheat varieties examined, even though the proportion of tillers attacked was similar to that of wheat.

Studies in the UK in the 1970s showed that damage was maximal when, at the time of egg laying, the plants were at the stem extension stage (GS31-39; Zadoks et al, 1974), and minimal when at or past the boot stage (GS45) (Golightly & Woodville, 1974). Thus, backward winter-sown or spring sown cereals are usually at greater risk than winter sown (Gratwick, 1992). Surveys done in England from 1970-1972 showed spring barley was the most heavily infested in two of the three years (Woodville, 1973). Feeding damage can cause reductions in crop height (Rijsten, 1967; Popov et al., 1993), as well as reductions in grain yield, but secondary infections by fungi and bacteria can exacerbate losses.

7.2. Yield effects

Damage to the stems causes a restriction of the nutrient flow to the grains in the ear, resulting in small, poorly developed or even blind ears (Golightly & Woodville, 1974), thus reducing yield. Yield can also be reduced by the lodging of damaged stems, which have been weakened by larval feeding activities (Golightly & Woodville, 1974; Gratwick, 1992; Nijveldt & Hulshoff, 1968).

Both kernel number and thousand grain weight (TGW) were significantly reduced by saddle gall midge larvae in studies in Romania (Figure 7; Popov et al., 1998), with consequent effects on yield. Losses of 0.6 t/ha were estimated from one study done in England in 1967 in which the range of damage was extensive (Woodville, 1968). Significant damage was reported when 5-10 galls per stem were present in Germany (Schütte, 1983), an economic threshold of 7 larvae per stem on wheat was suggested by Golightly and Woodville (1974), with lower levels suggested for barley due to its greater vulnerability to stem breaking. However, no significant relationships were found in analyses done to compare field yields with percent infestation on a wider scale (Woodville, 1973). Theoretical yield losses of 12.6% were calculated by Golightly & Woodville (1974), but much higher losses (circa 70%) were recorded in some fields in 2010 (ADAS Technical bulletin, Spring 2012).

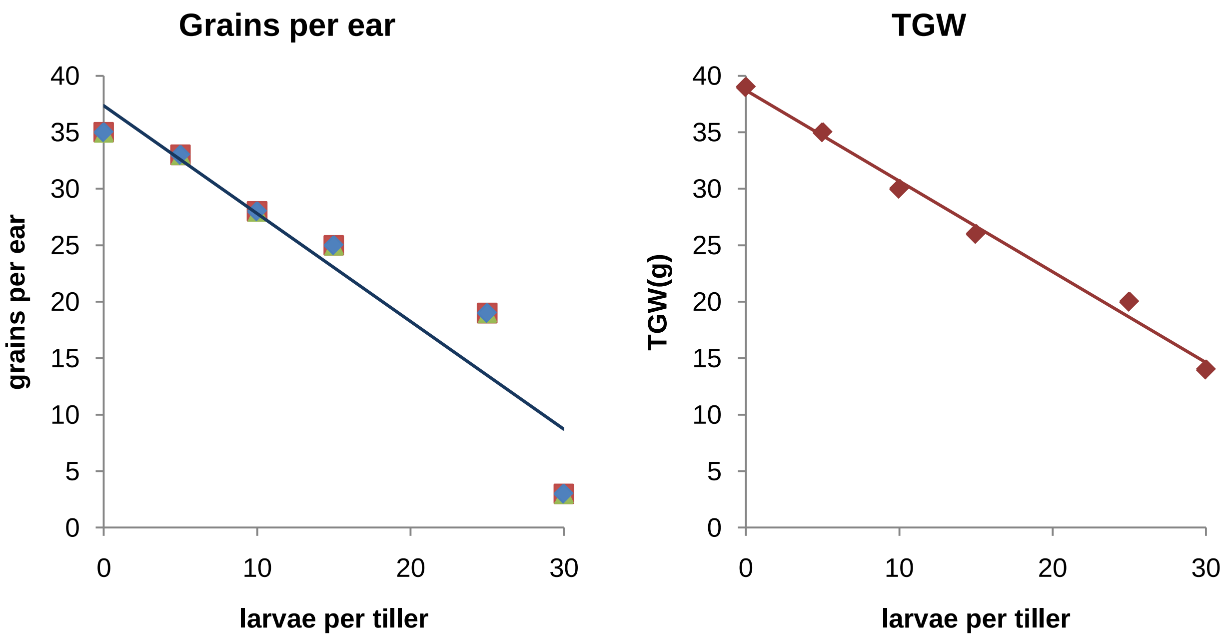

Figure 7. Effect of saddle gall midge larvae on the weight and number of grains per ear of wheat (after Popov *et al.*, 1998).

8. CONTROL MEASURES

8.1. Thresholds

Few trials have established realistic thresholds for control, but one study in Romania suggested that effective treatments applied at the appropriate timing where there were 30 larvae/m^2 in the soil would give economic returns (Popov et al., 1998). However, Golightly and Woodville (1974) and Gratwick (1992) cited populations of 5-12 million larvae/ha (>500/m^2) before economic damage would be caused. At later stages, Woodville (1973) cited a Danish threshold of 5 eggs per tiller as a level at which yield reduction would occur, not dissimilar to the 7 larvae per tiller proposed by Golightly & Woodville (1974).

8.2. Insecticides

8.2.1. Soil applied

Attempts to control the larvae in fields yet to be sown with spring crops such as maize or soya were not very effective. Applications of chlorpyrifos (as Lorsban at 5kg/ha; Dow), lindane (as Lindatox 20 at 5 l/ha), dimethoate (as Sinoratox R 35 at 4 l/ha or Sinoratox 5G at 40 kg/ha) and various dusts, gave poor control (<53%) (Popov et al., 1998). This was probably due to the difficulty of getting sufficient penetration of the soil to where the larvae were living.

8.2.2. Foliar applied

Foliar sprays have a much better chance of success if the application is timed to coincide with egg hatch and subsequent larval migration down the stem to the leaf sheath. Control of larvae once underneath the leaf sheath is very difficult (Gratwick, 1992). However, none of the currently available insecticides approved for use in cereals in the UK and also most of Europe, mention saddle gall midge on their labels, probably because of the sporadic nature of this pest's attacks, which make it difficult to predict when epidemics will occur, and therefore also difficult to set up registration trials to gather evidence of efficacy. Some evidence of the effectiveness of control measures is available in the literature, although many of the chemicals mentioned (mostly organophosphorous (OP) products) have long since been withdrawn from use in the UK due to their hazardous nature. These include fenitrothion, DDT plus parathion and fenitrothion (Woodville, 1973; Golightly & Woodville, 1974; Skuhravy, 1982).

The number and timing of applications of insecticides can be critical. In one trial done in Romania in 1986, when conditions for saddle gall midge colonization were very favourable (with 90% of tillers attacked), one application of alpha-cypermethrin (as Fastac at 0.1 l/ha; Cyanamid) on 5 May gave only 63% control, but later single applications gave less. Best control was given by three applications approximately two weeks apart, but good control was also achieved with two sprays, especially when one was applied in early May (Figure 8; after Popov et al., 1998).

Experiments done by the same authors with currently available insecticides in Romania showed that pyrethroids; deltamethrin, alpha-cypermethrin, lambda-cyhalothrin and esfenvalerate all gave excellent control, comparable to if not slightly better than that given by dimethoate, and older OP products (Table 1; Popov et al., 1998). No mention was made of the number of applications however.

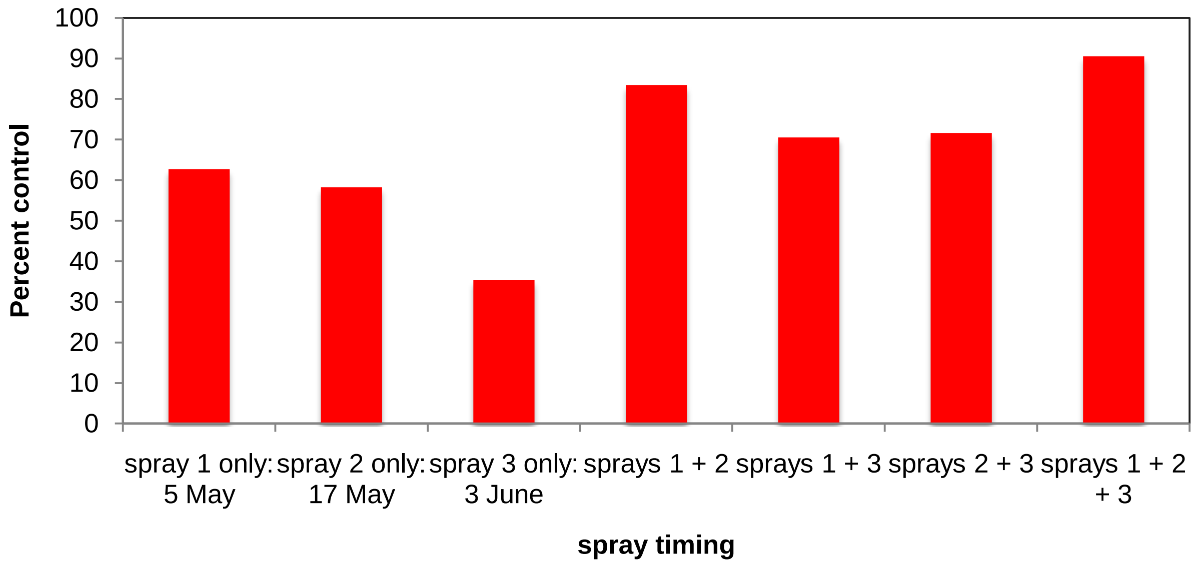

Figure 8. Effect of timing of sprays on control of saddle gall midge in 1986 (after Popov et al., 1998).

Table 1. Efficacy of insecticides against saddle gall midge: mean of three years (after Popov et al., 1998).

Treatment (a.i.)	Product	Dose g a.i./ha	Rate of product g/ha	% control
Untreated		-	-	(58.3 % damage)
OP's				
Dimethoate	Sinoratox 30 EC	1200	4000	84.0
Pyrethroids				
Deltamethrin	Decis 2.5 EC	7.5	300	86.5
Alpha-cypermethrin	Fastac 10 EC	10	100	90.2
Lambda-cyhalothrin	Karate 2.5 EC	7.5	300	86.4
Esfenvalerate	Sumi-Alpha 2.5 CE	7.5	300	83.7

8.3. Cultural control

Given the poor ability of adult midges to fly far from their overwintering sites, infestation of crops is inevitably greater where cereals are grown in continuous rotation in the same field. The use of rotations that include a non-cereal crop, such as sugar beet, potatoes or oilseed rape every two years or so, will help reduce numbers of midge larvae below damaging levels. Early sowing of cereals in higher risk areas may also help the crops get past the susceptible stages before the adult midges emerge (Golightly & Woodville, 1974; Gratwick, 1992). Use of winter sown oats as a break crop, but also to act as a trap crop on which eggs are laid but damage is slight, may also be a useful practice (Gratwick, 1992; Skuhravy et al, 1983).

No evidence of resistant varieties has been recorded, and this was reinforced by a study on the effect of leaf hairiness on gall formation in an infested site in the Netherlands; all cultivars tested, hairy or otherwise became heavily infested (Lange and Jochemsen, 1987).

Control of susceptible grass weeds in and around wheat and barley fields have been suggested as a means of reducing risk (Woodville, 1968).

8.4. Biological control

Consumption of larvae in the soil by soil-inhabiting predators, such as carabid and staphylinid beetles and spiders, may give some control (Golightly & Woodville, 1974; Basedow, 1986), although no hard evidence has been reported for this. The larvae when feeding on plants can also be attacked by the parasitoid, *Platygatser equestris* (Spittler, 1969). As many as 26.5% of larvae collected from wheat in a long-term study in Germany were parasitized in 1976, but few were found in other years (Basedow, 1986). One specimen of the species, *Chrysocharis seiuncta* was also identified.

9. CONCLUSION

Saddle gall midge has the potential to be a serious pest of cereals, especially wheat and barley in Central and Northern Europe where the climate is suitable for their development. However, it is only a sporadic pest occurring at low levels in most years, but rarely achieving yield-reducing levels, even in its most favourable locations. This may be due to poor co-ordination of its emergence timing with susceptible growth stages in the cereal crops that it attacks, and to detrimental weather conditions at the most vulnerable stages in its life cycle, namely when eggs hatch and newly emerged larvae are seeking feeding sites, and when larvae drop off onto the soil to enter diapause. When all these events are favourable to the pest, serious losses can occur.

Cultural control by including a non-cereal crop in the rotation can reduce risk of infestation, as adults do not fly very far from their overwintering sites. Chemical control can be given by OP and pyrethroid insecticides used to control other pests; there are no label recommendations specifically to control saddle gall midge. Timing of application is crucial to target the migration of larvae from egg-laying sites on the leaves to their feeding sites under leaf sheaths.

10. ACKNOWLEDGEMENTS

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11. REFERENCES

Allison, R. 2010. Gall midge outbreak may force re-think on 2010 cropping plans. *Farmers Weekly*. http://www.fwi.co.uk/Articles/30/07/2010/122574/Gall-midge-outbreak-may-force-rethink-on-2010-cropping.htm

Anon 2011. Faible pression pour les ravageurs de printemps en 2011. *Arvalis Choisir 2011*, 170.

Basedow, T. 1986. Die Abundanzdynamik der Sattelmücke, *Haplodiplosis marginata* (von Roser) Dipt., Cecidomyiidae), bei Fruchtwechsel, bei wiederholtem and bei permanentem Anbau von Weizen. *Journal of Applied Entomology* **102**: 11-19.

Case, P. 2011. Saddle gall midge outbreaks seen for a second year. *Farmers Weekly*. http://www.fwi.co.uk/Articles/10/05/2011/126724/Saddle-gall-midge-outbreaks-seen-for-second-year.htm

Daamen, R.A. and Stol, W. 1993. Surveys of cereal diseases and pests in the Netherlands. 6. Occurrence of insect pests in winter wheat. *Netherlands Journal of Plant Pathology* **99 (Supplement 3):** 51-56.

Deligeorgidis, P.N., Deligeorgidis, N.P., Ipsilandis, C.G., Vardiabasis,A., Vayopoulou, M., Giakalis, L. and G. Sidiropoulos, G. 2012. Four common insects of durum wheat cultivations in Western Macedonia, Greece. *ISRN Agronomy* **2012:** article ID 781012, 1-4.

Golightly, W.H. and Woodville, H.C. 1974. Studies of recent outbreaks of saddle gall midge. *Annals of Applied Biology*, **77:** 97-101.

Gratwick, M. 1992 (ed). Saddle gall midge. Chapter 60 *In: Crop Pests in the UK*. A collected edition of MAFF leaflets. Chapman & Hall, London, pp 306-309.

Lange, W. & Jochemsen, G. 1987. Leaf hairs in common wheat are no deterrent to attack by the saddle gall midge. *Cereal Research Communications***15:** 255-258.

Mölcke. 2006. Erfahrung mit Prognose und Bekämpfung des Schadauftretens von Sattelmücken und Weizelgallmücken (Diptera: Cecidomyiidae) in Schleswig-Holstein. *Deutsche Pflanzenschutz* **55:** 227.

Nijveldt, W.C. and Hulshoff, A.J.A. 1968. Waarnemingen inzake de tarwestengelgalmug *Haplodiplosis equestris* Wagner in Nederland. *Pflantenziektenkundige Dienst, Wageningen, Meded* **144:** 1-77.

Popov, C., Petcu, L. and Barbulescu, A. 1998. Researches on biology, ecology and control of saddle gall midge (*Haplodiplosis marginata* von Roser) in Romania. *Romanian Agricultural Research* **9-10:** 67-77.

Rijsten, E.G. 1967. Occurrence and control of *Haplodiplosis equestris* in Holland*. Pflanzenschutz Nachrichten Bayer* **1967(4):** 674-680.

Schütte, F. 1964. Zur Anfälligkeit einiger Getreide- und Gräserarten gengen *Haplodiplosis equestris* (Wagner). *Anz. Scadlingskde* **37:** 129-132.

Schütte, F. 1983. Sattelmücke. Informationen zum intergrierten Pflanzenschutz. *Nachrichtenbl. Deut. Pflanzenschutzzd. (Braunsweig)* **35:** 109.

Skuhravy, V. 1982. The saddle gall midge, *Haplodiplosis marginata* (von Roser) (Diptera, Cecidomyiidae), an important pest of wheat and barley in Czechoslovakia. *Folia Fac. Scient. Nat. Univ. Purkynianae Brunensis, 23/Biol* **74(7):** 133-135.

Skuhravy, V. Skuhrava, M. and Brewer, W.J. 1983. Ecology of the saddle gall midge *Haplodiplosis marginata* (von Roser) (Diptera, Cecidomyiidae). *Zietschrift für Angewandte Entomologie* **96:** 476-490.

Spittler, H. 1969. Beiträge zur Morphologie und Ökologie des Sattelmückenparasitien *Platygaster equestris* nov. spec. (Hymenopt., Proctotrupoidea, Scelionidae) unter besonderer Berücksichtigung seines abundanzdynamischen Einflusses auf *Haplodiplosis euquestris* Wagner (Diptera, Cecidomyiidae). *Zietschrift für Angewandte Entomologie* **63:** 353-381.

Weidner, H. 1985. Die Sattelmücke *Haplodiplosis equestris* (Wagner, 1871), ein Gersten- und Weizenschadling in Nordost-Bayern in den Jahren 1692 und 1693 (Diptera, Cecidomyiidae). *Anzeiger fur Schadlingskunde, Pflanzenschutz, Umweltschutz* **58(4):** 65-68.

Woodville, H.C. 1968. Saddle gall midge survey on barley 1967. *Plant Pathology* **17:** 64-66.

Woodville, H.C. 1970. Results of a three year survey of saddle gall midge (*Haplodiplosis equestris* (Wagn.)) on spring barley. *Plant Pathology* **19:** 141-145.

Woodville, H.C. 1973. Observations on saddle gall midge (*Haplodiplosis equestris* (Wagn.)) in Eastern England. *Plant Pathology* **22:** 177-181.

Zadoks, J.C., Chang, T.T., Konzak, C.F. 1974. A decimal code for the growth stages of cereals. *Weed Research* **14:** 415-421.