A BIOLOGICAL BATTLE AGAINST THE THOUSANDS OF GARDEN CHAFERS (*PHYLLOPERTHA HORTICOLA*) THAT ATTRACT LARGE NUMBERS OF GULLS (*LARUS* SP.) DURING THE SUMMER SEASON AT RYGGE AIR STATION, NORWAY

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ABSTRACT

Seven-eight years ago we first observed very large numbers of Garden Chafers (*Phyllopertha horticola*) swarming at Rygge Air Station in June and July, attracting large numbers of Black-headed - (*Larus ridibundus*) and Common Gulls (*Larus canus*) feeding on these flying beetles. Every summer season since then the Garden Chafers have been present, although in a smaller number in most recent years. The Garden Chafers appear to be the gulls' main food during this swarming, since we once found as many as 281 dead chafers inside the belly and oesophagus of one single Black-headed Gull. The large number of gulls at the Air Station naturally causes a serious hazard to the aviation. After first having been refused by the authorities to treat with insecticidal chemicals against the beetles, we started in 2004 to spray the grass areas along the runway with the biological control agent, *Heterohabditis megidis* (also known as *Nemasys H*), a parasitic nematode known to attack and control the larvae of the Garden Chafer living in the soil. In subsequent years both the runway and the two taxiways were sprayed with nematodes. The nematodes seem to have successfully controlled the Garden Chafer, as the number of Garden Chafer larvae in the soil at the Air Station has decreased since 2004, and the number of gulls present on the runway and taxiways has also decreased.

Key words: biological control agent, Garden Chafer, nematode, Black-headed gull, Common gull, bird strike, Rygge Air Station, Norway

INTRODUCTION

The problem of large numbers of gulls aggregating on the runway at Rygge Air Station was first observed in the summer of 2001, when they were present during three weeks in June-July. According to the staff at the Air Station there had been problems with birds also during previous summers, but nothing like the large numbers in 2001. The same problem was observed again in 2002 and 2003.

Especially Black-headed Gulls (BHG; *Larus ridibundus*) and Common Gulls (CG; *Larus canus*) cause a serious hazard to the aviation at Rygge Air Station (see Figure 1). From 1994 to 2003 gulls (BHG, CG and unidentified gull) were involved in 11 bird strikes here, in addition 15 bird strikes included other birds and in another 9 bird strikes the bird species were unknown. Although only one of the 11 gull-strikes at Rygge Air Station caused damage to the aircraft – right engine damages in an F-5 fighter aircraft – flocking gulls can cause a serious accident (e.g. Thorpe 2003, 2005).

We believed that the gulls were attracted to insects at the Air Station, since the staff observed the birds hovering above the grass areas apparently catching insects. Frequent feeding on insects by Black-headed - and Common Gulls, has been widely reported (e.g. Vernon 1972, Ewing & Ewing 1975, Cramp & Simmons 1983). In a survey conducted in June 2002, three species of insects were abundantly present at the Air Station: Garden Chafers (*Phyllopertha horticola*), Chrysomelid-beetles (*Chrysomelidae*) and Crambid snout moths (*Crambidae*; own unpublished data). In order to verify the diet of the gulls, two BHGs and one CG were shot at different places at the Air Station one day in June 2004, and their stomachs opened and examined. They had each eaten, respectively, 281, 37 and 164 Garden Chafers (compared to 10, 0 and 7 other insects). This showed that the chafers were at this time undoubtedly their main food.

Thus, it seemed that a strategy for control of the insects could be a way to solve the problems regarding aviation safety. In May 2003 we asked the authorities (the County Governor of Østfold) for permission to spray the insecticide “Karate” (a synthetic pyrethroid, Lamda-cyhalothrin), on the grass areas at the Air Station, but this was refused. We then turned our focus on a biological control agent, *Heterohabditis megidis* (also known as *Nemasys H*), which can be used for control of Garden Chafer larvae living in the soil (Grewal et al 2005). *H. megidis* is an entomopathogenic nematode that contributes to the natural regulation of insect populations in soil. The species has been found naturally infecting Garden Chafer larvae (also in Norway, Klingen et al 2002), but is not specific to this insect. Entomopathogenic nematodes, such as *H. megidis*, have a unique association with a lethal insect-pathogenic bacterium that has enabled mass production and commercialisation for use in inundative biological control of some insect pests (Griffin et al 2005). If this biological control agent would be able to control the Garden Chafers at the Air Station, then this would be an environmentally-friendly method of coping with the gull-aircraft conflict.

Figure 1. *A Norwegian Jet Falcon passing a flock of Black-headed and Common Gulls during take-off from Rygge Air Station. Photo: Captain Funderud, Royal Norwegian Air Force.*

MATERIALS AND METHODS

Study location - Rygge Air Station

Rygge Air Station is a military airfield situated at 59°23'N and 010°46'E, surrounded by farmland in the north, a lake in the east, and a motorway in the south (Figure 2). The traffic area consists of the runway 12/30 ("Runway", 2442 m long) and the taxiways "Yankee" (2412 m long) and "Sierra" (1200 m long; Figure 2). The vegetation around each run-/taxiway is grass, and further away from the traffic area but within the airfield border, are clusters of trees and buildings. The Air Station has been operated by military aircraft for more than 60 years, and has recently (1st of October 2007) opened up for commercial civil air traffic. The military aircraft operating at Rygge now are Jet Falcons and helicopters Bell 412 and Sea King, and the civil air traffic part is mainly operated by Boeing 737s.

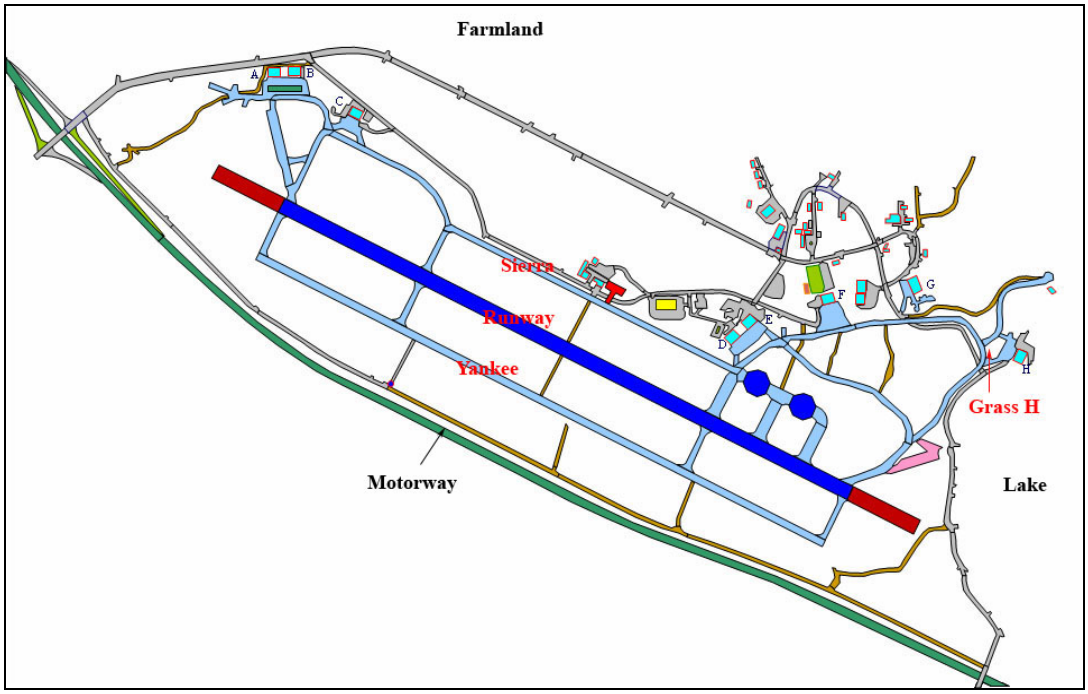

Figure 2. *Rygge Air Station, with its runway and taxiways and Grass H.*

Spraying with *Nemasys H* (*Heterohabditis megidis)*

Nemasys H, readily available at a Norwegian Garden centre, was in August 2004 dissolved in water and put on a tractor sprayer. This mixture was then sprayed on the grass along Runway on both sides in a 2 meter wide belt at the rate of 250 000-500 000 nematodes per square meter. We had previously observed that Garden Chafers (Figure 3) seemed to prefer the soil close to Runway, as this soil was sandier, less densely covered with vegetation and of a drier quality than the soil further away. The Garden Chafer larvae live on grass, cereal and clover roots (Harde, 1984). Hence, spraying on a 2 m wide belt seemed sufficient. Some part of Runway was not treated with *Nemasys H*, and acted as control site. Yankee and Sierra, where the Garden Chafers also were abundant, acted also as control sites in 2004.

Figure 3. *Adult Garden Chafer (left, 8,5-11 mm long; from Reitter 1909), three larvae from Rygge Air Station (middle, 15-20 mm long; photo: C.K.Aas) and two pupae also from Rygge Air Station (right, approximately the same size as the adult; photo: B.A. Rukke).*

In 2005 and every following year, including 2008, both Runway, Yankee and Sierra were sprayed with the biological control agent *Nemasys H* in the same manner, and in 2007-2008 the area “Grass H” (see Figure 2) was also included.

Mapping Garden Chafer larvae in the soil

Both in autumn six to nine weeks after spraying (except 2006) and the following spring (except 2007 and 2008) before the Garden Chafers started to swarm, we mapped the Garden Chafer larvae in the soil. We dug three holes with a spade, approximately 17 cm x 17 cm wide and 17 cm deep at regular intervals close to the runway or taxiway. We also dug three holes (one hole in 2007) 15 meters into the grass away from the runway or taxiway. Along Runway we dug at 9-30 positions 2004-2008, along Yankee we dug at 8-30 positions, and along Sierra we dug at 4-30 positions. In 2007-2008 we also dug at 6 positions on Grass H.

The soil we dug out was inspected for larvae of the Garden Chafer, and these larvae were counted. On the inspections in the springs 2005 and 2006, we also found and mapped some Garden Chafer pupae, and they are included in the analyses and for simplicity also called “larvae”. The counts were used to compare the number of larvae before and after spraying with *Nemasys H*.

Counting gulls on the runway and taxiways

During the period of swarming of the Garden Chafer, between 5th of June and 14th of July, the number of gulls present on the runway and taxiways was counted. The gulls were

counted from a car, whilst driving slowly the whole length on each of Runway, Yankee and Sierra. The counts were done between 08:10 and 16:00 hours and in all kinds of weather. Counts between 09:00 and 12:00 hours and in clear to partly clear sky (0/8-4/8 on a scale from clear to overcast) were used in all gull analyses except the one shown in Figure 6. The reason for this limitation was that during this period and in this weather the gulls were abundantly present, probably because of concurrent period of swarming of the Garden Chafer. The gull counts were done to assess the effect of spraying of *Nemasys H* on the presence of gulls.

Recording bird strikes

Bird strikes at Rygge Air Station were recorded before and after start of treatment with *Nemasys H*. Both military and civil aviation have a mandatory reporting system, and reports from the respective databases were used in this study.

RESULTS

Garden Chafer larvae (including both larvae and pupae) in the soil

Following the spraying of *Nemasys H* the number of Garden Chafer larvae along Runway was rather high six weeks later in 2004 (3,0 per position), but declined markedly in 2005 (0,7 in spring and 0,4 in autumn), 2006 (0,8), 2007 (0,0) and 2008 (0,0 per position) (ANOVA; $p<0.001$, df=5; Figure 4). Along Yankee the number of larvae per position declined significantly, from 2,1 in spring 2005 – after which *Nemasys H*-treatment started – to 0,0 in autumn 2005, 0,2 in 2006, 0,6 in 2007 and 0,3 in 2008 (ANOVA; $p<0.001$, df=4; Figure 4). Sierra was exposed to treatment in August 2005, and the numbers of Garden Chafer larvae per position declined significantly from 2,3 in 2004 and 2,6 in spring 2005 to 0,3 in autumn 2005, 0,4 in 2006, 0,8 in 2007 and 0,3 in 2008 (ANOVA; $p<0.01$, df=5; Figure 4).

The soil we dug out 15 meters into the grass away from the runway or taxiway contained almost no larvae at all. At these positions the vegetation was much denser, less sandy and moister than along the runway or taxiway, and we simply concluded that the larvae were not living in this microhabitat.

When comparing treated runway/taxiways with untreated ones, data from 2004 and spring 2005 were used. In 2004 there was no significant difference in number of larvae between *Nemasys H*-treated Runway and untreated Sierra (ANOVA; $p=0.68$, df=24; Figure 4, dark blue columns). In spring 2005 (when the larvae were still in the soil) we found a significant difference between each of the three runway/taxiways (ANOVA; $p<0.01$; df=2; Figure 4, purple columns).

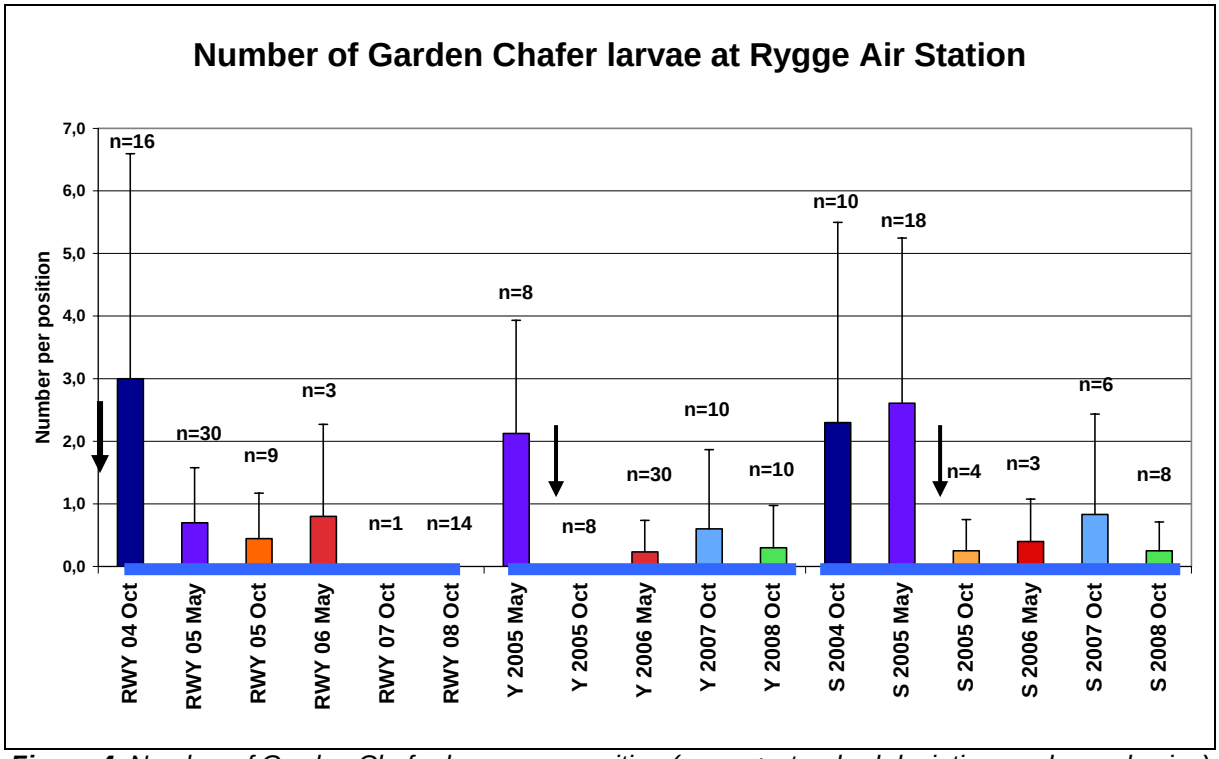

Figure 4. *Number of Garden Chafer larvae per position (mean + standard deviation, and sample size) on Runway (left), Yankee (middle) and Sierra (right) 2004-2008. Each season is marked with a colour: dark blue (autumn 2004), purple (spring 2005), orange (autumn 2005), red (spring 2006), light blue (autumn 2007) and green (autumn 2008). The arrows indicate the start of* Nemasys H-*treatment (Yankee and Sierra were not exposed to treatment until August 2005).*

Gulls on the runway and taxiways

The number of gulls observed on Runway was quite low in all the years 2005-2008; in 2005 significantly different from Yankee and Sierra (ANOVA; $p<0.001$, df=2; Figure 5). In 2006 and 2007 there were no significant differences between the three run-/taxiways (ANOVA; $p=0.16$ and $p=0.37$, respectively, df=2; Figure 5). In 2008 there was a tendency to differences in number of gulls beween the run-/taxiways (ANOVA; $p=0.08$, df=2; Figure 5).

On Yankee the number of gulls decreased from 2005 to 2006, but increased in 2007 before approaching a low 3,4 in 2008, but the differences were not significant (ANOVA; $p=0.12$, df=3; Figure 5). The peak in 2007 on Yankee is mainly due to 300 gulls on one observation alone (note the high standard deviation in Figure 5). On Sierra there was a gradual decrease in number of gulls from 65,9 in 2005 to 20,3 in 2008 but again not significant (ANOVA;$p=0.30$, df=2; Figure 5).

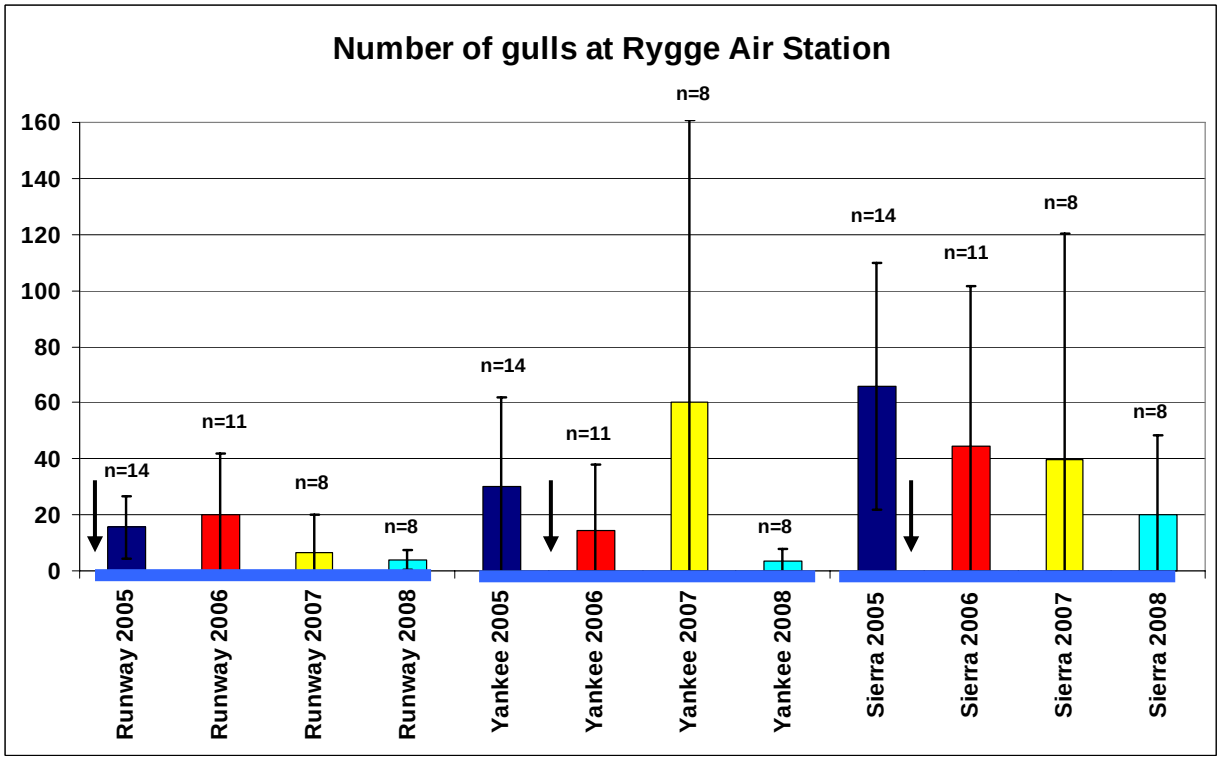

Figure 5. *Number of gulls per observation (mean + standard deviation, and sample size) on Runway (left), Yankee (middle) and Sierra (right) in June-July 2005-2008. Each year is marked with a colour. The arrows indicate the start of* Nemasys H*-treatment (Yankee and Sierra were not exposed to treatment until August 2005).*

Gulls and Garden Chafer larvae 2005-2008

The total number of gulls on Runway, Yankee and Sierra each summer period (controlled for observation days each year) was compared to the total number of Garden Chafer larvae along the same three runway/taxiways (multiplied with 10 to fit in the graph) and shown in Figure 6. No larva counts were carried out in the autumn 2006 or spring 2007, hence no larva point for 2007 could be drawn in Figure 6. It appears to be a connection between the total number of gulls and the total number of larvae over the years, but the sample size is too small to test statistically (Figure 6).

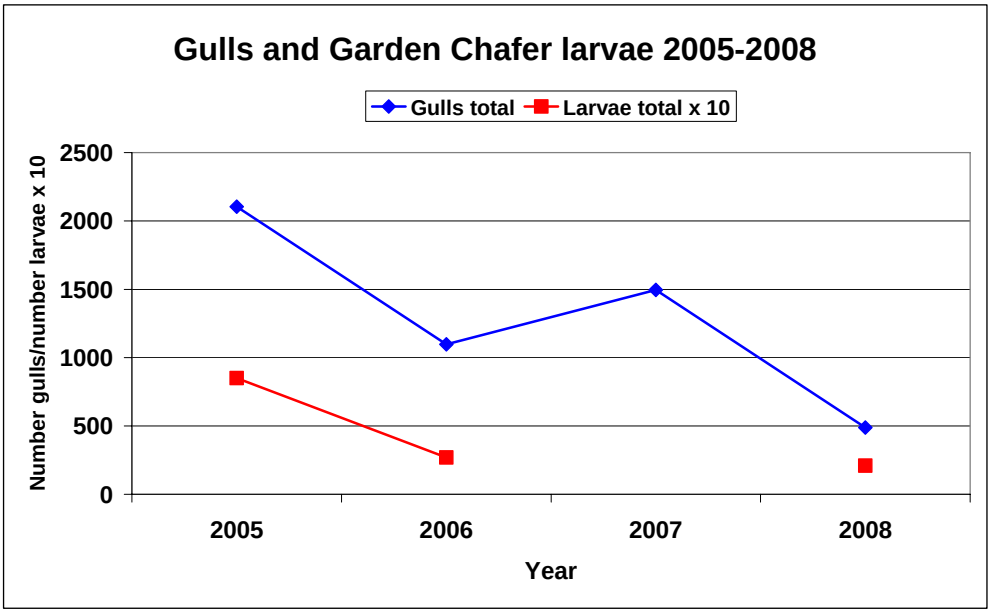

Figure 6. *The total number of gulls each summer 2005-2008 and the corresponding total number of larvae (in May 2005, May 2006, no data collected, and October 2007, respectively) plotted against year.*

Number of bird strikes at Rygge Air Station

Four military and one civil bird strikes were reported at Rygge Air Station during the summer weeks from 1st of June to 15th of July between 2003 and 2008, as shown in Figure 7. The five bird strikes – one in 2003, two in 2004, one in 2005 and one in 2007 – involved Black-headed Gulls twice, unidentified gull once, House Martin (*Delichon urbicum*) once and an unknown bird species once. All these birds could possibly have been attracted by the Garden Chafers to the Air Station.

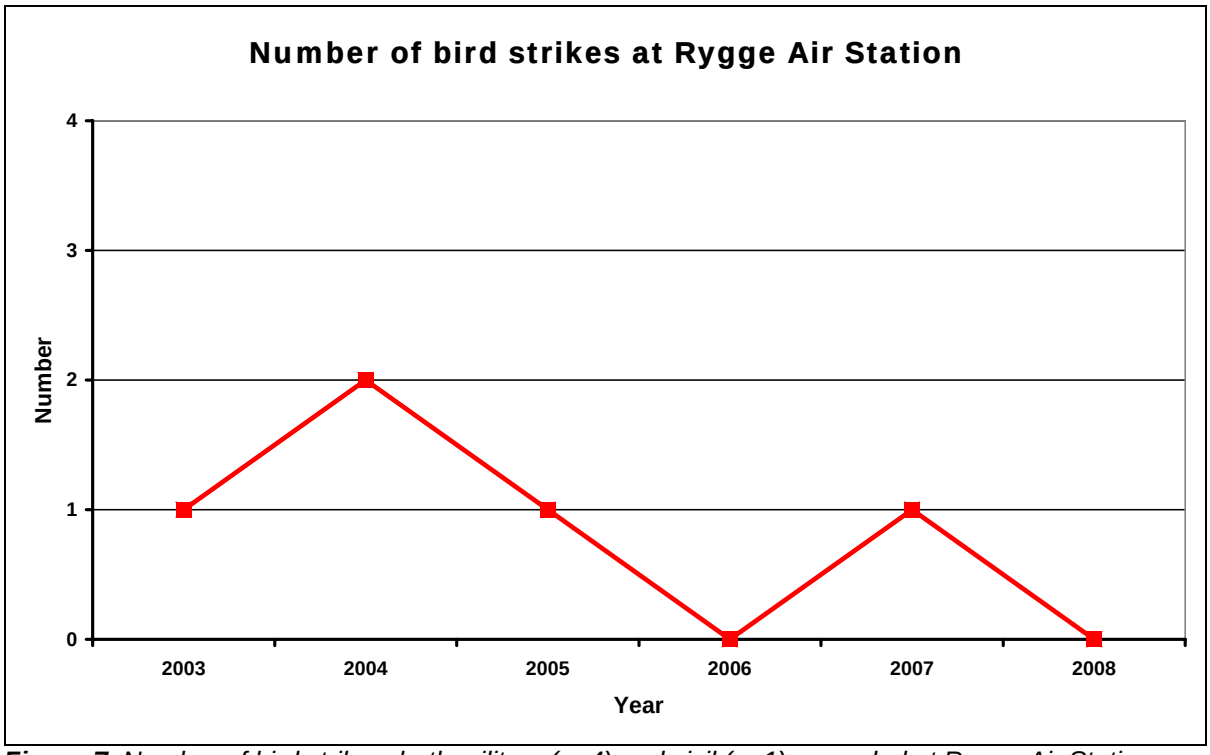

Figure 7. *Number of bird strikes, both military (n=4) and civil (n=1), recorded at Rygge Air Station during early summer (between 1st of June and 15th of July) in the years 2003-2008.*

DISCUSSION

The number of Garden Chafer larvae in the soil along Runway decreased significantly from 2004 to the following years. The treatment of *Nemasys H* started on Runway in August 2004, six and a half weeks prior to the larva counts, so we would have expected the number of larvae in 2004 to be much lower than what was found. When the number of larvae was as high as 3,0 that year, we interpret this finding as either a too early start of the larva counts or no effect of the *Nemasys H*-treatment. However, from 2005 onwards the number of larvae was significantly lower than 2004, and this indicates that the *Nemasys H*-treatment has had an effect on the prevalence of Garden Chafers on Runway. In the summer of 2007 on Runway, there was extensive excavation work on the areas next to the runway due to replacement of the tarmac. This probably accounts for no larvae found that same autumn.

On Yankee and Sierra, the number of larvae decreased significantly after the *Nemasys H*-treatment had started. These findings support the good effect of the treatment on the occurrence of Garden Chafers on the two taxiways.

The Garden Chafer counts in autumn 2004 and spring 2005 were the only registrations when Runway was treated with *Nemasys H* whereas Yankee and Sierra were not, i.e. where a treatment could be compared to control plots. In 2004 there was no difference between Runway and Sierra (Yankee was not inspected that year), but in spring 2005 there was a significant difference between all three run-/taxiways. The spring 2005 result also supports the hypothesis that the *Nemasys H*-treatment significantly can reduce the number of Garden Chafer larvae in the soil.

The number of gulls counted on Runway was significantly different from the two taxiways Yankee and Sierra in 2005 but not in 2006 and 2007. In 2008 there was a tendency to differences between the three run-/taxiways in number of gulls counted. The 2005 gull counting result is consistent with the 2005 larvae counting result: there were both fewer gulls and fewer larvae on the Runway compared to Yankee and Sierra. Since Runway was the only run-/taxiway treated with *Nemasys H* that year, these findings indicate an effect of the treatment on the number of both larvae in the soil and gulls on the runway. One observation of 300 gulls on Yankee in 2007 caused the high peak that year, without which the number of gulls in 2007 would have been smaller than in 2005 on Yankee.

The total number of gulls and the total number of larvae on Runway, Yankee and Sierra over the years appear to be connected, but the sample size is small. More data is required to see if there could be a significant correlation. Nevertheless, there was a decrease in the total number of gulls in the traffic area from 2005 to 2008, and this is an important result in relation to the bird strike risk.

The number of bird strikes at Rygge Air Station during early summer was too few to draw any firm conclusions. However, we note that 4 strikes occurred during 2003-2005 and only 1 strike during 2006-2008, a weak tendency that may be associated with the *Nemasys H*-treatment.

To conclude, during the study period the number of Garden Chafer larvae in the soil decreased significantly within each runway or taxiway, and in one year there was a significant difference in number of individuals between the *Nemasys H*-treated Runway and the untreated Yankee and Sierra. The number of gulls was significantly lower on Runway than on Yankee and Sierra in 2005. Also, the total number of gulls and the total number of larvae on Runway, Yankee and Sierra over the years appear to be connected. All these findings seem to support the hypothesis that the *Nemasys H*-treatment has lead to a decrease in Garden Chafer larvae in the soil, a decrease in number of gulls on Runway, and to a possible weak tendency of reduction of bird strikes on Rygge Air Station.

Since we also found that the Garden Chafer larvae did not live in the microhabitat 15 meters into the grass away from the runway or taxiway, as this vegetation was much denser, less sandy and moister, one alternative way to solve the Garden Chafer problem more permanently could be to alter the vegetation close to the runway and taxiways. There are probably different methods to do this, but that is another story!

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REFERENCES

Cramp, S. & Simmons, K.E.L. (ed.) 1982. The birds of the Western Palearctic. Vol. III, Waders to Gulls. Oxford Univ. Press, Oxford.

Ewing, A.W. and Ewing, L.S. 1975. Common and Black-headed Gulls flight-feeding over ragwort. *British Birds* 68, 44.

Griffin, C.T., Boemare, N.E. & Lewis, E.E. 2005. Biology and Behaviour. In: Nematodes as Biocontrol Agents (Eds Grewal, P.S., Ehlers, R.-U. & Shapiro-Ilan D.I.) CABI Publishing UK.Pp 47-78

Harde, K.W. 1984. A Field Guide in Colour to Beetles. Octopus Books Limited, London.

Klingen, I., Salinas Haukeland, S. & Meadow, R. 2002. Checklist of naturally occurring pathogens of insects and mites in Norway. *Norwegian Journal of Entomology*, 49: 23-28.

Reitter, E. 1909. Fauna Germanica. Käfer. Band II. K.G. Lutz' Verlag, Stuttgart.

Thorpe, J. 2003. Fatalities and destroyed civil aircraft due to bird strikes, 1912-2002. IBSC 26 Warsaw, 5-9 May 2003. Internet: http://www.int-birdstrike.org/Warsaw_Papers/IBSC26%20WPSA1.pdf

Thorpe, J. 2005. Fatalities and destroyed civil aircraft due to bird strikes, 2002 to 2004. IBSC 27 Athens, 23-27 May 2005. Internet: http://www.int-birdstrike.org/Athens_Papers/IBSC27%20WPII-3.pdf

Vernon, J.D.R. 1972. Feeding Habitats and Food of the Black-headed and Common Gulls. *Bird Study* 19, 173-186.