Effects of climate change on the dispersion of white grub damages in the Austrian grassland

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Abstract

Recent changes in occurrence of agricultural pests in Austria might already reflect climate change phenomena. In this study, an inventory of white grub (Melolontha melolontha, Amphimallon solstitiale and Phyllopertha horticola) damages in Austrian grassland including organic cultivation was performed by questioning plant protection consultants of 74 Agricultural County Chambers. Altogether, a cumulated 14.800 hectares of white grub damages were recorded. From 2000 onwards, a steady increase of white grub damages occurred with a climax in the year of heat and drought 2003. The infested fields extended along the alpine main ridge from Vorarlberg up to the alpine foreland. Additionally, southern slopes of the Danube valley in Upper and Lower Austria were affected. Very likely, the damages were mainly due to the garden chafer P. horticola. From 2004 to 2006, the extent of damages decreased again all over Austria. By studying meteorological data, it became obvious that the damaged areas were mainly situated in regions with a strong precipitation deficit. On-farm investigations performed in 2007 strengthened the hypothesis that drought and elevated soil temperatures might be the decisive factors for a strong development of grub populations and subsequent feeding damages. Additionally, drought can increase the effects of grub damage by delaying the regeneration of the damaged sward. A strongly damaged sward on slopes can be dangerous for the farmers e.g. by slipping machines.

Introduction

Recently the soil-dwelling grubs of the cockchafer (*Melolontha melolontha*), the June beetle (*Amphimallon solstitiale*) and the garden chafer (*Phyllopertha horticola*; Scarabaeidae, Coleoptera) caused significant damages to Austrian cultivated grassland. Heavy grub feeding to the grass roots can even endanger farmers by causing their farm machines to slip down slopes on the detached sward. From available literature on the biology of these species it was derived that climatic and soil conditions could be main factors responsible for high densities of white grubs and their feeding damages to the grass roots. Drought can intensify the effects of grub feeding to the sward by accelerating its withering. Grub damages particularly affect Austrian organic farming, due to the high percentage of grassland, approximately 60% (Schneeberger et al. 2005), and the delayed effect of entomopathogenic fungi products like Melocont® (*Beauveria brongniartii*) against cockchafer and GranMet®-P (*Metarhizium anisopliae*) against garden chafer. After application the fungus-epidemic takes time to spread in soil (Strasser 2004). So the design of a risk forecasting system and the assessment of the future development of regions at risk regarding climate change would help organic farmers to take measures in time.

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In this investigation, carried out as a part of the Startclim2006 project (Grünbacher et al. 2007) from autumn 2006 to summer 2007, interrelations between grub damages and climate data as well as site and soil parameters were investigated as the basis for a risk forecasting system suitable in practice.

Materials and methods

In order to gather information about the occurrence of grub damages in Austrian grassland from the year 2000 to 2006, we mailed grub-questionnaires to a total of 74 Agricultural County Chambers. The reported grub-damages were grouped by years and agricultural region according to Walter (2002). If the respondent could locate grub damage occurrences on municipal level, these areas were regarded as remarkably infested in the respective year of damage.

The regional precipitation deficits in the year of heat and drought 2003 were calculated on the basis of a digital elevation model of Austria and weather data from the Central Institute for Meteorology and Geodynamics (ZAMG). A chi-square test was used to statistically compare the intensity of aridity in areas affected by grub damage to the intensity in regions with grassland percentages more than 20% (Grüner Bericht 2006).

On four farms with serious grub damages in 2003 (counties "Murau/Judenburg" and "Weiz", Styria) inspections were performed to collect background data on the topographic situation and the cultivation measures of the damaged fields.

Results

From 74 mailed grub-questionnaires 60 were answered, resulting in a 81% response rate. Altogether a cumulated damaged acreage of 14,800 hectares was reported in the investigated period, mainly in grassland. Starting with only two counties in the years 2000 and 2001 respectively, the number of counties affected by grub damage increased in 2002 (6) and showed a prominent peak (33) in the very hot and dry year 2003 (Figure 1). In this year, 64% of the counties having reported grub damages, were situated in the alpine region, 30% in the foothills of the Alps. In the following years, the number of affected counties decreased to 16 in 2004 and 6 in 2005 and 2006.

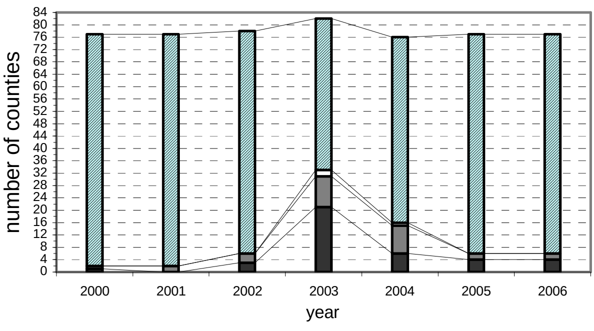

Figure 1: Counties affected by grub damage in alpine region (dark grey), in medium altitude (light grey), in lowland (white) and counties without reported damages or missing data (hatched) per year.

Figure 2 shows the situation in 2003, the year with the greatest extent of grub damages. The infested areas were mainly situated alongside the alpine main ridge from Vorarlberg in the West to the south-eastern foothills of the Alps, following the valleys of the central Alpine rivers like Inn, Salzach and Mur. Furthermore, damages were reported for several municipalities in the Innviertel, the southern slopes of the Danube valley and one small area of the Waldviertel in the North of Austria. The typical grassland regions in the northern Alpine foothills remained nearly unaffected.

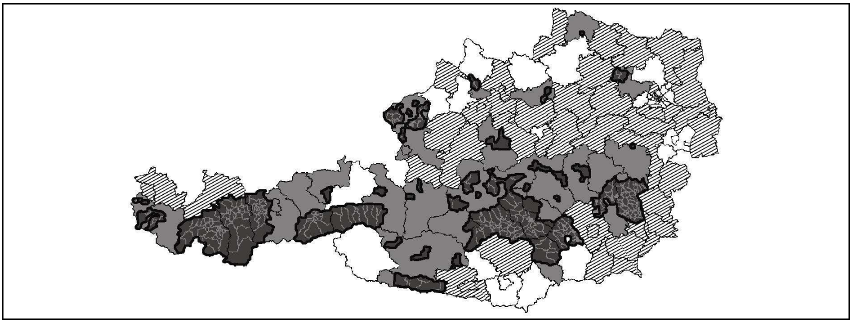

Figure 2: Austrian counties (grey) and municipalities (dark grey) affected by grub damage in the year 2003. Counties without response are coloured white, counties without reported damages or with missing data are hatched.

The infested regions in 2003 were characterized by drought during summer (Figure 3). They significantly had more parts with strong precipitation deficits than the whole Austrian area with a relevant grassland percentage (observed proportions in infested regions: >55% deficit = 10% of area, 46-55 = 46, 36-45 = 43, <35 = 1; expected in grassland >20%: >55 = 23; 46-55 = 47, 36-45 = 29, <35 = 1; chi-square: p = 0.000).

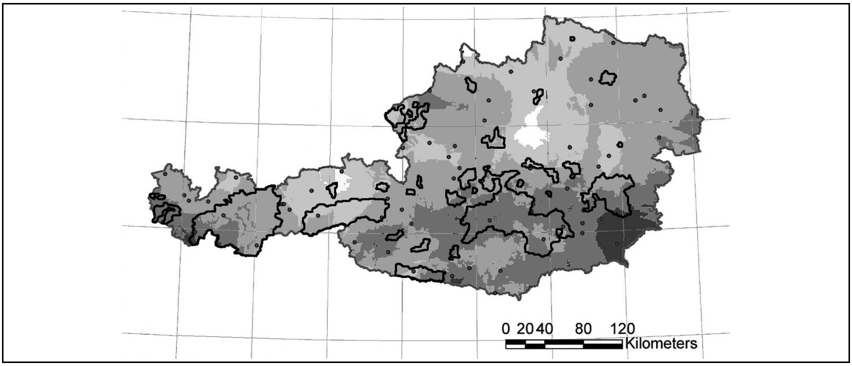

Figure 3: Precipitation deficits (%) of the period 1.1.–28.8.2003 in relation to normal precipitation (100%), averaged from the precipitation sums from 1.1.-28.8. of the years 1961-1990, visualized in shades of grey: <35% dark, 36–45%, 46–55%, 55-65%, >66% light. Areas damaged by grubs on a municipality level in 2003 are outlined black, weather stations are marked by dots.

Source: Grünbacher et al. (2007), Layout: Formayer H. (BOKU, Institute of Meteorology, Vienna).

The farm inspections showed a clear tendency of the damaged fields to south or east-facing slopes and sandy, permeable soils, rich in humus.

Discussion

In accordance to the literature, the questionnaires and farm inspections confirmed that hot and arid climatic conditions as well as permeable soils are decisive for the emergence of grub damages. In combination, these factors cause high soil temperatures, especially on south-exposed slopes, and so enhance the development of high grub densities by abbreviation of the egg- and larval period.

The massive grub damages in 2003 very likely can be attributed to the garden chafer, which is encountered in higher altitudes than the cockchafer. Its short, one year life cycle enables this insect to react much faster on favourable climatic conditions than the cockchafer with its three years development (Milne 1983).

Conclusions

Regarding the future scenarios for the effects of climate change in the alpine region with a higher probability of hot and dry summers (Kromp-Kolb 2004), we conclude that the years with remarkable grub damages will become more frequent and the damaged grassland acreage will increase.

The implementation of a reliable risk assessment system needs accurate knowledge on ecological demands of the above mentioned grub species, mainly concerning soil parameters. The validation of grub damage prognoses should be performed in long term outdoor investigations, supported by laboratory experiments.

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