Life cycles of *Penthaleus major* (Dugés) (Acari, Prostigmata) in hayfields in northern Iceland

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SUMMARY

The winter grain mite *Penthaleus major* (Dugés) is now occasionally observed as a summer pest in the cold temperate zone, especially in subarctic hayfields. The life cycle of the mite was studied from pitfall trappings in 19 hayfields at 10 farms in Eyjafjordur in northern Iceland throughout the summers of 1996 - 1998. Eggs, larval stage, three nymphal stages and the female adult stage were observed. Peak occurrences of the nymph stages and young adults were registered in mid-June. Two annual generations were observed, a summer generation and a winter generation, which goes through winter hibernation and resumes activity in early spring when the snow melts. A model for the progression of stages and sizes throughout the year in a subarctic environment is presented.

Key words: hayfields, Iceland, mite, Neozygites, Penthaleus, prostigmata

YFIRLIT

Lífsferill túnamítils, Penthaleus major (Dugés) *(Acari, Prostigmata), í túnum á norðanverðu Íslandi*
Túnamítill, *Penthaleus major* (Dugés), sem áður hefur valdið tjóni á vetrarkorni að vetri á suðlægum slóðum hefur nú einnig valdið tjóni á túngrösum að sumri á norðlægum slóðum í kaldtempraða beltinu. Lífsferill mítilsins var rannsakaður með því að safna honum í fallgildrur yfir sumartímann á 19 túnum á 9 bæjum við Eyjafjörð 1996-1998. Egg, lirfustig, þrjú gyðlustig og fullvaxin kvendýr fundust. Gyðlustigin og ung fullvaxin dýr náðu hámarki um miðjan júní. Greina mátti tvær kynslóðir, annars vegar sumarkynslóð og hins vegar vetrarkynslóð, sem eftir vetrardvala sýnir virkni snemma vors þegar snjór hverfur. Sýndur er þroskaferill og stærð dýranna yfir sumartímann.

INTRODUCTION

The mite *Penthaleus major* (Dugés) is known as a winter pest on winter cereals (Chada 1956). Since 1979, however, mass occurrence has been reported in pastures and hayfields in southwest Greenland (Nielsen 1984), the northern part of Iceland (Guðleifsson & Ólafsson 1987, Gudleifsson *et al.* 2002) and northern Norway (Johansen 1986, Haug 1989, Johansen & Haug 2002). At these high latitudes the mite appears to be a summer phenomenon connected with damage of the grasses, which then become silvery in appearance.

The mites lacerate the epidermis of the plants and remove chlorophyll from the cells (Chada 1956, Narayan 1962). In northern Iceland *P. major* is observed at the onset of plant growth in spring when the snow cover melts, and new attacks on plants are visible in May, June and early July to disappear during mid-summer (Gudleifsson *et al*. 2002). In some cases mass occurrences are also seen on the hayfield regrowth in August-September. Attacks of *P. major* reduces yield of perennial grasses (Kobayashi *et al*. 1991). In arctic and subarctic environments the reduction of yield due to the presence of *Penthaleus* is small and attempts to control the mites by pesticides in Greenland (Nielsen 1984), in Iceland (Gudleifsson *et al*. 2002) and in Norway (Johansen & Haug 2002) have been only partly successful.

In a general survey of arthropods in hayfields in northern Iceland by means of pitfall traps, a number of *P. major* specimens occurred in the captures. The specimens caught provided new qualitative information about the progression of stages and generations during the short, cold summer of the subarctic grassland.

MATERIALS AND METHODS

Pitfall traps were used to provide an indirect measure of the population density and abundance of *P. major*. The traps were placed in the centre of field plots on 10 farms in Eyjafjörður, northern Iceland. In 1996 invertebrates were collected at three plots at Möðruvellir. In 1997 traps were located on two plots on each of the following farms in Svarfaðardalur and Hörgárdalur: Þverá, Ingvarir, Hofsá, Barká, Brakandi and Stóri-Dunhagi, and in 1998 on two plots in Brautarhóll, Atlastaðir and Sakka. Traps were set out in the last week of May, when the snow had melted sufficiently, and collection stopped in September-October due to snow or few captures. Sampling halted temporarily for 3-7 days in early July because of hay-cutting, and in some cases also when a second cutting in early August took place. The traps consisted of 200 ml plastic beakers containing about 25 ml of water with one drop of detergent. They were dug into the soil and placed with the upper edge at the level of the soil surface. Wider lids were placed about 5 cm above the surface to hinder the rain from entering the traps. The traps were emptied at 2 to 7 day intervals and samples stored in 70% ethanol or in 5% benzalconium chloride for later sorting and identification. Mites were counted on Petri dishes under a stereoscope and the number of specimens calculated on a day basis. For identification mites were coloured and cleared in lactic acid with Lignin Pink dye, then washed with tap water on a suction filter and finally embedded into Hoyer's medium (Krantz 1978 p. 88) on slides and examined by normal phase contrast at x 100. Calculations based on the proportions of the mites on slides, the assessed number of mites in traps and the days of trapping gave the average number of mites at different stages caught by the traps per day. Results are presented for the day in the middle of each collection period. Measurements of idiosome length and the egg diameter (inside the chorion) were done by mouse-marking on screen on video-transmitted images (System Olympus Oylite). Temperature records for Figure 1 were averages of measurements 1997 and 1998 from the Agricultural Research Institute, Möðruvellir, close to the fields where collections took place.

RESULTS

Stage observations

The following stages of *P. major* were observed: egg stage, larval stage, three nymphal stages (proto-, deuto- and tritonymph) and the adult stage, the last always of females (Table 1). In general eggs were found in 81 % of adults, usually 1-5, but in very large specimens up to 12 eggs could be seen. In the trapped specimens no eggs with embryonic structures were observed (prelarva, larva), nor transitions between postembryonic stages.

Annual variation in trapped mites and eggs

Mites trapped per day (Figure 1) varied in a characteristic way during the snow-free period

Table 1. Idiosome and egg lengths - in micrometers - of specimens of *P. major* from three hayfields at Mödruvellir 1996.

Stages	Mean	Min	Max	s. d.	N
Eggs	145.4	80	243	17.8	1024
Larvae	247.8	188	306	39.4	12
Protonymphs	343.3	296	398	37.1	6
Deutonymphs	459.1	306	602	74.9	20
Tritonymphs	651.7	459	826	90.3	20
Adult females	876.1	612	1270	136.0	96

of the year. Peak abundance occurred in June followed by a drastic decrease in July, usually at the time of the first hay cut, and then a smaller peak in August-September during regrowth of the grasses. The bulk of eggs (inside the females) had their peak occurrence in late June and early July, with a smaller peak in August.

Other observations

Spherical bodies of fungal parasites (*Neozygites* cf. *acaricida* [Petch] S. Keller & Milner [Entomophtorales]) were seen in the body fluid of some specimens larger than 345 micrometers. In adults infested by *Neozygites* there were either no eggs or only 1-2 small ones. The phenomenon of fungal parasites was pronounced in June in adult specimens of the winter generation. In the second week of June one out of three specimens was infested. In July and the first three weeks of August no infested specimens were observed. In the last week of August and the rest of the year, where females of the summer generation occurred, infestation was only 5-10%.

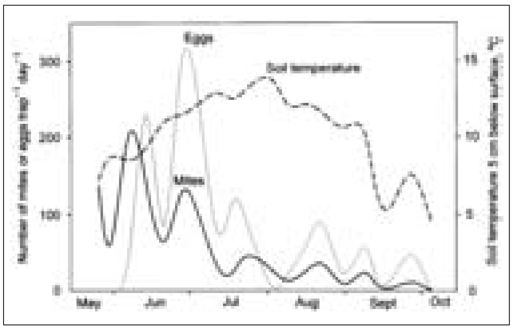

Figure 1. Annual progression in number of *Penthaleus major* specimens and eggs (inside females) captured in pitfall traps in northern Iceland 1997 – 1998.

From the counts of 348 trapping days *P. major* made up 73.0 % of the mites. The astigmate *Tyrophagus similis* Volgin 13.9%, Tydeidae spp. 4.2% and *Bryobia cristata* (Dugés) (immature stages only) 3.2%, while Mesostigmata spp., Oribatida spp. and *Tarsonemus* spp. accounted for 1.3, 0.8 and 0.8% respectively and *Pygmephorus islandicus* Sellnick, 0.5%.

DISCUSSION

Number of annual generations

The number of trapped specimens of *P. major* peaked in mid-June and declined during the rest of the year, leaving the general impression that there was only one large generation in the spring and then a slow decline (Figure 1). The sizes of the idiosomes (Figure 2) during the summer, however, indicated that there were two annual generations. Adults of the summer generation laid their eggs preferably during the last weeks of August (Figure 1), and from these eggs the winter generation emerged. Before the onset of winter the majority of these eggs were hatched and the bulk of larvae had almost completed its transformation into the protonymph stage. Thus the stage composition before, during, and just after hibernation consisted of a few larvae but mostly of protonymphs with a smaller number of later stages and possibly no eggs. Specimens of the winter generation formed the peak occurrences in the spring, which is pronounced in Figure 1. The duration

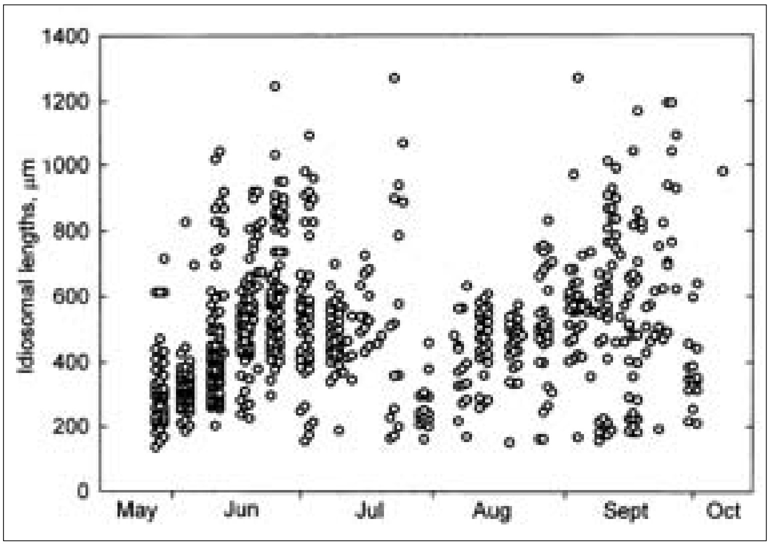

Figure 2. Idiosomal lengths of 717 specimens of *Penthaleus major* caught in pitfall traps in northern Iceland 1996 -1998.

of the summer generation, egg-to-egg, approximated 64 days. The winter generation, including hibernation, therefore took 300 days.

Annual variation in number of trapped specimens

The peak of the summer generation appeared to be much smaller than that of the (hibernating) winter generation (Figure 1). This is probably because the second hay cut, usually in August, removed specimens, food and shelter and rendered conditions worse for the survival of the remaining mites. The outcome of pitfall trapping is proportional, however, not only to the size of the population but also to factors determining trapping risk. It may be expected that the lower temperatures at the time of snow melt, and later when winter approached may have slowed down the activity of the mites and thus caused an underestimate of the population size, particularly in the autumn. Furthermore, immature stages have more resting periods (during moult they have no functional legs) and are thus temporary walkers. The smaller developmental stages obviously had been present before, during and just after hibernation, but made up an increasing proportion when they experienced rising temperatures and grew to larger sizes, as happened during the apparent population maximum around the 15th of June. Thus in theory the two generations might have been more equal in number of individuals than indicated by the pitfall trappings and may represent a similar load on the vegetation.

Duration of generations

The specimens found in this study conform to the description in Chada (1956), which means that the subarctic specimens, active in summer, probably are similar to those from warmer climates, being active on the field vegetation only in the winter. The duration of a generation was similar as well, 60.6 days plus time to develop the first eggs in Chada's study in Texas, and about 64 days in the present study. Therefore it is proper to include Chada's field observations for the duration of each developmental stage in our model for stage progression in *P. major* (Figure 3) which appears as a result of combining stage sizes from Table 1 and phenology of idiosomal lengths (Figure 2) with Chada's observations. Chada did not refer his observations to temperatures. The temperature regime near the present collection area was known (Figure 1) but was not implemented in the model (Figure 3).

Control options

The most optimal time to spray pesticide has been discussed, and the advice so far has been to consider a period of time when all eggs were hatched, and at the same time, if possible, no new eggs have been laid (Guðleifsson & Ólafsson 1987). This might work if the bulk of specimens do hatch from hibernating eggs. But

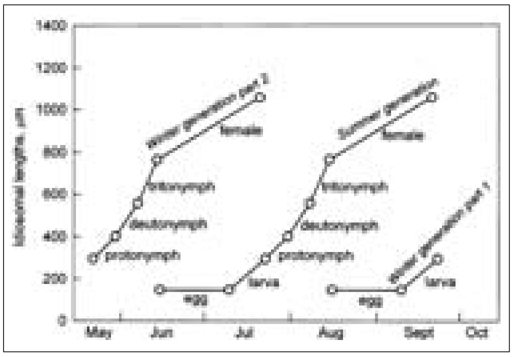

Figure 3. Model of progression of *Penthaleus major* in northern Iceland, constructed from dates and observed body sizes. Stage durations from Chada (1956).

as appears from Figure 3 *P. major* specimens in the spring are the result of hatchings in the early autumn and instead we have a mixture of stages dominated by the protonymph. This explains why spraying with pesticide in the spring or early summer may have an effect not only on the autumn population but also may reduce the number of specimens occurring after the snowmelt the following year (Gudleifsson *et al*. 2002).

Another grass-parasitizing mite, *Bryobia cristata,* in the same samples showed a similar hibernation pattern and emerged in the spring as a mixture of proto- and deutonymphs (Hallas & Gudleifsson 2004).

Regulatory factors for Penthaleus

No obvious competitors or predators among the other mites were captured in the sampling. A possible predator, the spider *Erigone atra* (Blackwall), appeared in high numbers on the same sites and at the same time as *P. major* in the present collections. Feeding experiments with this spider species indicated that it was unable to prey on *P. major* (Guðleifsson & Friðleifsson 2002). Cultural factors like hay cutting and grazing may remove a number of mites and eggs as well as the food and shelter for the remaining specimens. Apart from this and being preyed upon by unspecified predators, migrations etc., there are specific conditions that influence the size of the *P. major* population. *P. major* seems to prefer certain grass species (Poaceae) where it multiplies to become a pest. In Iceland this applies to the non-native grasses *Phleum pratense* and *Alopecurus pratensis* (Gudleifsson *et al*. 2002) and in Australia to *Holcus lanatus* and *Avena fatua* (Weeks & Hoffmann 1999). In Australia the infestation of *P. major* by the parasitic fungus *Neozygites* suppresses the production of eggs in females and eventually kills them (Geest *et al.* 2000) and may account for a mortality of 8 – 50% (Rath 1991). This finding seems to be similar in subarctic populations during the cold summer. The prevalence of this fungal disease in the present material was related to the high density of females.

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