Colonization ability and soil surface activity of certain insects, snails and earthworms near a melting glacier in southern Norway

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Pitfall traps were operated during two snow-free seasons and one winter period in the foreland of the melting Hardangerjøkulen glacier near Finse, southern Norway. While catches of beetles and spiders have been treated elsewhere, this paper presents catches of various other insects, as well as snails and earthworms. Tipulidae larvae and earthworms are basically soil-living but they practice a certain soil surface activity and may fall into traps. Tipulidae larvae were found in rather young soil, of 63 years age. The youngest soil with catches of the earthworm *Dendrobaena octaedra* (Savigny, 1826), the snail *Vitrina pellucida* (O. F. Müller, 1774), and larvae of the chrysomelid beetle *Chrysomela collaris* Linnaeus, 1758, was 160 years old. Larvae of the butterfly *Zygaena exulans* (Hohenwarth, 1792), and of adult *Boreus* sp. Latreille, 1816 (Mecoptera) were recorded on 79-year-old ground. The ability to conquer virgin land depends both on the dispersal ability of each species and of certain habitat qualities, as the development of vegetation and an organic soil layer. The present data may be used as a reference for later succession studies in the actual glacier foreland.

Key words: Norway, glacier, foreland, succession, Tipulidae, Mecoptera, Coleoptera, Lepidoptera, snails, earthworms.

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Introduction

Glaciers are retreating worldwide due to climate change (Roe *et al.* 2017). For ecologists, the deglaciated, virgin ground gives a unique possibility to study primary succession. Ground-dwelling invertebrates play an important role in that process, including the early phase of "ecosystem birth" (Hågvar *et al.* 2020, Ficetola *et al.* 2021). European studies have revealed unexpected and interesting results in the succession pattern, where "ecologically sound" assumptions have proved wrong (Hågvar & Gobbi 2022). In Norway, invertebrate succession has been intensely studied in the foreland of the Hardangerjøkulen glacier in southern Norway during the last twenty years (Hågvar 2012, Figure 1). Soil sampling revealed succession patterns of mites (Acari) and springtails (Collembola) (Hågvar *et al*. 2009a, Hågvar 2010). A large pitfall material of spiders (Aranea) and beetles (Coleoptera) was published by Bråten *et al.* (2012). Here, the colonization ability of certain other insects is shown. The traps even contained an interesting material of snails and earthworms.

Methods

In front of the receding Midtdalsbreen glacier snout near Finse, twenty pitfall traps were placed in each of six sites with different age since deglaciation: 3, 39, 63, 79, 160, and 205 years.

The sampling sites were situated in the treeless low- and mid-alpine zone, between 1300 and 1400 meters above sea level. The oldest site was situated 1.1 km from the ice edge (Bråten *et al.* 2012).

Pitfall trapping is not a standard method for sampling snails or soil-living animals like earthworms or Tipulidae larvae. However, these groups did fall into the traps, reflecting a certain surface activity. Earthworms may disperse by surface activity (e.g., Valckx *et al.* 2010) and Tipulidae larvae do sometimes crawl around in the surface litter. With as much as 120 pitfall traps operating throughout two years, we achieved a material of snails, earthworms and Tipulidae larvae (Figure 2) that tell something about their occurrence and colonization ability in the foreland.

FIGURE 1. View of the glacier foreland. Sampling activity in a 180-year-old site. Photo: Sigmund Hågvar.

FIGURE 2. Some animals from 160-year old ground: a Tipulidae larva, the earthworm *Dendrobaena octaedra*, and the snail *Vitrina pellucida*. Photo: Sigmund Hågvar.

Results

Table 1 shows that the earthworm *Dendrobaena octaedra* (Savigny, 1826), the snail *Vitrina pellucida* (O. F. Müller, 1774), and larvae of the beetle *Chrysomela collaris* Linnaeus, 1758, were documented on ground with ages 205 and 160 years but not on younger sampling sites. Adults of *Boreus* sp. Latreille, 1816 (Mecoptera) and larvae of the butterfly *Zygaena exulans* (Hohenwarth, 1792) were documented at ages 160 and 79 years. Larvae of Tipulidae fell into the traps at ages 205, 160, 79, and 63 years. They were only absent in traps at the two youngest sites (39 and 3 years).

Most catches of snails and earthworms were from 160-year-old ground, at 1300 meters above sea level. Here, the traps were situated in two rows, each with ten traps starting on a dry ridge and ending in a moist area below. While the ridge had a sandy soil with a patchy vegetation of various lichens, the vegetation was continuous in the lowest part with *Salix herbacea* L., *Vaccinium uliginosum* L., various green mosses and a mean organic soil layer of 16 mm. This gradient allows us to say something about the importance of soil type, moisture and vegetation cover, in addition to phenology. Table 2 shows presence/absence of snails, earthworms and Tipulidae larvae in each of these twenty traps during the different samplings. Earthworms were taken in thirteen different traps, snails in nine and Tipulidae larvae in eight traps. The number of individuals in a given trap at a certain sampling was usually lower than five. Only three traps (70, 79, and 80), and only one sampling date (15 September) did not catch any of these three groups.

Discussion

Vitrina pellucida is one of six snail species in the Finse area, of which five have a shell. This species has been recorded up to an altitude of 1470 meters but it avoids the most acid soils (Solhøy 1969,

TABLE 1. Age of deglaciated ground where various invertebrate groups were taken in pitfall traps, documenting surface activity.

Below: invertebrate group. Right: Age of ground (years)	**63**	**79**	**160**	**205**
Oligochaeta: *Dendrobaena octaedra* (Savigny, 1826)	-	-	x	x
Gastropoda: *Vitrina pellucida* (O.F.Müller, 1774)	-	-	x	x
Coleoptera: *Chrysomela collaris* Linnaeus, 1758, larvae	-	-	x	x
Lepidoptera: *Zygaena exulans* (Hohenwarth, 1792), larvae	-	x	x	-
Mecoptera: *Boreus* sp.	-	x	x	-
Nematocera: Tipulidae, larvae	x	x	x	x

TABLE 2. Occurrence of the snail *Vitrina pellucida* (crosses), the earthworm *Dendrobaena octaedra* (circles), and *Tipulidae larvae* (T) in twenty pitfall traps during two years on 160 year old ground. Vegetation cover close to each trap is given, and dry or moist soil is also roughly indicated. Traps were emptied every 14 days in the snow-free period.

Trap No.	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
Vegetation cover (%)	50	40	40	45	80	99	98	100	99	100	60	90	95	80	60	90	85	100	100	100
Dry/moist	Dry soil					Moist soil					Dry soil							Moist soil		
2007																				
7 July	-	-	-	-	x	x	o	-	-	-	-	-	-	-	-	-	-	-	-	-
21 July	-	-	-	x	xo	-	x	x	-	-	-	-	-	o	-	-	-	x	-	-
4 Aug.	-	-	-	-	x	x	x	-	-	-	-	-	-	-	-	x	x	x	-	-
18 Aug.	-	-	-	x	-	x	x	-	-	-	-	-	-	-	-	T	-	-	-	-
1 Sept.	oT	-	-	xoT	xT	x	x	-	-	-	-	-	-	-	xT	-	-	x	-	-
15 Sept.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2008																				
31 May	T	o	T	T	xoT	xo	x	-	-	-	o	T	oT	o	oT	o	-	-	-	-
14 June	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	x	-	-
28 June	-	-	-	-	-	-	-	-	o	-	-	-	-	-	-	-	-	-	-	-
12 July	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	x	-	-
26 July	-	-	-	-	-	x	x	x	-	-	-	-	-	-	-	-	-	x	-	-
9 Aug.	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	o	-	x	-	-
23 Aug.	-	-	-	-	-	x	-	-	-	-	-	o	-	-	-	-	-	x	-	-

1976). Over time, as vegetation develops further, *V. pellucida* could perhaps disperse to larger parts of the glacier foreland. It is interesting to note that the nine snail-catching traps were all situated in the medium part of the moisture gradient of the small hill (traps 64-68 and 75-78, Table 2). Drought or the lack of suitable food plants may explain the avoidance of the uppermost, sandy area with lichens. A considerable presence of mosses unsuitable as food may have been negative in the lowest and wettest part of the gradient. A local concentration of snails was further illustrated by rather stable catches in three specific traps, nos. 66, 67, and 78. These traps were situated in a favorable combination of moist soil and closed, mixed vegetation. Especially from these traps, we can read that snails were surface active throughout the snow-free season.

Earthworms and Tipulidae larvae are basically soil-living, but now and then they expose themselves on the surface. Surprisingly, most catches of these groups were taken in rather dry plots. Maybe their surface activity just after snow melt in May 2008 (Table 2) was due to favorable surface moisture, even on sandy soil, at that time. For earthworms, surface activity could be an active migration behaviour. The upper possible altitude for *D. octaedra* in the Finse area is unknown. Probably it can ascend higher in south-faced slopes than in the actual, slightly north-faced glacial foreland. An indirect proof of surface activity of Tipulidae larvae is that they are picked and eaten by the snow bunting bird (*Plectrophenax nivalis* (Linnaeus, 1758) (Hågvar *et al.* 2009b).

The development of an organic soil layer, in which earthworms and Tipulidae larvae may thrive, is very slow in the foreland. In sites younger than 63 years, the organic layer was negligible, only about 2 mm thick after 39 years and zero after 3 years (Hågvar *et al*. 2017). However, wind-blown litter may accumulate in microbabitats of very young soils, for instance along or between stones.

Adult Tipulidae were trapped on the 39 year-plot. On an eight years old moraine, small ponds had developed an organic bottom sediment, due to wind-transported moss fragments which were "captured" by pond surfaces (Hågvar & Pedersen 2015). Here, close to the ice edge, aquatic Tipulid larvae were recorded in the bottom sediments (Hågvar *et al*. 2016).

Boreus sp. is able to colonize still higher altitudes in the glacier foreland. *Boreus hyemalis* (Linnaeus, 1767) has been recorded at an altitude of 1400 meters both on Hardangervidda and on Dovrefjell (Fjellberg & Greve 1968).

The beetle *Chrysomela collaris* typically breeds in the outer parts of snowbeds. Here, its food plant *Salix herbacea* is common and the snow-free period is long enough to manage a one-year life cycle (Hågvar 1975 a,b). While the food plant even occurs on pioneer ground after a few years, it takes time to develop a typical snowbed vegetation, to which the species seems to be bound. The youngest ground on which adult beetles have been found is 79 years old (Bråten et al. 2012). This may indicate reproduction since adults have never been observed flying in the Finse area.

According to Birkemoe *et al.* (2016), larvae of the butterfly *Zygaena exulans* have been recorded up to an altitude of 1550 meters. However, this was in a south-faced hill (Sanddalsnuten) at the other side of the Finse valley, where temperature conditions were more favorable.

While the present data show minimum values for the colonization ability of each group, further studies using additional methods may check their presence on younger ground. The colonization of earthworms is expected to depend on the gradual development of an organic soil layer. However, it might be that pockets of organic matter could aggregate in special microsites and support founder populations, perhaps of wind-blown earthworms? Today´s documentation of invertebrate life in this glacier foreland could have a reference value in long-term monitoring.

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