Metsähallitus

Management plan for the habitats of Aradus angularis

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Ecology and distribution

Description

Aradus angularis (J. Sahlberg, 1886) is a black or dark brown-black Hemiptera 3.6 to 5 mm in length that belongs to the suborder Heteroptera. Thanks to its dark colour, the species is well camouflaged on scorched wood. Its surface is rough with ridges. Similarly to other flat bugs, its body is very flat as an adaptation to moving around in narrow gaps in the bark. Flat bugs have an angular body shape and long, forward-pointing antennae with four segments. The eyes are clearly protruding.

Flat bugs have an extremely long proboscis. It is approx. twice the length of the body and in repose, it is rolled up under the elongated head (Wikars 2006).

The species differs from other flat bugs in its colour and general appearance as well as the antennae and pronotum. An adult *A. angularis* is very similar to the much more common *A. lugubris* and the rare *A. laeviusculus*, which also are species of forest fire sites. In *A. lugubris*, the base of the second antennae segment is much narrower. Additionally, the tips of the second and third segment usually have some white colouring. In *A. laeviusculus*, the front corners of the pronotum are rounded, whereas in *A. angularis*, they are angular and protruding.

Life cycle

A. angularis ecology has been studied relatively little, but the species is known to live on scorched spruces and pines, where it feeds on wood-decay fungi. Adult females lay their eggs soon after a forest fire on the trunk of a dead tree and apparently stay there for a few days.

Nineteen species of the genus Aradidae have been found in Finland (Rintala and Rinne 2010). All flat bugs go through a partial metamorphosis. This means that the eggs laid by the females first develop into larvae resembling adult individuals, which are also called nymphs. Through successive nymph stages, the larvae develop into adults without the pupation typical for many insect groups.

Aradidae go through five different nymph stages in total. The final nymph stage of flat bugs may take months. Nymphs and adults often live together in groups which, however, individuals that have recently become adults leave relatively soon (Wikars 2006). Flat bugs may produce more than one generation during a growing season (Wikars 2006). Both the adults and nymphs may overwinter.

A. angularis numbers usually are relatively low (e.g. Heikkala et al. 2017). Data saved to the database of endangered species (LajiGIS) and open databases (Laji.fi, Artportalen.se) mainly contain information about single individuals. Most observations of *A. angularis* have been made in July and August.

Nutrition

Many flat bugs feed on liquids found in the rhizomes of wood-decay fungi, especially bracket fungi (Rintala and Rinne 2010). This is also true of *A. angularis*, which is presumed to use its long proboscis to suck cell sap from wood-decay fungi living under the bark on butts of scorched tree trunks. Both adults and nymphs use the same food source. They are not believed to specialise in any particular fungus species (ArtDatabanken 2019). In Sweden, the species has been found in the vicinity of both blue stain fungi and *Trichoderma*, which belong to sac fungi.

Habitats

A. angularis lives under the bark on the butts of scorched and dying spruces and pines and possibly also on pieces of bark that have fallen off the tree. The species only occurs in burned forests, mainly immediately after the fire, or one or at most four years after it (Wikars 2006, Heikkala et al. 2017). An individual specimen has been found six to eight years after a fire (Wikars 2006, ArtDatabanken 2019). The species may have a particular preference for trunks on warm and sunny sites.

The *A. angularis* observations in Finland have been made in connection with prescribed burning or natural forest fires. The sites of these fires have mainly been mature or old pine or mixed pine forests, in Northern Sweden however mostly mixed spruce forests. The species has also been observed in a burned compartment of young pine forest in Eastern Finland.

There is no scientific evidence of whether or not the sturdiness of the tree is significant for the occurrence of the species. While it has at times been presumed to prefer relatively large trees dying in an upright position, the size of the trunk is not necessarily a limiting factor. The sturdiness of the trees may affect such aspects as the reproductive success of *A. angularis*, the population size and the ease of finding suitable trees. When damaged, sturdier trees may secrete higher quantities of the volatile chemicals that attract flat bugs than small trees and branches (Seibold et al. 2014).

A suitable fire intensity that scorches the bark and damages the phloem layer, loosening the bark from the trunk, is likely to be more important, however. This creates suitable habitats for sac fungi. Many observations of the species have been made using different types of window traps, either attached to a tree trunk or suspended freely, to catch flying insects and especially beetles. The data collected using traps does not yield more accurate information about the choice of microhabitat of this species. In Sweden, the species has also been sought by screening the bark of conifers damaged by a fire and looking for it directly on and under the bark of a dead scorched tree. Nymphs have been found on spruces with a diameter of 10 to 40 cm and a strongly charred butt (Wikars 2006).

A. angularis, similarly to other pyrophilous flat bugs, has mostly been observed in the first couple of years immediately following the fire (Heikkala et al. 2017), despite the fact that scorched deadwood is available on the site of the fire for several years after it. A possible explanation is that the fungi which the species feed on are associated with recently burned trees. These pioneer species may do badly in competition with other, more vigorously growing fungi, and consequently disappear from the wood in a few years after the fire.

A. angularis may tolerate drought better than other flat bugs (Pettersson 2011). Wikars (2015) suggests that the species might be able to avoid competition by favouring drier habitats than other flat bugs.

In order for the species to survive at the landscape level, burned conifers must be available continuously. Burning in an area every three years would be enough to safeguard the occurrence of the species. In their study, Heikkala et al. (2017) found that pyrophilous flat bugs benefit from the prescribed burning of fellings that contain retention trees. A larger number of retention trees is better in terms of the richness of species and numbers of individuals. Compartments where trees have been harvested before burning attracted more flat bugs than unfelled control compartments. This may indicate that open and warm sites are more attractive to the species than shady sites with more trees. Another reason may be that the fire was more intense in forests where trees had been harvested before burning. In this study, *A. angularis* also appeared in a test compartment that had been clear felled before burning. However, the data does not indicate if the species managed to reproduce on a site mainly containing decaying trees with a small diameter, as window traps were used in the data collection. This way, flying individuals can be caught immediately after the fire as adults arrive on the site.

To benefit *A. angularis*, the fire must be intense enough to attract adults and to produce trunks suitable for reproduction that die without falling down. In addition to trees with a smaller diameter, the fire load should also contain sturdy spruces and pines, at least some of which are scorched black in the butt section. Larger burned sites contain more trees and better possibilities for creating suitable habitats.

Ability to find habitats and spread

Some flat bug species, including *A. lugubris,* have infrared radiation receptors in their bodies which help them find a forest fire (Schmidtz et al. 2010). No such organ has been found in *A. laeviusculus (*Schmidtz et al. 2010). The mechanism *A. angularis* uses to locate forest fires is so far not known. Potentially, it senses the volatile compounds contained in smoke or secreted by trees. There is no certainty of whether or not this species has infrared radiation receptors.

It is commonly presumed that *A. angularis* can cover long distances when searching for forest fires and suitable damaged trees. The movements of *A. angularis* or other rare pyrophilous flat bugs have not been examined in ecological studies or by means of genetics. However, the species has been found at a very long distance from its main range, even as far as Switzerland (Gossner et al. 2018), which is likely to mean that they can travel long distances, also making use of air currents.

Investing in the ability to fly well may, however, mean that these species do not reproduce as efficiently as others. For example, Wikars (1997) noticed that *Melanophila acuminata*, a pyrophilous beetle, had smaller ovaries and produced fewer eggs than its non-pyrophilous sister species. Similarly, the flight muscles of *M. acuminata* were larger, and the weight of the wings per unit of surface area was smaller. Wherever *A. angularis* is found, its numbers are always low, which together with the rareness of the species hampers any attempts to study its ecology.

In Finland, *A. angularis* individuals have been observed in eastern parts of the country close to the Russian border as well as in Northern Finland. Large-scale forest fires on the Russian side of the border help pyrophilous species to survive and may serve as source populations. These species are more likely to appear on forest fire sites in the east as there are no source populations in the west. In northern parts of Finland, no similar difference between the east and the west exists, as there also is an *A. angularis* population maintained by forest fires in northern Sweden.

Distribution and status

John Sahlberg discovered this species in Finland in 1894 in Inari, south of Kultala on the River Ivalonjoki (Rassi et al. 1986). Since then, *A. angularis* has been found in burned forests in the eastern and northern parts of the country on seven locations. The southernmost observations were made in Lieksa and Ilomantsi between 1998 and 2012. In addition to old observations from Inari, the species has been found in Northern Finland in Posio, Kittilä and, more recently, in Rovaniemi and Savukoski in 2014.

In addition to northern parts of Finland and Sweden (Västerbotten and Norrbotten), the species occurs elsewhere in the palearctic zone from Russia all the way to northeastern parts of China. It was also found outside its main range on a burned site in Switzerland in 2013 (Gossner et al. 2018).

Administrative status and legislation

EU Habitats Directive Annex II.
Protected under the Nature Conservation Act (Nature Conservation Decree 160/1997, Annex 2a 471/2013)
Endangered species (Nature Conservation Decree 160/1997, Annex 4 471/2013)
Red List category in 2019: vulnerable (VU)

The national action plan for species protection (Finnish Environment Institute 2010–2011) listed *A. angularis* as a species needing urgent protection, and it is also included in the updated list of species needing urgent protection from 2020. As the primary means for safeguarding it have been identified habitat management and restoration. Land use projects and decisions may also play a role in these measures.

Hyvärinen et al. 2019, Finnish Environment Institute 2021

In Finland, *A. angularis* is classified as vulnerable. When assessing the status of the species, as threats affecting it have been identified the low number of forest fires and interruption of the fire continuum (Hyvärinen et al. 2019).

Habitat management in protected areas

Distribution of *Aradus angularis* in protected areas

A. angularis bugs have been found on the following Natura 2000 sites:

North Karelia: Patvinsuo (Patvinsuo National Park) and old-growth forests on the eastern boundary of Lieksa,

Lapland: Mustarinnantunturi, Mustiaapa–Kaattasjärvi and UKK National Park–Sompio–Kemihaara (Urho Kekkonen National Park and Sompio Nature Reserve).

The national parks and nature reserves contained in Natura sites are given in brackets. For more information on Natura sites, visit the Finnish Environment Institute's map services (Finnish Environment Institute 2018). The most recent observations in all protected areas were made in connection with restoration burnings carried out by Parks & Wildlife Finland. Outside protected

areas, the species has been found on scorched trees in the vicinity of the Natura site of Näätävuoma–Sotkavuoma in Kittilä (prescribed burning for forest management) and close to Ruunaa Natura site in Lieksa in an area used for experiments in a research project on forest fires.

Fire continuum sites and prescribed burning carried out for restoration purposes

The fire continuum sites maintained by Metsähallitus (Päivinen & Aapala 2007, Hyvärinen & Aapala 2009) and prescribed burning for restoration purposes outside these sites play a key role in safeguarding the occurrences of *A. angularis*. On fire continuum sites, prescribed burning of forest takes place every three to five years in the protected areas as well as in the multiple-use forest areas in between them. The total number of fire continuum sites is 52 (Hyvärinen & Aapala 2009). The southernmost one of these sites is Sundalen in Hankoniemi, and the northernmost one is in Vätsäri Wilderness Area in Inari. Over the ten-year period 2009–2019, Parks & Wildlife Finland has burned on average 76 hectares of forest every year. On average, ten sites were burned per year, most of them in Southern Finland. In 2018, for example, Metsähallitus Parks & Wildlife Finland burned 132 hectares of forest on 15 sites, and in 2020 a total of 57 hectares on ten sites. In 1989–2020, the average area burned has been around seven hectares.

The following section describes the occurrence of *A. angularis* in protected areas as well as the situation of fire continuum plans and prescribed burning carried out by the regional units of Parks & Wildlife Finland.

Lake Region

Patvinsuo fire continuum site covers the locations where *A. angularis* has been observed in Eastern Finland, or the old-growth forests on the eastern boundary of Lieksa, Patvinsuo and Ruunaa. Efforts are being made to carry out prescribed burning in North Karelia at regular intervals. Suitable sites for burning are searched and planned on individual work sites without a specific fire continuum plan.

On the Natura site of old-growth forests on the eastern boundary of Lieksa, burning took place once in 2011. At that time, an *A. angularis* was caught in a window trap in monitoring after the burning. The site comprised pine-dominated young forest.

In Patvinsuo, restoration burning had been carried out four times by 2020 in 1989, 1995, 2001 and 2006. Additionally, a natural forest fire has blazed in this area at least once in the 2000s. In 1998, *A. angularis* was observed in a compartment that was burned in 1995.

In Ruunaa, Lieksa, burning has been carried out three times: in 2005, 2009 and 2020.

Ostrobothnia–Kainuu

On Mustarinnantunturi in Posio, *A. angularis* was observed on a site burned in 2011 in a species inventory carried out the following year. Additionally, burning took place in this area in 2017.

Mustarinnantunturi is part of a fire continuum site bearing the same name for which a fire continuum plan has been prepared (Kytö 2008).

An *A. angularis* observation was also made in Sydänmaanaro in Suomussalmi on a site where restoration burning took place in 2019 as part of the Light & Fire LIFE project (Reima Leinonen, personal communication). Sydänmaanaro is part of Malahvia fire continuum site, and a fire continuum plan was prepared for it in the Light & Fire LIFE project (Heikura 2016). The area comprises the following Natura sites: Karsikkovaara-Losolehto, Malahvia, Juortananasalo area, Sydänmaanaro and Mäntypuro. In Malahvia fire continuum area, burning has taken place in 2010, 2011, 2018, 2019 and 2020. Even before this, restoration burning for ecological management purposes was carried out in 2004–2006.

Lapland

In 2013, an area of approx. 18 hectares was burned in Mustiaapa-Kaattasjärvi in Rovaniemi, and an *A. angularis* was caught in a trap as monitoring was carried out in the following year. The area belongs to the fire continuum site of Kilsiaapa-Ristivuoma, which contains the Natura 2000 sites of Mustiaapa-Kaattasjärvi and Kilsiaapa-Ristivuoma. Prescribed burning took place in Kilsiaapa-Ristivuoma area in 2005, 2006 and 2007. The fire continuum plan dates back to 2005 (Välimäki and Kulmala 2005).

On the Natura site consisting of Urho Kekkonen National Park, Sompio and Kemihaara, prescribed burning of forest for ecological management purposes took place in Kemihaara in 2018. Natural forest fires blazed in Urho Kekkonen National Park in 2013 and 2018. A fire continuum plan was prepared for this area in the Light & Fire LIFE project (Puustinen 2016).

No prescribed burning for restoration purposes has been carried out in Näätävuoma–Sotkavuoma area in Kittilä. The fire continuum site of Näätävuoma–Sotkavuoma has been identified in this area (Hyvärinen and Aapala 2009), and a fire continuum plan is to be prepared for it in the pending LIFE project. Näätävuoma-Sotkavuoma is a mire reserve mainly consisting of aapa mires. Before the area was protected, some of the forests in the area were managed by clear felling and strip cutting. In Tollovuoma-Silmäsvuoma-Nunarvuoma area nearby, natural forest fires burned in 2001 and 2009.

Monitoring of the species and development of monitoring methods

Monitoring of insect species after prescribed burning of forest paints a versatile picture of the species that arrive on a burned site. On the other hand, the volume of accumulated samples in proportion to the low numbers of *A. angularis* does not serve the need to monitor this particular species cost-effectively. In addition to insect monitoring after prescribed burning, a direct and less labour-intensive method than inventories based on trapping would be needed to establish occurrences of the species.

The starting point could be the method developed by Wikars (2015), in which the butts of scorched spruces on the burned site are examined from the height of approx. 40 cm to breast height (130 cm). The diameter of the tree can be 5 to 15 cm. More important than the tree diameter, however, is a suitable fire intensity, causing the bark on the tree to heat up to the extent that it becomes scorched and the phloem is damaged. You debark the tree using a knife, axe or billhook, ensuring that the detached pieces of bark fall on a white cloth wrapped tightly around the butt or directly into an insect sieve. While detaching it carefully, you examine the bark and its underside, keeping an eye out for flat bug tunnels, nymphs and adults. Flat bugs are mostly found under loose bark. They can also typically be found on the ecotone between moist and dry wood. You crush the fallen pieces of bark carefully by hand and pour them into a sieve with a hole size of 5 to 10 mm, preferably approx. 8 mm. You shake the bark pieces in the sieve for a few minutes. You then go through the sample by spreading it as a thin layer on a sheet or tray and examine it carefully. You can do this in the forest or, in poor weather conditions, indoors. Following Wikars' instructions, samples are collected from 12 trees at a minimum distance of 100 metres apart. The number of sample trees must additionally not exceed 20% of suitable trees on the burned site to ensure that sufficient habitat is left for the species in the area.

When monitoring and inventorying *A. angularis*, you should remember that the species is protected. A derogation from the protection regulations is always needed for seeking for the species in the vicinity of known occurrences. Bark should always be detached judiciously from trees suitable for the species as this destroys its habitat. The search on the site must be called off immediately if the species is observed on it, or its occurrence is suspected.

Further research will be needed to study the ecology of the species. Training provided for personnel responsible for managing nature reserves and also ecological management in commercial forests could increase awareness of the species.

Recommendations for habitat management in protected areas

- Maintaining fire continuums in protected areas. Forest must be burned every three to five years on each fire continuum site following the plan (Hyvärinen & Aapala 2009, Appendix 7). Maintaining fire continuums in Eastern Finland and the areas of Peräpohjola and Forest Lapland is particularly crucial for the species. These continuums can also be supported by prescribed burning elsewhere, such as in protected areas outside the fire continuum sites.
- If reducing the fire load is necessary, long stumps of spruces and pines can be preserved in fellings carried out in the compartment before burning.
- Burning for ecological management purposes on fire continuum sites in multiple-use forests supports the availability of *A. angularis* habitats when the burned site offers scorched wood suitable for the species. Suitable sites are preferably large retention tree groups that also contain larger spruces and pines.

- Monitoring the realisation of the fire continuum at the level of fire continuum sites. The monitoring should also cover burning for ecological management purposes on fire continuum sites. The monitoring should primarily be organised as small-scale, reliable record-keeping to verify that burning takes place frequently enough across a sufficient area.

Consideration for the species in forest management and safeguarding its habitats by ecological management

The safeguarding of habitats suitable for *A. angularis* can also be supported in forests outside protected areas. The species is fully dependent on scorched wood. Consequently, preserving scorched trees and producing them under controlled circumstances are key measures. These measures are also beneficial in areas with no known occurrences of *A. angularis* in their vicinity, as a large number of other species that depend on or favour burned sites live in Finland, not only insects but, for example, fungi.

The prescribed burning of forest regeneration sites improves the thermal and nutrient conditions of the site. Felling residue left on the prescribed burning site may benefit some pyrophilous species. There is no certainty of its benefits for *A. angularis*, however. In compartments to be regenerated, the burning of retention tree groups creates habitats for this species. Large burned sites are more useful for it than smaller ones. A precondition for prescribed burning is making a prescribed burning notification referred to in section 8 of the Rescue Act (379/2011) to the rescue services.

Recommendations for habitat management on lands used for commercial forestry

- Preserving spruces and pines damaged by a forest fire on the burned site. Under the Forest Damages Prevention Act, at most 10 cubic metres per hectare of damaged spruces and 20 hectares of pines with a butt diameter of over 10 cm may be left in the forest.
- Prescribed burning of regeneration sites and retention tree groups for ecological management purposes. The site to be burned should also have sturdy or relatively sturdy spruces or pines.

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