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MONITORING AND CONTROL OF THE FIRST INFESTATION OF THE SUBTERRANEAN TERMITE *RETICULITERMES GRASSEI* (ISOPTERA: RHINOTERMITIDAE) IN THE NORTH-EASTERN PART OF SWITZERLAND

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Abstract At the end of April 2018, a pest control company brought three termite soldiers and some alates to the Urban Pest Advisory Service (UPAS) for species determination. They were found in a building in a medium-sized city on Lake Zurich (Canton Zurich). A mitochondrial DNA analysis by the University of Bologna, Italy, resulted in the species *Reticulitermes grassei* Clément. *R. grassei* is native on the Iberian Peninsula and in the southwest of France, whereas subterranean termites are not native in Switzerland. In June 2019, 24 termite bait stations were installed on the site of the infested house and three adjacent properties. One month later the first inspection showed termite activity in two bait stations of one of the adjacent properties. The approach and the challenges in the survey of infested area, the control methods, and the legal situation in Switzerland are presented.

Key Words Termite damage, introduced species, eradication, control measures, unintentional introduction

INTRODUCTION

Termites are social insects common in tropical and subtropical zones of the world where they play an important role in the decomposition of plant materials. Currently, there are 28 termite species recognized as invasive, which can become important pests in urban environments by damaging wooden structures. Subterranean termites can reach very large numbers with hundreds of thousands of individuals. They live in the soil and workers leave the nest and forage for food, usually non-decomposed wood (Evans et al., 2013). The subterranean termite *Reticulitermes grassei* Clément is native in the southwest of France and on the Iberian Peninsula. (Berville and Darrouzet, 2019; Clément et al., 2001; Verkerk and Bravery, 2004). In its native range, *R. grassei* is found in natural habitats as well as in urban areas. It is known to damage cork oaks in Spain and is regarded as a major pest in urban areas of Andalusia (Cárdenas et al., 2012). Two established introductions of this species are known: one was found at two beach houses at Saunton, North Devon, in the South of the United Kingdom in 1994. According to reports from local residents, the infestation seemed to be there for 25 years already (Evans et al., 2013; Verkerk and Bravery, 2004). The second established introduction of *R. grassei* was found in the City of Horta on Faial island in the Azores in the early 2000s (Ferreira et al., 2013).
Switzerland has no native termite species. Six records of drywood termites are recorded in the data base of the Urban Pest Advisory Service of the City of Zurich (UPAS) since 1998. There are two reports of subterranean *Reticulitermes* termites in Switzerland: in 1985, members of the Plant Protection Service found *R. lucifugus* several times in table potatoes imported from Naples, Italy (Billen, 1988). Apparently, this multiple introduction did not result in an established population. In 2013, *Reticulitermes* sp. was found in the wood chips storage room of a wood chip heating system and near a palm tree in the garden of the same building in Locarno, southern Switzerland (Delano Osterwalder, pers. comm.). This infestation was successfully eradicated but no species identification was made.

In April 2018 a pest management professional (PMP) brought three *Reticulitermes* sp. soldiers to the UPAS for identification and one week later several alates (members of the reproductive caste). They were coming out of holes in the oak wood parquet floor into the winter garden of a house in a medium-sized city on Lake Zurich (Canton Zurich). Some days later, they were found making holes into the wall of the winter garden and thus ending up on the outside of the house. The PMP treated the holes with diatomaceous earth and sprayed an insecticide barrier on the

inside of the floor-to-ceiling windows, and for the rest of the year the termites were no longer seen. An inspection of the infested property in June 2018 resulted in no other visible traces of the termites in the house and the surrounding garden. In the next year at the end of April 2019, there were again alates coming out of the holes in the oak wood parquet floor of the winter garden and the house owner insisted on an immediate treatment with diatomaceous earth.

Termites are not native in Switzerland and thus are classified as invasive organisms in addition to their potential to cause enormous financial damage. The infestation was therefore reported to the section Neobiota of the Environment Department Kanton Zurich (SNEKZ) in June 2018. The SNEKZ contacted the authorities of the city where the infestation occurred, and it was decided, that a survey of the extent of the infested area and an eradication should start in spring 2019. According to the cantonal ordinance on general and residential hygiene (Kanton Zürich, 1967), the authorities can enforce house owners to commission a pest control operation for the eradication and to bear the ensuing costs. The city authorities decided to commission the pest control company who first detected the termites with the survey and control in order to save time, and also that all the survey and control measures are done in the same high standard. The authorities will pay the work and allocate the arising expenses to the property owners, where termites are found after the results of the survey are known.

In order to eradicate the entire termite colony in the area, the use of soil treatment by termiticide liquids was not an option because of environmental reasons and the immediate vicinity of the Lake Zurich. Termite baiting stations with a chitin synthesis inhibitor (CSI) as the active substance were considered the best approach for assessing the extent of the infestation and a later eradication (Rust, 2014). This also minimizes the amount of active ingredient that has to be used (Ferrari and Marini, 1999). The foraging termite workers feed on the biocide-impregnated bait, go back to their nests and feed their nest mates by trophallaxis. The CSI affects the molt into the next stage and thus kills the whole termite state (Su and Scheffrahn, 1993).

As there were no subterranean termite infestations known in Switzerland until lately, there were no registered biocidal products for subterranean termite control available. The SNEKZ had to apply for a temporary exemption for a termite baiting system product at the National Notification Authority for Chemicals. The temporary registration was issued on April 18, 2019 and valid for 180 days. SNEKZ immediately applied for an extension of the temporary registration, because the control of termites can take some time and after the control, a monitoring system has to be installed to be sure of the success. An extension of a temporary registration of a biocidal product is only possible once and the maximum validity for a temporary registration is two years.

The purpose of this paper is, to present how the eradication of an unexpected occurrence of an introduced species was handled, and which challenges we were confronted with.

MATERIALS AND METHODS

Site Description

Property 1: The property where *R. grassei* was found initially is a two-story detached concrete house adjacent to the Lake Zurich at 409 m above sea level. Part of the garden is covered with lawn and part is covered with pebble stones. An olive tree (*Olea europaea* L.), with a trunk diameter of 25 to 30 cm, was planted in the garden in November 2008, two to three meters away from the winter garden. The winter garden's floor is made of oak wood. It is not known, when the floor was installed and where it came from.

Property 2: The property on the left-hand side is also a two-story detached concrete house with flagged floors. There are three smaller olive trees in large pots and three palm trees in the garden. The house owner bought these trees himself in Switzerland, but cannot remember where and when exactly. There is a bamboo thicket next to the boundary wall to property 1.

There is no visible wooden construction material in these two houses except the oak wood parquet floor in the winter garden of property 1.

Property 3: The property on the right hand side is a small boathouse with visible wooden beams.

Property 4: The next house to the right is a four-story house made of brick and concrete.

There are no Mediterranean plants in the gardens of properties 3 and 4.

Survey and Control Measures

Twenty ground bait stations, equipped with alpha cellulose bait and a piece of poplar wood (Termigard^{R} System, Quimunsa, Spain), were installed in the soil of each property in June 2019 (Figure 1). The ground stations used are 23 cm long plastic tubes with a diameter of 7.6 cm, closed at the bottom and with apertures on the sides so that the termites have access to the bait. First, a piece of poplar wood 6.2 cm high and 6 cm in diameter is inserted into the

plastic tube. Above the wood, a second plastic tube is inserted, with a diameter of 7 cm and 14.7 length and with apertures on the side. A 75 g alpha cellulose bait or, in case of termite activity, a 50 g alpha cellulose bait impregnated with diflubenzuron 0.25% (Termigard^{R} Plus, Quimunsa, Spain), a chitin synthesis inhibitor (CSI), is placed into the inner plastic tube. The alpha cellulose was moistened with distilled water to render it more attractive to the termites. The ground bait stations were installed underground even with the surface and closed with a lid. In addition, four wall bait stations, plastic boxes with dimensions of 15.5 x 8.5 x 4 cm and open at the back to provide access to the termites, were installed on floor level in the winter garden of property 1, one in each corner of the room. The wall stations were also filled with 75 g moistened alpha cellulose bait and glued to the wall with two small pieces of double-sided tape. All bait stations were checked for termite activity monthly from July to October 2019.

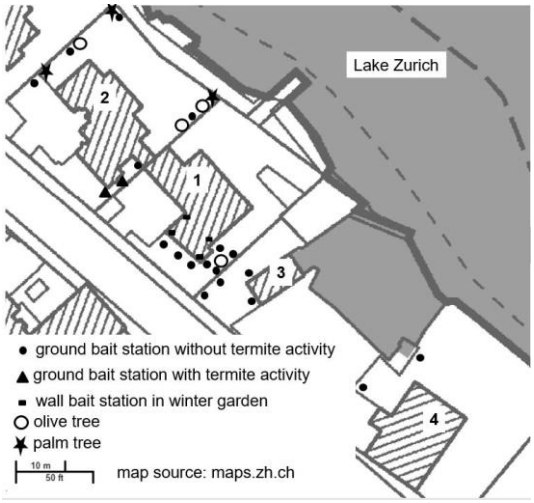

Figure 1. Area of survey of *R. grassei* activity. Numbers 1,2,3,4 indicate the described properties.Crosshatched areas indicate buildings.

Species Identification

Species identification of termites of the genus *Reticulitermes* based only on morphological characteristics is not reliable (Wang et al., 2009). Some termite workers from infested bait stations were sampled in 100 % Ethanol and sent to the Department of Biological, Geological and Environmental Sciences, University of Bologna, Italy for genetic identification by performing mitochondrial DNA analysis (Ghesini et al., 2020).

RESULTS AND DISCUSSION

This is the first report of subterranean termites in Switzerland north of the Alps and in the Canton Zurich. There was a *Reticulitermes* sp. infestation in the Canton Ticino, in southern Switzerland, in 2013. This was eradicated quickly without a species determination or a report to the cantonal authorities responsible for invasive organisms. From a scientific point of view, this is unfortunate, because it would be important to know the time of the first occurrence of an invasive organism, how exactly it was introduced, and which species was concerned.

Compared to the *R. grassei* establishment in Saunton, UK, the monthly average temperatures on the Lake Zurich are lower in winter and higher in summer. Monthly precipitation does not drop below 37 mm per month in either place, providing enough soil humidity in both places. (Timeanddate.com, 2020). Nonetheless, an establishment of *R. grassei* was possible under these conditions with the production of flying alates in two successive years at least. We know that cities are heat islands with increased underground temperatures in winter. Increased temperatures due to the winter garden could also be a factor.

Survey and Control Measures

After one and two months of alpha cellulose bait exposure (July and August), we found approximately 90 termite workers and 6 soldiers in two out of the 24 bait stations. These two stations were situated in the bamboo thicket in the garden of property 2 bordering property 1 (Figure 1). In September, we only found one worker in one of these bait stations and in October, no more termites were seen. It is not certain whether the infestation has already been eradicated or whether the termite activity is reduced due to the dropping temperatures. Cárdenas et al. (2012) found in their study on field activity of *R. grassei* in northern Andalusia, Spain, that activity started in May, peaked in July and August and declined afterwards.

We found no termite activity in property 1 from the end of April until October 2019. This is probably due to the application of diatomaceous earth earlier in April 2019. There was also no termite activity in the bait stations on properties 3 and 4. The small number of termites found seems to indicate that the population is not very large. It is not known how the termites were introduced. It could have been with the soil of the olive or palm trees or with the oak wood for the parquet floor of property 1. Evans et al. (2013) wrote that it can take a *Reticulitermes* sp. colony five to ten years to produce alates after a new introduction. That would be well in line with the hypothesis of the olive tree in front of the winter garden of property 1 as way of introduction, as it was planted in 2008 and the first time the house owners noted the presence of the termites was 2018.

The inspections of the bait stations were discontinued during winter. The owners of property 1 were instructed to report any termite appearance in their winter garden immediately and not to control them themselves. The bait stations were left in place over the winter and monthly inspections will start again in March 2020. The area where termites were found covers about 350 m^2 (32 m by 11 m). This is 7.5 times smaller than the area where termites were found at Sauton, UK (at least 2625 m^2: 75 m by 35 m). The radius of our treatment zone was 20 m, whereas in the UK, it was < 75 m (Verkerk and Bravery, 2004).

Species Identification

The result of the DNA analysis showed, that the termites from the Swiss sample belong to the species *Reticulitermes grassei* and are genetically similar to *R. grassei* from Andalusia, Spain. The introduction may have happened with soil of one of the imported olive or palm trees. The same type of introduction was suspected in the *R. grassei* cases in the UK and on the Azores (Jenkins et al., 2001).

Collaboration With House Owners

The occurrence of termites on their ground did not worry the owners of properties 1 and 2 much. Their houses are not built of wood and the damage was limited to some holes in the oak wood parquet floor and the wall of the winter garden of property 1. It was not possible to get reliable information on the origin of the oak wood in the winter garden of property 1 and on the origin of the imported olive and palm trees on property 2. This could be because ten years have passed or because nobody wants to be held responsible for the infestation, the survey costs fand eradication.

Legal Situation

The unexpected occurrence of an invasive species can cause unforeseen problems. For example, as in this case, you may not be able to legally purchase biocides to eradicate the invasive species. The Swiss authorities were very helpful in issuing a temporary exemption for a termite bait product due to an exceptional situation. Although, the short period of validity of two years might be a problem, because termite control and the subsequent monitoring can take a long time. We will have to convince the supplier to apply for a permanent registration in Switzerland. Subterranean termites are common in Italy and France, countries that border Switzerland. Further termite introductions are therefore likely.

Mediterranean plants such as olive or palm trees are very popular in Switzerland. The unintentional introduction of subterranean termites and other invasive organisms along with soil around the roots of a tree seems very likely. Liebhold et al. (2012) report that nearly 70 % of damaging forest insects and pathogens established in the US between 1860 and 2006 most likely entered on imported live plants. Between the fiscal years 2003-2010 they found 147 shipments of live plants infested with ants and 11 with termites. In the City of Zurich there are records of two invasive ant species, *Lasius neglectus* (Landau et al., 2017) and *Tapinoma magnum* (pers. observ.), and two non-native ant species with invasive potential, *Plagiolepis pygmaea* and *Tetramorium meridionale* (Schär and Dimitrova, 2020). All of them are associated with plant and soil movements.

A new law on plant protection became effective in Switzerland on January 1, 2020. It states that each imported live plant has to have a plant passport. This passport shows the latin name of the plant, the registration number, the retraceability code, and the land of origin. The passport certifies that the plant material sold meets the phytosanitary requirements and is subject to regular inspections. This covers the professional trade with live plants. The Federal Customs Administration and Plant Health authorities estimate that there are 60 t of plants and plant products imported per year by tourists at Zurich airport, mainly as souvenirs (Federal Customs Administration, 2019). The risk of travelers inadvertently bringing termites or ants in the soil of potted plants in their own car from their holidays in the Mediterranean area seems to be high. The year 2020 was launched by the Food and Agriculture Organization of the United Nations as the UN's international year of plant health. In this context, the Swiss authorities plan to increase the awareness of travelers on this issue through several information campaigns. This might also be helpful to reduce the unintentional introduction of subterranean termite and ant species.

CONCLUSIONS

The results of the 2019 survey indicate that this first established *R. grassei* infestation in north-eastern Switzerland is small and an eradication might be possible. The monitoring will have to be continued for several more years as the example of *R. grassei* in Saunton, UK, shows, where, after a cease in termite activity in 2000 after two years of baiting and a supposed successful eradication in 2004 (Verkerk and Bravery, 2004), termite activity resumed in 2009 (Evans et al., 2013). Of course, this could also have been a new introduction as the phylogenetic analysis of some termite specimens suggested the introduction of more than one maternal lineage, which can result from multiple or one single introduction of several colonies together (Jenkins et al. 2001).

Mediterranean plants are very popular in Switzerland and local temperature and precipitation do not seem to be limiting factors for the establishment of subterranean termites in the Swiss plateau, especially around the lakes and in the south of Switzerland. Therefore, it seems that we will have to expect and be prepared for more cases of subterranean termites in the future.

Pest management professionals are a very important factor in the detection of invasive urban pests. Therefore, communication with the authorities and continuous training and information on invasive species is important, so that they report unusual discoveries before taking action.

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