CHAPTER 1

INTRODUCTION

1.1 Statement and Significance of the Problem

The importance of trees in urban areas is well-founded as they serve society by improving the urban environment. Public goods like air quality, balanced microclimate, noise reduction, ornamental aspects, reduced rainwater runoff, biodiversity and human wellbeing aspects are encouraged and improved by trees (MCPHERSON *et al*., 2002). Recreational opportunities provided by trees in urban areas play an important role due to unhealthy business environments most people face in inner-city situations. The stress of city life can be counteracted by regular visits of green areas with diverse nature (e.g., GRAHN and STIGSDOTTER, 2003) and (HARTIG *et al*.,1996).

Even social aspects may be dramatically influenced in a positive way by green areas in cities. Evidence suggests, that urban poverty is more common to areas lacking trees and green spots than areas with green spaces (KWEON *et al*. 1998).

All the different and often very specific intentions for keeping green in urban areas are branched into private ownership which describes mainly the settings of home gardens, and the communal ownership of trees and green areas like parks, alleys and dispersed street trees, which are managed by the urban administration.

The owner of a subject like a tree is not only responsible for its initial selection, planting and occasional trimming, but also for all consequences of damage to property or even injury to human beings.

Therefore tree-owners are responsible to take preventive action in order to avoid possible damage or harm to others or property. This includes all kinds of arborist work from pruning to felling as well as preventive action in consequence of infestation of pathogens and pest organisms.

Sentences condemning tree-owners raised their awareness and search for improved tree management practices. Eminently in cases were insect pests or plant diseases endanger human health condition, contemporary and strict action is required.

For the sake of health protection, preventive actions are required already at low pest infestation levels. Assuring the beneficial aspects of trees in urban areas and to avoid indemnification are the two main reasons for private tree-owners and responsible bodies, like urban administrations, to constantly keep a close eye on their trees and their pathogens (MORTIMER and KANE, 2003).

On the other hand, there is an immense cost factor burdening the public budget providing these services. Management practices therefore need to be effective in terms of their mode of actions as well as in their economical sense.

Management practices attending public green areas need also to be sensitive about public interests and sentiments. Ignoring these may lead to expressed disagreement or even massive opposition, and as final outcome, may cost the public body even more than a more sensitive alternative would have cost.

This may apply to intentions which change the state of rare species of plants and animals known to be present at specific locations, well accepted recreation areas, or even the use of certain substances for plant protection in those areas.

To reduce public health risks caused by an insect may be a good and well accepted intention, which may find opposition if done in an offensive manner, for example by using controversially discussed chemicals. Applying these chemicals onto the leaf surface throughout the whole tree canopy may be a suitable method of controlling a certain pest, but the needed auto-lift may extend the costs to unacceptable levels. These brief examples describe the complexity of questions to be dealt with, before a management practice, which is not only suitable against the pest or disease and cost effective, but also sensitive to the public opinion and sentiment, can be installed and recommended for general use.

In this regard, this research makes its contribution to discuss an alternative management practice, which is both, cost effective as well as suitable against the pest, while considering public perception and interest.

1.2 General Concept

Deciduous trees in urban areas are often seriously damaged by herbivorous insects. The main damage may occur on the tree, but a threat to human health may directly come from the pest, as it is with the Oak processionary moth (OPM) (*Thaumetopoea processionea* L.).

In general, the insect damage occurs predominantly on the leaves, which serve them as their food source. The kind of damage already hints toward the pest species, since each pest species is characterized through a specific feeding habit on its host. This may be a specific leaf mine, leaf blister, free feeding, hole feeding, window feeding, skeletonized leaf feeding, leaf rolling, leaf galls and others.

Usually trees compensate such feeding activity quite well, depending on their vitality and general living-conditions. Only in cases of repeated mass outbreaks and total foliage loss, trees may get seriously damaged or killed. The development of the insect through the different stages from oviposition to adult insects is the general reason for this feeding activity. Dependent on the insect development stages, its habit, occurrence and threat, different types of abatement strategies have been developed.

The research of this work focused on:

- the herbivorous insects Oak processionary moth (OPM) (*Thaumetopoea processionea* L.) on oak trees (*Quercus robur* L.)
- the Horse chestnut leafminer (HCL) (*Cameraria ohridella* DESCHKA & DIMIC) on Horse chestnut trees (*Aesculus hippocastanum* L.)

- the Sycamore lace bug (SLB) (*Corythucha ciliata* Say) on Sycamore trees (*Platanus* x *hispanica* MUENCHH.).

Whereas the Sycamore lace bug and the Horse chestnut leafminer constitute a pest that may only irritate and displease people due to their mass occurrences, the Oak processionary moth in contrast, which has the capacity to severely harm human beings through their poisonous hairs causing skin irritations and in worse cases allergic reactions poises a real threat to human health. Therefore pest control measures are necessary.

As an alternative to full tree application of insecticides (synthetical insecticides or *Bacillus thuringiensis* (Bt)), stem applications of systemically functioning natural insecticides were conducted. In earlier pilot tests, the natural insecticide NeemAzal T/S (*a.i*. azadirachtin, a tetranortriterpenoid of the Indian Neem tree, *Azadirachta indica* A. Juss.) has been proven to show systemic effects after stem injection (PAVELA and KALINKIN, 2010). Since the injection method damages and destabilizes the tree in the long run, this research scrutinized the option of spot stem application of NeemAzal T/S in detail.

Azadirachtin and Neem raw extracts are known to have a repellent, feeding deterrent and lethal effect on insect larvae when exposed to treated food; (UNAL and AKKUZU, 2009). Several Neem-based insecticides are registered for various purposes in pest control, such as Colorado potato beetle, several lepidopterous pests as well as sap-feeding herbivores (HOUGH-GOLDSTEIN and KEIL, 1991).

Azadirachtin has semiochemical properties, which derive from antifeedant activity against many insect species. Increased neural activity of chemoreceptors is correlated with antifeedant responses in Lepidoptera. Supplemented by insect growth regulatory (IGR) and sterility effects, it is manifested in growth and moulting abnormalities resulting from disruption of neurosecretory peptides. Even though the antifeedant effects may vary among different insect species, the IGR and sterility effects of Azadirachtin are more consistent. The combination of feeding deterrence, growth and moulting aberrations and reduced fecundity improves crop protection (A. J. MORDUE (LUNTZ), 1998).

This research tries to show the effectiveness of low-priced spot stem application of natural insecticide NeemAzal T/S which is more sensitive to public opinion in comparison to the high costs of full tree application and low public acceptance of chemical formulations used for pest control. The results of the research presented show the effectiveness of this alternative management practice and hopes to encourage its wider application.

1.3 Rationale and Hypothesis

Due to global warming the life conditions for thermophilous insects like the Oak processionary moth (OPM) (*T. processionea*) has enhanced in recent years. Their distribution area has also increased to the north and mass outbreaks are more commonly observed (NETHERER and SCHOPF, 2009). The poisonous hairs of the caterpillars, distributed through the wind, may even get into respiratory tracts where infections up to allergic shocks may endanger human health conditions.

The released poisonous hairs, left in the environment, stay active for several months. Especially in public greens like playgrounds, parks, sport fields, and also forest lots close to civilization the OPM represents a danger for mankind.

Discovering OPM in early stages, whole tree application with Bt formulations like Dipel, or insect growth regulators like Dimilin (*a.i*. Diflubenzuron) used to be very effective, but also expensive. Once the pest is established, effective methods of control are hand picking or burning of the nest, which are both very time consuming and even more costly practices to control OPM (AVTZIS, 1989).

Not because of endangering human health, but because of their damage to urban trees and their nasty mass occurrence, the Horse chestnut leafminer (HCL) (*C. ohridella*) and the Sycamore lace bug (SLB) (*C. ciliata*) need to be controlled as well.

In the past, the collection of all fallen leaves including the overwintering eggs of the next generation of HCL has proven to be the most effective and manageable method for controlling next year's pest population.

Learning about the insecticidal properties of Azadirachtin has led to new approaches in finding strategies for combating these severe pests. Since Neem products have been used successfully in organic farming and gardening for many years, their extended use of application is comprehensible (TAMM, 2002). To assure their successful use, the application in early development stage of the pest is crucial.

The insects will accumulate the substance through feeding on the leaves in young larvae stages. Consequences of Azadirachtin accumulation may be growth disruption, development disruption, sterilization of adult insects and repellent or deterrent effects (BOSTID, 1992).

The antifeedant mode of action of Azadirachtin and four synthetic analogues had been investigated. The findings displayed, that polyphagous as well as oligophagous insects are behaviourally responsive to Azadirachtin. Most responsive species are even capable of differentiating very small changes in parent molecules.

A concentration of 0.3% of NeemAzal showed a 98% mortality rate already after 4 days, and 100% mortality after 8 and 14 days when tested in laboratory trials on the allergenic forest pest Oak processionary moth (OPM) (*T. processionea*). Increased concentrations of 0.5% and 1.0% NeemAzal showed the same results (BREUER and DE LOOF, 2002).

Since Neem products are commonly used in agriculture and gardening, their validity for use in public greens is also expected to be viable. Main attributes for the use in public green areas are a fast mode of action, marginal residues and harmless for humans, animals and environment.

Concerning the hypothesis this research states to proof a systemic distribution of the biological insecticide NeemAzal T/S in the treated plants. The applied insecticide will also accumulate in the leaves of the trees, where the target herbivores with their diet will ingest the product. The accumulated product will have repellent, feeding deterrent and lethal effect on insect larvae and therefore decrease development of pest population. Reduced mine area and smaller head capsule of larva and pupa on treated plants compared to the control will show this effect. The conservation of beneficial organisms is also expected.

By proving the systemic distribution after stem application and its effectiveness to control herbivorous insects, this research will discuss possible options for this method to be considered as a low-cost and ecological sound management practice to serve as first release for wider applications in the future.

1.4 Objectives of Research

As described above, this research discusses an alternative management practice, which so far has not been applied publicly. The intentions to be cost effective, friendly to the environment, as well as suitable and effective against the pest, while considering public interest and sentiment are qualities considered in this trial.

The general research objective is the control of pest population through spot stem application, which verifies the systemic distribution of insecticide within the tree.

The assessment of effects of the insecticide NeemAzal-T/S to the target pests will also help to develop further uses of the product and management practices.

Different tree species with distinct terminal tissues through which the insecticide systemically distributes, will show different distribution schemes and amounts accumulated, and therefore identifies effective practices and further research fields.

1.5 Scope of Research

Oak (*Q. robur*), Sycamore (*P. x hispanica*) and Horse chestnut (*A. hippocastanum*) trees in different locations in Stuttgart, Germany are to be treated with NeemAzal-T/S by stem application.

Effects of application will be assessed regarding their pest species Oak processionary moth (OPM) (*T. processionea*), Horse chestnut leafminer (HCL) (*C. ohridella*) and Sycamore lace bug (SLB) (*C. ciliata*).

Primary parameters are:

- changes in pest infestation
- possible retarded development and growth of larvae
- side-effects on parasitoids and other beneficial organisms found in the field

The effects on Oaks were derived from seven treated and seven control trees in the "Schwieberdinger Straße" in north-western Stuttgart. Approximately one km in south-east direction, but still in "Schwieberdinger Straße" data from nine treated and five control trees of Sycamore were taken.

The map shown in Figure 1.1 indicates the locations of the Oak and Sycamore trees.

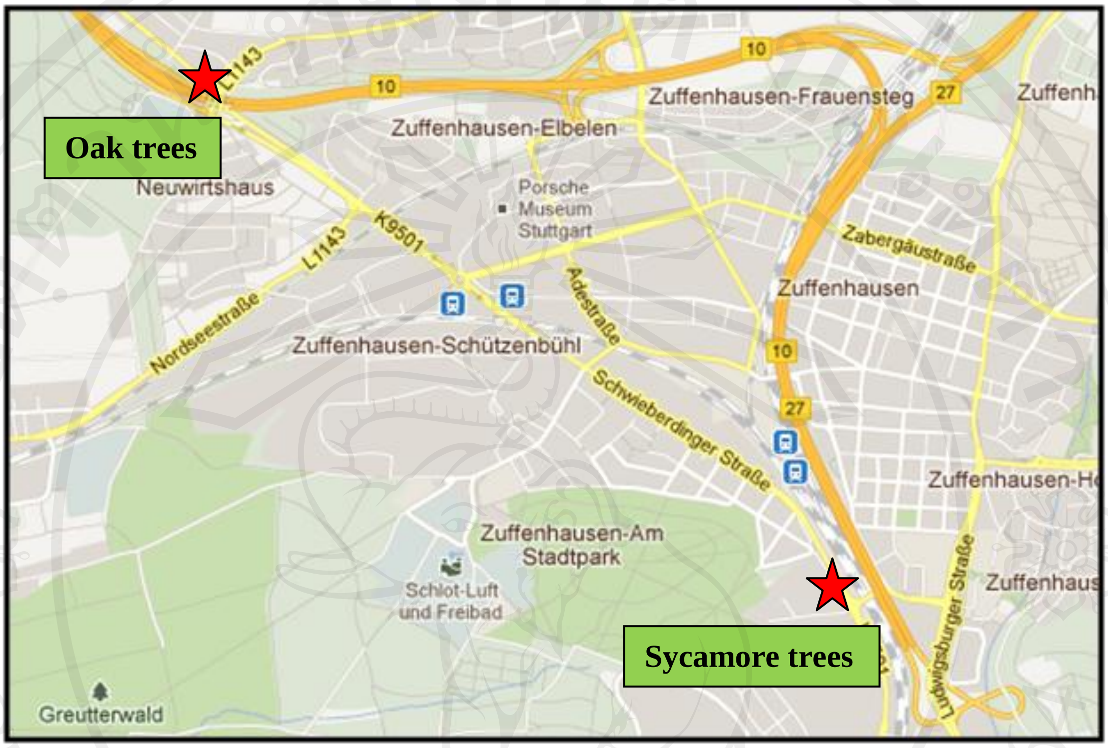

Figure 1.1: Location map of Oak and Sycamore trees in Stuttgart, Germany.

Data from Horse chestnut trees were derived from six treated and six control trees from "Haussmann Straße", close to the center of Stuttgart.

The map shown in Figure 1.2 indicates the location of the Horse chestnut trees.

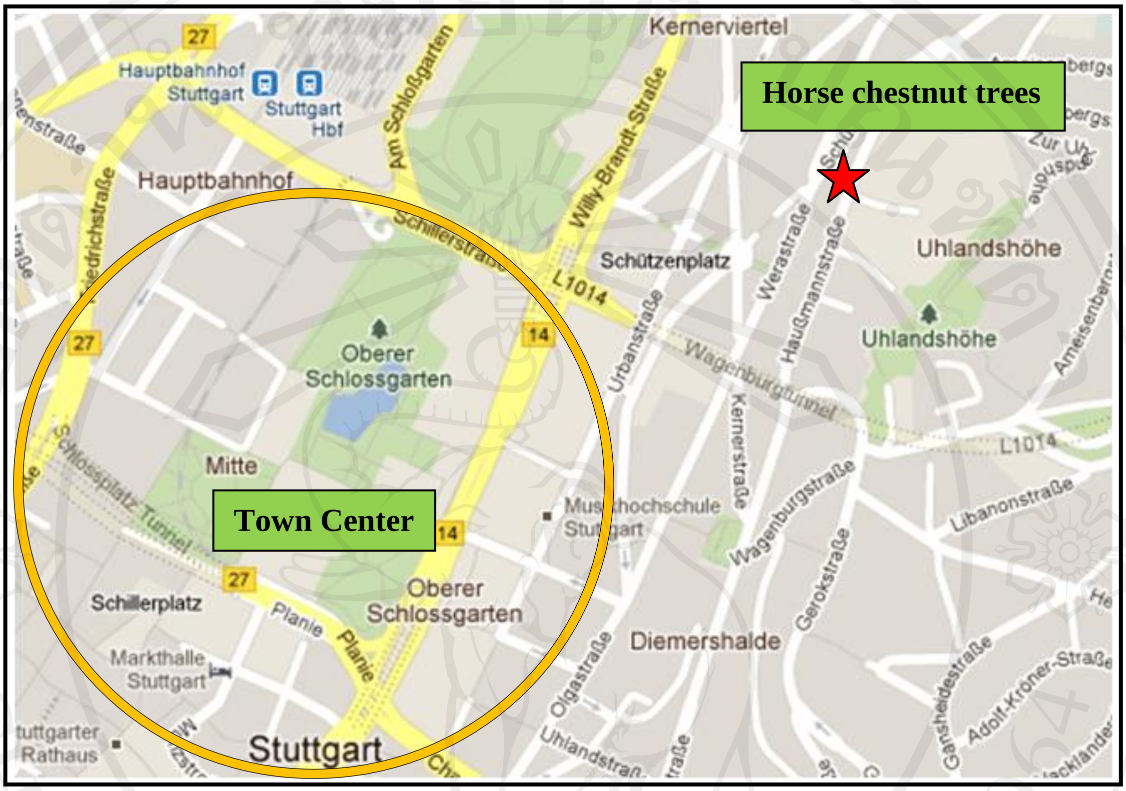

Figure 1.2: Location map of Horse chestnut trees in Stuttgart, Germany.

Analyses were conducted experimentally in the field and analytically in the lab. As scientific background for this research served a literature review including elaborations published in a time span from 1983 to 2011 and written either in English or in German.

This research was conducted in cooperation with the “Gartenbauamt Stuttgart” and the NeemAzal T/S producing company, Trifolio-M GmbH (Wetzlar, Germany). The university of Hohenheim / Germany and their institute for phytomedicine are involved as well as the university of Chiang Mai / Thailand.