CERTIFICACIÓN

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Quito, 11 de Mayo de 2015

PONTIFICIA UNIVERSIDAD CATÓLICA DEL ECUADOR

FACULTAD DE CIENCIAS EXACTAS Y NATURALES

ESCUELA DE CIENCIAS BIOLÓGICAS

A Test for Allelopathy of the Invasive *Cedrela odorata* L. (Meliaceae: Magnoliidae) in Galapagos

Trabajo de Titulación previo a la obtención del título de Licenciada en Ciencias Biológicas

MARÍA GLORIA RIVAS TORRES

Quito, 2015

Dedico este trabajo, prueba del esfuerzo hecho, a mis hijos: Matías y Nicolás, y; a Byron, porque son la razón para seguir luchando.

AGRADECIMIENTOS

Mi familia ha sido el pedestal que me ha sostenido en este tiempo. Les agradezco por el apoyo brindado durante la realización del estudio de campo y la fase de escritura, por su paciencia, acompañamiento y atención, en especial a mi hermano Gonzalo, porque de él aprendo a diario.

Al Lic. Álvaro Pérez por la paciencia, interés y ganas al leer este artículo.

A mis profesores y compañeros del departamento de Biología, que han sido un apoyo para poder culminar mi carrera.

Las instalaciones del Herbario de la Estación Charles Darwin se utilizaron gracias al gentil apoyo de la Dr. Patricia Jaramillo.

Es necesario mencionar de manera muy especial, a los Srs. Rafael Chango, Christian Sevilla, Danny Rueda, Wilson Cabrera, que hacen parte del staff técnico del Parque Nacional Galápagos, sin cuyo apoyo no hubiera sido posible realizar esta investigación. Adicionalmente, al personal y voluntarios del Parque Nacional Galápagos, quienes apoyaron con conocimientos, tiempo y la logística necesaria para trabajar.

A Senescyt, UF WEC (Wildlife Conservation Ecology) y TCD (tropical Conservation and Development Program) por proporcionar parte del financiamiento necesario para la realización del trabajo de campo.

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A test for Allelopathy of the Invasive *Cedrela odorata* L. (Meliaceae: Magnoliidae) in Galápagos

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ABSTRACT

Non-native plant species, especially in the Galapagos Islands, are considered to be one of the main threats to native organisms, ecosystems, human welfare and ecosystems worldwide. Following are the results of an experiment that was conducted to prove the potential inhibitory effects of the leaf and root extracts derived from the invasive *Cedrela odorata* L. (Meliaceae: Magnoliidae) tree on germination and growth of four native and four non-native species of the Galápagos archipelago. Experiments were set on the field using germination substrate for seeds, which along with seedlings of the eight species used for the experiment, were kept in the greenhouse of the Galápagos National Park (GNP). The effects of the extracts on germination and growth were compared against rainwater (control). Results showed that, although, overall the allelopathic influences were species specific for both germination and height patterns, individual species analysis revealed the extracts of *C. odorata* leaf and root caused a significantly negative effect on growth (height and dry weight) of the endemic *Scalesia pedunculata*, which is the main tree competitor of *C. odorata* in the Archipelago. These results may help to explain the dominance of *C. odorata* and the consequent exclusion of *S. pedunculata* in highly invaded area in Santa Cruz Island.

Keywords: Allelopathic effect, *Cedrela odorata*, invasive species, Galápagos, *Scalesia pedunculata*

INTRODUCTION

Non-native plant species are considered to be one of the main threats to native organisms, ecosystems, human welfare and ecosystems worldwide (Hejda *et al.* 2009). One of the most serious negative impacts of non-native (also known as introduced or exotic) plant species is their potential to spread fast and colonize recipient areas, becoming invasive and hence outcompeting native plants (*sensu* Richardson 2000). These capabilities can cause some colonized areas to be dominated by non-native and invasive species (Mascaro 2011).

The potential of certain plant species to produce chemical compounds that inhibit germination or growth of native species -known as allelopathy- has been proposed as one of the mechanisms that allows successful colonization by invasive species (Bais *et al*. 2003). Allelopathy mechanisms have been proven to inhibit the establishment of native plants ranging from herbs (Turk and Tawaha 2002) to tree species such as *Acacia pennatula* (Peguero *et al*. 2011). Relevant investigations have shown that the utilization of chemical weapons may not only favor the plant responsible for the chemical production, but also provide advantages to other introduced plants that can be positively affected by either the production of the compounds or the space availability, due to the absence of resident species excluded by the allelopathic substances (Callaway and Ridenour 2004).

In the Galápagos Islands invasive species are, nowadays, one of the main problems for native biota, and many of the unique forest of this archipelago are now dominated by invasive plants (Jaeger and Kowarik 2007). One of the newly formed forests dominated by non-native plants in Santa Cruz Island is the recently denominated *Cedrela odorata* (hereafter also called *Cedrela*) novel forest (Rivas *et al.* unpublished data). This forest is canopy-dominated by the tree *C. odorata* and is also recording a high richness and diversity of non-native plants (Rivas *et al.* unpub. data).

A recent study comparing a native forest against a patch of *Cedrela* novel forest in one of the inhabited islands of Galápagos, suggests the presence of *Cedrela* tree probably explains the higher non-native richness and diversity, currently recorded in this newly formed site (Rivas *et al.* unpub. data). This means that some facilitation mechanisms, i.e. some conditions that are altered by *Cedrela* and that are helping to non-native species outcompete natives, might be acting in this forest and may explain biotic differences of exotic plants in this site.

Investigations on other species of the family Meliaceae, including *Cedrela* have suggested that several taxa under this genus can produce a chemical compound (also known as cedrelanolide or a photogedunin), responsible of inhibiting germination and plant growth of other co-existing species (Cespedes *et al*. 2001, Isman 1997). Thus, it can be expected that the production of such chemical is also occurring in *C. odorata* and might be the mechanism directly or indirectly preventing native species establishment (and thus higher non-native dominance) in the areas were this invasive tree dominates.

However, no studies have analyzed if *Cedrela* has an allelopathic effect that can explain the impacts this tree has caused to the native flora of the Galapagos Islands. Therefore, the relevance of this study was to provide a hypothetical framework to elucidate if the presence of this invasive organism is facilitating the colonization and establishment of other non-native plants. In this contribution the results of an experimental study are presented including native and invasive species found in a *Cedrela* novel site, in order to test the allelopathic effect of *Cedrela*. Specifically the impact of leaf and root extracts of *C. odorata* were tested over germination and growth of native and invasive species in Santa Cruz. Additionally, soil chemistry analyses were performed of the samples irrigated with root and with leaf extract, to see if the composition of soils is somehow affected by these treatments.

MATERIALS AND METHODS

Study area.-The Galapagos Islands are and archipelago formed by a group of islands of volcanic origin, located around 1000 km west of the pacific coast of Ecuador (Figure 1). The directorate of the Galápagos National Park (GNP) is controlling and monitoring introduced plants into the protected area, which consists approximately 97% of the archipelago. Human settlements are located in the remaining 3% of the land that is also intended for agriculture and livestock (Figure 1). Native organisms living in Galápagos, as occurs in other oceanic islands, are being affected by the intentional or accidental introduction of foreign species. Updated studies on this issue reported that approximately 880 plant species have been introduced to the archipelago, which is almost twice the number of natives (Gardener *et al.* 2010). In 2011 around 15% of the introduced exotic species were categorized as invasive (Atkinson *et al.* 2011).

A considerable number of programs have been created to eradicate or at least contain these invasive species, given the number of detrimental impacts of some of these plants. In Galápagos the eradication programs of alien species have had mixed results (Gardener *et al.* 2010). For instance, the successful removal of feral cattle from degraded areas on San Cristobal Island, allowed previously contained guava *Psidium guajava* to grow rapidly into dense, extensive areas of shrubs (Zavaleta *et al*. 2001). Nevertheless the archipelago still has islands free of introduced species and ecosystems that exhibit acceptable conservation conditions (Gardener and Grenier 2011). On the other hand, inhabited areas in the archipelago that have been historically degraded due to anthropogenic activities, contain the majority of the recorded non-native and invasive species which are mostly occupying the wet highlands (from 250 m.a.s.l above) (Mauchamp and Atkinson 2010).

The highlands of Santa Cruz (the island with the highest human population) have been particularly impacted by invasive species and land clearing, due to the benign climatic conditions for agroforestry practices. This has resulted in around 86% of the original land cover to be radically transformed (Watson *et al.* 2010, Mauchamp and Atkinson 2010, Guézou *et al*. 2010).

Case study species.- *Cedrela odorata* (Meliaceae:Magnoliidae) is a shade tolerant tree that was introduced to Santa Cruz in the late 40's, for its timber value and is today, recorded in four islands: Santa Cruz, San Cristobal, Isabela and Floreana (Lundh 2006). Another report indicates that *Cedrela* was also planted in the mid 1960's to create a fence indicating the limit of the reserve area (deVries *com. pers*.). The largest population of *Cedrela* is recorded currently in Santa Cruz were it virtually dominates an area that extends to the "buffer zone" on the border of GNP (Figure 1). This area is now being denominated "*Cedrela* novel forest", because it shows a very dense canopy covering of this species and the forest floor has a “carpet” of its aborted leaves (G. Rivas *et al*. unpub. data). Previously, the site was composed by species from the lowlands and highlands, among which the endemic tree *Scalesia pedunculata* was dominating the native canopy (Itow 1995). To date, *Cedrela* forests cover about 28% of the historical range previously occupied by the native forest of Santa Cruz (Trueman *et al*. 2014).

In Galápagos, *Cedrela* can grow up to 30 meters tall and may have produced on average 40-50 wind-dispersed winged seeds per fruit (Cintron 1990). When this non-native tree fruits (December to March) during wet season, it generally sheds its leaves before the process begins, although some individuals lose their leaves in other seasons (G. Rivas *pers. obs*.). A recent study has found that plant composition of *Cedrela* forest is different from historical forests (Trueman *et al.* 2014) and is also different from other native forests that are dominated by the *Scalesia predunculata* tree (Rivas *et al.* unpub. data).

Other native and invasive species.- To test the allelopathic effect of *Cedrela* over other native and invasive plants seven species were included in the experimental study. Four native species namely *Scalesia pedunculata* Hook. F. (code name *S. pen*), *Psychotria rufipes* Hook. F. (*P. ruf*), *Psidium galapageium* Hook. F., (*P. gal*) and *Zanthoxylum fagara* L. Sarg. (*Z. fag*) were used as the indigenous taxa. Of these species, the first four are described as endemic for the Galápagos (Guézou *et al.* 2014). In addition, three invasive plants were included in the experiment: *Cestrum auriculatum* L’Hér., (code name *C. aur*), *Psidium guajava* L. (*P. gua*) and *Rubus niveus* Thunb., (*R. niv*). Code names are used in figures and tables. All these invasive species are recorded in the *Cedrela* forest and are known to cause pervasive effects over other native plants (Renteria and Buddenhaggen 2006).

Plant material collection.- Seeds from the eight different species were collected in July to December of 2012, and saved in refrigeration, to guarantee the seeds were not killed after preservation. Seedlings of the eight species were collected in the surrounding ecosystems (including the *Cedrela* novel forest) of Santa Cruz from July 2012 to February 2013 and transported immediately to the GNP greenhouse, where they were planted in a generic soil used in this facility and kept under the same climatic conditions. All plants were acclimated for a maximum of two months before starting the experiments.

Cedrela collection for extracts.- Mature leafs from branches attached to and aborted from adult individuals of *Cedrela*, located in the forest dominated by this tree, were collected early in the morning, before every time an extract was prepared to be used in the experiment. Also, roots from adult *Cedrela* individuals, in the same novel forest, were excavated and cut in small pieces of around 20 x 20 cm. As for leaves, roots were collected fresh for every new extract application.

Extract preparation: Collected *Cedrela* leaves and roots were transported to the greenhouse were the fresh material was infused into rain water recently collected at this facility.Specifically, leaves were broken into smaller pieces to occupy 1/3 of a 50 l plastic container. The rest of the container was filled with rainwater and left to rest for at least 3 hours. The same procedure, with the same quantities was applied for the collected *Cedrela* root material.

Experimental design.-A total of 24 plastic germination trays divided in 18 slots were filled with germination soil used at the greenhouse. In each of the slots of the plastic trays seeds of the treated plants were sowed (Table 1). Differences in seed numbers were due to the seeds size variation among the species. There were a total of 24 trays (three per species) that were randomly assigned to one of the three treatments: leaves extract, roots extract and control (rain water).

To test the potential effect of *Cedrela* roots and leaves chemicals over germination, a leaf extract was applied to 8 trays (one per species), containing the seeds that were planted before. This same scheme was applied to the 8 trays assigned for the roots infusion treatment. The remaining 8 trays were assigned for control, meaning that they were only irrigated with rain water. Treatments and control were applied on a weekly basis from May 15th to August 12th 2013. The experiment ended when all the species germinated and emergent seedlings were already providing shade to the non-germinated seeds.

To test the potential effect of *Cedrela* roots and leaves chemicals over seedlings growth, in the same greenhouse, but in separated benches, a total of 120 seedlings per species were located (except for *P. rufipes* which had only105 individuals due to lack of material) that were already planted and passed through acclimation in this facility. A total of 40 seedlings or one third of individuals per species were randomly assigned to receive the different *Cedrela* extract treatments. Infusions applied to seedlings were prepared exactly as described for the germination trials. Treatments for seedlings were applied the same days as for the germination trials. Even though all seeds and seedlings were under the same light and climatic conditions, seed trays and seedlings were moved every two weeks to ensure the results were not biased due to differences in any characteristic in the area designated inside the GNP greenhouse. This area was covered with transparent plastic to prevent precipitation from altering watering regimes.

Data collection .-Plastic trays containing the seeds of the target species were surveyed every week for a total of 12 weeks to record positive germination, the number of germinated seeds per treatment. Meanwhile, germination time was calculated as the number of weeks until germination for each species.

To evaluate if composition of soil is affected by *Cedrela* root and leaf extracts, a sample of soil was collected only for three species, namely *C. auriculatum, C. odorata* and *S. pedunculata*. These three species were chosen from the eight because: 1) Galápagos does not have a certified soil laboratory; therefore, transport of samples to the continent became very expensive. 2) One of the objectives of this study was to contrast these two invasive species against the endemic *S. pedunculata* tree competitor; and, 3) these three species showed in a preliminary analysis apparent significant variation among treatments. Soil analyses were performed to the entire germination tray per treatment for these three species, because laboratory methodology required at least half a kilo (500 gr.) of a mixed sample to run soil tests. This might have affected replication for posterior analyses.

On the other hand, to evaluate the potential allelopathic effect of *Cedrela* over seedling height (in cm from the base to the apex of each individual) of eight target plants height differences for each different treatment were recorded from May 15th to September 14th 2013. Additionally, after the seedling experiment ended, a subset of 30 individuals per species (10 per treatment) was randomly cropped from the original group of seedlings. Each individual of the subset was immediately dried and posteriorly weighted at the Charles Darwin Foundation herbarium facilities.

Data analyses.-To analyze treatments' effects over germination percentage and time, and seedling growth and dry weight, Mann-Whitney tests were performed (using JMP® software v.10.0, SAS Institute, US, 2012) for each of these parameters. This test was done for each plant species used in this investigation in order to understand the effects of treatment by each species. This non-parametric test was chosen after testing for data parameters such as distribution and homogeneity of variance In relation to soil samples, also, Mann-Whitney tests were used to analyze the physical (i.e. pH, organic matter, ion exchange, conductivity) and chemical (Ca, N, P, K, Mg, S) variables to each sample for the three different treatments.

RESULTS

Germination.- Overall, results showed that no effect of leaf and root infusions over germination percentage (Mann-Whitney: 0.28, p=0.86, S.error +-5.0) and seed germination time (Mann-Whitney: 1.41, p:0.49, S. error +-0.18). However, significant variations among the different species on both germination percentage (Mann-Whitney 21.08 p=0.003) and germination time were found (Mann-Whitney: 247 p=0.0001), independently of the applied treatment (Figure 3A). This means, germination percentages and time presented species specific variations. For instance, only two endemic species, namely *P. rufipes* (Mann-Whitney 21.0 p=0.0001 DF= 2) and *P. galapaguensis* (Mann-Whitney 36 p=0.0001 DF=2) were negatively affected by *Cedrela* extracts (Figure 2). Also, *S. pedunculata* and *C. odorata* germinated on average seven weeks earlier than species like *P. rufipes* and *Z. fagara* (Figure 3B).Additionally, species like *P. galapageium* and *C. odorata* presented germination percentages higher than 50% (independent of the treatment), while species like *S. pedunculata* and *Z. fagara* recorded less than 10% of germination (Figure 3A).

Growth.- Overall, results showed that invasive species grew more than their native counterparts (Mann-Whitney: 195, p=0.0001). Also, no effect of treatment over plant height was found (Mann-Whitney: 2.94, p=0.22, S.dev.=14.84, S. error +-0.48). However height of some species was affected distinctively by either the leaf (Mann-Whitney: 214.7, p= 0.0001) or root (Mann-Whitney: 155.9, p=0.0001) treatments (Figure 4). Among the affected plants, *S. pedunculata* growth, showed to be the only native species negatively affected (Mann-Whitney: 23.02, p=0.0001) in this parameter by the leaf and root treatments.

Dry weight.- As for plant growth, in general dry weight was not affected by the leaf and root treatments applied to the different seedlings (Mann-Whitney:1.08, p:0.58). However, when each species was analyzed individually, again the native plants *S. pedunculata* and one other resident species namely *P. rufipes*, showed significantly lower dry weights with the leaf and root treatments (Figure 4). For instance the dry weight of *S. pedunculata* was significantly lower for the individuals treated with root infusion (Mann-Whitney:4.00, p:0.04), while *P. rufipes* dry weight was significantly affected by both the root and the leaf extracts from *Cedrela* (Mann-Whitney:7.94, p:0.018) (Figure 5).

Physical and chemical soil analyses.- The analyses of soil samples for each treatment from the trays where *C. odorata, C. auriculatum* and *S.pedunculata* were planted, did not show significant differences among the physical and chemical characteristics (Table 2).

DISCUSSION

This study provided evidence of the allelopathic effect of an invasive tree in the Galapagos Islands. Specifically of how the leaf and root extracts of this tree may apparently affect growth of some native plant species that are important components of the resident ecosystems of this archipelago (Rivas *et al.* unpubl. data).

The fact that *Cedrela* extracts were not affecting germination percentage and time and, that these seed parameters - important for plant performance - were better explained by species differences, may also contribute to explain *Cedrela* novel forest plant composition. Invasive species such as *C. odorata*, *P. guajava* and *C. auriculatum* showed to have germinated in large amounts and relatively faster than most of the native species used in this experiment (Figure 3B). This means that invasive species, such as *Cedrela*, apart from having an advantage over native species due to allelopathic mechanisms, present seed traits that allow them to have an early competitive advantage over their resident counterparts. These advantages may help these invasive species in the long term, to outcompete and exclude native recruits from the *Cedrela* novel forest by having earlier access to available resources like light. Thus, allowing invasive species to dominate this site. Results obtained with this experiment, regarding the lack of allelopathic effects over seed germination of invasive species, differ from other studies in different plant species and habits. Sheng Z. (2007) studied the effect of *Eupatorium adenophorum* extracts over germination and seedling growth of 16 species of pasture. *E.adenophorum*. According to Sheng's results, extracts proved to have a retarding effect on germination vigor of most pastures, but few species showed inhibition in germination or death rate. Hence, this make us speculate that allelopathic mechanisms are species specific and need to be evaluated in a species by species basis and for different parameters related to seed germination traits. For instance, *S. pedunculata* presented a fast germination (Figure 2), similar to other invasive species, but had a very low germination rate in comparison with the exotic plants (Figure 3A). This pattern may contribute to explain the almost total absence of *S. pedunculata* trees in the *Cedrela* forest site, and how this endemic tree can be replaced by other exotic species that now dominate the canopy of invaded areas (Rivas *et al.* unpub. data). These findings may need to be validated by studies performed inside the own *Cedrela* forest, where this tree dominates, to evaluate if other important conditions for germination, such as water availability, or other abiotic factors are influencing seedling emergence. In addition, such experimental studies could also incorporate the mechanical extraction of *Cedrela*, to assess if the exclusion of this tree and the potential allelopathic effects it has over native species, disappears after the invasive tree is removed.

On the other hand, endemic species for these islands such as *S. pedunculata* and *P. rufipes* showed to have significantly less growth when exposed to *Cedrela* leaf and root extracts (Figure 5). This result, particularly regarding lower growth by *S. pedunculata* due to allelopathy, could have an important ecological implication when explaining the almost complete exclusion of *S. pedunculata* and the higher non-native richness and dominance recorded in the *Cedrela* novel forest (Rivas *et al.* unpub. data). This also could be interpreted as an additional factor to germination disadvantages. *S. pedunculata* and *P. rufipes* (both endemic) seedlings are also susceptible to chemical weapons produced by the dominant *Cedrela* tree, diminishing even more the probabilities of individuals of these indigenous plants to establish in novel areas. The fact that plant material extracts affect other species has been proven in other invasive plants, also providing additional evidence of the competitive advantage they represent for the invasive allelopathic organisms, and for other non-native species (Hierro and Callaway 2003; Sheng *et al*. 2007; Imatomi *et al.* 2015). Follow up studies are also needed regarding the novel *C. odorata* forest that contemplate how other important factors for seedling growth, such as water availability, are contributing to the competitive exclusion of species like *S. pedunculata* and other native species in this invaded site.

As mentioned, the exclusion of *S. pedunculata* from this novel forest has important implications that may explain the formation of a novel forest in the sites invaded by *Cedrela*. It also helps to elucidate why natural regeneration is apparently not occurring in this invaded forest. Under natural conditions *S. pedunculata* presents a die off mechanism where adults of the same or similar cohorts die in synchrony contributing to native regeneration and mainly aiding other *S. pedunculata* individuals to have the light necessary to re-colonize open areas (Itow 1995). This population mechanism is apparently now truncated due to the exclusion of *S. pedunculata* from the communities it used to dominate (such as the site where *Cedrela* now dominates) (Rivas *et al.* unpub. data), and the hypothetical advantages –including negative allelopathy- other invasive plants are having over this resident tree species.

This study did not find any apparent chemical and physical alteration of some important characteristics of the soils subjected to *Cedrela* extracts, that could explain the mechanisms involved in the negative effects of treatments over native species seedlings (Tablr 2). Relevant investigations analyzing allelopathic effects of other trees fromthe Meliaceae family and different herbs species, found that the compounds of the attacking organisms were mainly affecting the development of roots of the co-occurring resident plants (Lawan *et al.* 2011; Butcko and Jensen 2002). The particular alteration of roots characteristics were not analyzed by this study due to logistic constrains and will certainly need to be included in future related investigations. This may help explain the mechanisms that cause less growth of native seedlings. Results of this study will contribute to the knowledge regarding *Cedrela* allelopathic capacity and will mainly help to inform managers involved in restoration of invaded areas by this and other invasive species in this unique archipelago.

ACKNOWLEDGMENTS

Special thanks to Rafael Chango, Christian Sevilla, Danny Rueda, Wilson Cabrera for the logistic and technical support. I am also very grateful to Gonzalo Rivas and Luke Flory for help and discussions about data analyses, and Patricia Jaramillo for allowing me to use the FCD Herbarium facilities. Secretaría de Educación Superior, Ciencia, Tecnología e Innovación (Senescyt), the Tropical Conservation and Development Program-UF, and Wildlife Ecology and Conservation provided partial support for this study through scholarships provided to Gonzalo Rivas, as part of his doctoral dissertation project. This study was conducted under all regulation provided in the investigation permit No., PC-21-12 and regulated by GNP.

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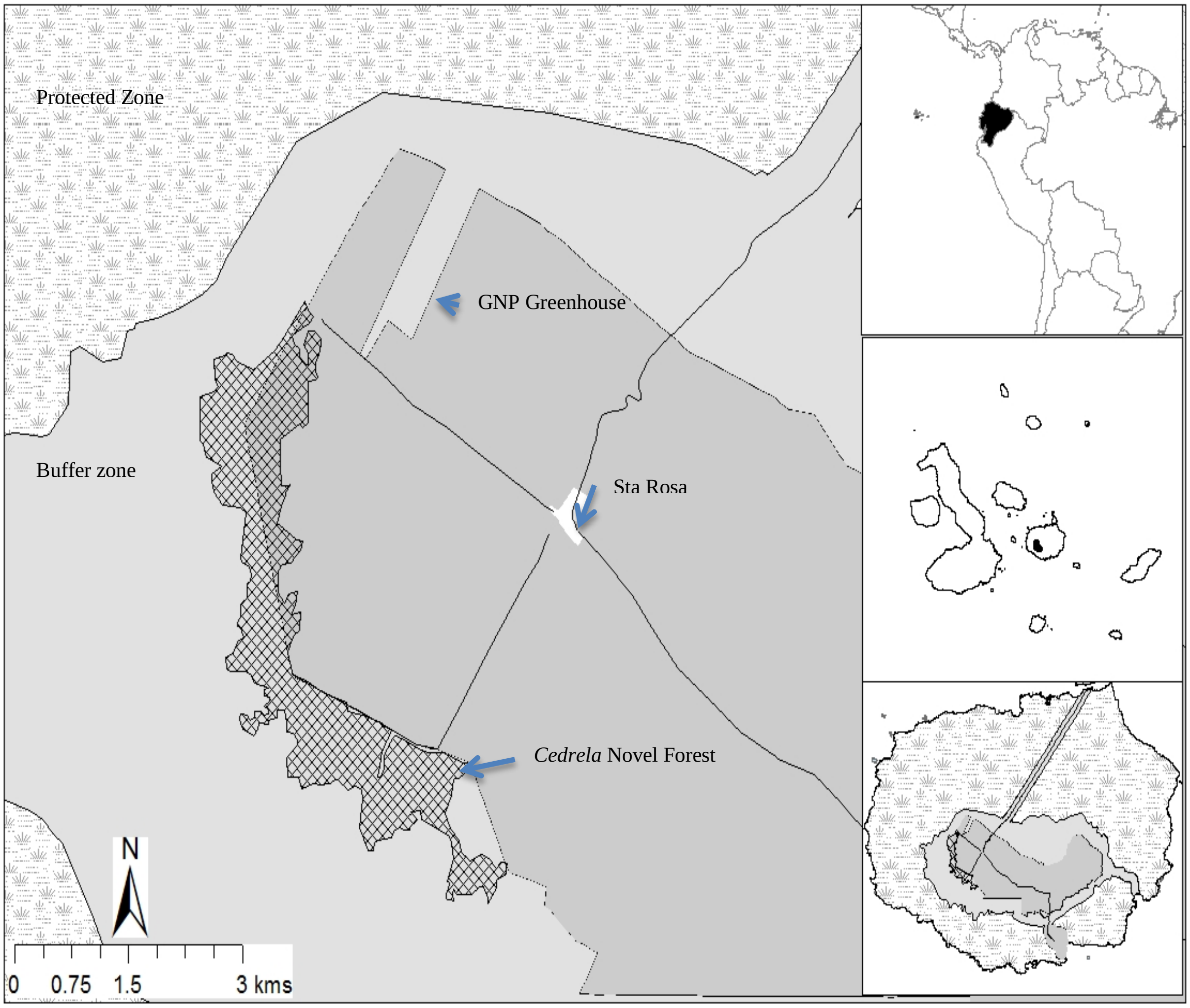

Figure 1. Map showing in the upper insert (right): the location of Galapagos in-front of the South American continent; and below: the location of Santa Cruz island within the archipelago. The map also shows the land uses distribution where Buffer and Protected zones are under preservation, while the Agricultural zone is under constant human pressures. *Cedrela* novel forest is located in the south-western portion of Santa Cruz and the GNP greenhouse is located just a few kilometers from this invaded site.

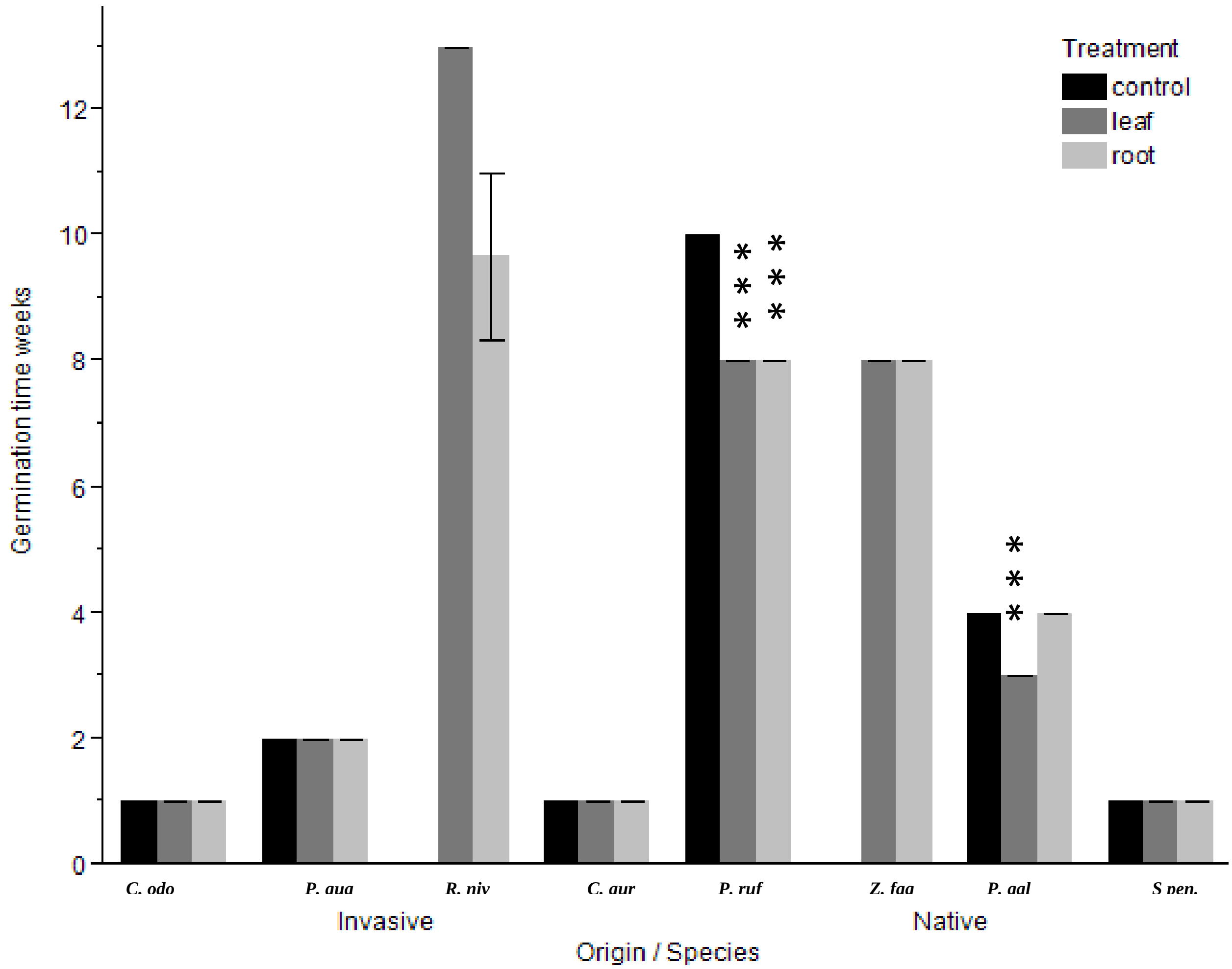

Figure 2. Graph showing the germination time in weeks per species according to their origin (invasive / native). The native *Psychotria rufipes* was negatively affected by both leaf and root extract when compared to control. Also a native plant species, namely *Psidium galapagensis* was affected by leaf extract. Statistical significance: one asterisk = marginally significant or $p < 0.05$; two asterisks = significant or $p < 0.01$; and three asterisks = highly significant or $p < 0.001$.

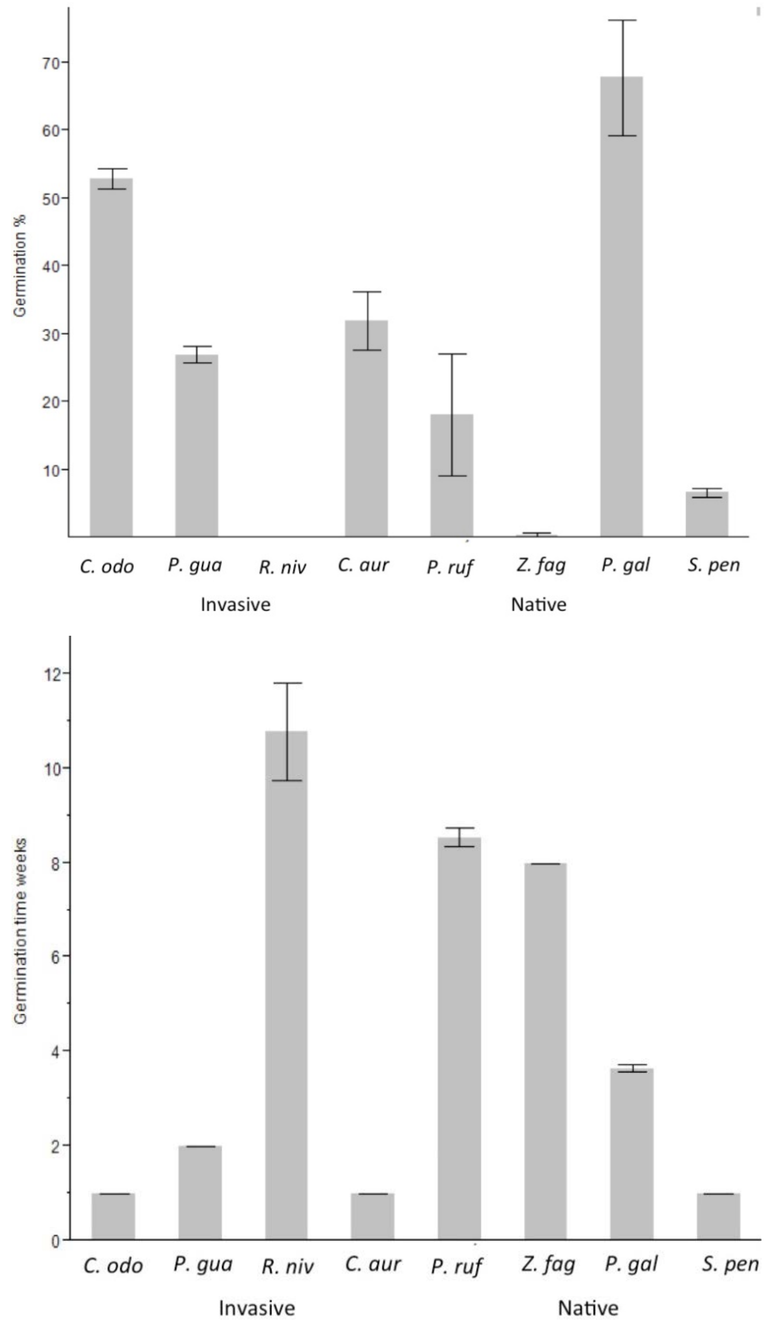

Figure 3. Graph showing: A. the germination percentages for each of the eight target species and; B. the average time of germination (in weeks) for the same eight plants. For the entire name codes please see the Materials and Methods section. Bars represent the standard error for the sample.

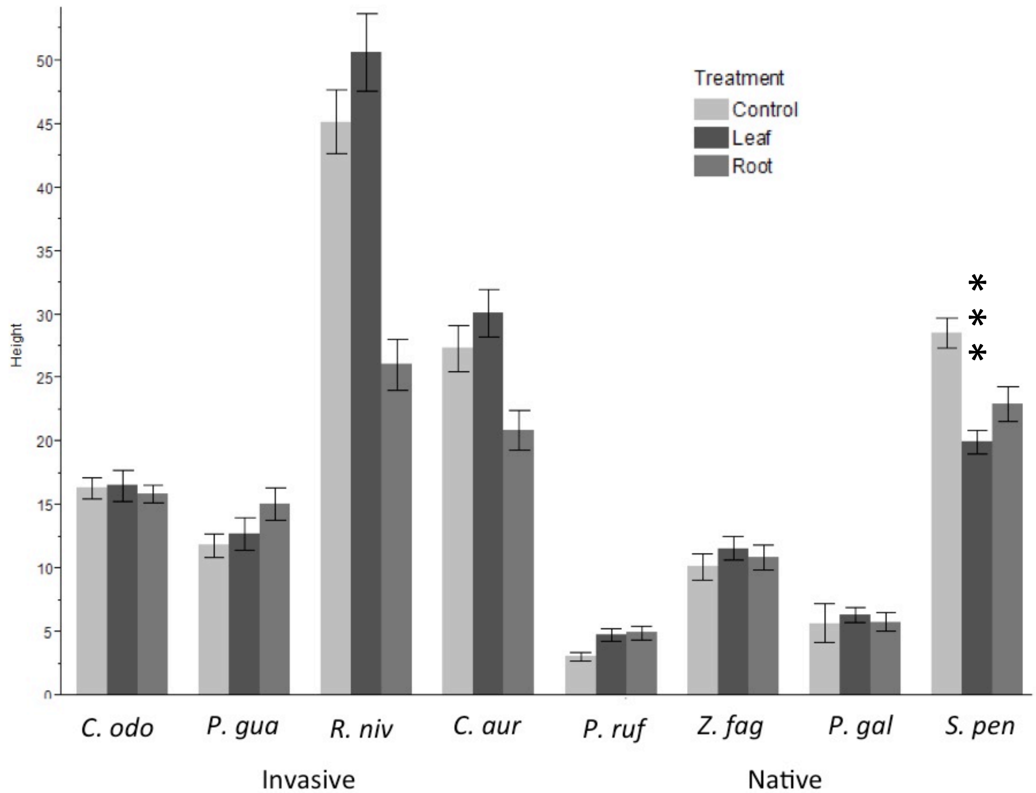

Figure 4. Average height (in centimeters) per treatment for the eight target species of this study. Note that among native species, only *Scalesia pedunculata* (S. pen) growth was negatively affected by the *Cedrela* extractions. For statistical significance (*) please refer to Figure 2.

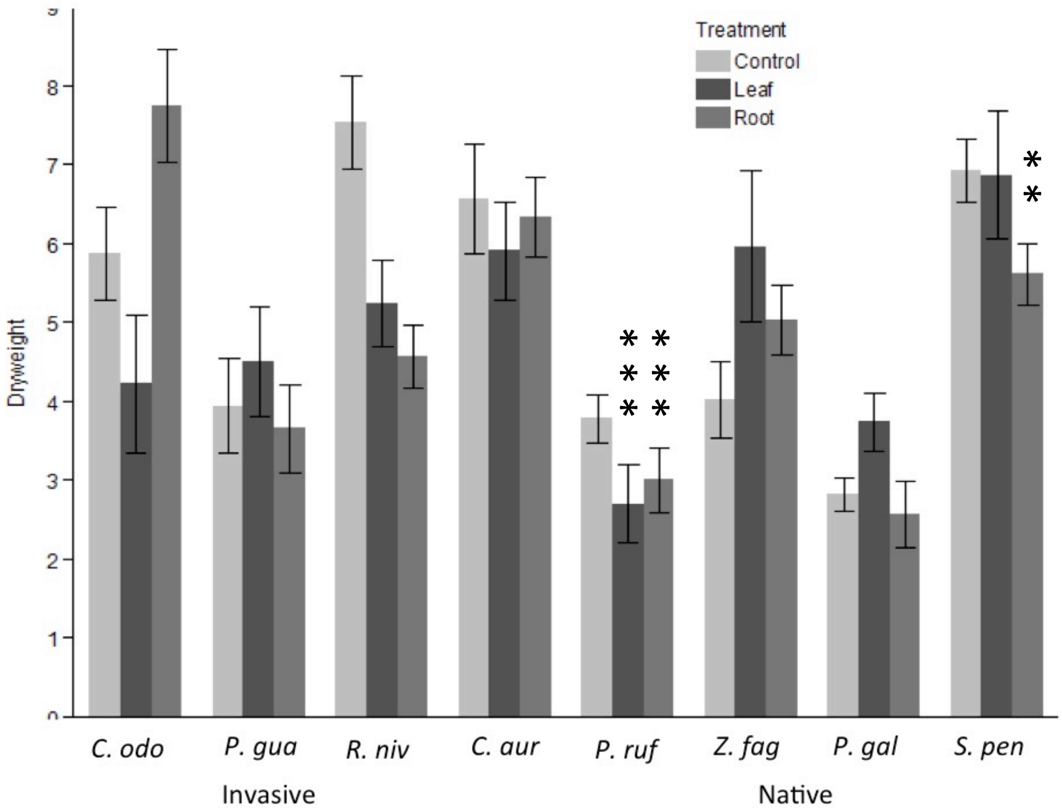

Figure 5. Average dry weight (in grams) per treatment for the eight target species of this study. Note that the natives *Psychotria rufipes* (P. ruf) and *Scalesia pedunculata* (S. pen) were the only resident species to be affected by the *Cedrela* extractions. For statistical significance (*) please refer to Figure 2.

Table 1. Detail of the number of seed sowed per species and treatment for the germination experiment

Species	No. of seeds/slot	Total No. of seeds/tray or treatment [1]	Number of trays/species*
Psidium galapageium	5	90	3
Psychotria rufipes	5	90	3
Zanthoxylum fagara	5	90	3
Cedrela odorata	5	90	3
Psidium guajava	15	270	3
Cestrum auriculatum	15	270	3
Rubus niveus	15	270	3
Scalesia pedunculata	25	450	3

*One tray was assigned to each treatment (1 tray for leaf extract, 1 tray for root extract, 1 tray for control)

[1] Considering each tray has 18 slots.

Table 2. Chemical and Physical values for the germination soil samples for three target species *Scalesia pedunculata, Cestrum auriculatum* and *Cedrela odorata* used in this investigation.

Species	*Origin*	*Treatment*	*Ph (NA)*	*Conductivity (dS/M)*	*Organic Matter (%)*	*Total Nitrogen (%)*	*Assimilable Phosphorus (ppm P)*	*Assimilable Potassium (meq K/100 mL)*	*Interchangable Calcium (meq Ca/100 mL)*	*Interchangeable Magnesium (meq Mg/100 mL)*	*Sulfur (ppm)*	*Ion exchange*	*Ca/Mg*	*Mg/K*	*Ca+Mg/K*
S. pen	Nat	leaf	6.51	0.24	65.9	3.29	22	2.05	63.73	21.05	0	85.2	3	10	41.4
C. aur	Inv	leaf	6.74	0.31	64.6	3.23	14.8	1.79	63.99	19.75	0	84.1	3.2	11	46.8
C. odo	Inv	leaf	6.74	0.25	66.58	3.33	17.5	2.56	58.65	26.21	0	85.4	2.1	10	33.1
S. pen	Nat	control	6.7	0.38	66.58	3.33	21.1	1.54	58.59	22.93	0	82	2.6	15	52.9
C. aur	Inv	control	6.75	0.26	56.6	2.82	25.1	1.28	62.81	14.4	0	77.7	4.4	11	60.3
C. odo	Inv	control	6.68	0.29	63.71	3.19	20.9	1.79	59.08	23.21	0	82.8	2.5	13	46
S. pen	Nat	root	6.51	0.35	66.41	3.32	22.3	2.05	62.35	18.94	0	81.8	3.3	9.2	39.7
C. aur	Inv	root	6.58	0.3	60.5	3.03	17.8	1.54	59.61	22.79	0	82.7	2.6	15	53.5
C. odo	Inv	root	6.71	0.28	65.19	3.21	26.1	1.54	58.12	20.91	0	79.4	2.8	14	51.3

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