# The multidimensionality of the plant

## *An art and ecophysiology approach to the comprehension of Amazonian tree seedlings (English-Galician edition)*

Autoras
Antía Iglesias Fernández
Marion Boisseaux

**Monografías**
Serie humanidades e ciencias xurídico-sociais

Antía Iglesias Fernández

Marion Boisseaux

Antía Iglesias Fernández (1997, Vigo, Spain) is a visual artist, designer and Phd student in the group Dx5 Digital and graphic art_ research, focus in the interconections between nature, art, design and science. Graduated in Fine Arts in 2019, specialized in graphic arts and printmaking. Master in Art Direction and Advertisment (2020) and Phd student in Creativity, Social Innnovation and Durability at the Universidade de Vigo, funded by Xunta de Galicia pre-doctoral contrats in 2021.

Marion Boisseaux (1995, Toulouse, France), is an horticulture and landscaping engineer. Graduted in Angers, France and specialized in Tropical ecosystem management in AgroParisTech, in Montpellier and Kourou. After her studies she worked for the ONF, French National Forest institute in Mayotte. From 2020, she's a Phd student in Tropical Ecology with the group EcoFog, Ecology of the tropical forest, in French Guiana, funded by University of Guyane, CNES (National French Center for Space Studies) and CTG (Territorial Collectivity of French Guyana).

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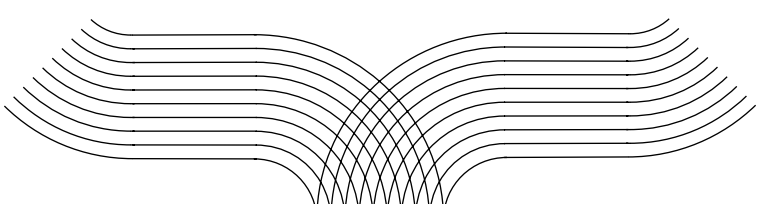

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‘The nexus of union is precisely the need to see, to put into images that which is perceived, measured, intuited and searched for with intensity and perseverance; either with the rigour of separation, of separating and sectioning in order to have a knowledge of the facts as little influenced as possible by interpretation. Or when this need to know becomes more ambiguous and is moved by experience, in the case of art, where from the particular, connections are established with the open, with the symbolic, where truth no longer depends on the methods of measurement but rather on mediation, the dealings between what provokes curiosity, passion and the obsession to know.’

Juan C. Meana, Eidos da imaxe. Grafías dos feitos e do pensamento, 2014 Museo MARCO Vigo.

“In science, the more different perspectives you have on the phenomena you’re studying, the richer the understanding becomes”

Catherine Murphy in Eldred, S. M. (2016, 31 agosto). Art&science collaborations: Change of perspective. Nature

Two doctoral students, Marion Boisseaux (tropical forest ecology) and Antía Iglesias Fernández (Arts & Design & Nature-interactions) developed during the months of September to December 2021 a collaboration that united art and science. The aim was to combine two different approaches in order to enhance our understanding of seven tropical tree species that were used to analyse the effects of drought in the Amazon rainforest by Marion's Phd project. We wanted to share the aesthetic and scientific experience by explaining the technical processes needed to produce both approaches, botanical illustrations and artistic image to complete the result data from the scientific research. By breaking down both of our working environments, we intended to better communicate with other academics but also to widen our audience on scientific concepts.

Dúas estudantes de doutoramento, Antía Iglesias Fernández (Belas Artes e interaccións Arte-natureza) e Marion Boisseaux (ecoloxía forestal tropical) desenvolveron durante os meses de setembro a decembro do 2021 unha colaboración que uniu arte e ciencia. A finalidade era combinar dúas aproximacións diferentes para realzar o nosa comprensión de sete brotes de árbores tropicais que son estudadas por Marion no seu Phd para analizar os efectos da sequía na selva amazónica. Queremos compartir a experiencia estética e científica para explicar os procesos técnicos necesarios para producir ambas aproximacións: ilustracións botánicas e imaxes artísticas que completen os resultados da investigación científica. Saíndo das nosas zonas de confort e os nosos ámbitos laborais habituais, pretendemos mellorar a comunicación multidisciplinar e divulgar a información científica, favorecendo a súa comprensión dende outros ámbitos.

“The aim of botanical illustration is to produce not only a picture that is pleasing to the eye but one which is botanically accurate, comprehensive and recognisable to species level. Such works broach the gap between art and science”.

Rosemary Wise - Botanical Illustrator, Oxford Botanical Garden

“I am interested in how nature printing images can be used and reinterpreted today as an image making medium in the artistic rather than the scientific field. I think it still has a lot of potential in education and can be a powerful tool in reconnecting people with nature.”

Pia Östulund - Freelance consultant for Oxford Botanical Garden

“However simple or sophisticated his drawing (the artist in plant science) was, it could only be of real service to science when botanists at large could study and use its information”

Bridson, G. D. R., & Wendel, D. E. (1986). Printmaking in the service of botany.

“The plant is to be evaluated as a thoroughly artistic-architectural structure. In addition to an ornamental-rhythmic creative primal instinct that prevails everywhere in nature, the plant only builds useful and functional forms. In its constant struggle for existence, it was forced to create resistant, vital and functional organs. It builds according to the same static laws that every master builder must observe. But the plant never lapses into merely sober practicality; it shapes and forms according to logic and expediency and forces everything with elemental force to the highest artistic form.”

Adam, H. C. (2008). Karl Blossfeldt: The Complete Published Work. Taschen America Llc.

# Our experience

*Antía Iglesias Fernández's voice*

The collaboration that took place between Marion and I was the result of an arduous task of weaving and chance, in equal parts. This social fabric was accompanied by a need for the interconnection of disciplines and promoted by a desire for communication.

This project started with Marion's suggestion of 'I would like to illustrate my project'. Personally, I consider that the limits between illustration and artistic representation and interpretation are blurred, but they exist. I do not consider myself an illustrator, rather a reality and irreality translator.

It is related with the chande, coincidence and possibility where I would like to frame this initiative, keeping a sensitive an poethical way, far from the pragmatism of science. It was also by chance that I arrive to the conclusion of that art and science chat with each other in the same reality and that it is in this dimension where creation make sense.

# A nosa experiencia

*A voz de Antía Iglesias Fernández*

A colaboración que se produxo entre Marion e mais eu foi o resultado dunha ardua tarefa de encaixe e azar, a partes iguais. Este tecido social foi acompañado por unha necesidade de interconexión de disciplinas e promovido por un desexo de comunicación.

O proxecto iniciouse por una suxerencia de Marion "gustaríame ilustrar o meu proxecto". Persoalmente, considero que os límites entre a ilustración e a representación e interpretación artística son difusos, pero existen. Non me considero unha ilustradora, senón unha tradutora da realidade e a irrealidade.

É en termos de azar, coincidencia e posibilidade nos que me gustaría enmarcar a iniciativa, mantendo unha compoñente sensíbel e poética, máis alá do pragmático da ciencia. De igual xeito azaroso, cheguei a comprensión de que a arte e a ciencia dialogan nunha mesma realidade e que é nesta dimensión onde as creacións teñen sentido.

# Our experience

*Marion Boisseaux's voice*

In fundamental research, there is usually a substantial amount of time before the development of direct applications.The journey is slow and unpredictable in terms of results. However, research addresses current challenges and society needs answers now. Climate change is one of the most urgent issues impacting everyone. As I explore the long corridors of ecophysiology and microbial ecology to determine the response of tropical seedlings to future droughts, I wanted to bring to light the scientific process in a way that was accessible to all.

Art is an extraordinary means to raise awareness. Art has the ability to draw attention and foster connections on an emotional level that science lacks. It was very rewarding to see Antía's interest in my project.

Our collaboration evolved along the way, becoming much more than just a means of communication but a real interdisciplinary dialogue.

# A nosa experiencia

*A voz de Marion Boisseaux*

Na investigación fundamental, adoita pasar moito tempo antes de que se desenvolvan aplicacións directas. O camiño é lento e imprevisible en canto aos resultados. Con todo, a investigación aborda os retos actuais e a sociedade necesita respostas xa. O cambio climático é un dos problemas máis urxentes que afectan a todo o mundo. Mentres exploro os longos corredores da ecofisioloxía e a ecoloxía microbiana para determinar a resposta das plántulas tropicais ás futuras secas, quixen sacar á luz o proceso científico dunha maneira accesible para todas as persoas.

A arte é un medio extraordinario para sensibilizar. A arte ten a capacidade de chamar a atención e fomentar conexións a un nivel emocional do que carece a ciencia. Foi moi gratificante ver o interese de Antía polo meu proxecto.

A nosa colaboración evolucionou ao longo do camiño, converténdose en moito máis ca un xeito de comunicación, senón nun verdadeiro diálogo interdisciplinario.

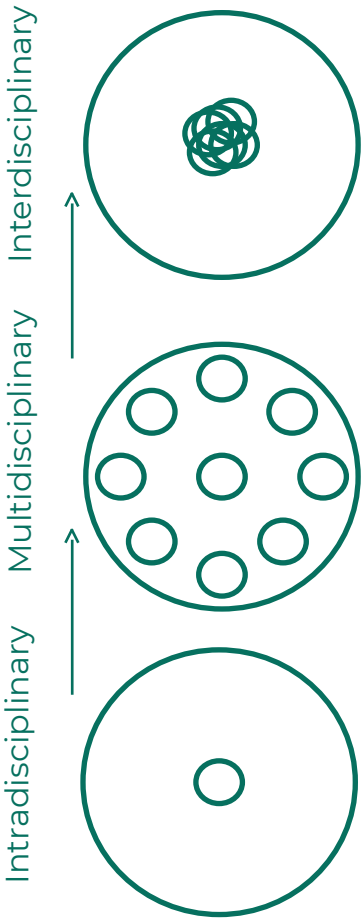
# Our Experience

*Our voices*

Art and science are movements whose waves do not usually coincide, but sometimes they do. In a subtle way, the communication began from an unknown environment (jungle), passed through a controlled environment (greenhouse), intermediate spaces (laboratory, office) to end up in an exhibition room and in the pages of a book; as well as in the images of a short documentary.

We started talking about illustrations, drawings of the different tropical seedlings interpreted or questioned by my gaze. We went through the line, the stain and the color, in a journey that seemed to have no clear purpose. After a period of adecuation, options began to be greater. We were able to talk about biomimetic representation, reproduction of textures and natural elements through graphic resources, light interactions, volume conformations, conversations between data and image and intermediate steps, some passing through, some definitive.

Art formed an option for science and science an excuse for representation and questioning. Interacting and connecting by tense threads, we began to speak a language that, although different, was understandable. Multidisciplinarity is a sometimes confusing and an intense option, it is presented as the multiple and extensive knowledge of distant lands or islands. However, more than just exhibiting side by side our points of views from our respective disciplines, we searched for a combination, a link, bridges across our field of research. We started to build rowing canoes, boats and planes that we must take to move from one to another. The inhabitants of these islands must make an effort to understand each other, but coexistence and inter-existence are possible and wonderful.



# A nosa experiencia

*As nosas voces*

A arte e a ciencia son movementos cuxas ondas non adoitan coincidir, pero ás veces isto acontece. De forma sutil, a comunicación partiu dunha contorna descoñecida (a selva), pasou por unha contorna controlada (invernadoiro), espazos intermedios (laboratorio, oficina) para acabar nunha sala de exposicións e nas páxinas dun libro; así como nas imaxes dun vídeo-documental.

Empezamos a falar de ilustracións, debuxos dos especimes de Marion interpretados ou cuestionados pola nosa mirada. Pasamos pola liña, a mancha e a cor, nunha viaxe que parecía as veces confusa. Tras un período de adecuación ao medio, as opcións tornaron maiores. Puidemos falar da representación biomimética, da reprodución de texturas i elementos naturais a través de recursos gráficos, das interaccións lumínicas, das conformacións dos volumes, das conversacións entre datos e imaxe e das estacións intermedias, algunhas de paso, outras definitivas.

A arte foi unha opción para a ciencia e a ciencia unha escusa para a representación e o cuestionamento. Interactuando e conectando por fíos tensos, empezamos a falar unha linguaxe que, aínda que diferente, era comprensible.

A multidisciplinariedade é unha opción ás veces confusa e intensa, preséntase como o coñecemento múltiple i extenso de terras ou illas afastadas. Con todo, máis que expoñer conxuntamente os nosos puntos de vista desde as nosas respectivas disciplinas, buscamos unha combinación, un vínculo, unha ponte que comunique os nosos campos de investigación. Empezamos a construír canoas de remo, barcos e avións que debíamos coller para trasladarnos entre elas. Os habitantes destas illas debíamos facer un esforzo para entendernos, pero a coexistencia e a interexistencia eran posibles e marabillosas. A integración da metodoloxía de contornas illadas pretende crear un enfoque máis holístico e no noso caso camiñamos polo fío entre a intra , multi e interdisciplinariedade.

Figure 1: Graphic analysis and representation of de difference between Intra-multi and interdisciplinarity.

Figura 1: Análise e representación gráfica da diferenza entre intra-multi e interdisciplinariedade.

The integration of the methodology from isolated environments aims at creating a more holistic approach and in our case we walked along the edge between intra- multi- and inter-disciplinarity.

In research , there is always a dominant factor: the doubt. The doubt takes on different forms in each specific discipline. For the scientist, he/she questions facts and data repeatedly and reevaluates the hypotheses. For the artist, this doubt is like a shadow that stalks and questions every step he/she takes, fostering creativity and leading to unknown paths. It is only naive to think that science or art is linear. Our path is rocky with doubt as our companion, a powerful strength and not a vulnerability.

## On this occasion the doubt was very specific :

- How can the artist's vision not intervene in the exact reproduction of an element about which information is needed as concrete as possible?

This question branched off into many other paths such as: To what extent can the creative hand represent what it sees? Or where does what you see meet the reality of what is in front of you? Art can be said to be made up of a metalanguage, constantly changing. A language that uses its own weapons of creation to propose content and rarely answers. In order to deal with these questions, action was proposed as a reactive form. That is, create and interpret, instead of the reverse process.

- Can the rigorous framework of a greenhouse experiment still provide space for the artist's expression?

Artistic and scientific research and their respective methodologies are swampy terrain where the limits of the former are blurry compared to the crystal-clear ones of the latter. . Within its breadth and wide margin of action, each one tends to establish a structure and steps to follow in order to find their own path.

On this occasion the path was the internalisation or appropriation of the scientific method applied to the artistic process.

Na investigación, sempre hai un factor dominante: a dúbida. A dúbida adopta formas diferentes en cada disciplina. Para o científico, cuestiona repetidamente os feitos e os datos e reevalúa as hipóteses. Para o artista, esta dúbida é como unha sombra que axexa e cuestiona cada paso que dá, fomentando a creatividade e conducindo a camiños descoñecidos. É inxenuo pensar que a ciencia ou a arte son lineais. O noso camiño é rochoso coa incertidume como compañeira, unha forza poderosa e non unha vulnerabilidade.

## Nesta ocasión a dúbida era moi concreta :

- Como pode a visión do artista non intervir na reprodución exacta dun elemento sobre o que se necesita unha información o máis concreta posible?

Esta pregunta ramificouse en moitos outros camiños como: Ata que punto pode a man creadora representar o que ve? Cal é o punto de encontro entre o que vemos e a realidade que temos diante?

Pódese dicir que a arte componse dunha metalinguaxe sobre a que vira todo o tempo. Unha linguaxe que utiliza as súas propias armas de creación para propor contidos e raramente respostas. Para facer fronte a estas cuestións, propúxose a acción como forma reactiva. É dicir, crear e interpretar, en lugar do proceso inverso.

- Pode o marco rigoroso dun experimento nun invernadoiro seguir dando espazo á expresión artística?

A investigación en arte e na ciencia, e as súas respectivas metodoloxías, son terreos pantanosos nos que os límites da primeira son borrosos en comparación cos cristalinos da segunda. Dentro da súa complexidade e ampla marxe de acción, cada unha tende a establecer unha estrutura e uns pasos para seguir e atopar o seu propio camiño.

Nesta ocasión o camiño foi a interiorización ou apropiación do método científico aplicado ao proceso artístico.

# I. Linking research projects

As doctoral students, both authors are developing their respective projects, which make up the background on which the collaboration is based. In order to bring the reader closer to their trajectories, below you can find the summary of their individual research, as well as other related work in progress and lines of research.

Thesis project, tentative title:

**“Biomaterials from the Galician natural environment applied to the design, printing and manufacture of everyday objects. Fetishism in favour of the object as a link“**

Antía Iglesias Fernández

Nowadays it can be found an increasing social need of claiming the natural environment where we live. For this reason, this thesis project is part of the Xunta de Galicia’s predoctoral grants, in Spain. We will investigate vegetable fibres for its application in the design, printing and manufacturing. It seeks to obtain unique objects, elaborated through the experimentation with materials and matrices from the natural environment.

It intends to achieve a method for taking advantage of invasive species. The experimentation with the fibres extracted of these species will serve to generate sustainable and biodegradable surfaces, as well as bioinks to be used with manual graphic techniques, such as xylography and direct printing.

By keeping the idea of a sustainable circular economy, the graphic line, the inks and the matrixs, will have the same origin. The same raw material will be processed for the extraction of pigment, for the surface and as a source of inspiration for artistic development.

The unrolled processes will vindicate the use of manual techniques of crafts and graphic techniques taking advantage of technological innovation at the same time that claiming the recovery of traditional knowledge.

It looks for the reproduction of natural textures by laser cutting wood cut or raw material direct printing. These procedures will allow a biomimetic approach to the origin place. The research will keep the vegetable world in the central axis of the investigation, so much in the scientific field as in the artistic. The manufactured objects will put in sample environmental, cultural, emotional and social values.

# I. Vinculando proxectos

Como estudantes de doutoramento, ambas autoras están a desenvolver os seus respectivos proxectos, que constitúen a bagaxe na que se basea a colaboración. Coa fin de achegar á persoa lectora as súas traxectorias, a continuación pódese atopar o resumo das súas investigacións individuais, así como outros traballos en curso e liñas de investigación relacionadas.

Proxecto de tese doutoral, título provisional:

"**Biomateriales da contorna natural galega aplicados ao deseño, impresión e fabricación de obxectos cotiáns. O fetichismo a favor do obxecto como vínculo"**

Antía Iglesias Fernández

Na actualidade constátase unha crecente necesidade social de reivindicar a contorna natural na que vivimos. Por iso, este proxecto de tese atópase financiado polos contratos predoctorais da Xunta de Galicia, España. Investigaremos as fibras vexetais para a súa aplicación no deseño, impresión e manufacturación. Búscase obter obxectos únicos, elaborados a través da experimentación con materiais e matrices da contorna natural.

Preténdese conseguir un método de aproveitamento de especies invasoras. A experimentación coas fibras extraídas destas especies servirá para xerar superficies sostibles e biodegradables, así como biotintas para ser utilizadas con técnicas gráficas manuais, como a xilografía e a estampación directa.

Mantendo a idea dunha economía circular sostible, a liña gráfica, as tintas e as matrices, terán a mesma orixe. Procesarase a mesma materia prima para a extracción do pigmento, para a superficie e como fonte de inspiración para o desenvolvemento artístico.

Os procesos levados a cabo reivindicarán o uso das técnicas manuais da artesanía e as técnicas de gravado aproveitando a innovación tecnolóxica á vez que reivindicando a recuperación dos coñecementos tradicionais.

Búscase a reprodución de texturas naturais mediante o corte de madeira con láser ou a estampación directa directo de materias primas. Estes procedementos permitirán un achegamento biomimético ao lugar de orixe. A investigación manterá o mundo vexetal no eixo central, tanto no ámbito científico como no artístico. Os obxectos fabricados poñerán en mostra valores ambientais, culturais, emocionais e sociais.

**This research is linked to two research groups, one in the field of Fine arts Dx5 Digital and graphic art_research, and the other from Forestry engineering AF4.**

**SAT-BioBasin Water security and bioproducts from invasive species in hydrographic basins -** Project from AF4 Forestry engineering, Universidade de Vigo

Global climate changes appear to affect most of the world's water resources by altering natural ecosystem processes. These natural resources and their ecosystems are affected by anthropogenic impacts, such as vegetation disturbances, land use changes, eutrophication, the destruction of riparian vegetation (a natural filter) , habitat loss and fragmentation, the proliferation of invasive species, etc. All these impacts alter and highly damage the quality of the water and they are addressed in the SAT-BioBasin project. The main objective is to analyse the effects of climate change (CC) on Umia River basin (Galicia, NW Spain) as a pilot study area. The use of new technologies, which are already proving successful in other areas, reducing costs and resources, is of great interest to address this environmental problem. For this reason, the use of satellite and UAVs images is proposed for the characterization and diagnosis of the state of riparian forests and water quality. Finally, after analysing the main influences of CC on the basin water security, as well as some preventive measures, the possibility of carrying out corrective measures is proposed to carry out a comprehensive management of the hydrological basins. The elimination of invasive species will be proposed with the aim of reducing their impact. A complete management of the problem is proposed with the use of these species to obtain sustainable bioproducts. This closes the cycle, with the total reduction of waste, as well as increasing energy efficiency.

Currently, these aspects are not agreed, the general approach is focused on carrying out measures to reduce and prevent invasive species but without a comprehensive approach that optimises these residues. SAT-BioBasin supports the development of innovative computational approaches for water security based on a novel chain starting from better data into better model, better prediction and finally into better decision. In this sense, the project aims to enhance knowledge-based decision making for sustainable management of water resources.

**Este proxecto está vinculado a dous grupos de investigación, un no ámbito das Belas Artes Dx5 Investigación dixital e gráfica, e o outro desde a enxeñería forestal AF4.**

**SAT- BioBasin Seguridade hídrica e bioproductos de especies invasoras en concas hidrográficas -** Proxecto do AF4 Enxeñería forestal, Universidade de Vigo

Os cambios climáticos globais parecen afectar á maioría dos recursos hídricos do mundo ao alterar os procesos naturais dos ecosistemas. Estes recursos naturais e os seus ecosistemas vense afectados por impactos antropoxénicos, como as alteracións da vexetación, os cambios no uso do chan, a eutrofización, a destrución da vexetación ribeirega (un filtro natural), a perda e fragmentación do hábitat, a proliferación de especies invasoras, etc. Todos estes impactos alteran e prexudican enormemente a calidade da auga e abórdanse no proxecto SAT- BioBasin. O obxectivo principal é analizar os efectos do cambio climático (CC) na conca do río Umia (Galicia, noroeste de España) como área de estudo piloto. O uso de novas tecnoloxías, que xa están a demostrar o seu éxito noutros ámbitos, reducindo custos e recursos, é de gran interese para abordar este problema ambiental. Por iso, proponse o uso de imaxes de satélite e UAVs para a caracterización e diagnóstico do estado dos bosques de ribeira e da calidade da auga. Finalmente, tras analizar as principais influencias do CC na seguridade hídrica da conca, así como algunhas medidas preventivas, proponse a posibilidade de levar a cabo medidas correctoras para realizar unha xestión integral das concas hidrolóxicas. Propoñerase a eliminación das especies invasoras co obxectivo de reducir o seu impacto. Proponse unha xestión integral do problema co aproveitamento destas especies para a obtención de bioproductos sostibles. Desta forma péchase o ciclo, coa redución total dos residuos, ademais de aumentar a eficiencia enerxética.

Actualmente, estes aspectos non están consensuados, o enfoque xeral céntrase en levar a cabo medidas de redución e prevención de especies invasoras pero sen un enfoque integral que optimice estes residuos. SAT- BioBasin apoia o desenvolvemento de enfoques computacionais innovadores para a seguridade hídrica baseados nunha nova cadea que parte de mellores datos cara a un mellor modelo, unha mellor predición e, finalmente, unha mellor decisión. Neste sentido, o proxecto pretende mellorar a toma de decisións baseada no coñecemento para a xestión sostible dos recursos hídricos.

**Related research lines from the DX5 Digital and graphic art_research:**

The imprint of the immaterial. Relationship between the visible and the invisible.

Conceptual and philosophical reflection on the multiple works of art in the 21st century. Complexity and sustainability.

Macrocosm and microcosm. Relational systems.

Sustainability systems applied to contemporary art.

Application of new industrial technologies to contemporary art.

**Liñas de investigación do DX5 Digital and graphic art_research relacionadas:**

A pegada do inmaterial. Relación entre o visible e o invisible.

A obra de arte múltiple no s.XXI. Complexidade e sustentabilidade.

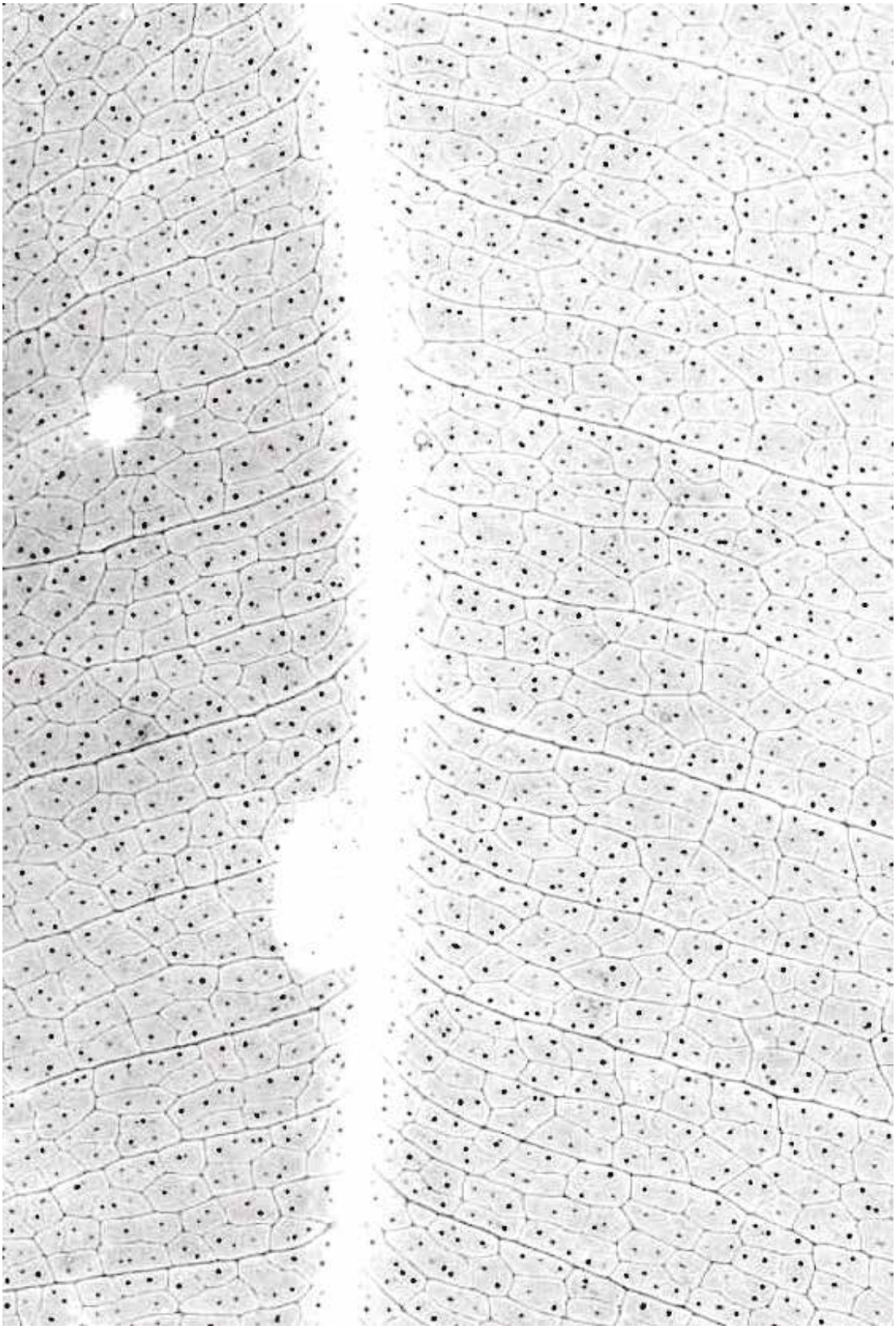
Macrocosmos e microcosmos. Sistemas relacionales.

Sistemas de sustentabilidade aplicados á arte contemporánea.

Novas tecnoloxías industriais á arte contemporánea.

Figure 2: Amplified and simplified image of the internal structure of the *Eperua falcata* leaf.

Figura 2: Imaxe aumentada e simplificada da estructura interna da folla da *Eperua falcata*.



Doctoral thesis project, title:

**“The relationships between species’ mechanistic traits and their distribution across contrasted habitats in the tropical forests of French Guiana in a context of climate change.”**

Marion Boisseaux

My PhD topic is to determine the response of tropical trees to future climates. To do so, I study within the context of the holobiont, an original approach combining tree ecophysiology and microbial ecology. On the one hand, I characterise the response strategies of tree species in contrasting environments using ecophysiological traits. This study will be conducted at the local scale, studying contrasting habitats, and the regional scale, along a precipitation gradient. On the other hand, I characterise the community composition and diversity of leaf and root associated microbiota using high throughput sequencing methods. Using field measurements combined with semi-controlled greenhouse experiments, I explore different drought scenarios to understand the resistance and resilience of tree species. Ultimately, the goal is to determine whether the microbiota associated with the phyllosphere and rhizosphere of tropical species are an additional means by which trees can improve their performance under future droughts.

**DRYER Drought Resilience of seasonallY floodEd Rest**

Carried out within the framework of Marion Boisseaux’s PhD thesis, the DRYER project funded by the Labex Ceba, provides significant insights into the life strategies of tropical trees. More frequent and intense drought events are being forecasted over the Amazon Basin. Previous work was mainly focused on terra firme forests, but few studies address the ecophysiological characteristics of seasonally flooded forests. Species within this habitat may be less susceptible to drought since the water table remains high and could become a refuge for species in the upcoming years. The project pays particular attention to the extent to which the microbial community contributes to tropical forest functioning, how tree-microbiome interactions will affect the resistance (ability to resist and maintain fitness) and the resilience (ability to recover) of plants in a changing environment. The scientific approach combines field sampling with a greenhouse experiment.

Proxecto de tese doutoral, título:

**“As relacións entre os trazos mecánicos das especies e a súa distribución en hábitats contrastados nos bosques tropicais da Guayana Francesa nun contexto de cambio climático”.**

Marion Boisseaux

O meu tema de doutoramento consiste en determinar a resposta das árbores tropicais aos climas futuros. Para iso, estudo no contexto do holobionte, un enfoque orixinal que combina a ecofisioloxía das árbores e a ecoloxía microbiana. Por unha banda, caracterizo as estratexias de resposta das especies arbóreas en contornas contrastadas mediante trazos ecofisiolóxicos. Este estudo realizarase a escala local, estudando os hábitats de contratación, e a escala rexional, ao longo dun gradiente de precipitación. Doutra banda, caracterizo a composición da comunidade e a diversidade da microbiota asociada a follas e raíces utilizando métodos de secuenciación de alto rendemento. Utilizando medicións de campo combinadas con experimentos semicontrolados en invernadoiro, exploro diferentes escenarios de seca para entender a resistencia e resiliencia das especies arbóreas. En última instancia, o obxectivo é determinar se a microbiota asociada á filosfera e á rizosfera das especies tropicais é un medio adicional polo que as árbores poden mellorar o seu rendemento en futuras secas.

**DRYER Resiliencia á seca dos restos estacionais asolagados**

Levado a cabo no marco da tese doutoral de Marion Boisseaux, o proxecto DRYER, financiado polo Labex Ceba, achega importantes coñecementos sobre as estratexias de vida das árbores tropicais. Prevense eventos de seca máis frecuentes e intensos na conca do Amazonas. Os traballos anteriores centrábanse principalmente nos bosques de terra firme, pero poucos estudos abordan as características ecofisiológicas dos bosques estacionalmente asolagados. As especies deste hábitat poden ser menos susceptibles á seca, xa que o nivel freático mantense alto e podería converterse nun refuxio para as especies nos próximos anos. O proxecto presta especial atención á medida en que a comunidade microbiana contribúe ao funcionamento dos bosques tropicais, a como as interaccións árbore-microbioma afectarán á resistencia (capacidade de resistir e manter a aptitude) e á resiliencia (capacidade de recuperación) das plantas nunha contorna cambiante. O enfoque científico combina a mostraxe de campo cun experimento en invernadoiro.

“Transdisciplinarity thus becomes the product of a dialogic vision of interconnected processes where different forms of knowledge contaminate, merge, influence and hybridise with each other, projecting a fertile irregular tapestry where art, as a form of social construction of reality that connects with collective imaginaries, becomes resonant, transforming itself into displacements beyond the forms that have traditionally organised it and venturing into hybrid landscapes, new territories yet to be codified under the label of that which is “new” that shapes our conscious experience.”

Alsina, P. (2007). Arte, ciencia y tecnología (spanish edition). Editorial UOC.
Translated from spanish.

# II. Introduction

Art and science are often defined in opposition to each other: one could involve the creation of 'aesthetic objects', and the other the gathering of facts to promote general laws of nature. Throughout history, art and science have reflected common values, appealing to the same concepts, methods and materials. (Eliane Strosberg). Nevertheless, both nurture the ideas of objectivity and method through a creative process.

Our collaboration emerged from the idea that art and science contribute to the understanding of the same object, but from different perspectives. Our aim is to show that objectivity and creativity are part of both an artist's and a scientist's method in the analysis of the same surrounding environment.

In trait-based ecology science, we measure what we call a 'trait', a characteristic of an individual (Violle et al 2007) such as the shape of a bird's beak, the size of a seed, the chemical composition of the leaf, the midday hydraulic potential of a plant. Today, they are databases full of these measured traits in the hope of explaining biodiversity patterns and responses to environmental changes. Given the multi-dimensionality of the forest, measuring different traits can hopefully help us characterise the 'niche' of the species. The niche concept was defined in 1957 by Hutchinson as the volume, in the space of environmental variables, where the species can survive indefinitely (the fundamental niche),

Two different species cannot occupy the same niche and therefore is specific to each species. The niche concept has a central role in synthetic thinking in ecology as it is a visualisation of the ecological mechanisms taking place between the organism and its environment (Pocheville 2015).

The illustration is the graphic representation of the information from a reality. For this, the creator, artist, illustrator, designer... and endless other identities, use the visible or non-visible 'traits' to form the best, clearest or smartest idea of what is represented. For the final end of visualisation, self-expression and questioning, illustration and art provides us with the necessary tools to get closer and be able to feel the world's most contemporary and problematic issues, such as the climate crisis, from a smooth and comprehensive perspective, open to everybody.

Throughout the book, we appeal to the reader's logic and emotions as we invite him/her to embark on a journey of perceptions

# II. Introdución

A arte e a ciencia defínense a miúdo en oposición: unha pode implicar a creación de 'obxectos estéticos', e a outra a recompilación de feitos para promover leis xerais da natureza. Ao longo da historia, a arte e a ciencia reflectiron valores comúns, apelando aos mesmos cconceptos, métodos e materiais. (Eliane Strosberg). Con todo, ambas nutren as ideas de obxectividade e método a través dun proceso creativo.

A nosa colaboración xurdiu do plantexamento de que a arte e a ciencia contribúen á comprensión dun mesmo obxecto, pero desde perspectivas diferentes. O noso obxectivo é mostrar que a obxectividade e a creatividade forman parte do método tanto dun artista como dun científico na análise dunha mesma contorna.

Na ciencia da ecoloxía baseada en trazos, medimos os chamados "trazos", unha característica dun individuo (Violle et ao 2007) como pode ser a forma do pico dun paxaro, o tamaño dunha semente, a composición química dunha folla ou o potencial hidráulico dunha planta ao mediodía. Hoxe en día, hai bases de datos cheas destes trazos medidos coa esperanza de explicar os patróns de biodiversidade e as respostas aos cambios ambientais.

Dada a multidimensionalidade do bosque, é de esperar que a medición de diferentes trazos nos axude a caracterizar o "nicho" da especie. O concepto de nicho foi definido en 1957 por Hutchinson como o volume, no espazo das variables ambientais, onde a especie pode sobrevivir indefinidamente (o nicho fundamental). Dúas especies diferentes non poden ocupar o mesmo nicho e, por tanto, é específico de cada especie.

Este concepto ten un papel central no pensamento sintético en ecoloxía, xa que é unha visualización dos mecanismos ecolóxicos que teñen lugar entre o organismo e a súa contorna (Pocheville 2015).

A ilustración defínese como a representación gráfica da información dunha realidade. Para iso, o creador, artista, ilustrador, deseñador... e unha infinidade de identidades máis, utiliza os "trazos" visibles ou non visibles para formar a mellor, máis clara ou máis intelixente idea do representado. Para o fin último da visualización, autoexpresión e cuestionamento, a ilustración e a arte proporciónannos as ferramentas necesarias para achegarnos e poder sentir os temas máis contemporáneos e problemáticos do mundo, como a crise climática, dende unha perspectiva sinxela e comprensible, aberta a todos.

through this multidisciplinary approach and encourage climate change awareness.

Our collaboration had the purpose of visualising seven species at the seedling stage, representing the future of our forests. An interpretation intended for the general audience, botanical illustrations, the biomimetic textures and scientific graphs capture the different artistic methods used as well as the scientific-technical meaning behind them. It allows scientific subjects to be addressed with expertise through understandable content that is different from other scientific texts. The aim of our book is to become a mean to better communicate: offer art as an emotional bridge between science and people, and bringing a part of the tropical forest into the everyday life of the reader.

Ao longo do libro, apelamos á lóxica e ás emocións do lector e convidámolo a emprender unha viaxe de percepcións a través deste enfoque multidisciplinar e a fomentar a conciencia sobre o cambio climático.

A nosa colaboración tiña como obxectivo visualizar sete especies en fase de plántula, que representan o futuro dos nosos bosques. Unha interpretación destinada ao público en xeral, as ilustracións botánicas, as texturas biomiméticas e os gráficos científicos plasman os diferentes métodos artísticos utilizados, así como o significado científico-técnico que hai detrás deles. Permite abordar os temas científicos con pericia a través dun contido comprensible e diferente ao doutros textos científicos. O obxectivo do noso libro é ser un medio para comunicar mellor: propor a arte como ponte emocional entre a ciencia e a xente, e levar unha parte do bosque tropical á vida cotiá da persoa lectora.

# II.I Botanical illustration

A botanical illustration is defined as 'The accurate pictorial representation of plants and their distinctive features for a scientific purpose'. (Hickman et al., 2017).

The origins of botanical illustration were linked to the register of the medicinal properties of the species. It is in 8th century BC that the first clay tablet appears, in which 61 names of plants are listed, as a testimony for their existence. The first complete botanical texts are registered in China 5th BC. And it is only in India (4th BC) that the first book will be published with descriptions of herbs and medicinal plants, intended to medicine students. (Bridson & Wendel, 1986). In Occident, we have to wait for the 5th AD for Dioscorides's De Materia Medica where there are references to 600 plants, all illustrated by hand with its associated medicinal properties (Bridson & Wendel, 1986).

Another element of botanical illustration that needs to be mentioned is the herbarium. An herbarium is defined, in the introduction of 'The illustrated Herbal' by the authors Wilfrid Blunt & Sandra Raphael, 1979 as: 'a book containing names and descriptions of herbs or plants in general, with their properties and virtues'. According to the British Library, a herbarium 'is a book of plants in which their appearance, properties and how they are to be used for ointments and medicines are described'. In addition to graphic representations and texts of the plants, pages were often accompanied by samples of dried and properly treated specimens to aid their preservation and cataloguing. Illustration and dry samples of the plants played a key role in botanical research in order to document diversity of a particular geographic area, become a reference for future identification and a source of DNA; together this information facilitates our understanding of the evolution of plants and the processes by which new plant species arise.

It is not until the 16th century AD that we found the first botanical illustrations and paintings whose purpose was not the dissemination of scientific knowledge or cataloguing species; but the mere reproduction of the natural beauty of plants, flowers, trees or shrubs. These publications were named Florilegium, plural, Florilega whose origin is found in the Latin flos (flower) or flores (flowers) and legere (to gather ot to collect), its literal meaning being 'a collection of flowers' (Botanical art & artists definitions). The development and rise of botanical illustration is closely linked to the

## II.I Ilustración botánica

Unha ilustración botánica defínese como "A representación pictórica precisa das plantas e as súas características distintivas cun propósito científico". (Hickman et al., 2017).

A orixe da ilustración botánica estivo vinculada ao rexistro das propiedades medicinais das especies. É no século VIII a. C. cando aparece o primer rexistro, a primeira tablilla de arxila na que se enumeran 61 nomes de plantas, buscando deixar constancia da súa existencia. Os primeiros textos botánicos completos localízanse na China do século V a. C. e é na India do século IV a. C. cando se publica o primeiro libro completo, con descricións de herbas e plantas, destinado aos estudantes de mediciña. En Occidente debemos agardar ata o V d. C. co manuscrito De materia médica de Discórides; onde se atopan 600 plantas ilustradas a man xunto coas súas propiedades (Bridson & Wendel, 1986).

Outro elemento da ilustración botánica que hai que mencionar é o herbario. Un herbario é definido, na introdución de *The illustrated Herbal* polos autores Wilfrid Blunt & Sandra Raphael, 1979 como: "un libro que contén nomes e descricións de herbas ou plantas en xeral, coas súas propiedades e virtudes". Ademais das representacións gráficas e os textos das plantas, as páxinas adoitaban ir acompañadas de mostras de exemplares secos e debidamente tratados para facilitar a súa conservación e catalogación. Tanto a ilustración como as mostras secas das plantas desempeñan un papel crave na investigación botánica: para documentar a diversidade dunha zona xeográfica concreta, xerar referencias para futuras identificacións ou obter fontes de ADN. Todo en conxunto, facilita a nosa comprensión da evolución das plantas e os procesos polos que xorden novas especies vexetais.

Non foi ata o século XVI d. C. cando atopamos as primeiras ilustracións ou pinturas botánicas cuxa finalidade non era a difusión de coñecementos científicos nin a catalogación de especies, senón a mera reprodución da beleza natural das plantas, flores, árbores ou arbustos. Estas publicacións recibían o nome de *Florilegium*, en plural *Florilega* cuxo orixe se atopa no latín flos (flor ou flores) e legere (reunir ou recoller), sendo o seu significado literal "unha colección de flores" (Botanical art & artists). O desenvolvemento e o auxe da ilustración botánica están estreitamente ligados ao crecemento e mellora tecnolóxica das técnicas de impresión. De feito, topamos unha historia paralela que vai da man dás técnicas gráficas e á evolución da imprenta. Este tema non se tratará en profundidade nesta ocasión,

technological development of printing techniques. We find a parallel history to botanical illustration, which goes hand in hand with the history of graphic techniques, and the printing press. This theme will not be dealt with in depth on this occasion, but it is recommended to read *Printmaking in the service of botany* from Bridson, G. D. R. R., & Wendel, D. E. (1986). .

Botanical illustration has played an important role in history and in the knowledge of foreign lands and cultures. We considered to mention that the role played by the naturalists and botanists who travelled on the first expeditions to America, whose purpose was to be able to record everything that was new to Europe until then. It is equally necessary to emphasise that the story we know from the West about the development of naturalistic reproduction of the plant world does not offer the whole picture and we lack information We need to be aware of the colonial language applied to this fragmented history.

As reported in the *Draw Botanical*, in the article 'decolonizing botanical art' Many BIPOC (Black, Indigenous, and people of colour) possessed knowledge of many indigenous plants, including their variety of uses. Once shared with colonizers, the discovery was taken as their own, with little to no mention of the original experts who helped them. This inequality situation is remarkable due the role that botanical illustration plays as a record and memory of a territory, and how, from Europe, we have a biased view of the first images obtained of plants from the American continent as they were made by European travellers, naturalists, botanists and artists.

To conclude these general ideas of the history of botanical illustration and its collaboration with science, we must understand that at that time, these illustrations were considered 'tools' and their creators recognised for mastering these skills and techniques. This is not the intention of the images in this book. Far from wanting to demonstrate technical mastery or a capacity for exact reproduction, what the authors seek is through the art, propitiate the interpretation and communication of our environment, from the creator to the spectator.

We focus our effort towards the appreciation of plants and together, art and science go hand in hand in this task, to bring both domains closer to the public.

pero recoméndase a lectura de *Printmaking in service of botany*, *de* Bridson, G. D. R. R., & Wendel, D. E. (1986).

A ilustración botánica desempeñou un importante papel na historia e no coñecemento de terras e culturas estranxeiras. Consideramos mencionar o papel desempeñado polos naturalistas e botánicos que viaxaron nas primeiras expedicións a América, cuxo propósito era poder rexistrar todo o que era novo para Europa. É igualmente necesario subliñar que a historia que coñecemos dende Occidente sobre o desenvolvemento da reprodución naturalista do mundo vexetal, non ofrece o panorama completo e fáltanos información. Debemos ser conscientes da linguaxe colonial aplicada a esta historia fragmentada.

Como se informa en *Draw Botanical*, no artigo *Decolonizing botanical* art, moitos BIPOC (negros, indíxenas e persoas de cor) posuían coñecementos sobre plantas indíxenas, incluída a súa variedade de usos. Unha vez compartido este coñecemento cos colonizadores, o descubrimento era tomado como propio, sen apenas mencionar aos expertos orixinais que lles axudaron. Esta situación de desigualdade é notable polo papel que xoga a ilustración botánica como rexistro e memoria dun territorio, e como, dende Europa, temos unha visión nesgada das primeiras imaxes obtidas das plantas do continente americano xa que estas foron realizadas por viaxeiros, naturalistas, botánicos e artistas Europeos.

Para concluír coas ideas xerais sobre a ilustración botánica e a súa colaboración para/coa ciencia, debemos comprender que nese momento as ilustracións eran consideradas 'ferramentas' e os seus creadores foron recoñecidos pola súa maestría no dominio das técnicas. Non é esta a intención das imaxes recollidas neste libro. Lonxe de buscar demostrar a maestría técnica ou capacidade de reproducción exacta da realidade, o que as autoras buscamos é, a través da arte, propiciar a interpretación e a comunicación do noso medio ambiente, dende á persoa creadora ata a persoa espectadora.

Centramos o noso esforzo na apreciación das plantas e xuntas, arte e ciencia van da man nesta tarefa, buscando atraer ámbolos dous dominios perto do público.

“The question of whether scientific illustration and botanic illustration in particular should be considered an art form, has been discussed repeatedly. There is no easy answer to that question (...) However a botanist can evaluate the degree to which a plate reflects reality, not just in terms of the individual characteristics but regarding the overall look of a plant. (...) The botanical illustrator reaches this high level of communication, which might be recognized as an art form, by looking past the dilemma posed over and over to scientific illustrators: Do you serve Science or Art? Doubtless both must be served seamlessly. (...) The gold standard for evaluating botanical images is assessing how well the creator understood the plant scientifically and how ably the illustrator depicted it with an artist’s mind and hand”.

Leonardi, C., & Stagi, F. (2019). The Architecture of Trees. Princeton Architectural Press.

# III. Materials and methods

**Species and sampling strategy**

Seven tropical species were chosen in seasonally flooded habitats during the wet season of French Guiana. Seedlings were sampled at Paracou, a research station in French Guiana (5°18′N, 52°53′W) being an exceptionally rich natural tropical forest.

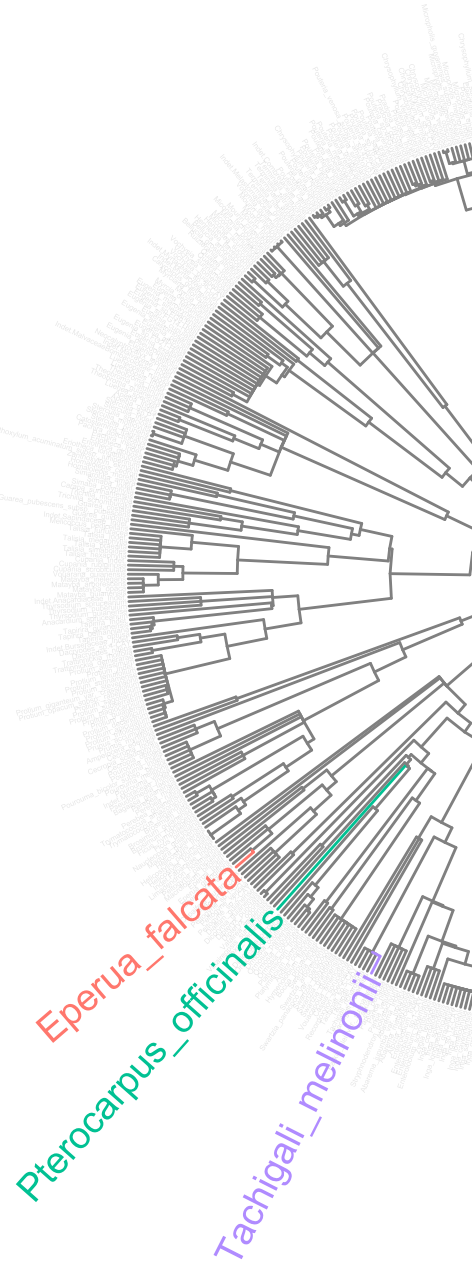
Figure 3. **The phylogenetic tree:** The position of the seven focal species in the French Guianese phylogeny.

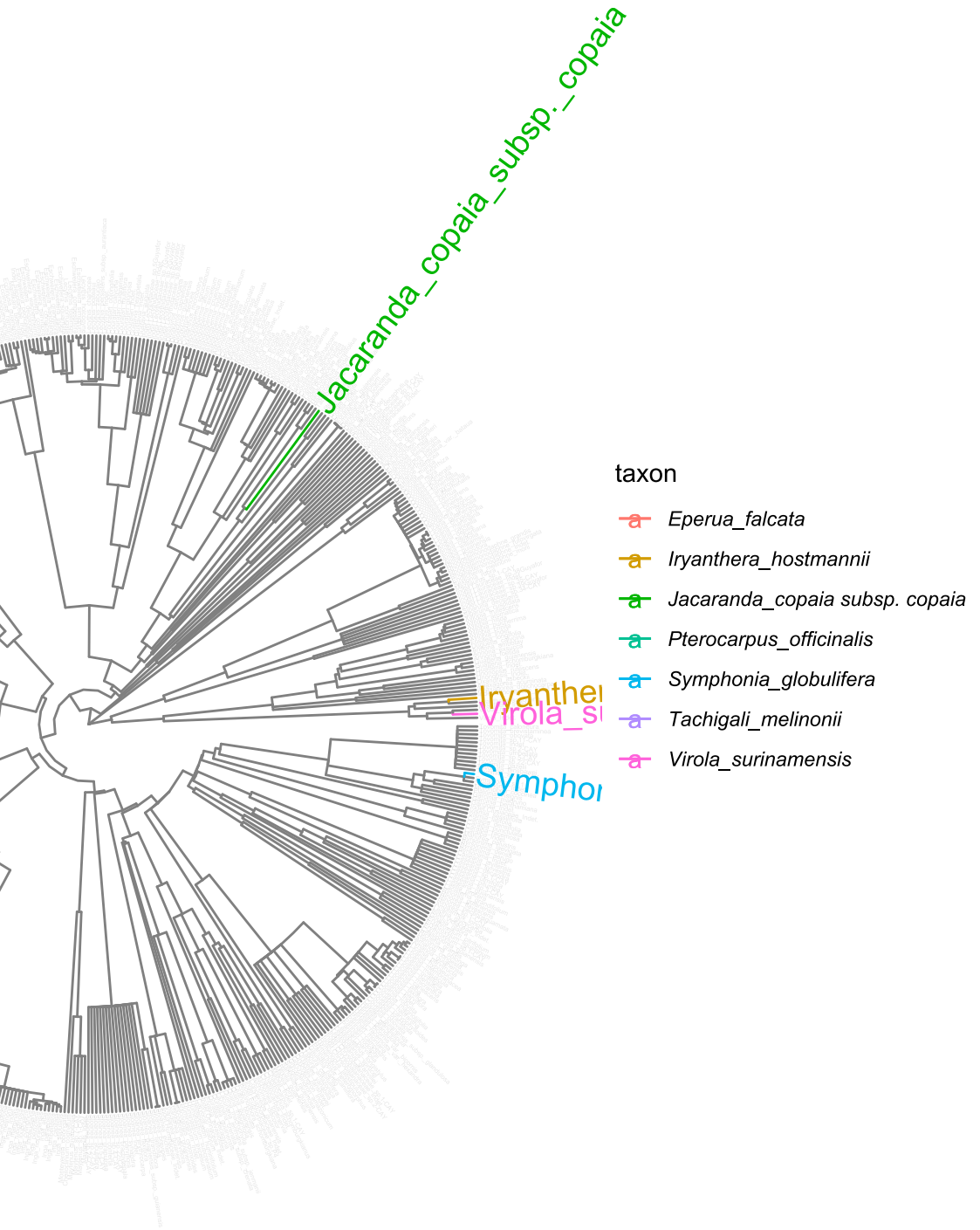
# III. Materiais e métodos

**Especies e estratexia de mostraxe**

Elixíronse sete especies tropicais en hábitats estacionalmente asolagados durante a estación húmida da Guayana Francesa. As plántulas mostreáronse en Paracou, unha estación de investigación na Guayana Francesa (5°18′ N, 52°53′ W) un bosque tropical natural excepcionalmente rico.

Figura 3. **A árbore filoxenética**: A posición das sete especies seleccionadas na filoxenia da Guayana Francesa.




Jacaranda_copaia_subsp._copaia
taxon
Eperua_falcata
Iryanthera_hostmannii
Jacaranda_copaia subsp. copaia
Pterocarpus_officinalis
Symphonia_globulifera
Tachigali_melinonii
Virola_surinamensis

## Greenhouse experiment

After collecting the seedlings, they were transplanted into pots filled with a mix of sandy substrate and forest soil. Seedlings were then placed into the greenhouse for the experiment according to a randomized block design. Part of the experiment was to see how the seedling resisted to drought. Drought was induced by completely withholding water. The annual mean number of consecutive days without rainfall in a dry season in French Guyana is 21 days. A decrease up to 30 % in precipitation trend is projected in the Amazon region by 2100 (IPCC 2014). The maximum number of consecutive days without rainfall recorded was 71 days in 1976. We exposed seedlings to the four following watering treatments:

**Well-watered (Control)**

**Water withheld during 21 days (D1)**

**Water withheld during 27 days (D2)**

**Water withheld during 71 days (D3)**

**Experimento en invernadoiro**

Despois de recoller as plántulas, trasplantáronse a macetas cheas dunha mestura de substrato areoso e de chan forestal. A continuación, colocáronse no invernadoiro para o experimento segundo un deseño de bloques aleatorios. Parte da experiencia consistía en ver como resistían as plántulas á seca. Esta induciuse mediante a supresión total da auga.

A media anual de días consecutivos sen precipitacións nunha estación seca na Guayana Francesa é de 21 días. Prevese unha diminución de ata o 30 % na tendencia das precipitacións na rexión amazónica para o ano 2100 ( IPCC 2014). O número máximo de días consecutivos sen precipitacións rexistrado foi de 71 días en 1976. Expuxemos as plántulas aos catro tratamentos de rega seguintes:

**Ben regadas (Control)**

**Retención de auga durante 21 días (D1)**

**Retención de auga durante 27 días (D2)**

**Non se rega durante 71 días (D3)**

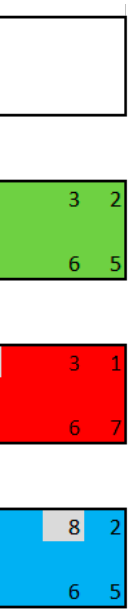



Figure 4: Top view of the **greenhouse experiment**. Each colour corresponds to a treatment : control (blue) ; green (D1) ; white (D2) ; red (D3). Numbers inside each block corresponds to one of the seventh species. **(1: *Eperua falcata* ; 2 : *Iryanthera hostmannii* ; 3 : *Jacaranda copaia subsp. copaia;* 4 : *Pterocarpus officinalis* ; 5 : *Symphonia globulifera* ; 6 : *Tachigali melinonii* ; 7 : *Virola surinamensis*).** The odd number of plants resulted in empty blocks (like n° 8).

Figura 4: Vista superior do **experimento en invernadoiro**. Cada cor corresponde a un tratamento: control (azul); verde (D1); branco (D2); vermello (D3). Os números dentro de cada bloque corresponden a unha das sete especies. **(1: *Eperua falcata* ; 2 : *Iryanthera hostmannii* ; 3 : *Jacaranda copaia subsp. copaia* ; 4 : *Pterocarpus officinalis* ; 5 : *Symphonia globulifera* ; 6 : *Tachigali melinonii* ; 7 : *Virola surinamensis*)** O número impar de plantas daba lugar a bloques baleiros (n° 8).

**Trait measurements**

Among several traits, all seedlings presented in this book were measured in height (cm) and diameter (mm) at the base of the stem, prior to and during the experiment to the nearest 0.5 cm, using respectively a tape measure and a calliper.

Measurements of the leaf area ($cm^2$) and major vein density were made on scans of whole leaves digitally scanned at 1600 dpi (Epson Perfection V800 Photo) and analysed with Image J software.

The leaf thickness was assessed using a hand-held micrometer (Mitutoyo Digital Micrometer Model 293-185, Kawasaki, Japan).

The chlorophyll fluorescence was measured using a portable chlorophyll fluorometer (Mini-PAM, WALZ, Effeltrich, Germany).

Once collected and oven dried for at least 48 hours, dry weights of the leaves, the roots and the stem were recorded using a high analytical precision balance (Sartorius Balance Entris BCE224-1S).

The root-to-shoot ratio was calculated as the ratio of belowground (root) to aboveground biomass (shoot).

The specific root length was obtained dividing the root length by the root mass. The root length was calculated using the WinRHIZO 2016 software.

**Drawing codes and techniques**

The first code corresponds to a verbal code based on the taxonomy of the plant.

For the second code, we worked from a **photography to a drawing**. To make the representation of this dimension we rely on a zenithal photograph (taken from the vertical axis perpendicular to the support), this proposes a certainly modified vision of the plant. In this way we observe how the young seedling manifests itself in a flat way, without force and out of the ground. Despite these drawbacks, we have access to the real proportion of the plant in terms of the relationship between roots, stem and leaves. By using a photograph, we have an indefinite access and can really analyse the forms of the plant, although conditioned by a frozen state.

**A gradient illustration allows us to work on the volume of the floor plan.**

The technique used to make these images is a graphite drawing, gradually controlling the pressure and thus allowing light and shadow to be controlled, as well as the perception of volume.

The **shaded drawing**, with a soft pencil, is one of the most classic or simple techniques that anyone can have access to. From the

**Medidas dos trazos**

De entre todos os seus trazos, ás plántulas presentadas neste libro medíuselles a altura (cm) e o diámetro (mm) na base do talo, antes e durante o experimento, cunha precisión de 0,5 cm, utilizando respectivamente unha cinta métrica e un calibrador.

As medicións da superficie da folla ($cm^2$) e da densidade das veas principais realizáronse sobre escaneos de follas enteiras, escaneadas dixitalmente a 1600 dpi ( Epson Perfection V800 Photo) e analizadas co software Image J.

O grosor das follas avaliouse cun micrómetro de man ( Mitutoyo Dixital Micrometer Model 293-185, Kawasaki, Xapón).

A fluorescencia da clorofila mediuse utilizando un fluorómetro de clorofila portátil ( Mini-PAM, WALZ, Effeltrich, Alemaña).

Unha vez recollidas e secadas no forno durante polo menos 48 horas, rexistráronse os pesos secos das follas, as raíces e o talo utilizando unha balanza de alta precisión analítica (Sartorius Balance Entris BCE224-1 S).

A relación raíz/talo calculouse como a relación entre a biomasa subterránea (raíz) e a superior (talo).

A lonxitude específica da raíz obtívose divdindo a loxintude entre a masa da raíz. A lonxitude foi calculada usando o software WinRHIZO 2016.

**Códigos e técnicas de debuxo**

O primeiro código correspóndese cun código verbal baseado na taxonomía da planta.

No segundo código traballamos o debuxo  a partir dunha **fotografía**. Para realizar a representación desta dimensión baseámonos nunha fotografía cenital (tomada desde o eixo vertical perpendicular ao soporte), isto propón unha visión certamente modificada da planta. Desta forma observamos como a xoven plántula manifféstase de forma plana, sen forza e fóra do chan. A pesar destes inconvintes, temos acceso á proporción real da planta en canto á relación entre raíces, talo e follas. Utilizando unha fotografía, un instante mantido no tempo, podemos analizar realmente as formas da planta, aínda que condicionadas por un estado conxelado.

**Unha ilustración en degradado permítenos traballar sobre o volume da planta.**

A técnica utilizada para realizar estas imaxes é o debuxo a grafito, controlando gradualmente a presión e permitindo así variar os claros e escuros, así como a percepción do volume.

O **debuxo sombreado,** cun lapis brando, é unha das técnicas máis clásicas ou

observation and control of the pressure, it is possible to replicate a fleeting reality, creating the illusion of light in the drawing.

**Calibrated markers** are associated with the practice of technical drawing, blueprints, architecture or precise illustration. For this reason, this technique brings us closer to a concrete result in which the lines have the predominance. Using a single mark on paper to reflect a complex structure is an act of specification and synthesis, forcing us to reduce information to its minimum expression in order to obtain maximum representation.

**Watercolour technique**: By using a colour technique we can try to understand the colour-dimension of the plant, and how it works within the light. This specific technique allows the artist to introduce light-shadows and to work over several layers that reminds of the density of the plant. Using two different brush sizes we could experiment with the stain and the line, the interior, its surroundings and contour. By the combination of several layers it is possible to go deeper into the colour and its measures of opacity, brightness and saturation.

**Laser-xylography:** it is presented as a possibility for biomimetical representation through printmaking techniques in collaboration with new technologies. By using a digital image, in (using the leaf scans used in the scientific part of the project), the image is the vectorized and adapted regarding the software used. The new vectorized image will then be used for the laser cutting machine. The result will be a wood matrix engraved by the laser which reproduces the vectorized image. We went from the actual leaf, to a digital image, and finally to a physical representation in 2D of the leaf on a wooden matrix. This idea to use a mechanical process for art creation enhances this scientific project with yet another artistic touch.

sinxelas ás que calquera pode acceder. A partir da observación e o control da presión, é posible replicar unha realidade fugaz.

Os **rotuladores calibrados** asócianse á práctica do debuxo técnico, os planos, a arquitectura ou a ilustración precisa. Por iso, esta técnica achéganos a un resultado concreto no que as liñas teñen o predominio. Utilizar unha soa marca sobre o papel para reflectir unha estrutura complexa é un acto de especificación e síntese, que nos obriga a reducir a información á súa mínima expresión para obter a máxima representación.

**Técnica da acuarela**: A técnica da acuarela permite comprender a dimensión cromática da planta e o seu funcionamento dentro da luz. Esta técnica específica permite ao artista introducir luces-sombras e traballar sobre varias capas que lembran a densidade da realidade vexetal. Ao traballala con dous tamaños de pinceis diferentes pódese experimentar coa mancha e a liña, o interior, a súa contorna e o contorno. Mediante a combinación de varias capas é posible profundar na cor e as súas medidas de opacidade, brillo e saturación.

**Xilografía-láser**: preséntase como unha posibilidade de representación biomimética mediante técnicas de gravado en colaboración coas novas tecnoloxías. Utilizouse unha imaxe dixital de partida, neste caso o rexistro científico de escaneos de follas, e seguíronse unha serie de pasos para adaptala á linguaxe da máquina e ao software. Conseguiuse obter unha matriz física, interpretada pola máquina de corte láser. Finalmente buscamos ter unha matriz de madeira cortada con calor que poida mostrar unha representación física da matriz intanxible (archivo dixital). Sendo este obxecto á vez impresión e matriz.

A idea do proceso de creación da máquina (automatización da creación) foi desenvolta posteriormente en diferentes proxectos, dando a esta investigación inicial outra representación artística.

# IV. Approach codes explanation

**Codes of approximation to a reality:** The plant designed through two disciplines, with tools and codes that dilute the limits between them. “The art that I call conceptual is so because it is based on an investigation into the nature of art”. A fundamental reference for our approach was the conceptual artist Joseph Kosuth who, with his work ‘One and three chairs’, delves into the codes of representation by making an approach to the chair through verbal, photographic and physical representation (definition, image and object).

Through two investigations, artistic and scientific, which intertwine and complement each other, we can faithfully approach the physical reality of the subject of study, the plant. Each of these codes, based on observation, highlights certain characteristics or essential features of the species. This generates the most accurate possible idea of the plant, highlighting its multidimensionality. Eight multidisciplinary definitions are presented here.

- **First code: verbal.** It reveals the species’ origin, evolution and taxonomic classification: domain, kingdom, phylum or division, class, order, family, genus, species. It is important that the plants are known and designated in a precise way, according to the rules of systematics.The classification and naming of organisms is an essential tool for scientific communication. It forms the foundation upon which biological research is based and the discipline is called “Taxonomy” (Sosef et al. 2020).

- **Second code: chiaroscuro** This code, based on a flat photographic image that allows us to observe the plant in its entirety, reworks the message by showing a representation where the volume of the species and the proportions between its parts are worked out. A clear outline of the shoot, which includes the total surface of the species, in a controlled contour.

- **Third code: linear.** The linear code allows, on a scale and with numerical figures by its side, to have a record of all the measurements of the specimen at a specific moment of its development. Stem length and width, anatomy of the leaves, leaf measurements... We can here relate to the root to shoot ratio a measure of the allocation of the plant’s resources. Plants with a higher proportion of roots can compete more effectively for soil nutrients, while those with a higher proportion of shoots can collect more light energy. From a tangible experience, the interrelation with the plant in a specific environment and situation allows us to approach a better and greater understanding of the

# IV. Explicación dos códigos de aproximación

**Códigos de aproximación a unha realidade**: A planta deseñada a través de dúas disciplinas, con ferramentas e códigos que dilúen os límites entre elas. Un referente fundamental para o noso plantexamento foi o artista conceptual Joseph Kosuth quen, coa súa obra 'One and three chairs' profundiza nos códigos de representación realizando un achegamento á silla a través da representación verbal, fotográfica e física (definición, imaxe e obxeto).

A través de dúas investigacións, a artística e a científica, que se entrelazan e complementan, podemos achegarnos fielmente á realidade física do obxecto de estudo, a planta. Cada un destes códigos, baseados na observación, pon de relevo determinadas características ou trazos esenciais da especie. Así se xera unha idea o máis precisa posible da planta, destacando a súa multidimensionalidade. Aquí preséntanse oito definicións multidisciplinares.

- **Primeiro código: verbal.** Revela a orixe, a evolución e a clasificación taxonómica da especie: dominio, reino, fío ou división, clase, orde, familia, xénero, especie. É importante que as plantas se coñezan e designen de forma precisa, segundo as regras da investigación sistemática. A clasificación e a denominación dos organismos é unha ferramenta esencial para a comunicación científica. Constitúe a base sobre a que se asenta a investigación biolóxica e esta disciplina denomínase " Taxonomía" ( Sosef et ao. 2020).

- **Segundo código: Claroscuro.** Este código, baseado nunha imaxe fotográfica plana que nos permite observar a planta ao completo, reelabora a mensaxe mostrando unha representación onde se traballa o volume da especie e as proporcións entre as súas partes. Un claro escuro do brote debuxado que inclúe a superficie total da especie, nunha contorna controlada.

- **Terceiro código: lineal.** O código lineal permite, sobre unha escala e con cifras numéricas ao seu lado, ter un rexistro de todas as medidas do exemplar nun momento concreto do seu desenvolvemento. A lonxitude e a anchura do talo, a anatomía e medidas das follas... Aquí podemos relacionar coa proporción entre raíces e brotes unha medida da asignación dos recursos da planta. As plantas cunha maior proporción de raíces poden competir máis eficazmente polos nutrientes do chan, mentres que as que teñen unha maior proporción de brotes poden recoller máis enerxía luminosa. Desde unha experiencia tanxible, a interrelación coa planta nunha contorna e situación concretos permítenos achegarnos a unha mellor e maior comprensión do

individual. From observation and analysis we can understand the shapes we want to represent and it is through precise and concrete lines that movements, anatomy and structures are reflected.

- **Fourth code: color.** It was used the aquarelle technique to capture the color and the incidence of light and shadows, without the use of line and contours. The color code, despite being filtered by the artist's eye, generates volume and three-dimensionality to the drawing. Accompanied by the respective data linked to chlorophyll, we can also understand the color dimension of the plant and its processes linked to light.

- **Fifth code: data.** A graphical and numerical approach to the species. The measurements were taken at different life moments of the plant, and reveal both the evolution of the plant and as well as its response to the environment over time.

- **Sixth code: lineal-roots.** This approach is an extension of the third code. We propose a linear representation of an isolated surface of the plant, the roots. By showing the roots of the plant and their dimensions, we are showing the hidden part of the plant, its support and the means by which water and nutrients are extracted. We pay a lot of attention to the finest root hairs, to the mycorrhizal roots (root-fungus associations) or to the nodules (root-bacteria associations).

- **Seventh code: imprints.** Faithful and direct representation of the leaf imprint of the species taken between two panes of glass and constant light on an Epson Perfection V800 scanner. This reveals the leaf's internal landscapes and venation structure. The design and function of leaf venation are important to plant performance (Sack and Scoffoni 2013).

- **Eighth code: photographic.** A faithful capture of the species in its environment at a given time. It provides an overview of the natural environment of the species : the other species in its neighbourhood, and abiotic factors such as light and humidity in its surrounding. It is considered a neutral image, it does not filter or bias information, allowing a reliable interpretation that lasts over time.

individuo. A partir da observación e a análise podemos entender as formas que queremos representar e é a través de liñas precisas e concretas que se reflicten os movementos, a anatomía e as estruturas.

- **Cuarto código: a cor.** Utilizouse a técnica da acuarela para captar a cor e a incidencia da luz e as sombras, sen utilizar a liña e os contornos. O código de cor, a pesar de estar filtrado polo ollo do artista, xera volume e tridimensionalidad ao debuxo. Acompañado dos respectivos datos vinculados á clorofila, tamén podemos entender a dimensión da cor da planta e os seus procesos vinculados á luz.

- **Quinto código: datos.** Unha aproximación gráfica e numérica ás especies. As medicións realizáronse en diferentes momentos da vida da planta, e revelan tanto a evolución da planta como a súa resposta ao medio ambiente ao longo do tempo.

- **Sexto código: lineal-raíces.** Esta aproximación supón unha prolongación do código terceiro. Proponse unha representación lineal dunha superficie illada da planta, as raíces. Ao mostrar as raíces da planta e as súas dimensións achegámonos a parte oculta da mesma, o seu soporte e o medio polo que se extrae a auga e os nutrientes do chan. Prestamos moita atención aos pelos radicais máis finos, ás raíces micorrizadas (asociacións raíz-fungo) ou aos nódulos (asociacións raíz-bacteria).

- **Sétimo código: rexistro.** Representación fiel e directa da huella da folla da especie tomada entre dous cristais e luz constante nun escáner Epson Perfection V800. Isto revela as paisaxes internas da folla e a estrutura da venación. O deseño e a función da venación da folla son importantes para o rendemento da planta ( Sack e Scoffoni 2013).

- **Oitavo código: fotográfico.** Unha captura fiel da especie na súa contorna nun momento dado. Proporciona unha visión xeral da contorna natural da especie: as outras especies na súa veciñanza, e os factores abióticos como a luz e a humidade. Considérase unha imaxe neutra, que non filtra nin sesga a información, o que permite a súa posterior interpretación.

# V. Codes of approximation to a physical reality

# V. Códigos de aproximación a unha realidade física

- *Eperua falcata*
- *Iryanthera hostmannii*
- *Jacaranda copaia subsp. copaia*
- *Pterocarpus officinalis*
- *Symphonia globulifera*
- *Tachigali melinonii*
- *Virola surinamensis*

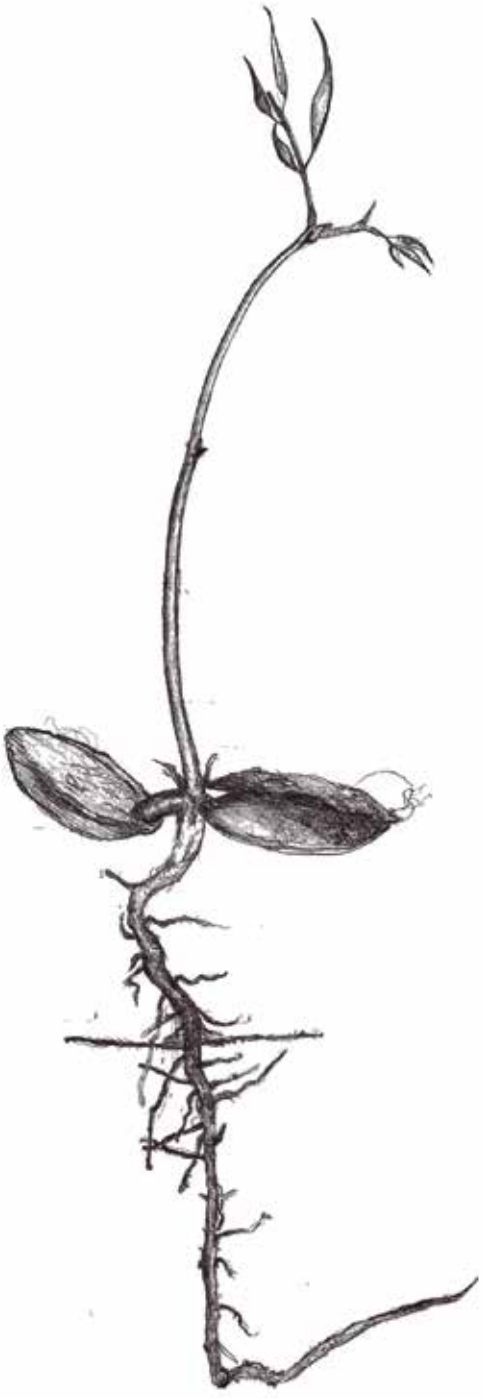
# *Eperua falcata*

*Plantae*
*Equisetopsida*
*Tracheophyta*
*Fabales*
*Fabaceae*
*Eperua*
*falcata*, *Aubl.* 1775

Colloquial names in French Guiana:
Nomes coloquiais na Guayana Francesa:

Créole **wapa, wapa-gr, pwa-sab**
French **wapa**
Kali'na **paliwu, paliwi, tyoto amote, watapa**
Nengee tongo **bii udu**
Palikur **wap-wasiunu, wapduwe**
Portugais **apa, apazeiro**
Teko **tapaka'i**
Wayana **wapa**
Wayapi **tapaka**

**Code I**



**Code II**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Soft pencil gradient draw.

**Code III**

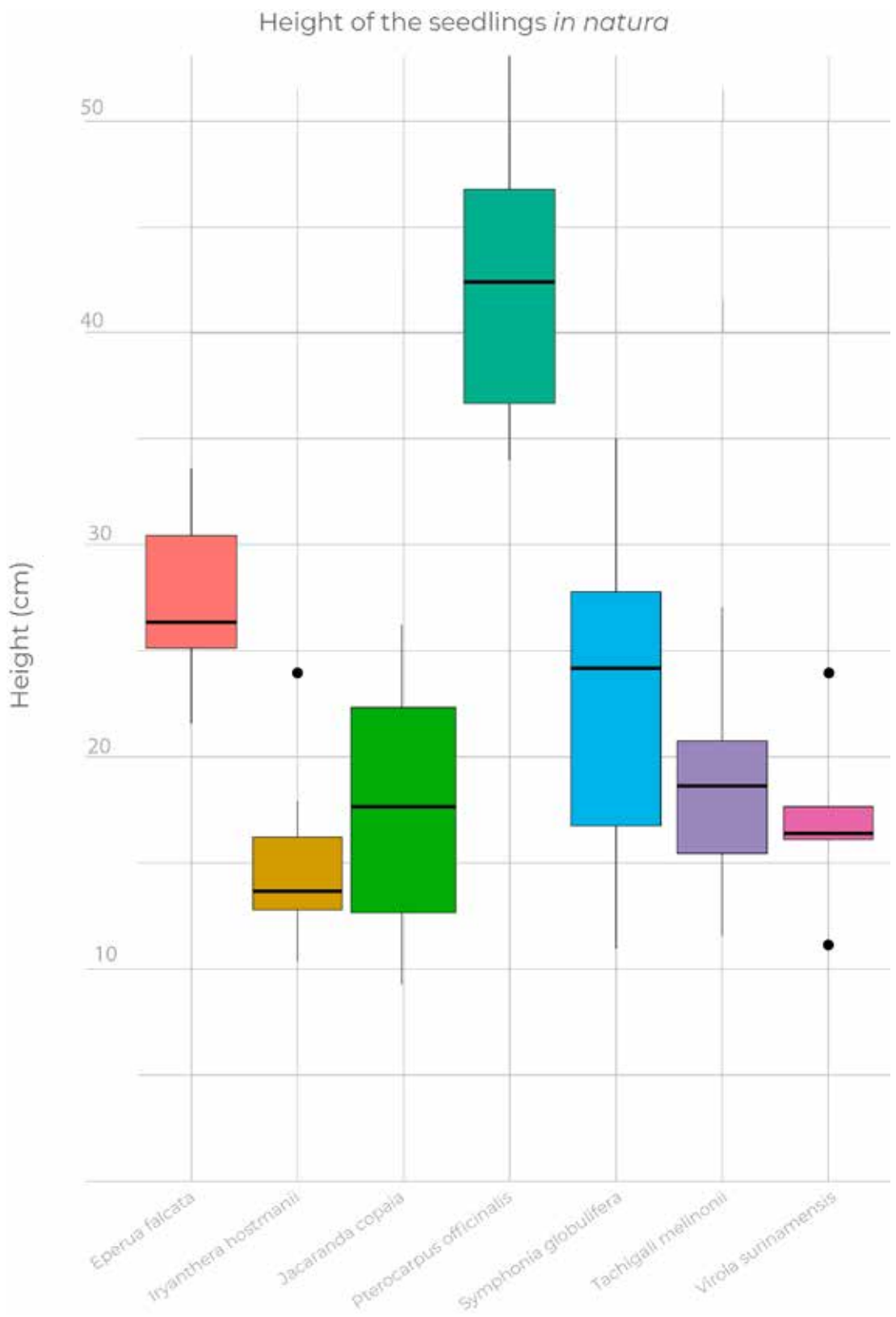
500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Line draw, calibrated pen 0,05 - 0,2.

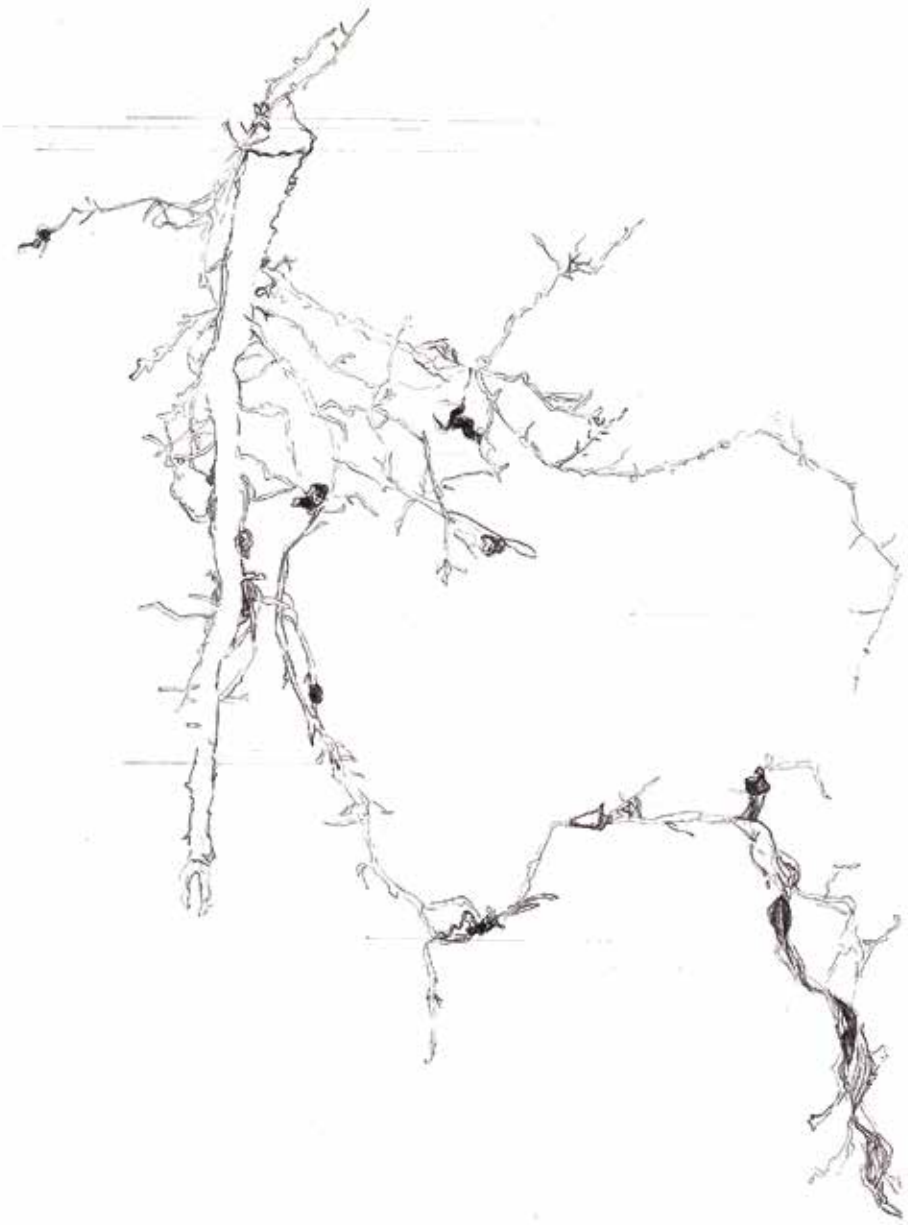
**Code IV**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Watercolor and calibrated pen 0,05.

We can see here the different sizes of the seedlings collected.
*Eperua falcata* was one of the tallest seedlings. Its seeds fall earlier to the ground, as early as March, compared to the other seedlings, later on in May. We can note the variability of the individuals within the same species with the magnitude of the boxplots.

Nesta imaxe podemos observar os diferentes tamaños dos brotes recollidos. *Eperua falcata* foi unha das de maior tamaño. As súas sementes caen antes ao chan, tan pronto como no mes de Marzo, en comparación coas demáis especies, a máis tardar en Maio. Podemos apreciar a variabilidade nos individuos da mesma especia na magnitude dos recadros do gráfico.


Height of the seedlings *in natura*
Height (cm)
50
40
30
20
10
Eperua falcata
Iryanthera hostmanii
Jacaranda copaia
Pterocarpus officinalis
Symphonia globulifera
Tachigali melinonii
Virola surinamensis



**Code VI**

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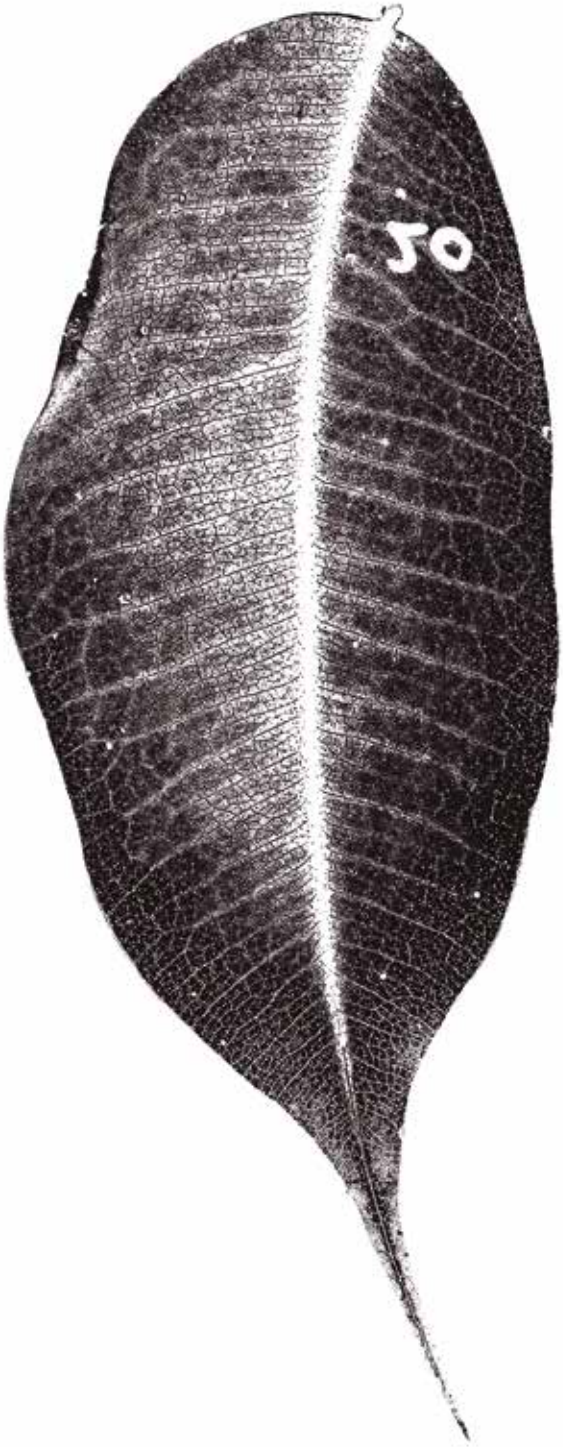
Line draw, calibrated pen 0,05 - 0,2.



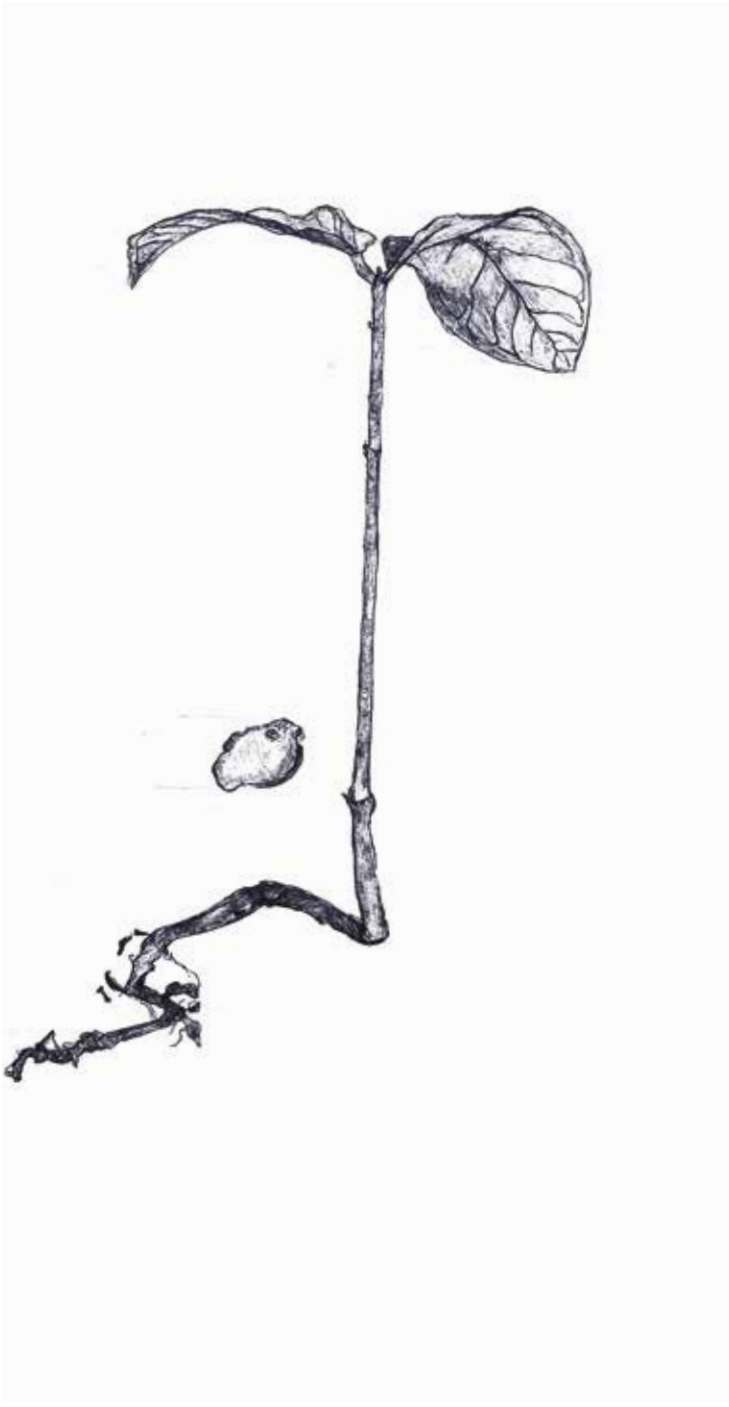

**Code VII** Digital image obtained from a leaf scan.

# *Iryanthera hostmannii*

*Plantae*
*Equisetopsida*
*Tracheophyta*
*Magnolianae*
*Myristicaceae*
*Iryanthera*
*hostmannii (Benth.) Warb., 1895*

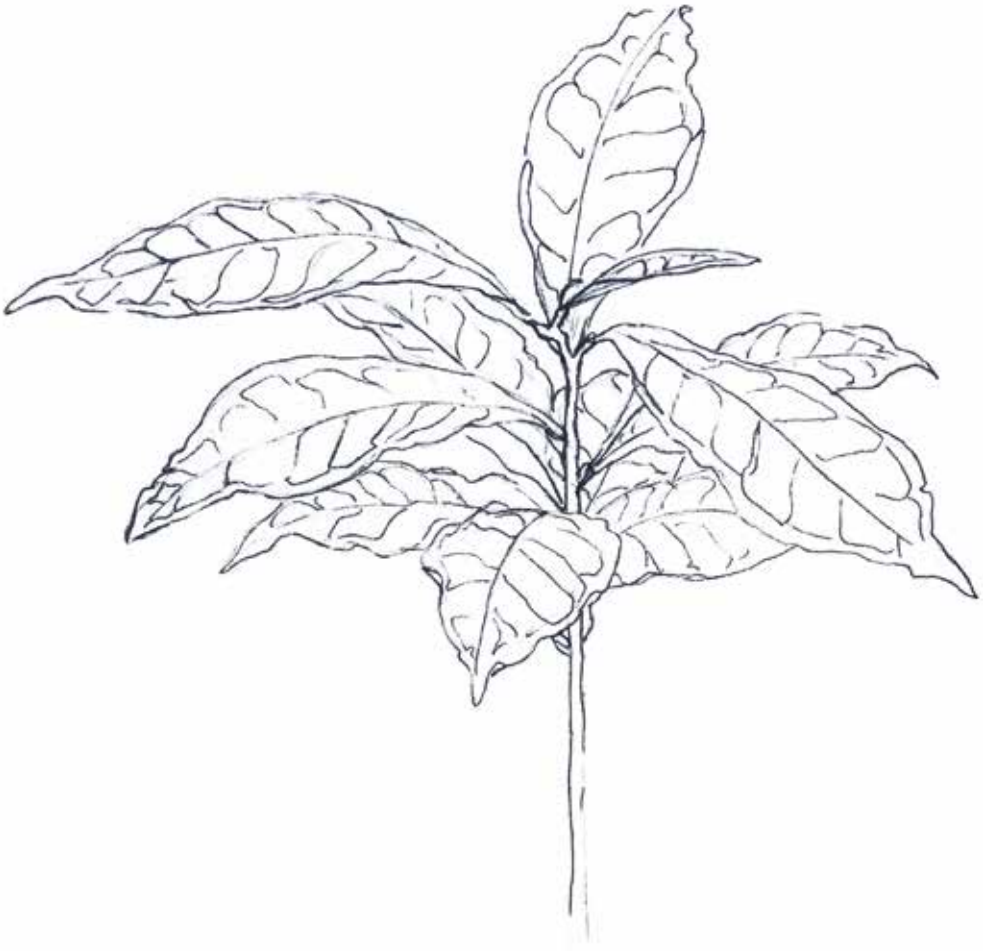
Colloquial names in French Guiana:
Nomes coloquiais na Guayana Francesa:
Créole **mousigo**
Français **moussigot, tossopassa marécage**
Kali'na **inyamu bati**
Nengee tongo **sabana tosopassa**
Palikur **wahusi-kamwi, wahusi-wasiunoduwe**
Portugais **ucuubarana**
Wayapi **kulupiyi, mukulupiyi**

**Code I**



**Code II**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Soft pencil gradient draw.

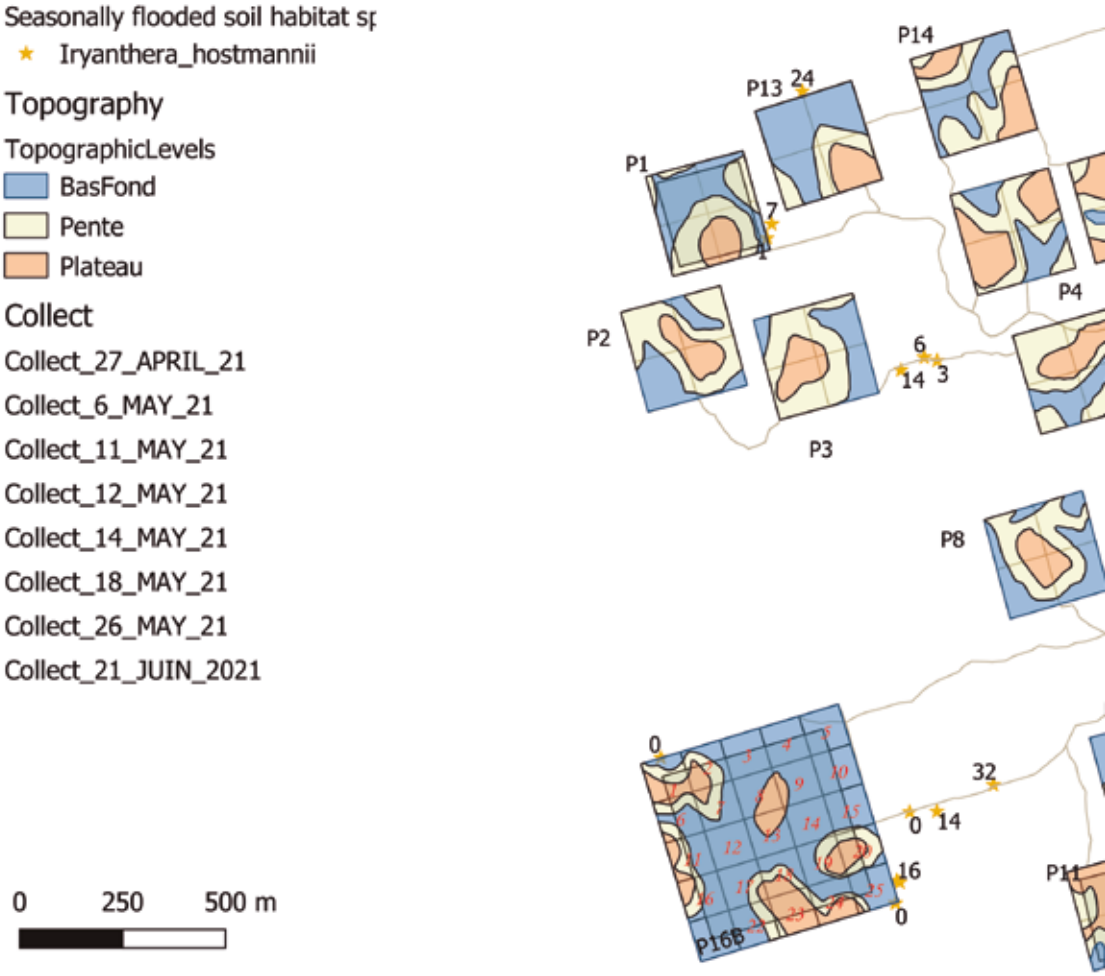


**Code III**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Line draw, calibrated pen 0,05 - 0,2.

**Code IV**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Watercolor and calibrated pen 0,05.




**Code V** Date, GPS location and map of harvest.


Here, we emphasize on the origen of the plant from Paracou research station. As seen on the map, the *Iryanthera hostmannii* seedlings were sampled from many mother trees and across the station. We recorded the dates and the precise GPS localisation for the traceability of each and every seedling.

Nesta imaxe enfatizamos o punto de orixe da planta nas instalacións la estación de investigación de Paracou. Como se aprecia no mapa, os brotes de *Iryanthera hostmannii* foron recollidos de diversas árboles-nai dentro da estación. Rexistramos as datas e a localización GPS precisa para a trazabilidade de cada un dos brotes.

**Code VI**

500 x 350 mm Hahnemühle Britannia Paper 300gm.
Line draw, calibrated pen 0,05 - 0,2.

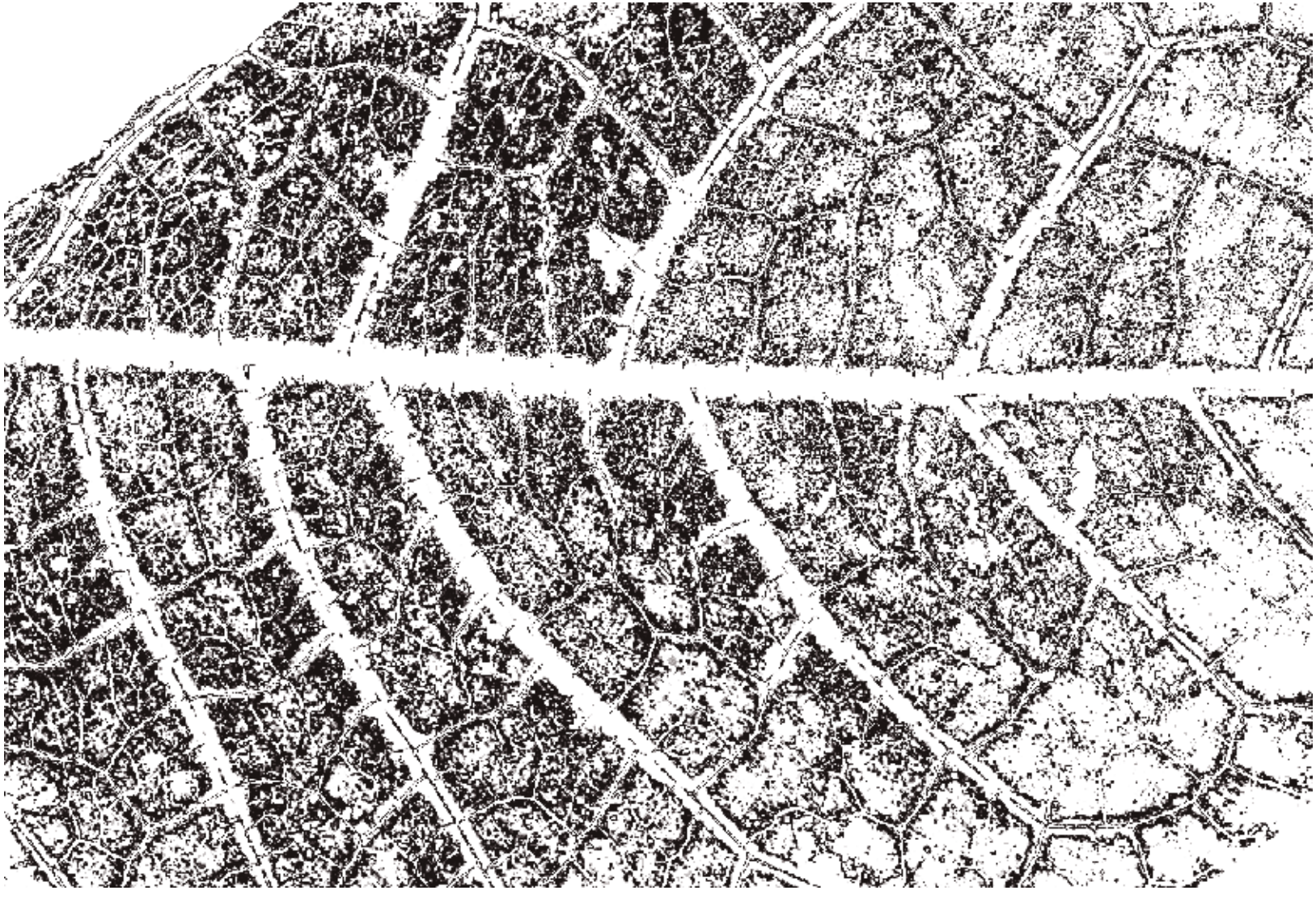
In **roots,** the beneficial effects of the microbiome, mycorrhizal fungi or Nitrogen-fixing bacteria, are known to promote nutrient and water uptake, stimulate germination, growth and plant fitness under abiotic stress. The draw also concentrated on the hidden part of the plant, illustrating that some plants had 'nodules', the formation of a new organ in the root area of the plant. Indeed, several plants have developed beneficial symbioses with diazotroph bacteria in order to acquire atmospheric nitrogen. In a nitrogen-deficient soil, the diazotroph bacteria will convert atmospheric nitrogen into ammonia, which the plant can assimilate. In return, the plant will host the bacteria and provide carbon photosynthates.

**Specific root length** (SRL, m g–1), is the length-to-mass ratio (L/M) of a root fragment, is probably the most frequently measured morphological parameter of fine roots. It is believed to characterise economic aspects of the root system and to be indicative of environmental changes, as it illustrates the root benefit to root cost. The root length is assumed to be proportional to resource acquisition (benefit) and the root mass to be proportional to construction and maintenance (cost) (Eissenstat & Yanai, 1997). Long and thin roots (high SRL) are believed to be the below-ground equivalent of thin leaves, which are less expensive to produce (Withington et al., 2006).

Nas **raíces**, sábese que os efectos beneficiosos do microbioma, os fungos micorrícicos ou as bacterias fixadoras de nitróxeno promoven a absorción de nutrientes e auga, estimulan a xerminación, o crecemento e a aptitude das plantas baixo estrés abiótico. O debuxo tamén se concentrou na parte oculta da planta, ilustrando que algunhas plantas tiñan 'nódulos', a formación dun novo órgano na área da raíz da planta. De feito, varias plantas desenvolveron simbioses beneficiosas con bacterias diazótrofas para adquirir nitróxeno atmosférico. Nun chan con deficiencia de nitróxeno, as bacterias diazótrofas converterán o nitróxeno atmosférico en amoníaco, que a planta pode asimilar. A cambio, a planta albergará á bacteria e proporcionará carbono fotosintetizado.

**A lonxitude específica da raíz** ( SRL, m g-1), é a relación lonxitude/masa ( L/M) dun fragmento de raíz, é probablemente o parámetro morfolóxico máis frecuentemente medido das raíces finas. Crese que caracteriza os aspectos económicos do sistema radicular e que é indicativo dos cambios ambientais, xa que ilustra o beneficio da raíz en relación co seu custo. Suponse que a lonxitude da raíz é proporcional á adquisición de recursos (beneficio) e a masa da raíz é proporcional á construción e o mantemento (custo) ( Eissenstat & Yanai, 1997). Crese que as raíces longas e finas ( SRL alto) son o equivalente baixo terra das follas finas, cuxa produción é menos custosa ( Withington et ao., 2006).

**Code VII** Digital image obtained from a leaf scan.



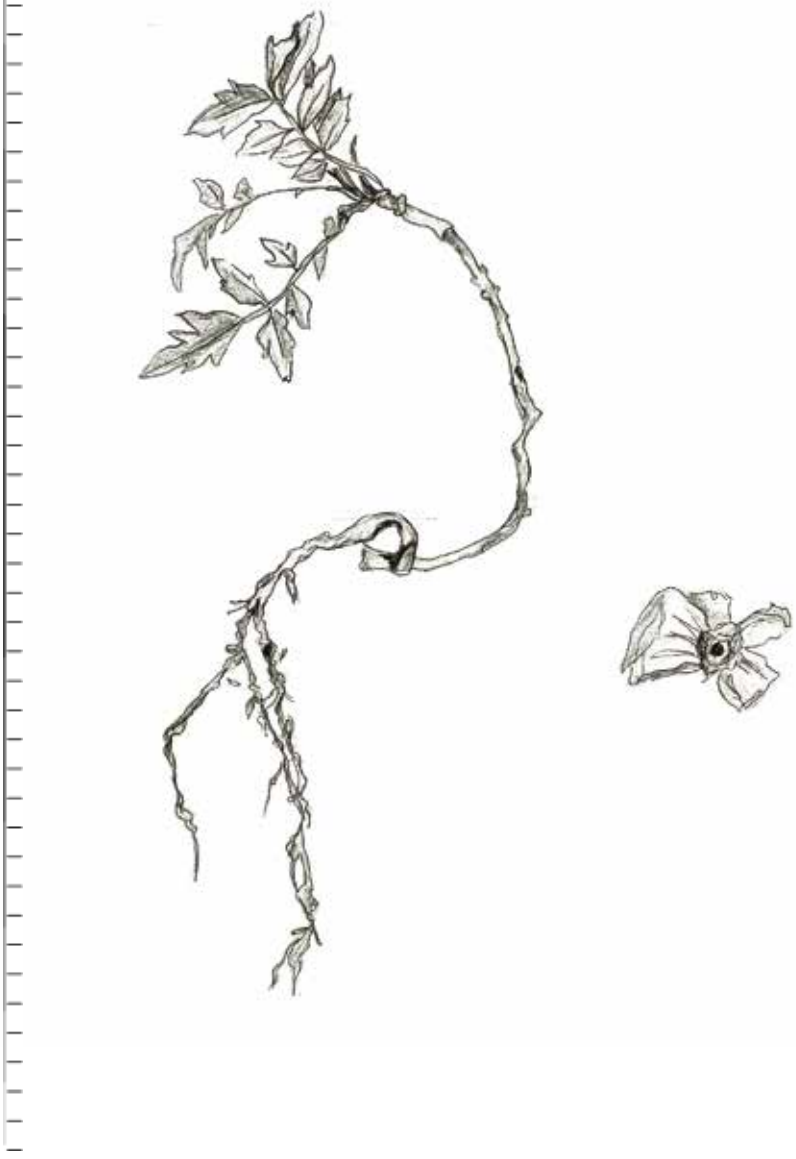
# *Jacaranda copaia subsp. copaia*

*Plantae*
*Equisetopsida*
*Tracheophyta*
*Lamiales*
*Bignoniaceae*
*Jacaranda*
*copaia (Aubl.) D. Don, 1823*
*subsp. copaia*

Colloquial names in French Guiana:
Nomes coloquiais na Guayana Francesa:

Créole **koupaya, bwa-pyan**
Français **copaia, faux simarouba**
Kali'na **kupaya. kopaya**
Nengee tongo **faya ati, yasimanbo**
Palikur **pada**
Portugais **caroba, pará-pará**
Teko **mee'i**
Wayana **kupaja, kupahja**
Wayapi **pala'i**

**Code I**



**Code II**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Soft pencil gradient draw.

**Code III**

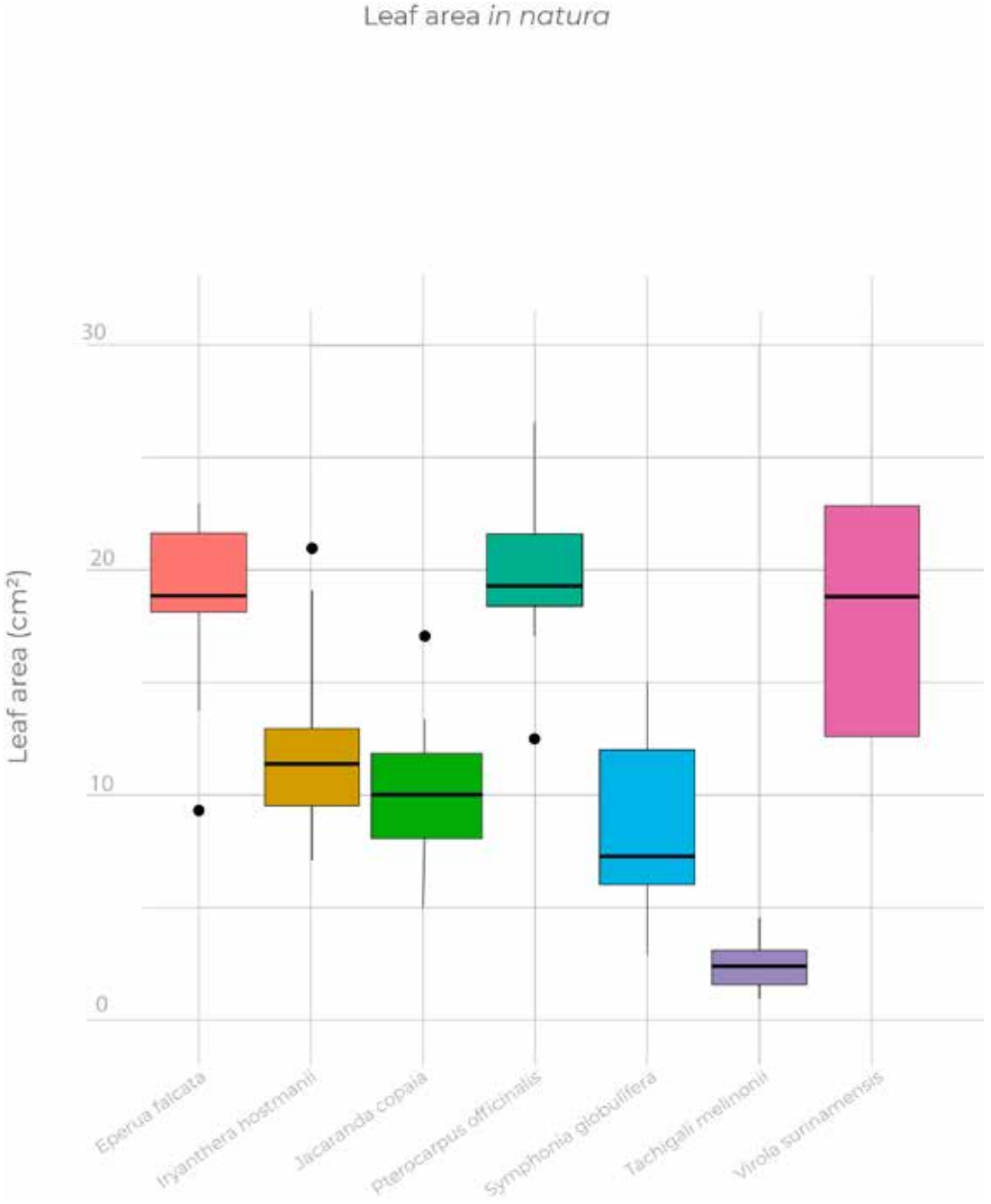
500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Line draw, calibrated pen 0,05 - 0,2.

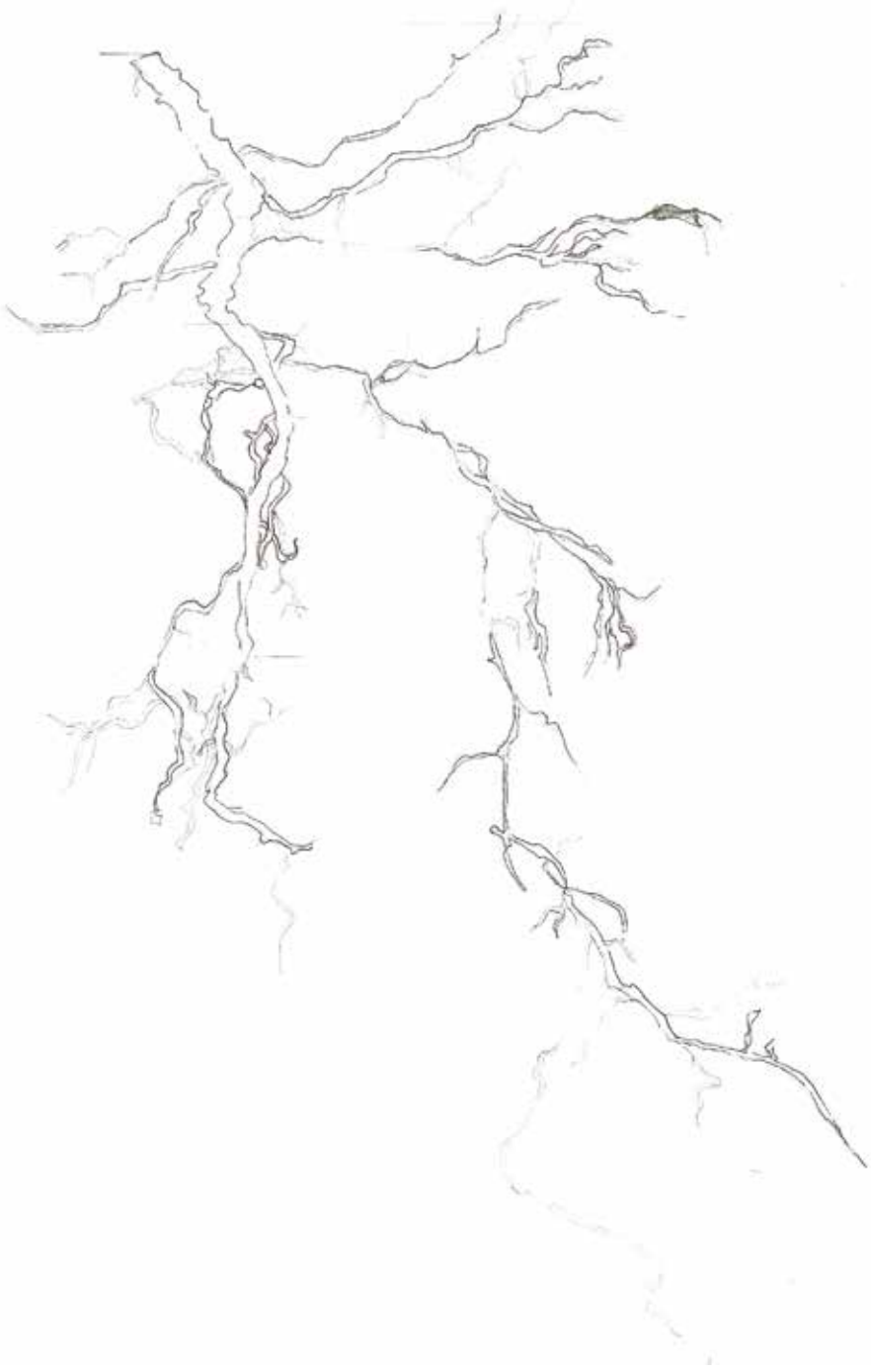
**Code IV**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Watercolor and calibrated pen 0,05.

There are many types of leaves in nature. Differences in leaf size can significantly alter whole chemical and structural characteristics. Leaf size may decline when the plant is in a stressful stressful environment, making the construction of large leaves too expensive. Leaves come mainly in two basic arrangements: simple and compound. Here, we have *Jacaranda copaia subsp. copaia*, the only non-fabaceae that grows compound leaves. The 3 Fabaceae species also have compound leaves.

Hai moitos tipos de follas na natureza. As diferenzas no tamaño das follas poden alterar significativamente as características químicas e estruturais do conxunto. O tamaño das follas pode diminuír cando a planta atópase nunha contorna estresante, o que fai que a construción de follas grandes sexa demasiado custosa. As follas preséntanse principalmente en dúas disposicións básicas: simples e compostas. Aquí temos á *Jacaranda copaia subsp. copaia*, a única non- fabácea que ten follas compostas. As 3 especies de Fabaceae tamén teñen follas compostas.


Leaf area *in natura*
Leaf area (cm²)
30
20
10
0
Eperua falcata
Iryanthera hostmanii
Jacaranda copaia
Pterocarpus officinalis
Symphonia globulifera
Tachigali melinonii
Virola surinamensis



**Code VI**

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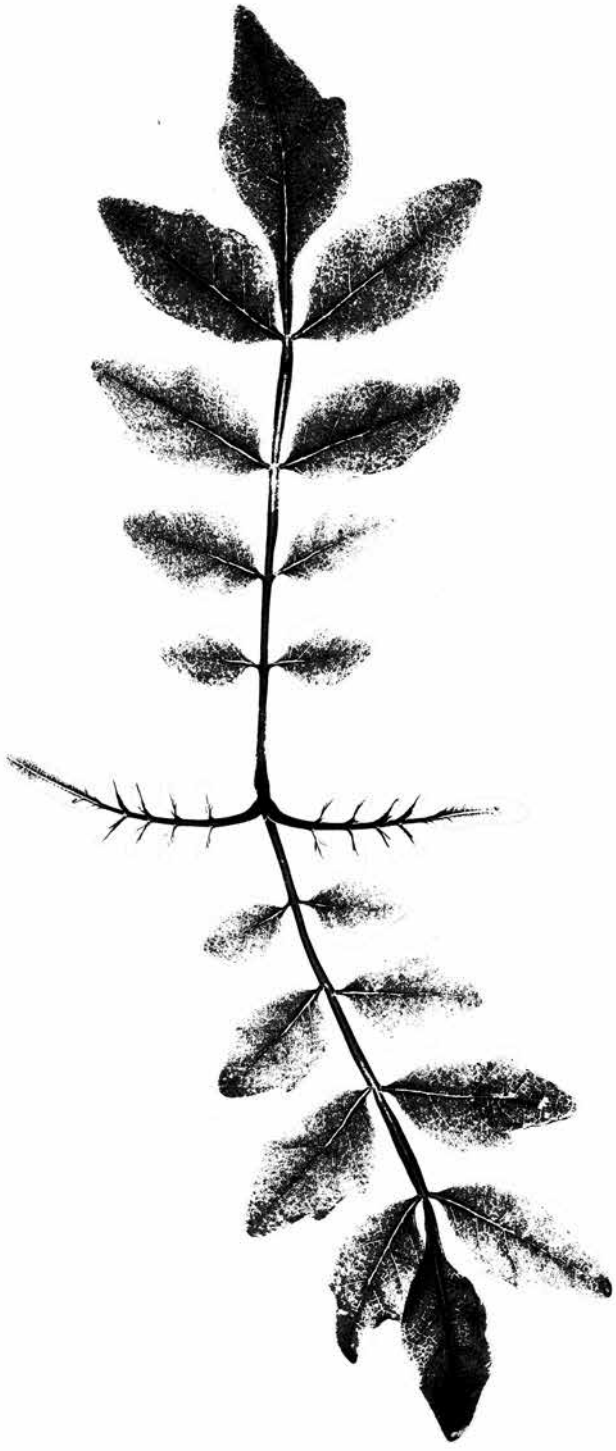
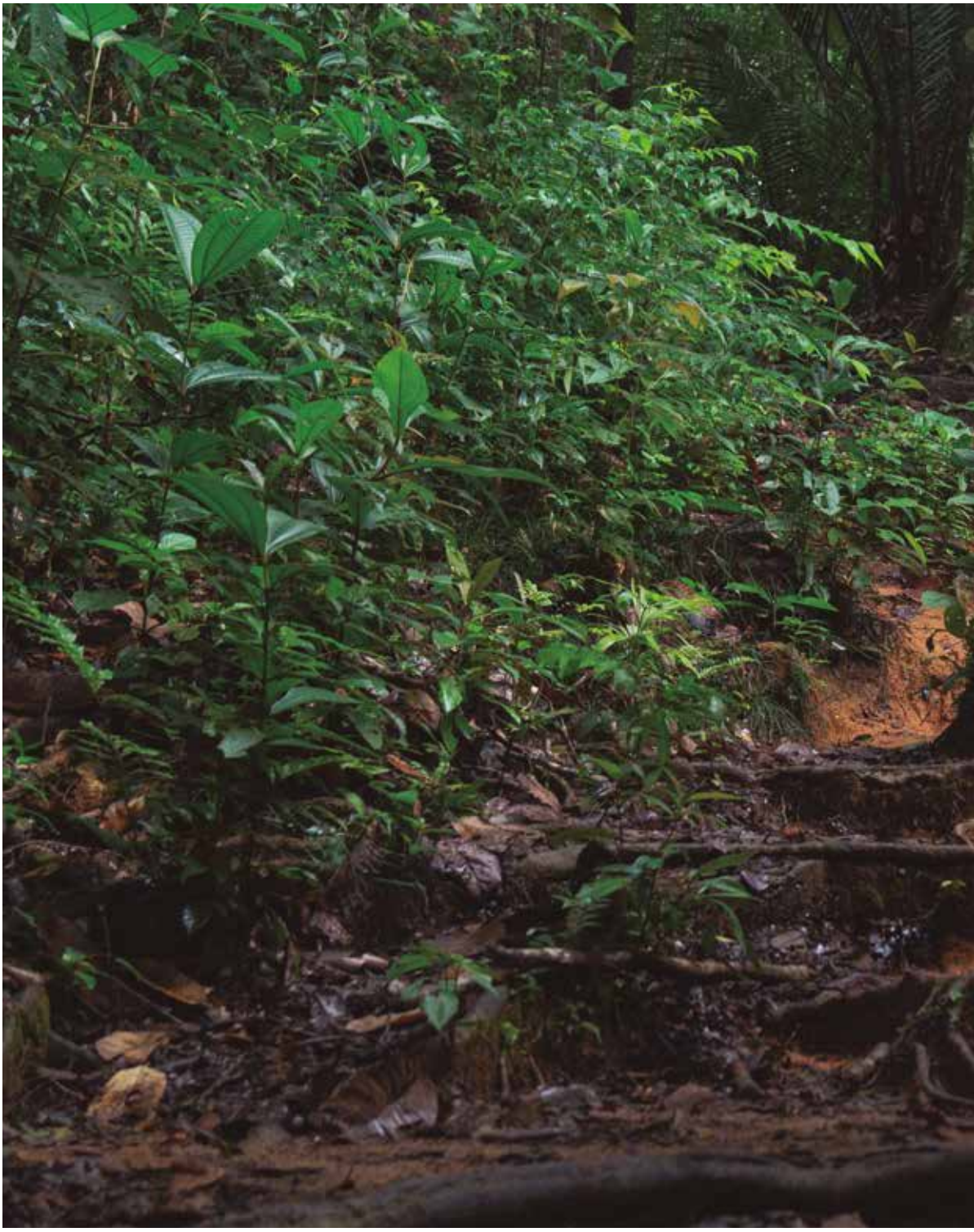
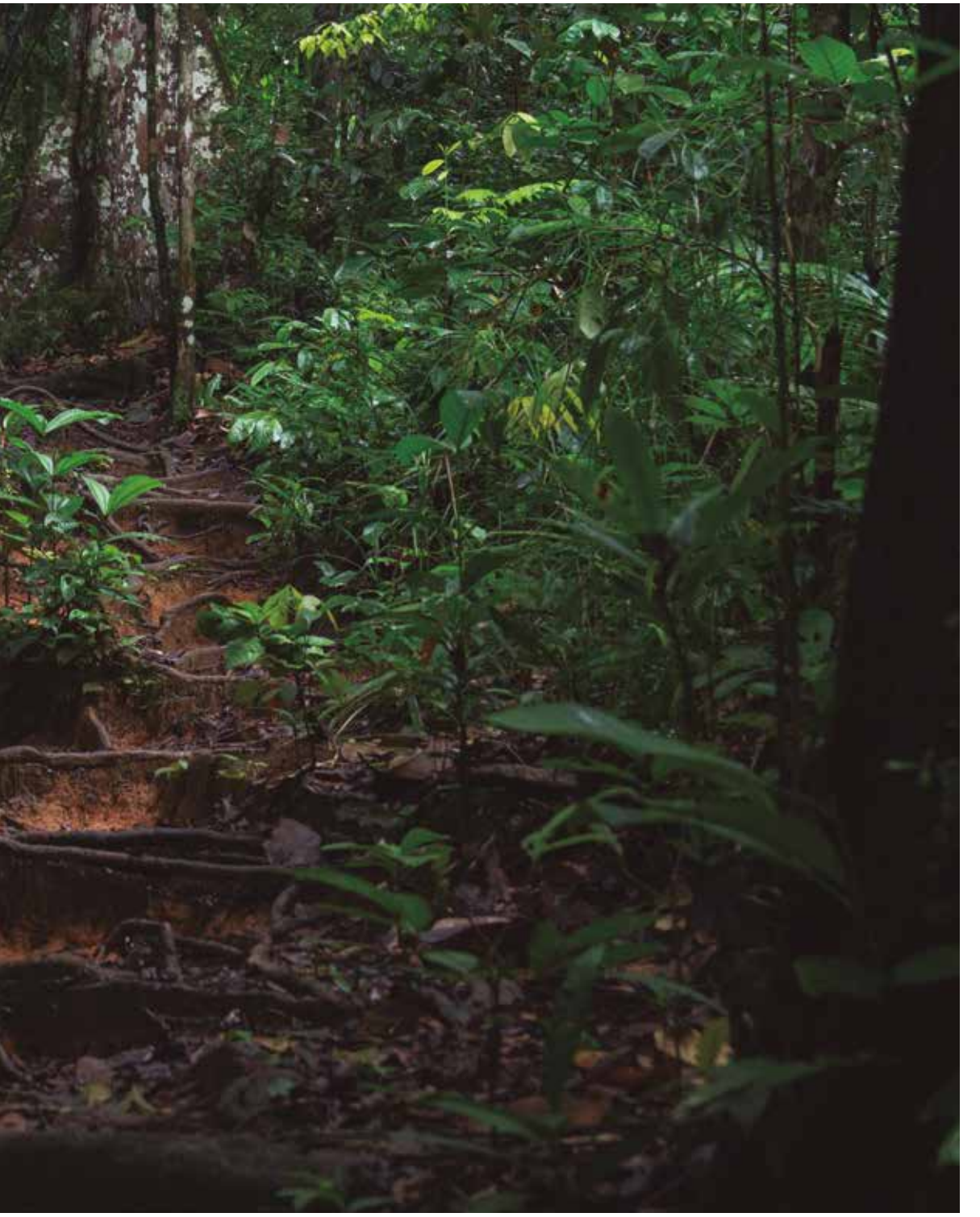
Line draw, calibrated pen 0,05 - 0,2.



**Code VII** Digital image obtained from a leaf scan.



Rainforest of French Guiana



*Jacaranda copaia subsp. copaia*

*Iryanthera hostiimani*

Flower of *Eperua falcata*

*Tachigali melinonii*

*Eperua falcata*

Watercolor of *Iryanthera hostiimani* next to its seedlings into the greenhouse.

Watercolor of *Pterocarpus officinalis* next to its seedlings into the greenhouse.

Watercolor of *Virola surinamensis* next to its seedlings into the greenhouse.

Watercolor of *Jacaranda copaia subsp copaia* next to its seedlings into the greenhouse.


Marked tree at the Scientifical Station of Paracou


25

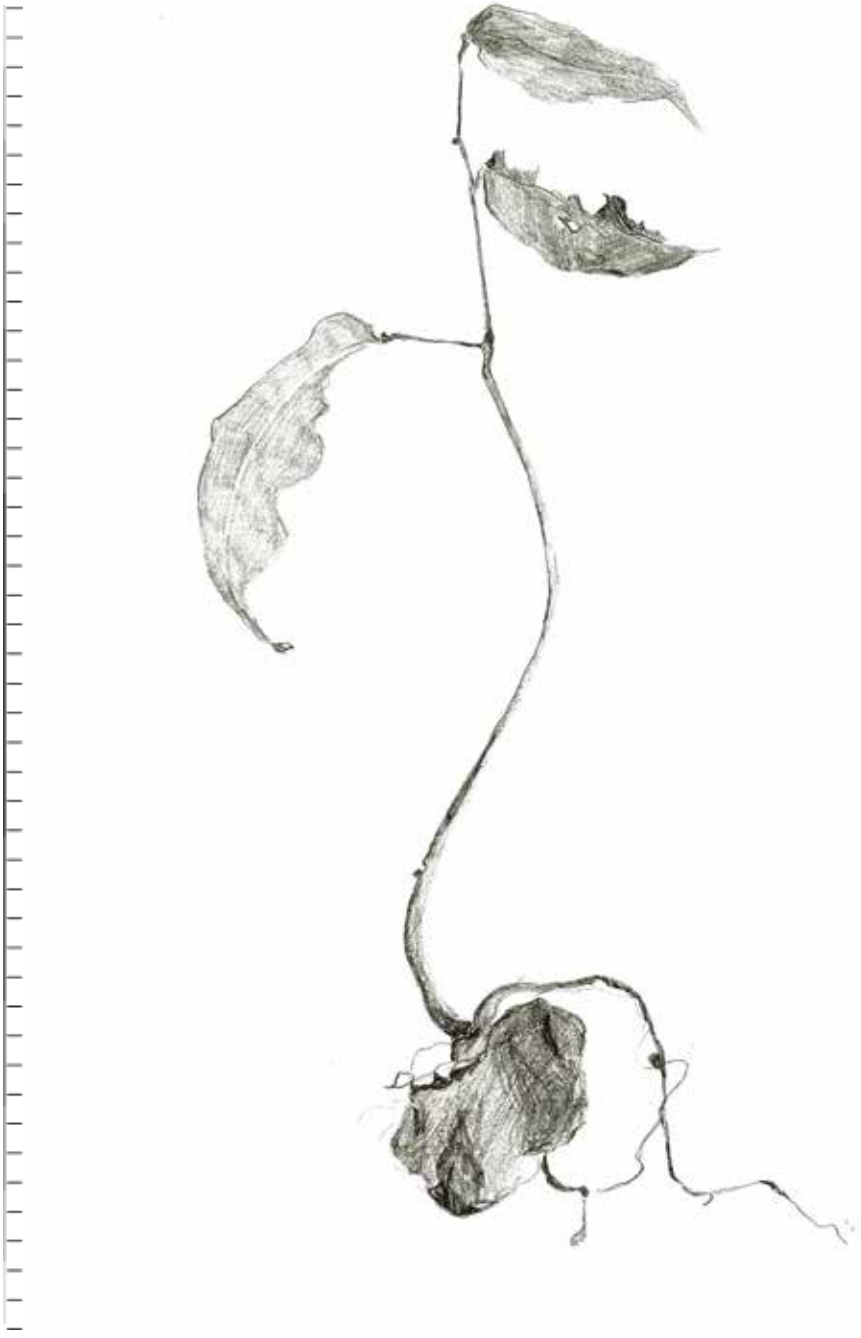
# *Pterocarpus officinalis*

*Plantae*
*Equisetopsida*
*Tracheophyta*
*Fabales*
*Fabaceae*
*Pterocarpus*
*officinalis Jacq. 1763*

Colloquial names in French Guiana:
Nomes coloquiais na Guayana Francesa:

Créole **moutouchi-marikaj, moutouchisavann**
Français **moutouchi rivière, moutouchi marécage**
Kali'na **mutusi**
Nengee tongo **sabana gwegwe**
Palikur **muhut**
Portugais **mututy**
Teko **bututsi**
Wayana **mïumïli**
Wayapi **mutusisi, mutusi**

**Code I**



**Code II**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Soft pencil gradient draw.

**Code III**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Line draw, calibrated pen 0,05 - 0,2.

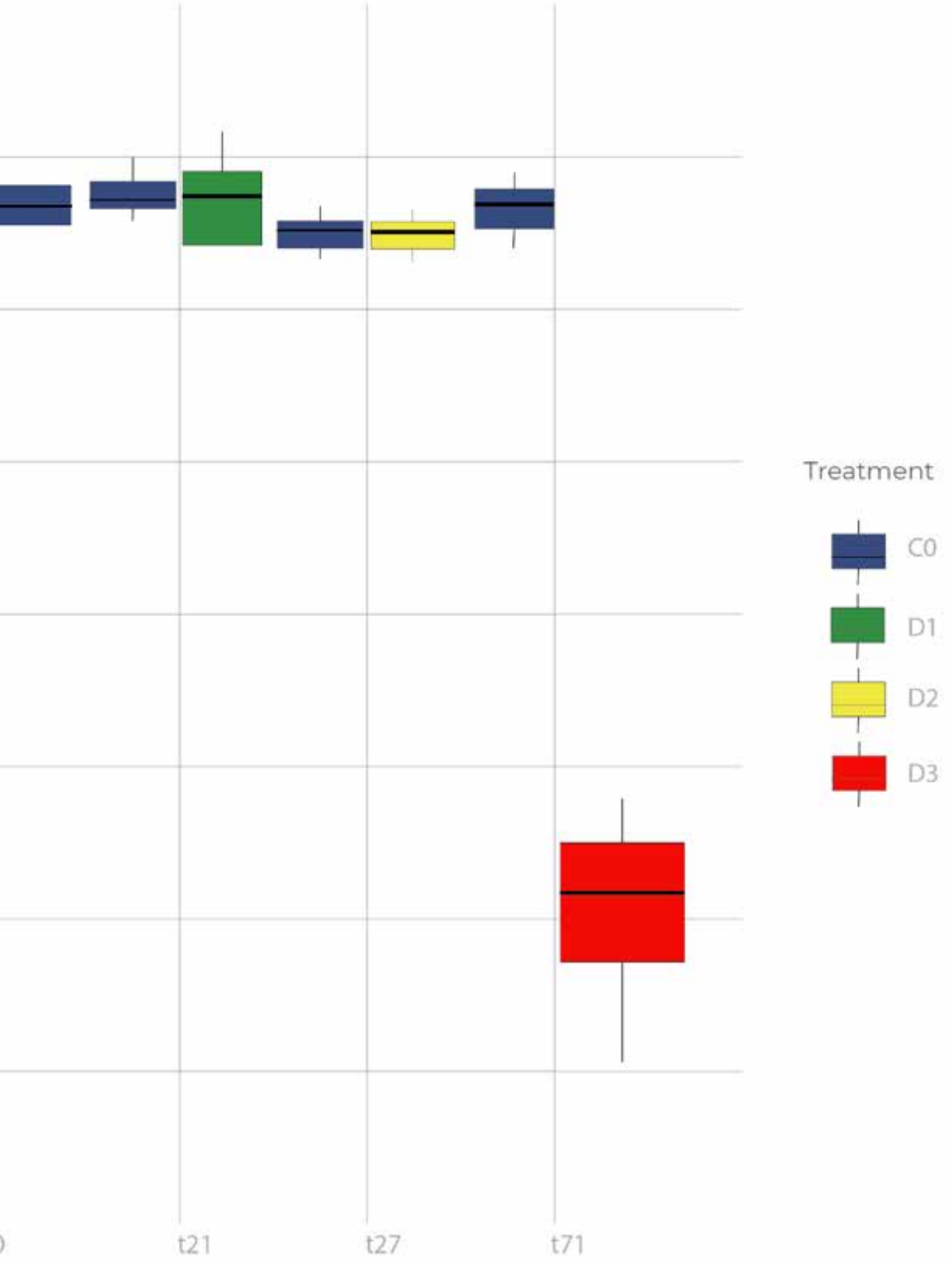
**Code IV**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Watercolor and calibrated pen 0,05.

Light energy absorbed by the chlorophyll molecules in a leaf mainly drives photosynthesis, the process by which plants use sunlight, water, and carbon dioxide to create oxygen and energy in the form of sugar. However, this light can also become excess heat to the system or be re-emitted as light, chlorophyll fluorescence. We assessed chlorophyll fluorescence using the Fv/ Fm trait. It is used as a sensitive indicator of plant photosynthetic performance, with optimal values of around 0.83 (Maxwell and Johnson 2000). *Pterocarpus officinalis* managed to keep an optimal chlorophyll fluorescence during the 21-day and 27-day droughts, but not during the extreme drought of 71 days, where the value drops to 0.250.

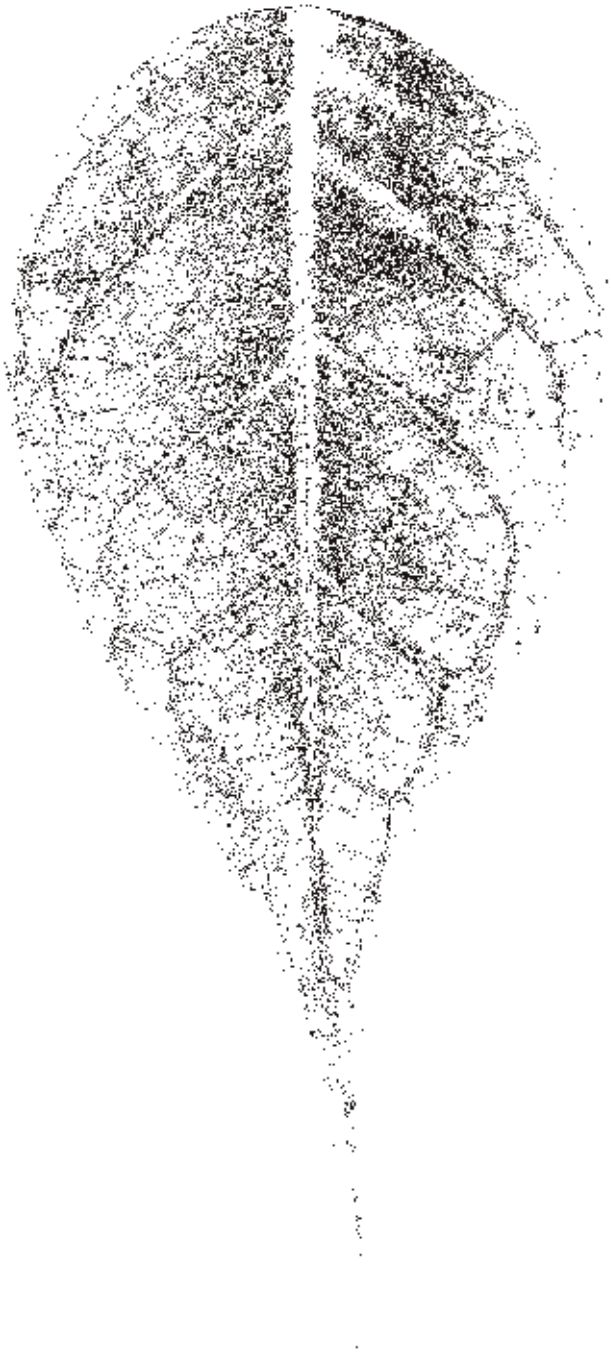
A enerxía luminosa absorbida polas moléculas de clorofila dunha folla impulsa principalmente a fotosíntesis, o proceso polo que as plantas utilizan a luz solar, a auga e o dióxido de carbono para crear osíxeno e enerxía en forma de azucre. Con todo, esta luz tamén pode converterse nun exceso de calor para o sistema ou ser reemitida como luz, a fluorescencia da clorofila. Avaliamos a fluorescencia da clorofila mediante o trazo Fv/ Fm. Utilízase como un indicador sensible do rendemento fotosintético da planta, con valores óptimos de ao redor de 0,83 ( Maxwell e Johnson 2000). *Pterocarpus officinalis* conseguiu manter unha fluorescencia clorofílica óptima durante as secas de 21 e 27 días, pero non durante a seca extrema de 71 días, na que o valor baixa a 0,250.


**Code V** Chlorophyll fluorescence through different drought treatments


t21
t27
t71
Treatment
C0
D1
D2
D3

**Code VI**

500 x 350 mm Hahnemühle Britannia Paper 300gm.
Line draw, calibrated pen 0,05 - 0,2.



**Code VII** Digital image obtained from a leave scan.

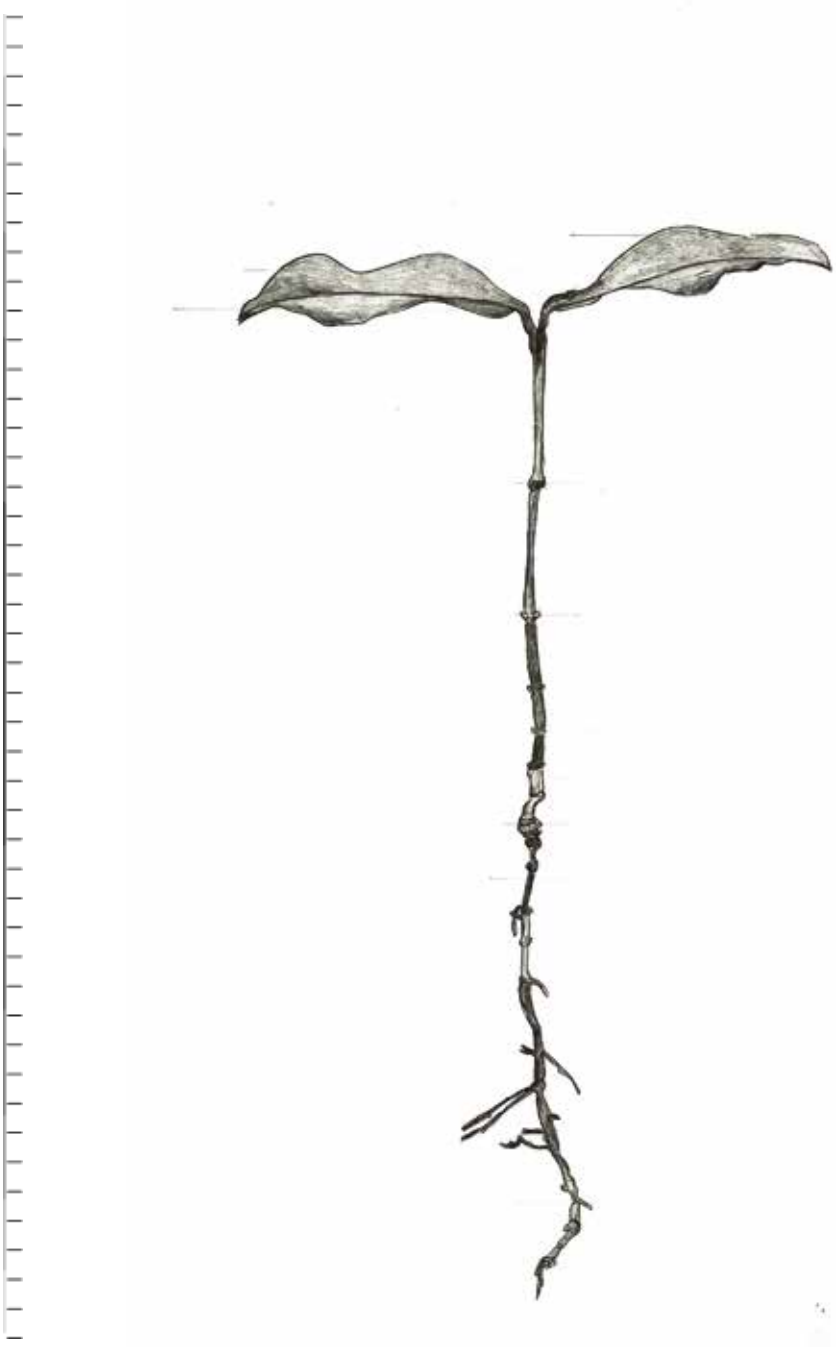
# *Symphonia globulifera*

*Plantae*
*Equisetopsida*
*Tracheophyta*
*Malpighiales*
*Clusiaceae*
*Symphonia*
*globulifera L.f.*, 1782

Colloquial names in French guiana:
Nomes coloquiais na Guayana Francesa:

Créole **manni-marikaj**
Français **manil marécage**
Kali'na **ananiyu, wesekapo epityi**
Nengee tongo **sabana mattaki, wataa mataaki**
Palikur **timarikasmatgene**
Portugais **ananí**
Teko **baytakini**
Wayana **mani epu, mani**
Wayapi **wanani, wanani**

**Code I**



**Code II**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Soft pencil gradient draw.

**Code III**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Line draw, calibrated pen 0,05 - 0,2.

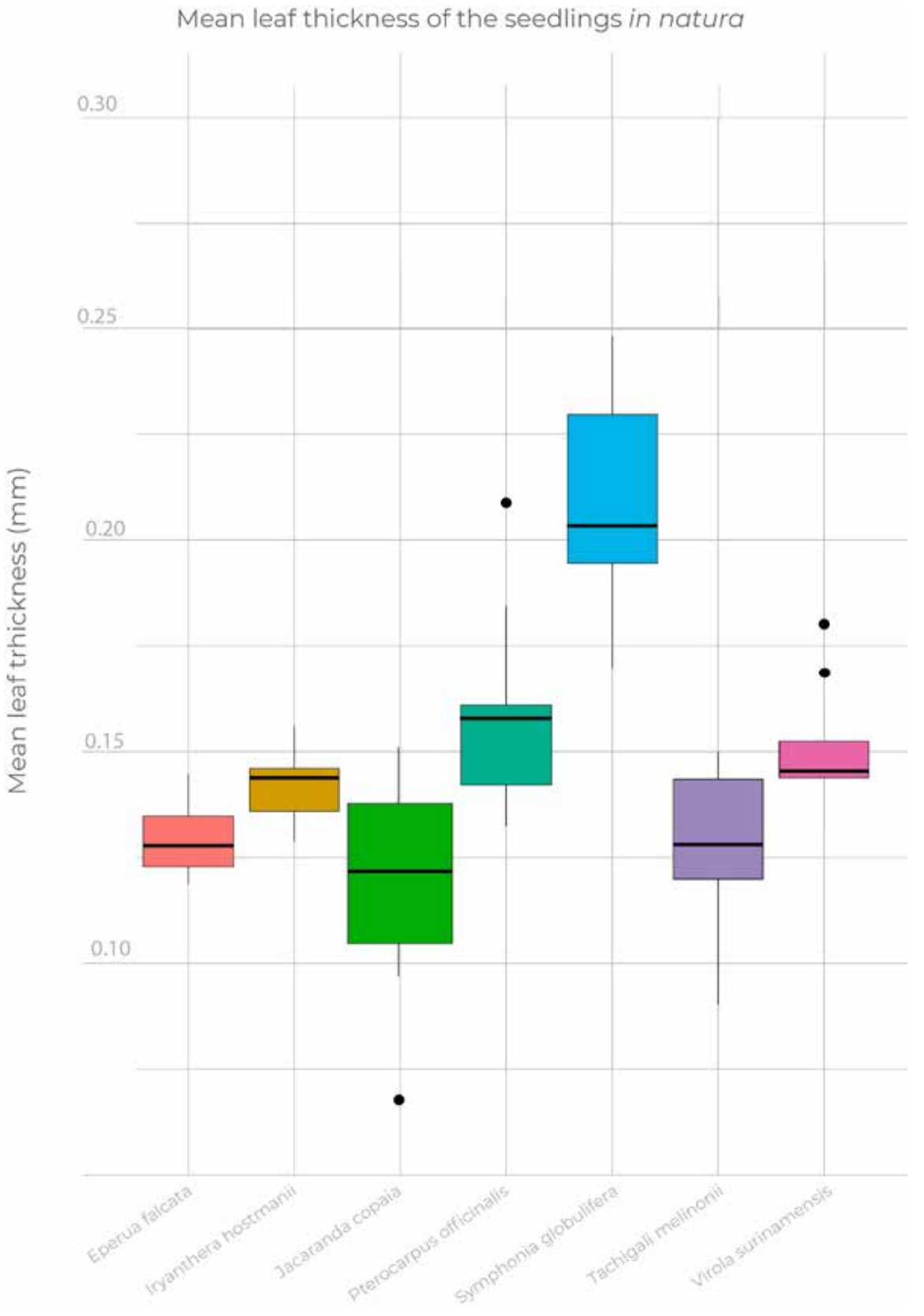
**Code IV**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Watercolor and calibrated pen 0,05.

The leaf thickness is a trait that determines the length of the optical path of light through a leaf and the number of anatomical features (e.g., cell walls and chloroplasts) that either reflect, absorb, or transmit light (Pauli et al. 2017). Thicker leaves as it is the case for *Symphonia globulifera* can typically have greater photosynthetic rates (Pettigrew et al., 1993) and can be related to a greater water content.

O grosor da folla é un trazo que determina a lonxitude do camiño óptico da luz a través dunha folla e o número de características anatómicas (por exemplo, paredes celulares e cloroplastos) que reflicten, absorben ou transmiten a luz ( Pauli et ao. 2017). As follas máis grosas, como é o caso de *Symphonia globulifera*, adoitan ter maiores taxas de fotosíntesis ( Pettigrew et ao., 1993) e poden estar relacionadas cun maior contido de auga.

**Code V** Mean leaf of thickness


Mean leaf thickness of the seedlings *in natura*
Mean leaf thickness (mm)
0.30
0.25
0.20
0.15
0.10
Eperua falcata
Iryanthera hostmanii
Jacaranda copaia
Pterocarpus officinalis
Symphonia globulifera
Tachigali melinonii
Virola surinamensis

**Code VI**

500 x 350 mm Hahnemühle Britannia Paper 300gm.
Line draw, calibrated pen 0,05 - 0,2.

**Code VII** Digital image obtained from a leave scan.

# *Tachigali melinonii*

*Plantae*
*Equisetopsida*
*Tracheophyta*
*Fabales*
*Fabaceae*
*Tachigali*
*melinonii (Harms)*
*Zarucchi & Herend., 1993*

Colloquial names in French Guiana:
Nomes coloquiais na Guayana Francesa:

Créole **sèd-rémi, tachi**
Kali'na **tipulu alaulama**
Nengee tongo **dyagidya**
Palikur **arey-avain**
Portugais **taxi**
Teko **tatsi inan**
Wayapi **yapakani'i**

**Code I**

**Code II**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Soft pencil gradient draw.

**Code III**

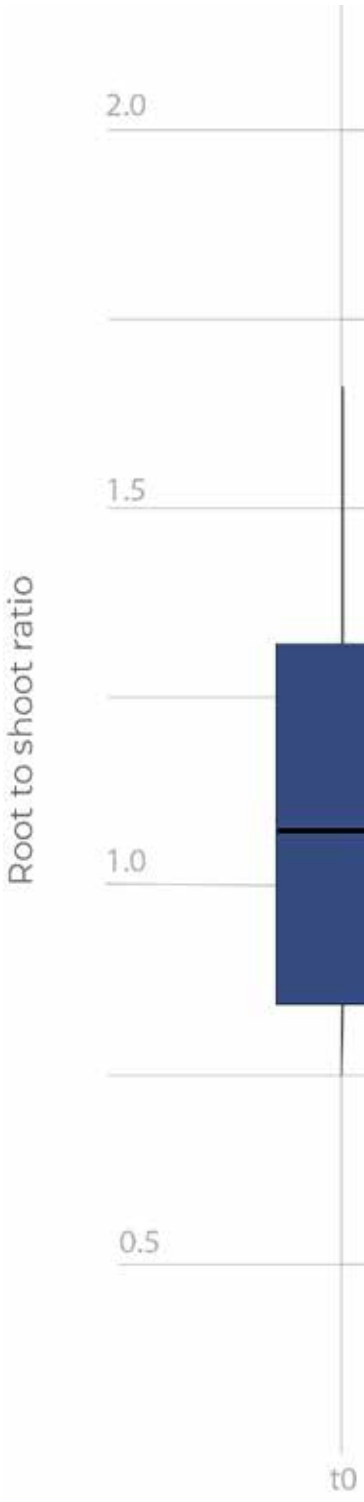
500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Line draw, calibrated pen 0,05 - 0,2.

**Code IV**

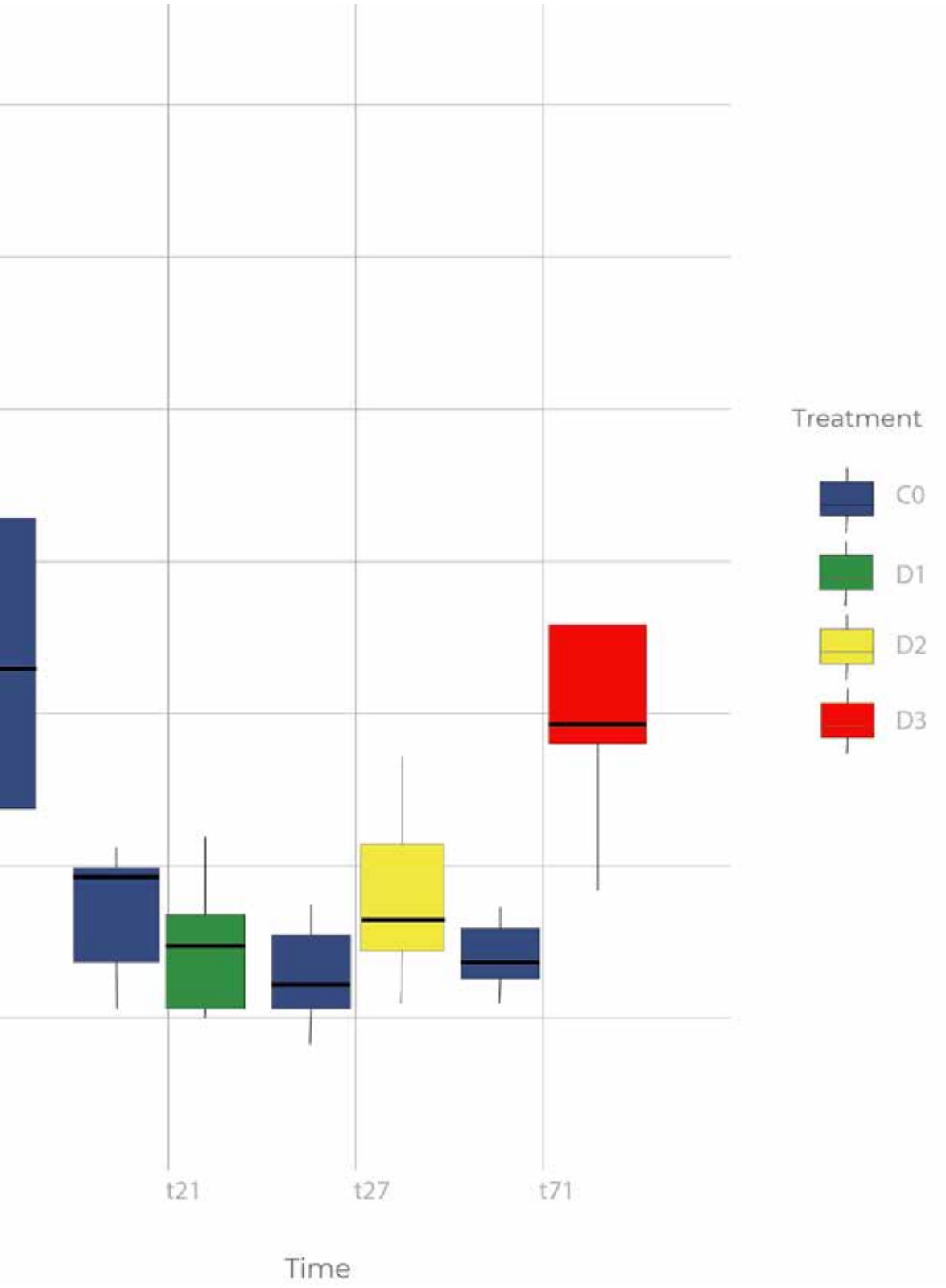
500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Watercolor and calibrated pen 0,05.

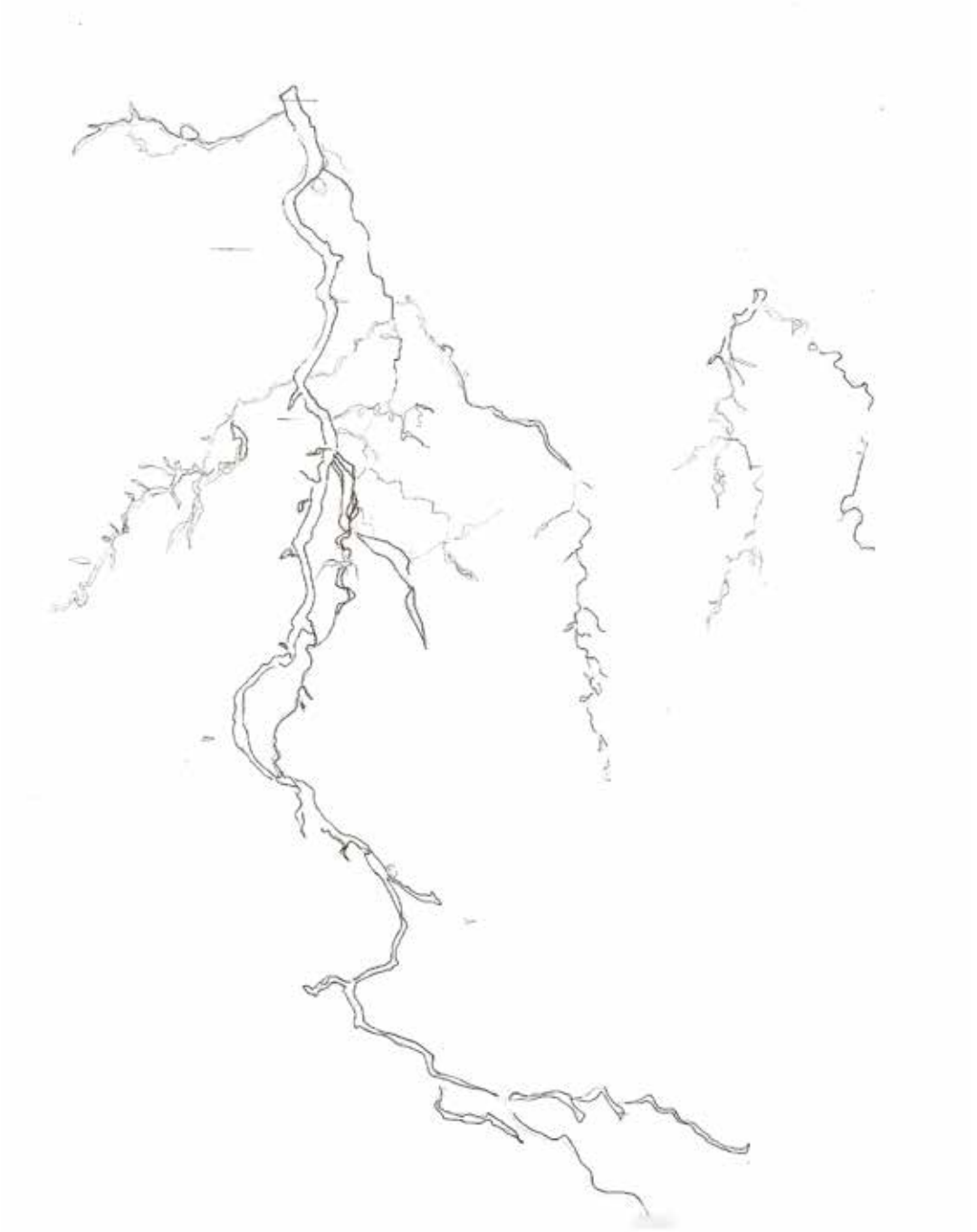
The root to shoot ratio measures of the allocation of the plant's resources. We can see here that when water is a limiting factor, the investment shifts the resources from shoots (leaves and stem) to the roots.

A relación raíz-brote mide a asignación dos recursos da planta. Podemos ver aquí que cando a auga é un factor limitante, o investimento despraza os recursos dos brotes (follas e talo) ás raíces.




**Code V** Root to shoot through different drought treatments


Treatment
C0
D1
D2
D3
t21
t27
t71
Time



**Code VI**

500 x 350 mm Hahnemühle Britannia Paper 300gm.
Line draw, calibrated pen 0,05 - 0,2.

**Code VII** Digital image obtained from a leave scan.

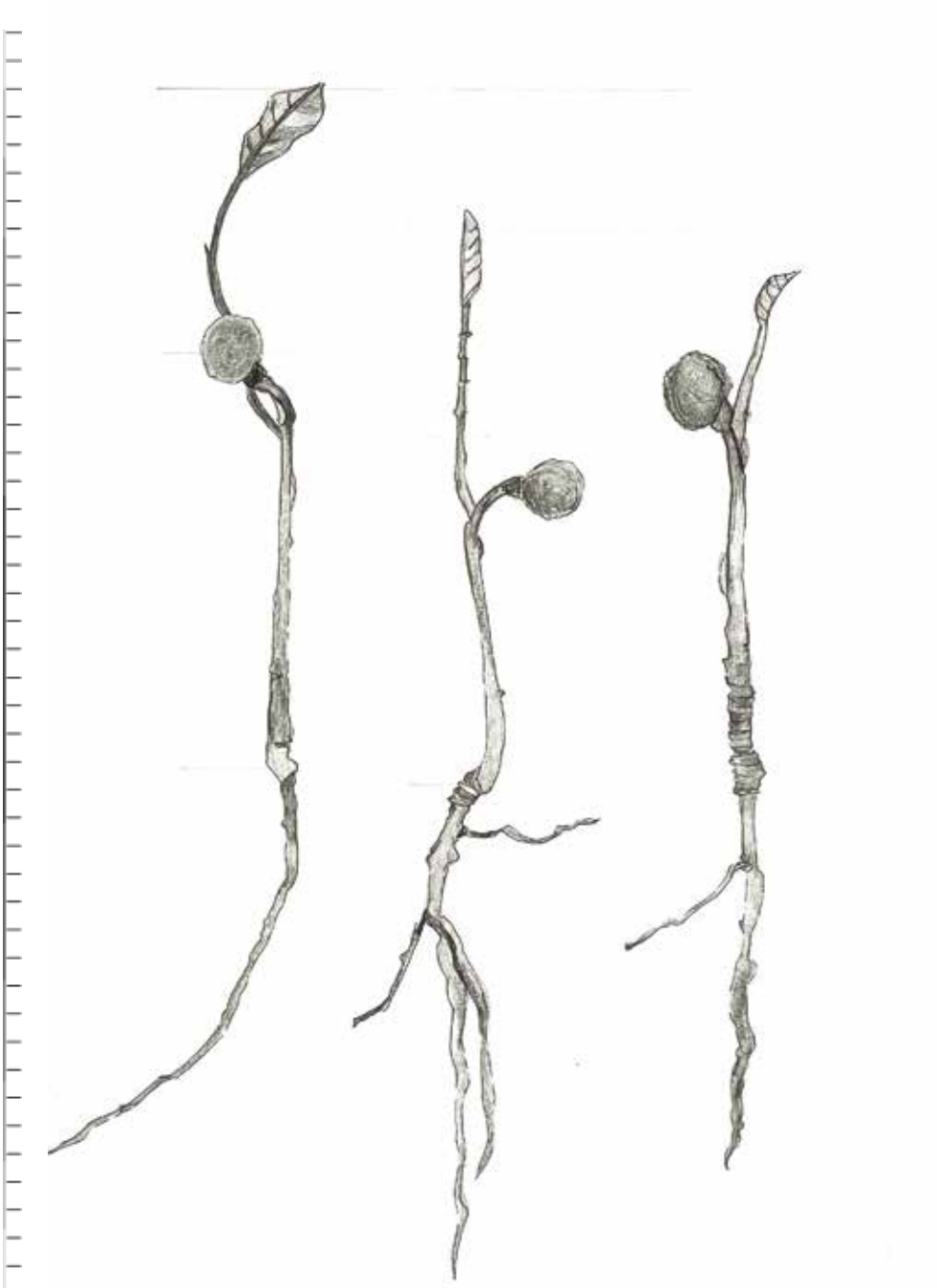
# *Virola surinamensis*

*Plantae*
*Equisetopsida*
*Tracheophyta*
*Magnolianae*
*Myristicaceae*
*Virola*
*surinamensis (Rol. ex Rottb.) Warb., 1897*

Colloquial names in French Guiana
Nomes coloquiais na Guayana Francesa:

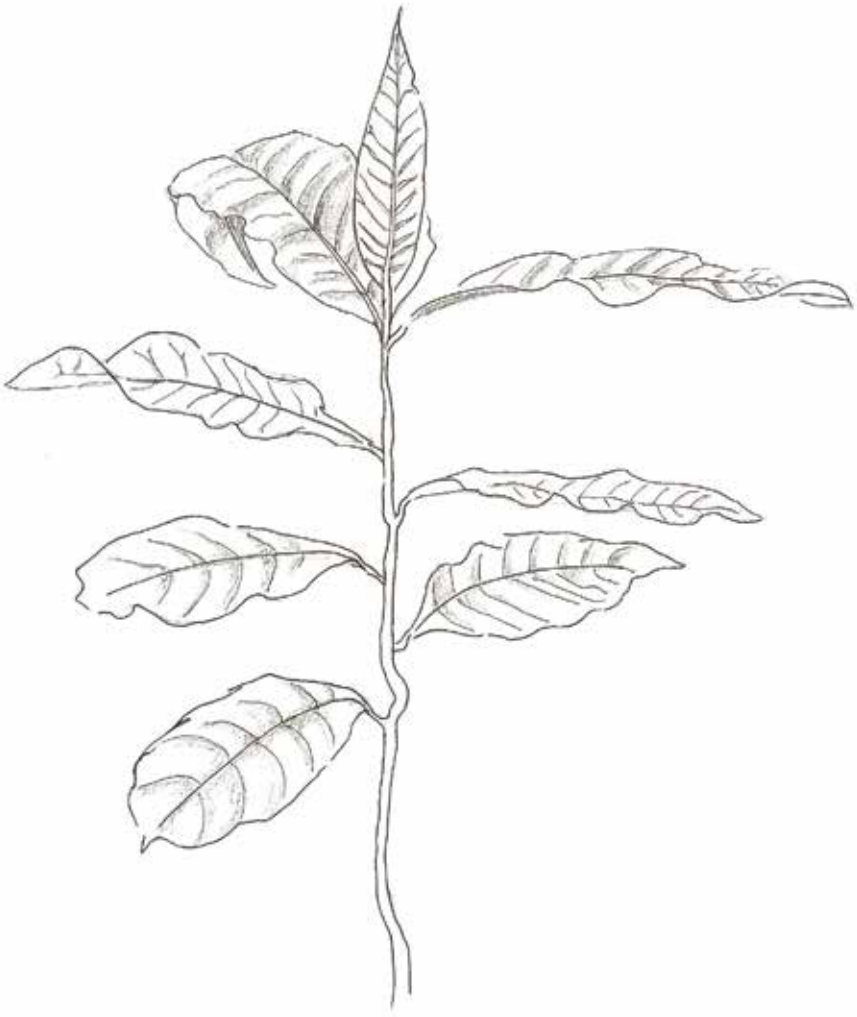
Créole **djadjamadou-marikaj**
Français **yayamadou marécage**
Kali'na **walusi, walushi**
Nengee tongo **malumba**
Palikur **wahusi**
Portugais **ucuúbabranca**
Teko **waletsi**
Wayana **aluti, waluti**
Wayapi **walusi**

**Code I**



**Code II**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Soft pencil gradient draw.



**Code III**

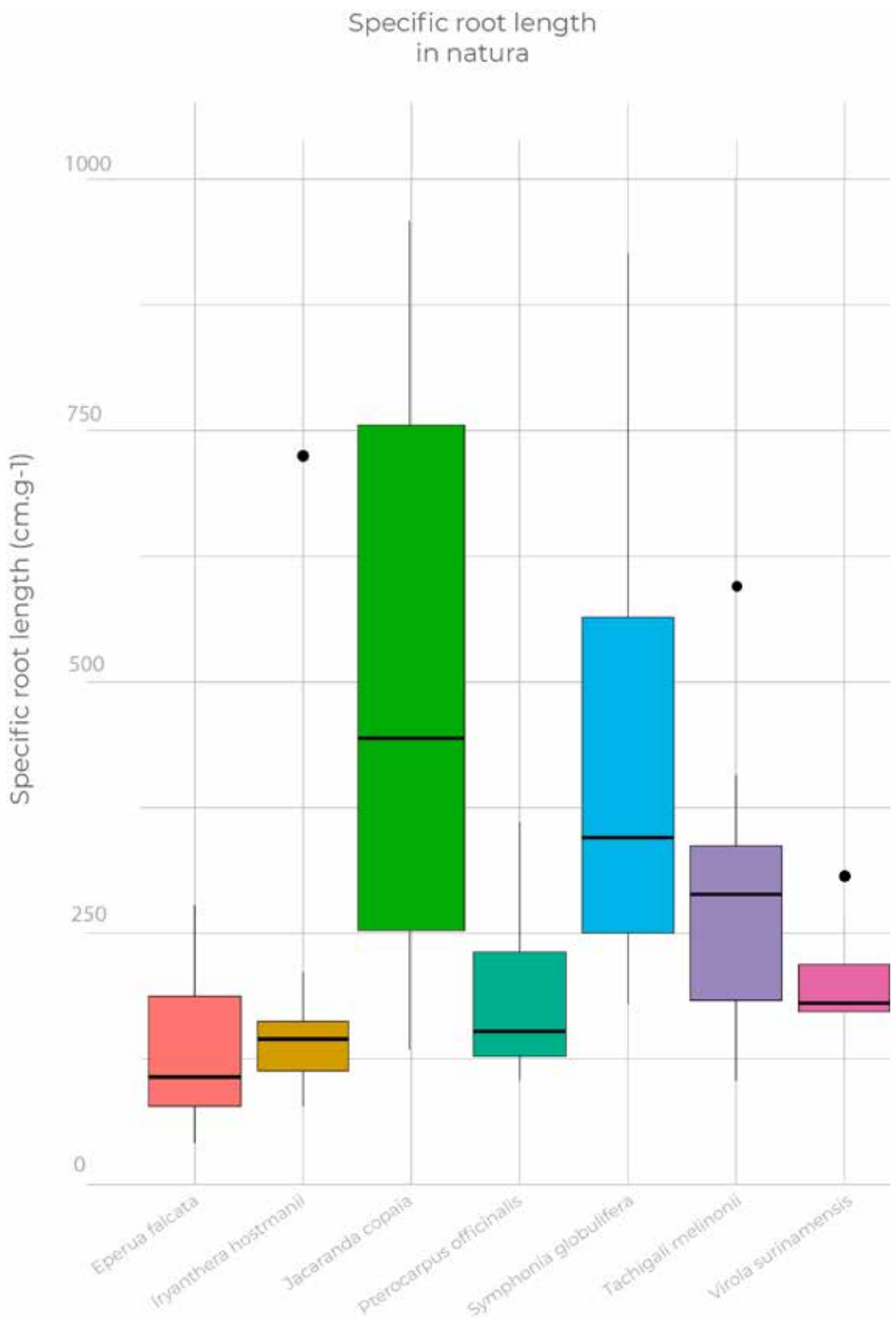
500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Line draw, calibrated pen 0,05 - 0,2.

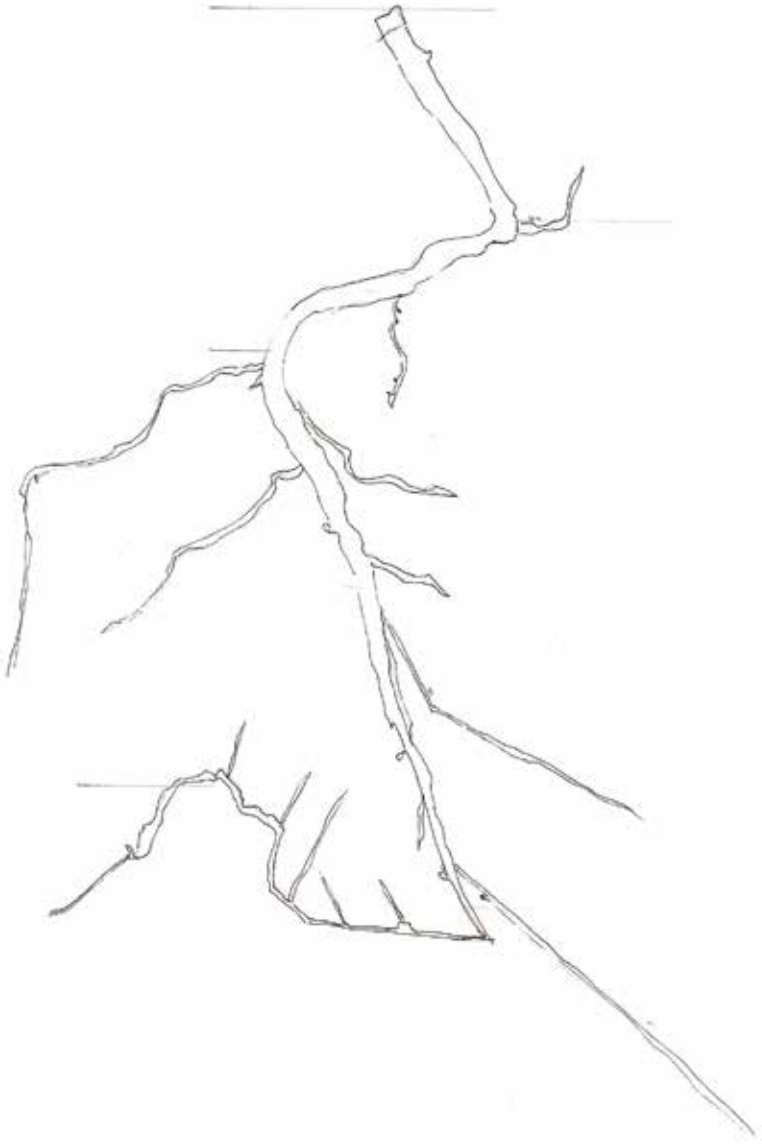
**Code IV**

500 x 350 mm Hahnemühle Britannia Paper 300 gm.
Watercolor and calibrated pen 0,05.

While measuring the specific root length (SRL, m.g–1), the length-to-mass ratio (L/M) of a root fragment, we observed that *Virola surinamensis* has very few fine roots compared to *Jacaranda copaia subsp. copaia*. Its root system is indeed made up of taproots, wide roots that dig the soil vertically and on which secondary roots develop laterally.

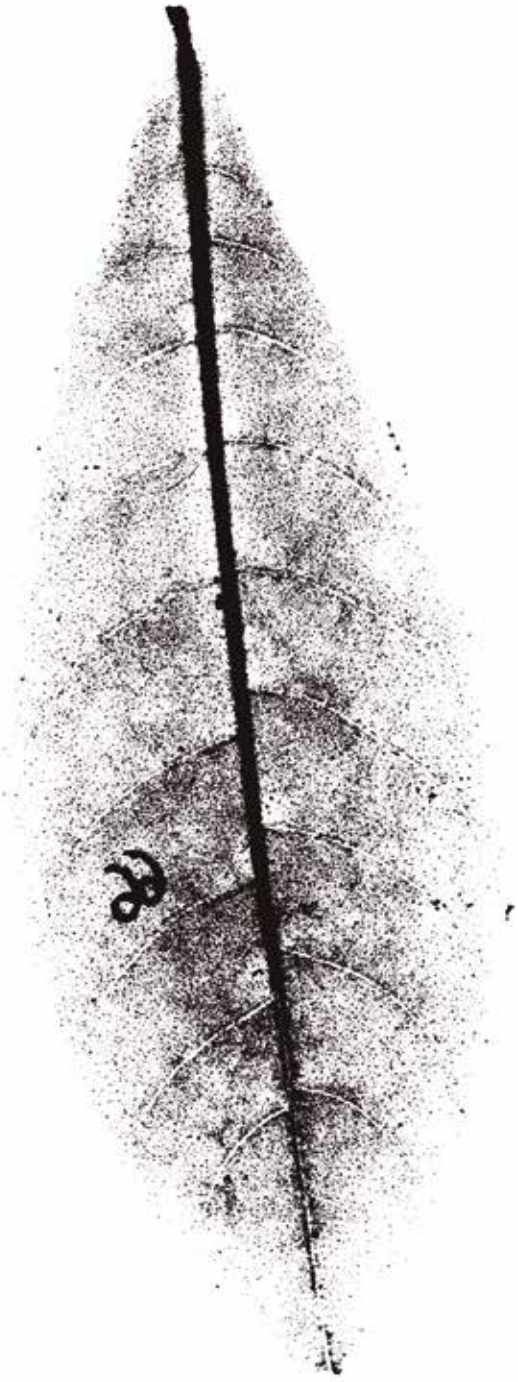
Ao medir a lonxitude específica da raíz (SRL, m.g-1), a relación lonxitude/masa (L/M) dun fragmento de raíz, observamos que *Virola surinamensis* ten moi poucas raíces finas en comparación coa *Jacaranda copaia subsp. copaia*. En efecto, o seu sistema radicular está formado por raíces pivotantes, raíces anchas que excavan o chan de xeito vertical e sobre as que medran lateralmente as raíces secundarias.


Specific root length
in natura
Specific root length (cm.g-1)
1000
750
500
250
0
Eperua falcata
Iryanthera hostmanii
Jacaranda copaia
Pterocarpus officinalis
Symphonia globulifera
Tachigali melinonii
Virola surinamensis

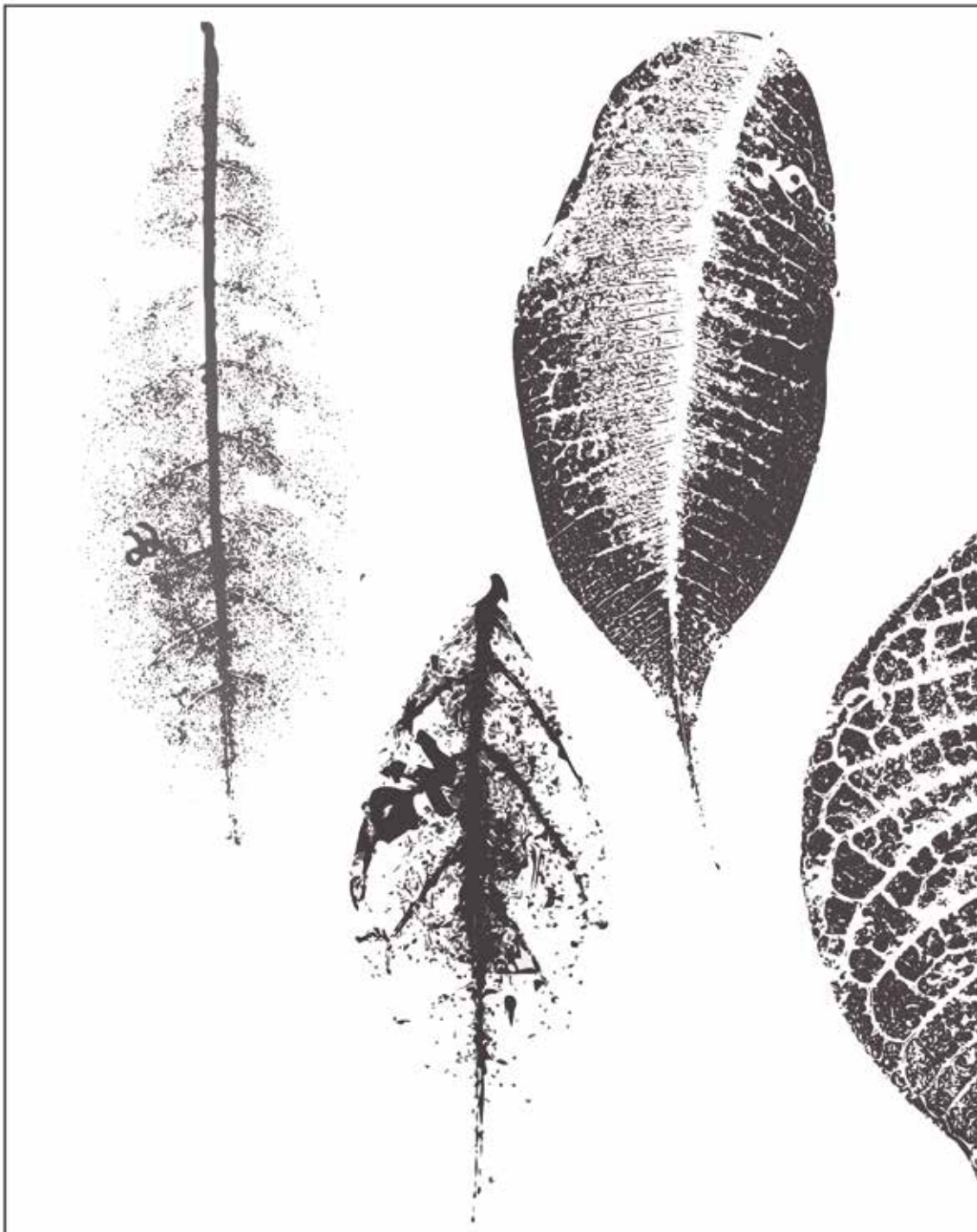


**Code VI**

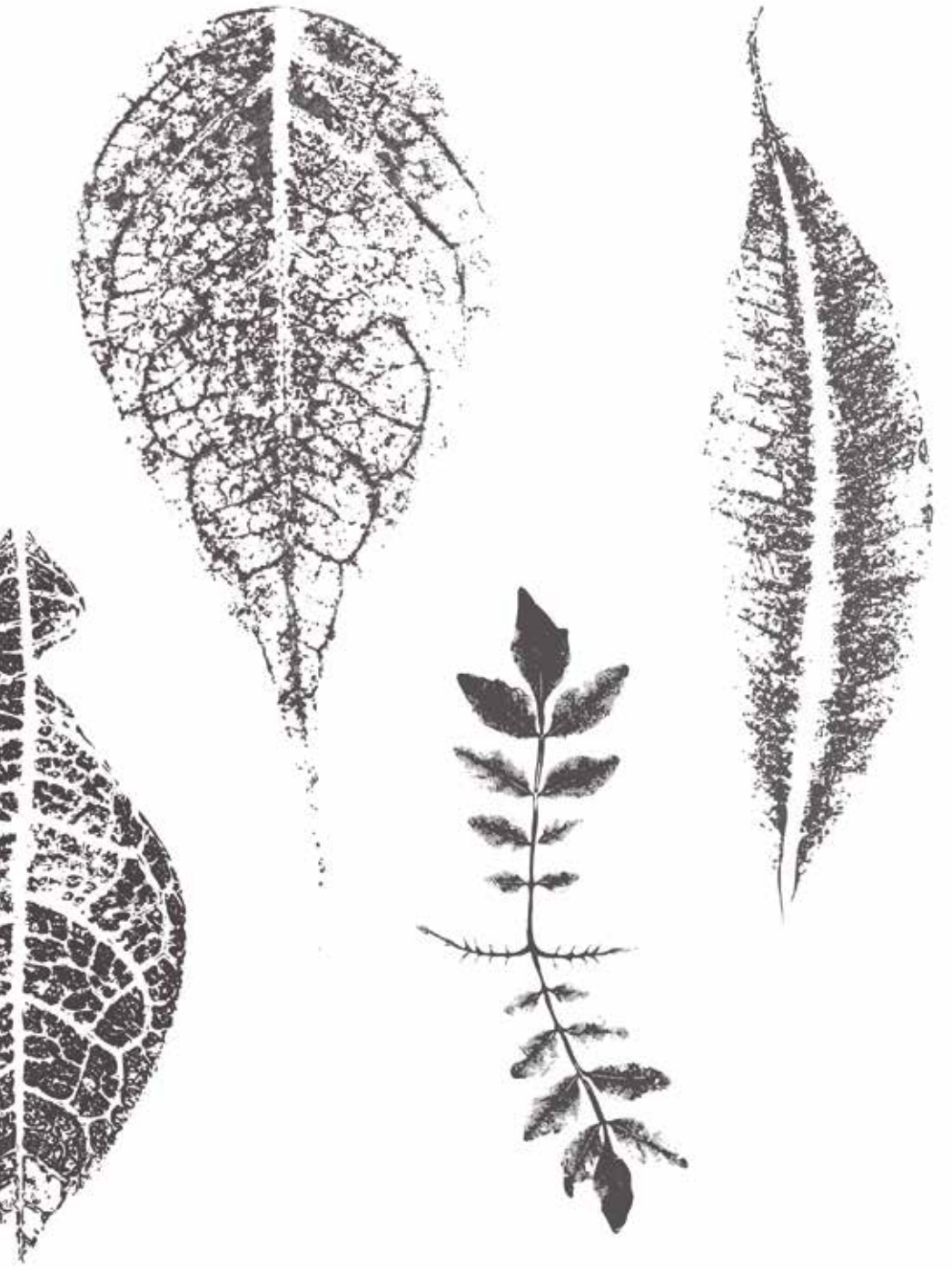
500 x 350 mm Hahnemühle Britannia Paper 300gm.
Line draw, calibrated pen 0,05 - 0,2.



**Code VII** Digital image obtained from a leave scan.



'REPRÉSENTATION BIOMIMÉTIQUE, LE MICRO-PAYS
Rencontre art-science, C
Colaboration Antía IGLESI



SAGE DANS LES FEUILLES D'ESPÈCES TROPICALES'
Guyane Françoise 2021
AS et Marion BOISSEAUX

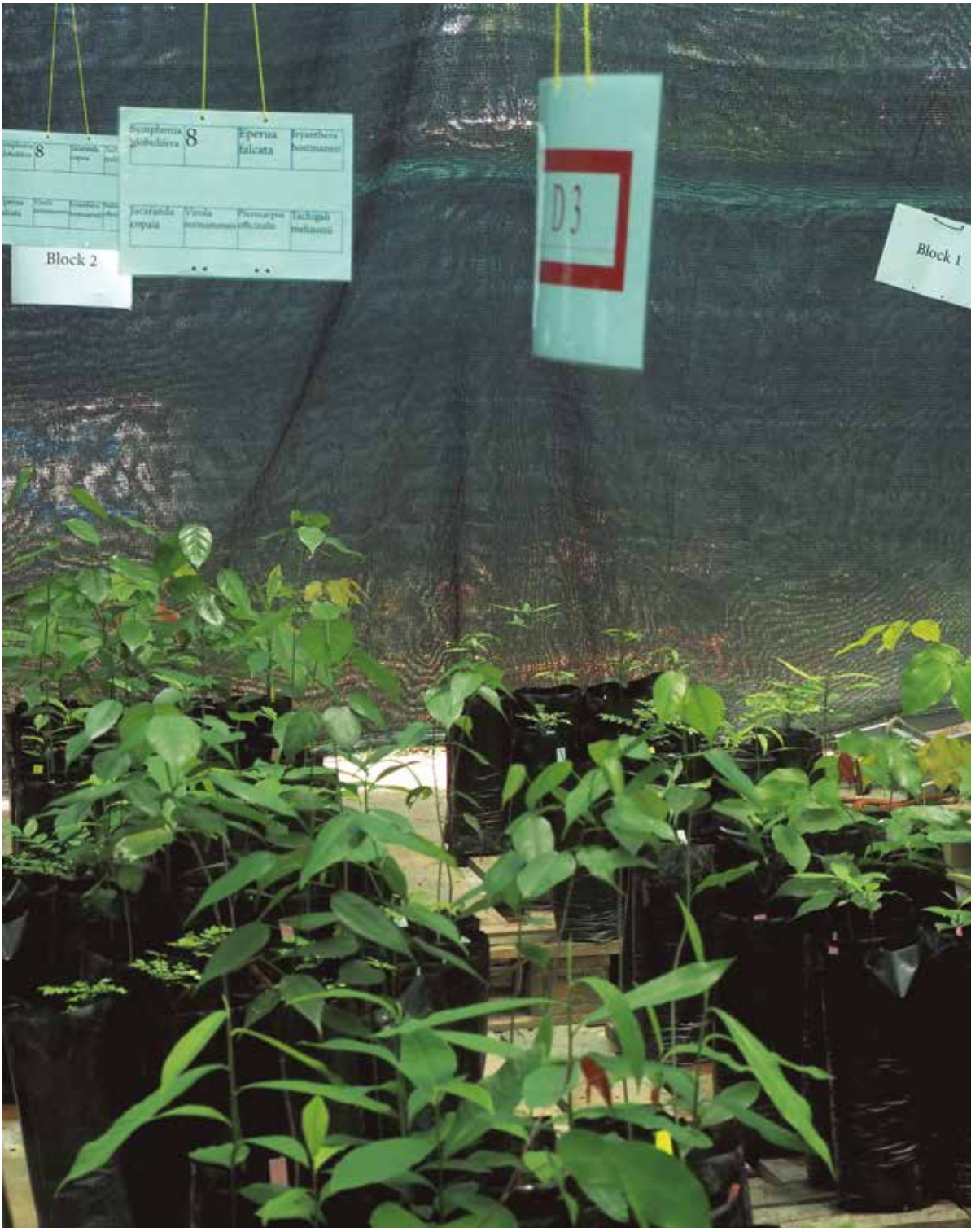
Greenhouse experience space


Control
D1
EPA

First greenhouse space - storage space

*Symphonia globulifera*

*Tachigali melinonii*




Greenhouse experience space


D 3
D 1

Laser-xilography matrixes

Laser-xilography matrixes

# VI. How to summarise multidimensionality?

In data analysis, we have to find statistical methods that are both descriptive and multidimensional.

**But how can we group all of our information to analyse simultaneously all our traits ?**

A common method to explore our data is the principal component analysis. We represent all of our individuals in an n-dimensional space, where n is equal to our number of traits and try to represent every individual in a 2-dimensional space without losing too much information.

Figures 5 & 6: Here, you can see how species occupy their own space when we observe them through our different traits :

- Height
- Stem diameter
- Number of leaves
- Chlorophyll fluorescence (fvfm)
- Leaf thickness (LT)
- Root to shoot ratio
- Root length.

We manage to keep more than half of the information when shrinking to 2-dimensions.

# VI. Cómo resumir a multidimensionalidade?

Na análise de datos, temos que atopar métodos estatísticos que sexan á vez descritivos e multidimensionais.

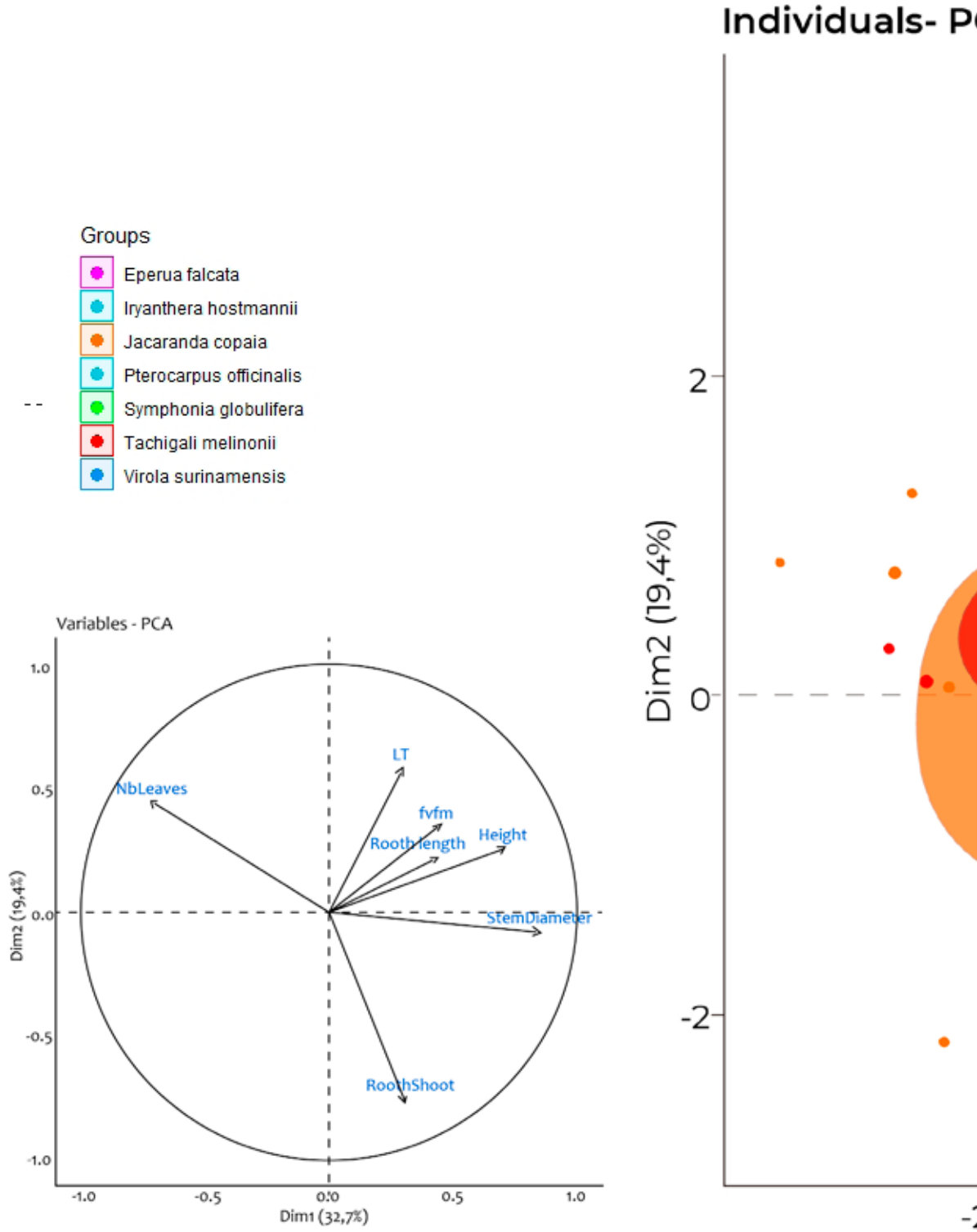
**Pero, como podemos agrupar toda a nosa información para analizar simultaneamente todos os nosos trazos?**

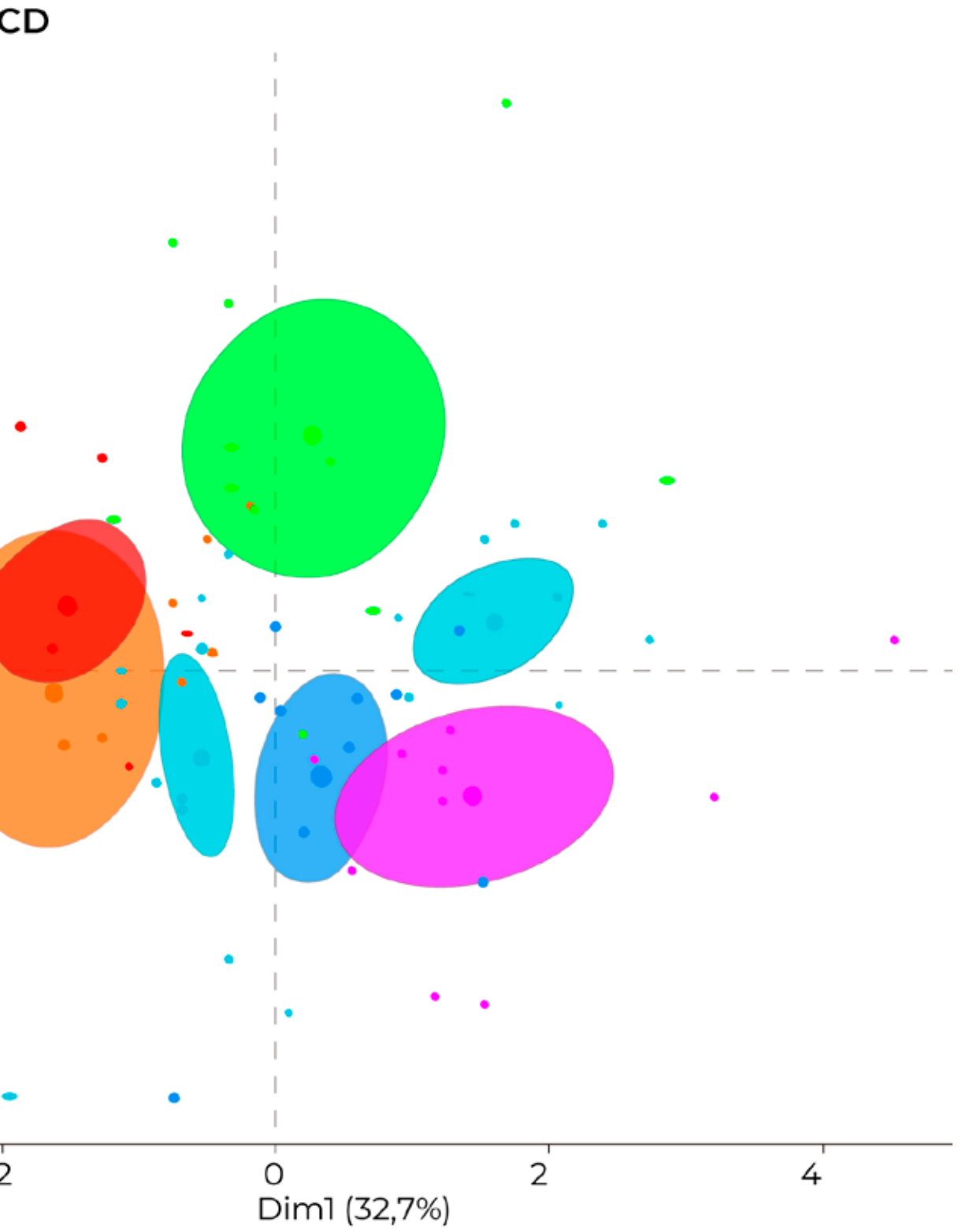
Un método habitual para explorar os nosos datos é a análise de compoñentes principais (ACP). Representamos a todos os nosos individuos nun espazo n- dimensional, onde *n* é igual ao noso número de trazos, e tentamos representar a cada individuo nun espazo bidimensional sen perder demasiada información.

Figuras 5 & 6: Aquí podes ver como as especies ocupan o seu propio espazo cando as observamos según as súas diferentes características ou trazos:

- Altura
- Diámetro do talo
- Número de follas
- Fluorescencia da clorofila (fvfm)
- Grosor das follas
- Relación raíz - brote
- Largo das raíces

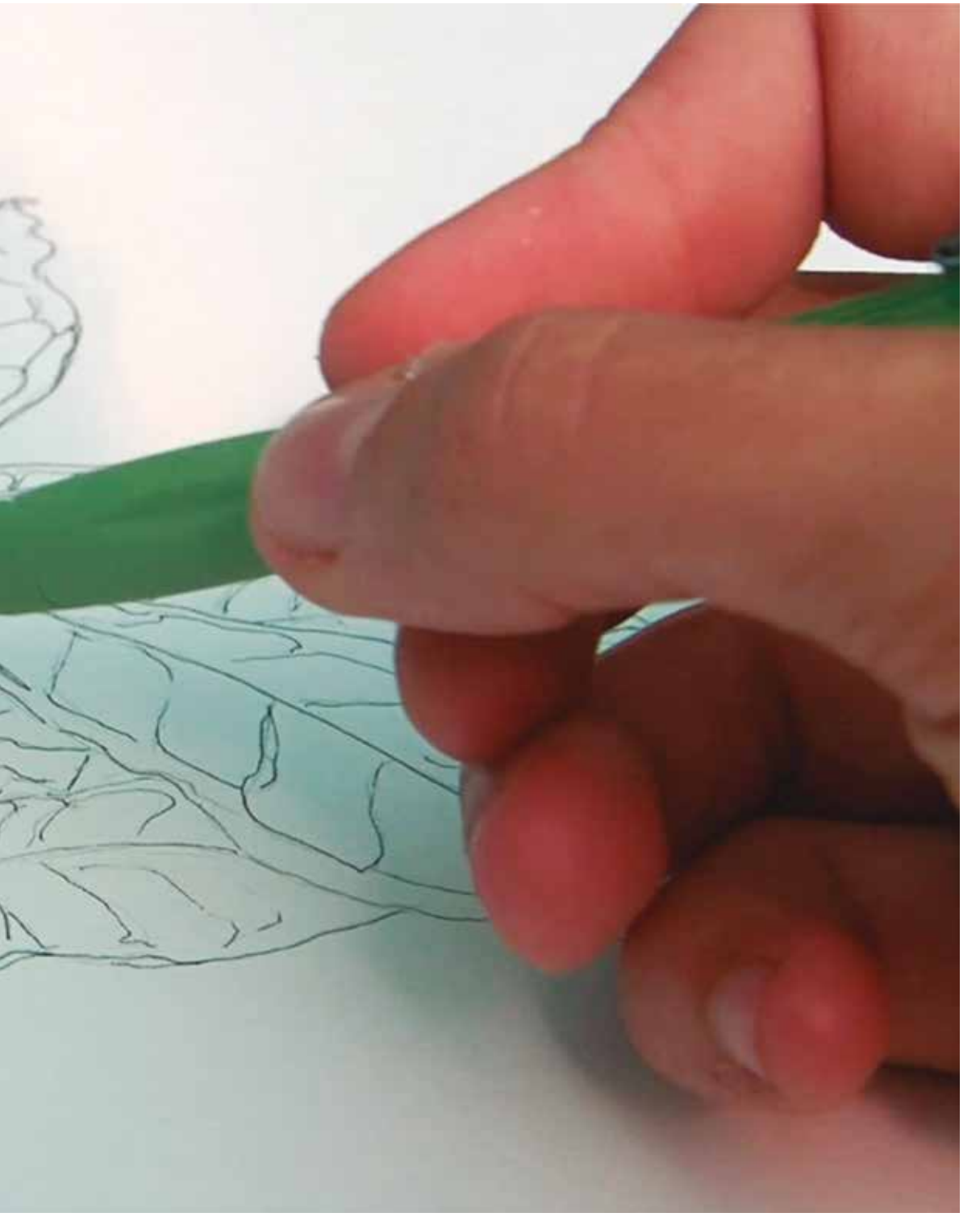
Conseguemos manter máis da metade da información cando a contraemos á dúas dimensións.


Individuals- P
Groups
Eperua falcata
Iryanthera hostmannii
Jacaranda copaia
Pterocarpus officinalis
Symphonia globulifera
Tachigali melinonii
Virola surinamensis
Dim2 (19,4%)
2
0
-2
Variables - PCA
LT
NbLeaves
fvfm
RootLength
Height
StemDiameter
RootShoot
Dim2 (19,4%)
1.0
0.5
0.0
-0.5
-1.0
-1.0
-0.5
0.0
0.5
1.0
Dim1 (32,7%)


CD
2
0
2
4
Dim1 (32,7%)


A quick look to the scientific process

A quick look to the artistic process



# VI. An artistic evolution

**Micro-landscapes** are found by decreasing the viewing area and zooming in.

When dealing with complex structures created with layers of dots, lines, knots, curves and shades our eye is not enough to capture the real representation of the object. We can just try to get next to it and to have a place where our creation becomes true. By using technology and scientific tools like the microscope, the scan, several softwares and interfaces and a laser cutting machine, we get a bit closer to this 'real representation'. This approach also gives us the opportunity to de-contextualise the image and opens a lot of different ways to dive in.

The textures and paths correspond to the imprint of each leaf of each specimen. Using several tools and technologies, these landscapes can be transferred to another surface, allowing them to be reproduced and increasing the tangible quality of images that we do not normally stop to look at.

By making use of scientific processes such as the study of stomata through microscopes or the reading of leaf veins, we arrive at plastically and visually interesting results.

Through parameterised processes, the hypothesis of the machine as creator has been put forward, reducing the intervention of the artistic hand to a minimum, partially eliminating the subjective component of the piece. From this approach, which is materialised in the form of wooden matrices made by laser cutting, the viability of the human/artistic eye to faithfully or accurately reproduce what we have before us is questioned. And consequently the added interest that a creation has, from both approaches. What does the intervention of an artist bring to our interpretation of the world? What does the objective and methodical representation through a machine tell us about our environment?

# VI. Unha evolución artística

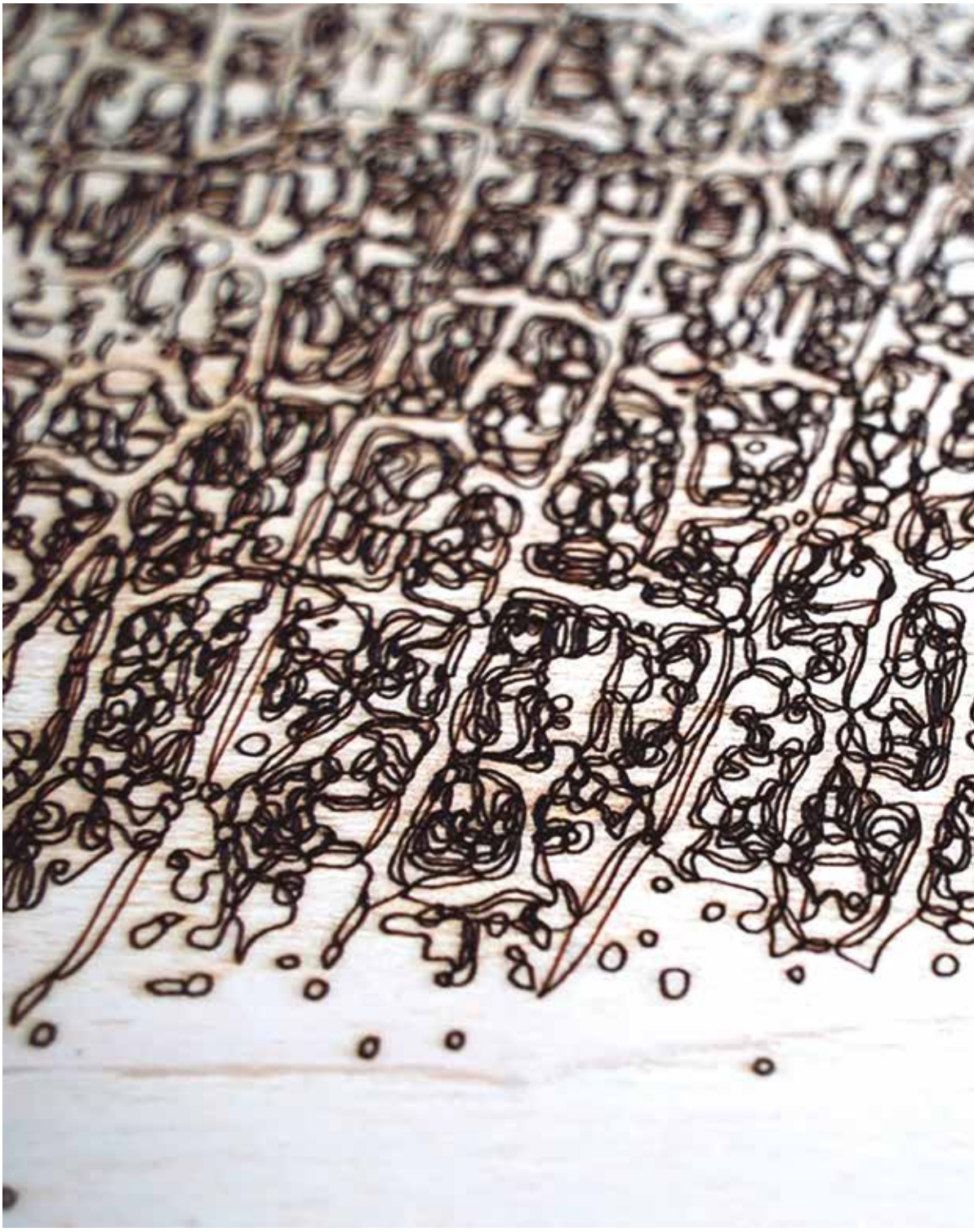
**Micro-paisaxes** atópanse ao diminuír a área de visualización e facer zoom.

Cando se trata de estruturas complexas creadas con capas de puntos, liñas, nós, curvas e sombras, o noso ollo non é suficiente para captar a representación real do obxecto. Simplemente podemos tentar achegarnos a el e ter un lugar onde a nosa creación fágase realidade. Mediante o uso de tecnoloxía e ferramentas científicas como o microscopio, o escáner, varios softwares e interfaces e unha máquina de corte por láser, achegámonos un pouco máis a esta 'representación real'. Este enfoque tamén nos brinda a oportunidade de descontextualizar a imaxe e abre moitas formas diferentes de mergullarnos.

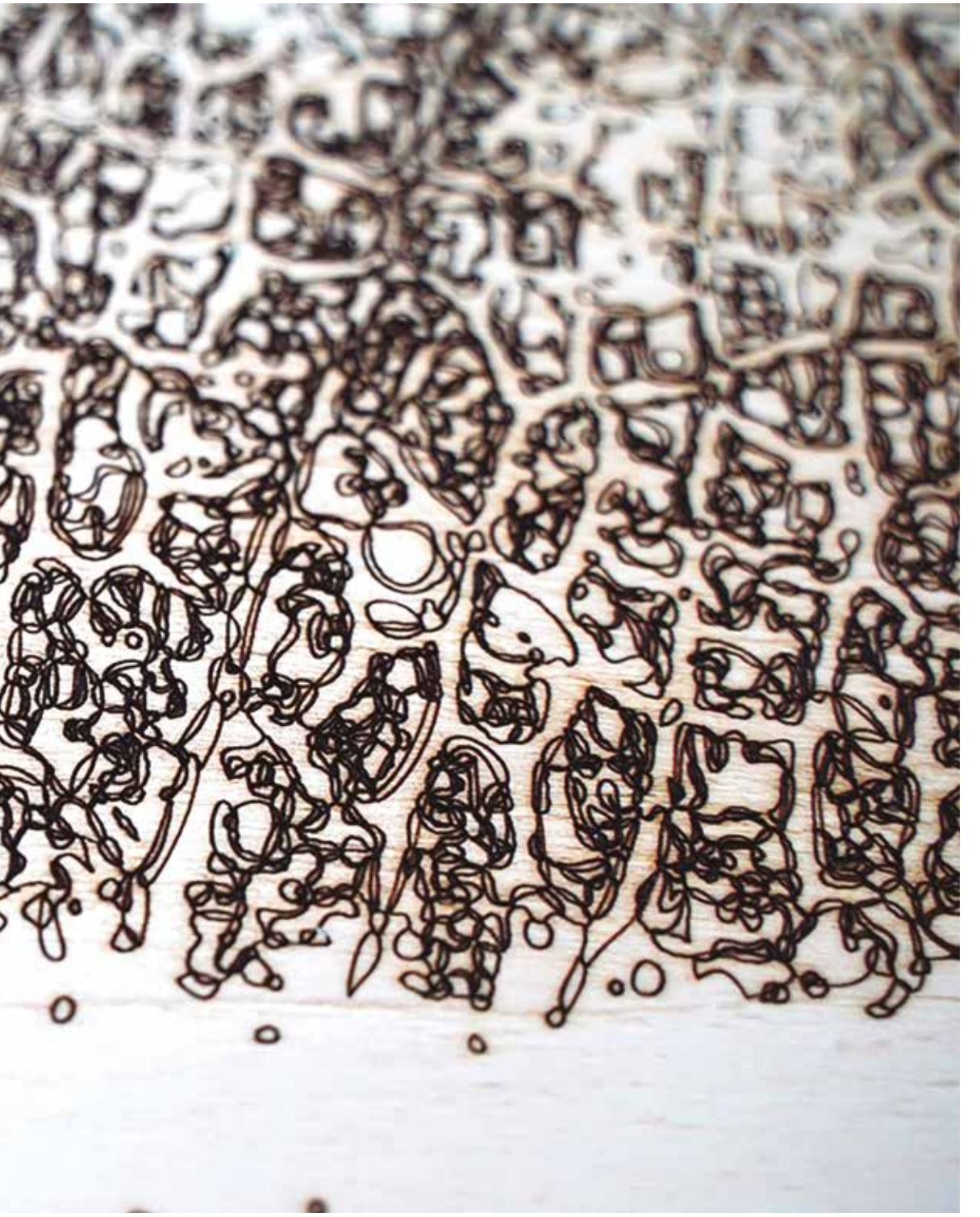
As texturas e percorridos corresponden á pegada de cada folla de cada exemplar. Mediante varias ferramentas e tecnoloxías, estas paisaxes poden trasladarse a outra superficie, o que permite reproducilos e aumentar a calidade tanxible de imaxes que normalmente non nos detemos a mirar.

Facendo uso de procesos científicos como o estudo dos estomas a través de microscopios ou a lectura das nervaduras das follas, chegamos a resultados plásticos e visualmente interesantes.

A través de procesos parametrizados expúxose a hipótese da máquina como creadora, reducindo ao mínimo a intervención da man artística, eliminando parcialmente o compoñente subxectivo da peza. Desde esta formulación, que se materializa en forma de matrices de madeira realizadas mediante corte por láser, cuéstionase a viabilidade do ollo humano/artístico para reproducir verídica ou fielmente o que temos ante nós. E en consecuencia o interese engadido que ten unha creación, desde ambos os enfoques. Que achega a intervención dun artista á nosa interpretación do mundo? Que nos di a representación obxectiva e metódica a través dunha máquina sobre a nosa contorna?



Detail of a micro-landscape. Wood matrix made by a laser cutting machine

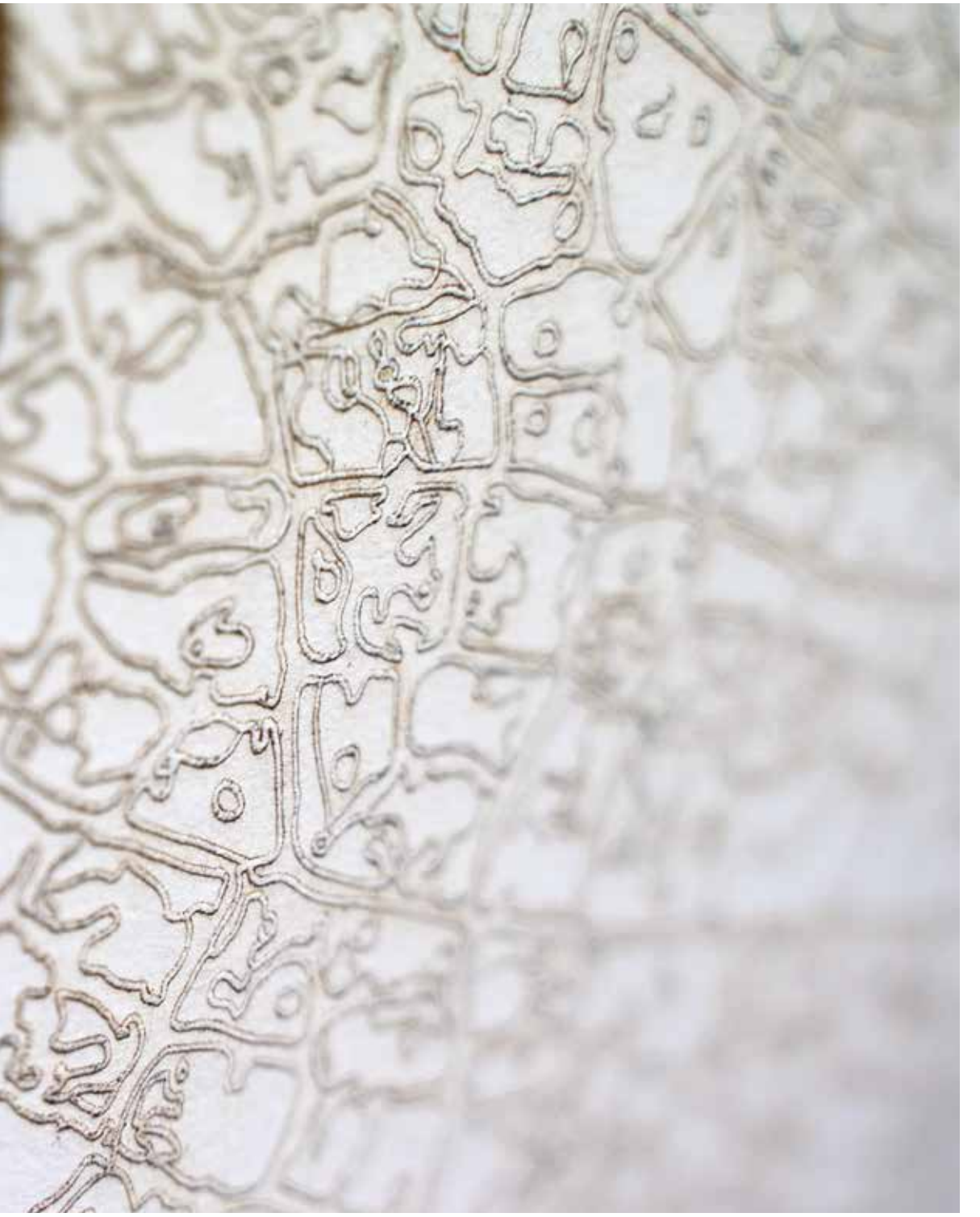


Antía Iglesias' workshop space

The resulting images are, once again, samples and reflections of the original plant. They combine different conceptualisations of the plant through processed versions of numerical data. These results are a physical materialization of the scientific research, images created via a set of lines and dots.

As imaxes resultantes son, unha vez máis, mostras e reflexos da planta orixinal. Unha versión procesada de datos numéricos; materialización directa da investigación científica, imaxes que conforman o seu interese en liñas e puntos.

Detail of two embossed prints from laser-xilography printing



# VII. Terms and curiosities

**Bio-mimetic** n (the design and production of materials, structures, and systems that are modelled on biological entities and processes).

In design vocabulary biomimicry could be summarised as "finding solutions through natural processes" in words of the designer Shneel Malik, who developed the project *Indus*, 'a tile-based filtration system, which is "inspired by the architecture of a leaf". It regenerates water for reuse within the manufacturing process. Water flows over a "series of vein-like channels containing algae prepared in a seaweed-based hydrogel" as part of a decontamination process.' (Wong, 2019).

In the Biomimicry Institute, Montana, United States of America, they use the term '**Bio-inspired design'.** Inside this term we could find three different approaches, **Biomimicry, Bioutilisation and Biomorphism**. Bio-inspired design is defined as a general term to describe "design and engineering approaches, including biomimicry, that use biology as a resource for solutions".

Under this perspective they assure that 'Biomimicry is about valuing nature for what we can learn, not what we can extract, harvest, or domesticate. In the process, we learn about ourselves, our purpose, and our connection to each other and our home on earth. (...) The emphasis is put on learning from and emulating the regenerative solutions living systems have for specific functional challenges.'

**Biomorphism** 'looks like nature, mimics natural forms and patterns' (Bernett, 2015).

**Bio-utilisation** 'uses nature, leverages organisms or biological materials' (Bernett, 2015)

'The **bio-inspired innovation** movement could offer resilience to climate change, health epidemics and economic uncertainty in the form of energy- and resource-optimised products, processes and systems.' (Bernett, 2015)

**Graphic image**
Visual compositions to solve problems and communicate ideas through typography, imagery, colour and form.

**Graphic techniques**
This is the name given to the whole set of processes that allow communication through visual language, by means of a variety of technologies or methodologies. Nowadays we master such a wide range of digital and analogue skills that we can, without a doubt, respond to almost any need, both technical and expressive

When we go back to the origins of this discipline, the first printing technique

# VII. Termos e curiosidades

**Biomimética** n (o deseño e a produción de materiais, estruturas e sistemas que seguen o modelo de entidades e procesos biolóxicos).

No vocabulario do deseño, a biomimética podería resumirse como "atopar solucións a través de procesos naturais", en palabras do deseñador Shneel Malik, que desenvolveu o proxecto *Indus*, "un sistema de filtración baseado en azulexos, que está "inspirado na arquitectura dunha folla". Rexenera a auga para reutilizala no proceso de fabricación. A auga flúe sobre unha "serie de canles en forma de vea que conteñen algas preparadas nun hidrogel a base de algas" como parte dun proceso de descontaminación.' ( Wong, 2019).

No Biomimicry Institute, Montana, Estados Unidos de América, utilizan o termo **'Bio-inspired design'.** Dentro deste termo podemos atopar tres enfoques diferentes, **Biomimicry, Bioutilisation e Biomorphism**. O deseño bioinspirado defínese como un termo xeral para describir "os enfoques de deseño e enxeñería, incluíndo a biomímesis, que utilizan a bioloxía como recurso para as solucións".

Baixo esta perspectiva aseguran que "o biomimetismo consiste en valorar a natureza polo que podemos aprender, non polo que podemos extraer, cultivar ou domesticar. No proceso, aprendemos sobre nós mesmos, o noso propósito e a nosa conexión cos demais e co noso fogar na Terra. (...) A énfase ponse na aprendizaxe e a emulación das solucións rexenerativas que teñen os sistemas vivos para os desafíos funcionais específicos".

O **biomorfismo** "parécese á natureza, imita as formas e patróns naturais" ( Bernett, 2015).

A **bioutilización** "utiliza a natureza, aproveita os organismos ou os materiais biolóxicos" ( Bernett, 2015)

"O movemento de **innovación bioinspirada** podería ofrecer resistencia ao cambio climático, ás epidemias sanitarias e á incerteza económica en forma de produtos, procesos e sistemas optimizados en canto a enerxía e recursos". (Bernett, 2015)

**Imaxe gráfica**
Composicións visuais para resolver problemas e comunicar ideas a través da tipografía, as imaxes, a cor e a forma.

**Técnicas gráficas**
Denomínase así a todo o conxunto de técnicas, posibilidades ou procesos que permiten a comunicación a través da linguaxe visual, mediante diversas tecnoloxías ou metodoloxías. Hoxe en día dispoñemos dun abanico tan amplo de técnicas dixitais e analóxicas que podemos, sen dúbida, responder a case calquera

was the handprints on walls, a monotype, recording our need to express ourselves as human beings.

By knowing our origins we can better understand or understand the interrelationships derived from the need to make ourselves seen. From this period onwards, various techniques appeared that allowed the reproduction and diffusion of the captured thought.

**Printmaking techniques**

Originally linked to the dissemination of knowledge, engraving techniques are those which, by means of mechanical and manual processes, consist in incising or digging with a tool a matrix. Linked in the same way to artistic creation, they have evolved throughout history at the same time as industrial innovation, favouring graphic, visual and technical experimentation.

The following is a brief chronological approach to the engraving skills traditionally related to botanical representation. It should be noted that within the world of 'graphic techniques' there are numerous possibilities, new processes and opportunities, so the list reflected here is limited to the most traditional or directly related to the history of botanical illustration (Bridson & Wendel, 1986). It was the invention of these processes that allowed botanical illustration to go a step further and become a collective knowledge. Favouring the dissemination of knowledge, 'graphic techniques' aided and abetted the creation of scientific images that helped to maintain a multiple and evolving record of the international flora.

**Xylography** Relief printing technique carried out on a wood matrix. It originated in the 5th century BC in the East and in the s. XIII in the West, being the oldest printing technique.

**Intaglio.** Dating back to the 14th-15th century, Intaglio is the name that covers all metal engraving techniques, regardless of the printing method used and the way of obtaining the image on the matrix. The main techniques are: **engraving, etching, drypoint, verniz brando, aquatint and mezzo-ink.** The process known as "À-la poupée" was the first way of applying colour to intaglio engraving.

**Lithography.** Discovered in 1789 by Aloys Senefelder, lithography is a printing technique based on the mutual repulsion of water and oil. After preparing the surface, the design can be drawn on with a grease pencil, which then retains the ink. The design is transferred to the paper by applying pressure.

Other engraving techniques that represent an intermediate stage between traditional manual

necesidade, tanto técnica como expresiva.

Cando nos remontamos á orixe desta disciplina, comprendemos que a primera técnica de estampación foron as marcas nas paredes, o monotipo, un rexistro da nosa necesidade de expresarnos e recoñecernos como seres humanos.

**A primeira técnica de impresión** foi a marca xerada por unha man sobre un muro, un monotipo que deu lugar á necesidade de rexistrar a nosa experiencia sensible como seres humanos.

Coñecendo as nosas orixes podemos entender ou atopar mellor as interrelacións derivadas da necesidade de facernos ver. A partir deste intre, paralelamente aos avances técnicos da historia, apareceron diversas técnicas que permitiron a reprodución e difusión do pensamento plasmado.

**Técnicas de gravado**

Orixinalmente vinculadas á difusión do coñecemento, as técnicas de gravado son aquelas que, mediante procesos técnicos e manuais posibilitan a reproducción múltiple dunha matriz física. Vinculadas de igual maneira á creación artística, evolucionaron ao longo da historia de xeito simultáneo ás innovación tecnolóxicas, favorecendo á experimentación gráfica, visual e técnica.

A continuación preséntase unha **pequena aproximación cronolóxica ás técnicas de gravado tradicionalmente relacionadas coa representación botánica.** É necesario destacar que dentro do mundo das técnicas gráficas temos numerosas posibilidades, novos procesos e oportunidades, polo que a lista aquí reflectida limitouse ás máis tradicionais ou directamente relacionadas coa historia da ilustración botánica (Bridson & Wendel, 1986).

Foi a invención destas técnicas o que permitíu que a ilustración botánica fora un paso máis aló e se convertira nun coñecemento colectivo. Favorecendo a diseminación do coñecemento, as técnicas gráficas axudaron e impulsaron a creación de imaxes científicas que axudaran a manter un rexistro múltiple i evolutivo da flora internacional.

**Xilografía** Técnica de impresión en relevo realizada sobre unha matriz de madeira. Xurde no s. V a.C en Oriente e no s. XIII en Occidente, sendo a técnica de impresión máis antiga.

**Calcografía** Termo que abarca todas as técnicas de gravado en metal, independentemente do método de impresión utilizado e da forma de obter a imaxe na matriz. Datada do s. XIV-XV. As principais son: **buril, aguafuerte, punta seca, verniz brando, aguatinta e mezzo-tinta.** O proceso denominado **"À-la poupée"** foi a primeira forma de aplicar a cor na calcografía.

processes and photography are: **cyanotype, daguerreotype and calotype.**

With the arrival of photography and its consequent application to botanical graphic representation, a great debate arose about its value as a substitute or complement to illustration.

According to a study ( Hickman et ao., 2017) botanical photography is becoming increasingly accepted and represented in botanical journals as a substitute for illustration due to the scarcity of experts in the sector as well as its production costs. However, in its origins this technique far from popular during fieldword. It was only in a couple of botanical books that photography was used, as in for example Ferns of the British Isles Described and Photographed, by Sidney Courtauld (1877) which contained 20 small photographs of plants.

Nowadays, there is still an ongoing debate about the ability of photography to replace the eye and the hand of the illustrator as well as faithfully represent the plant. However, all the techniques mentioned, and all those that we are not going to go into, provide us with different approaches, and their interrelation can favour the understanding the plant.

The combination of photography and botanical illustration allows us, for example, to approach the exact structure of the plant at a given moment using photography, while the illustration opens new perspectives to a particular appreciation of the anatomy resulting from the fine and prolonged observation in time of the plant.

**Nature printing.** Direct print of the matrix, being a leaf, plant or any natural element, fresh or dry. This method of direct printing is very interesting as it produces a similar image to the digital image produced with the scan.

**We can find some other graphic creations / type-of-books in relation with the world of botanical illustration. We considered relevant to focus on the significance and origin of the next terms: Florilegium and Herbarium. In relation with the collection of plants for public or private research and education, we also provide a detailed description of what a greenhouse is.**

**Florilegium.** As J. Buck reports for The Botanical Artist- Voumen 16 and for The American Society of Botanical Artists, the first Florilegium appears at the end of the 16th century. Florilegium contain little to no text. The intention is to show the pure beauty and colour of each flower, rather than to inform about its botanical details or medicinal aspects.

**Litografía**. Descuberta en 1789 por Alois Senefelder. A base da técnica é o principio de repulsión da auga e o aceite. Sobre a superficie da pedra debúxase cun lapis de graxa, que retén a tinta e xera a estampa por presión.

Outras técnicas de gravado que supoñen un estado intermedio entre os procesos manuais tradicionais e a fotografía son: a **cianotipia, daguerrotipo e o calotipo**

Coa chegada da fotografía e a súa consecuente aplicación á representación gráfica botánica, xurdiu un gran debate sobre o seu valor como substituto ou complemento da ilustración.

Segundo un estudo ( Hickman et ao., 2017) a fotografía botánica está a ser cada vez máis aceptada e representada nas revistas botánicas en substitución da ilustración debido á escaseza de expertos do sector así como polos seus custos de produción. Con todo, nas súas orixes esta técnica foi pouco aceptada no ámbito. En poucos libros de botánica utilizouse a fotografía, como en *Ferns of the British Isles Described and Photographed*, de Sidney Courtauld, de 1877, que contiña 20 pequenas fotografías de plantas.

Hoxe en día segue habendo desacordo sobre a capacidade da fotografía para substituír o ollo e a man do ilustrador e representar fielmente a planta. Con todo, parece necesario destacar que todas as técnicas mencionadas, e todas aquelas nas que non imos profundar, proporciónannos diferentes aproximacións ao elemento representado, e a súa interrelación pode favorecer o descubrimento de novas formas de entender a planta. A combinación de fotografía e ilustración botánica permítenos, por exemplo, achegarnos á estrutura exacta da planta nun momento determinado (fotografía) e a observación e ilustración do natural ábrenos unha porta á correcta apreciación da anatomía e estruturas, formas reais das follas e unha visión illada do elemento.

**Nature printing**. Principalmente relacionado coa xeración directa dunha huella ou rexistro da matriz, sendo esta matriz unha, folla, planta ou elemento vexetal, seco ou fresco. Este xeito de estampación directa ten especial relación e interés para nos debido a que a imaxe xerada é semellante ou nos remite á matriz intanxible dixital xerada por escaneado.

**Podemos atopar outras creacións ou tipos de libros en relación co mundo da ilustración botánica. Consideramos relevante aclarar a significancia e a orixe dos seguintes termos: Florilegium i Herbario. Máis aló deles i en relación co mundo da botánica e da nosa experiencia, consideramos necesario aclarar igualmente o significado dun Invernadeiro.**

**Florilegium** Como informa J. Buck para The Botanical

**Herbarium**. The term herbarium is defined according to its purpose. According to the British Library, a herbarium is a book of plants describing their appearance, their properties and how they should be used to prepare ointments and medicines.

For the introduction of the Medieval Herbaria to the Illustrative Traditions, Minta Collins states that "Ancient and medieval herbaria were originally conceived as books of simples, a simple being "a medicine or medicine composed or made from a single constituent, especially from a herb or plant". A typical chapter of a herbarium may contain the following details (without being exhaustive):

the plant's name with its synonyms; the characteristics; the distribution and habitat; literature of previous findings; the method of collection; the medicinal properties; any recipes to prepare ointment or medical cures with its contraindications, if any.

From these definitions, a herbarium has a scientific, descriptive and even an educational purpose rather than an aesthetic purpose of the species.

**Greenhouses** are structures covered with a transparent material in which plants are grown under controlled environmental conditions. In general greenhousesare associated with off-season production of vegetables, ornamental plants and high-value food crops in cold climate zones where outdoor production is not possible. Environmental control includes temperature, light, carbon dioxide levels, relative humidity, water, plant nutrients and pest control (Singh, 2008).

Artist- Voumen 16 e para The American Society of Botanical Artists, o primeiro Florilegium aparece a finais do século XVI. As florilegias conteñen pouco ou ningún texto. A énfase das creacións esta nas imaxes, destinadas a mostrar a beleza pura e a cor de cada flor, máis que a informar sobre os seus valores botánicos ou medicinais.

**Herbario** O termo herbario defínese de diferentes maneiras dependendo do seu propósito principal. Segundo a Biblioteca Británica, un herbario é un libro de plantas no que se describe o seu aspecto, as súas propiedades e como deben utilizarse para preparar ungüentos e mediciñas.

En palabras de Minta Collins para a introdución dos *Herbarios medievais as Tradicións Ilustrativas* "Os herbarios antigos e medievais foron concibidos orixinalmente como libros de simples, sendo un simple "unha medicina ou medicamento composto ou confeccionado cun só constituínte, especialmente dunha herba ou planta". Un capítulo típico dun tratado de herbas nomea a planta, dá unha lista de sinónimos, describe as súas características, a súa distribución e o seu hábitat, informa do que dixeron os autores anteriores sobre ela, as súas propiedades medicinais, como debe recollerse e prepararse, enumera as receitas que se fan con ela, ou enumera as curas para as que se utiliza, e dá calquera contraindicación. ".

Destas definicións pódese concluír que un herbario responde a unha finalidade científica, descritiva e mesmo instructiva/ educativa máis que a unha finalidade estética ou representativa da especie.

**Invernadoiro** son armazóns de estrutura inflada cubertos cun material transparente nos que se cultiva en condicións de ambiente controlado. En xeral, os invernadoiros e outras tecnoloxías para a produción de plantas en ambiente controlado asócianse á produción fóra de tempada de hortalizas, plantas ornamentais e cultivos alimentarios de alto valor en zonas de clima frío onde non é posible a produción ao aire libre. O control ambiental inclúe a temperatura, a luz, os niveis de dióxido de carbono, a humidade relativa, a auga, os nutrientes das plantas e o control de pragas (Singh, 2008).

# VIII. Conclusions

Kosuth's works inspired us to question the different modes of representation of a plant. We displayed our artistic and scientific points of view of the plant, using different drawing techniques supported by scientific data to describe what we were seeing. We have at least eight dimensions to take into account when talking about a plant: words, shades, lines, colours, roots, data, imprints, photographs. By simultaneously displaying these different aspects, we aim to prompt the reader to question what meaning does each dimension bring to the table. Behind each of the seven tropical tree species, we unravel new angles, always adding more information to enhance our understanding of these plants.

Each element taken from the two different disciplines can respectfully relate a story. However, not only a juxtaposition of stories, we engage in an unseen relationship: the reader is drawn to admire the beauty of the drawings while being fully aware of the data behind. Moreover, by exploring the plant's different aspects, we indirectly appeal to the reader's awareness of the existence of such species. Through this art-and-science dialogue, scientific data becomes therefore more relatable and tangible for the reader.

Art and science are not opposites. Science has great graphic potential from the perspective of art, as well as research methodologies, processes and results that go beyond the scientific field. Being a source of inspiration and information, art makes previously theoretical scenarios visible and is presented as a point of union with the community and the general public. Both disciplines can learn from each other and complement each other, seeking a more rounded and complete knowledge of our environment.

# VIII. Conclusións

O traballo de Kosuth inspirounos para cuestionar as diferentes maneiras de representar unha planta. Propuxemos os diversos puntos de vista da planta, dende a arte e a ciencia, usando variadas técnicas de debuxo acompañadas de información científica, para describir o que tiñamos diante. Determinamos que debíamos ter en conta ata oito dimensións cando falamos dunha planta: definición textual, sombras, liña, cores, raíces, data, huella e fotografía. Ao dispor de xeito simultáneo estes aspectos, buscamos facer que a persoa lectora cuestione o significado que aporta cada dimensión. Detrás de cada una das sete especies de árbores tropicais, desenmarañamos novos ángulos, sempre añadindo nova información que incremente o noso coñecemento sobre elas.

Cada elemento que recollimos de ambas disciplinas pode relatar unha historia por sí mesmo. De xeito que non se trata so da yuxtaposición das historias se non que entablamos unha relación invisible; a persoa lectora síntese atraída a admirar a beleza dos debuxos mentras é plenamente consciente da información científica que ten detrás. Ademais, ao explorar os diferentes aspectos da planta, chamamos indirectamente á conciencia da persoa lectora sobre á existencia destas especies. A través do diálogo entre a arte e a ciencia á información científica vólvese máis accesible e tanxible.

A arte e a cencia non son contrarios. A ciencia conta cun enorme potencial gráfico dende a perspectiva da arte, así como metodoloxías de investigación, procesos e resultados que abarcan máis que o ámbito científico. Sendo fonte de inspiración e información, a arte visibiliza escenarios antes teóricos e preséntase como un punto de unión coa comunidade e o público xeral. Ambas disciplinas poden aprender da outra e complementarse, procurando un coñecemento máis redondo e completo do noso entorno.

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*Thank you for sharing this experience with us. We hope we have contributed to your understanding of the natural world, through the eyes of art and science, with this yet incomplete display of the multidimensionality of the plant.*

*Grazas por compartir esta experiencia con nos, esperamos ter contribuido á súa comprensión do mundo natural, dende os ollos da arte e da ciencia a través desta, todavía incompleta, guía sobre a multidimensionalidade da planta.*

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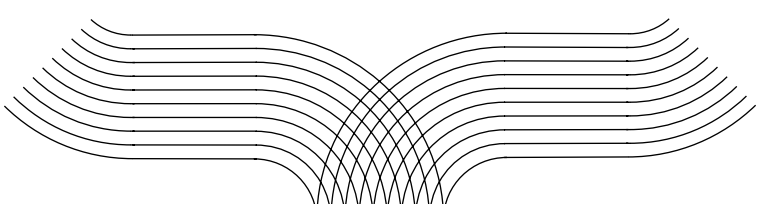

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# The multidimensionality of the plant

## *An art and ecophysiology approach to the comprehension of Amazonian tree seedlings (English-Galician edition)*

Art and Science together can better comunicate and disseminate our environment's knowledge. Two authors, from the field of Art and Tropical ecology, decided to intertwin their disciplines to develop a more complete picture of what a plant is. By integrating multiple perspectives, they will delve into the multidimensionality of the plant, seeking to understand holistically the nature of seven species of trees in the Amazon rainforest of French Guiana and how they will respond to climate change.

A arte e a ciencia xuntas poden comunicar e difundir mellor o coñecemento do entorno natural. Dúas autoras, procedentes do campo da Arte e da Ecoloxía tropical, decidiron entralazar as súas disciplinas para desenvolver una imaxe máis completa do que é una planta. Adentraranse na multidimensionalidade vexetal, tentando comprender dun xeito holístico a natureza de sete especies de árboles da selva amazónica da Guayana Francesa e a súa resposta ante o cambio climático.

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