UAB
Universitat Autònoma de Barcelona

Budding botanists
Diversity and distribution of children's ethnobotanical knowledge in Madagascar

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PhD Dissertation

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Under the supervision of:

Dr. Victoria Reyes-García
Dr. Stéphanie M. Carrière
Dr. Sandrine Gallois

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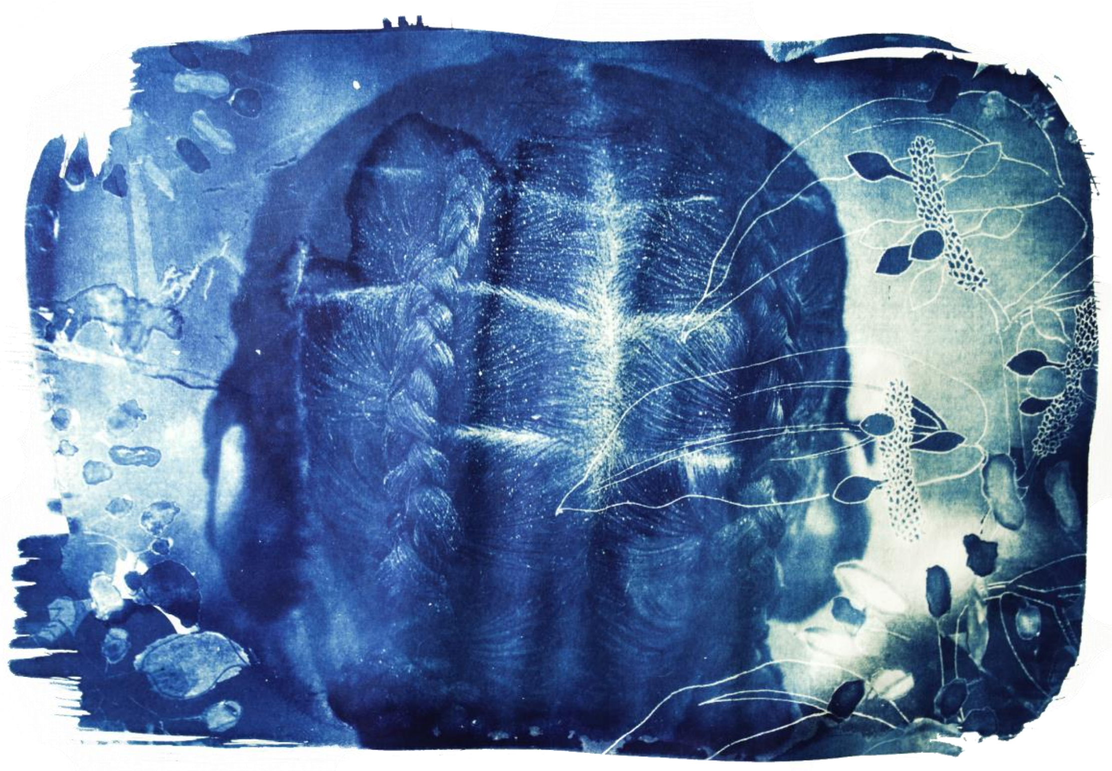

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« *J'écris pour tous ces enfants-là*
Ces enfants-là… […]
… eux pour qui la sylve Tanala n'a plus aucun secret, faune et flore réunis, il faut les voir escalader les sentes, débusquer le microcèbe, dans des endroits impossibles ou piéger le porc-épic à la chaire savoureuse, il faut les voir…
Je les regarde dans leur insouciance juvénile
N'exigeant rien du présent
Encore moins de l'avenir
Si ce n'est le soleil »

Henry Mahavanona.
Cauchemar de chlorophylle (2008)

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Abstract

Children are the cornerstone of biocultural transmission. So, understanding how children perceive, know, experience, and use plants is central to documenting biocultural diversity. Scholars have drawn attention to documentation gaps in studies addressing local ecological knowledge. Local ecological knowledge is often unevenly distributed within the same society, as socioeconomic characteristics of people, such as gender or life stages, shape knowledge acquisition. However, such intracultural variability in knowledge is often ignored in academic research, particularly when collecting adult men's knowledge, thus overlooking women and children's knowledge. In the current quest to overcome the ongoing biodiversity crisis, these biases in data documentation could hamper efforts for evidence-based policies.

To address these gaps, this PhD thesis aims to comprehend children's wild plant knowledge and uses in Madagascar. Specifically, the dissertation aims 1) to explore the extent of ethnobotanical knowledge among children (between 6 and 18 years of age) and 2) to examine the intracultural variability in wild edible plants' knowledge and uses across ages and gender. This work took place in two distinct agro-pastoralist groups living in Madagascar: the Betsileo and the Tanalanas. In both sites, I used a mixed-method approach, combining participant observation with ethnobotanical interviews with children and adults (n=221). Among Betsileo, I also developed a method that allows exploring children's ability to identify wild plants without relying on their verbalization abilities.

In its four empirical chapters, this thesis investigates: a) Betsileo's plant uses, folk taxonomy and classification (Chapter II); b) Betsileo children system of wild edible plants identification (Chapter III); c) intracultural variability in wild edible plant knowledge distribution among Betsileo (Chapter IV); and d) Tanalanas wild edible plant knowledge and its intracultural variability (Chapter V).

Results of this work show that Betsileo and Tanalanas children hold a high level of local ecological knowledge, as manifested in wild edible plant species identification, collection, and preparation. Results from Chapter III show that Betsileo children use a large spectrum of criteria to identify and distinguish different wild edible plant species. Children's identification criteria include complex botanical and ecological knowledge, consistent with scientific records. Findings from the two study sites presented in Chapters IV and V provide new evidence of the existence of children's specific knowledge, i.e., different from an adult's knowledge. In both cases, girls and boys named different species (with 21% of species cited being unique to children) and described methods of collecting and preparing wild edible plants that differ from those reported by adults. Indeed, my work shows that, in

addition to sharing knowledge with adults, children hold unique knowledge, suggesting that children are not only knowledge repositories but also knowledge producers, holding a body of children's specific knowledge shared among themselves.

In Chapters III, IV and V, my work shows the relationship between the social-ecological environment and ethnobotanical knowledge, thus contributing to understanding the process of knowledge acquisition. More specifically, my findings among both Betsileo and Tanalanas people show that local ecological knowledge is differentially distributed according to gender and life stages. For example, Betsileo women are experts on herbaceous plants while men are generalists. Also, Betsileo children cited more introduced species, while adults cited more endemic species. In both cases, intracultural knowledge variation can be explained by the fact that people from different gender and age engage in different daily activities, including mobility, which shapes their direct interactions with diverse wild edible plant species and thus their knowledge.

Finally, in Chapter V, I found that the way local ecological knowledge is distributed might contribute to the resilience of the knowledge system and by extension to the resilience of local livelihoods. Indeed, despite intracultural variations, the Tanalanas actively share a substantial amount of their knowledge regarding wild edible plants. It is noteworthy that children of a very young age already know most of the species (76%) reported by adults, including how to collect and prepare them. I argue that this distribution of shared knowledge may be a strategy to mitigate the risks associated with food scarcity.

By including children as full-fledged actors in the holding of knowledge, and by exploring in-depth children's specific knowledge, this thesis brings new insights to the discussion on local ecological knowledge distribution in small-scale societies. Overall, results from my work signal the need to embed children in local ecological knowledge studies. Promising lines for further research include exploring how children's specific knowledge is created and disseminated and developing more tools adapted to work with children. This work also highlights the importance of considering children to improve their representativeness in science-policy assessments. Finally, my study shows the great capacity of children to acquire complex botanical and ecological knowledge and use it. These results highlight the importance of environmental context and having a direct link with nature in the learning and shaping of local ecological knowledge, a result that might be used in the elaboration of environmental education programs.

FINTINA

Ny ankizy dia isan'ny kitro ifaharan'ny fampitana ny lova biokoltoraly (zavamananaina sy kolon-tsaina). Noho izany dia zava-dehibe ny fahafantarana ny hoe: manao ahoana ny fahitany, fahalalàny, fanandramany ary ny fampiasany ny zavamaniry mba hanoratana tahirin-kevitra momba ny fahasamihafàna biokoltoraly.

Ny mpikaroka dia nanamarika ny tsy fahampian'ny tahirin-kevitra momba ny fahalalàna ny tontolo iainana amin'ny toerana vofaritra iray. Ireo fahalalàna ireo mazàna dia mitsinjara tsy mitovy ao anaty fiaraha-monina iray, satria ny sata ara-paraha-monin'ny olona tsirairay tahaka ny maha-lahy na maha-vavy na ny fiainana nodiavina dia misy fiantraikany amin'ny fanangonany fahalalàna ho azy. Kanefa, izany fahasamihafana arakolotsaina izany dia tsy mazava tsara any anaty rakitsoratra siantifika indraindray, izay niainga tamin'ny fisafidianana diso ny olona notsongaina natao fanadihadiana izay olon-dehibe ny ankamaroany ka notsinotsinoavina ny ankizy sy ny vehivavy. Ambonin'izany, ho an'ny fikarohana ankehitriny izay mikatsaka ny hamahana ny olana momba ny karazan-javamananaina, izany fahadisoana hita taratra any anaty raki-tsoratra sy-tahirin-kevitra izany dia vato misakana amin'ny fametrahana politika mifototra amin'ny profo mivaingana.

Mba hamenoana ny banga, ny tanjon'ity Doctorat ity dia ny hahazo ny fahalalàna sy ny fampiasan'ny ankizy ireo zavamaniry dia eto Madagasikara. Tanjona voalohany 1) hitrandraka ireo fahalalàna zavamaniry ny ankizy (eo anelanelan'ny 6 ka hatramin'ny 18 taona), 2) hanadihady ny fahasamihafana anaty kolotsaina iray momba ny zavamaniry ireo fahalalàna sy fampiasana ny zavamaniry fihinana dia, miohjatra amin'ny taonan'ny sy ny maha-lahy na vavy. Ny asa fikarohana dia natao tamin'ny foko roa samihafa sady mpamboly no mpiompy tany Madagasikara: ny Betsileo sy ny Tanala. Fomba roa mifameno no nampiasaina, natambatra ny fizahana ifotony andraisan'ny rehetra anjara sy ny fanadiahadiana ara-javamaniry niaraka tamin'ny mpanome vaovao miisa 221 izay ankizy sy olon-dehibe. Ho an'ny Betsileo manokana, dia nisy ny fomba natao mba ahafahana mitrandraka ny fahaizan'ny ankizy mamantatra ireo zavamaniry dia izay tsy voasakan'ny tsy fahaizan'izy ireo miteny.

Mizara toko efatra lehibe ity asa ity: a) ny fampiasana sy fanasokajiana ny zavamaniry ho an'ny Betsileo (Toko II), b) tetika fahafantarana ireo zavaniry dia fihinana fantatry ny ankizy Betsileo (Toko III), d) ny fahasamihafana anaty kolotsaina voatsinjara anaty fahalalàna ny zavamaniry dia fihinana eo amin'ny Betsileo (Toko IV) ary e) ny fahalalàn'ny Tanala ireo zavamaniry dia fihinana sy ny fahasamihafàna anaty kolotsaina iray (Toko V).

Ny valin'ny fanadihadihana dia milaza fa ny ankizy Bestileo sy Tanala dia manana fahalalàna azo lazaina hoe avo lenta momba ny tontolo iainana misy azy izay azo tarafina amin'ny fahafantarana, fanagonana ary ny fikarakarana ireo zavamaniry dia fihinana. Ny Toko faha V dia mampiseho fa ny ankizy Bestileo dia mampiasa karazana mason-tsivana maro ahafahana mamantatra sy manavaka ireo karazan-javamaniry dia fihinana. Ireo mason-tsivana ireo dia mifanaraka amin'ny fahalalàna sy antotan'isa siantifika. Ny vokatra taterina ao amin'ny Toko faha-IV sy faha-V dia mitondra porofo vaovao momba ny fisian'ny fahalalàna manokana ananan'ny ankizy izany hoe samihafa miohatra amin'ny olon-dehibe. Ho an'ireo tranga roa dia samihafa ny anarana omen'ny zazalaly sy zazavavy (21% ny zavamaniry dia hain'ny ankizy manokana). Noho izany ity fikarohana ity dia mampiseho fa ankoatra ny fizarana fahalalàna miaraka amin'ny olon-dehibe, ny ankizy dia manana fahalalàna tsy manam-paharoa, izay ahafahana milaza fa izy ireo dia tsy itoeram-pahalalàna fotsiny fa mpamorona sy mpamokatra fahalalàna ihany koa, izany dia fahalalàna voatokana ho an'ny ankizy ary ifampizaran'izy ireo.

Ny Toko faha-III, fah IV sy faha-V, dia mampiseho ny fifandraisana eo amin'ny tontolon'ny fiaraha-monina sy ny fahalalàna ny zavamaniry izay ahafahana mahazo ny fomba fanovozana fahalalàna. Ny valin'ny fikarohana: ho an'ny Betsileo sy Tanala dia mampiseho fa ny fahalalàna ny tontolo iainana eo amin'ny faritra voatondro iray dia mitsinjara araka ny maha-lahy na maha-vavy sy ny dingana nodiavina teo amin'ny fiainana. Ohatra, ny vehivavy Betsileo dia mahafantatra kokoa ny bozaka aman'ahitra raha mahay ny akapoben'ny zavamaniry ny lehilahy. Eny fa na dia ny ankizy Betsileo aza dia mahavita mitanisa karazan-javamaniry vahiny nampidirina teto Madagasikara saingy ny olon-dehibe dia mahalala kokoa ny zavamaniry tsy misy afatsy eto Madagasikara. Ho an'ireo tranga roa ireo, ny fahasamihafan'ny fahalalàna dia azo hazavaina amin'ny alalàn'ny asa fanao andavan'andron'ny lehilahy na vehivavy sy ny fivezivezena mifanaraka amin'izany, ary misy fifandraisany mivantana amin'ny karazan-javamaniry dia fihinanana izany hoe ny fahalalàna azy ireo.

Farany, ny Toko faha-IV no nahatsapako fa ireo fahalalàna ara-tontolo iainana eo an-toerana dia voatsinjara ary azo ampiasaina amin'ny mety ho fiaretan'ny roivohary amin'ny fahalalàna, ary raha itarina dia tonga hatrany amin'ny asa fivelomana mihitsy. Noho izany na misy aza ny fahasamihafana ara-kolotsaina, ny Tanala dia mizara mavitrika ireo fahalalany ny zavamaniry dia fihinana amin'ny ankizy. Mahaliana ny mahita fa ny ankizy dia mahafantatra haingana ny ankabeazan'ny zavamaniry (76%) izay lazain'ny olon-dehibe. Amiko izany fifampizarana ny fahalalàna izany dia paikady ialana amin'ny ho mety tsy fisian'ny ny sakafo amin'ny hoavy.

Ny fametrahana ny ankizy ho isan'ny mpandray anjara feno amin'ny fitanana ny fahalalàna sy ny fitrandrahana lalina ireo fahalalàna manokanan'ny ankizy ireo dia zava-dehibe. Ity asa fikarohana ity dia mitondra fomba fijery vaovao momba ny adihevitra mahakasika ny fitsinjaran'ny fahalalàna ara-tontolo iainana amin'ny toerana voatondro iray anaty mari-drefy kely. Ny tohin'ity fikarohana ity dia ny hitrandrahana ireo fahalalàna manokan'ny ankizy ireo mba ho fitaovam-pikarohana mety ho n'ny ankizy. Ity asa ity koa dia manambara ny mahazava-dehibe ny amin'ny tokony hijerena manokana ny ankzy sy ny fahalalàna ara-kolotsaina samihafa mba hanatsarana ny fiheverana tsy ankanavaka amin'ny tombana siantifika sy politika. Farany, ity asa ity dia milaza fa ny ankizy dia mahavita ny manangona fahalalàna momba ny zavamaniry sy ny tontolo iainana ary mahay mampiasa izany. Ireo voka-pikarohana rehetra ireo dia mamaritra ny mahazava-dehibe ny tontolo iainana izay mifandray mivantana amin'ny zava-boahary sy amin'ny fampianarana momba ny fahalalàna aratontolo iainana, izay azo ampiasaina any an-tsekoly.

revised by Herizo RANDRIAMBANONA
researcher at CNRE

Résumé

Les enfants sont la clé de voûte de la transmission bioculturelle, il est donc essentiel de comprendre comment ils perçoivent, connaissent, expérimentent et utilisent les plantes pour documenter la diversité bioculturelle. Au sein des études portant sur les savoirs écologiques locaux, ceux spécifiques à l'enfance présentent encore de nombreuses lacunes. Les savoirs écologiques locaux sont souvent répartis de manière inégale au sein d'une même société, les caractéristiques socio-économiques individuelles, telles que le sexe ou les étapes de la vie, influençant l'acquisition et la teneur des connaissances. Cependant, les connaissances sur la variabilité intraculturelle des savoirs est souvent absente dans la littérature scientifique, dont les échantillons sont biaisés en faveur des hommes adultes, négligeant femmes et enfants. De plus, dans la quête actuelle pour faire face à la crise de la biodiversité, ces biais pourraient entraver les efforts pour des politiques basées sur des preuves.

Afin de combler ces lacunes, ce travail de doctorat vise à comprendre les savoirs et usages des plantes sauvages des enfants vivant à Madagascar. Plus précisément, cette thèse vise à 1) explorer l'étendue des connaissances ethnobotaniques des enfants (entre 6 et 18 ans) et 2) à examiner la variabilité intraculturelle des savoirs et usagess des plantes sauvages comestibles en fonction de l'âge et du sexe. Ce travail s'est déroulé dans deux groupes agropastoraux distincts vivant à Madagascar : les populations betsileos et nalanas. Dans les deux sites, j'ai utilisé une approche mixte, combinant l'observation participante avec des entretiens ethnobotaniques avec 221 informateurs, enfants et adultes. Chez les populations Betsileos, j'ai également développé une méthode qui permet d'explorer la capacité des enfants à identifier les plantes sauvages limitant les biais liés à leurs capacités de verbalisation.

Dans ses quatre chapitres empiriques, cette thèse étudie : a) les utilisations des plantes, la taxonomie et la classification des populations betsileos (Chapitre II); b) le système d'identification des plantes sauvages comestibles des enfants betsileos (Chapitre III); c) la variabilité intraculturelle dans la distribution des connaissances sur les plantes sauvages comestibles parmi les populations betsileos (Chapitre IV); et d) les connaissances des populations tanalanas sur les plantes sauvages comestibles et leur variabilité intraculturelle (Chapitre V).

Les résultats de cette thèse montrent que les enfants betsileos et tanalanas possèdent un niveau élevé de savoirs écologiques locaux, qui se manifeste dans l'identification, la collecte et la préparation des espèces de plantes sauvages comestibles. Les résultats du chapitre III montrent que les enfants betsileos utilisent un large éventail de critères pour identifier et distinguer les différentes espèces de

plantes sauvages comestibles. Les critères d'identification des enfants comprennent des connaissances botaniques et écologiques complexes qui correspondent à celles issues des données scientifiques. Les résultats des deux sites d'étude présentés dans les chapitres IV et V apportent de nouvelles preuves de l'existence de savoirs spécifiques aux enfants, c'est-à-dire différentes des savoirs des adultes. Dans les deux cas, filles et garçons ont nommé des espèces différentes (21 % des espèces citées étant propres aux enfants) et ont décrit des méthodes de collecte et de préparation des plantes sauvages comestibles qui diffèrent de celles rapportées par les adultes. Mon travail montre ainsi qu'en plus de partager des savoirs avec les adultes, les enfants détiennent des connaissances uniques, suggérant que les enfants ne sont pas seulement des dépositaires de savoirs issus des adultes mais aussi des producteurs de connaissances, détenant un ensemble de savoirs spécifiques aux enfants et partagées entre eux.

Dans les chapitres III, IV et V, mon travail montre la relation entre l'environnement socioécologique et les connaissances ethnobotaniques, résultats qui contribuent à la compréhension du processus d'acquisition des savoirs. Plus précisément, les résultats obtenus chez les populations betsileos et analanas montrent que les savoirs écologiques locaux sont répartis différemment selon le sexe et les étapes de la vie. Par exemple, les femmes betsileos semblent être des expertes en plantes herbacées alors que les hommes semblent être plus généralistes. De même, les enfants betsileos citent davantage d'espèces introduites alors que les adultes citent davantage d'espèces endémiques. Dans les deux cas, la variation des connaissances peut s'expliquer par le fait que les personnes de sexe et d'âge différents ont des activités quotidiennes et une mobilité différente, qui façonnent leurs interactions directes avec la diversité des espèces de plantes sauvages comestibles et donc leurs connaissances.

Enfin, dans le chapitre V, j'ai également constaté que la manière dont les savoirs écologiques locaux sont distribués peut contribuer à la résilience du système de connaissances et, par extension, à la résilience des moyens de subsistance locaux. En effet, malgré les variations intraculturelles, les populations tanalanas partagent activement une grande partie de leurs connaissances sur les plantes sauvages comestibles, en particulier avec les enfants. Il est intéressant de noter que les enfants connaissent très vite la plupart des espèces (76%) signalées par les adultes, y compris la façon de les cueillir et de les préparer. Je soutiens que cette distribution de connaissances partagées peut être une stratégie pour atténuer les risques liés aux pénuries alimentaires.

En incluant les enfants en tant qu'acteurs à part entière dans la détention des connaissances et en explorant en profondeur les connaissances spécifiques des enfants, cette thèse apporte de nouvelles perspectives à la discussion sur la distribution des savoirs écologiques locaux dans les sociétés à petite échelle. Dans l'ensemble, les résultats de mon travail soulignent la nécessité d'intégrer les enfants

dans les études sur les savoirs écologiques locaux. Les idéesprometteuses pour la poursuite de cetterecherche comprennent l'exploration de la façon dont les connaissances spécifiques des enfants sont créées et diffusées mais aussi le développement d'outils de recherche adaptés aux enfants. Ce travail souligne également l'importance de prendre en compte les enfants et les variations intraculturelles au sens large dans les études sur les savoirs écologiques locaux afin d'améliorer leur représentativité dans les évaluations scientifiques et politiques. Enfin, mon étude montre la grande capacité des enfants à acquérir des connaissances botaniques et écologiques complexes et à les utiliser. Ces résultats soulignent l'importance du contexte environnemental et du lien direct avec la nature dans l'apprentissage et la formation des savoirs écologiques locaux, résultat qui pourrait être utilisé dans l'élaboration de programmes d'éducation à l'environnement.

Resum

Els infants són la pedra angular de la transmissió biocultural. Per tant, entendre com els infants perceben, coneixen, viuen i utilitzen les plantes és clau per documentar la diversitat biocultural i fer front als canvis globals actuals. En aquest sentit, investigadors i investigadores han destacat les possibles mancances en la documentació dels coneixements ecològics locals. Aquests coneixements sovint es distribueixen de forma desigual dins d’una mateixa societat, ja que diferents característiques socioeconòmiques individuals, com are el gènere o les etapes de la vida, tenen una gran influència en l'adquisició de coneixements. No obstant això, aquesta variabilitat intracultural dels coneixements sovint passa desapercebuda en la literatura científica, que habitualment fa servir mostres esbiaixades, centrant-se principalment en homes i persones grans i ignorant el coneixement de les dones i els infants. Més enllà dels biaixos en la documentació de dades, aquestes mancances podrien dificultar els esforços per formular polítiques basades en evidències.

En el marc d'aquesta tesi que pretén abordar aquestes mancances, el treball de doctorat es centra principalment en la comprensió dels coneixements i usos de plantes silvestres per part dels infants a Madagascar. Més concretament, l'objectiu d'aquesta tesi és doble: 1) explorar l'abast dels coneixements etnobotànics en infants de 6 a 18 anys, i 2) examinar la variabilitat intracultural en els coneixements i usos de plantes silvestres comestibles en relació amb l'edat i el gènere. Aquest treball s'ha realitzat amb dos grups agropastorals diferents a Madagascar: els Betsileo i els Tanalana. En ambdós llocs, s'ha utilitzat un enfocament mixt que combina l’observació participativa amb entrevistes etnobotàniques a 221 informants, incloent tant infants com adults. En el cas dels Betsileo, també s'ha desenvolupat un mètode per explorar els coneixements etnobotànics dels infants més enllà de les seves capacitats de verbalització.

A través dels quatre capítols empírics d'aquesta tesi s'examinen els següents temes: a) els usos de les plantes, la taxonomia i la classificació entre els Betsileo (capítol II); b) el sistema d'identificació de plantes silvestres comestibles pels infants Betsileo (capítol III); c) la variabilitat intracultural en la distribució dels coneixements sobre plantes silvestres comestibles entre els Betsileo (capítol IV); i d) els coneixements sobre plantes silvestres comestibles entre els Tanalana i la seva variabilitat intracultural (capítol V).

Els resultats d'aquesta tesi demostren que els infants Betsileo i Tanalana tenen un alt nivell de coneixements ecològics locals, que es manifesten en la identificació, recol·lecció i preparació d'espècies de plantes silvestres comestibles. Els resultats del capítol III mostren que els infants Betsileo utilitzen una àmplia gamma de criteris per identificar i distingir diferents espècies de plantes silvestres

comestibles. Els criteris d'identificació dels infants inclouen coneixements botànics i ecològics complexos, en línia amb el coneixement científic. En els capítols IV i V, els meus resultats en els dos llocs d'estudi aporten noves evidències de l'existència de coneixements específics dels infants, marcadament diferenciats dels adults. En ambdós casos, nenes i nens anomenen espècies diferents (el 21% de totes les espècies mencionades són només anomenades pels infants) i descriuen mètodes de recol·lecció i preparació de plantes silvestres comestibles diferents dels adults. De fet, a banda de compartir coneixements amb els adults, la meva recerca demostra que els infants tenen coneixements únics i diferenciats dels adults, suggerint que els infants no només són dipositaris de coneixements, sinó que també generen els seus propis coneixements.

En els capítols III, IV i V, el meu treball mostra els efectes de l'entorn socioecològic en l'especialització dels coneixements i, per extensió, contribueix a la comprensió del processos d'adquisició de coneixements. Més concretament, els meus resultats mostren que els coneixements ecològics locals es distribueixen de manera diferenciada entre els Betsileo i els Tanalana en funció del gènere i les etapes de la vida. Per exemple, les dones són expertes en plantes herbàcies, mentre que els homes són més generalistes. A més, els infants tenen un coneixement més gran de les espècies introduïdes, mentre que els adults tenen un coneixement més gran de les espècies endèmiques. En ambdós casos, la variació dels coneixements pot explicar-se per la influència del gènere i l'edat en les activitats quotidianes, la mobilitat dels individus i, per tant, a través de les seves respectives interaccions amb la diversitat d'espècies de plantes silvestres comestibles.

Finalment, en el capítol V també s'observa que l'estructura de la distribució dels coneixements ecològics locals podria contribuir a la resiliència del sistema de coneixements i, per extensió, de les comunitats locals de Madagascar. De fet, malgrat les variacions dins de la seva cultura, els Tanalana comparteixen activament una quantitat substancial dels seus coneixements sobre plantes silvestres comestibles, especialment amb els infants. És remarcable que els infants coneixen molt aviat la majoria de les espècies (el 76%) i saben recol·lectar-les i preparar-les. En base a aquestes dades, argumento que aquesta distribució de coneixements compartits pot ser una estratègia per mitigar els riscos associats a la manca d'aliments.

Reconéixer i explorar a fons els coneixements dels infants i el seu paper cabdal en la la transmissió cultural aporta noves perspectives a al debat acadèmic sobre la distribució de coneixements ecològics locals en les societats de petita escala. En general, els resultats del meu treball destaquen la necessitat d'integrar els infants en els estudis sobre coneixements ecològics locals. Algunes línies prometedores per a futures investigacions inclouen l'exploració de la creació i la difusió de coneixements específics dels infants i el desenvolupament d'eines adaptades als infants. Aquest treball també posa de manifest la importància de tenir en compte els infants i la variabilitat intracultural de manera més àmplia en els estudis sobre coneixements ecològics locals per millorar la representativitat de les dones i els infants en les avaluacions científiques i polítiques. Finalment, la meva tesi mostra la gran capacitat dels infants per adquirir coneixements botànics i ecològics complexos i posar-los en pràctica. Aquests resultats destaquen la importància del context ambiental i d'un vincle directe amb la natura en l'aprenentatge i la formació de coneixements ecològics locals.

revised by Alvaro Fernandez-Llamazares Onrubia
researcher at ICTA-UAB

Resumen

Los niños son la piedra angular de la transmisión biocultural. Entender cómo los niños perciben, conocen, experimentan y utilizan las plantas es, por tanto, esencial para documentar la diversidad biocultural. Los investigadores han llamado la atención sobre las lagunas de documentación en los estudios de los conocimientos ecológicos locales. Los conocimientos ecológicos locales suelen estar distribuidos de forma desigual dentro de una misma sociedad, ya que las características socioeconómicas de las personas, como el sexo o las etapas de la vida, influyen en la adquisición de conocimientos. Sin embargo, esta variabilidad intracultural de los conocimientos suele quedar oculta en la literatura científica, que a menudo utiliza muestras sesgadas, centrándose en los hombres adultos y descuidando a las mujeres y los niños. Además, en la búsqueda actual por superar la crisis de la biodiversidad, estos sesgos en la documentación de los datos podrían obstaculizar los esfuerzos por lograr políticas basadas en pruebas.

Para colmar estas lagunas, este trabajo de doctorado pretende comprender el conocimiento y el uso que hacen los niños de las plantas silvestres en Madagascar. Más concretamente, la tesis pretende 1) explorar el alcance del conocimiento etnobotánico entre los niños (de edades comprendidas entre los 6 y los 18 años) y 2) examinar la variabilidad intracultural en el conocimiento y los usos de las plantas silvestres comestibles en función de la edad y el sexo. Este trabajo tuvo lugar en dos grupos agropastorales distintos que viven en Madagascar: los Betsileos y los Tanalanas. En ambos sitios, utilicé un enfoque de métodos mixtos, combinando la observación participante con entrevistas etnobotánicas a 221 informantes, tanto niños como adultos. Entre los betsileos, también desarrollé un método para explorar la capacidad de los niños para identificar plantas silvestres que limita los sesgos asociados a sus habilidades de verbalización.

En sus cuatro capítulos empíricos, esta tesis investiga: a) los usos, la taxonomía y la clasificación de las plantas de los betsileos (capítulo II); b) el sistema de identificación de plantas silvestres comestibles de los niños betsileos (capítulo III); c) la variabilidad intracultural en la distribución del conocimiento sobre plantas silvestres comestibles entre los betsileos (capítulo IV); y d) el conocimiento de los tanalanas sobre plantas silvestres comestibles y su variabilidad intracultural (capítulo V).

Los resultados de esta tesis muestran que los niños de Betsileo y Tanalanas poseen un elevado nivel de conocimientos ecológicos locales, que se manifiesta en la identificación, recolección y preparación de especies de plantas silvestres comestibles. Los resultados del Capítulo III muestran que los niños de Betsileo

utilizan una amplia gama de criterios para identificar y distinguir entre las diferentes especies de plantas silvestres comestibles. Los criterios de identificación de los niños incluyen conocimientos botánicos y ecológicos complejos que concuerdan con los datos científicos. Los resultados de los dos lugares de estudio presentados en los capítulos IV y V aportan más pruebas de la existencia de conocimientos específicos de los niños, es decir, conocimientos que difieren de los de un adulto. En ambos casos, las niñas y los niños nombraban especies diferentes (el 21% de las especies nombradas eran exclusivas de los niños) y describían métodos de recolección y preparación de plantas silvestres comestibles que diferían de los relatados por los adultos. De hecho, mi trabajo demuestra que, además de compartir conocimientos con los adultos, los niños poseen conocimientos únicos, lo que sugiere que los niños no son meros depositarios de conocimientos, sino también productores de conocimientos, poseedores de un corpus de conocimientos específicos de los niños y compartidos entre ellos.

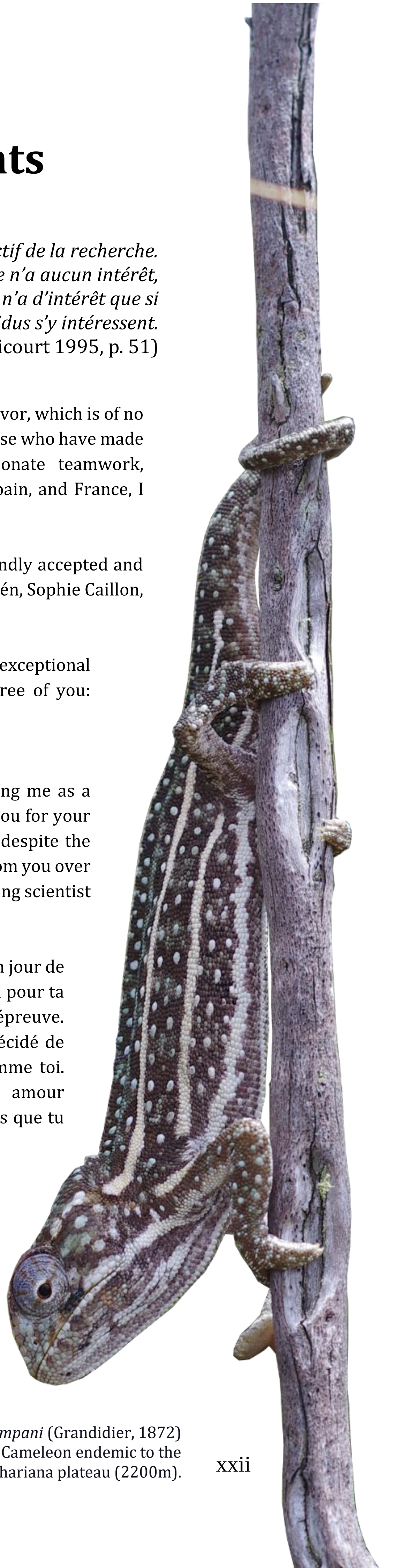
En los capítulos III, IV y V, mi trabajo muestra la relación entre el entorno socioecológico y el conocimiento etnobotánico, hallazgos que contribuyen a la comprensión del proceso de adquisición del conocimiento. Más concretamente, los resultados obtenidos entre los Betsileos y Tanalanas muestran que el conocimiento ecológico local se distribuye de forma diferente según el género y la etapa de la vida. Por ejemplo, las mujeres Betsileo parecen ser expertas en plantas herbáceas, mientras que los hombres parecen ser más generalistas. Del mismo modo, los niños betsileos citan más especies introducidas, mientras que los adultos citan más especies endémicas. En ambos casos, la variación en los conocimientos puede explicarse por el hecho de que las personas de diferentes sexos y edades tienen diferentes actividades cotidianas y movilidad, que configuran sus interacciones directas con la diversidad de especies de plantas silvestres comestibles y, por tanto, sus conocimientos.

Por último, en el Capítulo V también descubrí que la forma en que se distribuyen los conocimientos ecológicos locales puede contribuir a la resistencia del sistema de conocimientos y, por extensión, a la resistencia de los medios de vida locales. De hecho, a pesar de la variación intracultural, los tanalanas comparten activamente gran parte de sus conocimientos sobre plantas silvestres comestibles, en particular con los niños. Curiosamente, los niños aprenden muy rápido sobre la mayoría de las especies (76%) señaladas por los adultos, incluido cómo recolectarlas y prepararlas. Yo diría que esta distribución de conocimientos compartidos puede ser una estrategia para mitigar los riesgos asociados a la escasez de alimentos.

Al incluir a los niños como actores de pleno derecho en la posesión de conocimientos y explorar en profundidad los conocimientos específicos de los niños, esta tesis aporta nuevas perspectivas al debate sobre la distribución de los conocimientos ecológicos locales en las sociedades a pequeña escala. En general, los resultados de mi trabajo ponen de relieve la necesidad de incluir a los niños en los estudios sobre los conocimientos ecológicos locales. Entre las vías prometedoras para futuras investigaciones se incluyen la exploración de cómo se crea y difunde el conocimiento específico de los niños y el desarrollo de herramientas de investigación adaptadas a los niños. Este trabajo también pone de relieve la importancia de tener en cuenta a los niños y las variaciones intraculturales más amplias en los estudios de los conocimientos ecológicos locales para mejorar su representatividad en las evaluaciones científicas y políticas. Por último, mi estudio demuestra la gran capacidad de los niños para adquirir y utilizar conocimientos botánicos y ecológicos complejos. Estos resultados ponen de relieve la importancia del contexto ambiental y del vínculo directo con la naturaleza en el aprendizaje y la formación de los conocimientos ecológicos locales, un hallazgo que podría utilizarse en el desarrollo de programas de educación ambiental.

Acknowledgments

…j'attache de l'importance au caractère collectif de la recherche.
Je suis un individu, ce que je raconte n'a aucun intérêt,
ça n'a d'intérêt que si
d'autres individus s'y intéressent.
(A.-G Haudricourt 1995, p. 51)



As A.-G. Haudricourt points out, science is a collective endeavor, which is of no interest if pursued alone. For this reason, I would like to thank all those who have made this thesis possible. Because this thesis is the fruit of passionate teamwork, international collaboration and friendship between Madagascar, Spain, and France, I would like to express my thanks in different languages accordingly.

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Furcifer campani (Grandidier, 1872)
Cameleon endemic to the
Andohariana plateau (2200m).

I could go on for several pages expressing the admiration I have for the three of you and how much I have learned on a personal and professional level thanks to you, but I must also thank all the others and, incidentally, submit this thesis.

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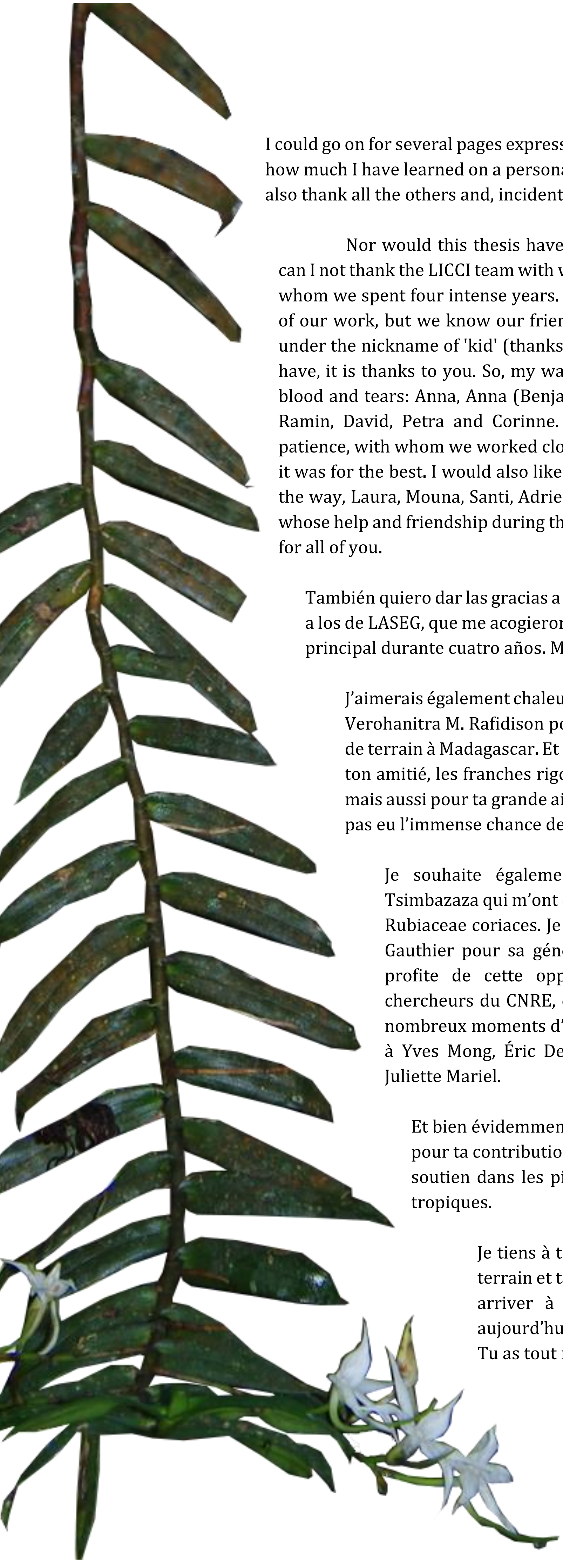

Angraecum dendrobiopsis Schltr.
in the Vohidray forest (1900m).

I would also like to thank and honor certain scientists who inspired me during this thesis. I'm thinking in particular of Francis Hallé, whose past exchanges certainly influenced this thesis and gave me a taste for Botany. André-Georges Haudricourt, whom I quote a lot, whose writings are fundamental for me in the discipline. And finally, Alexandra Elbakyan, founder of Sci-Hub, whose contribution to science is immeasurable.

J'aimerais aussi chaleureusement remercier Anne Collet et Philippe, deux personnes qui ont beaucoup compté pour moi et qui très tôt m'ont soutenue à une époque où on n'aurait pas parié une cacahuète sur moi. Finalement, vous voyez, vous avez peut-être misé sur le bon cheval. Merci à toi Philippe, et à notre amour pour les orchidées qui m'a fait faire du chemin.

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… et le soutien de la famille. Merci, Maman et Papa, pour votre soutien et votre amour inconditionnel, malgré les sueurs froides. Merci de m'avoir fait confiance et de m'avoir laissé partir si souvent et si loin. Tout ça, c'est grâce à vous. Merci à mes deux admirables grandes sœurs, vos pièces rapportées et vos rejetons. Merci pour votre soutien, votre amour et votre sagesse. Marion, Anne-Laure, vous êtes mes modèles.

Enfin…

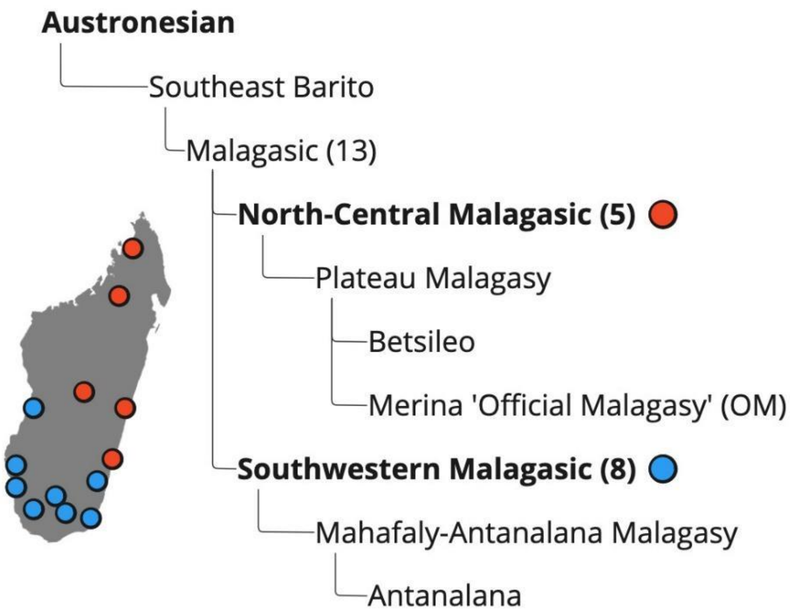
À vous tous qui m'avez accueilli chez vous, nourri de votre riz et de votre savoir (mais surtout de beaucoup de riz). À vous qui sans hésiter avez partagé vos vies avec moi et m'avez traité comme l'un de vos fils ou de vos frères, ce drôle de vazaha devenu grâce à vous un peu gasy. Votre force, votre résilience et vos valeurs continueront de m'inspirer toute ma vie. C'est donc volontiers que j'emporte avec moi un peu du *fomba* betsileo. Merci, Gaston, Ravola Germaine, Noeline, Michel, DePaul, Lova, Silvain. Ma thèse vous est dédiée.

Misaotra betsaka

Foreword

I report local names and words in ideographic typography based on how local people spell them. I choose to not report them in phonetic typography to simplify reading and the etymology explanations (Chapter II). The local names and words reported in this text refer to three distinct dialects of the Malagasy macrolanguage (i.e., Betsileo, Merina and Antanalana) involving different pronunciations. Here the three dialects used belong to two different languages (according to Serva & Pasquini, 2020, Glottolog 4.4.); the Betsileo and the Merina belong to North-central Malagasy while the Antanalana belongs to Southwestern Malagasic (see **Fig.1**).

Figure. 1 - Tree of the linguistic classification of the dialects presented in the thesis and their roots in the Austronesian language family and their distribution map. Numbers in (n) indicate the number of dialects by subgroups.



However, because most of the fieldwork was conducted in Betsileo, the following tables (**Tab.1** & **Tab.2**) present the different sounds and specificities of Betsileo pronunciation (Howe, 2021).

Table.1 – Betsileo consonants (Howe, 2021)

	Bilabial	Labio-dental	Dental	Alveolar	Retroflex	Palatal	Velar	Glottal
Plosive	p b		t d				k g	
Prenasalized plosive	^{m}p ^{m}b		^{n}t ^{n}d				^{ŋ}k ^{ŋ}g	
Affricate			t͡s	d͡z	ʈ͡ʂ ɖ͡ʐ			
Prenasalized affricate			t͡s	d͡z	^{ɳ}ʈ͡ʂ ^{ɳ}ɖ͡ʐ			
Nasal	m		n				(ŋ)	
Trill/Flap				r/ɾ				
Fricative		f v		s z				h
Approximant						(j)		
Lateral approximant				l				

One of the main peculiarities of Betsileo pronunciation and more particularly of Southern Betsileo is the palatalization of the velar nasal /ŋ/ when preceded by the vowel /i/ or /ai/ (Howe, 2021), as in the name of Andringitra National Park which is pronounced [aˈ^{n}ɖ͡ʐiŋ ^{i}ʈ͡ʂə̥].

Table.2 – Betsileo vowels

	Front	Central	Back
Closed	i		u
Half closed	e		o
Open		a	

The sounds /a/, /e/ and /i/ are spelled *a*, *e* and *i* or *y* respectively, while [o] and /u/ are spelled *ao* or *oa* and *o*.

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Glottolog 4.4. Available from: http://glottolog.org

Howe, P. (2021). Central Malagasy. *Journal of the International Phonetic Association*, *51*(1), 103-136.

Serva, M., & Pasquini, M. (2020). Dialects of Madagascar. *Plos one*, *15*(10), e0240170.

Main Acronyms and Abbreviations

APG IV	Angiosperm Phylogeny Group 4
CNRE	*Centre National de Recherches sur l'Environnement*
COBA	*Communauté de Base*
ERC	European Research Council
ERIC	Ethical Research Involving Children
FPIC	Free, Prior and Informed Consent
GFW	Global Forest Watch
GIS	Geographic Information System
GPS	Global Positioning System
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPLC	Indigenous People and Local Communities
IRD	*Institut de Recherche pour le Développement*
ISE	International Society for Ethnobiology
IUCN	International Union for Conservation of Nature
KMCC	Kew Madagascar Conservation Center
LEK	Local Ecological Knowledge
LICCI	Local Indicators of Climate Change Impact
MBG	Missouri Botanical Garden
MCA	Multiple Correspondence Analysis
MNHN	*Muséum National D'histoire Naturelle de Paris*
MNP	Madagascar National Parks
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organization
OM	Official Malagasy
PCA	Principal Component Analysis
POWO	Plant Of the World Online (Royal Kew Garden's digital herbarium)
SD	Standard Deviation
SRTM	Shuttle Radar Topography Mission
SSS	Small-Scale Societies
TAN	Tsimbazaza herbarium, Antananarivo
UAB	*Universitat Autònoma de Barcelona*
WEIRD	Western, Educated, Industrialized, Rich and Democratic
WEP	Wild Edible Plant
WFO	World Flora Online
WFP	Worl Food Programme

Glossary

Table.3a - General (not including local plants names, see appendix A.1)

ambody sitany	type of crop field, see Chapter II
ambody vala	home garden
andevo	slaves (status)
andevohova	free slaves (status)
antitra	elders
asotry	rice harvesting season
baibo	type of crop field, see Chapter II
baibo rano	type of paddy rice field, see Chapter II
bora	beetle larvae
fady	taboo, prohibition, traditional rules
fahavaratra	warm and rainy season
famadihana	traditional exhumation
fanafody	remedy, medicine
fandabana	table set made of plant fiber
faritra	administrative regions
fihavanana	blood relationship; friendship, comradeship
filoham-pokonolona	fokontany chief elections
foko /firazanana	ancestry, descent, clan
fokontany	administrative unit
fomba	customs, traditions
fombadrazana	ancestral customs
fortsihi/forsii	mats made of plant fiber
hasoavana	circumcision
havaratra	lean season
hazomanga	magical tree used by healers-diviners
horaka	type of paddy rice field, see Chapter II
hova	nobles (status)
kolanal	bird species (*Lophotibis cristata*)
kilonga	betsileo terms for children
kipa/kipaha	type of paddy rice field, see Chapter II
kisabaky	hopscotch game
lambo	wild boar
lohatona	dry and warm season
lolo	ghosts usually bad
loka	side dish
lomaka	type of paddy rice field, see Chapter II
mahahasinkova	synonym of *andevohova* (free slaves)
mamy	sweet, sugar
mandroso!	interjection to invite guests to eat
mokary	bread
mpiarakandro	zebu keepers
ody	amulets
olompotsy	commoners (status)
olondehibe	adults

ombiasa	healers-diviners specialized in plant
omby	zebus
mpanandro	healers-diviners specialized in divination
papeo	crawfish
ranonam'pango	the water poured on the rice
ravitoto	traditional dish
rayamam dreny	benefactor, a patron; lit. father and mother, elders
razana	ancestors
rinina	cold and dry season
saha	type of crop field, see Chapter II
sampy	talismans
tamboho	type of crop field, see Chapter II
tandraka	tenrec
tanety	slopes, hills
tanora	young adults
toaka gasy	local alcohol made of sugar cane
traka	group of edible plants used as side dish
trano	house
tsaika	fetus
tompo	master, owner (of slaves)
vala	hamlet
vary	rice
voandalana	present brought back from a trip
zaza	children
zaza kely	infant

Table.3b - Plant parts

fakany	roots
ravina	leaves
raviny	spur
ravony	flower
sampany	branches
tahony	stems
vatany	trunk
voa/voany	seed, fruit, tuber
voatany	tuber
zavamaniry	plants

Chapter I

General Introduction

1.1 Motivation and Aims

What kind of world are we leaving for children? [1] This question encapsulates the intricate and multifaceted challenge that humanities[2] is currently facing. It goes beyond merely acknowledging the climate crisis, the degradation of ecosystems, and the consequential conflicts and impacts on future generations. It also reflects the fundamental choices we make as a society.

As humanities face a tipping point in global social-ecological changes, there is an urgent need to address these issues. As a result, several intergovernmental platforms, such as the Intergovernmental Panel on Climate Change -IPCC- and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services -IPBES- made scientific reports and briefs to guide policymakers and alert them on the necessity of paradigm shifts (Diaz et al., 2018, IPCC, 2022). In this line, a striking assessment from IPBES is the recognition of the crucial need to involve Local Ecological Knowledge (LEK) in biological diversity assessments and conventions (Diaz et al., 2018; United Nations, 1992). These endeavors to involve LEK in science-policy assessments are supported by a growing bulk of literature and long-term work examining IPLCs contributions to biodiversity conservation and global ecological changes detection (Gadgil et al., 1993; Reyes-Garcia & Benyei, 2019; Garnett et al., 2018; Lauer et al., 2010; Fernandez-Llamazares et al., 2015; Singer et al., 2023). Indeed, LEK systems are intimately related to environmental management, and many local practices embedded in cultural systems (e.g., rules, taboos, systems of values and socio-cultural norms) are important to sustainably manage a large diversity of biological resources (Puri & Vogl, 2005; Martin et al., 2009). The inherent co-evolutionary relationship between cultural and biological diversity is widely recognized (Gorenflo et al., 2012; Posey, 1985).

[1] This question was the title of a round table organized by UNESCO in 1978. It was subsequently the subject of a report published in World Tribune (M'Bow,1978).

[2] Throughout this chapter, I will use the term "humanities" to underline the diversity of the relationship to the world and to account for the different 'modes of existence' according to Latour (2012) and the systems of knowledge which result from it.

However, science-policies still present gaps as for instance the exclusion of some cultural groups and the absence of certain species in their assessments (Camara-Leret & Dennehy, 2019). Moreover, the intracultural representativeness in LEK studies is also a pervasive gap to fill. Indeed, research shows that LEK is often unevenly distributed within the same society (Natcher et al., 2020), and varies according to socioeconomic characteristics, such as for instance gender or life stages (Diaz Reviriego et al., 2016; Gallois et al., 2017). However, the diversity of knowledge within a culture is frequently obscured in academic literature due to a biased selection of subjects, typically favoring men and older individuals while disregarding women and children (Hitomi & Loring, 2018). The exclusion of women and children in studies on LEK presents a significant concern when it comes to comprehensiveness, as it overlooks a crucial segment of knowledge holders within a community, as well as their valuable insights into biodiversity.

As a matter of fact, tropical regions, where two-thirds of the world's biodiversity reside (Raven et al., 2020), are home to 40% of the human population, half of the women and more than 55% of young and children (Edelman et al., 2014). Therefore, focusing only on male knowledge-holders undermines the holistic understanding and representation of the knowledge within a community while maintaining large amounts of LEK undocumented.

Despite the growing body of literature examining the role of gender as a differentiating factor in LEK (Diaz Reviriego, 2016; Torre Avilez et al., 2016), children have received relatively less attention in the field of ethnobiology (Corsaro, 2003; Friedl, 2004; Gallois et al., 2018). So far, most research addressing knowledge distribution within a society describes age as a factor shaping knowledge accumulation, rather than knowledge differentiation (Godoy et al., 2015; Blacutt-Riviero et al., 2016; Gallois et al., 2017). In other words, children are generally considered as "adults to be'', rather than a specific group with distinctive knowledge (Dounias & Ameeruddy-Thomas, 2017). Indeed, childhood is an extensive life period that plays a critical role in cultural learning, particularly in the acquisition of LEK (Zarger & Stepp, 2004; Demps et al., 2012; Reyes-Garcia et al., 2009). However, several scholars argue that children are not only knowledge repositories but also knowledge producers, holding a body of children's specific knowledge shared among themselves (Corsaro, 2012; Johanson, 2010; Crittenden & Zes, 2015; Lew-

Levy et al., 2020). This specific body of knowledge not necessarily shared with adults is called "children's culture" (Gallois et al., 2017; Corsaro, 2012; Johanson, 2010). As children-specific knowledge is supported by horizontal transfer channel and prosociality (Dounias & Ameeruddy-Thomas, 2017; Crittenden & Zes, 2015; Gallois et al., 2018), this pattern of children's knowledge differentiation might be pervasive in many human societies as it might be an inherent component in the process of knowledge ontogeny.

Children-specific knowledge might hold implications for biodiversity conservation, especially considering that children from IPLCs often have access to a diverse range of plant species and exhibit rich food habits including daily snaking (Dounias & Ameeruddy-Thomas, 2017). Among the plant species consumed and known by children, many of them are wild edible plants (WEP). These non-cultivated plants can thrive in a wide range of habitats, which can vary in their degree of human influence. The majority of these WEP form an essential component of the daily diet of IPLCs (Reyes-García et al., 2019). They play a crucial role in the food system by promoting dietary diversity, improving nutrition and contributing to the preservation of food sovereignty and security (Golden et al., 2011; Shumsky et al. 2014; Reyes-García et al., 2019). In addition, WEP species might play an important role in the biocultural revitalisation and adaptation to global changes by being crops' wild relative, stabilizing socio-ecosystems, and enhancing biodiversity (Hajjar and Hodgkin 2007; Penafiel et al., 2011; Thorn et al., 2020). Thus, recognizing and exploring in-depth the knowledge about WEP held by children within IPLCs can contribute to effective strategies for biodiversity conservation.

This PhD work primarily focuses on comprehending children's WEP knowledge and their practices in Madagascar, a hotspot of biodiversity where biodiversity sampling effort is needed (Good et al., 2006; Rivers et al., 2011; Raven et al., 2020; Camara-Leret et al., 2020). Specifically, the dissertation aims to explore the extent of ethnobotanical knowledge among children and examine the intracultural variability regarding WEP. Additionally, it emphasizes gender and age as factors that contribute to the differentiation of knowledge within two distinct agro-pastoralist groups living in Madagascar: the Betsileo people from the central plateau and the Tanalanas people from the arid southwest coast.

1.2 Theoretical Background

"*Botany is the ethnobotany of botanists,*
who have a secret language,
like all ethnic groups..."

(Quote from A.-G Haudricourt in Bahuchet, 2011: p.4).

Studying children's LEK of WEP requires the mobilization of concepts from different and complementary disciplines such as anthropology, ecology, and botany. Therefore, in this section, I aim to provide a concise overview of the key concepts from the theoretical framework used in this study, being: 1) Local Ecological Knowledge, 2) Children's Ethnobiology and 3) Wild Edible Plants.

Local Ecological Knowledge

The concept of Local Ecological Knowledge takes its roots in the conceptual framework of biocultural diversity. The concept of the interconnectedness of humans and nature, admitting the idea that the diversity of life on Earth is biological, cultural, and linguistic first came out in the academic sphere as the "inextricable link" between cultural and biological diversities in the Declaration of Belém issued by the International Society of Ethnobiology -ISE- in 1988 (Maffi & Woodley, 2012). Throughout their history, humans have used, conceptualized, and implemented strategies to sustainably modify the natural environment to meet material and immaterial needs, simultaneously in different parts of the world (Maffi & Woodley, 2012; Scott, 2021). Interacting closely with a diversity of species and environments, humans have adapted and developed a multitude of 'modes of existence' profoundly interrelated with the natural world resulting in a great biocultural diversity (Latour, 2012; Legare, 2017). Some authors refer to biocultural diversity as a coevolutionary relationship (Gorenflo et al., 2012; Posey, 1985). Luisa Maffi & Ellen Woodley state that: "*Biocultural diversity comprises the diversity of life in all of its manifestations - biological, cultural, and linguistic - which are interrelated (and likely co-evolved) within a complex socio-ecological adaptive system*." (Maffi & Woodley, 2012: p.5).

This interdependence between humans and biological diversity translates into a diversity of cultures, ontologies, ways of knowing, "thinking the world", living in it and interacting with it (Legare, 2017). In IPLCs living in immediate dependence on the natural environment, the resulting biocultural interactions are intrinsically related to and enabled by the accumulation of sophisticated LEK. This LEK can be defined as the indivisible cultural wholes of knowledge, practices, values, and worldviews that is held by IPLCs, who have lived in close association with their natural surroundings for generations (Orlove et al., 2023). It encompasses the deep understanding and wisdom handed through direct observations, experiences, and cultural transmission with the local ecosystems (Berkes, Colding & Folkes, 2000). LEK is often used synonymously with the concept of Traditional or Local Knowledge Systems (Gallois, 2016), which is usually "*related to other cultural domains such as religious and medicinal belief systems, social structures and linguistics…*" (Puri, 2013). LEK's multi-dimensional and interconnected nature makes it challenging to distinguish between environmental knowledge and other forms of cultural knowledge (Zent and Maffi, 2009). As a result, LEK not only serves as the foundation for subsistence systems, but also functions as a means to express cultural identity, language, and beliefs.

In addition, for a couple of years the ethnobiology lexicon re-use of the term "Situated Knowledge" also used in sociology to address knowledge from margins of the society (Hunter, 2009). The assortment of terminologies employed in this context reflects the intention to acknowledge and attribute value to these "other systems of knowledge" as significant and worthwhile sources of understanding (Nazarea, 1999; Roué & Nakashima, 2018). This semantic reflection around these "other knowledge systems " is not new and probably appears with structural anthropology (Lévi-Strauss, 1962) and the field of ethnobiology defining local knowledge as science (Spaulding, 1963) with the use of the term ethno-sciences (Sturtevant, 1964). Philippe Descola refers to Amazonian populations as "*societies of astute botanists and pharmacologists*" (1996). These considerations animated the debate about the complementary nature of this knowledge system, into biodiversity conservation efforts (Gratani et al., 2011; Roué & Nakashima, 2018).

However, despite the ongoing discussion on how to create synergies between knowledge systems (Davis & Ruddle, 2010; Tengö et al., 2014), LEK contributions to sustainably manage biodiversity is widely recognized (Gerhardinger et al., 2009; Charnley et al., 2007; Puri & Vogl, 2005; Martin et al., 2009; Brondízio et al., 2021). Scholars noticed that IPLCs "*implement strategies for resource use which, while transforming their environment in a sustainable way, did not disrupt its principles of functioning and reproduction*" (Descola, 1996: p.292). Indeed, cultural systems (e.g, cosmologies, rules, taboos, systems of values and socio-cultural norms) play an important role in managing biodiversity by mitigating the pressures (e.g., overharvesting, logging) on the different species and their habitats (Michon et al., 2020). Also, the contribution of LEK goes beyond biodiversity conservation by having a direct implication for the resilience of the food production systems, human and ecological well-being (Caillon et al., 2017; Jackson et al., 2020; Antonelli, 2023).

However, LEK and the biocultural diversity they support is threatened by the rapid acceleration and intensity of global cultural, economic, and environmental changes, often on top of intense colonial history and ongoing inequalities, questioning the vulnerability and the future of the biocultural heritage (Raschke & Cheema, 2008; Aswani et al., 2018; Jackson et al., 2020; Reyes-García et al., 2023a). This LEK extinction is particularly accelerated by species and language extinction, or external drivers as climate change (Schunko et al., 2022; Cámara-Leret & Bascompte, 2021; Reyes-García et al. 2014; IPCC, 2022). "*Unlike the burning of the Library of Alexandria, however, the knowledge acquired by nonliterate societies may vanish in silence*" (Cámara-Leret et al., 2019: p.1). Indeed, as LEK is a dynamic system, constantly evolving, the preservation of the biocultural heritage relies on its transmission through generations and often orally (Gallois, 2016). Consequently, emphasizing LEK studies on key actors in knowledge transfer seems a research priority to overcome the challenge of knowledge extinction in the context of the Anthropocene. Children's cognitive abilities, social-cultural learning processes and their role as educational intermediaries position them as the cornerstone in knowledge transfer, bridging the gap between generations and ensuring the continuity of knowledge, skills, and cultural heritage (Corsaro, 2003; Thompson, 2012; Morelli, 2017; Gallois & Reyes-García, 2018).

Children’s Ethnobiology

Children have been left out of LEK studies, in line with their reduced presence within anthropological and ethnographic studies (Ingold, 1994; Corsaro, 2003). Despite the pioneer child-focus work of Margaret Mead (1930), it is only since the 1990s that anthropology has taken hold of childhood as a subject of study, first focusing on hunter-gatherer children (Hewlett, 2017; Lancy, 2022). Lawrence A Hirschfeld (2002) explains *Why anthropologists don’t like children?* arguing that cultural learning is mostly approached through adults’ role, underestimating children's contribution not only to cultural reproduction but also to shaping adult culture. In such approaches, children are considered as part of a relationship (child/parental) rather than *just a young person, in and for themselves* (Bird-David, 2017: p.99). Consequently, ‘children’ have been long not studied as a social group (Bird-David, 2017). At the turn of the 21st century, anthropologists emphasized the developmental process of childhood among hunter-gatherer societies, asking “*Why Does Childhood Exist?*” and putting childhood at the heart of human evolution theory (Jones, 2017; Konner, 2016). Theoretical work on human evolution based on childhood studies is still mostly focused on foraging societies (Lancaster et al., 2000; Crittenden et al., 2013; Pretelli et al., 2022), even if other researchers question the approach on the grounds of ethical, moral, and scientific (Bell, 2017). The use of hunter-gatherer societies as a model for understanding the evolution of human behavior is problematic because it feeds a primitivist view of these societies while omitting the complex, non-linear histories of these societies, and possible cultural reversion (Hiller, 2006; Pierron et al., 2014).

Indeed, a growing bulk of literature agrees that childhood is an extensive life period playing an important role in cultural learning, particularly in the acquisition of local ecological knowledge (Zarger & Stepp, 2004; Reyes-Garcia et al., 2009; Demps et al., 2012; Ruiz-Mallén et al., 2013). Cross-cultural studies have shown that individuals in forager societies learn complex subsistence skills during childhood (Lew-Levy et al., 2017). Earlier studies have demonstrated that a substantial body of ecological knowledge is acquired before adolescence (Bird & Bird, 2002; Bock, 2002; Hunn, 2002; Jones & Marlowe, 2002; Blacutt-Rivero et al., 2016; Gallois & Reyes-García, 2018). For example, plant knowledge acquisition starts during early childhood and is well mastered by young adults (Quinlan et al., 2016; Gallois et al., 2017; Schniter et al., 2021).

The process of cultural learning, particularly the acquisition of local ecological knowledge, encompasses various ways for knowledge acquisition, including individual experiences, knowledge transfer processes and the prevalence of a direct link with the natural environment (Legare, 2017; Gallois & Reyes-García, 2018). As Paulo Freire aptly stated, "*No one educates others, no one educates himself alone; humans educate themselves together through the world*" (1968: p.80). Indeed, children growing up in small-scale societies such as rural communities acquire knowledge through learning based-experience of their environmental and cultural setting (Wahid et al., 2019). Observation and imitation of the social-ecological environment are cornerstones of knowledge acquisition (Zarger, 2010; Hewlett et al., 2011; Lew-Levy et al., 2017). Children observe and mimic adults' practices while integrating these new practices into their repertoire of behaviours and producing their own new practices (Berl & Hewlett, 2015). Cultural learning during childhood is also driven by socializing and thus having knowledge transfer between individuals on a daily basis during collective livelihood activity, usually in peer groups or with older (Setalaphruk & Price, 2007; Lancy et al., 2010; Wrzus et al. 2013; Quinlan et al., 2016; Gallois et al., 2018). Moreover, the pioneering work of Barry S. Hewlett and L. Luca Cavalli-Sforza (1986) on cultural transmission shows that various channels of knowledge transfer exist: vertical e.g., from adult to children, specifically parents or grandparents to the child; and, from adults other than parents and grandparents to the child; and horizontal e.g., from child to child, and (One-to-many). Moreover, recent work hypothesizes that most children's knowledge acquisition in small-scale societies follows horizontal transmission from child to child (Lew-Levy et al., 2017, 2020; Gallois et al., 2018). The predominance of vertical transmission (from parents to child) might have been overestimated due to normative bias (Aunger, 2000; Boyette, 2013; Gallois & Reyes-García, 2018), ignoring the role of children's unique channels of communication such as play-related activities and specific language in the horizontal transmission of knowledge (Reyes-García et al., 2009).

In sum, according to Gallois & Reyes-García (2018) and Gallois et al., (2016), knowledge transmission appears to follow a multiple-stage learning model, where the modalities of knowledge acquisition depend on the environment, kinship relation, sex, and age of the individual. In this non-linear accumulation of knowledge, novice learners first acquire knowledge from their closest environment. Then individuals will enhance this knowledge by incorporating more specialized models based on the relevant domain of knowledge (Demps et al. 2012; Wrzus et al. 2013; Schniter et al. 2015; Reyes-García et al. 2016).

However, the large amount of LEK acquired before adulthood is not only the accumulation of the knowledge that an individual is meant to know once an adult, but it displays specificities of children (as social group) (Gallois & Reyes-García, 2018). In addition to being a knowledge repository and learner, children also produce specific knowledge (Gallois et al., 2017). Children by interacting and sharing LEK with their peers maintain a dynamic body of 'children-specific knowledge'. The creation of this specific body of LEK might be due to the interpretative reproduction of culture by children introducing variation in knowledge (Corsaro, 2007, 2010) no longer mobilized by adults (Gallois et al., 2017). The children-specific knowledge might also be the result of socio-environmental across generations digging a knowledge gap between adults and children as stated in the shifting baseline hypothesis (Hanazaki et al., 2013; Fernández-Llamazares et al., 2015). Accordingly, change in the abundance of the composition of the biodiversity such as the apparition of introduced species or the disappearance of native one over a short period of time might explain the difference in adult and children LEK.

The concept of a "children's culture" encapsulates the idea that there are ethnobiological knowledge and practices held by children that are not always shared with adults, but also that there are tools, perception and management strategies that remain and are reproduced in children's world (Gallois et al., 2017; Gallois & Reyes-García, 2018). For instance, Mikea children (mainly girls) are the only ones who play *kilangaa* a leg xylophone made up of several pieces of wood placed on lower legs (Stiles, 1994). The analysis of Betsileo children's landscape drawings shows that children's perception of the environment emphasizes wild species, compared to adults who mainly work with domesticated ones (Carrière, 2010). Similar results have been found while asking children and adults from Guinea-Bissau about how to identify chimpanzees (Sousa et al., 2014). In a similar way, Baka, Betsileo, Mikea, and Martu children actively engage in biodiversity management strategies by targeting specific groups of animals while hunting such as small birds, mammals, and lizards (Gallois et al., 2017; Viano, 2004; Tucker & Young, 2017; Bird & Bird, 2017).

In sum, a growing body of literature suggests that children's specific knowledge is not anecdotal and reflects a deep involvement of children in subsistence strategies, actively contributing to the household economy, children's nutrition, and well-being (Gallois & Reyes-García, 2018). Indeed, among children's knowledge, we report an important number of knowledge relative to wild edible and particularly WEPs whose collection by children directly contributes to the food system of their household (Styger et al., 1999; Tucker & Young, 2017; Crittenden et al., 2013).

Wild Edible Plants

This dissertation focuses on children's knowledge about WEP. Thus, it seems necessary to clarify this term, and to give an overview of their contribution to the food system and why it is a relevant entry to study children's culture.

The use of WEP, Wild Food Plants (WFP) or Underutilized Plants (UP), is probably as ancient as human history (Scott et al., 2021). WEP shares a common history with cultivated plants, dating back to the beginning of human sedentarization (Cauvin, 1997; Scott et al., 2021; Bahuchet, 2017). Therefore, WEPs are often defined in opposition to cultivated or domesticated plants such as the "*species that grow spontaneously in self-sustaining populations outside cultivated areas, along the field margins, hedges, grasslands, and forest woodlands*" (Heywood, 1999). According to Heywood's definition, WEP does not occur in cultivated areas. This definition therefore omits the thousands of species growing in home gardens, agroforests, or fallows around the world (Cruz-Garcia & Struik, 2015; Alemayehu et al., 2015; Assogbadjo et al., 2012) nor does it include the notion of degree of human intervention and local management subtleties challenging the concept of wild (Shirsat et al., 2023).

Considering that WEPs are central to this research, it is worth exploring what is understood as wild. In this sense, in **Box 1**, I make a short State of the Art of the current definitions and debates around the notion of “wild” to go beyond the dichotomy of wild/domesticated. I discuss a nuanced definition of WEP, including the degree of artificialization of the environment where they grow and the degree of human intervention, arguing that this definition is subjective.

Box 1: What is Wild?

Addressing the issue of wild resources and their contribution to the diet involves indirectly engaging with the situated representations and perceptions held by the people who rely on these resources (Dounias, 1996). Indeed, the concept of wilderness concomitant to that of domestication is the result of a naturalist representation of the world opposing nature to culture, taking the human being out of nature by drawing a clear line between human and non-human (Descola, 2007). This representation, exacerbated in the 18th century, distinguishes the wild nature, which is depicted as hostile and dirty, from a nature ordered, tamed by the human hand, cultivated, and domesticated (Buffon, 1764). If nowadays nature is no longer considered a "Green Hell", it is still borrowed from an Edenic perception of nature, considering it immaculate, virgin, untouched and free from the hand of humans, continuing to feed the dichotomy notably through ideological movements like "deep ecology" (Grey, 1993).

Thus, the concept of domestication is based on the idea of domination of a living species and implies a different worldview and ideology than that of nomadic hunting and gathering (Bahuchet, 2017: p 37). The appearance of domestication simultaneously occurred 10,000 years ago in several regions of the world, accompanied by a "revolution of symbols", with the first sedentarization of humans (Cauvin, 1997; Scott et al., 2021; Bahuchet, 2017). Indeed, etymologically, domestication is the act of bringing and maintaining a living species (animal or plant) close to the home "Domus". Domestication might be defined as the process of coevolution between domesticator and domesticate involving different levels of care and management, conscious or unconscious, which results in a phenotypic modification of one species under the pressure of selection to meet the needs of another, mostly human (Purugganan, 2022).

However, the acceptations proposed by the different scientific fields (biologically or anthropologically grounded definitions) struggle to find a satisfactory definition (Zeder, 2015; Clutton-Brock, 2002; Purugganan, 2022). Recent advances in the field of historical ecology have proposed, with the concept of "anthropogenic forest", to conceive domestication through different scales, notably that of the population and the landscape, freeing itself from the sole morphological modification at the level of the species (Balée, 2013; Clement et al., 2015; Michon, 2015). It is the case for example of many Amazonian trees, whose domestication process, if any, was not done by the selection of individuals according to precise criteria, but rather by the favoring of the species thanks to the opening of the environment, such as the case of the Brazil nut tree (Porcher et al., 2018; Shepard and Ramirez, 2011) or of the Açaí (Posey, 1996; Kahn, 1996). These observations place the species at the interface of wild and domesticated status.

In parallel, many ethnoecological researchers have observed similar cases of *in-situ* care of many other species across the world (Dounias, 1996; Gallois et al., 2017). Some groups of plants illustrate this complexity of appreciation as to the notion or status of "wild" or "cultivated", such as the different species of the genus *Dioscorea* who's different "degrees of gathering" - to use the term employed by J.-L. Guillaumet (1996) - vary according to the species and the cultural groups that use them throughout tropical Africa (Hamon et al., 1992). This process of maintaining a plant within its original biotic environment has been described as para-cultivation (among others: semi-domestication, peri-domestication) and the concept of the wild is questioned to speak of presumably 'wild' resources or plants (Dounias, 1996; Yasuoka, 2013; Gallois et al., 2017). In some cases, para-cultivation is not seen as an alternative to domestication but as a step towards domestication, bringing in the notion of intentionality in the process of adoptive transplantation, to speak of "proto-cultivation" (Chelidonio, 2015; Worojie et al., 2021).

These numerous cases challenging the wild/domesticated dichotomy have led some scholars to speak of a continuum of domestication (Dounias, 1996). To better understand the complexity of the different modalities and terms used to qualify the domesticated and the presumed 'wild' plants, I propose a representation of this continuum of domestication built on two axes, 1) the degree of care provided and 2) the level of artificialization of the environment in which the species is produced or collected (**Fig.2A**). Moreover, because many species of these presumed 'wild' plants are also commensal and/or invasive and grow in arable land, gardens, rubbish tips and more generally in disturbed and open environments, I introduce in this continuum the notion of synanthropic species (Frumin et a., 2015; Edmonds & Chweya, 1997). In this case, it is not the human who will bring care to a "wild" plant, but a "wild" plant which comes to settle in an anthropogenic environment. This supposed discontinuity between the wild and the domesticated is all the more porous as the mobility of the species and the configuration of the habitat in which they are found often allows the co-occurrence of wild and domesticated relatives giving rise to numerous hybridization processes, feralization (Daniels & Bekoff, 1989) and introgression of genes (Rappaport, 2000; Aguirre-Liguori et al., 2016) blurring the boundaries between the lineages (**Fig.2B**). Consequently, the definition of a wild edible plant may be considered arbitrary or subjective, depending on the degree of human intervention at a given time and in a given region, and varying according to the point of view of the person using it. This is the case, for example, of the guava tree (*Psidium guajava* L.) domesticated in Latin America, introduced to Madagascar less than a century ago, and growing spontaneously on village outskirts, which the Betsileo people consider as "wild".

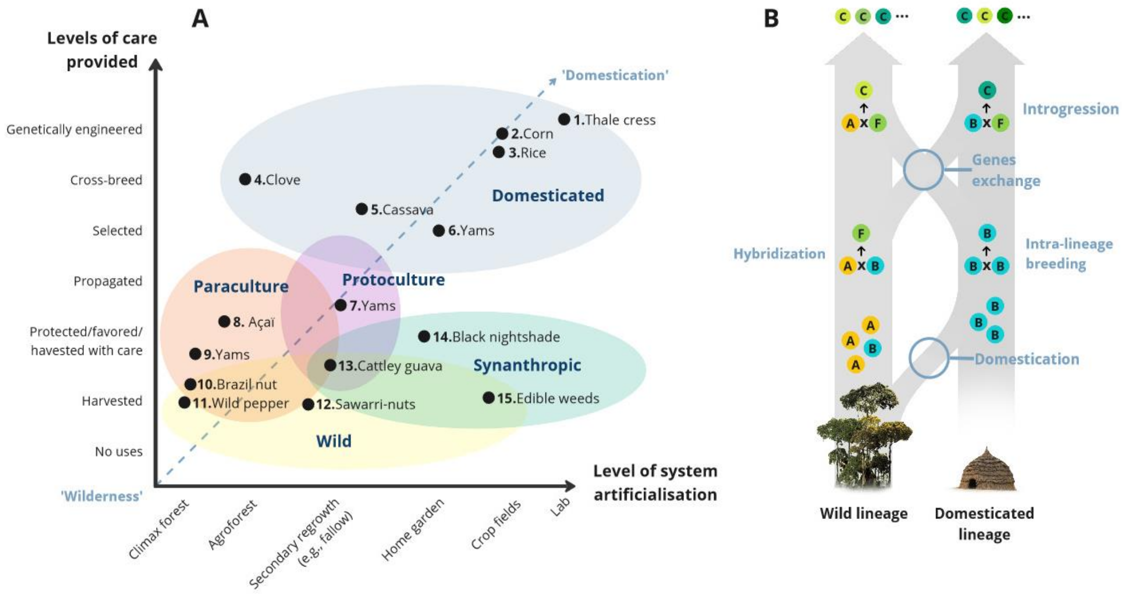

Figure.2 - Continuum of domestication. (A) Representation of the wild vs. domesticated continuum according to the level of care and artificialization of the environment. The placement of species on the gradient and their classification was done using the following references. **1.** *Arabidopsis thaliana* (L.) Heynh. (Meyerowitz, 1987), **2.** *Zea mays* L. (Negrotto et al., 2000), **3.** *Oryza sativa* L. (Radanielina et al., 2013), **4.** *Syzygium aromaticum* (L.) Merr. & L.M.Perry (Mariel et al,. 2021), **5.** *Manihot esculenta* Crantz (Rival & McKey, 2008), **6.** *Dioscorea spp.* (Sugihara et al., 2021), **7.** *Dioscorea spp.* (Coursey, 1975; Worojie et al., 2021), **8.** *Euterpe precatoria* Mart. (Posey, 1996; Kahn, 1996), **9.** *Dioscorea spp.* (Dounias, 1996; Yasuoka, 2013; Gallois et al., 2017), **10.** *Bertholletia excelsa* Bonpl. (Porcher et al., 2018; Shepard and Ramirez, 2011), **11.** *Piper borbonense* (Miq.) C.DC. (Rasambo et al., 2021), **12.** *Caryocar villosum* Pers. (Guillaumet, 1996), **13.** *Psidium cattleianum* Sabine (Carrière et al., 2008), **14.** *Solanum nigrum* L. (Edmonds & Chweya, 1997), **15.** (Cruz-Garcia and Struik, 2015), **(B)**. Graph B shows the porosity of the wild/domesticated dichotomy from the point of view of gene mobility, especially in the case where the co-occurrence of domesticated (blue B dots) and wild (orange A dots) relatives allows hybridization (green F dots) and feralisation and thus introgression over several generations (green C dots).

Given the complexity and diversity of situations that can influence the status of wild or domesticated or in between, as stated in **Box 1**, it is relevant to refer to the local context and adopt the emic point of view to define WEP. Thus, according to the Tanalanas and Betsileo people, in this dissertation, I will use the term 'wild edible plants' as the set of uncultivated plants.

For many small-scale societies relying on a mixed economy - farmer, agropastoralist and hunter and gatherer - WEP, occupy an important place in the food environment (Downs et al., 2020), despite being often underestimated in food studies (Termote et al., 2012; Tata Ngome et al., 2017). Indeed, WEP directly contributes in many ways to local well-being and health, maintaining local livelihoods, and cultural identities, safeguarding biocultural diversity and local resilience by 1) providing a source of food and nutrition, 2) enhancing biodiversity resilience and 3) maintaining LEK associated with WEPs.

First, WEP contributes to maintaining food security and sovereignty due to their availability and nutritional quality (Asprilla-Perea & Díaz-Puente, 2019; Ulian et al., 2020). WEP consumption is often associated with temporary use, particularly when there is the need to guarantee food security during annual lean periods or food shortages (Vinceti et al., 2018). For the same reason, in some contexts the consumption of these plants is associated with a feeling of shame, as they may reflect a certain image of poverty or failure in agricultural production, considering WEP as low-status food (Guinand & Lemessa, 2000; Cocks et al., 2008; Peeters & Maxwell, 2011; Cruz Garcia & Howard, 2013). Yet, while rarely highlighted in farmers' societies, the use of WEP goes well beyond the lean season and is often used on a daily basis, being an integral part of the local gastronomy (Luczaj et al., 2012; Pieroni et al., 2016). The collection of WEP throughout the years allows for improving the diet by diversifying the source of nutrients (Aryal et al., 2018; Smith et al., 2019) alongside the staple food (starch-based) usually provided by crops (Powell et al., 2015). Indeed, the diversity of WEP and parts consumed provides various micronutrients (e.g., calcium, copper, iron, manganese, potash, sulfur, zinc) and vitamins, thus enriching local diets (Rowland et al., 2017; Cantwell-Jones et al., 2022). The nutritional contribution of these plants is not negligible, especially for children whose risk of anemia has been proven to be reduced by as much as 29% thanks to WEP consumption (Golden et al., 2011). The multiplication of WEPs providing similar services enhances the utilitarian redundancy and thus the resilience of the food system (Nascimento et al., 2015). Therefore, the collection of numerous WEP species, as well as the polyculture, allows the provision of a wide diversity of food resources and thus absorbs potential shocks of seasonal and annual production variations. In addition, WEP also contributes to health because their collection and consumption are rarely limited to the nutritional aspect and have multiple uses, including medicinal and magical where the boundaries between those categories of uses are often complex and blurred (Ladio & Lozada, 2004; Jeambey et al., 2009; Sujarwo et al., 2016).

Secondly, the utilization and management of WEPs not only guarantee the maintenance of food security by providing a direct and readily available food source but also contribute to the enhancement of biodiversity and agrobiodiversity resilience in the face of global change (Sujarwo et al., 2016). As stated by Antonelli (2013: p.2), *'climate-smart' food sources can be derived from underutilized plants and wild relatives of cultivated crops*. Since WEPs often comprise wild relatives of cultivated species, they might serve as a valuable gene pool with beneficial traits for the adaptation of landraces to climatic changes such as water stress resistance and maintain stable yield (Aberkane et al., 2021; Kashyap et al., 2022). Therefore, WEPs are essential for promoting the resilience of crops, however, WEPs are also threatened by overexploitation (Schunko et al., 2022). In addition, WEP sustainable management might also serve indirectly to preserve other species and habitats, and those over generations through LEK transmission (Asfaw, 2008; Uprety et al., 2012; Cruz et al., 2013; Kidane & Kejela, 2021).

The third reason why WEPs are important is that collection, preparation, and consumption allow for maintaining LEK associated with WEPs. The practices and expression of the LEKs linked to these plants are a way of performing culture and particularly food culture. Indeed, food holds a central position within culture due to its multifaceted role in shaping social, economic, technological, and symbolic dimensions of human societies (Mintz & Du Bois, 2002). For this reason, in the field of food anthropology or gastronomic ethnobiology, food is considered a “total social fact” (Fig.3) which can only be understood through a holistic approach (Mauss, 1926; Pieroni et al., 2016). Food not only serves as a fundamental source of sustenance but also acts as a vehicle for the expression and transmission of cultural values, beliefs, identity, and memory that reflect historical, environmental, and sociocultural factors (Holtzman, 2006; Almerico, 2014; Bahuchet, 2016). Therefore, collection, preparation, and consumption of WEP foster social cohesion, as communal meals, and cultural events (such as funerals and kid’s circumcision in Betsileo's case; see Chapter II, section *Food, habits, and symbolism*) provide opportunities for interpersonal bonding, the reinforcement of kinship ties, and the sharing of knowledge and customs across generations dynamically (Mintz & Du Bois, 2002; Rasse & Debos, 2006; Asfaw, 2008).

As such, because food is central in any culture, the study of children's WEP knowledge seems to be a relevant entry to contribute to the children's culture study.

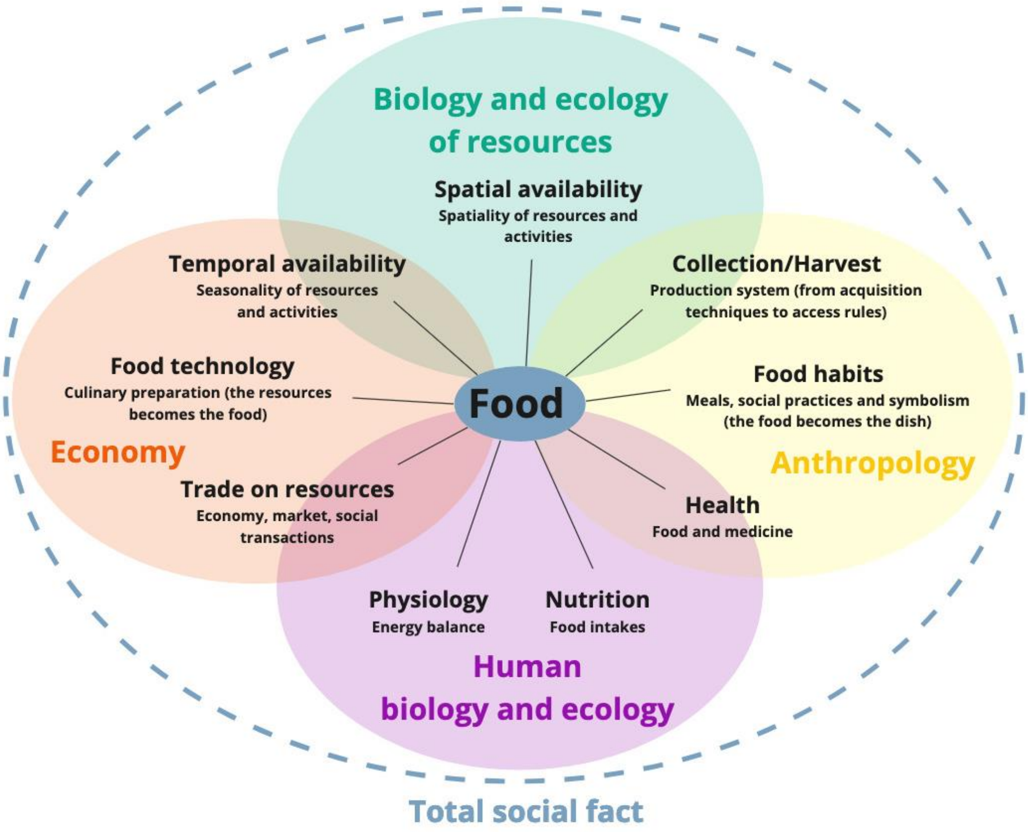

Figure.3 - **Food as a "total social fact".** Representation according to Marcel Mauss (1926) and inspired by Dounias & Froment (2019).

1.3 Research Strategies and Methodological Approach

Context of the Thesis

This PhD research was conducted as part of a large five-year research project called LICCI "*Local Indicators of Climate Change Impacts: The Contribution of Local Knowledge to Climate Change Research*" led by Dr. Victoria Reyes-García. The LICCI project was funded by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program as an ERC Consolidator Grant (No 771056 LICCI). The overarching objective of the LICCI project was to bring Indigenous and local knowledge into climate change research across over 40 study sites, involving a diverse group of partners and collaborators, including scholars from Indigenous peoples and local communities. Consequently, during the thesis, I have been involved in different tasks related to the LICCI project such as developing and testing the LICCI protocols (Reyes-García et al., 2023b), LICCI data collection on the field, data entry and cleaning, and co-writing with other LICCI core team members. During this project, I was also in charge of the dissemination strategy with Anna Porcuna Ferrer and the web design of the website[3] and the citizen science platform OpenTEK[4] in collaboration with Ramin Soleymani and Petra Benyei, who did the web development. In parallel, I also actively contribute to the LICCI working group "Wild Edible Plants", led By Christoph Schunko and Xiaoyue Li (Schunko et al., 2022). Additionally, and with the help of native research assistants/translators, I collected data for the LICCI project in two different study sites, one of them overlapping with this work (Betsileo fieldsite).

Fieldwork and data collection were authorized by local authorities (*Fokontany* chiefs), a local research institute, the CNRE (Centre National de Recherches sur l'Environnement), and the ethics committee of the Autonomous University of Barcelona CEEAH (4902). In addition, I followed the ethical charter of Ethical Research Involving Children (Graham et al., 2015) and the International Society of Ethnobiology Code of Ethics (2006). Every participant in this study who

[3] https://licci.eu/
[4] https://opentek.eu/licci/

shared their knowledge with me for the purpose of this work did it with free prior informed consent (FPIC).

The research findings presented here result from seven months of fieldwork split into three stays between April 2019 and April 2022, interrupted by the COVID-19 (SARS-CoV-2) pandemic (Fig.4). Originally scheduled for one year of consecutive fieldwork in the same study site to collect data on Betsileo children's knowledge and contribution to their food system, fieldwork was shortened, and the research outline modified. Specifically, I abandoned the idea of analyzing the contribution of WEP to diets, as this would have required extended fieldwork and focusing on knowledge distribution.

The first phase of fieldwork (April – May 2019) in the framework of the LICCI project was conducted with the LICCI core team member Xiaoyue Li. We teamed up with French researchers from IRD (Institut de recherche Recherche pour le Développement) and CIRAD (Centre de Coopération International en Recherche Agronomique pour le Développement) to test the LICCI protocol with Betsimisaraka people and spot potential study site for the rest of the thesis. During this first stay, Xiaoyue Li and I, with the assistance of research assistant/translator Didie Cresson, collected data on the uses of WEP in the southwest of Madagascar (Mahafaly region) with the Tanalanas people. The primary objective of this data collection was to test the feasibility of collecting data from children.

The second stay (starting in December 2019) was dedicated to the main data collection among Betsileo people from Namoly in the central plateau of Madagascar. During this second and longer stay (four months), I started learning the Betsileo language, while sharing daily life by getting involved in the different activities (e.g., paddy rice preparation, celebrations). All along this phase, I collected background data, the first set of data for the LICCI project, and data about WEP knowledge using participant observation, free listing, focus group discussion combined with pile sorting interviews, and informal and semi-structured interviews. During this time, I worked closely with two field assistants, Betsileo speakers from the village, Depaul François, and Myosotys Lova Hasinasandratra.

Mid-March 2020, due to the pandemic, I was repatriated to Réunion island (France) and then to Spain in August. This short four-month fieldwork did not allow me to collect the data needed to test my hypothesis. Because of the pandemic, Madagascar's borders were closed, and flights were suspended for two years. Since this period did not allow for the collection of additional data and given the uncertainty of being able to return to the field, I decided to valorize the data collected in the Mahafaly region and to include it as a chapter of the thesis (Chapter V). However, the short time spent among Tanalanas people did not allow me to collect background data limiting the ethnographical exploration and contextualization in the present thesis (see section 1.4 Structure and aims of the dissertation).

Finally, the third and last field phase lasted two months (March to April 2022), and it could only be conducted once the borders were reopened. This last phase was dedicated to collecting the last set of data using the child drawing and completing them with further qualitative data. This period also provided an opportunity to reconnect with the Betsileo community after a challenging year marked by a pandemic and cyclone Batsirai. Additionally, I presented the initial research results during this stay. The data collected during this stay was conducted with the help of a student in botany from the University of Antananarivo I supervised, Sitrakiniaina Clara Raketabakoly.

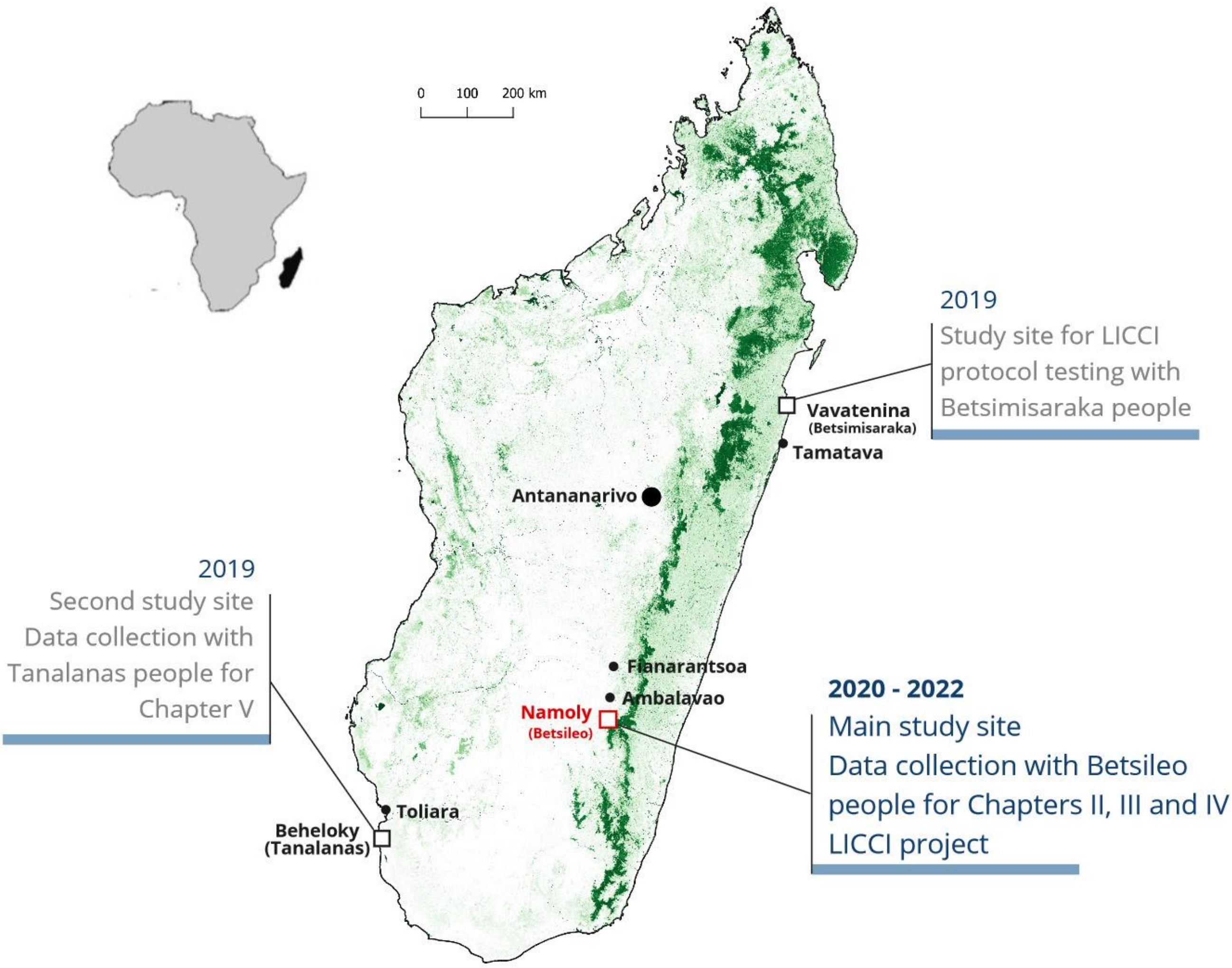

Figure.4 - Map of the study site and timeline of the thesis

Throughout this thesis and the fieldwork, I worked in close collaboration with researchers from IRD, CNRE and Madagascar National Parks (MNP) who helped me with the logistics of setting up the research area. Some of the first results have been presented to these institutions and are progressively inserted in the research axes of the International Mixed Laboratory (LMI Paysages) recently created by Dr Stéphanie M. Carrière associating researchers from IRD, UMR SENS. cirad and CNRE. Finally, I also collaborated closely with the Herbarium of the

Zoological and Botanical Park of Tsimbazaza (TAN) based in Antananarivo for the identification of different taxa.

Methodological Approach

As this thesis work is part of the broad and multifaceted field of ethnobiology, it seems important to briefly define the discipline and to present the different methods and approaches used here and the framework in which I collected and analyzed data. According to the Society of Ethnobiology (2023), Ethnobiology is a multidisciplinary field that studies the dynamic relationships among peoples, biota, and environments. The methodological approach used in ethnobiology involves a combination of qualitative and quantitative methods from different fields to document, analyze and interpret these relationships.

In this thesis, I borrow methods, approaches and concepts belonging to cognitive anthropology, food anthropology, psychology, linguistics, geography, ecology, botany, systematics, and phylogeny, without claiming my full expertise in these areas. Therefore, in view of the subject and the method used, I consider that the work I present here belongs to the branch of ethnobotany.

In this section, I give a general overview of the methods and approaches used throughout the work. However, the specific details of how the data was collected and analyzed are provided in each of the empirical chapters.

Ethnobiology

In order to provide context for the subject of my thesis, I collected ethnographic information throughout my fieldwork. This allowed me to become acquainted with the study site, the traditions and livelihood activities of the Betsileo people, and also to address the lack of information on the Namoly Valley and its unique characteristics. To achieve this, I engaged in daily participant observation and held numerous formal and informal interviews with various key informants. During my stay in a village, located in the heart of the Namoly Valley, I carefully selected key informants with the help of the Rakoto family (a pseudonym used for anonymity). The Rakoto family kindly accommodated me in their home for the first few weeks until I was able to find an available room at the MNP premises. During my fieldwork, I maintained regular contact with the Rakoto family by eating three meals a day with them, despite being accommodated on the other side of the village. This arrangement provided me with numerous opportunities to engage in informal conversations during mealtimes. Through this close relationship, I was able to establish a group of key informants that included family members of varying ages and genders, including children. Then, after a few weeks, I could expand my key informant networks beyond this family for different areas of expertise (e.g., agriculture, medicine, divination) and to diversify sources of information. This close relationship not only allowed me to learn the Betsileo language and customs but also gave me the opportunity to test certain methods before collecting the data (notably Pebble games and the pile sorting method).

The purpose of this ethnographic exploration was to achieve several thematic objectives. The primary objective was to gain an understanding of the local livelihood. To achieve this objective, I conducted several focus group discussions aimed at establishing the seasonal calendar and depicting the agricultural system and its landscape. Additionally, I collected data for the LICCI project using the crop diversity protocol[5]. In addition, the various semi-directive interviews of the LICCI protocol allowed me to capture the perception of socio-environmental changes in the valley and the variation of this perception between individuals. It allowed me to collect ethnographic data on the dynamics of the valley essential to contextualize my work and identify local issues in terms of food sovereignty. I completed this data with some interviews with elders and traditional chefs (*Ray aman-dreny*), who shared with me their knowledge on the history and legend of the valley.

The second objective of this ethnographic exploration was to gain a better understanding of the social organization of the Betsileo people. To do so, I conducted semi-structured interviews with both men and women, focusing on belief systems, customs, and traditional rules (*fady*). Additionally, I conducted interviews with a group of women about childhood, childcare, and nutrition.

The third objective of this ethnographic exploration was to explore the relationship between the Betsileo people and their environment, particularly plants. To assess the diversity of plants known and the variability among informants, I

[5] CITRON, crop diversity: https://licci.eu/crop-diversity/

conducted free listing and interviews with as many individuals as possible, including children, adults, women, and men. In addition, to understand how individuals classify and value living beings, I conducted focus group discussions with both women and men using pile sorting (Martin, 1995). Specifically, I asked participants to place the groups generated by the sorting stack along a free gradient. The participants stated that the gradient would indicate the usefulness of the species. Then, I used pile sorting only with plant species to understand their plant classification system. The results of this exercise are presented in Chapter III. In addition to various informal talks on the preparation of wild edible plants before and during meals, I also conducted many walk-in-the-woods to complete information on the use and collection of plants (Gallois et al., 2020). Through my research stay, I conducted walk-in-the-woods in the most different ecological habitats (see Chapter IV) to catch the diversity of the places of collection.

Finally, throughout my fieldwork, I tried to actively participate in the life of the valley. With the invaluable assistance of my Betsileo translator, who spoke French and the Rakoto family, I was able to participate in various cultural activities and events, including funerals. I also adapted my data collection schedule to the local rhythm and availability of informants.

Ecology

To be able to contextualize the complex ecological habitat mosaic with which people interact daily and where they collect plants, and to understand the dynamic of these ecological habitats, I used a geographical approach and tools. I made use of GIS (geographic information system) to map my study sites (using QGIS 3.28.3 software). I combined remote sensing data such as topographic data (generated with elevation SRTM data at 90m spatial resolution from the CGIAR-CSI database), vegetation using Normalized Difference Vegetation Index (NDVI data provided by the IRD), and deforestation (from Global Forest Watch) with field observations. I completed my maps and updated them with the different field trips to dialogue with remote sensing data and ground reality. Maps have been used for the understanding and interpretation of my study sites throughout my thesis (Fig.5). In particular, this allowed me to build the different categories of vegetation used in Chapters III and IV.

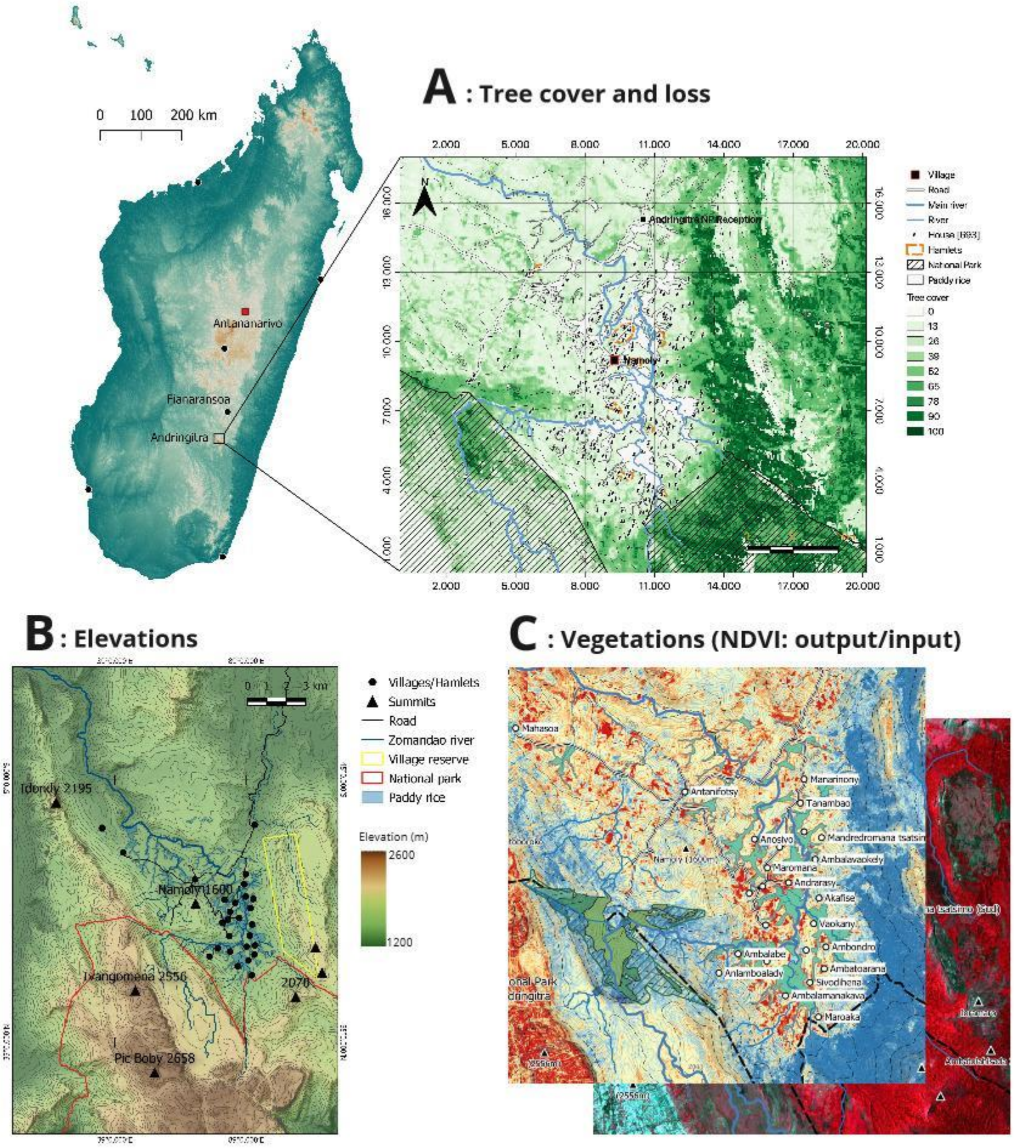

Figure.5 - Map of the study site of Namoly with tree cover (A), elevation (B) and NDVI (C).

Botany

To document the corpus of ethnobotanical knowledge on WEP, in this work I have also used different methods to identify the plant species elicited during the interviews. Trained in botany, I used vouchers and photographs or both to identify plant species (see **Appendix A.1** for the complete list of species reported by Betsileo people and **A4.S1 tab** for the plants reported by the Tanalanas people).

Vouchers: I used vouchers only for the plant identification of the WEP species. To collect and prepare them, I followed the field guide used by the Missouri Botanical Garden (Liesner, 1995). However, obtaining herbarium numbers was not possible for multiple reasons. First, due to the pandemic during the second phase of the field, the vouchers could not be deposited. Secondly, during the last phase of the field, the time on the field did not allow me to prepare the herbarium for their deposit in the Tsimbazaza herbarium (TAN). Not having the necessary authorizations, the plant material could not be taken out of Madagascar, for a possible deposit in another herbarium. I am aware that the absence of a deposit hinders the verifiability of my plant identification work by other ethnobotanists, botanists, and taxonomists. However, during the last phase of the field, I was able to verify the identification of all the species collected in vouchers (and photographs if necessary) with the botanists of the TAN and thus obtain the numbers of the vouchers used as a reference for comparison including the different types if available. In some cases, the specimens collected had no correspondence with those of the TAN, so I used different digitized herbarium for the comparison and the determination of the species; mainly those of (KMCC) the Royal Kew Garden (POWO), the (MBG) Missouri Botanical Garden (present in Tropicos Madagascar (2023)) and those of (P) the National Museum of Natural History in Paris (MNHN) (see details in **Appendix A.1**).

Photographs: Not having the authorizations for the collection of plant specimens in the MNP Andringitra, identification of the species present only in this zone (including rare endemic ones) have been made through photos. The identification of these species was confirmed by TAN botanists from photos but also with the help of the iNaturalist community after submitting photos on the platform, and more specifically the members of the Zavamaniry Gasy Plants of Madagascar[6] project led by the Kew Madagascar Conservation Center (KMCC), of which I am also an active member. The use of iNaturalist for the identification of plant species was recently the subject of a publication demonstrating the potential of the platform as an alternative photo voucher in ethnobotany (Greene et al., 2023). In parallel with the work of Alexander M. Greene, I also created iNaturalist lists constituting

[6] https://www.inaturalist.org/projects/zavamaniry-gasy-plants-of-madagascar

photographic references for the identification of useful species in the two study sites visited during the thesis (see *Wild edible plants of Namoly*[7] and *Wild edible plants of Mahafaly region*[8]). These lists are the first steps in the creation of a user-friendly field guide on the Namoly useful plant diversity as the result of a knowledge co-production project initiated with the Betsileo people to be launched in the next few years.

Final plant identification and local names correspondence were triangulated with literature (when available). For tree species, I mainly used the vernacular names section of GE Schatz's book entitled "*Flore Générique des Arbres de Madagascar*" (2001) and for the other species, I used the online Malagasy Encyclopedic Dictionary[9] including more than 6000 words corresponding to plant species. All botanic families and scientific names were checked using the World Flora Online Plant List and the last updates of APG IV. Of the complete established list of identified species (excluding two species not known), only one taxon does not have an accepted Latin name and remains in Unchecked status (*Stephanotis floribunda* Brongn.). Finally, for animals and fungi (mainly in Chapter III), I used iNaturalist to identify them and Global Biodiversity Information Facility (GBIF, 2023) to check the species names.

Finally, in chapters II and V (see **A4.S1 Fig**), I use phylogenetics to illustrate the taxonomic diversity of the plants used by the Betsileo and the Tanalanas and their correspondences with the Betsileo classification system (Chapter II).

[7] https://www.inaturalist.org/lists/2939378-Wild-edible-plants-of-Namoly
[8] https://www.inaturalist.org/lists/4326140-Wild-edible-plants-of-Mahafaly-region
[9] http://malagasyword.org

1.4 Aims and Structure of the Thesis

The purpose of this thesis is to advance the understanding of (1) children's specific ethnobotanical knowledge richness and (2) intracultural variability about WEP while focusing on gender and age as factors of knowledge differentiation. These main research objectives are addressed through four specific aims serving as a guide for empirical research conducted among Betsileo in the central highlands and Tanalanas people in the southwest tropical dry forest of Madagascar:

1. To explore Betsileo's ethnobotany and to contribute to the documentation of the plant uses, folk taxonomy and classification (Chapter II);
2. To understand how Betsileo children, identify and distinguish plant species, with a focus on WEP (Chapter III);
3. To assess intracultural variability in WEP knowledge distribution among Betsileo (Chapter IV); and
4. To examine the diversity of WEP knowledge adapted to the dry environments of Tanalanas people and explore the intracultural variability in this knowledge (Chapter V).

This dissertation is a hybrid between a monograph and a compilation of empirical research chapters in the format of scientific articles. It is organized into three parts and seven chapters. The first part is a comprehensive introduction of the research topic and description of the case studies which emphasizes the Betsileo ethnographic settings. Due to the short time spent with the Tanalanas for the reasons explained above, in this part, I do not develop the Tanalana ethnographic settings, but rather just give a quick overview of this study site. The second part, focusing on Betsileo's ethnobotany, contains a descriptive chapter and a research article. The third part is composed of two research articles both addressing knowledge distribution. I end my dissertation with a final chapter with the main conclusions.

The empirical chapters of this thesis present some similarities, specifically in the description of the study site and the methodological approach which might be redundant for the reader with the information contained in the introduction

(Chapter II). However, I choose to keep these chapters in the format they have been published (or sent for publication) in order to maintain their internal cohesion.

At the time of delivering this dissertation, one of the empirical chapters is published (Chapter IV, *Plos One*) and two are submitted (Chapters III, *People and Nature* and V, *Human Ecology*). Finally, the ethnobotanical data provided in Chapter II will soon be converted into a manuscript to be submitted to *Economic Botany*.

Chapter I provides an overview of the topics addressed in this thesis, drawing on a literature review to contextualize the research within the broader field of ethnobiology and children's anthropology. In addition, the chapter outlines the main objectives and motivations of the study, as well as the methodology used to address the research questions.

Chapter II introduces the study site and provides information on the overall ethnographic Betsileo settings. More specifically, using literature and first-hand ethnographic information, I introduce some key elements of the Betsileo cultural context such as the livelihood activities, their food habits, and childhood to contextualize the three following chapters (Chapters III, IV and V). This chapter also provides an overview of the Betsileo ethnobotanical knowledge and documents some cognitive aspects of their knowledge. More specifically, the first-hand data and results presented in the chapter describe the main type of uses Betsileo people from Namoly have of the plants involving different knowledge realms (e.g., construction, WEP, medicinal, magical uses) as well as how they name and classify plant into emic categories highlighted by their system of value, uses and some phylogenetic perspectives.

In line with the previous chapter, Chapter III explores the overlooked ethnobotanical aspect of plant species identification. Using the method of the drawing interview, I developed a new approach to exploring children's plant identification criteria. I inventory the diversity of plant details observed and retained by children to identify WEP species and assess variability within individuals through an intersectional lens including age and gender. I discuss the effect of the factors on this specific knowledge acquisition and the gender differentiation of identification skills. Finally, I open the discussion on the missing sensory and emotional dimensions that might be involved in identification knowledge. This chapter corresponds to the article "How do young identify plants? Using the drawing method to explore early ethnobotanical knowledge in Madagascar", under review in *People and Nature* and submitted in April 2023.

Chapter IV tests the effect of gender and the life stage on the WEP knowledge diversity among Betsileo people. In this chapter, I analyze whether the number of WEP plant species known, the plant characteristics, their ecological distribution and their attributed importance follow some intracultural variation pattern. I discuss this heterogeneously distributed knowledge through the lenses of socio-cultural, ecological and transmission contexts. This chapter corresponds to the article "Growing up in the Betsileo Landscape: Children's WEP knowledge in Highlands", published in *Plos One* in February 2022.

Chapter V explores the intracultural variation of WEP knowledge in the context of a dry environment and frequent food scarcity situations among Tanalanas people. I analyze the distinct distribution pattern regarding theoretical and practical knowledge according to gender and life stages. I discuss how resource limitation and food scarcity might be so pervasive in the area that extensive sharing of knowledge on WEP could be a risk-management strategy adapted to the extremely dry environment. This chapter corresponds to the article "As Proficient as Adults: Distribution of Children's Knowledge of WEP in the Arid Mahafaly region", under review in *Human Ecology* since January 2023.

Chapter VI serves as a comprehensive discussion of the research findings presented throughout the thesis. This concluding chapter synthesizes the key results from the preceding chapters, drawing on both theoretical and methodological perspectives to address the primary research question. Additionally, the chapter identifies the limitations of the study, suggests areas for future research, and proposes potential policy implications stemming from the research findings.

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Chapter II

Case Studies

2.1 Madagascar Biocultural History and Diversity

A Short Introduction to Plants and People

Separated from Africa 135 million years ago and then from India 100 to 88 million years ago (Yoder & Nowak, 2006; Barthelemy et al., 2022), and populated by different waves of human migration for over 10,000 years (Pierron et al., 2017; Hansford et al., 2018) Madagascar is the result of a long and complex biocultural history (Goodman, 2022).

World-renowned as one of the world's richest biodiversity islands, Madagascar's record level of endemism reaches 96% for plants (Schatz, 2001). The endemic flora of Madagascar alone represents 16% of the number of known vascular plants in the Afrotropical region (Raven et al., 2020). While there are about 11,399 native species described, the total number is estimated at 14,000 species. These belong to 249 vascular plant families, comprising 1698 genera. Madagascar's floristic richness is directly related to the tens of millions of years of isolation after the fragmentation of Gondwana, as shown by the divergence with India regarding woody plant lineages (Barthelemy et al., 2022). This isolation allowed the speciation and the appearance of unique phylums giving rise to five endemic botanical families (Asteropeiaceae Takht., Barbeuriaceae Naka, Physenaceae Takht., Sarcoleanaceae Caruel and Sphaerosepalaceae Tiegh) and numerous endemic genus and species in other botanical families, such as the different species of traveler's tree (*Ravenala* spp.) and baobabs (*Adansonia* spp.), to name a few, making Madagascar's biodiversity so particular.

In addition, the topography and influence of the island's different climatic regimes have given rise to a great diversity of terrestrial ecosystems, from the xerophytic thickets of the south-west to the humid tropical forests of the east and the high-altitude ecosystems of the central highlands with their numerous inselbergs, where numerous species have specialized (Goodman, 2022). These ecosystems' complexity and shaping are also linked to thousands of years of shared human history (Burns et al., 2016; Carrière et al., 2022).

Echoing the priceless biological treasures it harbors, the island nation also boasts remarkable cultural diversity. The island has been shaped by the migrations of various ethnic groups over centuries and millennia, resulting in a mosaic of distinct cultural traditions, languages, and customs (Adelaar, 1989; Allibert, 2007; Capredon et al., 2012). For many years, Madagascar was known as one of the last territories populated by humans, who were thought to have arrived late in the 5th century (Dewar & Wright, 1993), thus ignoring the existence of prehistory on the island. The lack of archaeological material and written history led ecologists and paleologists to propose models of extinction of the megafauna during the Holocene without the presence of humans unlike the rest of the world (Crowley et al., 2010; Virah-Sawmy et al., 2010). However, recent archaeological excavations, notably the presence of stone tools found in rock shelters (Dewar et al., 2013) and the discovery of butchery marks on extinct elephant birds (Aepyornis and Mullerornis) have pushed back the first human arrival by several thousand years before present (years B.P.), with estimations of a possible arrival >10,500 years ago (Hansford et al., 2018).

Our understanding of the biocultural interactions occurring in the distant past is low, but recent advances in genomics and linguistics allow us to confirm the mixed origin (Bantus/Austronesians) of the current Malagasy population (Pierron et al., 2017; Serva & Pasquini, 2022). Indeed, successive waves of intercontinental and internal migration, first from the Austronesians of southern Borneo (2000-3000 years BP) and then from the southern Bantu (1500 years BP), have led to genetic admixture resulting in a complex genomic and human diversity of the island (Pierron et al., 2017). The Malagasy language and culture have followed a similar path, with an Indonesian base tinged with Bantu and then Arabic (arrived in the 12th century) influences reflected in the diversity of terms used and cultural practices including beliefs and divination (Serva & Pasquini, 2022; Chemillier et al., 2007). Madagascar’s complex migratory history has given rise to 18 ethnic groups (with many clans and subdivisions within the groups, some speaking different dialects) and between 12 to 29 dialects belonging to the Malagasy macrolanguage (the number differs according to the sources: Glottologue.org, motmalgache.org).

Predominantly agropastoralists, Malagasy ethnic groups boast a wide range of livelihoods, including fishing communities (some of them recently settled), agroforestry communities, hunter-gatherers, rice farmers, and zebu herders displaying sophisticated local land management practices and rules.

However, local fire management practices, which contribute to rapid land cover shifts, raise questions about the impact of human activity, which is both a source of landscape diversification and a threat. Indeed, local land management practices are often at the heart of the debate on the origins of landscapes, the rate of deforestation, and conservation efforts (Serva & Pasquini, 2022; Kull, 2000; Culbertson et al., 2022).

2.2 Betsileo people from the South

Study Area - Localisation and Ecology

Within this rich biological and cultural diversity, my fieldwork was carried out in the Namoly valley (-22.12377, 46.92166), in the district of Ambalavao, in the region of Haute-Matsiatra in the southeast of the central highlands of Madagascar. This valley forms the southern limit of the Betsileo territory, stretching from the Mania River in the north to the foot of the Andringitra Massif in the south. The study area is located on the edge of the Andringitra National Park with high altitudinal gradients (720 to 2658 m). The two mountain ranges in the shape of "V" that border the valley are its bioclimatic and cultural limits (Fig. 6). Indeed, the valley is a rich ecological habitat mosaic at the crossroads of two great anthromes (Anthropogenic biomes, Ellis et al., 2010). To the west and south, the dry savannah is exposed to the dry monsoon winds and managed by pastoralists Bara and Sakalava (Populated rangelands, according to the anthromes classification). To the east, there is a humid tropical forest exposed to the moisture-bearing trade winds (easterlies) and inhabited by horticulturalists Tanala people (Populated woodlands). This site displays a specific microclimate due to the altitude, the topography, and the exposition of the wind and rain brought by episodic cyclones. According to the Köppen-Geiger classification, the valley is warm temperate, with winter dry, and warm summer (Cwb) surrounded by humid subtropical climate, Cwa[10] climate to the west and Cfa[11] climate to the east. This microclimate and this particular topography result in a great diversity of landscapes and ecosystems surrounding Betsileo settlements (Carrière et al., 2022), which are mostly organized in hamlets at the bottom of the valley (at 1500 m above sea level; **Fig.7**). On the western slope (**Fig.6b**), the Precambrian granitic massif - a large inselberg culminating at 2658m (Imarivolanitra) – supports rupicolous vegetation on its top (2500m, **Fig.7a**) and altimontane meadow and ericoid thickets down the cliff (2100m, **Fig.7b** and **c**). This highland vegetation holds the richest botanical diversity and the highest rate of endemism of Madagascar (Rabarimanarivo et al., 2019; Goodman & Benstead, 2005). On the eastern slope (**Fig.6a**), sclerophyllous moist forest (1800 - 2000, **Fig.7d**) and moist altitude dense forest (1500 - 1800m, **Fig.7e**) support many subsistence economic activities relying on knowledge associated with forest (Carrière et al., 2005; Moreau, 2006; Rafidison et al., 2020). At the bottom of the valley (**Fig.6c**), the landscape is made up of a mosaic of rice fields and secondary regrowth vegetation that is both woody and shrubby, mainly open and colonized by ferns, surrounding the villages, pastures, and other crop fields (**Fig.7f** and **g**). Given its location, Betsileo people from the Namoly Valley have access to a large diversity of resources and, particularly, to a large choice of wild edible plants.

The valley counts approximately 3.800 inhabitants distributed in 662 households isolated or clustered in hamlets called *vala* (cattle pens) of 3 to 15 houses. The isolated houses and hamlets are spread all along the valley, distant from each other by about 500m. The valley has two access routes. The first is a road to the north (**Fig.6**), connecting Namoly to the town of Ambalavao via Sendrisoa (the first market village). However, since the bridges were destroyed in 2022 by cyclone Batsirai, this road is only accessible by car as far as Sendrisoa, a four-hour walk away. The second route is west via Vohitsaoka, then across the Andringitra massif on foot for around 20 km.

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[10] Cwa: Mild temperate, fully humid with hot summer (Köppen-Geiger classification).
[11] Cfa: Mild temperate, with dry winter and hot summer (Köppen-Geiger classification).

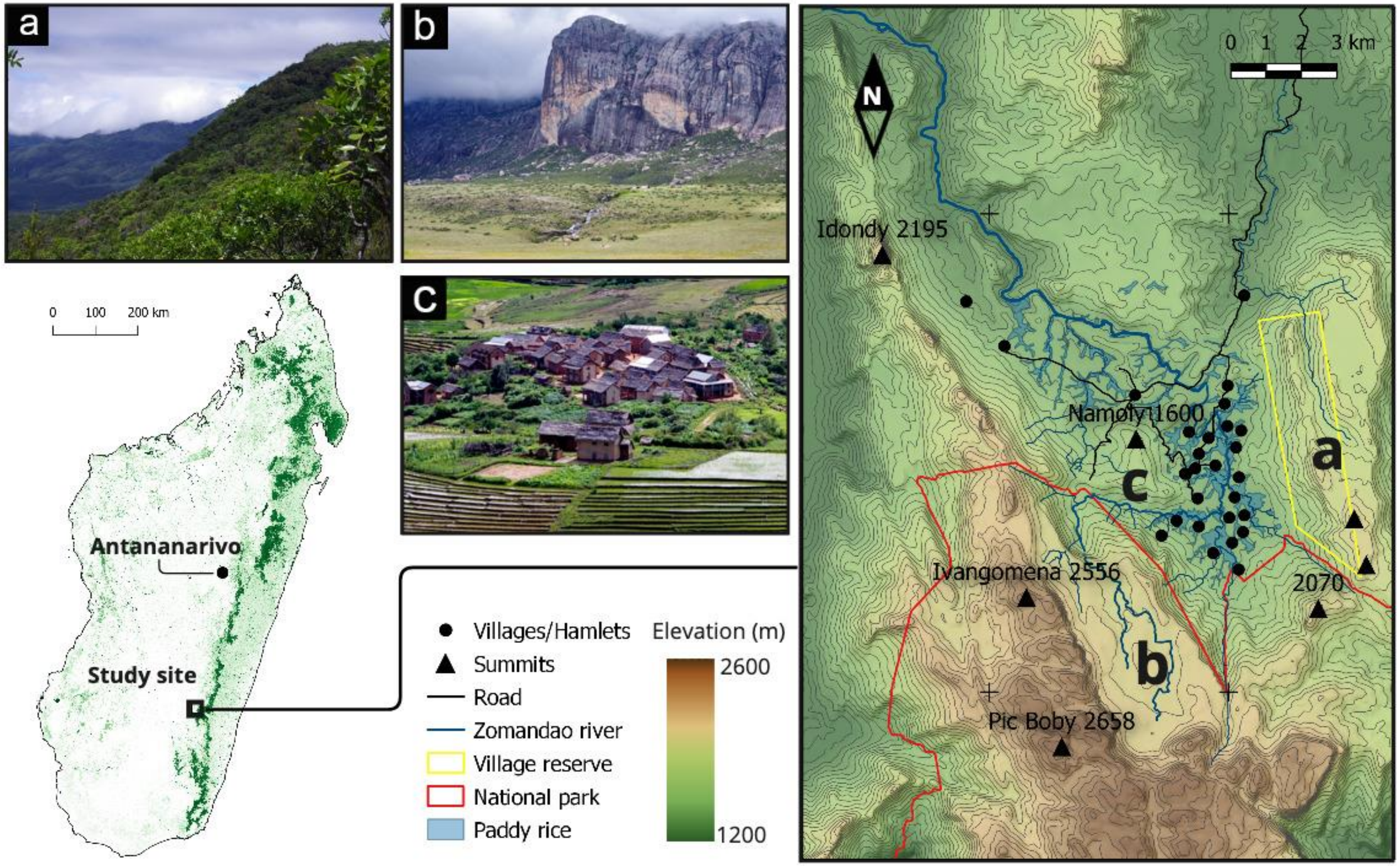

Figure.6 - Map of the study site: The Namoly valley landscape and its main ecological zones. a. Eastern slope: moist altitude forest, **b.** Western slope: altimontane meadow of Andringitra Massif, **c.** Valley bottom: villages, crop fields and paddy rice fields. The map was built under QGIS 3.10.0 by the author, using elevation SRTM data at 90 m spatial resolution from the CGIAR-CSI database (Jarvis, 2014).

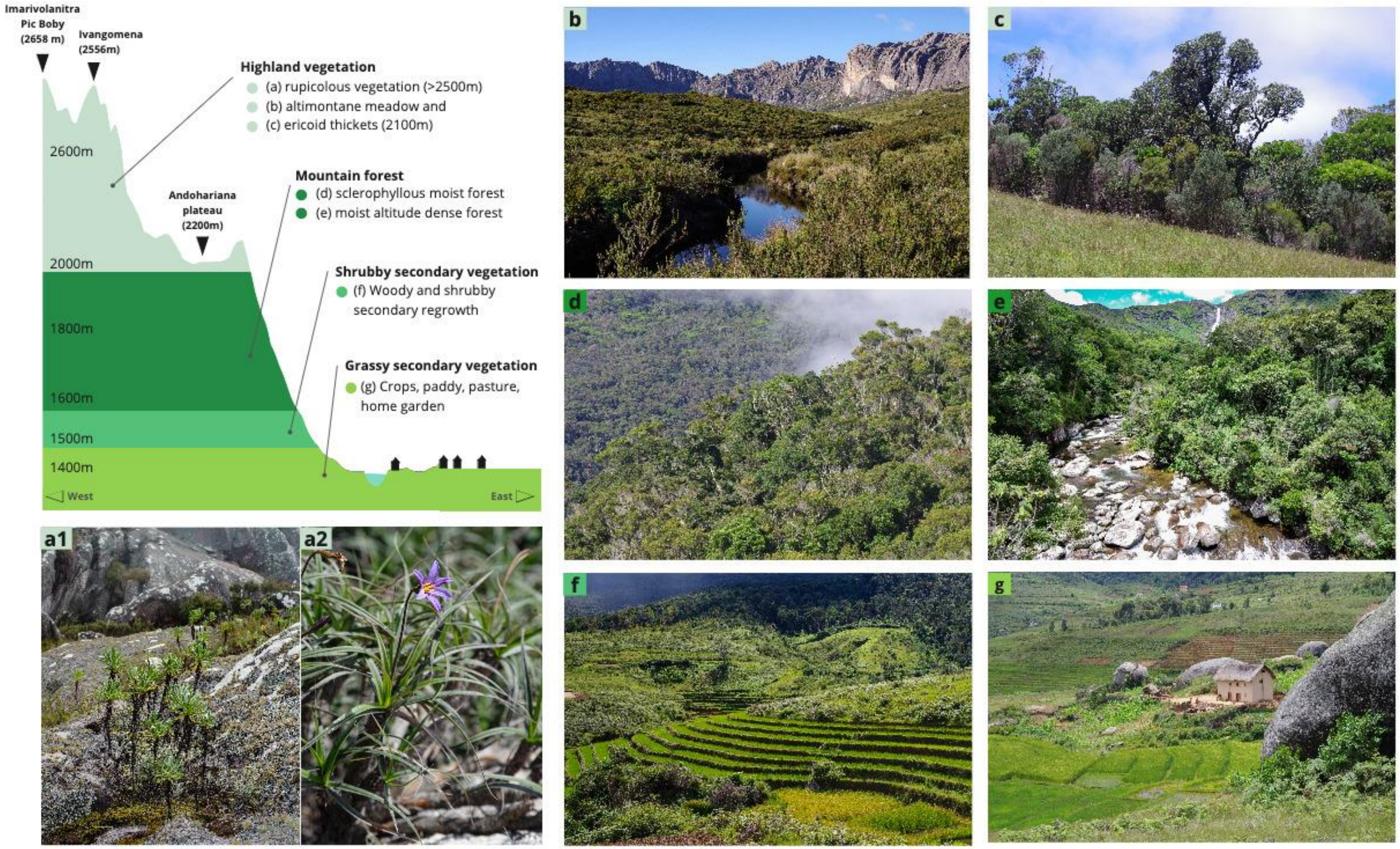

Figure.7 - Altitudinal zonation of vegetation in Namoly valley. a. Rupicolous vegetation (>2500m), **a1.** *Helichrysum syncephaloides* Humbert and **a2.** *Xerophyta andringitrensis* (H.Perrier) Phillipson & Lowry, **b.** Altimontane meadow (2100m), **c.** Ericoid thickets (1900-2100m), **d.** Sclerophyllous moist forest (1800 - 2000), **e.** Moist altitude dense forest (1500 - 1800m), **f.** Woody and shrubby secondary regrowth vegetation surrounding the paddy rice (1500m) **g.** Grassy regrowth vegetation (1400-1500).

Cultural Context

The Betsileo, "the many invincible" (*be*- numerous, *tsy*- negation, and *leo*- stunned, defeated) are Madagascar's third largest ethnic group, with over 2,200,000 people living in the southern highlands, whose capital is Fianarantsoa. Their large territory covers two *faritra* (administrative regions): Amoron'i mania and Matsiatra Ambony (or Haute Matsiatra). Betsileo is a complex society including many clans such as the Tanala and the Zafimaniry. The southern Betsileo also claim to be Antemoro (an ethnic group inhabiting the east coast), although their ancestors came from the north of Betsileo territory. In addition, intermarriage and migration have made this society a dynamic and multi-faceted ethnic complex. It is *difficult to give an encapsulated description of Betsileo society that would unambiguously apply to the north and the south* of their territory (Regnier, 2020: p.9). The use of the term Betsileo to designate these people dates back to the creation of the Betsileo province during the reign of King Radama I (1793-1828), in reference to their tenacity during the wars of the kingdoms (Kottak, 1977).

The Betsileo in the literature

Although the term Betsileo appears in the literature at least since 1892, there are few studies of Betsileo culture (Fig.8). Most of the literature focuses on the agricultural productivity and mining resources of the Betsileo region (Betsileo territory), particularly during French colonization. The only documents during this period focused on the human geography of the territory and the labor capacity of the Betsileo people, with the aim of enslaving them for the benefit of colonial policies (Sharp, 2003). Since the end of the French colonization (1946) and up to the 1980s, the number of publications referring to Betsileo has increased, with an emphasis on agricultural productivity, for the purposes of the "development" of the local economy. It was also at this time that the first works referring to the use of plants were published, notably those by R. Decary (1962) and P., M. & L. Boiteau (1980), although this literature did not focus exclusively on Betsileo knowledge. It was not until the 1990s, in parallel with the rise of biodiversity studies and conservation efforts in Madagascar, that researchers started focusing on the Betsileo local knowledge related to biodiversity management (Kottak, 1999). This was followed in the 2000s by a growing number of works in ethnoecology, and social geography linked to changes in protected area management policy. In 2003, the management of most of the country's protected areas was transferred to the local communities, who organised themselves into the Communauté de Base called COBA or VOI in Malagasy language (Blanc-Pamard & Ramiarantsoa, 2008). In total, considering all the publications consulted for this literature review and mentioning the term Betsileo (641 publications combining data available on Web of Science n=33, Google Scholar n=56 and Persee n=552), only a small proportion (27%) deal in depth with the Betsileo people and culture (Fig.8). In particular, the monograph by R. P. Dubois (1938), the works by C. P. Kottak (1971a) and A. Rahamefy (2008), and more recently, those by D. Regnier (2012, 2015) on marriage rules and essentialism, to name but a few. However, this review does not take into account the many reports produced but not published on the subject in French and Malagasy.

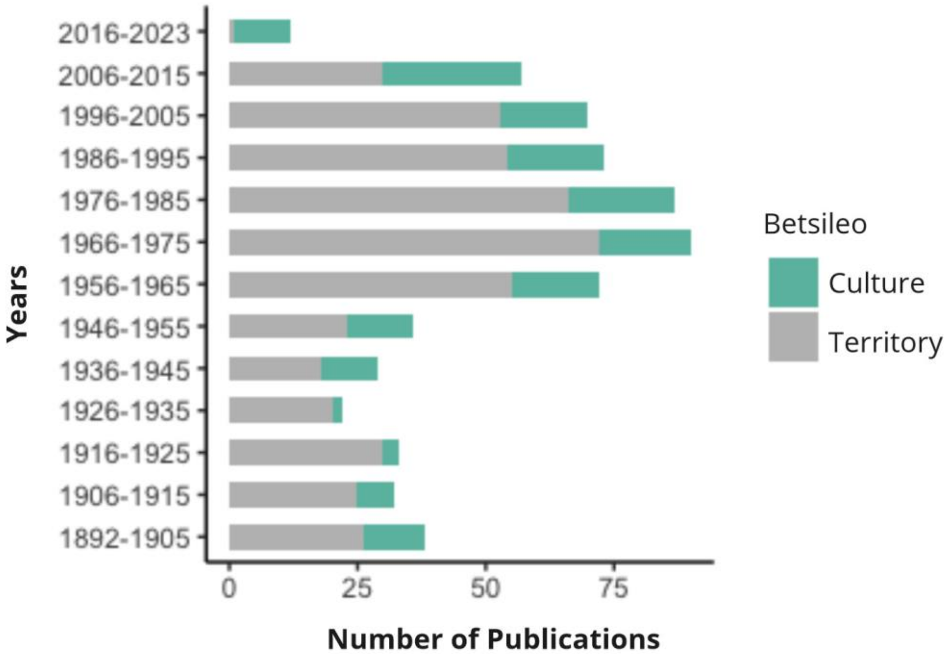

Figure.8 - Publications referring to the term Betsileo over time. In blue, publications referring to the Betsileo culture as a people. In gray, publications referring to the Betsileo territory in terms of human, mining, and agricultural resources. Literature review of 641 publications combining data available on Web of Science (33), Google Scholar (56) and Persee (552).

Historical context of Betsileo from Namoly

The Namoly Valley, located 55 km from Ambalavao in the extreme south of Betsileo territory, has long remained uninhabited by the Betsileo people due to its steepness and difficulty of access. The area has been occupied by Betsileo only since the end of the 19th century. Some village elders speak of an early occupation by the Vazimba, whose tombs and megaliths can be found at the entrance to the valley. It was with the conflicts between kingdoms linked to King Radama I's attempts at unification, between the end of the 18th and the beginning of the 19th century, that the first wave of Betsileo migration arrived in the south. Many local historians recount the flight of the Betsileo, hiding in the mountains to escape slavery and Radama's massacre at Ifandana. The Betsileo arrived in the south and gradually settled around the valley. Only the *mpiarakandro* (zebu keepers) entered the valley. Then, around 1880, with the need to find new irrigable land motivated by the transformation of the Betsileo economy (from rain-fed to irrigated rice grower), Namoly gradually saw the arrival of the first village and rice fields (Regnier, 2020). In 1929, following the work of botanist Henri Perrier de la Bathie, the Andringitra massif bordering the Namoly valley was classified as an integral reserve and became Madagascar's first National Park. Finally, with the transfer of management to COBA in 2003, the valley saw the emergence of locally managed village reserves.

Society and Social Organization

Betsileo social organization is driven by familial lineage, which in turn is tomb-centered and local descent groups called *foko* or *firazanana* (Regnier, 2020). Most *foko* members prefer a patrilocal place of residence after marriage and are buried in their father's tomb (Regnier, 2020; Kottak, 1971a & b). Families are organized into households occupying different neighbouring houses (**Fig.9a**). The head of the family, the *rayaman dreny* (*ray*- father, *aman*- with, and *dreny*- mother), often occupies the houses at the top of the hills (**Fig.9b**) and has decision-making authority within the family circle. This lineage system determines the transmission of the material heritage (e.g., land, cattle) as well as the magical knowledge in *ombiasa* and *mpanandro* families (healers-diviners).

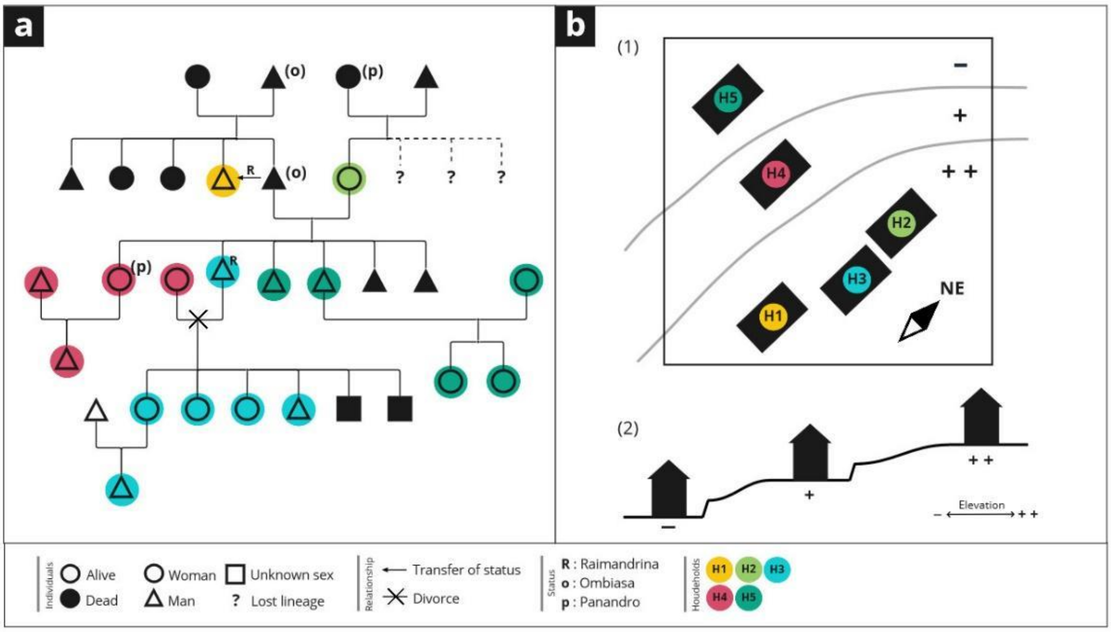

Figure.9 - Lineage and spatial organization of households among the Betsileo. a. Family tree and **b.** Distribution of houses on the hillside (1) top view, (2) profile view. Built from the example of the Rakoto family.

Betsileo society is also divided into three groups of endogamous status, which still govern several social rules, notably at funerals and weddings (Regnier, 2012), but also at the invocation of ancestors, whose symbolic interpretation differs from one class to another (Regnier, 2014). The highest social status is the *hova* (nobles) of royal lineages, once considered sacred and almost divine. These individuals still play an important role in many ceremonies, even though their allegiance has gradually disappeared. Then came the *olompotsy* (commoners), the subjects, some of whom, the *andevohova* also called *mahahasinkova* were considered free slaves in the service of the *hova*. Finally come the *andevo* (slaves), whose lives are dedicated to the work of their masters, the *tompo*. Their status as slaves does not imply physical mistreatment but confers a restricted social status.

Today, the importance of this status in daily life has diminished, however, certain *hova* clans' descent families still retain a certain political clout, at least in access to water for irrigating rice fields (Moreau, 2002).

At the political level, like most Malagasy villages, the inhabitants of the Namoly Valley have an administrative authority called "*fokontany*" (the smallest administrative unit; *fokonolona*- villagers, *tany*- land) and a traditional authority the *rayaman dreny* (usually the elders of the village). The Namoly Valley comprises five fokontany, each with an elected president known as "*filoham-pokonolona*" who represents the residents. The president is responsible for the administrative affairs of the commune, including land, zebu (cattle), and rice sales. They also address village issues at the district level, such as requesting funds for desilting rice fields or reconstructing bridges, as it was the case, for instance after Cyclone Batsirai in 2022. However, the president does not hold political authority, as most decisions are collectively made in village assemblies under the supervision of the *rayaman dreny*. These assemblies aim to reach decisions through consensus among men of the entire village. The Betsileo community from Namoly exhibits a pronounced spirit of communalism, a direct expression of the *fihavanana*, the feeling of solidarity; in sum, to make a group (Ravololomanga, 2006; Sandron, 2008). However, the expression of the *fihavanana* is decreasing with the progressive change in the value system and abandonment of customs.

Believes System and World Understanding

Betsileo society and livelihood is also influenced by their beliefs based on a cult of ancestors admitting a god called Zanahary and magico-religious rules working as a system of prohibitions or taboos called *fady* (Fig.10). The *fady* can vary according to village, clan, family, gender, age, social status, and individuals. These prohibitions help to maintain social cohesion and limit crime, as well as regulate access to resources. *Fady*'s function is directly linked to the *razana* (ancestors) or to the spirits of natural areas such as ghosts called *lolo* (Fig.10). *Fady* are an integral part of the traditional practice known as *fomba*, closely linked to Betsileo identity. Incidentally, Betsileo from the south, living in Namoly valley argue that their *fombadrazana* (ancestral customs) differ from the Betsileo living further north (Regnier, 2020).

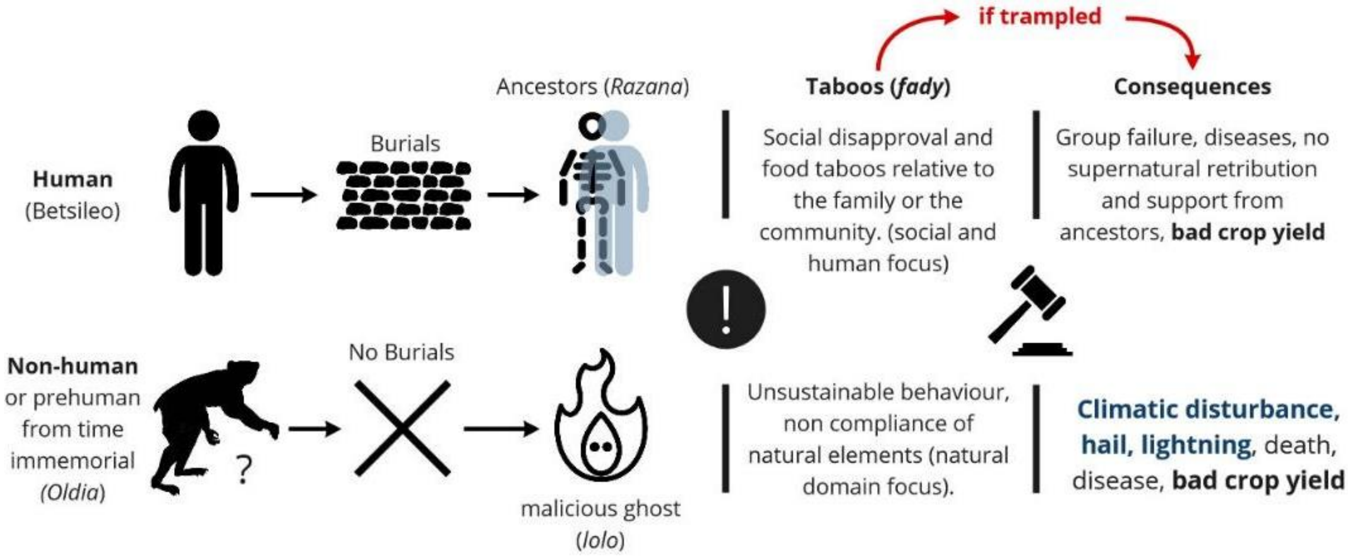

Figure.10 - Functioning of the fady system. Consequences of the lack of respect for fady, depending on the origin of the fady (human or non-human).

The *fady* system directly influences Betsileo's understanding of the world and governs decision-making, as can be seen in the example of adaptation to climate change. Betsileos perceive many climate-related changes, most often embedded in long chains of complex physical and ecological processes involving spiritual entities. For example, Betsileo argues that the progressive abandonment of customs, such as the respect of the different *fady* has direct consequences on people's lives, and sudden changes in climate (e.g., hail, lightning, and heavy rain). Thus, the Betsileo interpret recent changes in the climate system as the synergy of independent bioclimatic processes and the decadence of their society linked to the loss of ancestral customs (**Fig.11**). Adaptation strategies adopted by Betsileo consequently involve both technical (i.e., modification of the irrigation system, abandonment of landrace) and magico-religious responses (i.e., increase in the number of requests to ancestors, use of specific magic ritual, and solicitation of traditional healers-diviners (**Fig.12**)).

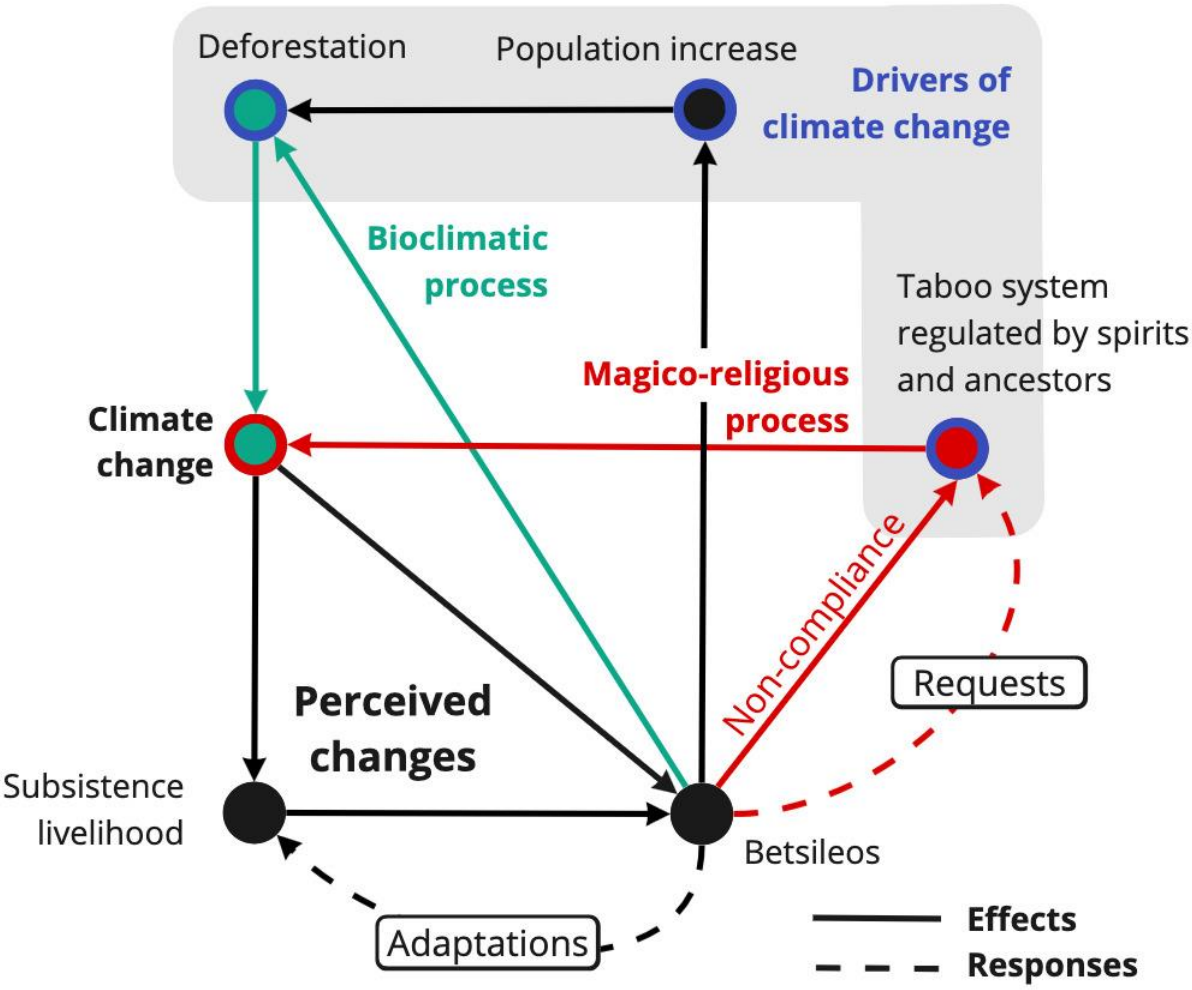

Figure.11- Scheme of Betsileo perceptions of the drivers of climate change. Links between bioclimatic process and magico-religious process

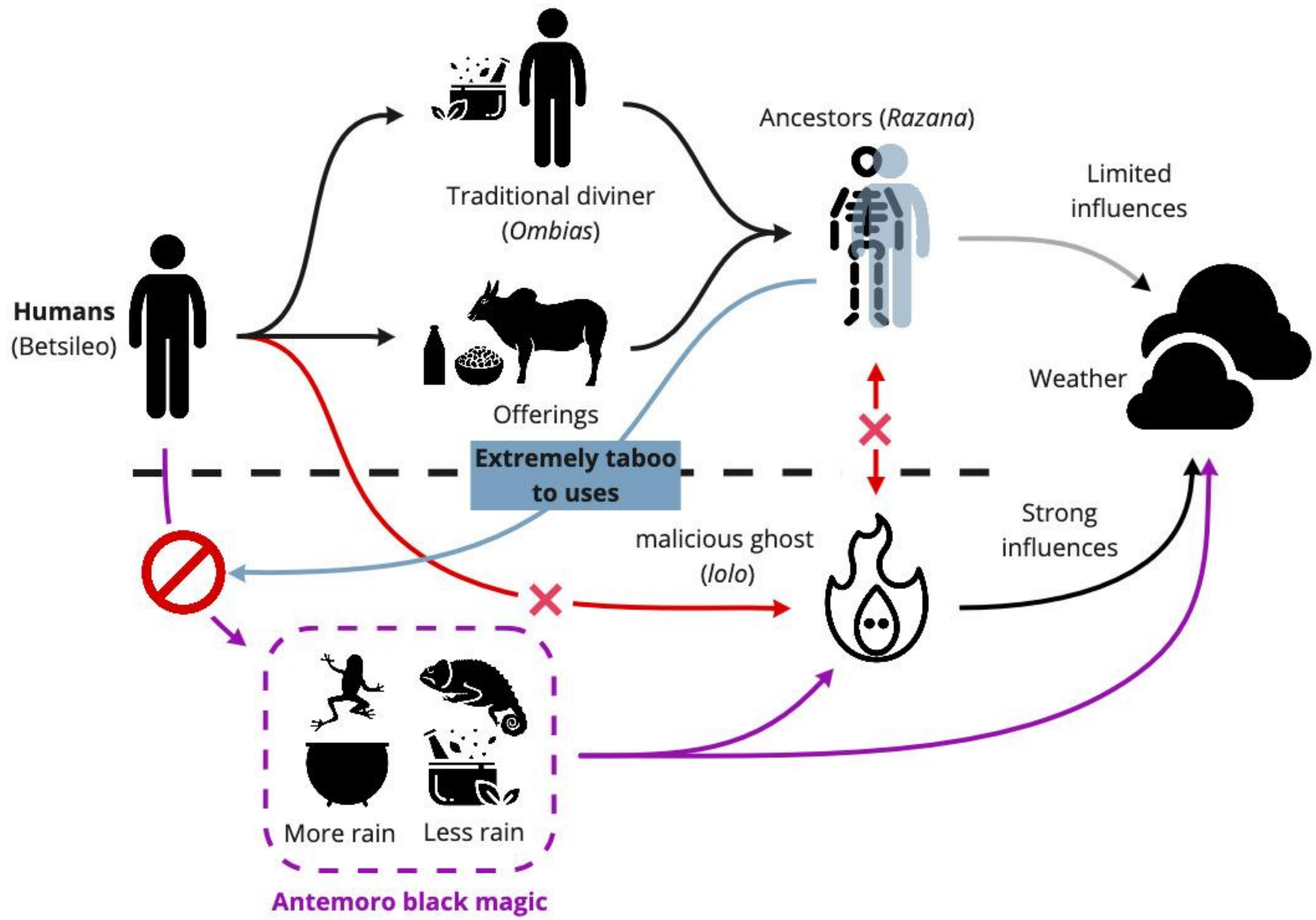

Figure.12 - Magico-religious responses and requests to ancestors: the case of climate change.When requests for help from ancestors are not sufficient to solve weather-related problems, magical practices borrowed from other ethnic groups can be used despite the taboos associated with their use.

Livelihood Activities and Subsistence System

Livelihood activities and seasonal calendar

Betsileo have adopted an agro-pastoral livelihood system based on a combination of irrigated lowland and rainfed rice (*vary*) cultivation and cattle (*omby*, i.e., zebus) herding. In addition to farming activities, Betsileo relies on a mixed economy including gathering, fishing, hunting, exchange, and trading of goods varying with the seasons.

The Namoly valley has three main seasons: the *fahavaratra.* warm and rainy season from mid-October to the end of March; the *rinina*, cold and dry season, from April to August: and the *lohatona*, dry and warm season, from mid-August to mid-October. During *fahavaratra*, in November, women transplanted the rice seedlings from the nursery to the paddies before the first rainfalls. In December the season of cyclones, which are more frequent during February and March. It is also the end of hibernation for many animals and therefore the start of hunting and collection of bora larvae by men in the forest. Then the *rinina* season starts at the beginning of April with the harvesting period (*asotry*) until July. All members of the household collaborate in harvesting. During this period, market activity is at its peak for the year, when women sell rice and other vegetable products. At the end of the season, men and boys start fishing in the river. Finally, during the *lohatona* season, men prepare the first rice paddies for the following year. Women focus on nurturing the rice nurseries and cultivating home gardens and other crops.

Throughout the year, children help adults in their respective tasks according to their gender. Girls help their mothers in the home garden and other crop fields, while boys follow their father keeping and relocating the zebus to specific pastures throughout the year.

In addition to these three climatic seasons, the Betsileo also differentiate the lean season (*havaratra*), occurring from mid-October to March just before the rice-harvesting season (*asotry*), which is central in structuring activities. At this time the rice is scarce and wild animals are in hibernation. During the lean season, most of the people go to the forest to collect wild edible plants, including women, men, and children. Indeed, unlike in the rest of the island, where there are two rice harvests, the colder climatic regime of the Namoly valley only allows for one harvest of rice per year, which makes people of the valley more vulnerable to extreme changes. People manage a wide diversity of crops, which traditionally allowed them to cope with variability in rice yield and limited risk of shortage (Radanielina et al., 2014), although recent changes in local climatic patterns harm rice yield and thus extend the lean season (Harvey et al., 2014).

In addition, due to the proximity of the Andringitra National Park, many people (including men, women and young) in the village work as tourist guides during the tourist season (from June to July mainly). The touristic activities represent an important part of the annual income for the local guides.

Cropping

Given its topography, Betsileo people from the Namoly valley have developed a large complex of paddy rice with sophisticated irrigation systems. Most of the hills of the valley are covered by paddy rice. In the valley, four types of paddy rice exist, namely *baibo rano*, *lomaka*, *kipa* (or *kipaha*) and *horaka* (see Fig.13). Additionally, five different cropping systems unrelated to rice production are present, usually non-irrigated, namely *ambody vala*, *tamboho*, *baibo*, *saha* and *ambody sitany*. The four paddy rice systems differ mainly by the water depth, the temperature of the water, and their position on the slopes of the hills and thus in the irrigation systems. Three types of paddy rice are irrigated and shallow, *baibo rano*, *lomaka* and *kipa*. These three paddy rice varieties are all connected to the irrigation systems and filled with cold water. The last decade the modification of the cropping systems, their conversions, the apparition of a new one ('*kipa*') and their multiplication. Progressively, since 1980, the valley's landscape has changed (Fig.13B & C). People began to colonize the rest of the hills by installing small, irrigated rice fields for short-cycle rice varieties production. The old and traditional paddy rice, *horaka*, is a rainfed located downhill (Fig.13). Horaka rice is prepared by hand because it is planted too deep to bring zebus in. The water of the *horaka*, filled during the rainfalls of December and not connected to the irrigation canal, is usually warmer than the other paddies (+3 to 5°C). The cold and warm waters paddies do not grow the same rice landraces. Then, regarding the other fields, on top of the hills, close to dwellings, there is the *ambody vala* (home garden) where a great diversity of crops and condiments are cultivated, with some fruit trees. Two types of non-irrigated cropping systems dedicated to potatoes and corn production are settled on the slopes (*tanety*), differing only by their rotation pattern: *tamboho* (long rotation) and *baibo* (short rotation). Then, the *saha*, a flooded cropping system where mainly bananas and taro grow are found in the steep valleys, where a few springs pass. This system is limited to a few meters square and is not very common. Finally, around the rice threshing areas, we found the *ambody sitany* where only corn is cultivated.

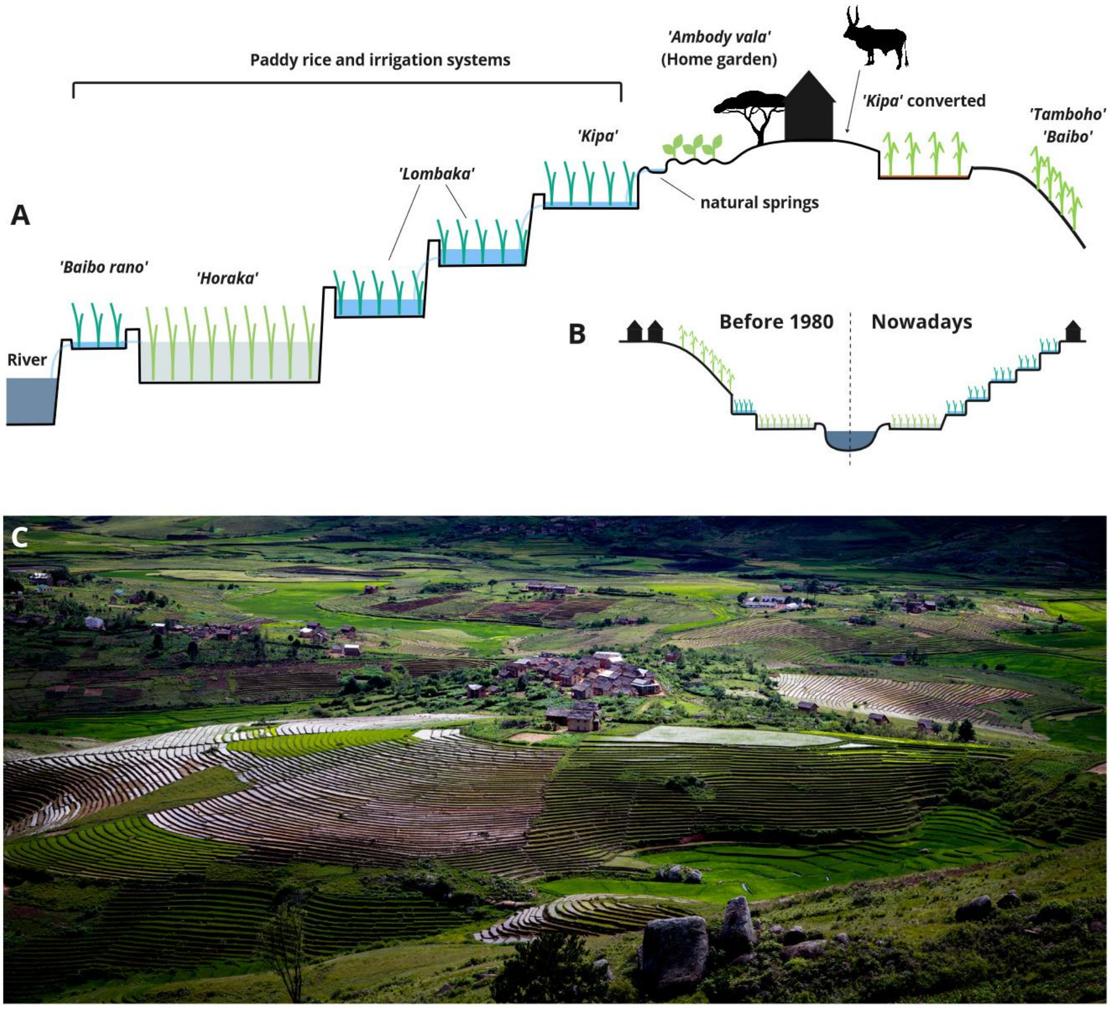

Figure.13 - Cropping systems of the Namoly Valley. (A). Betsileo paddy rice and irrigation systems, (B). Recent evolution of the agricultural landscape of the valley. (C) Overview of the rice-growing system, with the kipa covering the hills' slopes up to the top where the houses and home gardens are located.

Betsileo Childhood

"Ny zanaka no voalohan-karena"
"Children are the first wealth."
Malagasy proverb (Navone, 1987)

Betsileo consider children, *kilonga* or *zaza,* individuals between the ages of 4 and 14 (Fig.14). Before the age of four, they are called *tsaika*, fetus and then *zaza kely*, infants. Boys are circumcised a little before the age of seven. Before circumcision, boys are not considered as family members. The terms *zaza* and *kilonga* are interchangeable; *kilonga* being the Betsileo term for children, *zaza* being more generic and widespread in Madagascar. Some interviewees use the term *zaza* more specifically to refer to the period between the ages of four and ten, when children attend school. After childhood (14 years old), Betsileo people acknowledge a prolonged transitional phase into full adulthood, which can span from 14 to 40 years of age, which could be akin to young adult. During this period, individuals are called *tanora*. Upon reaching approximately 18 years old, Betsileo individuals partake in their first wedding ceremony and establish a new household. The Betsileo community perceives the age of 40 as the milestone when a person officially attains full adulthood, referred to as *olondehibe*. Finally, individuals become recognized as elders, *antitra*, once they surpass the age of 60. Long after their deaths, the Betsileo will become *razana* (ancestors).

Children are commonly raised within an alloparental system, which involves multiple households within the same extended family. Typically, children (boys and girls) up to the age of six spend their time with women in the vicinity of the houses, playing and accompanying their mother and other women to the subsistence activities.

Above six, most of the children (girls and boys) of the valley attend school. At this age, children are already very independent and walk several kilometers to school every day on their own. During the school year, children attend school almost every day (four to five days a week). However, during the rice harvest period, children often drop out of school. The school day varies from five to eight hours a day maximum, leaving free time for other activities (playing or helping their parents).

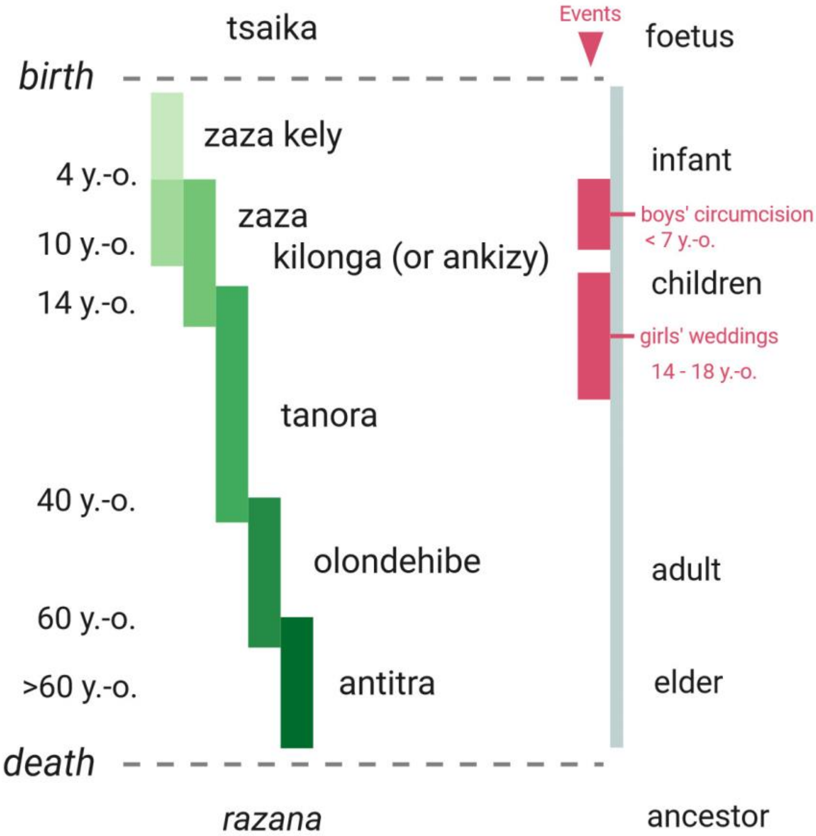

Figure.14 - Terminology of the individual development among lifespan and associated main events.

Betsileo children above six, when they're not at school and have no tasks assigned, freely go off in small groups (boys and girls usually separately) to play in the forest and in the surrounding pasturage, without adults. Previous research conducted in this society indicates that children have a rich perception of nature, incorporating the utilization of various wild species, which contrasts with the primary farming activities of adults (Carrière et al., 2017; Carrière & Gastineau, 2010).

Around the age of six or eight, children begin to take part in daily tasks following a clear gendered division of labor. Betsileo boys (around 7 to 10 years old) imitate their parents (zebu keepers) by having their own livestock of tenrec (*Tenrec ecaudatus*) which they found in forest and feed by catching frogs in the paddy rice.

In the forest they also gather a lot of WEP for snacks consumed directly or shared later with girls when they are back home. They also play a lot, making all sorts of toys from wild plants, such as marbles from *kiahomby* seeds (*Crotalaria craspedocarpa* R.Vig.) or small wheel axles from *kilanzovola* stems (*Leonotis nepetifolia* (L.) R.Br.). The youngest boys contribute by assisting in the supervision of zebus in meadows close to the settlements, and between the ages of 9 to 12, they accompany their fathers to more distant pastures. The rest of the time, the boys fetch firewood, fish in the Zomandao river or help harvest rice. The boys also protect the rice fields at harvest time by hunting birds. From the age of 12, the boys begin to take on more difficult tasks, such as finding and transporting wood from one village to another.

Young girls from age 8, actively participate in farming and cooking tasks alongside their mothers, while older (from age 12) girls take on the responsibility of caring for younger children in the absence of women. Young girls are in charge of fetching water and carrying rice from the field to the house. They also often help their mothers in the home garden and collect wild edible plants (*traka*) in the village's home gardens and in the forest. The girls also prepare the fruit that the boys bring them from the pastures and forest. When a woman becomes pregnant, the girls learn from the other women how to assist them. By helping them, they also learn about the use of different medicinal plants relative to pregnancy. According to the villagers, *ombiasa* (healer-diviner) work, which used to be reserved for men, is increasingly being carried out by women, who begin to acquire this knowledge as children. Finally, the girls between the different tasks also spend time socializing, playing hopscotch (*kisabaky*) or braiding their hair.

"Ny olombelona tahaka ny akondro ny zanany manolotra an-dray aman-dreny ny ray aman-dreny manaloka ny zanany"

"Humans are like banana trees: the offspring show up next to the parents, and the parents protect them."

Malagasy proverb (Navone, 1987)

According to Betsileo culture, *children are the first wealth.* They hold immense significance as they serve as the familial connection, are the successors of bloodlines and the future labor force responsible for upkeep the family rice fields. Numerous customs and taboos, known as fady, exist specifically for the protection of children. These *fady*, including dietary restrictions, are solely applicable to children, who are considered the rightful owners of such practices. To ensure their defense against malevolent spirits or sorcery, the *ombiasa*, upon the parents' request, craft talismans and protective amulets called *ody* (**Fig.15**).

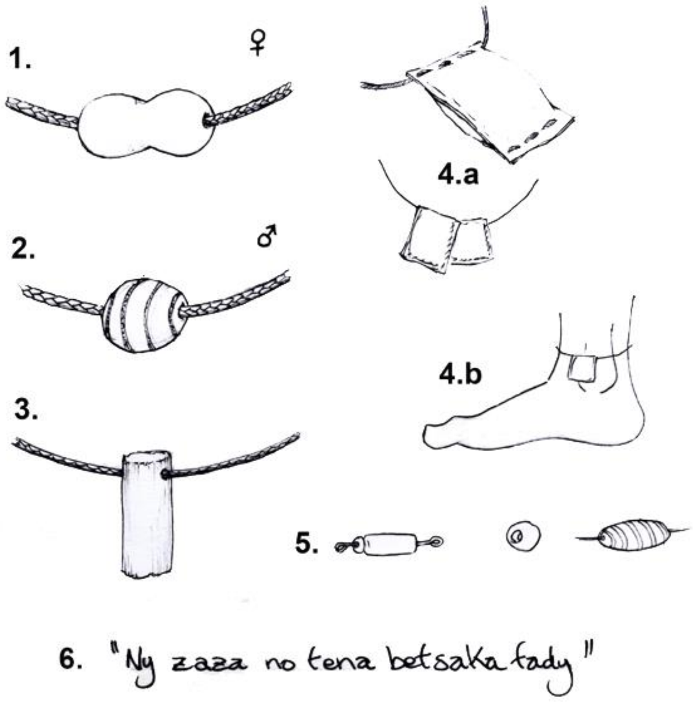

Figure.15 - *Ody* Betsileo, amulets, and talismans for magical protection of children. (1) *Tsileondoza favy*, an amulet designed to protect little girls. The jewel is almost always cylindrical and wider than taller. (2) *Tsileondoza la*, an amulet designed to protect little boys, often a spherical bead. (3) Another version of amulets made from a piece of *Viki* stem (*Phragmites mauritianus* Kunth), often associated with medicinal properties (albumin deficit). (4) *Ody* very widespread throughout the islands and very present in Mahafaly country, made from *lamba mena*, a piece of red cloth (tinted with powdered bark) containing *Hazomanga** powder (*Cedrelopsis grevei* Baill. & Courchet). Most *ody* for children are worn around the neck or ankle (4. b). (5) Many other types of pearl are used to make *ody*, depending on the recommendations of the *Ombiasas*. (6) The phrase "*Ny zaza no tena betsaka fady*", i.e., "children are the owners of *fady* (taboos)", justifies the need to magically protect children against fady and witchcraft.
**Hazomanga* see "Naming plants" section in Chapter II.

2.3 Food, Habits, and Symbolism

This section describes Betsielo food context, framing the consumption of wild edible plants, particularly among children. Following S. Bahuchet (2017), I distinguish food style from the food itself and address food intake in the rhythm of life and social organization. To do so, I first describe food diversity, then food preparation methods and the meal, before focusing on the social and symbolic role of food intake.

Food Diversity

The Betsileos rely on a wide variety of species for their daily activities, many of which are used in their diet (Fig.16). Being agro-pastoralists, most of the biomass consumed is meat, cereals, and vegetables. The Betsileos raise many animals for their consumption, for plowing and for their symbolic value, although the proportion of meat in the daily diet is anecdotal. Zebus are the first species to be raised by the Betsileos, but also the most symbolically important. Zebus are only consumed during major cultural events such as funerals, circumcisions, weddings, *famadihana* (exhumation), and inaugurations of new houses. Pigs are also raised but are rarely eaten. Their consumption may be linked to dietary restrictions, a remnant of the Arab influence that arrived in the 12th century. Locally, it is *fady* to bring pork to the Andringitra mountains, which are considered sacred because of the many tombs on the cliffs of the Betsileos and Antemoro kings. Chickens, ducks, and geese are mainly raised for their eggs. The consumption of eggs and bananas constitutes a dietary prohibition for pregnant women, as according to the *Ombiasa* their consumption might cause epilepsy in children. The animal proteins most frequently consumed come from fishing (with cane or creel) in the Zomandao River or from the high forest springs for the *'papeo'* crayfish (*Astacoides granulimanus* Monod & Petit, 1929, Fig.16b). There are five species of fish and one species of eel '*amalo*' (*Anguilla mossambica*) caught here. Eel meat is particularly appreciated, and most often prepared and eaten with young shoots of *ambiaty* (*Gymnanthemum appendiculatum*, Asteraceae) a wild edible plant species growing around the fields. The simple mention of this plant during the interviews often results in the willingness to explain the complete recipe and its variants for the preparation of *ambiaty* eel, testifying to the gustatory interest of these two species. Many animal species are also hunted and collected, particularly bushpig *lambo* (*Potamochoerus larvatus*) hunted with an assegai or traps (Viano, 2004) and the tenrec '*tandraka*' (*Tenrec ecaudatus*) often captured alive and then raised by children. Many undergrowth walking birds are also snared, including the *kolanal* (*Lophotibis cristata*) and *Coua* species. The different species of chameleons and snakes that are sometimes consumed in the rest of the island are fady among the Betsileos because they can be the reincarnation of the ancestors '*razana'* or divinities (Fuchs & Callmander, 2007). The protected status of all lemurs, as well as specific *fady*, prohibit their consumption, however, bats are often consumed (Rocha et al., 2021). Many insects are consumed seasonally during the lean season and the swarming, including beetle larvae *'bora'*, grasshoppers, cicadas, and spiders (Van Itterbeeck et al., 2019). Finally, beekeeping (*Apis mellifera unicolor*) and the collection of wild honey are quite common, although it is not an important part of the diet. Honey is often used as *fanafody* and in preparations for its medicinal and magical properties.

Plants are the most important part of the Betsileo diet, starting with the rice '*vary*', their cultural superfood. Rice is central to the Betsileo diet, as it is to the rest of Madagascar. The whole economy and seasonal calendar are organized around the cultivation of rice. Namoly Valley is renowned throughout the Haute Matsitra region for the quality of its rice, which it is attributed to a favorable microclimate. Indeed, the valley, perched at an altitude of 1500m at the crossroads of humid depressions, allows the cultivation of 26 rice landraces*, including an *Angiky mena* variety, dedicated almost exclusively to offerings to the ancestors. For the Betsileo, rice is irreplaceable in the diet, and when it is lacking, they prefer to use their savings to buy rice rather than to substitute it with other food. Despite rice prevalence, many other staple foods are grown and consumed in the valley. There are 40-50 varieties of cassava, 30 varieties of beans, 14 varieties of sweet potato, two varieties of groundnut, two varieties of maize, one variety of taro, one variety of potato *ovory fotsy* unique to Namoly and one variety of yam *(Dioscorea esculenta*). Although many tubers are cultivated, it is common to collect wild tubers in the village reserve forest and the Andringitra massif during the lean season. Of the 14 species of wild edible tubers found in the valley, wild yams *Ovy ala* (*D. ovinala*, *D. heteropoda* & *D. trichantha*), arrowroot *Tavolo* (*Tacca leontopetaloides*), *Toamamy* (*Rousseauxia andringitrensis*) are the main ones collected and consumed. Few fruit trees are cultivated and most of the fruit consumed comes from the collection of wild edible plants of which there are about 53 species. Among these, some species, such as the *lamoty*

(*Flacourtia ramontchi*), are collected collectively in the forest during the fruit ripening season. The fruits are often eaten as snacks outside of meals and collected along paths and trails. Children also consume the nectar of several flower species by sucking the contents of the spur after removing the corolla. This is the case for several species of the genus *Cynorkis* '*singilofo*' (*C.flexuosa*, *C.speciosa*,*C.gibba*, and *C.gigantea*), '*longoza*' *Hedychium coronarium* and '*kilanzovola*' (*Leonotis nepetifolia*). Many other plants (about 32 species), especially herbaceous ones, are consumed boiled, as an accompaniment to rice. These herbaceous species are called by generic names: *bredy*, *anana*, *ana* or *traka* (see sections 3.2 & 3.3). The *traka, which* in Madagascar are regularly grown in home gardens, in Namoly are mainly wild plants collected in many habitats (see Chapter VI). Only two species of *traka*, (*Acmella oleracea*) and (*Brassica juncea*), are cultivated. These excludes co-products of other crops such as pumpkin and cassava leaves, which are chopped to prepare the traditional dish *ravitoto*. The 29 other species of *traka* I counted were all wild.

More than a dozen species of wild edible plants are also consumed raw and appreciated for their acidity, such as the various *Oxalis* '*kisira*' species or the '*nakasimba*' (*Toddalia asiatica*). Finally, some condiment species, such as onions and chillies (*Capsicum frutescens*) are cultivated. These species are typically consumed together in a preparation also including white vinegar, lemon, and salt, thus having antibiotic properties (Bahuchet, 2017: p 200). Also considered as a condiment are *Manguevotra* in Betsileo or most known as *Brède mafana* in Merina (*Acmella oleracea* (L.) R.K.Jansen), cultivated and *Komoto dia* (*Acmella caulirhiza* Delile), wild, whose anaesthetic properties are highly valued (**Fig.16a**).

Overall, most of the food consumed in the valley is produced or collected locally. Some fruit and vegetables (e.g., different varieties of chili, onions, eggplant, and tomato) and dried fish are purchased. Betsileo also provision themselves on the weekly market or bring from Ambalavao, oil, salt, sugar,coffee, bouillon cubes, beer and soda are bought at the weekly market as well as. The local alcohol, *tokagasy*, is locally produced, discreetly by fermenting sugar cane with wild *vahyataka* liana (*Rhynchosia versicolor* Baker.) to speed up the process (**Fig.16d**).

*Main rice landraces cultivated: *Ambalalava fotsy*, *Ambalalava mena*, *Angiki fotsy*, *Angiki mena*, *Bengal fotsy*, *Bengal mena*, *Godra*, *Japone*, *Kiritika fotsy*, *Kiritika mena*, *Laniera*, *Magnarivo*, *Mangafototra*, *Sego*, *Simizy*.

Figure.16 - Food diversity and meals. a. preparation of *Acmella oleracea* (L.) R.K.Jansen as a side dish with rice, **b.** wild crayfish *Astacoides granulimanus* Monod & Petit, 1929 cooked with eggplant during a plant-collecting trip. **c.** daily dish with rice (*vary*) as staple food accompanied by boiled vegetables (*loka*) and rice water in the blue cup (*ranon'ampango*), **d.** *Tokagasy*, the local alcohol used for funerals and fermented with *Rhynchosia versicolor* Baker., **e.** Lianescente stem of *Piper borbonense* (Miq.) C.DC. collected in the forest.

Meal and Preparation Methods

"The method of preparation and the arrangement of the dishes provide a framework indeed quite rigid, but within it, the ingredients can change; they will be chosen and adapted according to the method of preparation."

Bahuchet, 2017: p 160

The meal is composed of two main elements, the *vary* and the *loka* (Fig.16c). The *vary*, literally rice or more rarely another staple food (with a high reluctance to completely substitute rice even during the lean season), is the base of the diet and the main dish. The *loka* is the side dish, mainly boiled *traka*, WEP and cultivated vegetables (eggplants, beans). The *loka* is both the vegetables and the broth. Occasionally it happens that the *loka* has meat. The meat will then be separated from the vegetables as a second *loka* on a different plate. There is usually only one *loka*, but at large family gatherings it is not uncommon to have several different *loka* but always separate, usually beans on one side and wild edible plants on the other, *traka dia* (*dia*=wild).

The diet in Namoly could be simplified as follows: The *vary* is the source of carbohydrates, the quantity, the *loka* is the source of micronutrients, the quality. In addition to the WEP prepared in *loka*, WEP are also daily consumed as snacks. Thus, this suggests that a non-negligible share of the micronutrients consumed in the valley might come from WEP consumption.

Along with the *vary* and the *loka* comes also after each meal the *ranon'ampango*, the boiled water with the crust of rice burned at the bottom of the pan, to quench one's thirst.

Meals are eaten on the floor of the first floor of the house, when receiving a guest, or on the second floor (the kitchen under the roof) on a daily basis. The floors are covered with large *fortsihi* or *forsii*, mats made of plant fiber (*Raffia* spp., *Pandanus* spp. or *Cyperus* spp.). In the case of a guest, the dishes are laid out on a *fandabana*, a smaller mat (table set). The absence of this *fandabana* in the presence of a guest brings dishonor to the family that welcomes the guest.

The *fandabana* is an important element in the art of the Malagasy table which also informs on the status of both the hosts and the guest. When I arrived, being considered as a guest in the family that welcomed me, the *fandabana* was systematically present under my plate. As the months went by, it disappeared, reflecting the growing closeness with the family, until I was offered one when I left so that I could in turn invite them to my home to eat.

Food preparation is mainly managed by women and girls. Apart from condiments and fruits that are picked and eaten on the spot (mostly raw), most of the food is boiled, including meat. Cooking with water is the main way of preparing food daily. Most other techniques such as infusions, decoctions, etc. are reserved for traditional medicine. The only exception is the preparation of wild tubers. Some tubers such as *tavolo* (*Tacca leontopetaloides*) and *voasipikopiko* (*Canna orchioides*) need detoxification before being consumed, while others such as wild yams and *toamamy* (*Rousseauxia andringitrensis*) are not toxic and can be eaten raw or simply grilled. Zebu meat can also be grilled at funerals, but most of the time after its distribution among family members it is dried and then boiled the next day. Some condiments such as wild pepper (*Piper borbonense* (Miq.) C.DC. see **Fig.16e**), whose stems are used, are dried to be preserved. Finally, some villagers bake *mokary* (local bread) made of cassava and rice flour, often for sale.

Meals are taken three times a day (morning, noon, and evening) inside the *trano*. In the morning, Betsileo eat *vary sosoa*, a rice soup, and the other two meals are composed of *vary*/*laoka*. During collective, family work, such as the preparation of rice fields or the threshing of rice, which can bring together about twenty people, the meal is taken outside by the men while the women eat later near the houses. The order in which one eats, depending on one's status, gender, and age, is an important structural constant in taking meals, as detailed in the following section.

The Social and Symbolic Role of Food Intake

"Humans are as much a consumer of food as of symbols".

(Trémolier, 1967)

As introduced in section *2.4 Food Anthropology*, the meal constitutes an important codified structural framework of rules and symbolic representation in the Betsileo culture. From a socio-cultural point of view, the meal has three main purposes: (1) to reinforce the hierarchical structure, (2) to strengthen the cohesion of the group, and (3) to prolong family ties after death.

Establish the hierarchical structure: At the time of the meal, the order in which the family members eat, as well as the arrangement of people in the room, will depend on the social status, gender, and age of each one. The head of the family, *rayaman dreny*, respected, will eat first, then the other men and finally the women. The guests eat most often at first, except during the burials or according to their social status- they will eat after the *rayaman dreny*. Then the turn of the oldest men, the *antitra*, will come, then by decreasing order of age all the other present men. Finally, the children and then the women. The cook or cooks (young girl or older woman) will eat last, often after the men leave the room and rarely have access to the meat, if there is any. During men's collective work, the gendered pattern is all the more marked as women remain at home to eat after having gone to serve the men in the field.

This social hierarchy is also prevalent in the placement of people in a room for eating. Indeed, the arrangement of people in an arc in the room is also highly codified according to the cardinal points. As all houses are oriented northeast, a median line separates the NW side from the SE side of the house and determines the placement of people for the meal. The persons of the first family circle are seated in the southeast part of the house while those of the second family circle are on the northwest side. The *rayaman dreny* are seated in the northeast corner of the house and turned inwards slightly to the east to leave access to the food for the ancestors. For the second family circle, the older men sit with their backs to the north and the women with their backs to the west. Opposite near the hearth are the children and women of the first circle (see Fig.17). The oldest people are placed closest to the corner of the ancestors, a sign of the respect that they are given.

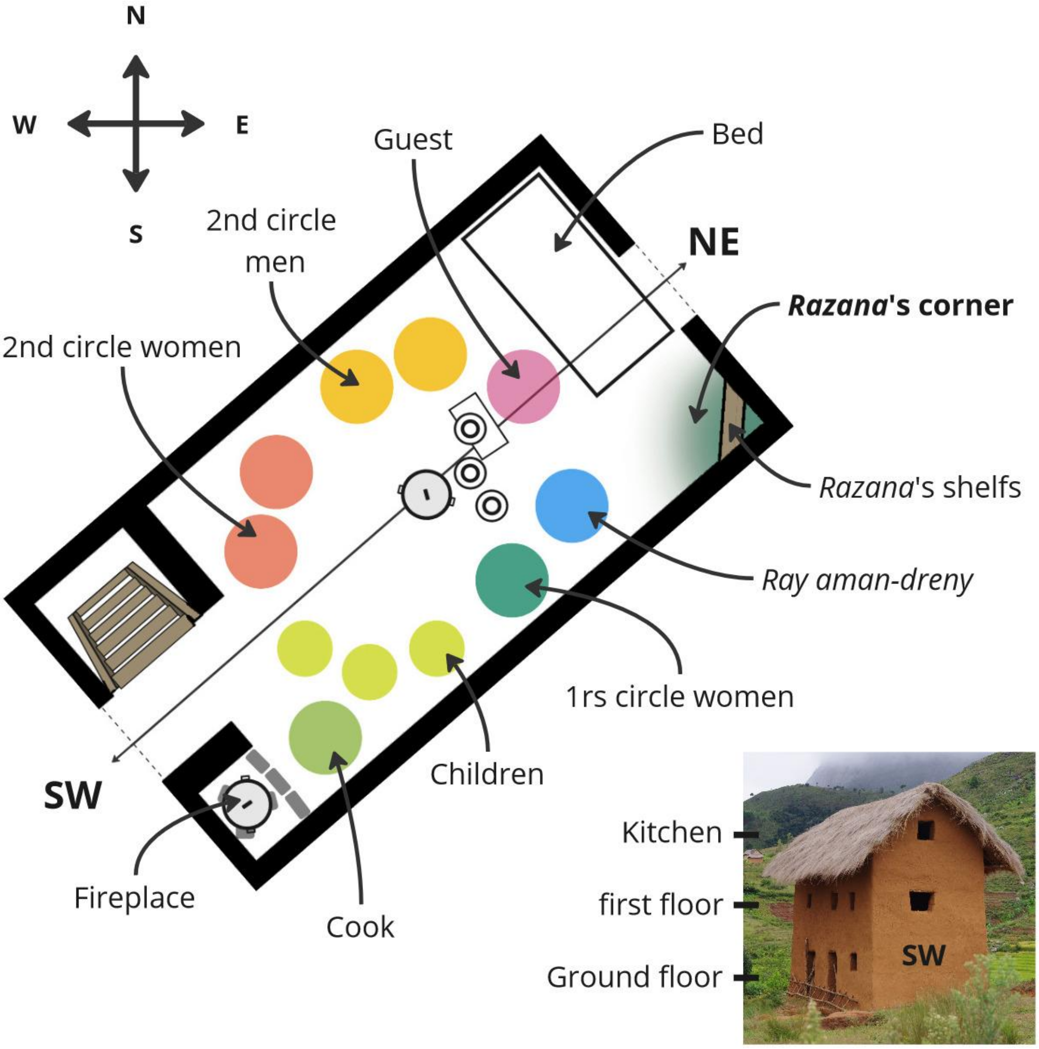

Figure.17 - Spatial organization and hierarchy during the meal. Footprint of the second floor where the kitchen is located. The placement of people at a meal depends on their rank, gender, and age, as well as on the cardinal points polarized by the corner of the ancestors (*razana*) in the northeast.

Strengthen the group's cohesion: Betsileo never eat alone, and never let anyone eat alone. For the Betsileo, if there is one fundamental aspect that is intrinsic to the notion of a meal, it is group cohesion. The *fihavanana*, the complex concept of solidarity governed by numerous rules and value systems throughout Madagascar (Rakotonarivo, 2010; Sandron, 2008), is particularly important to the Betsileos when it comes to eating. A person who eats alone is a marginalized person or one who has no family. Betsileo will always invite people to eat even if they have no direct ties with the family, to not leave them alone. This loneliness is often experienced as a tragedy that should be avoided as much as possible. In the same way, it is frequent that an orphan is taken into charge by their uncle and considered as his child.

The invitation to eat, proof of solidarity and respect, is also a matter of gift and counter-gift (Mauss, 1923) because it is also an invitation to help. During collective work in the rice fields, many people outside the family circle participate and will be invited to eat or leave with rice. To invite a traveler to eat is also an opportunity to take advantage of new and fresh food from another valley. This concept is reflected in the "fruit of the journey" (*voandalana*). It is the fruit that one picks for the road and that one brings back to one's family or that one offers to the guest. In the Malagasy culture, the symbolic act of sharing is more important when it comes to sharing a sweet food, such as fruits. In Malagasy, the word "*mamy*" has a double meaning, referring to both sugar/sweet and happiness. By analogy, to share sweetness, it is also to share happiness, but above all, a "sharing" and the expression of the *fihavanana*, the feeling of solidarity; in sum, to make a group (Ravololomanga 2006). Around noon, it is therefore very common to hear "*mandroso!*", literally "*come in!*" which are invitations to share the meal. This invitation continues to be made by people after they die, as a primary concern of the deceased caring for the living. It said that in the ruins of the abandoned village of Namoly, around noon, you can hear the voices of the spirits inviting you to eat.

Extending family ties after death: Food is not the prerogative of the living and continues to play an important role after death in Madagascar, both in daily life and during ceremonies. Ancestors being omnipresent in daily life, the Betsileos dedicate the northeast corner of their house to them. And when it comes to the meal, one must be careful to leave a free space when sitting down so that they can participate in the meal (Fig.17). While this practice (not applied daily) is made to not forget ancestors' heritage and presence, the symbolic sharing of food and offerings is much more important during ceremonies. During collective work, family reunions, and political meetings, it is customary to pour a cap of *toaka gasy* on the northeast wall to honor the ancestors. When one goes to the mountains or remote forest for several days, one will also make offerings of rice and *toaka gasy* on the spot, both to ask for the protection of the ancestors during the journey and to ask for permission to pass through to the entities (spirits, ghosts) that own the place (**Fig.16d**).

Finally, the sharing of food, especially zebu meat, takes on a special significance during funeral ceremonies such as burials and the *famadihana*. During these ceremonies, zebu sacrifices are made to honor the ancestors (**Fig.18**) and the meat is shared among the members of the community participating in the ceremony, which can reach more than 600 people[12]. The size of the slice of meat distributed to people and the order of distribution follows complex matrilineal hierarchies. It happens that the first circle of the family of the deceased can neither touch nor eat the meat. This practice, according to the work of Campbell (2013), could be a remnant of the endo-cannibal practices of Austronesian heritage and disappeared two hundred years ago with the arrival of the first missionaries. These practices, still present in Indonesia among the Toradjas of Sulawesi (Titaÿna, 1934) and in Papua New Guinea (Whitfield, 2011), consist of consuming the flesh of the deceased so that a part of the physical body continues to live on through the living community (Decary, 1928). Campbell (2013) hypothesizes that in Madagascar, the flesh of the deceased would have been progressively replaced by zebu meat, but certain rules persist, such as the prohibition for the first family circle to consume the meat to preserve its symbolic aspect. The idea that the flesh remains in the family, or the community is also reflected in the circumcision (*hasoavana*) of young boys, whose foreskin is consumed by the grandfather or the *rayaman dreny* with a piece of banana to bring the child into the family. What results from these practices is that the sharing and consumption of food are at the heart of many structuring rites dedicated to federating and tightening the links within the family and the community and those beyond the living world with continuity in the world of the ancestors.

[12] See also: Link to personal website with audio recording of traditional song during funerals. https://vporcher.wixsite.com/porcher-photographie/gallery

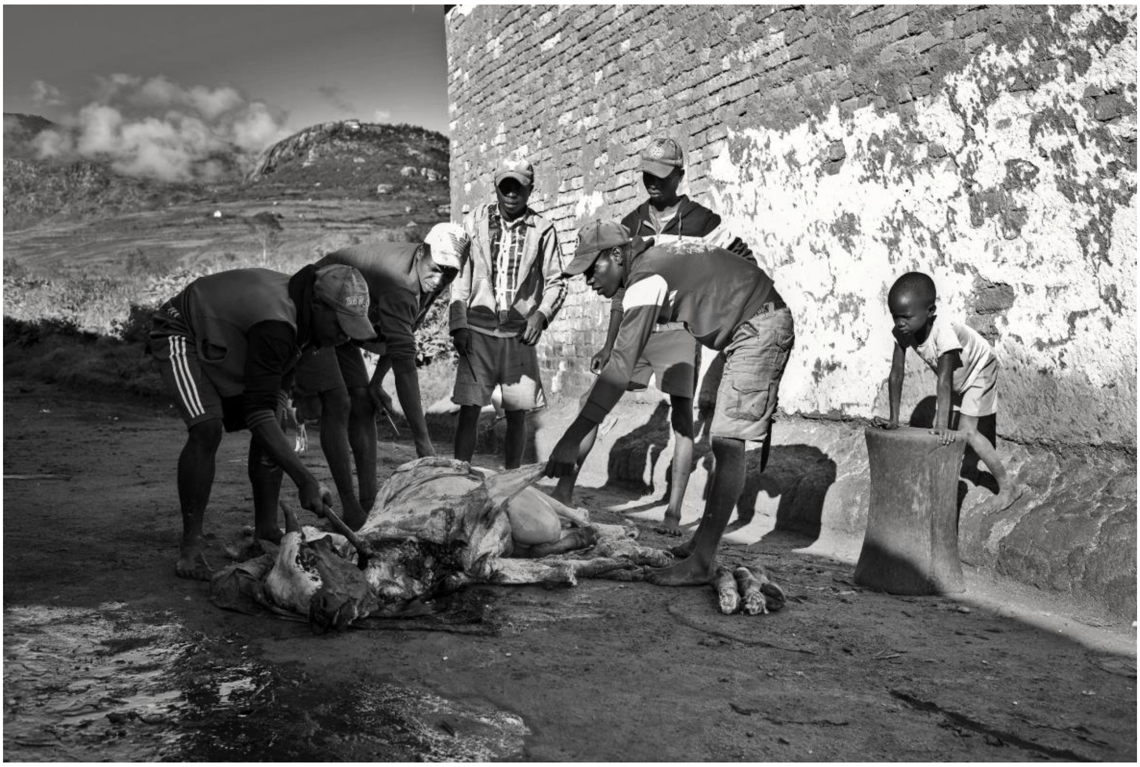

Figure.18 - Zebu sacrifice. Sacrifice and use of zebu's blood in a ritual to break a person's coma state (between life and death). The blood is used by the *ombiasa* for the ritual, and the meat is distributed within the family and consumed the same day to attract the favor of the ancestors. These sacrifices are part of children's daily lives and are ideal opportunities for cultural learning.

2.4 Betsileo Ethnobotany

"Ny mandala mahita ny raviny
Ny manontany mahita ny fotony"

"Who passes by sees the leaves.
Who questions sees the roots".

Malagasy proverb (Navone, 1987)

In this section, I briefly present some aspects of Betsileo ethnobotany that will be useful for the following chapters, specifically on how plants are named and classified and present some main use categories. The ethnobotanical data presented here results from a series of interviews with key informants (Healer-diviner experts in plants, two adult men and one woman), as well as with other informants and participant observation during several months. The Key informant helped me to decompose and explained every plant name. Then to build local classification keys I used successive sorts approach with key informant and pile sort method in focus group discussion with other informants (Weller & Romney, 1988).

Naming the plants

Naming plants, along with identifying them, is probably one of the first ethnobotanical skills that are acquired. Looking at how plants are named reveals both the language used, and the wealth of knowledge encapsulated in the terms (Hidayati et al, 2022). In Malagasy botany, and specifically in Betsileo botany, the criteria used to name and define an ethnospecies are most often linked to plants' morphology, ecology, uses (or the person using it), symbolic value, or gustative aspect (Lemoine et al., 2023). Many plant names are also derived from the plant parts used (see glossary Tab.3b). In addition, the linguistic morphology of the terms used to designate ethnoespecies is also highly variable. Terms can be self-explanatory, when they refer to salient apparent features of the taxa, as for example in the case of *voafotsy* made up of *voa*- fruit and *fotsy*- white (*Aphloia theiformis* (Vahl) Benn.). Names can also be metaphoric, referring to an entity sharing common features with the named taxa. For instance, this is the case of *lanary* (*Plagioscyphus* *jumellei* (Choux) Capuron) which designates the colour brown or russet, similar to the coat of a zebu, referring to the colour of the fruit; and *fandrindambo* (*Cadaba virgata* Bojer) made of *fandrika*- trap and *lambo*- board, expressing how dense and thorny can be this vine, i.e., capable of blocking a boar.

Here, I will present an overview of the different linguistic morphologies of plant names in the Betsileo language. To analyze WEPs names, I draw on the work of Hidayati et al. 2022, on names in the Kanekes language (Indonesia). Accordingly, I use the same categories of linguistic morphology to illustrate how the Betsileo terms designating plants are constructed.

- Compounding and blending

Most plant names are composed of noun+adjective, such as in *ovy be*, *ovy*- yam and *be*- big/good (*Dioscorea esculenta* (Lour.) Burkill). Some names are also blended, resulting in the contraction of the noun as for the different species of leafy vegetable called *anana* contracted into *ana* with the addition of the adjective. For example, *anamafaitra* composed of *anana* and *mafaitra*- bitter (*Solanum americanum* Mill.), or *anamamy*, *anana* + *mamy*- sweet (*Solanum nigrum* L.).

Other forms are designed on the combination of noun + noun (**Fig.19**) and noun+verb. *sonjo parakandro* is made of two nouns: *sonjo*- taro (referring here to the tuber of *Colocasia esculenta* (L.) Schott) + *parakandro*- zebu keeper, meaning the edible tuber from the pasture, or eaten by the zebu keeper (*Hypoxis angustifolia* Lam.). *Kitonda*, combines noun+verb, with *kito*- a small thing, and *nda*- to give, referring to the fruits of *Medinilla torrentum* Jum. & H.Perrier.

- Prefixation

The use of a prefix before a noun is indicative of negation, diminutive or superlative. Several plant names are built from the prefix *voan*- fruit, as in *voatsitakajaza*, *voan*- + *tsisy* (negation), *takatra* (access), and *zaza* (children), 'the fruits that are not accessible to children', to designate the fruit of *Vaccinium secundiflorum* Hook., which grows on the Andohariana plateau (2200m) several hours' walk from the village.

Another form of prefixation is the duplication of syllables with the use of the prefix *ki* to express resemblance, as in *kisonjosonjo*, 'which looks a little like a *sonjo* ‘taro', (*Sagittaria guayanensis* Kunth) or used as a diminutive, for example *kisirakisira* composed of *kisira* ‘salt’, where *kisirakisira* means a little salty (*Oxalis latifolia* Kunth).

- Locative and temporal

Several plant names encapsulate the habitat of the taxa, such as the numerous plants ending with the suffix -*dia* or -*ala* meaning wild or from the forest (*voan'ala; Psychotria isalensis* (Bremek.) A.P.Davis & Govaerts), -*tany* on the ground (v*oamasakatany*; *Perrierodendron quartzitorum* J.-F.Leroy, Lowry, Haev., Labat & G.E.Schatz), or -*andro* close to the water (*matanandro; Centella asiatica* (L.) Urb.). But also, the phenology like in *voamasakariva, voan*- 'fruit' + *masaka*- 'ripen' + *riva*- 'evening' suggesting when to harvest the fruit (*Phyllanthus iratsiensis* Leandri).

- Onomatopoeia

A naming process incorporates onomatopoeia into the names. This process can combine a name with a sound as in *tsipoapoaka*. The construction of this term is complex because it has two converging meanings. The term is composed of *tsy*- the negation and *paokapaoka* which is the Merina term for *Physalis peruviana* L. The term *paokapaoka* refers to the sound made by the calyx filled with air when pressed. But the negation *tsy* indicates that the designated taxa are not *P. peruviana*. *Tsipoapoaka* refers in fact to *Nicandra physalodes* (L.) Gaertn. which is very similar to *P. peruviana* (also a Solanaceae) but whose calyces do not make a sound. *tsipoapoaka* means ‘the one that is not the one that makes a noise’.

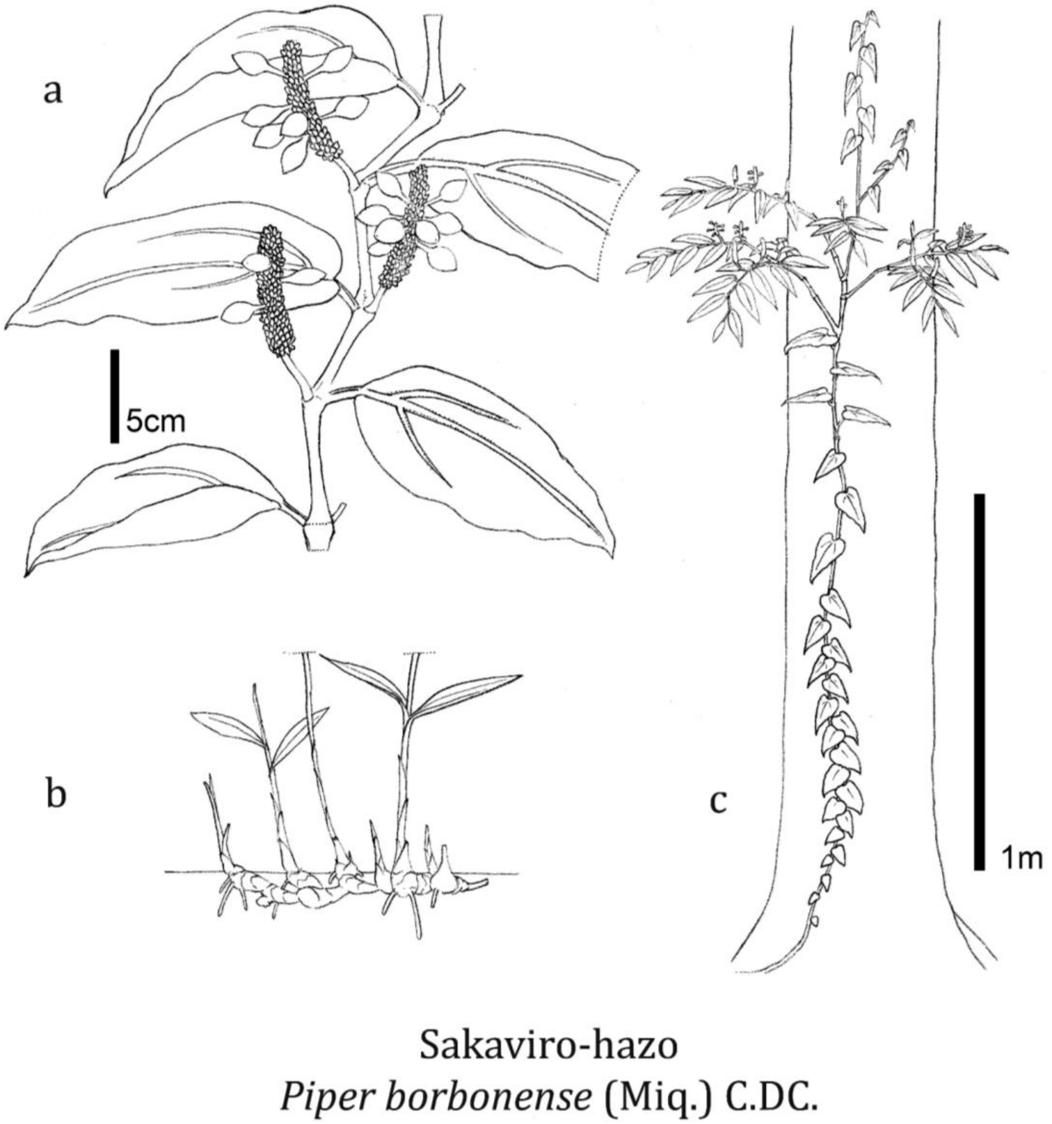

Figure.19 - Example of a plant name using a compounding process. Sakaviro-hazo (*Piper borbonense* (Miq.) C.DC.) made of *sakaviro* (ginger) and *hazo* (tree) to refer both to the astringent taste of this black pepper and its life form, growing on the tree trunk. Illustration of a. *P. borbonense*'s infructescence, b. ginger plant and c. *P. borbonense's* life form.

Finally, many species also have more than one name. We find plants named differently according to the place where the plant is found, the *fady* linked to the plant, or the plant use, supplanting the name designating the plant as a species. For example, *kisira be* (*Oxalis xiphophylla* Baker) is called *fagnasy* when it grows in forest because it is *fady* (taboo) to use the word *sira* (salt) in forest.

Moreover, several species, considered magical and enabling links with the *razana* (ancestors), are called *hazomanga*. The term *Hazomanga*, which might be translated as 'the wood of excellence' or 'sacred wood', is used only when the use of those species is relative to the magical context. Outside this magical context the several species are named differently. For example, the Betsileo of Namoly mainly use *Cedrelopsis greve*i Baill. & Courchet as a *hazomanga*. *Hazomanga* is widely used in ceremonies (funerals, circumcision, requests to ancestors) and to make *ody* (protective amulets) and *sampy* (small wooden idols). When not used as *hazomanga*, *C. greve*i is called *katrafay* and used for roofing. The use of different terms depending on the context of use more than the part of the plant used, as is often the case.

2.3 Plant Classification

"The analysis of a culture's terminological systems will not, of course, exhaustively reveal the cognitive world of its members, but it will certainly tap a central proportion of it [...]. To the extent that cognitive coding tends to be linguistic and tends to be efficient, the study of the referential use of standard, readily elicitable linguistic responses - or termes - should provide a fruitful beginning point for mapping a cognitive system" (C. Frake, 1962: p75).

As expressed by C. Frake (1962: p75), the local plant classification system (and other living beings) and its terminology allow us to glimpse how a world is perceived and organized locally. The way plants are classified and named are closely and conceptually linked to the terms used (Mandaville, 2019). For example, in Malagasy and in Betsileo, the generic terms *zavamaniry* used to designate a plant refers directly to the concept of plant as a living being, the terms literally mean 'everything that grows or makes shoots', *zavatra* (the things) and *maniry* (to sprout, to grow). By opposition, animals are called *zavamiaina*: everything that has breath, with *aina* (life, breath). Consequently, many animals such as corals are assimilated to plants in Malagasy classification (Boiteau, 1999). Based on a series of interviews with key informants, using successive sorts approach to build local classification keys (Weller & Romney, 1988), I found that Betsileo folk plant classification follows different arrangement rules based on morphological similarity but also culinary uses. I proposed here to summarize those arrangement rules into a classification key and tree (Fig.20 & Fig.21). Two large groups can be distinguished, first those plants whose classification does not follow the arrangement rules (1' in Fig.20). These plants are generically called *zavamaniry* (plants). The group includes ferns because, according to Betsileo, ferns have no stem but are often rigid. The group also includes plants of less importance to the Betsileo, whose use is often limited. In the second large group (1 in **Fig.20**), there are plants that follow arrangement rules, which are classified into two other groups, plants with (2 in **Fig.20**) and plants without stem (2' in **Fig.20**). Among plants with stems, there are rigid plants, standing by themselves and giving wood (3 in **Fig.20**) which are called *hazo* (tree) and the ones with soft of flexible stems (3' in **Fig.20**), group in which there is the *voaninkazo* (5 in **Fig.20**), flowering plant considered beautiful and mostly non edible and the *traka* (6 in **Fig.20**), or edible plants. *Traka* represents an important group of plants for the Betsileo, as they are wild edible plants that are used daily in cooking as a side dish to the rice. The species that belong to this group, therefore, depend not only on their morphology but also on their edibility and precious use as dishes. Finally, among the stemless plants (2' in **Fig.20**), there are two groups, the *ahitra* (grasses), mainly Poaceae herbaceous (4 in **Fig.20**), and the *volokazo* (literally the hairs on the trees), plants growing on trees, notably mosses (bryophytes) and *Selaginella* spp. but also some small species of epiphytic *Peperomia* Ruiz & Pav. (4' in **Fig.20**).

1. Plant following arrangement rules.

    2. Plant with stem
        3. rigid stem that stands by itself (self-supporting), which most often gives timbers. .... *Hazo*
        3'. soft or flexible stem, which doesn't give timbers
            5. Flowering plant, esthetic and mostly not edible. .... *Voaninkazo*
            6. Soft plant that can be cooked whole with leaves, stems, and flowers, by boiling them and used as a side dish '*loka*' with rice. .... *Traka*

    2'. Plant without stem
        4. Low growing plant which sprout on the ground. .... *Ahitra*
        4'. Plant which grow only on the trees. .... *Volokazo*

1'. Plant not following arrangement rules of the other subgroup. (In this 'out group' we find many lower plants less useful than that of the previous subgroup, or almost not considered as plants (e.i, ferns). they use the generic term of '*zavamaniry*' (plants) to distinguish them). .... *Zavamaniry*

Figure.20 - Betsileo plant classification arrangement rules. Based on data from interviews with key informants. Betsileo arrangement rules to classify plants follows a kind of "step-wise analysis" focusing on distinctions and similarities between plants (Scharf, 2009). Rulesare presented in the form of Bonnier-type flora (in Fig.20 and Fig.21).

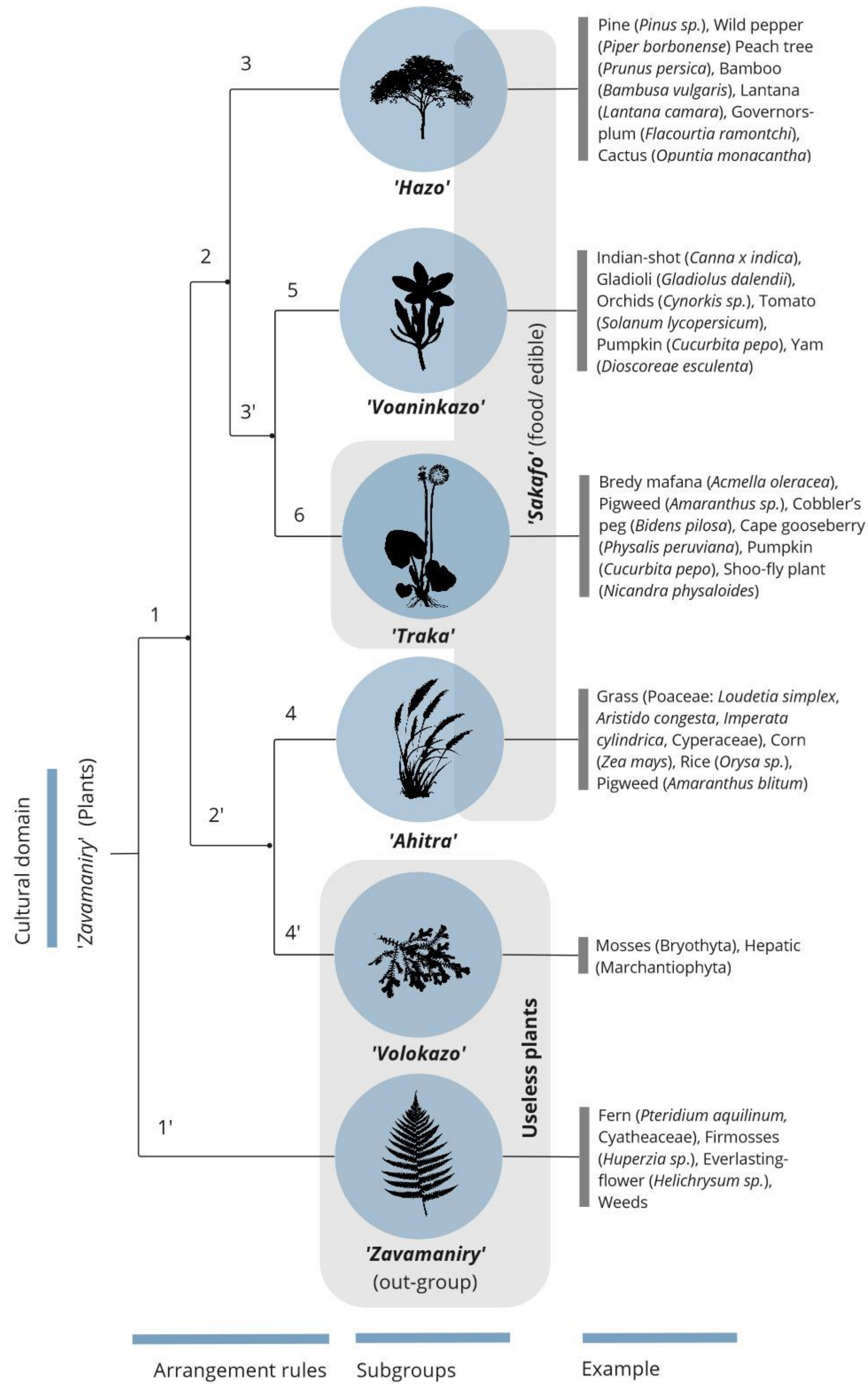

Figure.21 - Betsileo plant subgroups according to classification arrangement rules. Arrangement rules (see Fig. 20), subgroups and examples of taxa fitting in.

The local classification system, with rules mainly based on morphological aspects, can easily be superimposed on a phylogenetic approach to highlight the direct links between Betsileo plant subgroups and phylogenetic groups (**Fig.22**). I build the phylogenetic trees, using the phyloT software which is based on the NCBI taxonomy database and not on molecular data (Schoch et al., 2020).

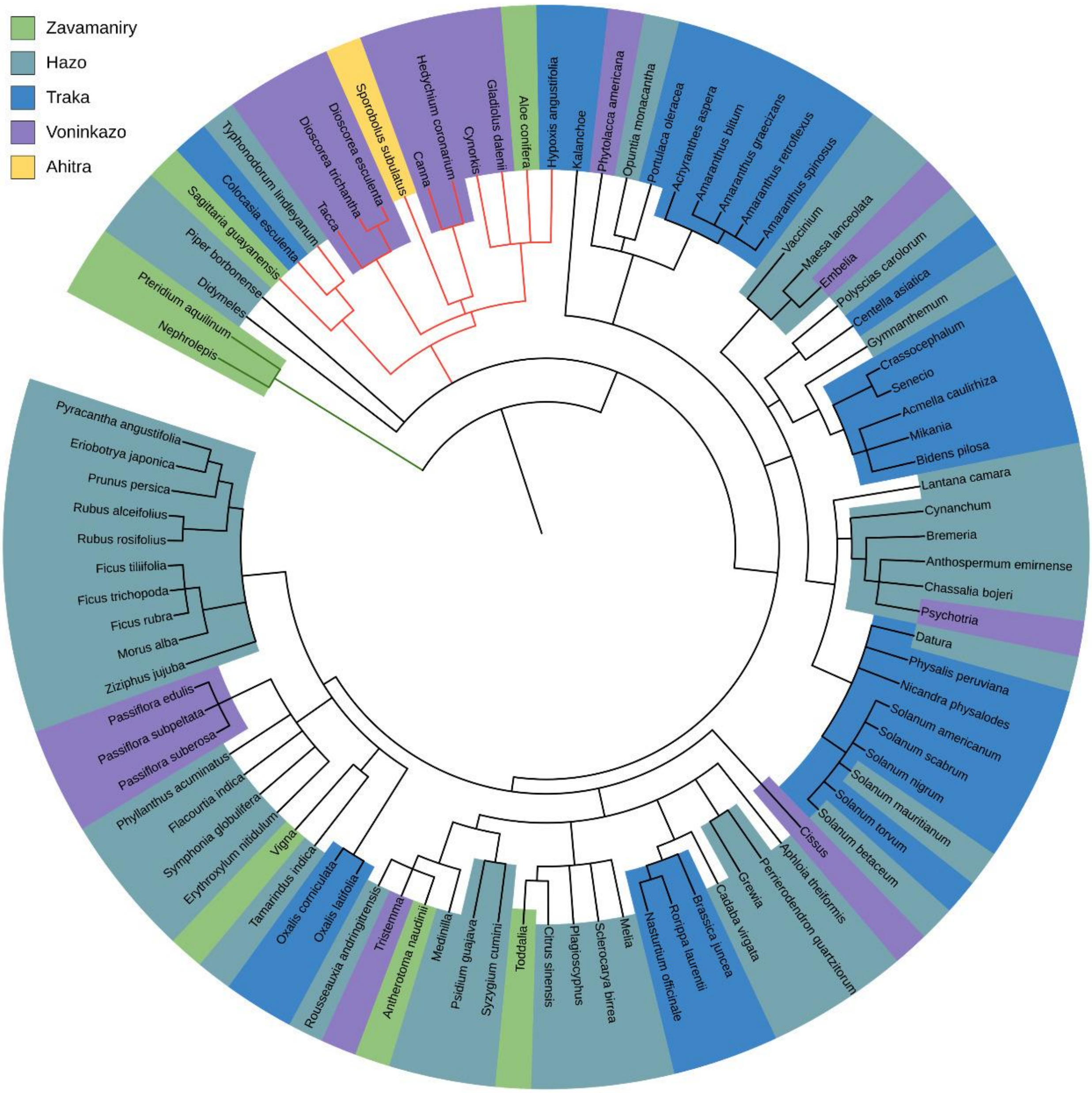

Figure.22 - Rooted phylogenetic tree with Betsileo plant subgroups. The tree is constructed based on the NCBI taxonomy database, generated with phyloT using 92 WEP species and classified in the different subgroups during a focus group discussion. Red branches indicate monocots (Liliopsida) and green ones the ferns (Pteridophyta).

However, the local classification system can vary according to species and uses, resulting in a classification based on both similarity and cultural significance (**Fig.23**). In the example presented in **Fig.23**, I used a pile sorting method in focus group discussion (Weller & Romney, 1988). Informants (4 adult women and 4 adult men), freely classified plants and animals by group related to their use (e.g., 1. staple food, 2. timber) and their similarity (e.g., 4. flying, 5. aquatic organisms) before placing the groups according to their usefulness and status as cultivated or uncultivated resources. This other classification shows a different reading of the Betsileo cognitive world, placing staple food and livestock at the top of their value system.

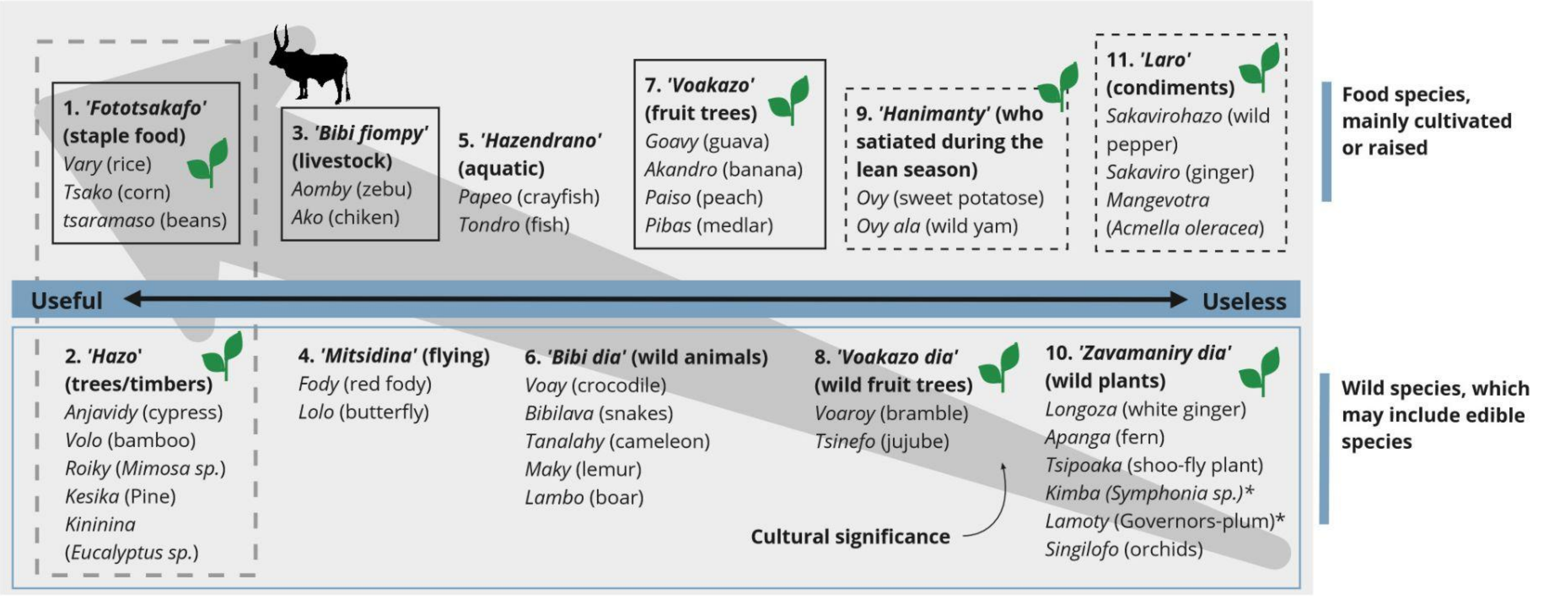

Figure.23 - Classification of plants and animals according to Betsileo cultural significance. Classification of 25 plant species and 11 animal species using the pile sorting method in focus group discussion (with 4 adult women and 4 adult men). The groups were then placed by the informants along two freely chosen axes. The green leaves indicate the plant groups, and the zebu indicates the livestock group.

2.4 Plant Uses

In this section I give a brief overview of the diversity of plant uses and the extended ethnobotanical knowledge held by Betsileo people. A whole assessment of plant use would need a longer and more exhaustive approach that could not be done due to fieldwork length restriction, as described in Chapter I. In this overview, I am using nine different main categories of use following the economic botany data collection standard as a guideline (Cook, 1995) while including emic categories relevant to describe Betsileo uses: wild edible plants, *fanafody*, fuel, fodder, toys, construction, household tools, wickerwork, and bioindicators (see example in Fig.24). Many species of plants have multiple uses, for example, they are used both as edible, medicinal or used as materials. I specify the different categories of use in the Appendix **A.1** for each plant species mentioned in the thesis and reported during interviews with various Betsileo informants.

Regarding wild edible plants, as presented in Chapters III and IV, I counted a total of 187 local names corresponding to 127 taxa (see Appendix **A.1**). This estimation contrasts with the Chao2 estimator that calculated a maximum number of 168 taxa (see Chapter VI). These numbers probably underestimate the real diversity used, according to my key informants, who estimated a higher number of wild edible plant species.

The Betsileo also use a large number of plants to treat their woes (including magical ones) which they call *fanafody* (generic term for remedy). According to key informants, most of the plants in the Namoly valley (approximately a thousand) can be used as *fanafody*. The *fanafody* are used in at least four areas: medicinal, veterinary, divination, and magical protection such as *ody* (protective amulet) making. The classic medicinal uses (infection, cough, diarrhea, fatigue) are often known by many people (whose specific knowledge varies with age and gender, among others), but the *Ombiasa* and the *Panandro* hold most of the knowledge about the magical uses of plants.

A main daily use of plants, and particularly of wood, is fuel. People and use of firewood for cooking rice daily. The consequent use of fuelwood, which creates the debate on its creative and destructive potential in the context of a biodiversity hotspot (Kull, 2004), often obscures the deep knowledge of species selection and the different uses of fuelwood. Fuelwood are selected based on their properties such as hardness or the presence of essential oil and resin. There are at least four types of fuelwoods: the resinous one to start fires usually *kesika* (*Pinus*), the wood for charcoal called *vandrôzana* (*Sarcolaena* spp.), the one for cooking called *kakazo* (several species), and the fumigation wood or soot wood to prevent the proliferation of mold and fleas called *maimbelona* (*Myrothamnus moschata* Baill.).

Because the Betsileo are outstanding pastoralists, they know both the veterinary uses of plants for zebus but also the different species of fodder that make up the different grazing areas. As such, they distinguish at least 13 species of grass (Poaceae) for grazing zebus and their respective quality (see appendix. **A1**). The fine recognition of these Poaceae species and their phenology influencing grazing decisions and their fire management is a complex local science that deserves more attention.

Children often utilize various plants to create different toys. They ingeniously employ inflorescences, fruits, or fibers to craft miniature vehicles or dolls.

Certain tree species are meticulously chosen for their high density and resistance to decay, making them ideal for construction of canoes or wood frames. Examples of such species include *kokogna* (*Ravenea glauca* Jum. & H.Perrier) and *vagna* (*Sloanea rhodantha* (Baker) Capuron).

Plants play a vital role in the creation of everyday household tools, such as handles for agricultural and cooking tools. Additionally, they are used in the production of household hygiene items like *sevabe* (*Solanum mauritianum* Scop.) leaves, which serve as sponges or soaps.

The art of wickerwork and basketry holds great significance in Malagasy craftsmanship, with numerous plant species being utilized for their fibers. Examples include *Raphia* (*Raphia farinifera* (Gaertn.) Hylander), *Pandanus* spp., and *Cyperus* spp.

Moreover, the Betsileo people employ plants as bioindicators of seasonal changes. Various species exhibit distinct phenology, such as flowering or fruiting, which serves as a marker for seasonal transitions or signals the beginning of agricultural activities in their calendar.

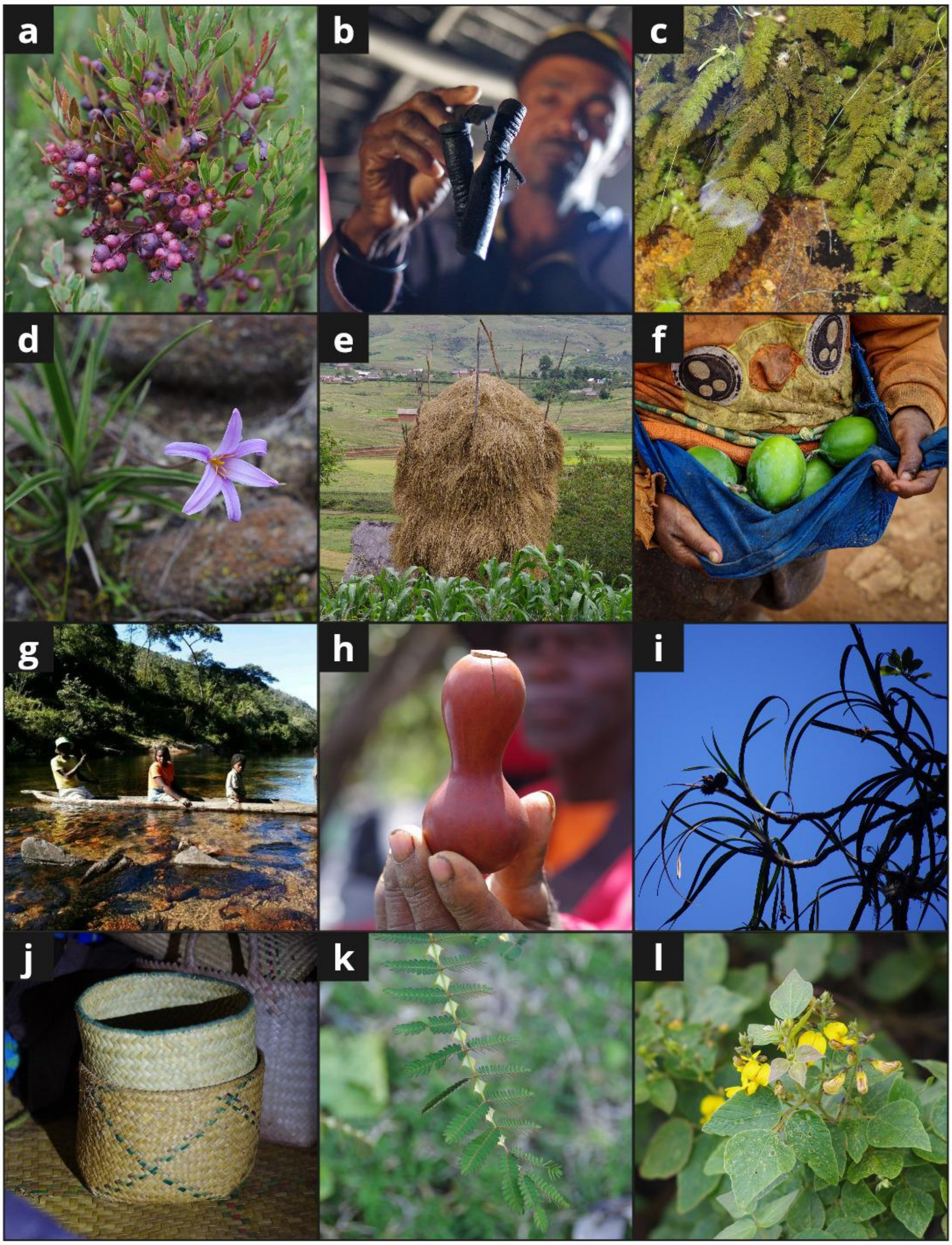

Figure.24 - Illustration of some plant species and their use by the Betsileo. a. *Vaccinium secundiflorum* Hook. consumed mainly by children as a wild edible plant, **b.** *Hazomanga* (*Cedrelopsis grevei* Baill. & Courchet) and *torovoka* (*Ficus menabeensis* H.Perrier) used as *ody* (talimant) to communicate with the ancestors, **c.** *Hydrostachys fimbriata* C.Cusset, rare aquatic plant used as a medicinal plant to treat pregnant women against syphilis, **d.** *Xerophyta andringitrensis* (H.Perrier) Phillipson & Lowrye. formerly used to carve tombs in the rock. **e.** rice stubble stored and used to feed zebus, **f.** fruits of *Passiflora subpeltata* Ortega collected and used by children as a play ball, **g.** canoe dug from the stipe of a *Ravenea glauca* Jum. & H.Perrier, **h.** tobacco tin made from calabash, **i.** *Pandanus andringitrensis* Huynh, the leaves are used to make baskets and the wood for construction, **j.** woven basket with undetermined plant fiber, **k.** *Mimosa latispinosa* Lam. used as a bioindicator whose flowering indicates the rice transplanting period.

and **l.** *Rhynchosia versicolor* Baker. used to accelerate the fermentation process of the local alcohol, *tokagasy*. All photos were taken by V. Porcher except for g. taken by Myosotys Lova Hasinasandratra.

In conclusion, the Betsileo people possess a rich and valuable ethnobotanical knowledge that has been passed down through generations. Their profound understanding of local flora and their traditional uses highlights the intricate relationship between humans and their surrounding environment.This ethnobotanical knowledge plays a crucial role in their daily lives, encompassing not only health and wellness but also cultural and spiritual dimensions. As custodians of this invaluable knowledge, the Betsileo community plays a significant role in preserving biodiversity, sustainable resource management, and maintaining their unique cultural heritage.

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Chapter III

How do children identify plants? Using the drawing method to explore early ethnobotanical knowledge in Madagascar.

Abstract

In small-scale societies, people learn to identify plant species during childhood. Plant recognition is an important baseline knowledge, immediately useful to avoid intoxication risk due to wrong identification. Plant recognition is at the basis of other ethnobotanical knowledge. However, despite many studies on folk classification, we still have a narrow understanding of the criteria locally used for species identification; the gap being even larger regarding children's plant identification criteria. Here, we study the criteria used by Betsileo children and adolescents to identify wild edible plant (WEP) species using a child-adapted method including drawings and follow-up interviews. We worked with 80 teenagers (from 12 to 17 years old; 51 girls, and 29 boys). Our results suggest that teenagers use a large spectrum of visual criteria to identify plants and that these criteria match with botanical and ecological knowledge documented in the literature and herbarium vouchers. We found that 35% of the identification criteria used were non-morphological (e.g., phenology, biotic interactions), suggesting deep ecological knowledge. On average, teenagers use more than nine distinct criteria per plant, which allows them to identify most plant species with a very high level of precision. The precision level of plant representation increases with age for boys, but remains constant for girls, suggesting different dynamics in plant identification knowledge acquisition. We also found that boys and girls use different identification criteria: girls focus on morphological criteria while boys also incorporate ecological criteria, such as landscape features and biotic interactions, in their spectrum of identification keys. Our results highlight the complexity of teenagers' plant knowledge and the importance of the ecological context for plant identification. Finally, our finding suggests that gender plays an important role in plant identification's knowledge acquisition, probably because gender differentiates daily interactions with plants.

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3.1 Introduction

In 1960, A. H. Smith was amazed in Ryùkyù Islands by Kabira children's ability to identify plants using a diversity of details: "*Even a child can often identify the species of a tree from a small fragment of wood, and, what is more, the sex of that tree, […] and this, by observing the appearance of the wood and bark, the odor, the hardness, and other characters of the same kind.*" (p. 150).

The abilities to identify and name useful plants are probably among the first skills and knowledge learned in childhood in small-scale societies (Reyes-García et al., 2007; Porcher et al., 2022), with cross-cultural studies showing that individuals in forager societies also learn any other complex subsistence skills during childhood (Lew-Levy et al., 2017). Identifying plant species -and other elements of nature- seems to be an essential prerequisite for the acquisition of more complex knowledge and skills that an individual will accumulate over the life course, for which it is not surprising that plant knowledge acquisition starts during early childhood and is well mastered by young adults (Quilan et al., 2016; Gallois et al., 2017; Schniter et al., 2021). For example, plant identification is vital to distinguish between poisonous and edible plants and thus to avoid the risk of poisoning (Cuadra et al., 2012). Importantly, beyond being a basic skill to interact with the environment (de Garine & Hugh-Jones, 1996), learning to decode the natural environment by identifying and differentiating species is also a way of making sense and ordering the living world, and therefore of situating oneself into it (Ingold, 2004). Plant identification is therefore a fundamental aspect of cultural learning from which other bio-cultural interactions will flow, nurtured by cultural settings such as ontologies and or "mode of existence" (Descola, 2021; Latour, 2012).

Despite the potential importance of plant identification for livelihood activities and culture, researchers have not explored which criteria children use to identify plants. Many studies in cognitive anthropology have explored local ecological knowledge, with a growing interest in folk classification in the 1970s (Conklin, 1980). More recent work has emphasized the measurement of plant, fungi or animal identification skills (Quilan et al., 2016; van den Boog et al., 2017), and recent studies on linguistic ethnobiology reveal that the nomenclature locally used to name plant species often encodes information on taxa morphology, ecology, uses, and phenology, among others, thus giving an indication of some identification criteria used locally (Hidayati et al., 2022). However, the local plant lexicon might only offer a partial view of the details used by local people for the precise identification of a taxon and only a few studies have studied on the local criteria used for plant species identification (e.g., Berlin, 1992; Atran, 1999; Zent, 1999; Jerningan 2006). The few studies on folk classification have focused on criteria used to define broad biological categories (i.e., kingdom, family, genus), not addressing species identification criteria. Moreover, information about children's folk taxonomies is absent or anecdotal in such works (e.g., Smith, 1960; Lancy, 1996; Morris, 2010; Tian & Leÿs 2021).

Local criteria used in plant identification might be complex and rely on many different knowledge dimensions, which might even show variation among individuals according to the age or gender (Shepard, 2004; Jernigan, 2006 and 2008). As ethnobotanical knowledge is the result of human-plant interactions mediated by human senses, it is not surprising that sensory aspects are used for species identification (Shepard, 2004). Understanding such identification criteria could contribute to developing more holistic and transdisciplinary approaches to document local plant identification criteria and to explore potential variation in the criteria used according to age, gender, and cultural setting. In addition, these approaches might also allow recognizing complementary between knowledge systems, by addressing divergence and overlaps between local and scientific plant identification criteria (Tengö et al., 2014; Roué & Nakashima, 2018).

Studying the criteria used by children to identify plant species entails a double challenge, which might explain why the topic has not been addressed before. The first challenge is to capture the system used for plant identification from an emic point of view. Embracing the diversity and the complexity of “knowledge” calls up different knowledge dimensions, cognitions, and sensory aspects in a holistic approach. The second challenge is to capture the complexity of the knowledge held by children, an effort that deserves to use adapted tools. In the last decade, several works have developed and used a methodological tool that combines drawings and interviews to document children’s ethnoecological knowledge (Carrière et al., 2010a, b), a combination that allows recording specific information that the child may not always be able to express verbally (Carrière et al., 2017; Dounias & Aumeeruddy-Thomas, 2017). Indeed, this tool has proven particularly efficient in catching emic perspectives providing a concrete focal point for discussion with children (Mitchell, 2006; Soukup, 2014). Results from this work have brought new insights into the emergent field of children's anthropology particularly regarding children's perception of natural landscapes and environmental changes (Alerby, 2000; Pellier et al., 2014; Chabanet et al., 2018; Fache et al., 2022), although the tool has not yet been used to explore specific knowledge realms such as plant identification and folk taxonomy.

The goal of this work was to understand how Betsileo adolescents identify and distinguish WEP species, focusing on visual aspects through the use of drawing interviews. We organize our work around four research questions: (1) What criteria do Betsileo adolescents use to identify WEP? (2) How precise are adolescents while representing plants? (3) Do the criteria used and the precision vary according to adolescents' gender and age? and (4) Do adolescent identification criteria share similarity with science?

3.2 Material and methods

Study site

Fieldwork was conducted from February to April 2022, in a village in the Namoly valley, district of Haute-Matsiatra, southeast central highland of Madagascar. The valley is composed of more than 20 small hamlets spread all along the north limit of the Andringitra National Park. The area is a complex mosaic of ecological habitats, from more anthropogenic vegetation (i.e., paddy rice, crop, pastures, villages) to less disturbed ones (i.e., inselberg, cloud forest, moist altitude forest) where a diversity of rare endemic and introduced species grow. While relying on a mix-economy, Betsileo people are mainly agro-pastoralists. Rice cultivation, mostly in flooded rice terraces, numerous crop fields and home gardens, zebu grazing and logging activities rhythm the daily life of the Betsileo and shape the landscape, offering a great diversity of WEP colonizing the different habitats of the valley. Adults and children collect, prepare, and consume WEP as snacks, side dishes, or staple food, for which WEP constitute a non-negligible part of the diet throughout the year.

Ethics

Before starting data collection, we obtained the agreement from the relevant administrative-territorial organizations (Fokontany chefs) and obtained oral free prior and informed consent (FPIC) from each participant. As we worked with adolescents, we asked for both their own FPIC and their parents' FPIC, always reiterating adolescents' right to withdraw from the study at any time. This research was approved by the ethics committee of the Autonomous University of Barcelona (CEEAH 4902). It was carried out following the ethical charter of Ethical Research Involving Children (Graham et al., 2013) and the ethical code of the International Society of Ethnobiology (ISE).

Data collection

We worked with 85 adolescents (between 12 to 17 years old) including 55 girls and 30 boys. Our sample constitutes almost the full population of adolescents of this age class for the study site (only five adolescents in the valley were not part of the sample). Adolescents of our sampling come from 17 different hamlets spread over the whole valley.

To document the criteria used by teenagers to identify WEP species and the precision in the use of such criteria, we used a transdisciplinary approach and adapted the drawing interview method developed by Carrière et al. (2017). This method follows a two-phase protocol. During the first phase, we asked the 85 participants to make a drawing following this instruction: "Draw me the wild edible plants you know with all the details that allow you to recognize the plant and differentiate it from another." We did not give a time limitation and the first phase lasted between one hour and a half and two hours. In the second phase, we interviewed the adolescents about their drawings. Specifically, we asked them to explain the details in their drawing (e.g., shape, color choices). We also collected information about the plant species' local name, morphology, phenology, and ecology, as well as the name of other species drawn in association with the WEP (including plant, animal, and fungi), and the anthropic and landscape features drawn, if any. Interviews lasted about 15 minutes per drawing and were conducted in Betsileo by V.P. and S.C.R. A first inspection of the drawings suggested that some participants copied from their neighbors during the session. We removed these drawings from the analysis, for which our final sample is 80 drawings.

Data analysis

To meet our research objectives, we analyzed the adolescents' drawings in three stages (Fig.25) and tested the effect of gender and age (our third objective) throughout the different stages of the analysis. First, to have a general overview of the WEP known by Betsileo adolescents, we counted the number of WEP species represented in each drawing, the total diversity of species drawn by all the participants, and whether the average number of species varied according to adolescent's sex (Fig.25 stage 1).

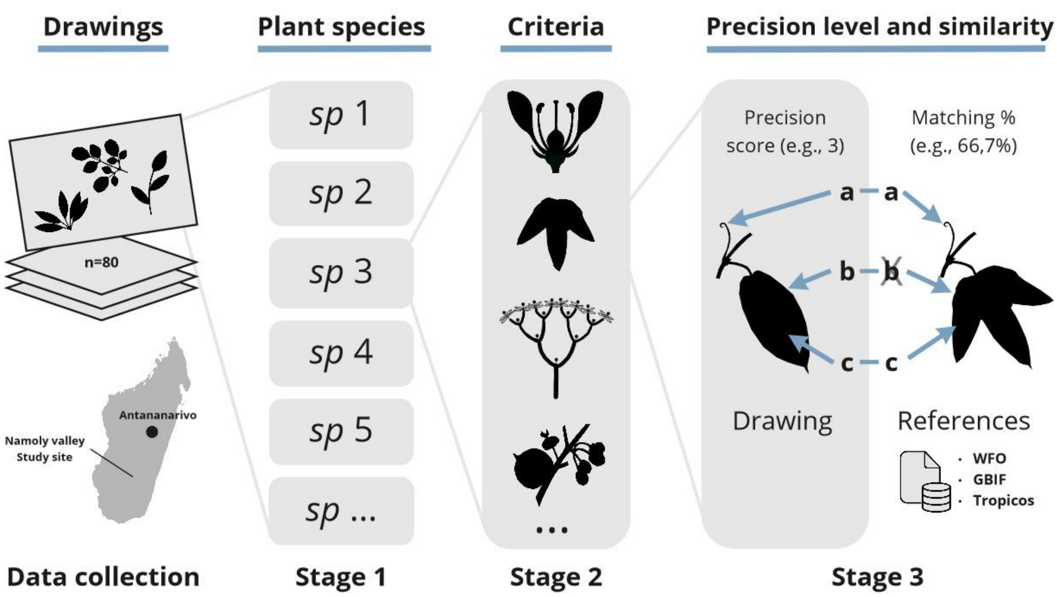


Figure.25 - Graphical abstract of the methodological approach: from data collection to analysis.

We then used information collected from the drawings and during interviews to assess the identification criteria used (Fig.25, stage 2). Overall, we identified 16 different identification criteria that we distributed across four categories, this included nine morphological, two phenological, four ecological, and one anthropic identification criteria (see Tab.4, Appendix **A2.S0**). We grouped under morphological criteria those that follow standard botanical identification keys (Schatz, 2001) (i.e., life forms, plant architecture, phyllotaxy, fertile position, leaves morphology, root system, flower, and fruit morphology), also adding plant architecture, i.e., the rhythmicity, dynamics, and position of ramification (Barthélémy & Caraglio, 2007), because the architectural models of most plants were frequently represented. As some plant species have specific organs, we also added a criterion called "Extra accurate details" (EAD) where we included any specific detail drawn (e.g., tendrils, stipules, spines, and other specific plant structures not included in the previous variables). To better catch the complexity and the variability in the plant representation, we coded every plant following the 16 criteria according to the precision (level of details and complexity) of their representation (Fig.25, stage 3). For example, criteria such as phyllotaxy were coded as simple absence/presence (0-1), while criteria such as flower morphology were coded according to the precision of their representation with a score (0-3) from the most simple 1 to the most precise 3, and were the absence of the criteria on the plant is coded 0 (Tab.4, for details about the coding system see, Appendix **A2.S0**). We used this coding system to calculate the precision score of each plant drawn as the sum of the score of each criterion used to represent it.

Table 4. Criteria used to analyze adolescents's WEP identification.

Categories	Code_ID	Variable description	Code
WEP	nbspW	Number of WEP species: count of the WEP species drawn.	/
Morphology	life	Life forms: type, e.g., vine, tree, herbaceous	(0-1)
	archi	Plant architecture: rhythmicity, dynamics, and position of ramification	(0-1)
	phylo	Phyllotaxy: arrangement of leaves on the axis	(0-1)
	ferPo	Fertile position: position of the flowers and fruits on the plant	(0-1)
	Leav	Leaves morphology	(0-3)
	root	Root system: type	(0-2)
	flo	Flower morphology	(0-3)
	fru	Fruit morphology	(0-4)
	EAD	Extra accurate details: e.g. tendril, stipule, hairs, buds	(0-1)
Phenology	pheF	Reproductive phenology	(0-1)
	pheL	Vegetative phenology: e.g. leaves, new shoot, sprout	(0-1)
Ecology	Land	Landscape items: e.g., forest, road, field.	(0-1)
	Soil	Soil: color, texture	(0-2)
	fauna	Fauna interactions, number of animal species	(0-max)
	flora	Flora interactions, number of non-edible plant species	(0-max)
Anthropic	use	Uses: human interaction with WEP, e.g., gathering. consumption	(0-1)

We considered whether the adolescent used each of the 16 criteria in the drawing by coding the corresponding variable as presence/absence. Then, we calculated the frequency with which an identification criterion was used by an adolescent and the average number of criteria used to identify a WEP, taking into consideration all the plants represented in a drawing. We compared the average number of criteria used by girls and boys using the Welch two-sample t-test and tested the relation between the number of criteria and the age with linear regression.

To establish profiles of adolescents according to the criteria used in their drawings, we performed a Principal Component Analysis (PCA using the r package *factoextra*) on a matrix describing the 80 drawings from the 16 criteria transformed in the presence/absence variable. Using our PCA, we calculated the contribution of each variable to the distribution of drawings in two main factorial planes (Dim 2,1 and Dim 2,3). Finally, to discriminate against adolescent's profiles according to their gender, we added the gender of the individuals as explanatory variables and calculated the confidence interval (ellipse) of 95% around barycenters of each gender group (girls and boys) in both factorial planes.

To assess whether adolescents' precision in representing plants varies across gender and age, we calculated the precision level of each participant based on the average precision score of all the plants. Then, we test the relation between gender, age and the precision level by comparing them using linear regression and the Welch two-sample t-test to compare the average precision score between girls and boys.

To compare gender precision according to identification criteria in a given species, we calculated the girl's and boy's probabilities to represent the same plant species precisely. To do so, we focused on four species and four criteria (i.e., "Flower morphology", "Reproductive phenology", "Fauna interactions'' and "Landscape items''). We chose four species represented by at least 20 girls and 20 boys to obtain a balanced sample (i.e., *Physalis peruviana*, *Vaccinium secundiflorum*, *Opuntia monacantha* and *Passiflora subpeltata*). We selected these criteria based on their variable contribution calculated by PCA, choosing the most discriminating ones. To calculate the probability species were presented with precision, we used a non-parametric Bayesian bootstrap with a Dirichlet distribution to model the randomness of a probability mass function (PMF) with the function *ethno_boot* from the R package ethnobotanyR.

In our final analysis, we assess the similarity between local and scientific knowledge in plant identification, by calculating the average percentage of matches between Betsileo's drawings and plant science for each identification criterion. We coded the information as match/mismatch for each species drawn by each participant and calculated the average percentage of matches per criterion based on all the plants drawn. We used vouchers from TAN herbarium and plant science literature as references (botanical description and ecology from World Flora Online (2023), Plant Of the World Online (2023), Global Biodiversity Information Facility (2023), Tropicos Madagascar (2023)).

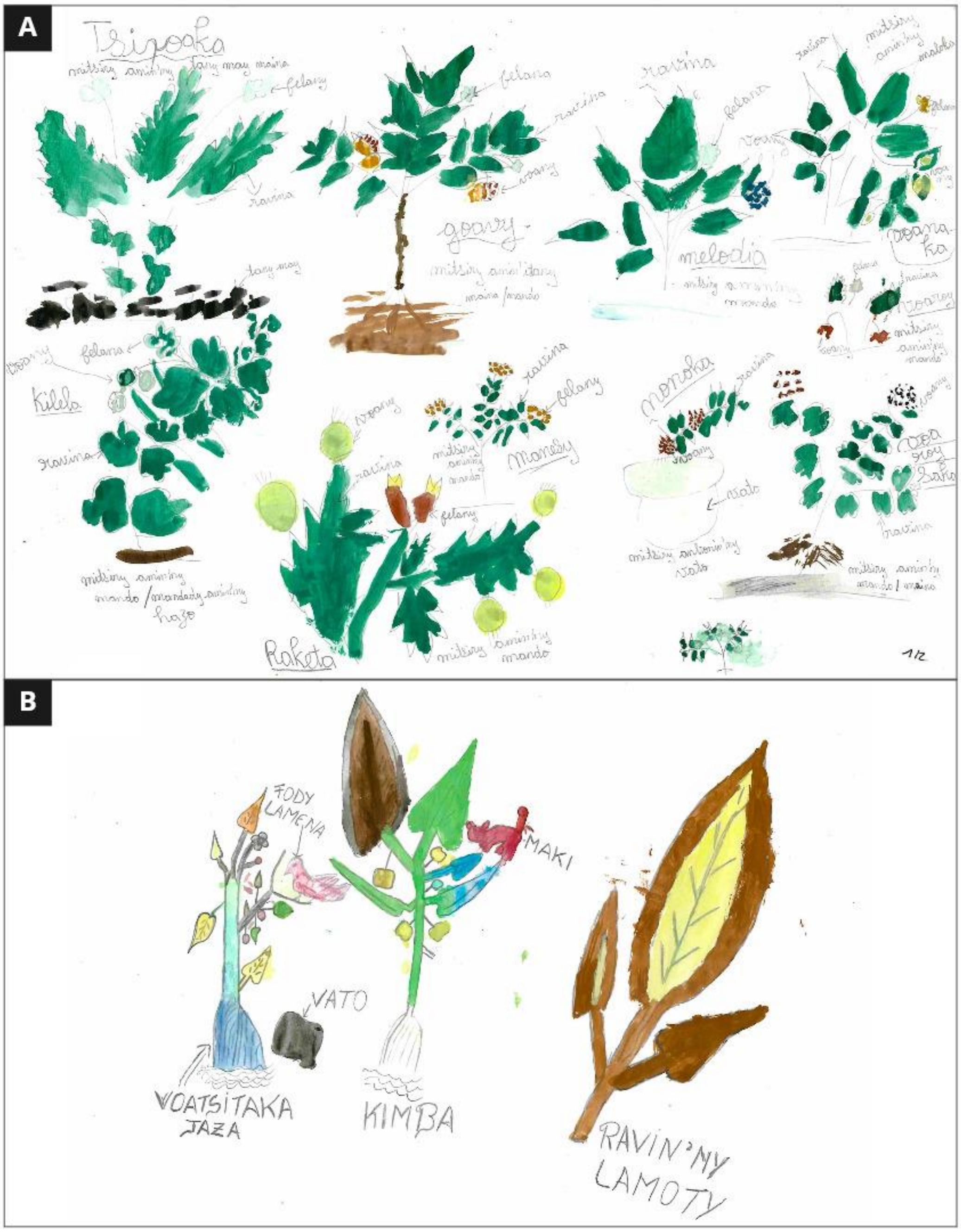
3.3 Results

The species drawn by adolescents

The 80 adolescents drew more than 500 items, representing a total of 58 WEP species, four non-WEP species, and 19 animal species associated with the WEP (see **A2.S1 Table** for the complete list of species interacting with the WEP). WEP species drawn belong to 31 botanical families (according to APG IV classification) and include 27 introduced, 11 natives, and 20 endemic species. Most WEPs drawn are consumed for their fruit (43 sp). The WEP species drawn also include leafy vegetables which are usually boiled to be consumed (7 sp), leaves that are consumed raw (5 sp), and plants consumed for the nectar contained in the spur of flowers (3 sp). Two species are consumed both for their nectar and their tubers which are eaten raw.

On average, each adolescent drew 5.96 WEP species (SD=2.46, range 1-18), girls drew 6.38 WEP species (SD=2.63; range 2 - 18) and boys 5.22 (SD=1.96; range 1-9). Girls drew 50 different WEP species whereas boys drew 36. Overall, 26 WEP species were shared between the subsamples of girls and boys. Twenty-four WEP species were found only on girls' drawings while ten were found only on boys' drawings. The species drawn only by girls were mostly introduced (54%), synanthropic herbaceous species growing around dwellings in the village or along roads and fields (e.g., **Fig.26A**). Among the species drawn only by boys, there were more endemic species (70%) coming from distinct and less anthropized areas such as forests in the surroundings (e.g., **Fig.26B**).

Figure.26 - Example of children drawings. A. Drawing made by a 14-year-old girl, illustrating ten different WEP species growing near the houses. Life form, leaf shape, phyllotaxy, fruit morphology and reproductive phenology, and soil type are the main criteria appearing in the drawing. The drawing shows precisely the different morphology of leaves from one species to another but also the opposite phyllotaxy of *Psidium guajava* L., which denotes the alternate phyllotaxy of the other



represented species. She also represented the different colors and textures of soil corresponding to each species. She explained during the interview that she chose the color black for the soil of *Tsiopaka* (*Bengt-jonsellia laurentii* (Jonsel) Al-Shehbaz) to represent the plant growing in the fields after burning the plots. **B.** Drawing by a 15-year-old boy illustrating three species of endemic trees growing in the forests. The drawing emphasizes the phenology of the leaves by distinguishing the young leaves (orange or bluish depending on the species) from the older ones (green) and those ready to fall (yellow or brown with a dry margin in black). He explained during the interview that the color of the young and old leaves was different from one species to another. He also represented the biotic interactions with a nesting bird (male red *fody*) in *Vaccinium secundiflorum* Hook and a lemur (striped-tailed lemur) eating the fruits of *Symphonia clusioides* Baker.

Plant identification criteria

Fifteen out of the 16 different identification criteria considered are found in at least 25% of the drawings and eight criteria were used in all drawings (Fig.27A). In the same drawing sheet, adolescents did not use the same number of criteria from one plant species to another; this induces a great variability in the level of details from one plant species to another drawn by the same individual. However, the participants used at least two criteria for each WEP drawn, with a mean number of 9.90 different criteria (SD=1.52) by plant species drawn. On average, boys used more criteria in their drawings than girls, the difference being statistically significant in a Welch two-sample t-test (respectively avg = 10.48 with SD = -0.70; avg = 8.64 with SD = -2.97; t=-3.2339, df=62.885, *p*-value=0.001, Fig.27B). Overall, of the 500 plants represented, 64.4% of the identification criteria were morphological, again 35.5% non-morphological.

The PCA explains 41.1% of the variability between individual drawings on the first three factorial axes (19.5, 12.8, and 8.8%; axes 1, 2, and 3, respectively, Fig.27C and **A2.S1 Fig**.). In the first factorial plane (Dim 2,1), the PCA grouped the variables in two main clusters: the morphological criteria (negative part of the first axis) and the non-morphological criteria (negative part of the second axis). Indeed, the first axis separates drawings using many criteria from drawings using few criteria, where all the morphological and phenological criteria (except for "Roots") and the ecological criterion "Soil" are linked with the negative part of the first axis. The second axis separates the drawings considering those that include ecological and anthropic criteria, found in the negative part of the axis, from the ones that do not include them (Fig.27C). The variables with a larger contribution to the first factorial plane are “Uses,” “Fauna interaction,” “Reproductive phenology,” and “Flower morphology.” The second factorial plane (Dim 2,3) shows a similar pattern with a larger contribution of non-morphological variables, “Uses”, “Fauna interaction,” and “Landscape items” (**A2.S1 Fig**).

The barycenter of the values for the variable gender (i.e., the mean point of individuals of the same gender, with 95% confidence ellipse) are separated by the axes on both factorial planes, suggesting that girls and boys do not use the same criteria to identify WEP, or use them in a divergent way in their drawings (**Fig.27C**).

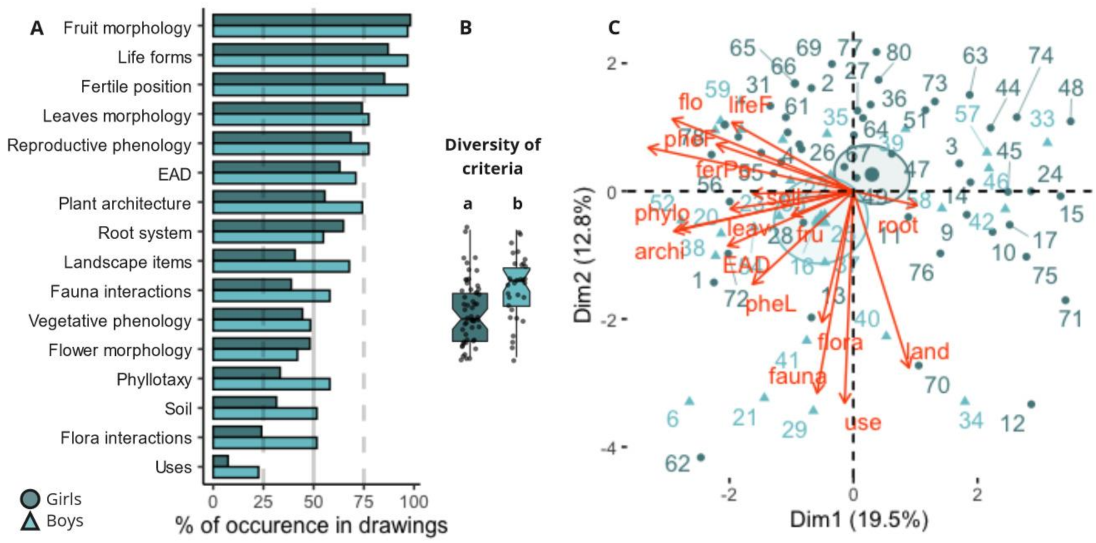


Figure.27 - Criteria used by adolescents to identify WEP species. (A) Frequency of occurrence of the 16 criteria in the 80 drawings (individuals) split by gender and ranked from the most to the least frequent (barplot). Results from girls’ drawings are indicated in blue-gray and from boys in clear blue. **(B)** The average number of criteria used by girls (a) and boys (b) in a drawing is indicated by the notched boxplot. Significant differences between girls (n=51) and boys (n=29) are indicated by different letters (Welch two-sample t-test; *p*-value<0.001*** for **a** and **b**). The notch displays a confidence interval based on the median, and box widths are proportional to sample size. **(C)** Analysis of the 80 drawings and 16 identification criteria (see **Tab.4**) with Principal Component Analysis (PCA). Biplot of individuals (drawings) and variables that explain the two first axes Dim 2,1 (left). Barycenter’s of the clouds of points of individuals of each gender are represented, with their confidence interval (ellipse).

Precision level

When looking at the level of precision of adolescents' representation of the different WEP species, we found a variability within the same drawing. Adolescents' precision was variable among the different identification criteria used. For example, regarding morphological criteria, adolescents emphasized the fruit, flower, and leaves morphology, providing a lot of details on the type, shape and colors of the organs represented by contrast with other criteria such as root systems, phyllotaxy, or plant architecture. Indeed, adolescents drew and described during interviews a fruit morphology that is distinct from one species to another and often very precise and detailed such as the type of fruit or infructescence, its shape and color. For example, the aggregated drupelets of the genus *Rubus* L., the simple or clustered drupes of the genus *Syzygium* changing from fuchsia to black as it matures (Fig.29Ai), the accrescent calyx protecting the fruit of cape gooseberry (*Physalis peruviana*), or the fleshy 2-locular fruit of *Plagioscyphus stelechantus* (Radlk.) Capuron were often represented with details. Furthermore, sometimes the species was represented only by its fruit, the vegetative parts being absent and criteria like root systems were drawn with less precision, very simplified, or just absent. Moreover, the precision level varies within identification criteria with the species drawn even within the same drawing (i.e., by the same individual). Big trees with small leaves were usually less accurately represented than easy to handle herbaceous plants. This is the case for example with the leaf morphology of *Passiflora* species, growing everywhere and daily consumed by children, for which tri-lobed leaves, tendrils, and foliated stipule are almost systematically represented (Fig.29Aii). Regarding non-morphological criteria, they were extremely precise and diverse. For example, biotic interactions included the detailed representation and explanations of the species of plants and animals interacting with the WEP, including the sex of the animals. WEP species were also contextualized in their habitat, with some drawings including details about edaphic conditions, ecology, phenological stages and humans using them (Fig.29Biv).

When comparing the probability to reach the highest precision score for a selection of criteria for the four most represented plant species, we did not find a specific gender-related trend (Fig.28). In other words, for each criterion of each plant tested, the probability of high precision is highly variable showing or not gender differences without a clear repetitive gender pattern (**Fig.28**).

Finally, when comparing individual precision scores, we found that boys were overall more precise than girls in their drawing, as boys displayed more details (t=-2.443, df=54.14, *p*-value=0.01, of the Welch two sample t-test). In addition, we did not find any age effect on girls' precision scores. However, we found that boys' precision score is significantly positively related to age (R=0.48, p<0.01**), meaning that boys' accuracy increases with age (**A2.S2 Fig.**).

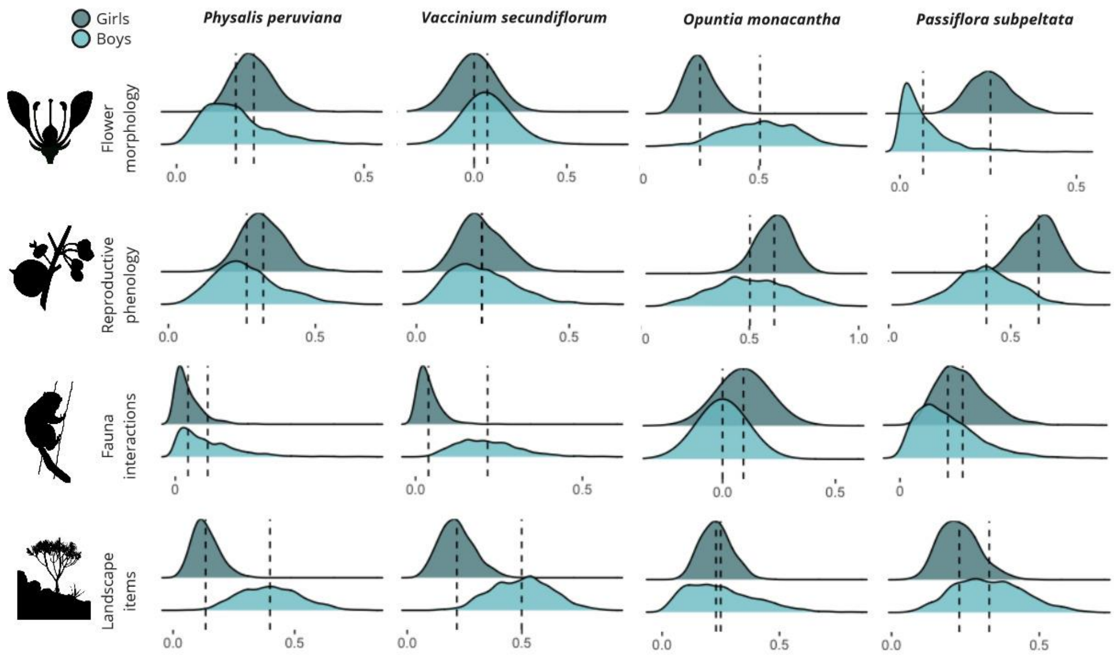


Figure.28 - Precision level by criteria and species according to gender. 0 indicates the lowest probability to reach the highest score while 1 indicates the highest probability. Dot lines indicate the respective average probability of the group. Results from girls' drawings are displayed in blue-gray and boys in clear blue.

Synergies between local and scientific knowledge

After checking each criterion used for each plant drawn (see example Fig.29A & B), we found that most of the plants represented (61.4%) matched with the botanical description or biotic interaction recorded in the literature. Overall, we found that morphological criteria matched with a lower percentage than non-morphological criteria (Fig.29C). Among the morphological criteria, the life form, and the position of the fertile organs (fruit, flower) on the plants (apical, axial, cauliflory) were the criteria with the highest similarity with botanical description, respectively matching on at 81.2% and 70.74% on average. Precise details such as the spine, stipules, or tendrils (EAD) matched at 69.75% on average (Fig.29A & C). Fruit and flower morphology matched with botanical description at 58.5% and 55.1% while leaves morphology matched at 47.93%. Phyllotaxy, root systems and plant architecture matched botanical description by less than 40%. Non-morphological criteria, excluding “Uses”, all matched with ecological literature by over 75% on average. Information provided by adolescents through drawing and interviews about the soil e.g., color, texture, and humidity, in which WEP species grow, matched 98.9% on average with literature. Reproductive and vegetative phenology as well as the landscape items describing WEP habitat matched over 90% with the literature. Information about fauna and flora interaction with WEP species were also highly matching with naturalist literature over 86% on average. In this sense, Betsileo's adolescents and scientists do focus on the same criteria to identify WEP species and their ecology.

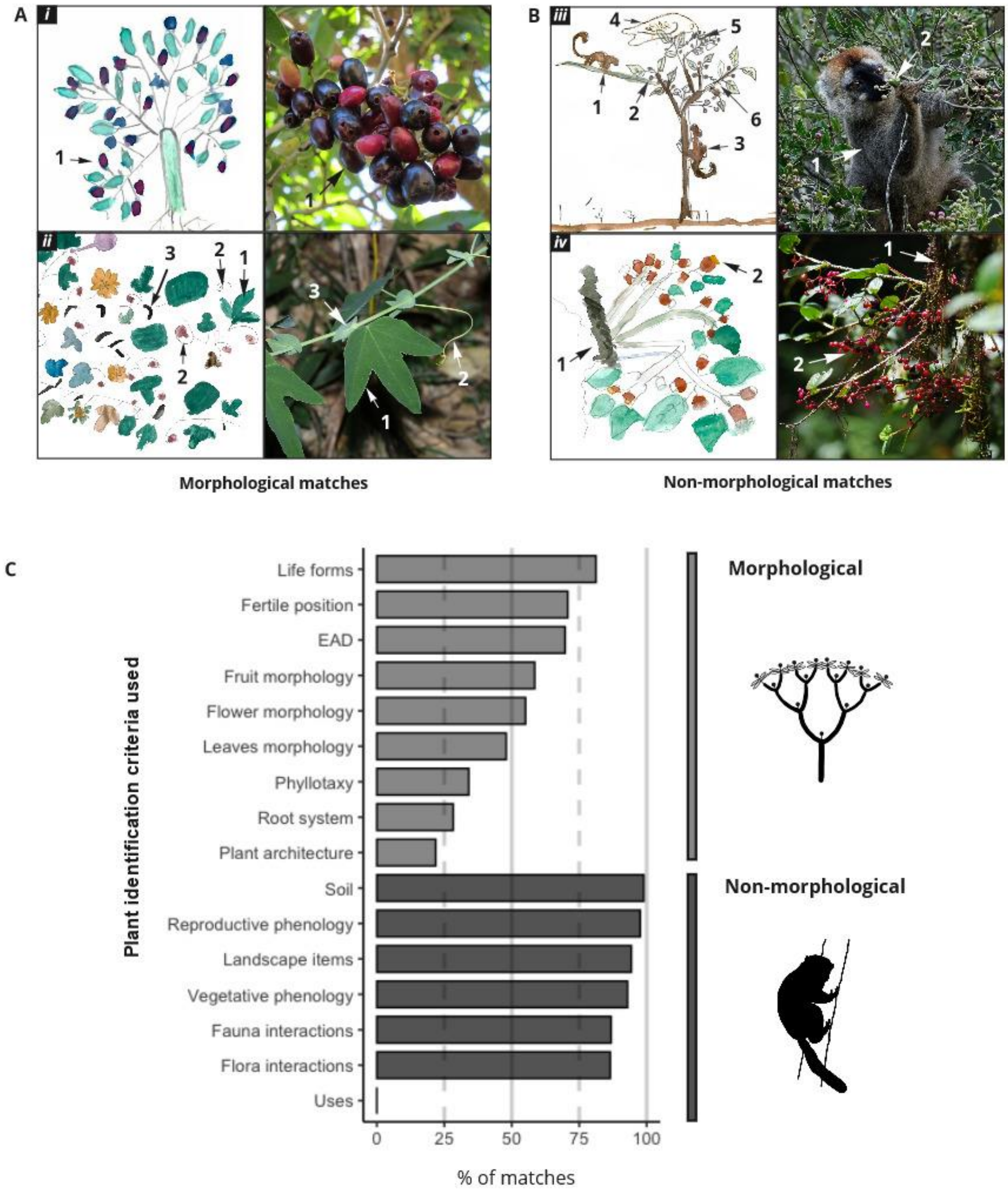


Figure.29 - Similarity between plant identification criteria used by Betsileo adolescents and botanical identification. Selection of **(A)** morphological and **(B)** non-morphological criteria matching between adolescents' drawings (left) and naturalistic observations: pictures (right). Numbers indicate the corresponding matching point between the drawing and the pictures. (*i*) *Syzygium* clustered drupes turning dark (1). (*ii*) *Passiflora subpeltata*, tri-lobed leaves (1), tendrils (2) and foliated stipule (3). (*iii*) *Syzygium bernieri* fruit eaten by *Eulemur rufifrons* (1 & 2) and four other interactions with another lemur and three bird species (3, 4, 5 & 6). (*iv*) *Medinilla torentum* growing on rock and or epiphytic (1) with fruit and flower at the same time (2). Photo credits (*i*) Bat Vorontsova, (*ii)* Greg Tasney, (*iii*) Chien Lee, (*iv*) V.P. **(C)** Average percentage of matching between Betsileo's drawing and botanists per morphological and non-morphological criterion.

3.4 Discussion

Betsileo teenagers display wide and rich ethnobotanical knowledge allowing them to accurately identify WEP species while using a large number of precise criteria involving deep knowledge about plant morphology and ecology. We found that plant identification knowledge varies with gender and age. Indeed, our results suggest that boys seem to use more criteria than girls to represent plants and that boys' (but not girls') precision in the use of identifying criteria rises with age.

In answer to our original question: *How do children identify plants?* We discuss our results and their implications for understanding adolescent's folk taxonomy and knowledge acquisition according to three main aspects: (1) the criteria used, (2) the combination of different criteria, and (3) the variability of this knowledge by gender and age. Finally, we discuss the limitations of our method and perspectives to explore further these knowledge realms.

Plant identification criteria

Adolescents use a great diversity of criteria to identify and distinguish one plant species from another, drawing rich representations of plant species. Our results are the first ones to show the richness of such knowledge, as the few previously existing works only provide anecdotal information suggesting the existence of such knowledge, but do not fully explore it.

Like most flora and botanical determination keys developed by botanists, Betsileo adolescents use a strategy to identify plants drawing on a series of details - whose number and nature varies from one species to another (Scharf, 2009). Indeed, we found that adolescents were not only precise and used multiple criteria to identify plants but that more than half of the knowledge presented matched with botanists' representations of the same species (Fig.29). In that sense, both systems of knowledge seem to converge partially on the criteria used to identify plant species. However, we found that morphological criteria were both less precise and less similar to scientific records than non-morphological ones. This lower level of precision might be due to individual reinterpretation of identification criteria, which might have been not fully understood or remembered, inducing errors in the drawing. This interpretation will be in line with the fuzzy-trace theory of memory, which states that humans encode information into two traces: in verbatim (i.e., the exact memory of a detail or pattern) and in gist (i.e., a semantic and conceptual memory of what we perceive the pattern to be) (Barghout, 2014). Considering that drawing is a projective tool requiring recall capacity, we think that the lower precision in plant drawing might be due to information encoded as gist by teenagers. This suggests that, while learning how to identify plants, teenagers might consciously focus or not on some specific criteria and detail rather than on others. Indeed, the criteria most used by adolescents were the fruit morphology, the fertile position, and the life forms, criteria used by more than 75% of our sampling. The focus on fruit might be explained by the fact that 74% of the species drawn are consumed for their fruit, and the results could be different if the focus of the work was not on WEP. Using the part consumed or sought after as a main criterion for identifying plant species is a common strategy in small-scale societies (Shepard, 2004; Jernigan, 2006). Despite low precision in specific criteria at the plant level, teenagers displayed high precision while drawing and detailing plant parts (particularly flowers, fruit, and leaves), which actually resulted in the creation of a specific variable (EAD) to catch precision in these observations. Also, non-matching morphological criteria between the drawings and scientific records might be interpreted as both the results of a fuzzy representation of criteria receiving less attention by adolescents and as an unexplored divergence between knowledge systems (Aikenhead & Ogawa, 2007). The diversity of criteria used unveils the deep understanding that adolescents Betsileo have of plants by both describing fine morphological specificity and contextualizing them into a biotic and abiotic network of interactions.

Combination of criteria

Beyond the diversity of criteria used, our results show that Betsileo adolescents frequently used these criteria simultaneously, using on average 9.90 different criteria to describe a species. Moreover, our PCA shows that criteria were used by clusters (Fig.27C), which suggests that an individual using a criterion of a given cluster is likely to use at the same time one or several criteria of the same cluster. In other words, for Betsileo adolescents plant identification relies on a wide spectrum of details - not limited to the morphological criteria - used in combination to provide a holistic identification. Thus, rather than as a juxtaposition of observed details, the plant species drawn are a complex and coherent figuration of what the individual understood (consciously or not) about the plant and the different relations between elements of the plants and with the surrounding environment (plant organ, animals, landscape items). This holistic perception is also intrinsic to certain criteria such as phyllotaxy, the position of the fertile organs or even the architecture of the plants, which are all based on a spatial organization of the different parts of the plant. This is well illustrated by **Fig.29Biv**, where the teenager used these three criteria together to draw a *Medinilla torentum*. In that drawing, the phyllotaxy (opposite leaves), the position of the fruits (axial on the last internodes or modules) and the architecture (model of LEEUWENBERG, Hallé & Oldeman, 1970) in the drawing not only precisely match with the photo (**Fig.29Biv**) and the botanical description, but also reflect a deep understanding of growth habit of the plant species. It is worth noting that identifying plant species by means of holist perceptions and interpretations of interwoven cultural and biological dimensions have been foreseen and studied across different cultural groups (Shepard, 2004; Dev, 2018; Greene et al., 2020). Unlike standard botanical determination keys, usually based on "step-wise analyses" focusing on distinctions between plants (Scharf, 2009), our result suggests that young Betsileo might identify plants following a model proposed by gestalt psychology. Gestalt psychology considers that the processes of perception and mental representation treat phenomena as a coherent whole, a system, emphasizing less on the elementary units of this system than on the relations that unite them (Wagemans et al., 2012; Kohler, 2015). This aligns with a significant body of research suggesting that local ecological knowledge is holistic in nature (Berkes & Berkes 2009; Latour, 2012; Tagalik et al., 2018). Thus, this consideration justifies our holistic approach using drawing interviews, giving a glimpse of the rich and complex knowledge system held by teenagers to identify plant species.

We found that 35.5% of the criteria used to identify plants were non-morphological. Indeed, we regularly found different species of lemur and birds represented with sexual dimorphism (see supplementary). For example, the red fody male (*Foudia madagascariensis*) builds the nest in a Malagasy bleu berry bush (*Vaccinium secundiflorum* Hook.) (**Fig.26B**). Similarly, we frequently found lemur from the genus *Eulemur* (probably *Eulemur rufifrons* (Bennett, 1833)) feeding on *Syzygium*

(Fig.29Ai). Finally, plant-insect interactions were also represented, particularly host plants' relationship with undetermined Lepidoptera with *Passiflora* and Malagasy silkworm (*Borocera cajani* Vinson, 1863) with *Aphloia theiformis* (Vahl) Benn. The use of other species to identify or spot the desired species (or other elements of nature) have been observed in other small-scale societies such as Hadza people using the honeyguide bird to find beehives among others (Cram et al., 2022). The ecology and the vegetation where the WEP grow was also very detailed during interviews. This important rate of non-morphological criteria involved highlights the importance of the context in the plant identification process and suggests a complex holistic understanding. Moreover, the great precision in the representation and identification of plant species by their morphology and ecological environment suggests that young Betsileo have a great capacity to observe and recall their surroundings. Indeed, children's and adolescent's observation ability has been recorded in several small-scale societies across the world. For example, an Eveny Siberian pastoralist adolescent is able to recognize each reindeer in a herd of several hundred (Ulturgasheva 2012), and Aché (Paraguayan forest foragers) and Khanky (Siberian pastoralist) children can follow tracks and not get lost using fine detail such as broken twigs, and moss on trees (Hill & Hurtado, 1996; Golovnev & Golovneva, 2016).

Gender and age variability

Our most striking result is that the criteria and the level of precision used to identify plants vary according to gender and age. Indeed, we found that boys used more criteria than girls but also distinct ones. Our PCA showed that girls were less likely to use non-morphological criteria such as landscape items or biotic interactions. Boys were also more precise than girls and became more precise as they grow up, meanwhile, girls' precision does not evolve with age. This distinct pattern in identification knowledge can be discussed through the lenses of socio-cultural and ecological context. In most small-scale societies, adolescence is a pivotal period when socio-cultural norms such as the gendered division of labor are adopted and guide the daily activities of individuals in different ways (Fehr et al., 2008; Gallois et al., 2018; Lew-Levy et al., 2020). In the Betsileo context, the gendered division of labor results in a specialization of ethnobotanical knowledge but also a great contrast in the mobility of individuals (Porcher et al., 2022). Boys, who are more likely to be involved in herding, are expected to move more frequently and widely through different ecological habitats than girls, whose mobility is restricted to the domestic sphere and crop fields. Therefore, girls and boys interact with different plant species in different ecological and sensory contexts. This could explain why boys use more criteria related to biological interaction than girls. The long days spent watching over the herds might allow them to keep a close eye on the ecological cradle where the edible plants they collect grow. In addition, young Betsileo boys are in their childhood formidable bird hunters suggesting a wide spectrum of complementary ecological knowledge (Viano, 2004). Together our results suggest that girls and boys have different exposure to nature for which they might have developed different strategies to identify WEP species, strategies that are adapted to the social-ecological context in which they grow. In ecosystems such as moist altitude dense forests -surrounding the valley, identifying plants might require being more precise and multiplying the number of criteria used to ensure a correct plant identification among the great diversity of plant species occurring in this habitat. However, in the village surrounding where girls mainly live and work (e.g., crop field, home garden), the WEP diversity is well-known, named and used by most of the Betsileo (Porcher et al., 2022), the probability to misidentify or being confused with another plant might be lower than in any other ecosystems, which might not imply to develop or use the same criteria to identify plants. Both Betsileo girls and boys increase their mobility while growing, but boys are more mobile which exposes them to many distinct ecosystems while herding. Therefore, the increasing precision with age we found in boys might be correlated to their increasing mobility and thus, the need to improve and adapt their identification knowledge to a wider ecological context.

In addition, by looking at teenagers' ability to represent a criterion with high level of precision for a given species, we found that there is also some species-dependent pattern according to gender (Fig.28). Indeed, for the same species tested, girls and boys do not focus on the same criteria, with the same precision. This finding supports our precedent idea showing that girls and boys experience the plant species differently and suggest that they developed their sense of observation in a different context reflecting a gendered socialization. That also might be the case for other sensory modalities which need to be addressed in further research (Shepard, 2004). Finally, our findings indicate that girls represented a greater number of WEPs compared to boys, suggesting a more comprehensive understanding of the diversity of WEPs. This result is consistent with our prior research, which demonstrated that girls exhibit greater knowledge of WEPs and, more specifically, on the herbaceous plants used in daily side dishes than boys (Porcher et al., 2022). This intracultural variability in LEK (i.e., boys' identification skills and girls' extended knowledge of WEP's diversity and uses) supports previous evidence on the importance of the role of the socio-ecological environment in understanding LEK variability in children.

The *invisible spectrum*

It is first worth noting that the diversity of WEP species drawn by Betsileo adolescents represents more than ¾ of the diversity previously found with other methods (84 sp, see Porcher et al., 2022). In that sense, our method is relevant for understanding which criteria are used by the Betsileo for identifying the WEP as it provides information that covers a representative sampling of the WEP in the area. Thus, our drawing-interview method provides both qualitative and quantitative data allowing us to deepen our understanding of local knowledge realms.

However, we are also aware that our method and approach probably caught only a fraction of the criteria really used by young Betsileo, and this is so mainly for three main reasons. First if, as mentioned, young Betsileo identify plants through a multitude of criteria interpreted as a coherent whole, then it is possible that some of the criteria used must also be unconscious, or not empirically perceptible, materialized by sensations or feelings; this would constitute a limitation when using drawings.

Second, we decided to base our analysis on standard criteria well-known from botany, but many other criteria to identify plants, including morphological ones, might escape from traditional botany. For example, plant architecture is a recent discovery in botany and a great tool for identifying and classifying plants (Hallé & Oldeman, 1970; Barthélémy & Caraglio, 2007) and indeed 25% of our sample used plant architecture as criterion. The relevance of this criterion recently added to the botanist toolkit suggests that other criteria not yet considered by botany might be used by local communities and might have escaped our analysis. To minimize this bias, further research might work with local people in co-producing a list of criteria using a multiple-evidence-based approach (Tengö et al., 2014; Roué & Nakashima, 2018).

Finally, we choose to focus on visual criteria through the use of drawing, which limits the plant representation into a two-dimensions figuration, challenging teenagers' figure-ground organization (Wagemans et al., 2012) and forcing them to be creative in their graphical representation of complex criteria. This might bias our data favoring individuals with better capacities in this type of representation. This is the case, for example, in a drawing shown above (**Fig.26B**), where the child has found a way to represent in two dimensions the margin of the leaf as it rolls up while drying. Moreover, by focusing on visual aspects, our approach does not allow us to elicit other sensory criteria such as sound, textures, smell, taste or other sensory and emotional experience that may play an important role for children in taxa identification, particularly as sensory sphere constantly evolves during childhood (Morris, 2010; Vennerød et al., 2018). Indeed, among these different sensory aspects, the chemosensory - i.e., smell and taste- has been the subject of studies demonstrating its key role in the identification of tree species and medicinal properties by both local people (Shepard, 2004; Jernigan, 2006) and botanists (Schatz, 2001). Less studied, proprioception and touch, by the feet also play a role in tree identification for Maasaï children by feeling the texture, the thorns, and the flexibility of the branches to which they climb (Tian & Leÿs 2021).

Considering our results and their limitations, our work both unveils a diverse and complex system of criteria to identify plant species and suppose the existence of an *invisible spectrum* of local knowledge driven by sensory modalities and performativity, requiring new approaches and methods to be recorded. Therefore, further research should be devoted to develop new approaches for assessing the identification criteria, and ecological knowledge in general, including not only the cognitive, but also the sensory and emotional part of the human-nature relation.

3.5 Conclusion

Betsileo adolescents hold a broad and sophisticated system of plant identification based on a deep knowledge of plant morphology and ecology, involving a wide spectrum of identification criteria, which vary according to age and gender due to distinct daily experiences with plants and habitats. This knowledge, acquired very early in childhood, constitutes the foundation of future interactions with nature and should be at the heart of environmental humanities studies and knowledge co-production projects to tackle socio-ecological concerns. Moreover, this knowledge caught by our drawing-interview method and transdisciplinary approach seems to involve different knowledge dimensions beyond cognitive aspects, suggesting a large spectrum not yet explored. Therefore, we encourage further studies to explore these aspects by developing new methods and approaches complementary to conventional ethnoecological tools involving and adapted to children and young to catch sensory modalities of folk children taxonomy and more broadly local ecological knowledge.

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Chapter IV

Growing up in the Betsileo landscape: Children's wild edible plants knowledge in highlands.

Abstract

Understanding local knowledge about wild edible plants (WEP) is essential for assessing plant services, reducing the risks of knowledge extinction, recognizing the rights of local communities, and improving biodiversity conservation efforts. However, the knowledge of specific groups such as women or children tends to be under-represented in local ecological knowledge (LEK) research. In this study, we explore how knowledge of WEP is distributed across gender and life stages (adults/children) among Betsileo people in the southern highlands of Madagascar. Using data from free listings with 42 adults and 40 children, gender-balanced, we show that knowledge on WEP differs widely across gender and life stage. In addition, we find that children have extended knowledge of WEP while reporting different species than adults. Women's knowledge specializes in herbaceous species (versus other plant life forms), while men's knowledge specializes in endemic species (versus native or introduced). Finally, we find that introduced species are more frequently cited by children, while adults cite more endemic species. We discuss the LEK differentiation mechanisms and the implications of acquiring life stage's knowledge in the highland landscapes of Madagascar. Given our findings, we highlight the importance of considering groups with under-represented knowledge repositories, such as children and women, into future research.

This chapter corresponds to the article:

Porcher, V., Carrière, S. M., Gallois, S., Randriambanona, H., Rafidison, V. M., & Reyes-García, V. (2022). Growing up in the Betsileo landscape: Children's wild edible plants knowledge in Madagascar. *PloS one*, *17*(2), e0264147.

4.1 Introduction

Among the numerous services provided by plants, food provision is probably the most important for humans (Maslow 1943; Vinceti et al., 2012). For many Indigenous Peoples and local communities (IPLC), local ecological knowledge (LEK) about wild edible plants (WEP) allows maintaining local livelihood and cultural identity (Pieroni & Sõukand 2019). LEK about WEP is also critical for safeguarding biocultural diversity and local resilience in times of food scarcity (Ong & Kim 2017; Asprilla-Perea & Díaz-Puente 2019). LEK, however, is drastically threatened by multiple factors and rapid socio-ecological changes–e.g., habitat lost, or species and language extinction (Aswani et al., 2018; Fernández-Llamazares et al., 2021; Cámara-Leret & Bascompte 2021).

An important finding of previous research on LEK is that this body of knowledge is often unevenly distributed within the same society (Natcher et al., 2020), although not much of this research has focused on WEP knowledge (Pasquini et al., 2018). For example, research shows that intracultural variability in knowledge distribution is influenced by socio-economic characteristics of people, such as gender or life stage (Andriamparany et al., 2014; De Albuquerque et al., 2011). This is so because such characteristics shape people's involvement in subsistence activities, and therefore interaction with the environment or specific environmental features. Therefore, considering individual characteristics when documenting the knowledge of a society is key to identifying the principal repositories of LEK (Hitomi & Loring 2018).

Among the factors that shape intracultural distribution of knowledge, much research has focused on gender and age (Koster et al., 2020; Godoy et al., 2015; Díaz-Reviriego et al., 2016b). Regarding age, studies explored the intracultural differences due to generational variations (Koster et al., 2020; Godoy et al., 2015; Okui et al., 2021), but very few have embedded children into the sampling (Gallois & Reyes-García 2018). So far, most research addressing knowledge distribution within a society describes age as a factor shaping knowledge accumulation, rather than knowledge differentiation (Godoy et al., 2015; Blacutt-Rivero et al., 2016) In other words, children are generally considered as "adults to be", rather than a group with distinctive knowledge (Dounias et al., 2016).

Despite this general view, recent work in ethnobiology has highlighted that children display specific knowledge that they do not necessarily share with adults (Gallois et al., 2015), or what authors call « children's culture » (Corsaro 2012; Johanson 2013; Gallois et al., 2017). The finding is important because it questions the assumption that the transmission of cultural knowledge in childhood is mainly vertical, i.e., knowledge being transmitted from adults to children, children being mostly the receivers in the process of knowledge transmission (Lew-Levy et al., 2020). Moreover, the finding that children have differentiated knowledge also has implications for our understanding of children's potential contribution to livelihood activities (Hewlett 2014) and food systems (Crittenden & Zes 2015). For example, using their specialized knowledge, hunter and gatherer Mikea children from south-west Madagascar gather wild edibles that constitute a substantial part of their daily intake (Tuker & Young 2005). These gathering activities have important positive impacts on children's health (Golden et al., 2011).

In this study, we examine intracultural variability in wild edible plant knowledge distribution among the Betsileo, Madagascar. We focus on Madagascar because while LEK on WEP have been well studied in several megadiverse regions such as Amazonia (Odonne 2016) and New Guinea (Cámara-Leret et al., 2019), Madagascar has received less attention, despite being a hotspot of biological and cultural diversity. Madagascar, which counts with 12 indigenous languages (Glottolog 4.4) and 11.399 native vascular plant species known (Catalogue of the Plants of Madagascar 2023), is particularly touched by land cover shifts (Kull 2013), climate change impacts (Brown et al., 2015) and more recently by an extreme food crisis (Rice 2020). We focus on differences in knowledge distribution associated to gender and life stage (adults vs children) with a particular focus on children. We also look at gendered differences in knowledge distribution, as previous research shows that gender is a structuring factor in shaping knowledge distribution. By using an intersectional lens, i.e., considering gender and life stage, as knowledge differentiation factors, this study contributes to the advancement of existing literature on gendered LEK and questions assumptions on cultural knowledge transmission and acquisition during childhood (Gallois & Reyes-García 2018). We work with southern Betsileo population because the knowledge of this group has not been largely documented, although a previous study suggested that Betsileo's children hold large amounts of environmental knowledge (Carrière 2010; Carrière & Gastineau 2010), making this case study an ideal to test life stage variations in LEK.

4.2 Material and methods

Study area

Fieldwork was carried out in the Namoly valley (-22.12377, 46.92166), southeast of the central highlands of Madagascar (Fig.30). The study area is located on the edge of the Andringitra National Park with high altitudinal gradients (720 to 2658 m). The area has been occupied since the end of the 19th century by the Betsileo people, the third largest ethnic group in the island (Dubois 1938; Kottak 1980; Regnier 2012). The topography and the park display a rich ecological habitat mosaic surrounding Betsileo settlements, at the bottom of the valley (1500 m above sea level). On the eastern slope (Fig.30A), moist altitude dense forest (1500–1800m) and sclerophyllous moist forest (1800–2000) support many subsistence economic activities and knowledge associated with forest (Carrière et al., 2005; Moreau 2006; Rafidison et al., 2020). On the western slope (Fig.30B), the Precambrian granitic massif—a large inselberg culminating at 2658m –supports rupicolous vegetation on its top (2500m) and altimontane meadow and ericoid thickets down the cliff (2100m). This highland vegetation holds the richest botanical diversity and the highest rate of endemism of Madagascar (Rabarimanarivo et al., 2019; Goodman & Benstead 2005). At the bottom of the valley (Fig.30C), the landscape is made up of a mosaic of rice field and secondary regrowth vegetation that is both woody and shrubby, mainly open and colonized by ferns, surrounding the houses, pastures, and other crops fields. Given its location, Betsileo people from the Namoly valley have access to a large diversity of resources and, particularly, to a large choice of wild edible plants. The valley counts approximately 3.800 inhabitants distributed in 662 households isolated or clustered in *vala* (hamlets) of 3 to 15 houses. The isolated houses and hamlets are spread all along the valley, distant from each other by about 500m.

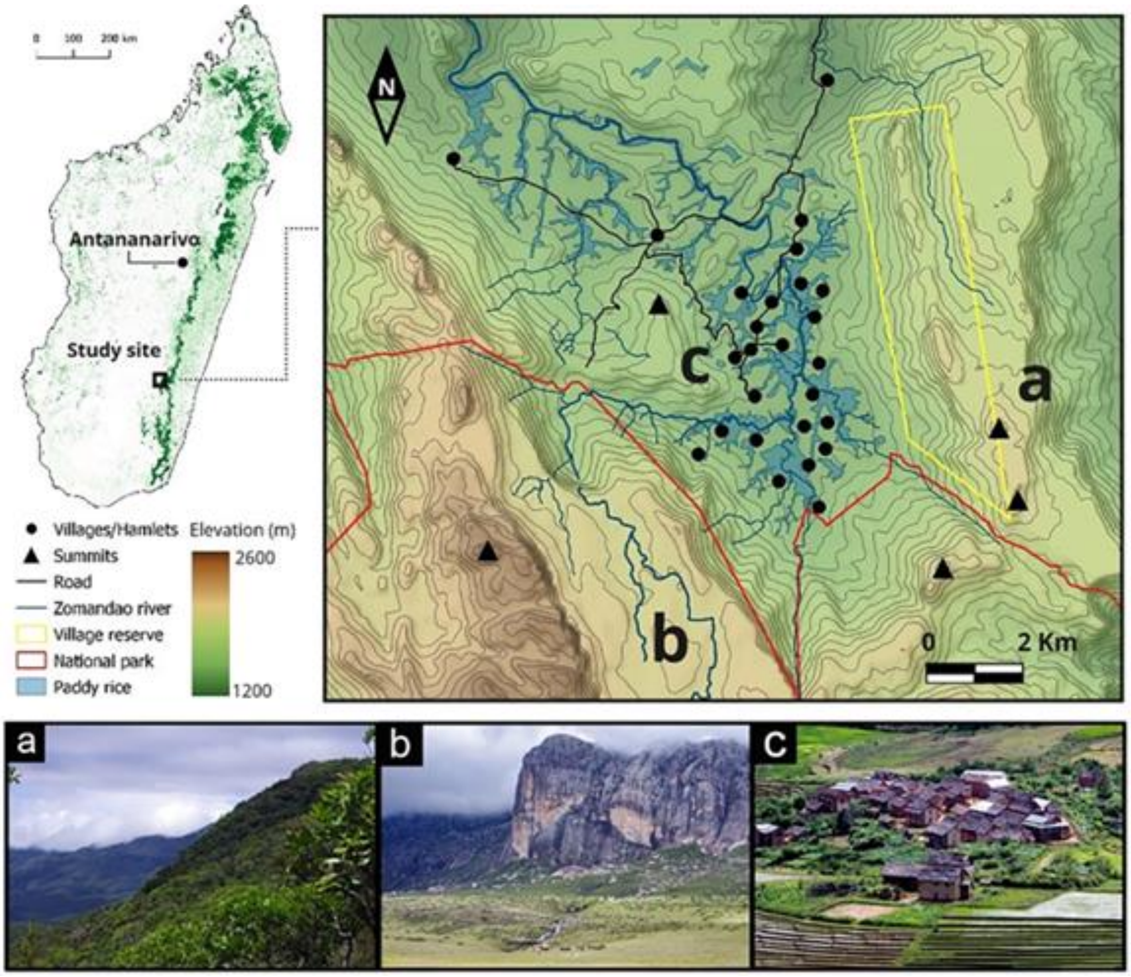

Figure.30 - Map of the study site: The Namoly valley landscape and their main ecological zones. **a.** eastern slope: moist altitude dense forest (1500–1800m) and sclerophyllous moist forest (1800–2000), **b.** western slope: altimontane meadow, ericoid thickets (2100m) and rupicolous vegetation (2500m), **c.** valley bottom (1500m): surrounding houses, pastures, crop fields. The map was built under QGIS 3.10.0 by the authors, using elevation SRTM data V4. at 90m spatial resolution from the CGIAR-CSI database (Jarvis et al., 2008). See also Fig.31 for altitudinal zonation of vegetation in Namoly valley.

Betsileo social organization

Up to this date, the Betsileo have a complex system of social stratification structured by patrilineal kinship lines, where male elders play a central social role (Regnier 2012; Kottak 1971). The social organization and traditional rules maintained by the traditional chefs (*rayaman dreny*) lead to a division of labor by age and gender. This differentiation is particularly marked in subsistence activities (Kottak 1972). Betsileo people consider children, *kilonga*, individuals between 4 and 14 years of age (before they are *zaza kely*, infant). Betsileo consider that after childhood, individuals have an extended period of transition to adulthood, which might last from 14 to 40 years of age, during which individuals are named *tanora*. Around 18 years old, Betsileo people have their first wedding and create a new household. People consider that a person reaches adulthood, *olon-dehibe*, by the age of 40 years. People become elders, *antitra*, after 60 years of age. For the purpose of the study, we will define children as individuals under 18 years old (Graham et al., 2015).

As many other Malagasy ethnic groups, the Betsileo have adopted an agro-pastoral livelihood system based on a combination of irrigated lowland and rainfed rice cultivation and zebu breeding. All household members work together during the rice harvesting season (*asotry*). However, men take care of zebus and prepare the rice fields. Men also engage in activities that require mobility, i.e., gathering, fishing, hunting, exchange, and trade of goods, and take the zebus to specific pastures during the year. All these activities expose them to different ecological habitats across the valley. In turn, women take care of the rice nurseries and work in home gardens and other crops. Women's activities are mostly organized around the settlements and cover less environments than men's activities. Children are often raised in an alloparental care system involving several households from the same family. Children up to six years of age often stay with the women around the houses. Children living in the valley, most of whom attend school, are independent from a very early age and travel several kilometers a day from the age of six. The youngest boys help to keep the zebus in the meadows near the settlements and, by the time they are 10 to 12 years old, they accompany their fathers to the more distant pastures. Young girls share farming and cooking activities with their mothers and older girls look after the younger children in the absence of adults. Previous research within this society shows that children's representations of nature include the use of many wild species, a representation that contrasts with adult's main activity as farmers (Carrière 2010; Carrière & Gastineau 2010).

For the Betsileo, the lean season (*havaratra*), occurring from mid-October to March just before the rice-harvesting season (*asotry*), is central in structuring livelihood activities. Unlike the rest of the island, where there are two rice harvests, the colder climatic regime of the Namoly valley only allows for one annual harvest of rice, which makes people of the valley more vulnerable to climatic variability. People manage a wide diversity of crops, which traditionally allowed them to cope with variability in rice yield and limited the risk of food shortages (Radanielina et al., 2014), although recent change in local climatic patterns harm rice yield and thus extend the lean season (Harvey et al., 2014). Mainly collected as condiments, side dishes, or for snacking, wild edible plants are also largely used by Betsileo people as a staple food during the lean season.

Data collection

Fieldwork was conducted in the municipality of Namoly in the district of Ambalavao from January to March 2020 during the lean season, when smallholder farmers are more vulnerable to food crisis, a situation that might increase their reliance on wild edible plants (Ong & Kim 2017; Asprilla-Perea & Díaz-Puente 2019; Fentahum & Hager 2009). Before starting data collection, we obtained the agreement from the relevant administrative territorial organizations (*Fokontany* chefs). Free Prior and Informed Consent (FPIC) was requested from each informant before conducting interviews. For children, we requested both their own and their parents' FPIC, always reiterating to the child their right to withdraw at any time (Harcourt & Conroy 2006). This research project was approved by the ethics committee of the Autonomous University of Barcelona CEEAH (4902) and was carried out following the ethical charter of Ethical Research Involving Children (Graham et al., 2015).

Sample

Our sample includes women and men and girls and boys. We conducted 82 free listing interviews to collect wild edible data among adults (n=42) and children (n=40). We used a convenient sampling method to obtain a balanced sample considering gender and life stage. Our sample includes 22 women, 20 men, 22 girls and 18 boys from 52 households. We also selected eight key informants, five adults and three children, to collect additional data with semi-structured interviews (Alexiades 1996). The five adults (two women and three men) were *ombiasa* (traditional healers working with plants and animals), well-known in the valley for their expertise. As children's key informants, we selected two boys and one girl around 10 and 12 years old able to cite and identify more than 20 plant species in our free listing exercise (which represents twice the average number of plants cited by children). The eight key informants were not related through kinship.

Ethnobotanical data

Ethnobotanical data were collected using free listings and semi-structured interviews with key informants. We collected ethnobotanical data using free listings because this tool gives a good overview of local knowledge and can be adapted to children, so data collected using free listings allow us to compare adults' and children's knowledge (Gallois & Reyes-García 2018).

Because people of the study area do not have a unique term for the concept "wild edible plants'', our prompt for free listing was: "Which non-cultivated plants do you know that are edible?" We used the word *sakafo*, which means food, meal or edible. To facilitate the work with children and to build a relationship of trust with them, before starting data collection we spent two weeks of direct and participant observation (Ruiz-Mallén et al., 2013; Hagino & Yamauchi 2016). To avoid that children identified the interview with schoolwork, free listing interviews with children were mostly conducted outside school, mostly at home (Fargas-Malet et al., 2010; James 2001). If parents wanted to assist in the interview, we asked them not to influence children's responses (Fargas-Malet et al., 2010). Free listing interviews with adults were conducted at home or in communal spaces, like the marketplace.

To obtain more detailed data on each WEP listed in free listing, we conducted semi-structured interviews with adults and children's key informants. During semi-structured interviews with key informants, and for each WEPs reported in free listing, we asked about i) synonymy, ii) parts consumed, and iii) wild edible plant location and hamlets-to-location walking time. To collect this information with children, we complemented our semi-structured interview with walks in the surrounding forests. Semi-structured interviews with adult key informants were longer than semi-structured interviews with children (2 hours vs. 45 minutes). Semi-structured interviews with adults were conducted at their home or during wild edible plant collection walks.

Botanical data

In February 2019, with the help of local experts, we collected and made vouchers for WEP reported during free listings. We prepared plant vouchers following the field guide used by Missouri Botanical Garden (Liesner 1995). WEPs were identified by comparing the local names, vouchers and photographs taken by the first author with species identified in literature and Malagasy flora database (Henri & Jean-F 1936; Callamander et al., 2011; Schartz & Wilmé 2001). Family and scientific names were checked with the World Flora Online (WFO 2023). For each species reported during free listing, we determined its life form. We considered "trees" as plants erected from the ground with a single trunk, "shrubs" as multiple woody stems plants, "climbers" as support-dependent plants, and "herbaceous" as annuals plants without a trunk, usually non-woody. Based on the type of vegetation and disturbance levels on the area (Goodman & Benstead 2003; Goodman 1996) (see S1 Table in S1 File for habitats description), we described five ecological habitats where WEP grow: Grassy Secondary Vegetation, Shrubby Secondary Vegetation, Mountain Forest, and Highland vegetation. We used the Tropicos database (Catalogue of the Plants of Madagascar 2023) to determine the biogeographical distribution (endemic, native, and introduced) of plants in free listings.

Data analysis

We started the analysis using a MANOVA to test the relation between the habitats and the biogeographical characteristic of the WEPs cited. This test allows us to assess the number of endemic (to Madagascar), native (to Africa including Madagascar and the Mascareignes region) and introduced (voluntarily or accidentally) species in each habitat.

Then, to assess the level to which WEPs knowledge varies within people in the study site, we used gender (i.e., women vs. men), life stage (i.e., adults vs children), and the combination of both to build different subsamples for the analysis.

Number of WEPs cited and estimated

To get an overview of the WEP knowledge distribution, we used free listing data to calculate the total number of WEP cited–i.e., observed richness -, differentiating between citations by the full sample and by each subsample. We also analyzed the number of WEPs shared and not shared by the four subsamples. Then, we estimated the theoretical number of WEP known–i.e., the estimated richness–using the non-parametric estimator Chao 2, i.e., the asymptote of the accumulation curve of species cited (Costa et al., 2016). Estimated richness was calculated for the full sample and for subsamples and compared to the respective observed richness.

To assess variation on the number of wild edible plants listed across gender and life stage, we compared the length of the lists generated by the four subsamples (i.e., women, men, girls, and boys) using a Kruskal-Wallis's rank sum test. We also used a Welch two sample t-test to compare the mean list length of adults vs. children and of females vs. males. Finally, we investigated the relation of list length with age (discrete variable), gender, and their interaction using a Poisson generalized linear model (GLM) with a log link function.

Dissimilarity and species' composition

To explore differences in the WEPs reported associated to the informant's gender and life stage, we performed an analysis of variance using distance matrices. We started using the Jaccard index to build a dissimilarity matrix of informants vs. species. We then tested for differences between groups using a PERMANOVA, from the 'adonis' function in the vegan package of R (Oksanen et al., 2017).

WEPs importance

To evaluate the influence of gender and life stage on the importance attributed to wild edible plants by each of the subsamples, for each subsample we calculated a cognitive salient index: the *B*'score index (Robbins et al., 2017).

Wild edible plants characteristics

We described WEPs characteristics according to their life form, parts consumed, growth habitats, and biogeography (see **A3.S1 Tab.** for habitat variables description). To test whether there are differences in the characteristics of the wild edible plants cited by the four subsamples, we used a MANOVA. Four models were performed including as explanatory variables life stage, gender, and the interaction between them: i) the life form model with four response categories (i.e., herbaceous, trees, shrubs and climbers); ii) the habitat model with five response categories (i.e., HV, MF, SSV, GSV and WET); iii) the part consumed model with seven response categories (i.e., whole, fruit, leaves, new shoots, tuber, seeds, and nectar); and iv) the biogeography model with three response categories (i.e., endemic, native and introduced). The MANOVA tests were performed in R (Team R. Core 2013) with the package stats version 4.0.3. We used a boxplot representation to display the trends elicited by the MANOVA. We also used Kruskal-Wallis's chi-squared test as post-hoc to solve the effects of combined explicative variables resulting from MANOVA. Finally, we used a Chi-square test to compare the distribution of endemic, native and introduced species among the ten most salient species–based on the *B*'score index—listed by the four subsamples.

4.3 Results

Informants listed a total of 136 local names of wild edibles. Once synonyms were solved, the cleaned list included 117 wild edible plants, one fungus, and two arthropods' species. We removed the fungi and the arthropods for the analysis, so our final list includes 117 WEP species, of which we were not able to identify two plants (**A.1**). The plant species reported belong to 52 botanical families and 91 genera. Most of the WEP species reported were herbaceous (n = 57 species), followed by trees (n = 27), shrubs (n = 19) and climbers (n = 14). Many of the WEP cited have multiple parts consumed with different preparation modes (e.g., raw, boiled, braised). For almost half of the species (n = 53), fruits are consumed, usually eaten raw as snacks. Other parts consumed include the whole aerial part (29 species), the tubers (14 species), the leaves (13 species), the new shoots (4 species), the nectar (2 species), and the seeds (2 species). Almost a third of the WEP cited are collected in areas dominated by grassy secondary vegetation (62 species). Fewer WEP are collected in areas dominated by shrubby secondary vegetation (21 species), mountain forest (19 species), highland vegetation (11 species), or wetlands (4 species). About half of the WEP species cited were introduced (57 species), the rest of the species cited were equally distributed between endemic (30 species) and native (30 species). There is a direct relation between the number of introduced, endemic and native's species of WEPs and their corresponding ecological habitats (**A3.S2 Table**). The richest habitats in endemic species were the habitats with highest altitude and less accessible from settlements in the bottom of the valley (Fig.31).

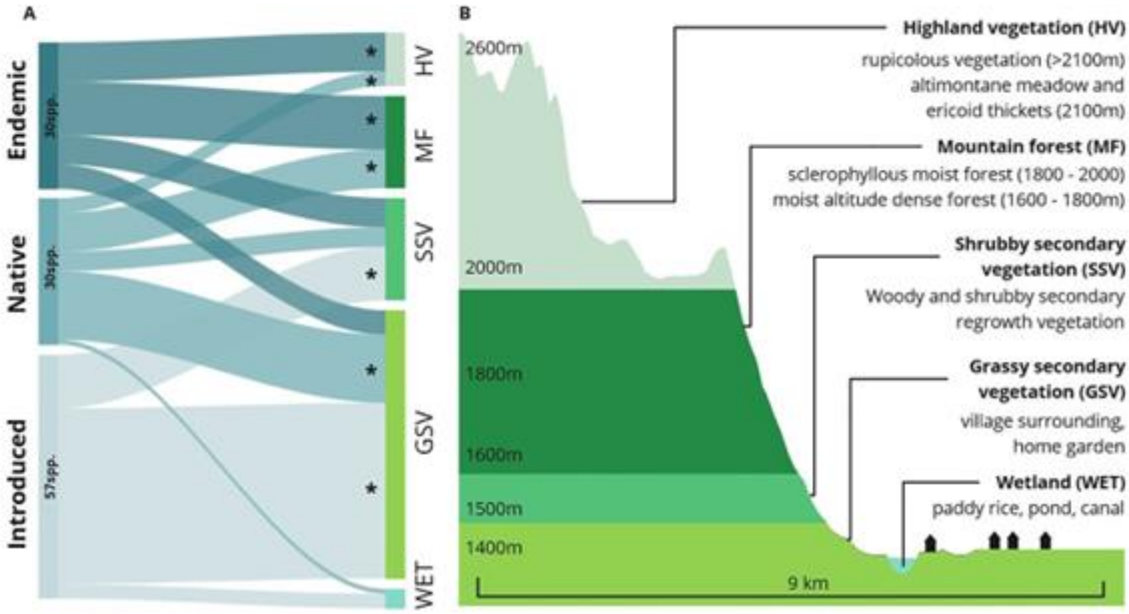

Figure.31 - Biogeography and habitat of Betsileo WEPs collection. A. Sankey diagram showing the proportion of endemic, native, and introduced WEP species found in each habitat. The thickness of the lines refers to the number of species. "*" indicate significant relation based on MANOVA (threshold at $p < 0.001$) (S2 Table in S1 File). **B.** altitudinal zonation of vegetation in Namoly valley from west to east. X and Y axes are not at the same scale.

Number of WEPs cited by subsamples

The number of WEP species cited by informants did not reach the estimated richness (69.5% of completeness) according to the asymptotic value from Chao's estimator (**A3.S1 Fig.**). Children cited 84 species, representing 68% of the estimated richness, and adults cited 91 species, or 55% of the estimated richness, which suggests that both subsamples might know more species than those cited during our free listings (**A3.S1 Fig. c 6 b**). Similarly, females cited 97 species, 62% of the estimated richness, and males 85 species, 70% of the estimated richness, which again suggests that both subsamples might know almost a third WEP species more than they cited (**A3.S1 Fig. d & e**).

Adults cited more WEP species (avg = 13.40; SD = 5.51) than children (avg = 9.58; SD = 4.71), while female (avg. = 11.45; SD = 5.34) and male (avg. = 11.70; SD = 5.67) respondents cited about the same number of WEP species (**Fig.32A**). We found that the differences in lists length were statistically significant for life stage (t = 3.3571, df = 78.462, p <0.001) and statistically not significant for gender (t = -0.201, df = 74.869, p = 0.840).

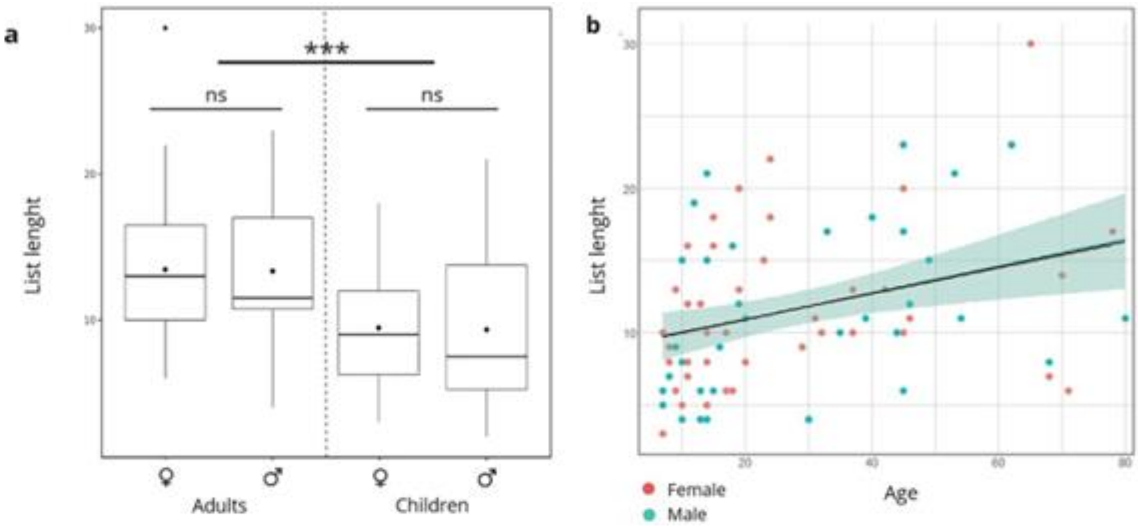

Figure.32 - Gender and life stage effect on the number of WEPs cited. a. comparison of the mean WEP species richness cited by subsamples of informants, **b.** linear correlation between WEP list length and age (female = red dots and male = blue dots). ns = non-significant.

Results from the linear regression of list length against informants' age show a positive relation between the two variables (estimate = 0.007, Std. error = 0.001 z value = 4.652, $p \leq 0.001$***) (**Fig.32B**). In this same regression, the variable that captured the gender of the informant was statistically insignificant (p = 0.97).

WEP species' composition by subsamples

Only 25% (n = 30 spp.) of the 117 WEP in our list were cited by all subsamples. Most WEP species cited by a subsample were specific to it, i.e., not, or rarely cited by other subsamples. Twenty-six WEPs were mentioned only by children and 33 WEPs were only mentioned by adults. Females cited 32 WEP not mentioned by males, while males cited 20 species not listed by females. Most WEP cited only by one of the subsamples were cited only once, and only a few of these species were cited more than five times (**Fig.33**).

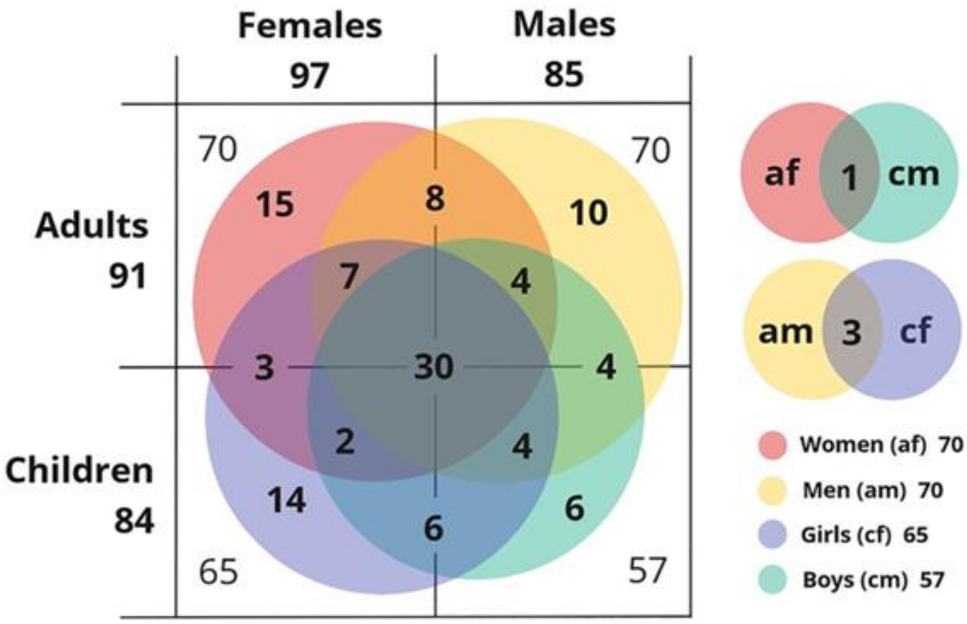

Figure.33 - Venn diagram of WEP species shared by the four subsamples. Representation of the number and the distribution of WEP species cited by each subsample.

The WEP reported by the different subsamples differs widely. According to results of a PERMANOVA, the WEP listed by adults and children (F = 4.015, R2 = 0.047, p = 0.001) and by females and males (F = 1.723, R2 = 0.020, p<0.01) are significantly different. Women and men listed different WEP (F = 1.849, R2 = 0.044, p<0.01), but there was no statistically significant difference in the lists of girls and boys (F = 0.875, R2 = 0.023, p = 0.672). We also found significant differences between the lists of girls and women (F = 2.568, R2 = 0.057, p<0.001), boys and women (F = 1.879, R2 = 0.048, p<0.01), girls and men (F = 3.842, R2 = 0.087, p<0.001) and boys and men (F = 2.446, R2 = 0.065, p<0.001).

Importance attributed to WEPs

The 30 WEP's species common to all subsamples are also the most frequently cited within each subsample. According to the *B*'score index, only three WEP species overlap among the ten most salient species in each subgroup (*Aphloia theiformis* (Vahl) Benn. Aphloiaceae, *Syzygium cumini* (L.) Skeels Myrtaceae and *Bengt-jonsellia laurentii* (Jonsell) Al-Shehbaz Brassicaceae) (**Tab.5**). *B. laurentii* seems particularly salient for children as, on average, it was listed second in both girls' and boys' subsamples.

Table.5 Sub-lists of the ten most salient WEPs species according to the *B*'score index. Biogeography: (E: endemic to Madagascar, N: native to Africa including Madagascar and the Mascareignes region I: Introduced in Madagascar). Habitat: MF (mountain forest), HV (highland vegetation), SSV (shrubby secondary vegetation) and GSV (grassy secondary vegetation).

	Local name	Scientific name	Family	Biogeography	Habitat	Frequency	*B*'score
	Women						
1	*Lamoty*	*Flacourtia indica* (Burm.f.) Merr.	Salicaceae	N	MF	0.73	0.602
2	*Trakavola*	*Bidens pilosa* L.	Compositae	N	GSV	0.77	0.59
3	*Voafotsy*	*Aphloia theiformis* (Vahl) Benn.	Apholiaceae	N	MF	0.68	0.584
4	*Tsipoaka*	*Rorippa laurentii* Jonsell	Brassicaceae	E	HV	0.68	0.56
5	*rotsy*	*Syzygium cumini* (L.) Skeels	Myrtaceae	I	SSV	0.64	0.549
6	*voanaka*	*Physalis peruviana* L.	Solanaceae	I	GSV	0.59	0.425
7	*kimaosy*	*Vigna angivensis* Baker	Leguminosae	E	GSV	0.55	0.392
8	*giranadela*	*Passiflora edulis* Sims	Passifloraceae	I	GSV	0.41	0.344
9	*ovy ala*	*Dioscorea trichantha* Baker	Dioscoreaceae	E	SSV	0.41	0.304
10	*lanary*	*Plagioscyphus jumellei* (Choux) Capuron	Sapindaceae	E	MF	0.36	0.291
	Men						

1	*giranadela*	*Passiflora edulis* Sims	Passifloraceae	I	GSV	0.75	0.529
2	*rotsy*	*Syzygium cumini* (L.) Skeels	Myrtaceae	I	SSV	0.6	0.489
3	*lamoty*	*Flacourtia indica* (Burm.f.) Merr.	Salicaceae	N	MF	0.55	0.46
4	*tsipoaka*	*Rorippa laurentii* Jonsell	Brassicaceae	E	HV	0.65	0.456
5	*voafotsy*	*Aphloia theiformis* (Vahl) Benn.	Apholiaceae	N	MF	0.5	0.431
6	*voatsitakajaza*	*Vaccinium secundiflorum* Hook.	Ericaceae	E	HV	0.55	0.423
7	*lanary*	*Plagioscyphus jumellei* (Choux) Capuron	Sapindaceae	E	MF	0.5	0.419
8	*ovy ala*	*Dioscorea trichantha* Baker	Dioscoreaceae	E	SSV	0.6	0.406
9	*kilenga*	*Kalanchoe miniata Hils. & Bojer ex Tul.*	Crassulaceae	E	GSV	0.45	0.294
10	*kitonda*	*Medinilla* sp.	Melastomataceae	E	MF	0.4	0.294
	Girls						
1	*voanaka*	*Physalis peruviana* L.	Solanaceae	I	GSV	0.55	0.414
2	*tsipoaka*	*Rorippa laurentii* Jonsell	Brassicaceae	E	HV	0.59	0.403
3	*voafotsy*	*Aphloia theiformis* (Vahl) Benn.	Apholiaceae	N	MF	0.45	0.396
4	*kilela*	*Passiflora subpeltata* Ortega	Passifloraceae	I	GSV	0.55	0.387
5	*trakavola*	*Bidens pilosa* L.	Compositae	N	GSV	0.5	0.364
6	*voaroy*	*Rubus rosifolius* Sm.	Rosaceae	I	SSV	0.5	0.349
7	*goavy*	*Psidium guajava* L.	Myrtaceae	I	SSV	0.41	0.318
8	*rotsy*	*Syzygium cumini* (L.) Skeels	Myrtaceae	I	SSV	0.36	0.293
9	*roimboza*	*Lantana camara* L.	Verbenaceae	I	GSV	0.41	0.274
10	*ana*	*Solanum* cf. *nigrum*	Solanaceae	I	GSV	0.32	0.214

	Boys						
1	*goavy*	*Psidium guajava* L.	Myrtaceae	I	SSV	0.5	0.371
2	*tsipoaka*	*Rorippa laurentii* Jonsell	Brassicaceae	E	HV	0.5	0.329
3	*voafotsy*	*Aphloia theiformis* (Vahl) Benn.	Apholiaceae	N	MF	0.39	0.308
4	*lamoty*	*Flacourtia indica* (Burm.f.) Merr.	Salicaceae	N	MF	0.33	0.295
5	*paiso*	*Prunus persica* (L.) Batsch	Rosaceae	I	GSV	0.33	0.29
6	*rotsy*	*Syzygium cumini* (L.) Skeels	Myrtaceae	I	SSV	0.33	0.278
7	*Kilela*	*Passiflora subpeltata* Ortega	Passifloraceae	I	GSV	0.39	0.268
8	*Voanaka*	*Physalis peruviana* L.	Solanaceae	I	GSV	0.39	0.252
9	*Roimboza*	*Lantana camara* L.	Verbenaceae	I	GSV	0.33	0.252
10	*Trakavola*	*Bidens pilosa* L.	Compositae	N	GSV	0.39	0.226

Wild edible plants characteristics

The subsamples of adults and children and, to some extent, women, and men, listed WEP with different life forms, parts consumed, ecological habitats, and biogeographical distributions (**A3.S3 Tab.,** **Fig.34**). Results from a MANOVA test suggest significant differences in the number of shrubs, trees, and climber's species cited by adults and children, with adults citing more WEP in these life forms than children (**A3.S3 Tab.,** **Fig.34i**, **5iii** and **5iv**). The subsample of women significantly cited more herbaceous WEPs than any other subsample (**A3.S3 Tab.,** **Fig.34ii**).

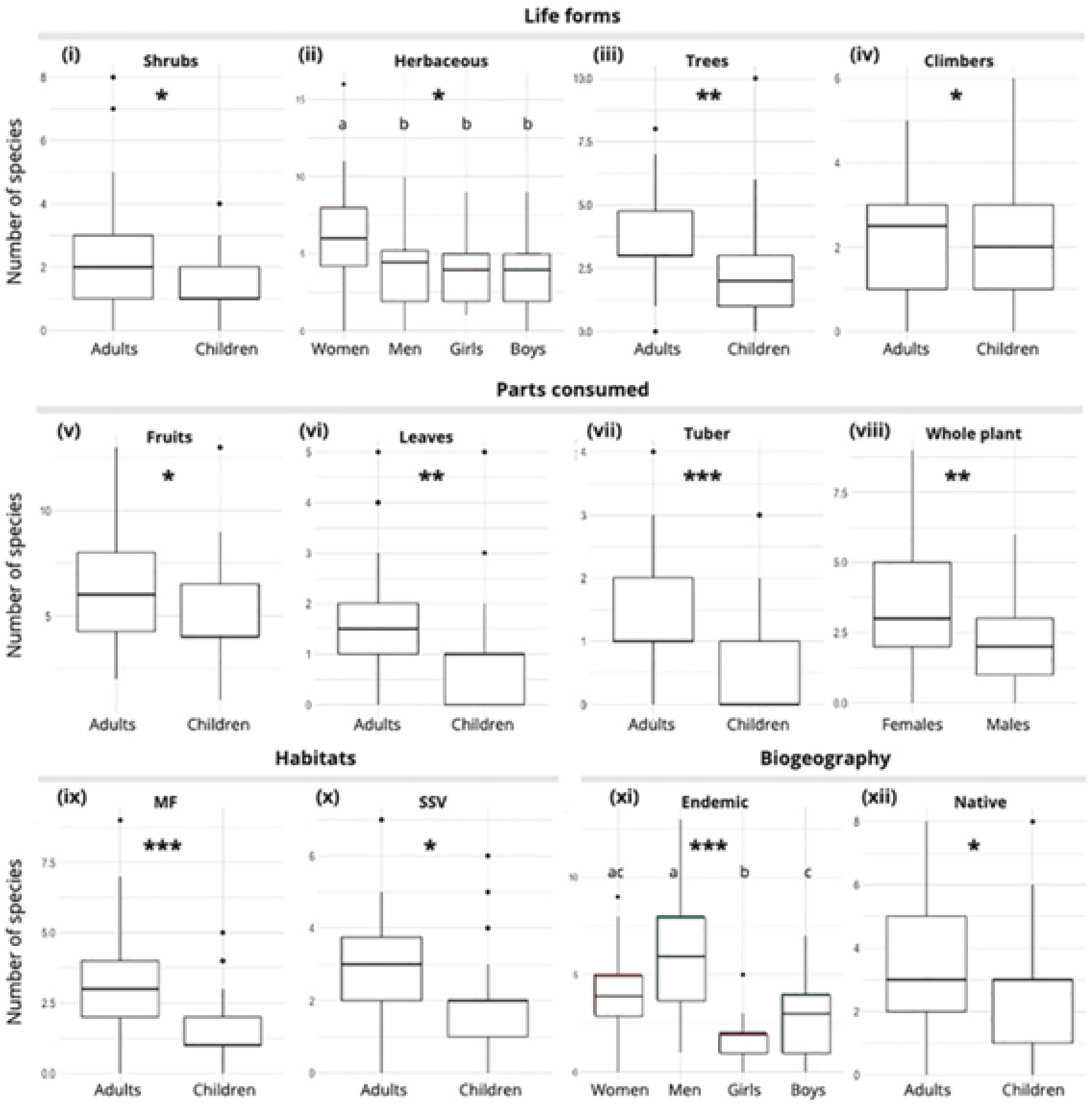

Figure.34 - Number of WEPs cited by categories and subsamples. "*" indicate significant relations based on MANOVA. Letters indicate a similar number of plant species cited based on Kruskal-Wallis's chi-squared (threshold at *p* < 0.01).

A similar analysis suggested that WEPs eaten for their fruits, leaves, or tubers were more cited by adults than by children (**Fig.34v**, **5vi** and **5vii**). WEPs eaten as whole were significantly more cited by women and girls than by men and boys (**Fig.34viii**).

Regarding ecological habitat, adults cited more WEPs species from mountain forest habitat (p-value < 0.001) and from shrubby secondary vegetation (p-value < 0.05) than children (**A3.*S3* Tab.**, **Fig.34ix** and **x**). We did not find a statistically significant difference between the number of WEP species from grassy secondary vegetation cited by adults and children, suggesting that the two subsamples listed about the same number of WEPs from this ecological habitat. We did not find any gender difference on the number of WEP cited for any habitats.

Regarding biogeographical distribution of WEP, we did not find differences across subsamples in the number of introduced WEP species listed. However, we found that adults cited more endemic and native WEP species than children (**A3.S3 Tab.**, **Fig.34xi** and **xii**). It is worth noting that men cited a significantly higher number of WEP endemic species than other informant's subgroups (**Fig.34xi**).

Finally, we found that the distribution of endemic and introduced species in the list of the ten most salient species cited by adult and children was significantly different from what would be expected if the distribution was random (Chi-square = 9.389, df = 3, *p*-value = 0.024). Indeed, according to Pearson's residuals value from a chi-square test (**Fig.35**), in their respective lists, adults cited more endemic species as salient than children, while children cited more introduced species as salient than adults.

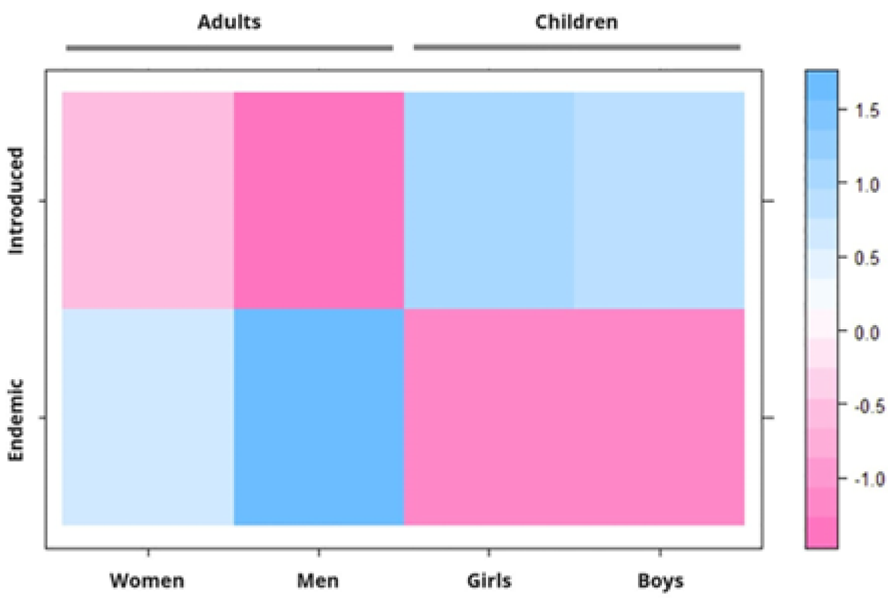

Figure.35 - Pearson's residuals from a chi-square test on biogeographical characteristics of WEPs cited by informants using subsample based on B'score rank.

4.4 Discussion

Before discussing our results, we want to acknowledge that we are aware that results presented might be biased. A main source of bias results from the use of free listing for data collection. The free listing method calls upon the memory thus some information might have been lost during interviews (De Sousa et al., 2016; Brewer 2002). In that sense, we acknowledge that the knowledge on WEP presented here might not be exhaustive, indeed our analysis shows that the number of species mentioned by the participants did not reach the estimated richness (**A3.S3 Tab.**). Despite this caveat, our converging results show an important intracultural variation in WEP's knowledge distribution.

Intracultural variation of knowledge

Wild edible plants knowledge (i.e., number of WEP listed, the species listed, and their botanical characteristics) is differentially distributed among the Betsileo population. While sharing knowledge on a common set of WEP species, Betsileo women, men, girls, and boys from Namoly valley have differentiated knowledge for most WEP species. Indeed, the small proportion of WEP known by all subgroups (i.e., 25% of all species listed) suggests that the WEP knowledge system is heterogeneously distributed.

Previous work has shown that sharing a large "core set" of knowledge in an extreme situation of plant scarcity and in an unpredictable environment can enhance the group's resilience and adaptation strategies (Blanco & Carrière 2016; Caneva et al., 2017). However, having differentiated knowledge within the same group might be also beneficial, as it enlarges the set of useful species to rely on (Torres-Alivez et al., 2019). Indeed, in the same way a high plant diversity is essential to maintain nature's contributions to people (Isbell et al., 2011). Relying on a large and diverse set of useful plant species allows overlap in the knowledge system regarding species with similar functions and supporting similar services (Nacimeinto et al., 2015). Because it enhances utilitarian redundancy, local knowledge on a diversity of plants providing similar services can contribute to enforce the adaptive capacity and resilience of the knowledge system (Díaz-Reviriego et al., 2016b; Nacimeinto et al., 2015).

According to our results, knowledge on WEP differs widely across life stages and gender, with children displaying an extended WEP knowledge of their own. In fact, our results support the argument that the different roles they play in society make females, males, adults, and children relate differently with nature, including individual and social daily experience that shape their knowledge (De Albuquerque et al 2011).

Life stage and children's knowledge

Betsileo children participating in this study were able to list a large number of WEP (84 species, 69% of which are in common with adults). This is one of the largest numbers of WEP listed found in research on the topic. In fact, among the ten studies we found reporting the number of WEP known by children, only one reported a higher number of WEP species known by children: a study among mestizo children in the Peruvian Amazon (Cruz-Garcia et al., 2018).

Our research also shows that children know different WEP species than adults, rank them in a different way, and that WEP species known by children and adults have different characteristics. These differences between children and adults might bring some new insights into our understanding of plant biodiversity. For instance, the fact that children ranked WEP differently than adults raises not previously considered conservation issues. For example, Rorippa laurentii Jonsell, a species particularly salient for children, is a rare species known only in the study area (Catalogue of the Plants of Madagascar 2023) and not yet evaluated by the IUCN red list, nor recorded as a useful plant in the world checklist of useful plant species (Diazgranados et al., 2020). Given the importance of this species for children, it might work to evaluate its ecological status to manage it accordingly.

Differences between children and adults WEP knowledge highlighted by our results might be discussed through the lenses of socio-cultural, ecological, and cultural transmission contexts. In particular, we advance three arguments.

First, adults and children have differentiated knowledge because the social organization in which they live frames their mobility and their daily activities and access to diverse habitats and plant species. In the study site, Betsileo children's mobility is limited to the surrounding settlements. Around the age of 12, Betsileo girls and boys become more independent and go to farther areas with different habitats, like forests where they harvest timber, fuel, or other products. Increasing mobility provides Betsileo children the opportunity to explore new habitats and gather different WEP. Unlike children, adults', and specially men's, daily activities (shepherding, hunting, fuel and other NTFP harvest) put them in contact with remote, less disturbed areas, such as ericoid thickets, where high levels of biodiversity and a high rate of endemism remains (Goodman & Benstead 2005). Interestingly, we noticed that most WEP growing in habitats close to the settlements were equally known by both adults and children. These results highlight that specific sets of knowledge are acquired very early in life and then maintained through it, while others are learned or transmitted during adulthood due to the apparition of new specific activities and increasing mobility (Carrière 2010).

Second, environmental changes in plant distribution leading to intergenerational knowledge differences might also explain differences between adults and children. Indeed, our results show that adults cited endemic species more frequently and earlier in their lists, whereas the pattern was opposite for children, among whom introduced species were more salient. According to the ecological apparency hypothesis, there is a positive correlation between the cultural salience of a species and its distribution and abundance (Soldati et al., 2016). In the study area, endemic and introduced species were not equally distributed between ecological habitats but followed an altitudinal gradient with more introduced species in the bottom of the valley, where people live (Fig.31). Indeed, most introduced species have synanthropic behavior and growth abundantly around human settlements (Frumin et al., 2015) (Fig.31), for which children, mostly living and playing around houses, have daily interactions with introduced species. A complementary explanation to the finding that introduced species were more salient for children than for adults relate to differences in their baselines. A high number of plant species have been introduced to Madagascar during the last two decades (Kull et al., 2012), for which children might now be exposed to introduced species that adults and elders did not know during childhood for the same ecological habitat. The fact that each generation perceives and interact differently with biodiversity due to environmental changes occurring in the meantime has been used to explain lack of perception of change in younger generations under the idea that there is a "shifting baseline syndrome" (Hanazaki et al., 2013; Fernández-Llamazares et al., 2015). Here, given the rapid land cover change in the highlands of Madagascar (Kull 2013; Brown et al., 2015), the hypothesis of a "shifting baseline syndrome" can be used to explain differences in WEP knowledge between adults and children, where children have differentiated knowledge of new species.

Third, the fact that Betsileo children hold a WEP knowledge that is distinct from that of adults might be also explained by horizontal mechanisms of knowledge transmission and acquisition. As in other small-scale societies (Lew-Levy et al., 2020), Betsileo children learn alongside their parents: however, they spend most of their time with each other. During this time without adults, playing or engaging in subsistence activities, children learn from each other as it has also been observed in other communities (Gallois et al., 2017; Crittenden & Zes 2015; Tuker & Young 2015; Bird-David 2005; Crittenden 2012). This behavior might support the development of specific language elements and WEP knowledge (Gallois et al., 2017). A growing corpus of studies leads us to consider horizontal transmission as a predominant way for children to receive knowledge in small-scale societies (Gallois & Reyes-García 2018). Other aspects related to the ontogenetic of cultural learning might explain such variation between adults and children (Legare & Harris 2016). Factors such as the motor/physical and sensorial development during childhood, taking part of an embodied learning (Marchand 2010), should be taken into consideration in further studies, especially the ones focusing on edible plants as organoleptic aspects shape food choices, and thus practices and knowledge related to food (De Garine 1996; Gallois et al., 2020).

Gendered differences in WEP knowledge

Our results show that women and men listed about the same number of WEP, although the specific WEP in their lists were different. This finding is not new and have been shown across different societies and knowledge domains including medicinal plants (Torres-Avilez et al., 2016; Lyon & Hardesty 2012), hunting (Reyes-García et al., 2020), wild edibles (Guimbo et al., 2011), and home garden biodiversity (Díaz-Reviriego et al., 2016a). In line with these findings, our results show that women and men listed WEP with different life forms and from which different parts are consumed. For example, girls as women listed more plants eaten as a whole than males; and women listed more herbaceous plants (i.e., leafy vegetables) than men. Most of these plants cited by women and girls, characterized by similar life forms (herbaceous) and parts consumed (whole aerial part), locally known as *traka*, are central components in many dishes mainly prepared by females. These plants (*traka*) are usually boiled to be eaten with rice as condiment while the broth (ro) is drunk and appreciated for its taste (Boiteau et al., 1990). Early in life, girls learn from their mothers how to collect and prepare them, which may explain the important knowledge overlap between girls and women. According to our result, this Betsileo female knowledge seems to be structured around a specific plant life form or type (*traka*)—defined by their accessibility, abundance, morphology, and preparation mode (boiled) regardless of the species themselves. The finding is consistent with the idea proposed by Bahuchet (2017), that the preparation mode provides a rigid framework for ingredients selection, where ingredients can change but will always be chosen and adapted to the preparation mode.

As for life stages, gendered mobility associated with social organization and daily activities also shapes WEP knowledge. For example, the fact that females in our sample listed more herbaceous plants than men could be explained by the specificity of girl and women mobility due to strong gendered division of labor. Indeed, most herbaceous plants cited by females grow in grassy secondary vegetation, such as home gardens and house surroundings, where most of the female's activities are performed. Differently, when men take the zebus to remote highland pastures, they pass through many undisturbed ecological habitats (see Fig.31) and thus are exposed to a different plant species, which might explain the high number of endemic plant species known by men in comparison to women.

Finally, our results are innovative in showing that the gendered patterns in knowledge distribution also vary according to the intersectionality of gender and life stage: differences among WEP knowledge are larger between women and men than between girls and boys. Few studies have focused on the knowledge differences between girls and boys, but the few existing studies on the topic show that knowledge about WEP is similar among girls and boys (Gallois et al., 2017; Crittenden 2009). Girls and boys growing together under an alloparental scheme and in the same domestic environment share a common set of knowledge (Gallois et al., 2017; Crittenden 2009). The gradual gendered differentiation in knowledge is due to the progressive incorporation of normative rules of the society as children age (Fehr et al., 2008) and to the progressive gendered division in daily activities, from socialization and to division of labor (Lew-Levy et al., 2020).

4.5 Conclusion

Our results show that wild edible plant knowledge is differentially distributed among the Betsileo population in the study site. We provide solid evidence that life stage and gender are determinants in this intracultural variability and generate specific sets of knowledge across different groups. Certain sets of WEP knowledge are acquired during adulthood while other specific sets of knowledge are acquired very early, making children reliable knowledge holders.

In addition, over the lifetime, gender plays an important part in the specialization of WEP knowledge. Our study stresses the need to explore more the complexities of intersectionality in knowledge acquisition to catch intracultural variations of knowledge in small-scale societies as exhaustively as possible by emphasizing children. It also suggests that embedding children into further studies on LEK might contribute to our understanding of biodiversity and raise conservation issues. Given our findings and the growing literature in the emerging field of children ethnoecology, we call for further studies to consider children when exploring local ecological knowledge, and for doing so, to use tools and methodologies adapted to children.

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Chapter V

As proficient as adults: Distribution of children's knowledge of wild edible plants in the arid Mahafaly region, Madagascar.

Abstract

In drylands, where resources are scarce, wild edible plant (WEP) knowledge is crucial to overcome food scarcity. Understanding the distribution pattern of local ecological knowledge (LEK) about WEP and identifying knowledge holders are key steps to assessing the resilience and vulnerability of knowledge systems. However, little is known about how WEP knowledge is distributed across life stages and gender of people living in arid regions. Here, we study the distribution of WEP knowledge within a small-scale society from southwestern Madagascar, a region known for its dry climate and related food crises. We worked with Tanalana male and female children and adults using semi-structured interviews and free listings. Tanalana people display a sophisticated LEK adapted to the extreme environment in which they live, with a distinct distribution pattern regarding theoretical and practical knowledge across life stages and gender. While women and men cited similar WEP, children and adults cited different sets of WEP, suggesting they hold differentiated bodies of theoretical knowledge, however our results suggest similarity in practical knowledge across life-stage and gender. We argue that resource limitation and food scarcity might be so pervasive in the area that extensive sharing of knowledge on WEP could be an adaptation to the extremely dry environment.

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5.1 Introduction

Drylands are challenging environments characterized by unpredictability and scarcity of resources that directly affect the food system and water access of local people (Coughlan de Perez et al., 2019). Sustaining and relying on agro-pastoral systems in a highly stochastic environment, such as drylands, implies constantly adjusting herding and crops irrigation strategies to maintain food security (Randolph et al., 2007; Reynolds et al., 2007). Among the diversity of strategies developed to cope with variability in food availability, such as yearly lean season, human societies worldwide have assembled sophisticated local ecological knowledge (LEK) about wild edible plants (WEPs) (Brand & Cherikoff, 1985, Cruz García, 2006; Golden et al., 2011). Knowledge about WEP is particularly valuable for small-scale societies that rely heavily on nature for their livelihoods and are therefore more vulnerable to abrupt environmental changes (Diaz et al., 2019). Indeed, WEP and their related knowledge constitute a safety net during food crises by providing access to alternative sources of carbohydrates and micronutrients that contribute to enhancing daily diet diversification (Golden et al., 2011) and hydration (Brand & Cherikoff, 1985). For instance, among the Baka, frequently consumed WEP, such as *Gnetum africanum* Welw. and yams (*Dioscorea* L.), provide an important source of protein and increase dietary diversity, especially in the lean season (Dounias, 1996; Gallois et al., 2020). Although there is little literature on the subject, to our knowledge, many plants with water storage, such as the bamboo and liana in the Amazon or kurrajong and yams roots in Australia, are known for their thirst-quenching properties (Brand & Cherikoff, 1985). This knowledge results from a longstanding biocultural relationship, where humans have learned to take advantage of the functional plant diversity in the environment for their needs (Cámara-Leret et al., 2017). While plant biodiversity in tropical rainforests, and corresponding local knowledge about them, has been extensively studied, biodiversity in tropical dry forests has received less attention (Quesada et al., 2009). Thus, our understanding of the knowledge systems of these ecological environments is still limited. Considering the multiple threats to biodiversity and cultural heritage increasing the exposure to food risk of local population (Jackson et al., 2020), there is a need to understand LEK about WEP of people from dryland to assess their knowledge system resilience and vulnerability to prevent risk.

An important step to assess people's exposure to food insecurity and water scarcity is to understand how WEP knowledge is distributed in society and to identify individuals or groups of individuals who hold this knowledge. Knowledge distribution has been discussed as a social-risk management strategy, potentially contributing to resilience in local systems: The more distributed the knowledge within a population, the more likely this population would be able to deal with disturbance (Blanco & Carrière, 2016). Nevertheless, as bodies of knowledge differ across and within social groups, gender, or age (Diaz-Reviriego et al., 2016; Porcher et al., 2022), it is also important to explore differences in the knowledge held by different sub-groups of the population, as knowledge diversity can contribute to the resilience of the knowledge system (Díaz-Reviriego et al., 2016). For example, Gallois et al., (2017) concluded that children from different small-scale societies hold specific bodies of knowledge, not necessarily shared by adults, and Crittenden (2015) stated that children's knowledge about WEP contribute to the food system by actively engaging foraging activities. However, little is known about how WEP knowledge is distributed across life stages and gender of people living in arid regions (de Oliveira Campos et al., 2015), particularly what is the knowledge of children in comparison to the knowledge of adults.

Recent work shows that children are a repository of unique knowledge (Gallois et al., 2017). Children are also important agencies in knowledge transfer, between themselves, with adults, and across generations (Gallois et al., 2018; Cruz García, 2006). Childhood is a key period, where most of the cultural learning occurs, including knowledge about wild edible plants (Schniter et al., 2021). However, while many studies have looked at cultural learning from an evolutionary point of view, mainly within hunter-gatherer societies, hypothesizing that human childhood is a long period of training to learn difficult foraging tasks (Kaplan et al., 2000; Lew-levy et al.,2021), hardly any studies had analyzed cultural learning as a potential adaptive response to food scarcity.

In this study, we assess (1) the diversity of WEP knowledge of people living in tropical dry forests and (2) the distribution pattern of WEP knowledge across life stages and gender, with particular attention to children's knowledge and skills. We worked in southwest Madagascar with Tanalana people - a subgroup of Mahafaly people. The region is particularly affected by food insecurity, with above 40%

prevalence of insufficient food consumption and 41.6% of children affected by chronic malnutrition (WFP, 2020). Despite the unique and fragile biodiversity present in the area (Randriamalala et al., 2019), local WEP remain understudied, except for a study focusing on the consumption of six different species of edible yams which found that yam collection was directly linked with low income, demonstrating the importance of this food resource (Andriamparany et al., 2014).

5.2 Method

Study site

We conducted fieldwork in a Tanalana village located in the district of the Atsimo-Andrefana, at about 60 km of Toliara, in the northern Mahafaly region of southwest Madagascar (Fig.36A). The Mahafaly region is one of the most arid areas of Madagascar, with average 300 mm of precipitation per year and six to seven dry months (from April to October). The landscape is mainly constituted from the east to the west by a limestone plateau (up to 300 m high) and a coastal plain, none of them retaining water on the surface, and both covered by dry and spiny vegetation called the xerophytic thicket. The xerophytic thicket, listed among the most important ecological regions in the world (Elmqvist et al., 2007), counts numerous unique animal and plant species with one of the highest endemism levels of the island. This dry vegetation is distinct from usual tropical dry forests owing to its particularly low canopy and hyper-specialised plant species (Randriamalala et al., 2019). Most plant species from the xerophytic thicket display a diversity of life forms adapted to dry conditions, where organisms have physically evolved to reduce water loss, store moisture efficiently, and prevent herbivory (Rosell, 2022). Water storage organs adapted to low precipitation are also potential water reservoirs for humans and cattle. Plant species distribution in the xerophytic thicket is mainly influenced by soil composition, particularly two main poor soil types: the lixisol and the calcisol (Randriamalala et al., 2019). All along the coast from west to east, these two main soil types induce distinct vegetation and species composition (Fig.36A).

Despite its constraining climatic conditions, different ethnic groups (e.g., Vezo, Mikea, Mahafaly) have settled and adapted to the region deploying a diversity of livelihood activities (e.g., fishing, foraging, agro-pastoralism). Like most other

Mahafaly, Tanalana people (speaking the Antanalana dialect) rely on a mixed economy derived from agriculture and pastoralism (Noromiarilanto et al., 2016; Hänke & Barkmann, 2017), complemented by hunting and gathering (Andriamparany et al., 2014). The main diet of the Tanalana is based on the consumption of cassava, as a type of staple food, pastoral products such as goat meat and milk, and fish which they buy or exchange with the Vezo. Apart from watermelons and squashes, very few fruits and vegetables are grown. The supply of vitamins and micronutrients from agriculture is therefore limited and justifies the research and consumption of WEP, especially during the lean season (from November to April), when hunting and the collection of WEP and honey are crucial to cope with agricultural food scarcity (**Fig.36B**) and the lack of water (Cirad, 2015; Noromiarilanto et al., 2016). Furthermore, the availability of fresh and drinkable water is deficient and follows a seasonal pattern (**Fig.36B**) (Cirad, 2015). From December to late February, people collect water from rain and temporary ponds and puddles. During this period, they also store water in familial baobab water tanks that will be used during the hottest months (June, July, and August). From March to May, people rely on water stored in plants for their needs. Several plants (WEP and crops) are locally known and consumed for the high-water content contained in their tissues and organs as fluids, such as watermelon, baobab spongy flesh or water tuber from yams (Ratsihoarana, 2019). These aqueous sources provided by plants are also used for cooking, especially to boil rice. Prickly pear rackets, usually used for cattle water needs, are also used during severe droughts. During October and November, drinkable water is very restricted, and the risk of dehydration is high. In addition, people use daily seawater or water unsafe to drink for uses such as cooking and showering.

Hunting, trade, pastoralism, and the need to collect WEP and water drive Tanalana mobility, which differs across life stages and gender. During adolescence, women move to their partners' village (Neudert et al., 2015). Men's mobility is more temporal and determined by seasonal grazing patterns across the xerophytic thicket landscapes (Feldt & Schlecht, 2016). Men's mobility is also motivated by exchange of goods, hunting, water collection, and plant gathering for food and medicinal purposes. Several times a year, and mainly during the lean season, adult men (sometimes accompanied by children) travel for several weeks to look for WEP and water, while women and girls stay and look after the crops and the schooled children. Outside the transhumance period, boys look after the livestock (zebu and goat) around the village. In general, Tanalana children explore the surroundings of the villages during collective games or in search of snacks (WEP) and small animals for entertainment (cricket).

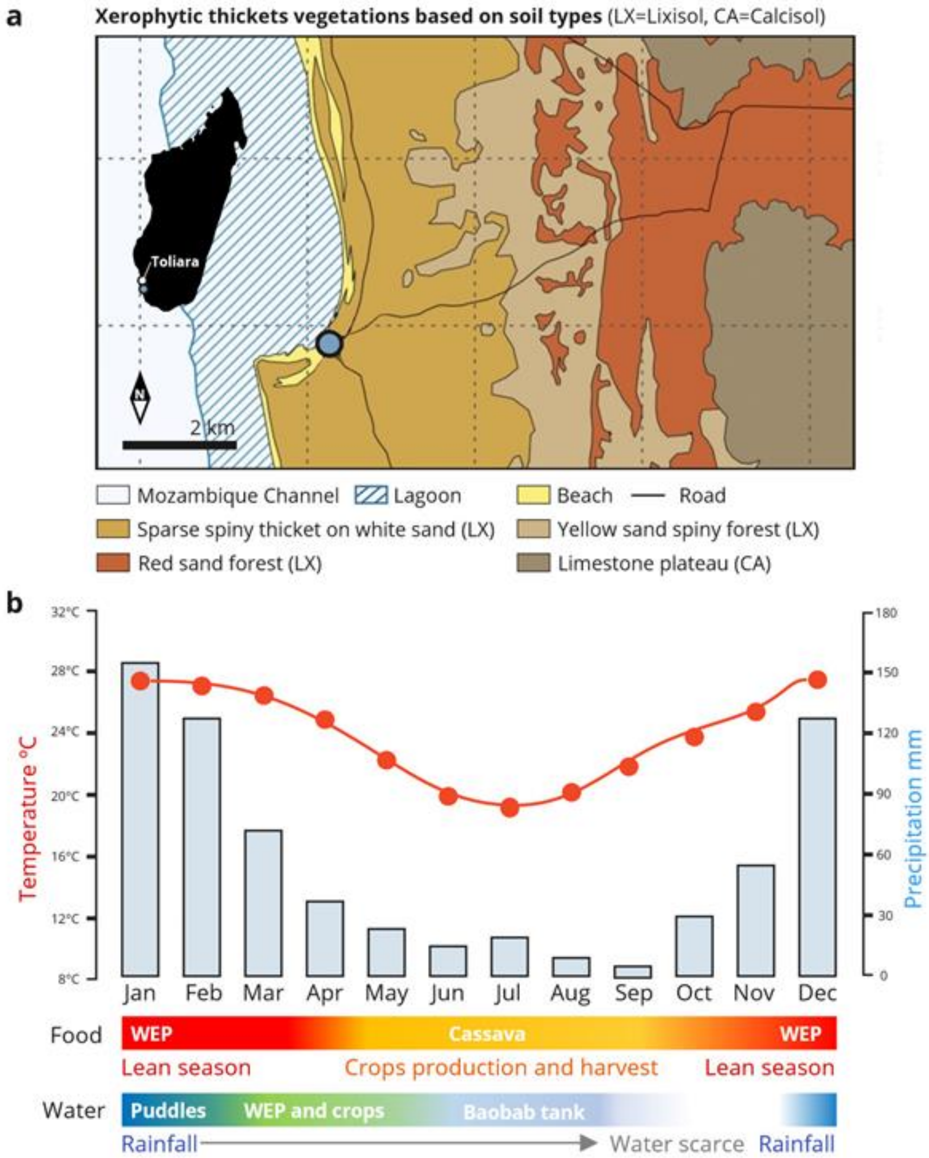

Figure.36 - Study site: Ecosystem distribution, weather, and food and water availability. (a) Map of the study site displaying the different xerophytic vegetation according to soil types. The blue dot indicates the position of the village in which we conducted the research. **(b)** Monthly mean precipitation (mm) and temperature (ºC) of Atsimo-Andrefana region for 1991–2020 (weather data from Climate Change Knowledge Portal, https://climateknowledgeportal.worldbank.org/) and corresponding food and water procurement and origin (Cirad, 2015).

Sample

Fieldwork was conducted in April 2019 in a village in the Atsimo-Andrefana region. We interviewed 35 Tanalana informants. Participant selection was based on a convenient sampling method (Etikan et al., 2016). We are aware of the limitations of a nonprobability sampling, i.e., the non-representativity of the sampling and the potential bias. However, we aimed to limit these biases by selecting informants from different households and parts of the village, and to obtain a balanced and intersectional sample combining life stage (adult vs. child) and gender (male vs. female). Accordingly, our sample includes eight women, 10 men, nine girls, and eight boys. We consider children as people below 15 years old, which corresponds to the average age of the first weddings and the creation of new households by the Tanalana. Wedding implies a great mobility for girls, who set up their new home in their husband's village and a change in the activities of both girls and boys, who now have new responsibilities linked to their new marital status, e.g., the obtention of herder/livestock and first child, which might influence their ethnobotanical knowledge. Our sample of children includes girls and boys from seven to 15 years old. The interviews were carried out by a research team of one local researcher, D.C., who had previous experience working in the region, and two foreign researchers, including two women (D.C & X.L) and one man (V.P). The interviews were conducted in the Malagasy Mahafaly-Antanalana language, with the help of D.C. The notes were then translated from Malagasy into English for analysis by D.C and V.P. Before starting data collection, we obtained the agreement from the local authorities (Fokontany chefs) and oral free prior and informed consent (FPIC) from each informant (see detail in ethical approval). No children or adults declined to participate in the study. The Code of Ethics of the International Society of Ethnobiology was followed, giving participants the right to withdraw from the study at any time.

Data collection

To document the diversity of locally known WEP and how they are collected and prepared, we conducted interviews following a two-step process. First, we used free listings to document the species known by each informant (Paniagua-Zambrana et al., 2018). Specifically, we asked informants to list the local names of all the WEP they knew. In a second time we conducted a semi-structured interview in which we asked participants to name the plant parts consumed, and to explain whether they provided food, water, or both. Then, we asked each informant to tell us the three WEP they considered the most important out of the species reported in their free listing and to explain why they considered them of particular importance. Finally, we ended our semi-structured interviews by asking the informants to describe how they collected and prepared the three WEP species considered most important **(A.4 Supplementary Method S1**). To facilitate the work with children and to build a relationship of trust with them, before starting data collection we spend time with them during a walk in the wood session. During the walk, we collected WEP together with the children. To avoid that child identified the free listing and semi-structured interviews as schoolwork, free listing and interviews with children were conducted outside school, mostly at home. If parents wanted to assist in the interview, they were allowed, but we asked them not to influence children's responses.

For all WEP reported, scientific names were obtained after identification in the field by the first author and D.C with the help of a local botanist from the University of Toliara. Taxonomic verification was made using the last update of World Flora Online (2022).

Data analysis

To document WEP knowledge distribution across life stages and gender, we used the information collected through free listing and semi-structured interviews. To explore WEPs knowledge variation among people in the study site, we build different subsamples based on life stage (i.e., adults vs. children) and gender (i.e., female vs. male), and the combination of both (i.e., women, men, girls, and boys).

Number and WEP's species known

We counted the number of WEP species reported by each informant during free listing. To check for variability in knowledge distribution across life stage and gender, we used a Poisson generalized linear model (GLM) with the log link function to make the model fit in a linear form.

We also plotted the accumulation curves of the number of known species against the number of informants in each sub-sample and calculated the sample completeness by comparing the estimated richness with the observed richness. We estimated the theoretical number of WEP known – i.e., the estimated richness– using the bootstrap estimator, i.e., the asymptote of the accumulation curve of species cited (Smith & van Belle, 1984). This allowed us to compare the maximum knowledge threshold in WEP species for an optimal sample of children and adults.

We also explored differences in the WEPs composition – the different WEP species reported by informants – between life stages and gender. First, we built a dissimilarity matrix from the informants vs. species matrix, using the Raup-Crick index. Then, we analyzed variance using distance matrices testing for differences between life stages and gender using a permutational multivariate analysis of variance (McArdle & Anderson, 2001). Analysis was processed using the R vegan package (Oksanen et al., 2022).

Wild edible plants characteristics

Because the uses of WEP might relate to plant morphology, for each species recorded during the free listing, we obtained information of three characteristics: life form, water-provider type, and nutritional contribution. To classify plants according to 'life forms', we considered "trees" as plants erected from the ground with a single trunk, "shrubs" as plants with multiple woody stems, "climbers" as support-dependent plants, "non-woody shrubs" as arborescent monocots (i.e., palms, tree aloes), and "herbaceous" as short-lived plant species without a trunk, usually non-woody (Phillipson et al., 2006). We used information provided by respondents and based on the parts consumed for water to classify water-providing species into four categories: fruits, leaves, tuber, and water tuber. We distinguished between "tubers", which are species usually consumed for carbohydrates, but which also provide aqueous sources, and "water tubers", which are species mainly consumed for their massive water supply. Finally, the nutritional contribution of each WEP was determined using the FAO food groups (Kennedy et al., 2011) based on the part consumed. Reported WEP species were classified into five categories: VA-rich fruits (VA = Vitamin A); white roots and tubers; VA-rich vegetables; pulses and nuts; and spices and condiments.

In our analysis, for each life form and part consumed providing food and water, we counted the number of species and displayed the proportions reported by children, adults, and both. We used the Chi-squared test to compare the distribution of plants in each subcategory, known by children, adults, and both.

Criteria for important WEP species

To understand why WEP are important, we analyzed the terms used by informants to answer the question: "Why is this WEP important?" We classified the terms used during the interviews to define a WEP as important into five categories: organoleptic, nutritional, food accessibility, economic, and food security. We then calculated the frequency of use of the different categories for our four subsamples. To assess the differences in the distribution of terms used between life stages and gender, we used a Chi-square test.

Comparing collection and preparation practices

We used the information on food collection and preparation methods to assess the plant part consumed and the processing methods, tools and materials and products or condiments used to prepare them. We categorized the information using the Economic Botany Data Collection Standard (Cook, 1995). This helped us to create a matrix that linked each participant to the WEP species, and their associated preparation method reported. Then, we built bipartite graphs to display the knowledge networks of children and adults.

To test whether there were differences in collection and preparation methods across life stages and gender, we built two indices: 1) the collection skills (CS) and 2) the preparation skills (PS), that captured informant's skills based on the practices they reported and their level of complexity. For a given practice (i), we established the level of complexity based on three main elements: the number of tools (NT_i), the number of steps (NS_i), and the number of condiments (NC_i) used in the preparation. We calculated the respective level of complexity of each practice by summing the above variables, setting the baseline at one to avoid a zero score – e.g., when WEP is eaten raw. Then, we calculated informants' *CS* and *PS* scores by averaging the complexity level of practices reported per informant. We compared the mean *CS* and *PS* score across life stages and gender using a normal GLM.

5.3 Results

Informants listed 59 WEP species once synonyms were solved (see **A4.S1 Tab.**). Two additional species ('tabozebozety' and 'tavenala') were listed but not identified, for which we could not determine their characteristics and excluded them from the analysis. The species reported belong to 26 botanical families and 40 genera with more than 50% of endemism at the species level (**A4.S1 Fig**). The most represented family was Malvaceae, with seven species distributed in two genera *Adansonia* L. and *Grewia* L. The genera *Grewia* L. (including five species) and *Opuntia* Mill (including four species) were the most cited, reported 49 and 41 times respectively. Nine WEP species were reported by all subsamples (i.e., women, men, girls, and boys) and by almost all informants. The most represented taxa were *Ziziphus spina-christi* (L.) Willd. ('*tsinefo*') reported by all informants (n = 35) and *Salvadora angustifolia* Turill ('*sasavy*') cited by 80% of people interviewed. Six species were cited by 50% to 70% of the sample: *Sclerocarya birrea* (A.Rich.) Hochst. ('*sakoa*'), *Terminalia ulexoides* H. Perrier ('*fatra*'), *Boscia angustifolia* A.Rich. ('*lalangy*'), *Flacourtia indica* (Burm. F.) Merr. ('*lamoty*'), *Grewia leucophylla* Capuron. ('*sely*'), *Dioscorea bemandry* Jum. & H.Perrier ('*baboky*') and *Dioscorea alatipes* Burk. & H.Perr. The remaining 51 species were cited less than ten times (i.e., by less than 30% of the informants).

Number and WEP species known

Children and adults listed a similar number of WEP species. Adults cited 49 species while children cited 45 species (**Fig.37a** and **b**); the GLM showing that there is no statistically significant relation between informants' life stages and the number of species cited (estimate = -0.058, Std. error = 0.153, z value = -0.381, *p*-value = 0.703). The number of WEP species cited by children and adults was high in relation to the estimated total sampling completeness (respectively 77.5% and 81.2%) and tended to a similar estimated richness (58.0 species for children and 60.3 species for adults, Fig.37b, **A4.S2 Tab**). Results for Chao2, bootstrap, first-order and second-order Jackknife estimators are presented in Supplementary **A4.*S*2 Tab.**

Children and adults listed 33 known WEP species in common. But children listed 12 species which were not reported by adults and adults listed 16 species which were not reported by children (**A4.S1 Tab**). In other words, although children and adults listed the same number of WEP, they did not list the same species (F = 19.63, R2 = 0.33, $p < 0.05$), suggesting that children and adults know a distinct body of species.

Regarding gender, male cited more WEP species than females (53 vs. 37; Fig.2a). Results from the GLM indicate a strong relation between gender and the number of species cited (estimate = 0.334, Std. error = 0.099, z value = 23.358, *p*-value < 0.001). The number of WEP species cited by females and males in relation to the estimated total sampling completeness was similar (respectively 79.17% and 77.48%), however they tended to a distinct estimated richness (46.73 species for females and 68.40 species for males, Fig.37c, **A4.S2 Tab**). Females listed eight species not reported by males and males listed 24 species not reported by females, while 29 species were listed by both females and males. Despite the difference in numbers, both genders reported similar species (F = 6.77, R2 = 0.11, $p = 0.183$), suggesting that females and males have more known species in common than known species specific to their gender.

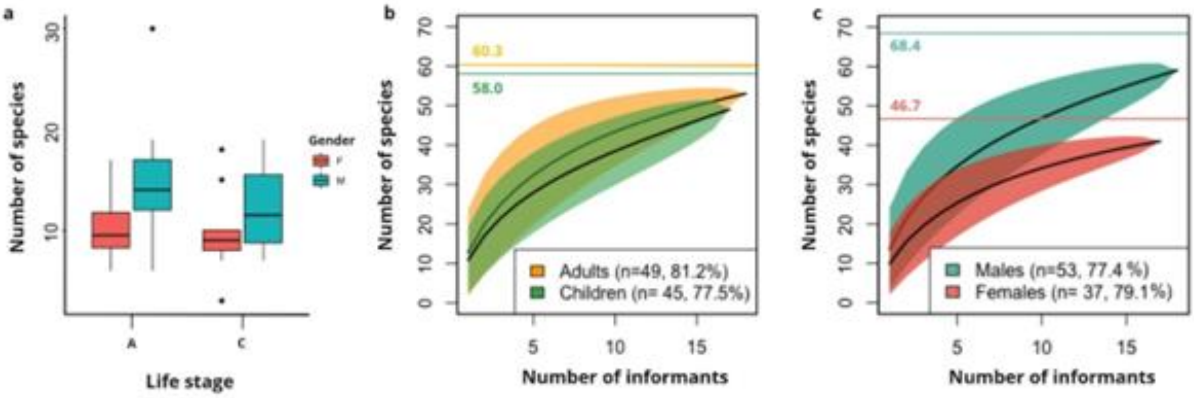

Figure.37 - Number of WEP species cited by informants and data saturation. (a) Number of WEP species cited by A=Adults, C=Children, F=Female (red box) and M=Male (blue box). The black dots represent the outliers. **(b & c)** Accumulation curves and sampling completeness for adults (yellow), children (green), male (blue) and female (red). The yellow, green, blue, and red numbers indicate the respective richness expected for adults and children, calculated with the bootstrap estimator. n = observed richness. The percentage indicates the sampling completeness.

Wild edible plants characteristics

Most WEP species reported were trees (22) and shrubs (18), followed by climbers (9), herbs (6) and non-woody shrubs (4) (**Fig.38b** & **c**). Among WEPs, some are not only edible but also "drinkable", as they are locally known for providing water in quantity (**Fig.38b** & **c**) and used in periods of drought. According to our informants, most of these species receive special care, including non-destructive collection practices to allow for the annual harvesting of the consumed parts and drinking water resources extracted from these plants. Amongst the 59 species listed, 23 were reported as hydrating or used for thirst-quenching. More than half of these species provide water through their tubers (9) and fruits (8). Four species are consumed for water contained in their leaves and two species are known to provide large quantities of water through their tubers (water tubers). Regarding food groups, 34 WEP reported are classified as having fruits rich in vitamin A (VA-rich fruits); eight WEP fall into the category of white roots and tubers; six species are VA-rich vegetables and pulses and nuts. Only one WEP falls in the category of spices and condiments (**Fig.38b** & **c**). We found no significant differences between life stages or gender in the listing of species belonging to different life forms, water-provider type, and nutritional composition. The distribution of species listed in these categories was not significantly different from random expectations (see **A4.S3 Tab**), meaning that children and adults cited approximately the same number of WEPs in each subcategory of WEP characteristics. Results are similar when comparing the lists of females and males in each subcategory of WEP characteristics.

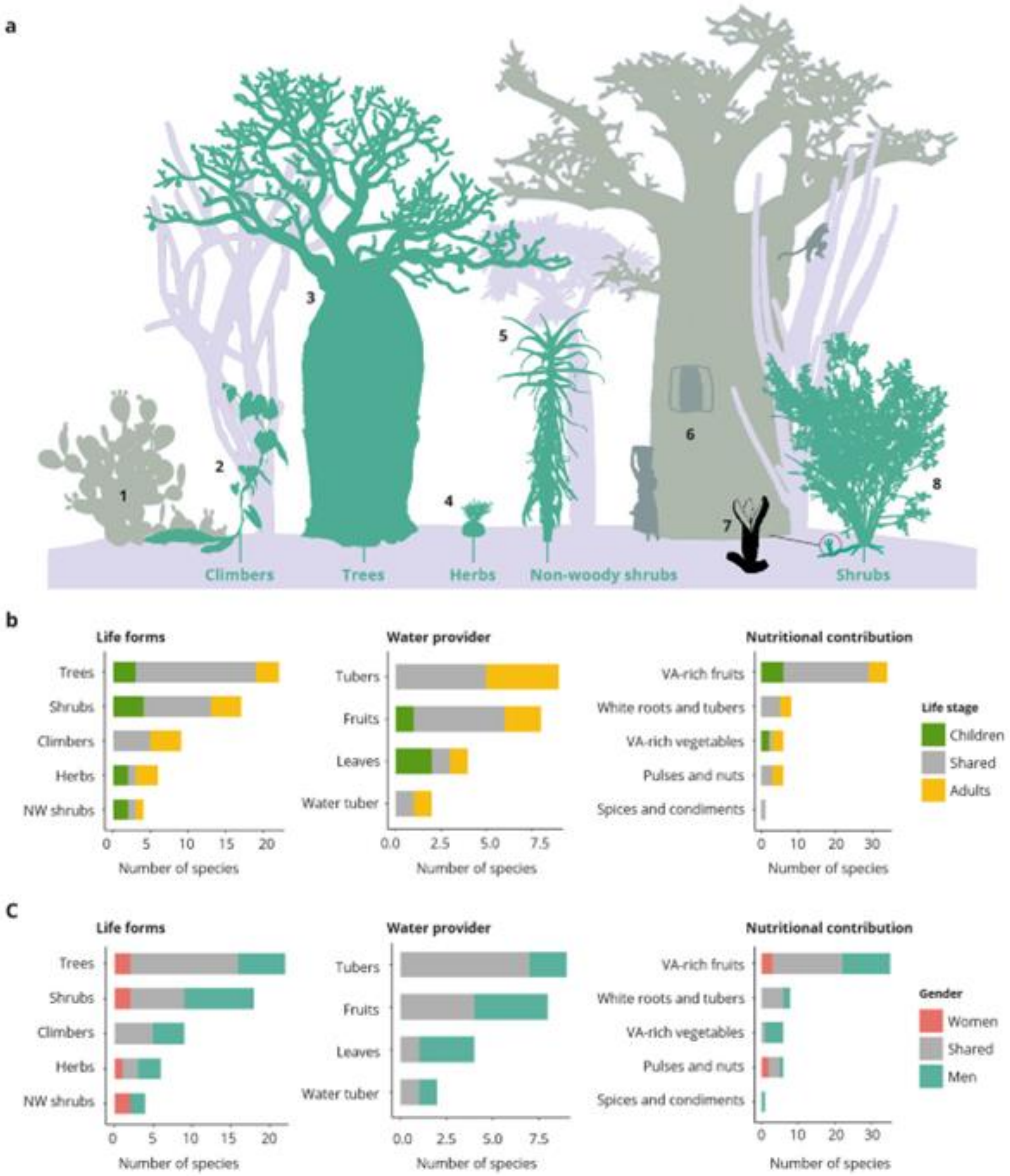

Figure.38 - Plant life forms and resources in the xerophytic thicket. (a) Xerophytic thicket plant life-forms diversity (in green) on the lixisol, (1) *Opuntia stricta* 'raketa', (2) *Dioscorea bemandry* 'baboky' water tuber, (3) *Adansonia fony var. rubrostipa* 'fony', (4) *Ipomoea bolusiana* 'moky', (5) *Aloe divaricata* 'vahomdrandro', (6) opening on *Adansonia za* 'za', hollowed out to be used as a water tank without killing the tree, (7) *Hydnora esculenta* 'voatany' holoparasitic plant growing on the roots of other trees, (8) *Azima tetracantha* 'tsingilo'. **(b)** Number of species known by adults (yellow), by children (green), and by both (grey) and **(c)** number of species known by women (red), by men (bleu), and by both (grey), by life forms, water-provided type, and nutritional contribution.

Criteria for important species

Twenty-three of the 59 WEP species were listed as important by at least one informant. *Ziziphus spina-christi*, *Flacourtia indica*, *Salvadora angustifolia*, *Grewia leucophylla*, and *Boscia angustifolia* were the species most frequently cited as important (**A4.S2 Fig**). The criteria belonged to five main categories: organoleptic (64 times), nutritional (42 times), food accessibility (10 times), economy (3 times) and food security (1 time). Regardless of informant's life stage and gender, the criteria most often used to define a WEP as important related to its *organoleptic* characteristics, mainly taste. The term *'mamy'* (sweet) was the most used (45 times), followed by '*soa*' (good taste) (17 times), and finally '*masiloka*' (acid) cited twice. *Nutritional* aspects were also used to define WEP as important, particularly related to the feeling of fulfilment. The term '*voky*' (satiating) was used 18 times, followed by *'menaka'* (fat and oily) cited eight times, '*sakafo*' (edible) cited four times, '*salama*' (healthy) cited four times (usually referring to the vitamin), and finally '*jabobo*' (provide water) cited three times. Terms related to *food accessibility* were also used, with the term '*miharamaky*' (abundant), referring both to the species productivity and its ecological abundance, being reported eight times and the term '*manavanana*' (effortless to collect) being cited twice. Few people used criteria related to *economic* aspects with the term '*mahaletake*' (i.e., marketable) being cited three times. Finally, one informant used the term '*avotsiky*' (preservable) referring to a *food security* aspect and the need to anticipate the lean season by storing wild food (**A4.S2 Fig**).
We find differences in the mention of these criteria between adults and children (Chi-square = 24.256, df = 11, p-value = 0.0117). Children used more times the criteria "good taste" than adults, while adults used more time "satiating" and "abundant" as criteria to define WEP as important (**A4.S4 Tab.**). However, we did not find differences between men and women (Chi-square = 15.108, df = 11, p-value = 0.1776).

Comparing collection and preparation practices

During semi-structured interviews, collection and preparation methods were described for 31 of the 59 species listed. Four collection and 16 preparation methods have been described, with multiple variations in the techniques, tools, or condiments used for preparation (**A4.S5 Tab.**).

Regardless of life stage or gender, all informants used the same collection methods. Most of the WEP are trees and thorny shrubs collected with the help of a stick to make the fruit fall into a net previously installed on the ground. Tubers are usually collected with a spade (called '*fangale*') or with the hands when the tuber is not deep. Our GLM did not detect any effect of life stage (estimate = 0.092, Std. error = 0.150, z value = 0.616, *p*-value = 0.543) or gender (estimate = 0.220, Std. error = 0.151 z value = 1.458, *p*-value = 0.156) on the use of different collection skills (**Fig.39a**).

Regarding preparation methods, many techniques are used to prepare WEP for consumption (e.g., roasted, boiled, leached, ground, squeezed, fermented), which involve a diverse use of condiments and tools. Many techniques are also used to prepare WEP as a food additive for the preparation of other foods, as for example to prepare goat milk where WEP is used as fermenting agents (**A4.S5 Tab.**). Women described nine different preparation methods, of which three were not reported by men. Men described 14 preparation methods, including eight that women did not mention. Adults described 13 preparation methods, of which seven were not mentioned by children (**Fig.39c**) and children described nine preparation methods, of which three were not described by adults. Both children and adults reported one preparation method linked to one species not mentioned by the other group (**Fig.39c**). Among the 31 species for which preparation methods were described, 16 WEPs were mentioned by all subsamples, with similar preparation. Regarding preparation skills, GLM indicated that adults were more knowledgeable in terms of WEP preparation than children (estimate = -1.338, Std. error = 0.383, z value = -3.489, *p*-value < 0.01). Moreover, while we did not find any gender differences in preparation skills among adults, we found that girls have a lower score in preparation skills compared to boys (estimate = 0.8976, Std. error = 0.4130, z value = 2.173, *p*-value < 0.05) (**Fig.39b**).

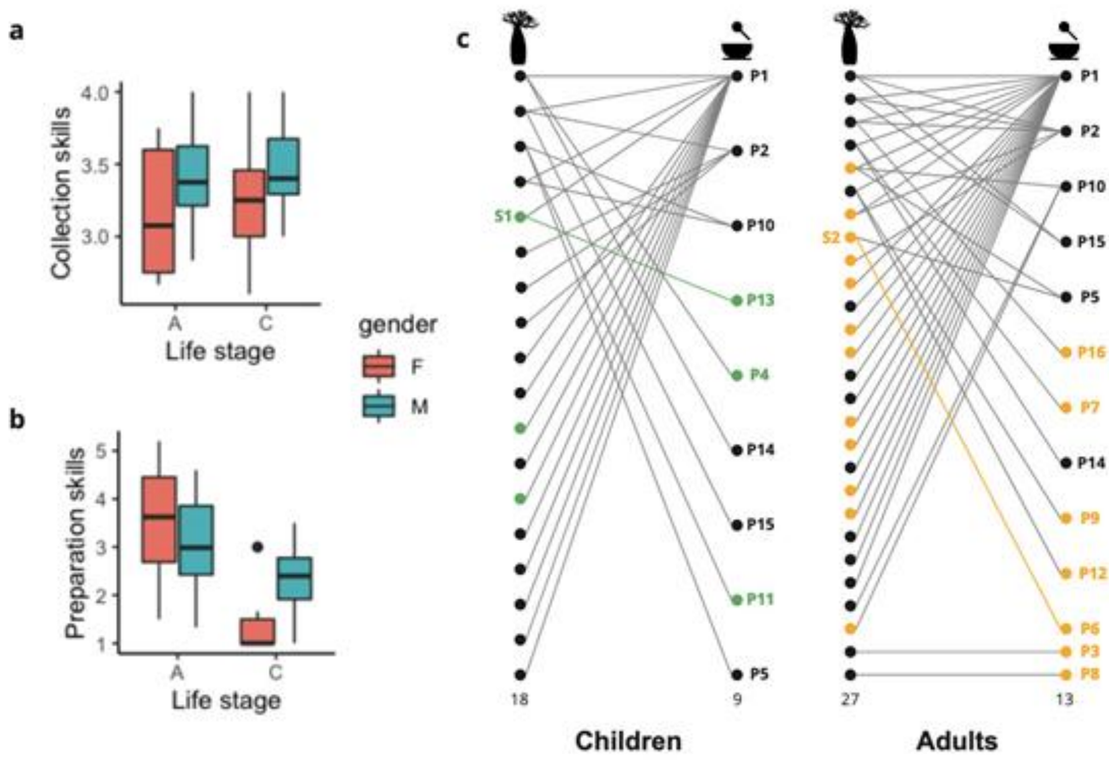

Figure.39 - Collection and preparation skills per life stage and gender and preparation knowledge network. (a) collection skills and **(b)** preparation skills. A = Adults, C = Children, F = Female (red box) and M = Male (blue box), the black dots represent outliers. **(c)** Preparation knowledge network for children and adults. Nodes under the baobab tree and kitchen tool represent the species and preparation methods. Links between nodes represent knowledge linking a WEP species and a preparation method. Node colors indicate species or preparation common to children and adults (black), specific to children (green) or to adults (yellow). Numbers under the nodes indicate the respective number of species and preparation methods known by children and adults. The preparation methods from P1 to P16 are described in Supplementary Table S5.

5.4 Discussion

Tanalana people hold a great diversity of WEP knowledge in common, although they also display intracultural variation in WEP's knowledge distribution, as shown by the distinct distribution pattern regarding theoretical and practical knowledge across life stages and gender. Thus, in free listings, children and adults cited different sets of species, suggesting differentiated bodies WEP theoretical knowledge. As for gender, men cited more WEP than women. We found low intracultural variation in WEP collection and preparation methods, suggesting that all Tanalana share them. We discuss such insights in terms of learning opportunities and how these might contribute to the resilience of local knowledge systems constituting a risk-management strategy. We argue that the harsh environmental conditions of the area might shape Tanalana WEP knowledge distribution and the early acquisition of this LEK by children.

Intracultural variation through life stage and gender lenses

An important insight of this work refers to the differences in plants named by children's and adults', which suggest the existence of a children's culture. As seen in our results, children know different species and methods of WEP preparation than adults and define important WEPs differently. This finding is not new, as similar findings have been observed across small-scale societies and ecological regions including two cases in Madagascar (Gallois et al., 2017; Tucker & Young, 2017; Porcher et al., 2022). Thus, our insights reinforce the idea that children hold specialized knowledge and -potentially- what has been called "a children's culture" (Johanson, 2010; Gallois et al., 2017). Differentiated children's knowledge might be explained by several mechanisms driven by sociocultural and environmental contexts. One of the currently admitted theories behind children's specific knowledge is the importance of horizontal transmission among children – from child to child- (Reyes-García et al., 2016), which fosters the acquisition of specific knowledge not shared with adults. While vertical transmission – knowledge transfer from adults, usually from parents to children – is usually the most intuitive process occurring, some studies argue that horizontal transmission might be a predominant mechanism among children in small-scale societies (Hewlett & Cavalli-Sforza, 1986; Gallois et al., 2018; Santoro et al., 2020). This transmission process is usually supported by subsistence activities that encourage prosocial behavior like playing, foraging, and food sharing (Crittenden, 2015; Frazao-Moreira, 1997).

Tanalana children, who regularly experience the effects of the lean season, might rely on food sharing, which supports knowledge transmission between them. This mechanism adds to others, such as the *fihavanana* – the set of traditional rules and norms, built on values of sharing, trust, social peace and interpersonal solidarity –

which structure Tanalana society and condition their cultural learning (Richter, 2001). Here, we hypothesize that environmental conditions and food scarcity might partially explain the diversified body of knowledge held by Tanalana children. Together with the transmission process, children might also create their own knowledge about their environment (Lancy, 2010) throughout their growing period (Ingold, 2003). Thus, the difference in species cited by children in relation to adults might also be the result of foraging decisions made by children to collect WEP best adapted to their strength, size, and preferences (Gallois et al, 2017). This might be the case for the tuber of *Hydnora esculenta,* only cited by children (Andriamisaina, 2019), which usually grow a few centimeters underneath the soil and require less energy to be collected than *Dioscorea* tubers, buried several meters deep and weighing several kilograms (depending on the species). In addition, the difference between adults and children can also be due to vegetation changes over generations, such as the "shifting baseline syndrome", which can influence knowledge dynamics (Hanazaki et al., 2013).

In contrast to most previous studies, we found that Tanalana women display a particularly reduced theoretical body of WEP knowledge, reflected in the absence of a set of WEP species specific to women and in the low number of WEP known. We argue that this finding might be explained through the ecological context of this society and women's reduced mobility pattern. Across cultural groups and ecoregions, women hold extensive plant knowledge (Miara et al., 2018) and particularly knowledge of WEP growing in home gardens (Díaz-Reviriego et al., 2016b) with a high specialization in herbaceous WEP (Voeks, 2007; Porcher et al., 2022). The reduced presence of herbaceous WEP in Tanalana women's list might be explained by the xerophytic thicket characteristics, too dry for such life forms. Indeed, the only herbaceous WEP found in the region were hyper-specialized to dry conditions with succulent leaves (Fig.38). For example, the traditional "*anana*" (in Malagasy), a leafy vegetable herbaceous species, that can grow wild or cultivated, and that is consumed boiled and accompanying the staple food (rice, cassava), an unavoidable dish in Malagasy diet, is absent here. The absence of this group of plants and the almost non-existence of home gardens obliterate an important part of knowledge that women usually master in other Malagasy regions. Moreover, women and girls' reduced mobility due to their domestic-sphere-oriented activities might also affect their knowledge of WEP. Recent work in the high plateau of Madagascar shows the importance of mobility in the knowledge differentiation pattern across life stage and gender (Porcher et al., 2022). Pastoralism among the Tanalana, as other Malagasy people, is a predominantly male activity, which promotes men's mobility but restricts women. In addition, in this region, during the lean season, men travel several weeks away from the village to collect WEP and water. These seasonal trips allow men to cross different types of vegetation and thus to expand their knowledge of WEP. In contrast, women, who stay at the village, only have access to the nearby WEP. For example, from our interviews and additional sources (Cirad, 2015), we know that women are actively involved in collecting water when the baobab tanks are full in the dry season. These familial baobab trees (belonging to households) can be found several kilometers away from the village and therefore imply a certain seasonal mobility of women across the xerophytic thicket. Importantly, reduced women's knowledge about WEP might have a direct effect on their nutritional intake and, by extension, their ability to cope with food crises (Jackson et al., 2020). Further studies involving socio-cultural perspectives are needed to explore gendered knowledge transmission and women's knowledge acquisition in this region.

It has been shown that many gender-related factors, such as early marriage, gender inequality - school dropout syndrome, difficulties in agricultural production or migration, could affect women's acquisition of LEK, which in turn could increase women's vulnerability (Noromiarilanto et al., 2016; Randriamparany & Randrianalijaona, 2022). In this line, we found variation in children's preparation skills, with girls displaying lower skills than boys and women providing a lower number of WEP than men. Although, it would be necessary to conduct further works to elucidate this gap, we believe that it may be due to the shyness displayed by girls and women while being interviewed. Therefore, our results may not be representative of females' actual practical knowledge. Verbalization of complex ideas can be a limitation for the children during interviews and induce shyness feeding an existing gender-shame (Gazelle et al., 2014), drawing methods will be more adapted to work with children.

Explaining early learning and children's knowledge

One of the main insights of our study is that Tanalana children know as much as adults, citing a similar number of WEP species than adults, while reporting different species, a finding that, to the best of our knowledge, has not been reported in other societies. Indeed, regarding the theoretical knowledge (i.e., the number of WEP species known), children almost reach the maximum threshold predicted for WEP species known by adults. In other words, Tanalana children know about the same number of WEP species than adults, and Tanalana adults are not necessarily more knowledgeable than children. Our results also show that useful WEP traits (life forms and resources) are known and widely spread in the community, without variation across life stage and gender. This implies that Tanalana children do not accumulate new WEP species knowledge, or very few, as they grow and that they already have information about WEP useful traits as part of their knowledge, knowing what to look for (traits). These findings are consistent with previous studies that challenge the assumption that individuals' LEK accumulation is linear, resulting in greater expertise or skills in older individuals (Koster et al., 2016). Here, we argue that high expertise for a given knowledge domain may be acquired earlier in life. According to Schniter et al. (2021), knowledge related to wild edible or toxic plants might be one of the knowledge domains acquired the earliest during lifespan. It is also true for practical knowledge, as Tanalana children share a similar level of WEP collection skills and know almost half of the preparation method reported by adults. Knowledge about WEP is acquired through children's daily involvement in gathering and preparing WEP and does not require many tools and techniques, where most of the species are eaten raw and collected without specific tools. These relatively low complexity techniques might thus foster an early acquisition of skills, in contrast with other subsistence activities such as hunting, for which it has been shown that skills acquisition requires a long period of time (Demps et al., 2012; Lew-levi et al.,2021; Koster et al., 2016 and 2020). This pattern of "early knowledge acquisition" has been also observed among Mikea children, a neighboring ethnic group of hunter and gatherers living in similar environmental conditions (Tucker & Young, 2017). Furthermore, other factors such as time allocation during childhood and the presence or absence of adults within children's daily activities might be a factor in shaping children's knowledge of WEP (Gallois et al., 2017). Further research would be needed to explore the link between time allocation and children's knowledge acquisition in Tanalana societies. The fact that children from different ethnic groups from the same arid ecoregion but with different livelihood activities, i.e., hunter and gatherers and agro-pastoralists, hold complex subsistence skills at an early age suggests an effect of the environment on children's knowledge and the age of their acquisition. In this region, children's "dwelt-in world" (Ingold, 2003), or the way the children experience their environment, is particularly constraint by the harsh environmental conditions and might imply a certain engagement vis-à-vis of resources foraging, resulting in a contextual specialized and early knowledge acquisition or "enskilment" (Ingold, 2003). Considering the extreme living conditions of xerophytic thicket, quickly learning how to recognize, collect, and prepare WEP is definitively crucial to limiting food risk and, by extension, to survival. According to Tucker and Young (2017) this self-learning can be enhanced in a safe environment (e.g., free from predators, venomous animals, or poisonous plants) such as the xerophytic thicket, where wrong plant identification is less risky than in other environments.

Risk-management strategy as a component of Tanalana's LEK

We identify three main aspects of the Tanalana's knowledge prone to contribute to LEK system resilience and thus constituting a risk-management strategy for Tanalana people.

A first aspect is the nature of LEK held by Tanalan people. In the xerophytic thicket, an environment that offers limited water and food resources, Tanalana people have developed sophisticated knowledge to find and prepare them, mostly in tree species and shrubs with fruits rich in vitamin *A* (57% of the WEP reported) and tubers used as staple food. The Tanalana have taken advantage of the hyper-specialization and functional diversity of plants growing in the xerophytic thicket for their needs. One of the specificities of their ecological knowledge, and one of our striking results, is the large proportion of WEPs known for providing water resources. This most likely reflects the magnitude of water stress in the region. Despite the human pressure on the xerophytic thicket (Randriamalala et al., 2019), several species particularly important for providing water receive specific care and are protected by traditional management rules, or 'fady'. For example, according to our informants, the collection of the water tubers of *Dioscorea bermandry*, '*baboky*', is done in a non-destructive manner to ensure sustainable collection, similarly to the yam's protoculture done by Baka people in Cameron (Dounias, 1996). *Adansonia za*, '*za*', appreciated for its fruits, is also used as a water tank (Fig.38a 6) - being able to contain up to 800 liters- by carving the trunk without killing the tree (Cirad, 2015). In sum, the widely spread WEP knowledge held by Tanalana people across life stages and gender testifies to a long experience with a limiting environment stressing hunger and thirst.

A second aspect is the structure of the LEK system and in particular its distribution and the age of knowledge acquisition. Indeed, we showed that while children and adults look for similar plant traits, they both cited different WEP species and used different criteria to define WEP as important. This utilitarian redundancy might enforce adaptive capacity and knowledge system resilience (Díaz-Reviriego et al., 2016). Blanco and Carrière's work in Morocco (2016) shows that sharing knowledge about WEP might be an adaptation to the harsh conditions of desert life - scarce and unpredictable precipitation directly affecting the food system. In this work, authors argue that the reduced knowledge variation might allow the whole community to collect most of the plant and maximize resource collection. Our results support the argument as they show that, in a dry environment where resources are limited most of the theoretical and practical knowledge are shared by everyone. Indeed, the observed "shared" distribution of WEP knowledge of Tanalana people (including children early knowledge acquisition) might also be an adaptation to the difficult and unpredictable environmental conditions. In addition, Tucker and Young (2017) argue that the early skills of children advance the age of "positive net production" and thus reduce the physical and economic burdens of adults. While we did not collect any data on foraging time allocation or foraging productivity, our field observations suggest a certain autonomy of children towards WEP collection and consumption. In this sense, even if we cannot prove that Tanalana children's WEP's foraging proficiency reduces adults' burdens, we can suggest that it might at least improve children's nutritional status, by providing micronutrients through daily snacking habits, as it has been shown elsewhere (Golden et al., 2011).

A third aspect that explains Tanalana's knowledge resilience is the symbolic values and the behavior toward WEP. If basic needs might play an important role in the WEP knowledge distribution, other socio-cultural factors are not negligible. The optimal foraging theory states that foraging is driven by the balance between energy obtained and energy spent to collect or prepare the food (Winterhalder & Alden Smith, 1981). Targeting tree species bearing fruits, which do not need specific preparation (see Fig.39c P1) and providing a high energy rate due to their sugar and micronutrients, aligns with this theory of effort-gain optimization. However, several studies have shown that the cost of the gathering is not always a limiting factor and that low-energy resources are often collected despite their high cost (Hagino & Yamauchi, 2016; Gallois & Henry, 2021) challenging this neoclassical approach. The act of foraging itself, in some cases, might be perceived locally and culturally as more important than the resource provided, particularly when it relies on a collective activity because it supports socio-cultural interactions, knowledge transfer, cultural learning process, and group cohesion (Gallois & Duda, 2016). Indeed, diet, including food selection and collection, depends on many psycho-cultural factors (Gaoue et al., 2017; Gallois & Henry, 2021). As Trémolière (1962) put it "*human is a consumer of symbols as much as of food.*" In the Malagasy culture, the symbolic act of sharing is more important when it comes to sharing a sweet food, such as fruits. In Malagasy, the word "*mamy*" has a double meaning, referring to both sugar/sweet and happiness. By analogy, to share sweetness, it is also to share happiness, but above all, a "sharing" and the expression of the *fihavanana*, the feeling of solidarity; in sum, to make a group (Ravololomanga, 2006). Thus, considering sweet WEP as important WEP is not only revealing a nutritional need but a more complex food representation -learnt at an early age- involving social behavior such as solidarity and cooperation, enhancing the group's ability to overcome crises, though a social risk-management strategy (Moritz et al., 2011).

However, while these strategies might enhance knowledge system resilience, they do not necessarily fully protect people from food crises. Indeed, despite the great WEP knowledge held by the Tanalana people, malnutrition is still a critical challenge in this region (WFP 2020), questioning the ability of the local knowledge system to overcome crises. Recent work has stated that indigenous food system vulnerability to disaster might be approached emphasizing the socio-ecological system framework while addressing several aspects of this system such as the historical, human, economic, environmental and governance dimensions (Jackson, 2020). Indeed, according to historical sources and local experiences (Ralaingita et al., 2022), despite the current food crisis with a debated climatic origin, the region experienced several episodes of intense drought followed by food crises in the 1920 and 1930. Furthermore, the 200 years of French colonization ended in 1960 has also deeply affected the local knowledge system's integrity and resilience (Raschke & Cheema, 2008). In addition, migration, poverty, the decrease in WEP abundance due to overexploitation (Schunko et al., 2022), vegetation loss (Randriamalala et al., 2019), and bad governance might deeply affect the current vulnerability of the local food system. Thus, knowledge distribution is an important dimension to understanding Indigenous and local knowledge and food system vulnerability, but it has also to be analyzed in a broader context.

5.5 Conclusion

Our results show that Tanalana people hold a great diversity of WEP knowledge, while displaying a different body of theoretical knowledge between children and adults. The distinct distribution pattern regarding theoretical and practical knowledge across life stages and gender attests to the complexity of understanding knowledge system distribution, which might be deeply linked to the knowledge domain itself. In addition to the social components, such as life stage and gender, our study argues that the environment -and in particular resource limitations- might also shape knowledge distribution patterns and knowledge acquisition. We believe that WEP knowledge widely shared in the community might allow optimize resource collection and more individual autonomy toward WEP proficiency. Also, our insights brought further evidence of children’s expertise of their ecological environment, which is acquired early in life. Such insights are of high relevance especially when designing food security policies and development programs, which should take into consideration not only the local ecological and cultural variabilities, but also include all social groups of the communities.

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Chapter VI

Conclusion

In this thesis, I analyze the diversity and distribution of children's ethnobotanical knowledge in two agro-pastoralist societies in Madagascar, the Betsileo and the Tanalanas. This work brings new empirical data to research on local ecological knowledge distribution in small-scale societies through the intersectional lens of life stage and gender as well as on children-specific ethnobotanical knowledge. This dissertation contributes to filling the theoretical and methodological gap identified by previous studies on children's culture (Gallois, 2016; Gallois et al., 2017) and on how LEK is distributed within a group according to individuals' sociodemographic characteristics (Andriamparany et al., 2014; Natcher et al., 2020). Overall, the major theoretical contributions of this work are showing 1) that children hold high levels of local ecological knowledge, including multiple knowledge dimensions (Chapters III, IV and V), 2) that children from Madagascar's small-scale societies hold specific LEK (Chapter IV and V), 3) that LEK distribution is shaped by sociodemographic characteristics such as gender and life stage (Chapter IV and V), and 4) that knowledge acquisition and specialization might vary from one ecological context to another, contributing to social-ecological resilience (e.g., as risk-management strategy) (Chapter V). Additionally, this dissertation also brings an important methodological contribution, as I develop a method to explore children's ethnobotanical knowledge which is independent of their verbalization ability (Chapter III).

In this section, I present the major theoretical and methodological contributions of my work, while also acknowledging the limitations and drawbacks. Additionally, I provide recommendations for future research on the subject and discuss the policy implications of the results.

6.1 Theoretical contributions

With this dissertation, I strive to contribute to the growing bulk of literature on children's LEK by bringing insights from two case studies. Moreover, I also aim to contribute to the literature on LEK distribution in small-scale societies by including children as full-fledged actors in the creation, holding, and dissemination of knowledge.

Results from this work are in line with the concept of children's peer culture developed by Johanson (2010) and Corsaro (2012) and tested by Gallois et al. (2017). The first theoretical contribution of this work, tested with Betsileo and Tanalanas children, is that a non-negligible share of children's ecological knowledge about wild plants (e.g., species and practices) is not reported by adults (Chapters IV and V). Moreover, specific aspects, such as a different nomenclature for some species (Chapter IV) and activities carried out only by children (Chapter II), suggest that the knowledge system specific to children that is broader than the one captured in this work. However, this specific body of knowledge not shared with adults does not represent the totality of knowledge held by children, which is in constant evolution. Moreover, the gendered differentiation of knowledge acquisition early in middle childhood plays an important role in the constitution of specific's knowledge. Additionally, the adoption of new practices as children grows up also contributes significantly to the constitution of individual knowledge. Having emphasized that children hold a specific body of knowledge which changes according to their sociocultural context justifies the use of an intersectional lens in further studies of intracultural knowledge distribution.

The second theoretical contribution of this work relates to children's ability to identify plant species. By exploring the criteria used by children to describe, recognize, and contextualize WEP in their ecological and cultural settings, my results open a new field of research on children's taxonomy and stress the need to explore LEK beyond visual and verbal aspects (Chapter III). My findings align well with precedent work on children's perception of the environment (Carrière et al., 2010), largely as they confirm the pre-empted high level of ecological knowledge complexity through different dimensions involving cognitive, sensory, and emotional aspects while showing the consistency of children's naturalistic observations with scientific records. Furthermore, results from my work create an opportunity for dialogue among different "modes of existence" (as described by Latour in 2012), specifically between children and scientists. In essence, it opens the door to building a foundation where children and scientists can engage in meaningful exchanges and jointly contribute to the co-production of knowledge while ensuring that the methods and tools employed are suitable and considerate of the children's unique perspectives.

As a third theoretical contribution, this thesis highlights the effects of the social-ecological environment on knowledge specialization (Chapters III - V). The empirical data from the two different study sites show how knowledge might reflect the social-ecological setting in which gender and life stage (among others) shape the acquisition of specific bodies of knowledge within the same group of people through their daily activities and experiences of the surrounding environment. This finding, sitting in an already large bulk of literature on knowledge distribution (e.g., Reyes-García et al., 2009; Lunga & Musarurwa, 2016), also aligns well with the idea of a lived, experienced word, a "dwelt-in world" to paraphrase Ingold (2003), nurturing knowledge and know-how. By extension, the sociocultural and ecological frames depicted in this thesis help us to understand the conditions of the "enskilment" (Ingold, 2003) and thus, contribute to the study of the LEK acquisition process. In that sense, my findings show that most wild edible plant knowledge was learned and mastered early during middle childhood, arguably through direct experience with plants at an individual level and throughout the cultural transmission process.

Finally, the results presented in the thesis also suggest that the way in which LEK of WEP is distributed might contribute to the resilience of the knowledge system and thus constitute a strategy to smooth food consumption (Chapters IV & V). More specifically, the two last chapters show that Betsileo and Tanalanas present a slightly different pattern of knowledge distribution, which might be matching distinct strategies answering to their respective environmental constraints. Albeit the result can be interpreted through the lens of utilitarian redundancy in both cases (Díaz-Reviriego et al., 2016). Within the Betsileo people, the level of knowledge differentiation appears to be higher, with a rich set of WEP species spread across the group. This distribution of WEP species supports a high resilience of their knowledge system. In contrast, Tanalana people seem to share most of their WEP knowledge to maximize wild food collection as a strategy to limit the risks of food scarcity, as proposed by Blanco et al. (2016).

6.2 Methodological contributions

One of the main reasons for the poor understanding of children's local ecological knowledge is the lack of empirical research on the topic. Adding to the complexity to understand local ecological knowledge, focusing on children constitutes an additional challenge, which moreover suffers from important methodological weaknesses. While some researchers have focused on children's LEK (Crittenden, 2016; Blacutt-Rivero et al., 2016), they have mostly used the standard interview method and participatory observation, considerably limiting the field of possible ways to interact with children. Few works have proposed innovative and children-adapted methods (e.g., walk in the wood; identification transect, photo voices) to collect children LEK (Gallois & Reyes-García, 2018). Therefore, an important contribution of this thesis has been to fill this methodological gap by proposing and testing data collection methods adapted to children.

This thesis brings a novel method adapted to children for exploring their LEK: the use of drawings. Insights from this work demonstrate the effectiveness of the children's drawing method in gathering both qualitative and quantitative data in a way that is suited for children. Moreover, my work introduces a novel tool for investigating knowledge about plant identification beyond its application with children. To the best of my knowledge, no other studies have focused on visual local plant identification criteria, and even fewer have done so using drawing. With the growing interest in the sensitive approach, this method makes a valuable contribution to the field of ethnobiology.

6.3 Limitations and caveats

In this section, I present the main limitations and caveats of this work, with the goal to avoid a wrong interpretation of the results presented in this thesis. The first limitation of this work refers to its narrow focus on wild edible plants. The dissertation would have benefitted from data related to other local knowledge realms. Having emphasized children's wild edible plant knowledge, my work does not give an exhaustive overview of the children's local ecological knowledge referring to other domains of ethnobotanical (i.e., medicinal, veterinary, wickerwork, bioindicator ‘s plant knowledge) and ethnozoological knowledge. Therefore, results from this work should be only interpreted in relation to WEP and are not necessarily applicable to other types of knowledge.

Along the same line, despite the punctual use of drawings, most of the data used in the analyses is derived from free listing and more rarely from interviews, which do not capture the full complexity of local ecological knowledge (at least in Chapters IV and V). In addition, defining LEK as the indivisible cultural wholes of knowledge, practices, values, and worldviews (Orlove et al., 2023), I am aware that important LEK mediums such as beliefs, skills or language are not fully considered here, which does not allow the holistic aspect of this knowledge to be conveyed.

The second caveat relates to the socio-demographic characteristics used in the analysis. Indeed, in this work, I structured my analysis around life stage and gender, as the main factors which shape knowledge acquisition and specialization. But the use of these two variables limits the possible interpretations of them, thus omitting the complex overlay potentially driven by other factors such as access to schooling, household activities, and more broadly the context of family life and individual experience, to mention only some of them. Moreover, I did not take into consideration the impact of social status and how sociocultural hierarchy might shape LEK through the right to access nature, despite knowing the local importance of this social structure on a daily basis and social relationships (Regnier, 2015).

Finally, despite the effort to provide an overview of the Betsileo and Tanalanas cultural and environmental settings, longer fieldwork would have been necessary to fill an important ethnographic information gap, particularly concerning the

Tanalanas people. Simultaneously, longer fieldwork would have also allowed a better mastery of Malagasy languages, which would have allowed the deepening of certain aspects of knowledge rooted in linguistics, a certain openness and creation of social links indispensable to the survey and interviews, and finally a better communication during the interviews as well as a better control during the retranscription of information.

6.4 Future research

Overall, the limitations exposed illustrate the value that further investigation could have in filling the above gaps. To face the urgency and the great challenge of local knowledge extinction (Camara-Leret and Bascompte, 2021; Fernández-Llamazares et al., 2021), it seems crucial to better understand local ecological knowledge dynamics through its transfer and creation process. Children being the cornerstone of biocultural heritage, it is relevant to encourage studies on children's knowledge. Based on the results from this work, I highlight some specific points for future research in this field.

The first point I would like to raise is exploring LEK through in-depth certain cognitive aspects which have received little attention in ethnobiology literature (e.g., sonorscape, and chemosensory) and start developing tools to approach the sensory and emotional dimensions of LEK. In continuation of my research, it would be valuable to investigate the perceptions and representations of spaces by children in relation to their daily activities. This might contribute to a better understanding of the link between the landscapes explored by children and their knowledge acquisition. A potential way of conducting such research could be with the use of participatory mapping linked to GIS to compare the areas explored by children with those explored by adults.

Finally, the field of childhood anthropology and cultural learning suffers from a lack of case studies for comparative work. By bringing two new case studies to the table, my work suggests both the diversity in children's specific knowledge and the common patterns that need to be highlighted. Future comparative work could reach its full potential through the availability of open-source data sets and close collaboration between schools (among themselves) and local populations to address issues related to childhood and cultural learning of LEK in a dynamic of co-production of knowledge and solutions.

6.5 Policy implications

I end by presenting some policy implications that I derive from the work presented here. These implications particularly highlight the importance of considering children in decision-making on areas such as biodiversity conservation efforts, cultural knowledge revitalization, and knowledge co-production. These policy implications go beyond the case studies and Indigenous Peoples and Local Communities as they align with the pursuit of transformative change for societies and resonate with certain Sustainable Development Goals (SDGs)* proposed by the United Nations (2015).

First, the work presented in this thesis attests that local ecological knowledge is differentially distributed among Betsileo and Tanalana's societies with intra- and intercultural variability according to gender and life stage (Chapters IV and V). This finding aligns well with the growing body of literature showing the importance of considering gender and life stage while working with IPLC in conservation efforts (Alvarez & Lovera, 2016; Chambon et al., 2023) in the context of global ecological changes (Chabanet et al., 2018; Fache et al., 2022). Therefore, and consistent with previous work recognizing the need to incorporate the role that culture plays in nature's contribution to people into science assessment and policy (Thaman et al., 2013; Isbell et al., 2017; Diaz et al., 2018), an implication of my work is that policies aiming at promoting local ecological knowledge into biodiversity conservation effort (e.i., IPBES) should take into consideration the great variability of LEK holders. This can be done by adopting an intersectional lens. From a gender equality perspective, this consideration will imply both empowering women and girls (SDG n°5) and bringing new insight for socio-ecosystem protections (SDG N°15). I highly encourage considering children's LEK system in these policies, particularly considering gender perspectives, as specific bodies of knowledge acquisition occur with sexual differentiation.

Along the same line, if embedding a diversity of local actors might be beneficial to reinvent resource management (SDG n°17), diversifying the communication channels might also enhance actors' synergies for the co-production of solutions to socio-environmental issues. As the drawing interview suggests (Chapter III), local ecological knowledge is expressed beyond verbalization.

Focusing on knowledge related to wild edible plants, my study shows the large number of plants used by two agro-pastoralist communities in Madagascar suggesting a significant place of WEP in their respective food systems. Indeed, wild edible plants and their contribution in the lean season are often poorly known and therefore absent from science assessment and policy. However, WEPs can help to achieve food security, improve nutrition (SDG N°2) and the well-being of the local population (SDG N°3). Therefore, I stress the need to consider the role of WEPs in the policies (i.e., WFP) and incorporating WEP nutritional contribution in NGOs programs aiming to fight hunger in Madagascar and in the rest of the world (Hajzeri & Kwadwo, 2019; Pieterse et al., 2023).

Finally, my study shows the children's capacity to acquire complex botanical and ecological knowledge and perform it (Chapters III, IV and V). These results suggest two points that should be considered by decision-makers. First, it shows certain biophilia among children, as well as the importance of environmental context and the direct link to nature in the learning of local ecological knowledge. Therefore, defending children's right to nature should be an important element to promote child protection proceedings around the world. This right to nature for children is intrinsically linked to the notion of biocultural heritage and the responsibility we have to preserve and provide diverse ecosystems and socio-ecosystems for the next generation. *"Planting trees [...] I can think of no better way to take care of the future"* (Voltaire).

Second, my results showing the ability of children to retain complex LEKs should motivate and justify environmental education programs not to underestimate the ability of children and offer them programs adapted from an early age (SDG N°4). As Malagasy say, *"Children are the first wealth."* We have to act accordingly.

*List of the Sustainable Development Goals (SDG) proposed by the United Nations that the policy implications presented above might cover:
N°2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
N°3: Ensure healthy lives and promote well-being for all at all ages.
N°4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
N°5: Achieve gender equality and empower all women and girls.
N°15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
N°17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

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Appendices

A.1 List of plant species reported by Betsileo people

Uses categories: (1) wild edible plants, (2) *fanafody*, a. medicinal, b. magical, (3) fuel, (4) fodder, (5) toys, (6) construction, (7) household tools, (8) wickerwork & basketry and (9) bioindicators.
REF TAN N°: Specimen number consulted at the Tsimbazaza herbarium, for identification.
REF Online N°: Specimen number consulted online, for identification. (K= Kew, P & MNHN = Paris and MO & BM= Missouri Botanical Garden)
REF Photo: Photo source used for identification as specimen reference, from GIBF, iNaturalist or both.

Wild Edible Plant

Uses	Betsileo	Synonym	Latin name	Family	REF TAN N°	REF Online N°	REF Photo
1	alamangitsy		*Physena madagascariensis* Steud.	Physenaceae		K000384039	iNat
1	ambiaty		*Gymnanthemum appendiculatum* (Less.) H.Rob.	Asteraceae	L.J. Dorr & L.C. Barnett 3161		
1	amonta		*Ficus lutea* Vahl	Moraceae		K000232546	iNat
1	ana		*Solanum* spp.	Solanaceae			GBIF
1	anadia		*Solanum* spp. (Wild)	Solanaceae			GBIF
1	anadranodia		*Rorippa madagascariensis* (A.P de Candolle) Hara	Brassicaceae	TAN 1759		
1	anadraza	anamamy dia, anadia, "amelo"	*Solanum* sp. cf nigrum	Solanaceae	TAN 452		
1	anahazo		*Amaranthus retroflexus* L.	Amaranthaceae		K000914061	GBIF
1	anamafaitra	anamavo, anadia	*Solanum americanum* Mill.	Solanaceae	TAN 452		
1	anamamy	ana	*Solanum nigrum* L.	Solanaceae	TAN 452		
1	anana androbosy		*Rorippa millefolia* (Baker) Jonsell	Brassicaceae	TAN 1764		

1	ananambo	agnadambo, voadandamboa	*Moringa oleifera* Lam.	Moringaceae	Gautier, Luino et Rasolonjatovo; LG 6110		GBIF
1	anapisaka	anadranodia	*Rorippa insularis* Jonsell	Brassicaceae	TAN 1755		
1	anapoza	kalabotretraka, kalaptetraka	*Portulaca oleracea* L.	Portulacaceae		K000313628	GBIF
1	anatsonga	mamoreba dia	*Brassica juncea* (L.) Czern.	Brassicaceae		K001039916	iNat
1, 2b, 7	apanga		*Pteridium aquilinum* (L.) Kuhn	Dennstaedtiaceae		K001109251	iNat
1	ara		*Ficus tiliifolia* Baker	Moraceae	J.B Razafindrabe et al. 77		
1	aviavy		*Ficus trichopoda* Baker	Moraceae	Thomas B. Croat 28818		
1	bokony		*Cineraria anampoza* (Baker) Baker	Asteraceae		K000306879	
1	fagnasy	kisira be	*Oxalis latifolia* Kunth	Oxalidaceae	T.Andriamihajariv o et al 414		GBIF
1	fandrindambo		*Cadaba virgata* Bojer	Capparaceae	Rakotomlaza et al180		
1	fasikaisy	faskiasy	*Tarenna grevei* (Drake) Homolle	Rubiaceae	Fidy Ratovoson et al. 844, TAN000755		
1	fatora		*Bremeria scabrella* (Wernham) A.P.Davis & Razafim.	Rubiaceae		K000032530	
1	fomoritany		Unknown 1	//	//	//	
1	fopoho		*Ficus trichoclada* Baker	Moraceae	G. Cremers 3544		

1	goavy	goavy fotsy, goavy mena	*Psidium guajava* L.	Myrtaceae	Thomas B. Croat 28562		GBIF
1	goavy tsinahy		*Psidium cattleianum* Afzel. ex Sabine	Myrtaceae	Thomas B. Croat 32595		GBIF
1	grenadelle	grananana	*Passiflora edulis* Sims	Passifloraceae		K001238070	iNat
1	grenadelle ala		*Passiflora suberosa* L.	Passifloraceae		K000036557	GBIF
1, 2b, 7	hazotra	voamasakariva	*Phyllanthus fuscoluridus var. villosus* (Leandri) Ralim. & Petra Hoffm.	Phyllantaceae	J. Leandri 3381	MNHN-P-P00309535	
1	kifoky		*Cynanchum sessiliflorum* (Decne.) Liede	Apocynaceae	Ramandibiarisoa et al. 78		
1	kihasihasy		*Hibiscus trionum* L.	Malvaceae		K000348512	GBIF
1, 4	kilanjy		*Sporobolus subulatus* Hack.	Poaceae		K000365310	GBIF
1, 5	kilanzovola	halanjanahary	*Leonotis nepetifolia* (L.) R.Br.	Lamiaceae	R.B.r MO 63166-0299		GBIF
1, 5	kilela	kileladreniny, kilelambazaha, grananana	*Passiflora subpeltata* Ortega	Passifloraceae			GBIF
1	kilenga		*Kalanchoe miniata var. andringitrensis*	Crassulaceae	H. Perrier 14780	K000323457	
1, 2b, 4, 6	kily		*Tamarindus indica* L.	Fabaceae			GBIF
1	kimaosy		*Vigna angivensis* Baker	Fabaceae	TAN 1091	K001097233	
1, 9	kimba		*Symphonia clusioides* Baker	Clusiaceae	R. Randrianaivo et al 432		
1, 2a	kinananakoho	ramiary	*Datura stramonium* L.	Solanaceae	Thomas B. Croat 28445		GBIF
1	kindaindaivola	sakavirondambo	*Gladiolus andringitrae* Goldblatt	Iridaceae	TAN 186	MNHN-P-P00057374	
			Gladiolus dalenii Van Geel	Iridaceae	TAN 204	MNHN-P-P00440126	
1	kisira		*Oxalis bakeriana* Exell	Oxalidaceae	Thomas B. Croat 28453		

1	kisira		*Oxalis corniculata* L. (variaty 1)	Oxalidaceae	Thomas B. Croat 29130		GBIF
1	kisira kisira	kisira tany, siramboalavo	*Oxalis corniculata* L. (variaty 2)	Oxalidaceae	Thomas B. Croat 29130		GBIF
1	kisira pahe		*Amaranthus spinosus* L.	Amaranthaceae	H. Humbert 17560		GBIF
1	kitonda		*Medinilla torrentum* Jum. & H. Perrier *Medinilla papillosa* Baker	Melastomataceae	Leg. H. Humbert 6167	MNHN-P-P00060459	
1	kitongasoa	fotsyavadika	*Bechium nudicaule* (Less.) H.Rob.	Asteraceae	Dake in Bull. Soc. Bot. Fr., XLVI (1889), 244.	K000273178	
1, 2a	kitoto	kitotoha, voamasakatany	*Halleria tetragona* Baker	Scrophulariaceae	Razafindrabe et al 171		
1	kitrembo		*Embelia concinna* Baker	Primulaceae		K000974895	iNat
1, 2a, 2b	kivengy	kivenga	*Nephrolepis tuberosa* (Bory ex Willd.) C.Presl	Nephrolepidaceae	Malcomber et al 2426		GBIF
1	komohay		*Amaranthus* spp.	Amaranthaceae			
1	komohay favy		*Amaranthus graecizans* L.	Amaranthaceae		K000243574	
1	komohay la		*Amaranthus blitum* L.	Amaranthaceae		K000243574	GBIF
1	komotodoha	komoto dia, manguevotra tahalaka	*Acmella caulirhiza* Delile	Asteraceae		K000410421	GBIF
1	lamoty		*Flacourtia ramontchi* L'herit	Salicaceae	Thomas B. Croat 32019		
1	lamoty		*Vaccinium emirnense* Hook	Ericaceae	P. Hoffman et al. 259		
1, 6	lanary		*Plagioscyphus stelechantus* (Radlk.) Capuron	Sapindaceae	J. Rabenantoandro et al 91		
1, 7	longoza		*Hedychium coronarium* J.Koenig	Zingiberaceae	Thomas B. Croat 32539		

1	magnesy	anambohay, mandresy	*Galinsoga parviflora* Cav.	Asteraceae	J. Bosser 12552	MO-3157190	
1, 2a	mamijazay		Unknown 2	Asteraceae	//	//	
1	manguevotra	brède mafana	*Acmella oleracea* (L.) R.K.Jansen	Asteraceae		K000054454	GBIF
1	matanandro		*Centella asiatica* (L.) Urb.	Apiaceae	J. Bosser 2879		
1, 9	melo hazo	anamelo, melo	*Phytolacca americana* L.	Phytolaccaceae			GBIF/iNat
1	menahy	voamenahihy	*Erythroxylum nitidum* Baker	Erythroxylaceae	D.J. Mabberley 1024		
1	nakasimba	voanakasimba	*Toddalia asiatica* (L.) Lam.	Rutaceae	R.E. Gereau et al 3288		
1	nonoka		*Ficus reflexa Thunb.*	Moraceae	Det.K.Sikes (MO) 1996		
1	ovy ala		*Dioscorea heteropoda* Baker	Dioscoreaceae		K000751453	
			Dioscorea trichantha Baker	Dioscoreaceae	Labat J.-N., T. Deroin 2270		
1	ovy be		*Dioscorea esculenta* (Lour.) Burkill	Dioscoreaceae			iNat
1	paiso		*Prunus persica* (L.) Stokes	Rosaceae			GBIF
1	petity		*Pyracantha angustifolia* (Franch.) C.K.Schneid.	Rosaceae	Glen, H.F. 3030		
1	pibasy		*Eriobotrya japonica* (Thunb.) Lindl.	Rosaceae	Thomas B. Croat 28899		
1	raketa		*Opuntia monacantha* (Willd.) Haw.	Cactaceae		MO-3093934	iNat
1	roimboza	taindelotsinoa, riadriaky	*Lantana camara* L.	Verbenaceae	3079 RN		
1	rotsy		*Syzygium cumini* (L.) Skeels	Myrtaceae		MO-623698	
1	rotsy ala	rotsy bory	*Syzygium bernieri* (Drake) Labat & G.E. Schatz	Myrtaceae	R. Rabevohitra 2114		
1	roy roy		*Rubus alceifolius* Poir.	Rosaceae	Thomas B. Croat 32648		
1	sakavirohazo		*Piper borbonense* (Miq.) C.DC.	Piperaceae	LRK 548		
1	sakoa		*Sclerocarya birrea* (A.Rich.) Hochst.	Anacardiaceae	J.Bosser 3259		

1	sely		*Grewia stenophylla* Bojer	Malvaceae	M. R. Decary 13276		
1, 2b, 7	seva	voaseva, sevabe	*Solanum mauritianum* Scop.	Solanaceae	James S. Miller et P.P. Lowry II 4017		
1	sevafotsy		*Buddleja madagascariensis* Lam.	Scrophulariaceae	G. Mc Pherson & H. van der Werff 16489		
1	singilofo		*Cynorkis speciosa* Ridl.	Orchidaceae		BM 000911487	
1	sitrotroka	Sirabibilava	*Antherotoma naudinii* Hook.fil.	Melastomataceae	J.Andriantiana et al 681		
1	soamorondrano		*Rhytachne rottboellioides* Ham.	Poaceae		K000290845	GBIF
1	sonjo parakandro	kisonjosonjo	*Hypoxis angustifolia* Lam.	Hypoxidaceae		K000255958	iNat
1	Sonjodia	sonjo ala	*Colocasia esculenta* (L.) Schott	Araceae			iNat
1	sonjo	taro	*Colocasia esculenta* (L.) Schott	Araceae			iNat
1	tavolo		*Tacca leontopetaloides* (L.) Kuntze	Taccaceae	Caddick et al 306		iNat
1	toamamy		*Rousseauxia andringitrensis* (H.Perrier) Jacq.-Fél.	Melastomataceae	LRK 807		iNat
1, 2a, 2b, 6	tohiravy		*Phyllarthron bojerianum* DC.	Bignogniaceae	J. B. Razafindrabe 316		
1, 2b	torovoka		*Ficus menabeensis* H.Perrier	Moraceae	P.B. Phillipson et al 4072		
1	trakanala		*Rorippa* sp.	Brassicaceae			GBIF
1	trakavola	trakavarata, anamadinika	*Bidens pilosa* L.	Asteraceae	Thomas B. Croat 28663		
1	tsaboratahalaka		*Mimulus madagascariensis* Benth	Scrophulariaceae	J. Bosser 12341		
1	tsinefo		*Ziziphus jujuba* Mill.	Rhamnaceae	L. J. Dorr & L. Koenders 2948		
1	tsipoaka	tsipôka	*Bengt-jonsellia lanrentii* (Jonsel) Al-Shehbaz	Brassicaceae	TAN 1757		

1	tsipoapoaka	bireda, voabireda	*Nicandra physalodes* (L.) Gaertn.	Solanaceae	M. Andriamahay & SE. Rakotoarisoa SNGF 2324		GBIF
1	tsipotika		*Achyranthes aspera* L.	Amaranthaceae	G. Razafindrakoto 3982		
1	tsitsitrotroka	trotroka	*Tristemma mauritianum* J.F.Gmel.	Melastomataceae	F. Almeda 8667		
1	vahomavo		*Rhynchosia versicolor* Baker	Fabaceae	Peltier 1731		
1	varobe		*Aloe conifera* H.Perrier	Asphodelaceae	Rakotoarisoa, S.E. 739		
1	via		*Typhonodorum lindleyanum* Schott	Araceae		K000345977	GBIF/iNat
1	viala	ovy ala	*Dioscorea ovinala* Baker	Dioscoreaceae		K000751728	
1	vihia		*Mikania microptera* DC.	Asteraceae		K000500131	GBIF
1	voafandra		*Ananas comosus* (L.) Merr.	Bromeliaceae		K000976774	GBIF
1	voafotsy	fandramana	*Aphloia theiformis* (Vahl) Benn.	Aphloiaceae	James S. Miller 3668		GBIF/iNat
1	voakitaitay		*Rhipsalis baccifera* (J.S.Muell.) Stearn	Cactaceae	G. McPherson, et al. 14210		
1	voalady	voala dia, voan'ala	*Psychotria isalensis* (Bremek.) A.P.Davis & Govaerts	Rubiaceae		P00086265	GBIF/INat
1	voalefokamboa		*Nymphoides bosseri* A. Raynal	Menyanthaceae	Mitt. Bot. Staatssamml. Muchen 10:132.1971		
1	voanaka		*Physalis peruviana* L.	Solanaceae	Thomas B. Croat 29919		
1	voandelaka		*Melia azedarach* L.	Meliaceae	Thomas B. Croat 28513		
1	voangivy		*Solanum myoxotrichum* Baker	Solanaceae	Vorontsova MS et al 598		
1	voankazo		*Prunus* spp.	Rosaceae			

1	voapoala		*Solanum torvum* Sw.	Solanaceae	L. Rakotomalala & S. Malcomber 25		
1	voarafy	bongehazo	*Maesa lanceolata* Forssk.	Primulaceae		K000613990	iNat
1	voaroifotsy	roifotsy	*Rubus apetalus* Poir.	Rosaceae	Thomas B. Croat 29450		
1	voaroihazo		*Morus alba* L.	Moraceae	J. Bosser 11020		iNat
1	voaroitsaka	roitsaka	*Rubus rosifolius* Sm.	Rosaceae	H-J Schlieben 8046		
1	voaroy	roy	*Rubus myrianthus Baker*	Rosaceae	H. Perrier de la Bathie 15073		
1	voasary		*Citrus aurantiaca* Swingle	Rutaceae	TAN 5485		
1	voasipikopiko		*Canna orchiodes* L.H.Bailey	Cannaceae	Thoms B. Croat 28815		
1	voatabiahazo	voatabiala	*Solanum insanum* L.	Solanaceae	MS 578		
1, 6	voatavon'ala		*Thilachium sumangui* Bojer	Capparaceae		K000230765	iNat
1	voatsitakajaza	famorinjaza, myrtille	*Vaccinium secundiflorum* Hook.	Ericaceae	Rakotovao et al 2551		
1	voloboka		*Cissus vitiginea* L.	Vitaceae		K000736272	GBIF

Other plant reported

Uses	Betsileo	Synonym	Latin name	Family
4	ahipisaka		*Paspalum conjugatum* P.J.Bergius	Poaceae
4	ahistako		*Setaria pumila* Roem. & Schult.	Poaceae
2a, 2b, 6, 7	amera	mera	*Brachylaena perrieri* (Drake) Humbert	Asteraceae
7	anjavidy		*Erica madagascariensis* (H.Perrier) Dorr & E.G.H.Oliv.	Ericaceae
2a, 2b	anjavidy mavo		*Seriphium cryptophyllum* (Baker) Koek.	Asteraceae
2a	bakakely		*Acanthospermum hispidum* DC.	Asteraceae

2a, 2b	dendemy		*Anthocleista madagascariensis* Baker	Gentianaceae
2a, 2b, 6	dindembe	dendemibe	*Anthocleista amplexicaulis* Baker	Gentianaceae
2a	dingadinga		*Psiadia altissima* Benth. & Hook.f.	Asteraceae
3	endaka		*Xerophyta andringitrensis* (H.Perrier) Phillipson & Lowry	Velloziaceae
2a	famory	faniry	*Gomphocarpus fruticosus* (L.) W.T.Aiton	Apocynaceae
2a, 2b	fanamo		*Pyranthus pauciflorus* (Baker) Du Puy & Labat	Fabaceae
3, 6	fanasandovia	hosandahy, tongolombato	*Xerophyta dasylirioides* Baker	Velloziaceae
8	fiara		*Raphia farinifera* (Gaertn.) Hylander	Arecaceae
2a	fotsiavadika		*Gerbera elliptica* Hambert	Asteraceae
7	hafitra	hafotra	*Dombeya* sp.	Malvaceae
2a, 2b	hazondrano		*Ilex mitis* Radlk.	Aquifoliaceae
8	herana		*Cyperus latifolius* Poir.	Cyperaceae
4	horo		*Loudetia simplex* (Nees) C.E.Hubb.	Poaceae
3	hosambavy		*Xerophyta pinifolia* Lam.	Velloziaceae
2a	kanda		*Distephanus glutinosus* (DC.) H.Rob. & B.Kahn	Asteraceae
2a	kelivoloina		*Erigeron sumatrensis* Retz.	Asteraceae
3, 6	kesika		*Pinus kesiya* Royle ex Gordon	Pinaceae
5	kiahomby		C*rotalaria craspedocarpa* R.Vig.	Fabaceae
4	kilansy		*Brachiaria epacridifolia* A.Camus	Poaceae

2a	kilelamaitso		*Senecio* sp.	Asteraceae
2a	kilelamavo	kimavo	*Helichrysum cordifolium* DC.	Asteraceae
2a	kilihimena	kilahimena	*Gerbera bojeri* Sch.Bip.	Asteraceae
2a	kimatanandro		*Drosera natalensis* Diels	Droseraceae
2a, 2b	kimboiboy		*Hubertia faujasioides* (Baker) C.Jeffrey	Asteraceae
4	kindesy		*Cynodon dactylon* (L.) Pers.	Poaceae
2a	kirikitsa		*Senna tora* (L.) Roxb.	Fabaceae
2a	kisanga mena		*Anthospermum emirnense* Baker	Rubiaceae
4	kitaratasy		*Sporobolus pyramidalis* P.Beauv.	Poaceae
2a	kitongatsala		*Senecio vaingaindranii* Scott Elliot	Asteraceae
4	kofafa lahi		*Aristida rufescens* Steud.	Poaceae
4	kofafa vavi		*Aristida congesta* Roem. & Schult.	Poaceae
6	kokogna		*Ravenea glauca* Jum. & H.Perrier	Arecaceae
2a	kuity		*Psiadia salviifolia* Baker	Asteraceae
4	mafaibaratra		*Eulalia villosa* Nees	Poaceae
2a	mahatanandomena		*Drosera madagascariensis* DC.	Droseraceae
2b, 3	maimbelona	riadriatra	*Myrothamnus moschata* Baill.	Myrothamnaceae
6	malambovonana		*Erythroxylum sphaeranthum* H.Perrier	Erythroxylaceae
4	menakapaly		*Melinis repens (Willd.) Zizka*	Poaceae
2a, 6	mera		*Brachylaena ramiflora* Humbert	Asteraceae
2a	paraky		*Nicotiana tabacum* L.	Solanaceae
6	ravenea		*Ravenea madagascariensis* Becc.	Arecaceae

2a, 4	roiky		*Acacia* spp.	Fabaceae
9	roiky		*Mimosa latispinosa* Lam.	Fabaceae
2a	rondra		*Hydrostachys fimbriata* C.Cusset	Hydrostachyaceae
2a	tandrokosina	tandrokosiala	*Pentopetia androsaemifolia* Decne.	Apocynaceae
2b	tapakotsindravoaevavy		*Angraecum sororium* Schltr.	Orchidaceae
4	teny		*Imperata cylindrica* (L.) P.Beauv.	Poaceae
2a	tsilarondrirotra		*Indigofera mangokyensis* R.Vig., p.p.B	Fabaceae
2a	tsimatipangady	tsimaitofangady	*Sida rhombifolia* L.	Malvaceae
2b, 6	vagna		*Sloanea rhodantha* (Baker) Capuron	Elaeocarpaceae
2a	vahihatake		*Canavalia* sp.	Fabaceae
2b	vahodrano		*Crinum firmifolium* Baker	Amaryllidaceae
6, 7, 8	vakoa		*Pandanus andringitrensis* Huynh	Pandanaceae
6	varongifotsy		*Ocotea rigidifolia* Kosterm.	Lauraceae
			Ocotea trichophlebia Baker	Lauraceae
6	varongimainty		*Ocotea eriothyrsa* Kosterm.	Lauraceae
6, 7	varongy		Ethnospecies of hardwood	//
4	verobe		*Hyparrhenia cymbaria* Stapf	Poaceae
4	verofehy		*Hyparrhenia rufa* Stapf	Poaceae
6	vihia		*Valiha diffusa* S.Dransf.	Poaceae
2a, 2b	viki	viky, vikika	*Flagellaria indica* L.	Flagellariaceae
2a	voamaitilan	aika,	*Indigofera tinctoria* L.	Fabaceae
7	voatavo	calabasa	*Lagenaria siceraria* (Molina) Standl.	Cucurbitaceae
8	zozoro		*Cyperus alterniflorus* R.Br.	Cyperaceae

A.2 Supplementary material Chapter III

A2.S0 Appendix. Coding the plants by criteria and level of complexity.

We coded the presence/absence and the level of complexity of identification criteria (n=16) and for each plant drawn (n=500). Here we detail our coding system for each criterion with illustrated examples for each case encountered during coding and their corresponding score. We do not code the drawing quality nor the correctness of the representation or similarity with any references, but the level of complexity in the representation independently of a resonance with reality. In case of doubt about the interpretation of the drawing, we chose the category with a lower value.

<u>Life forms</u> (life)

We code "life forms" in the presence or absence (0-1) of complete plant representation. A partial representation of the plant (e.g., branch, fruit) is coded 0 and the complete representation of the life form of the plant is coded 1. Even if the type of life forms (tree, shrub, liana, herbaceous) is specified for the species represented during the interview by the participant, if the complete plant is not represented, we consider that the life forms is not used by the participant as an identification criterion.

(0) (0) (1) (1)

<u>Plant architecture</u> (archi)

We code "Plant architecture" as the presence or absence (0-1) of a rhythmic and spatial organization of growth units such as branches (branching position) or inflorescence (for herbaceous plants). The absence is coded 0 and the presence 1.

(0) (1) (1) (1) (1)

<u>Phyllotaxy</u> (phylo)

We code "Phyllotaxy" in the presence or absence (0-1) of an explicit rhythmic organization of the leaves on the stems in a homogeneous way in the whole plant drawn if there are several stems represented. The absence is coded 0 and the presence 1.

(0) (0) (0) (1) (1)

Fertile position (ferPo)
We code "Fertile position" as the presence or absence (0-1) of a non-random position of fruits and/or flowers on the plant. The explicit placement (pattern) of the fertile organs on precise axes of the plant (ex: on the trunk, the branches, at the end of the stem, at the branching). The absence is coded 0 and the presence 1.

(0) (1) (1) (1)

Leaves morphology (Leav)
We code the "Leaf morphology" according to the level of complexity of the representation (0-3). The absence of leaves is coded as 0, the presence of leaves in the most simplified form is coded as 1. The presence of leaves with at least one explicitly defined sub-criterion such as shape, color or connection to the stem is coded as 2. The presence of leaves with more than two of the preceding subcriteria and or with details such as venation, composition (simple / compound), and margin is coded as 3.

(0) (1) (2) (3)

Root system (root)
We code the "Root system" according to the level of complexity of the representation (0-2). The absence of roots is coded as 0, the presence of roots in the most simplified form is coded as1. Branched or specific root systems such as tuber are coded as 2.

(0) (1) (2) (2)

Flower morphology (flo)
We code the "Flower morphology" according to the level of complexity of the representation (0-3). The absence of flowers is coded with a score of 0, the presence of flowers in the most simplified form is coded as 1. The presence of flowers with at least two explicitly defined subcriteria such as shape, color, or connection to the stem is coded as 2. The presence of flowers with shape, color and inflorescence structure or details of sexual parts is coded as 3.

(0) (1) (2) (3) (3)

<u>Fruit morphology</u> (fru)

We code the "fruit morphology" according to the level of complexity of the representation (0-4). The absence of fruit or seeds is coded with a score of 0, the presence of fruit in the most simplified form is coded as 1. The presence of fruits with at least two explicitly defined subcriteria such as shape, color, or connection to the stem is coded as 2. Fruits with explicit shape, color and infrutescence structure (specific organization of the fruit) are coded as 3. A representation of a fruit combining all the previous sub-criteria, plus specific details such as calyxes, venation or others is worth 4.

(0) (1) (2) (3) (4)

<u>Extra accurate details</u> (EAD)

We code "Extra accurate details" as the presence or absence (0-1) of details not included in the other morphological criteria such as tendrils, stipules, spines, hairs, glands, etc. The absence is coded 0 and the presence 1.

(1) (1) (1)

<u>Reproductive phenology</u> (pheF)

We code "Reproductive phenology" as the presence or absence (0-1) of details indicating the phenology of the reproductive organs, such as the simultaneous presence of flowers and fruits on the plant, variation in size and/or color of fruits on the same plant or specific maturation process such as dehiscence. The absence is coded 0 and the presence 1.

(0) (1) (1)

<u>Vegetative phenology</u> (pheL)
We code "Vegetative phenology" as the presence or absence (0-1) of details indicating the phenology of the vegetative organs, such as variation in leaf size and/or color, leaf drop, young leaves (delayed greening is often represented) or buds on the same plant. The absence is coded 0 and the presence 1.

(1) (1) (1)

<u>Landscape items</u> (Land)
We code the "Landscape items" as the presence or absence (0-1) of items contextualizing the habitat in which the represented plant grows, such as rocks, roads, dwelling, field, forest etc. The absence is coded 0 and the presence 1.

(1) (1) (1)

<u>Soil</u> (Soil)
We code the "Soil" according to the level of complexity of the representation (0-2). The absence of soil represented is coded with a score of 0, the presence of soil in the most simplified form is worth 1. Soil represented with color, texture worth 2.

(0) (1) (2)

<u>Fauna interactions</u> (fauna)

We code the "Fauna interactions" according to the number of different species interacting with the same plant represented. The absence of animal species is coded 0. Two individuals from the same species with a sexual dimorphism represented on the same plant species were coded as 2. The maximum recorded for the same plant was 5 different species.


(1)


(5)

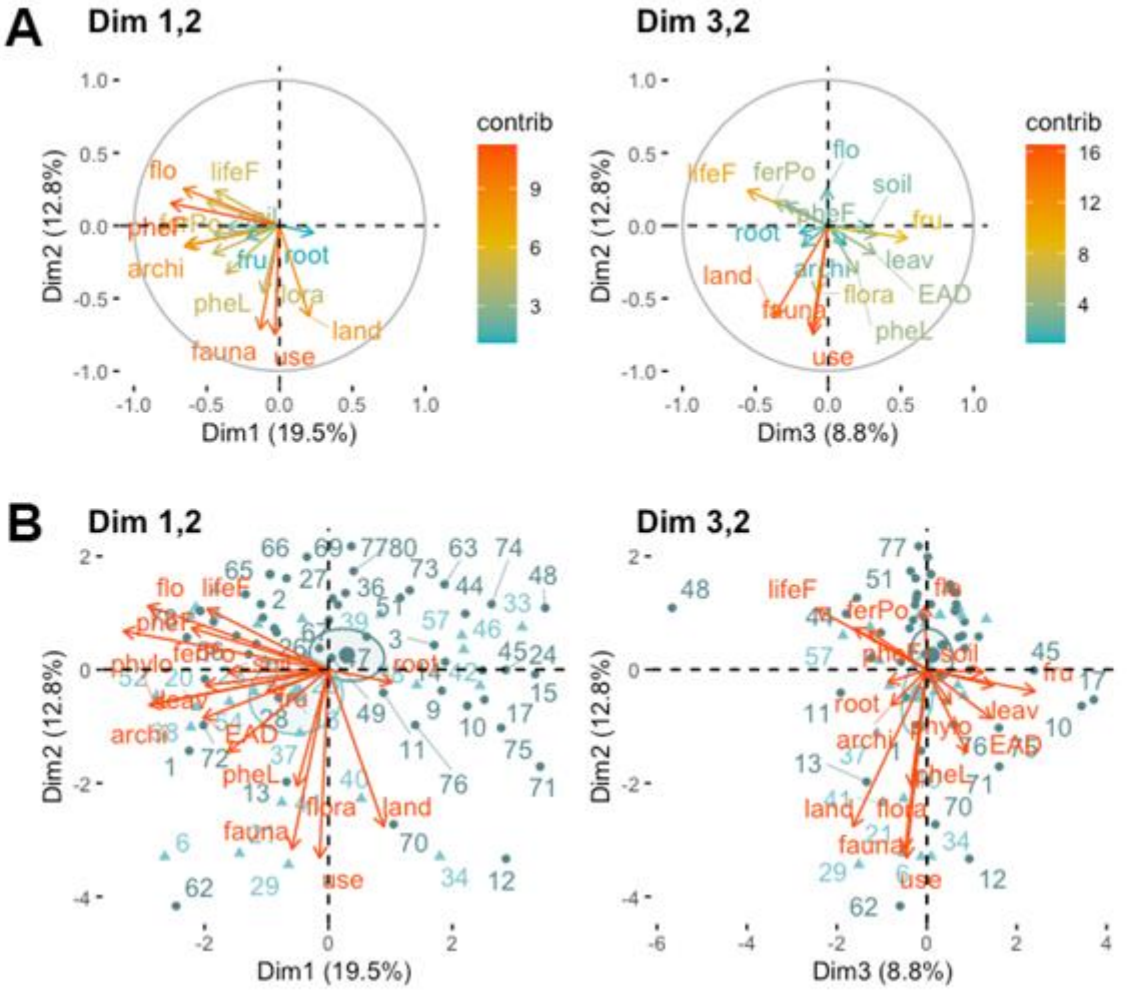
Flora interactions (flora)
We code the "Flora interactions" according to the number of different species interacting with the same plant represented. The absence of plant species interacting with the WEP drawn is coded 0. The maximum recorded for the same plant was 3 different species.


(3)

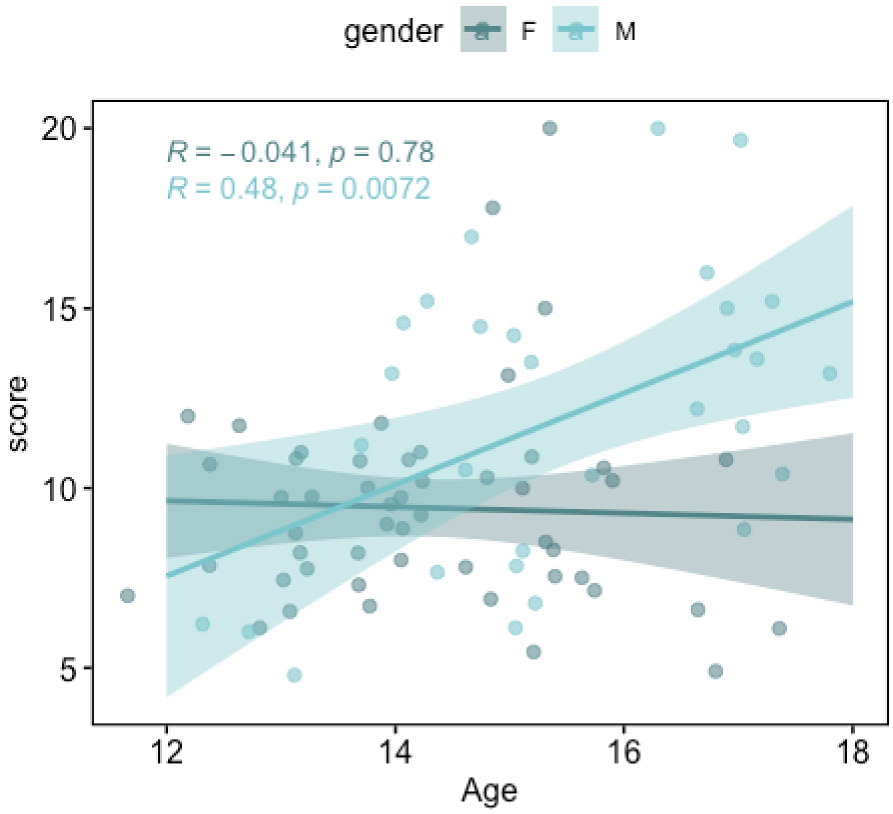
Uses (use)
We code "Uses" according to the presence or absence (0-1) of a human interaction with the drawn plant (e.g., gathering, preparation). Absence is coded 0 and presence is coded 1.


(1)


(1)



A2.S1 Figure. Analysis of the 80 drawings and 16 identification criteria (see **Table 4**) with Principal Component Analysis (PCA). **(A)** Variable contributions to the principal axes Dim 2,1 (left) and Dim 2,3 (right). Variable contributions follow a color gradient from the lowest (blue) to the highest (red). **(B)** Biplot of individuals (drawings) and variables that explain the three first axes Dim 2,1 (left) and Dim 2,3 (right). Barycenters of the clouds of points of individuals of each gender are represented, with their confidence interval (ellipse). Girls are indicated in blue-gray and boys in clear blue.



A2.S2 Figure. Relation between individual score of precision in drawing with age and gender. Scatter plot with linear regression. Girls are indicated in blue-gray and boys in clear blue.

A2.S1 Table. List of species drawn by children, wild edible plant (WEP), other plants and commensal animal species. All the plant species were identified on the field and in TAN herbarium by V.P. and SC.R. (see Porcher et al., 2022). Animal species were identified by V.P. using GBIF, zoology literature and local names were cross checked using the Dictionnaire encyclopédique malgache (Beaujardière, 2023). [Ethno.sp] indicates when the plant name refers to an ethnospecies and [Ethno.sp. Var] to a variety of ethnospecies. (*) indicates the endemic species, (UC) the unchecked taxa according to World flora Online (WFO). For animal species we indicate the (Class) with the family, we also indicate the sex by ♀ and ♂ when the sexual dimorphism of the species is reported in both drawings and interviews by children.

Betsileo	Latin	Family
Wild edible plant species represented (n=58)		
Akondro	*Musa ×paradisiaca* L.	Musaceae
Ampalibe	*Artocarpus heterophyllus* Lam.	Moraceae
Ana	*Solanum* sp. [Ethno.sp]	Solanaceae
Anadraza	*Solanum* sp. [Ethno.sp. Var]	Solanaceae
Anamamy	*Solanum nigrum* L.	Solanaceae
Apomgambendanitr a	*Punica granatum* L.	Lythraceae
Ara	*Ficus tiliifolia* Baker*	Moraceae
Fopoho	*Ficus trichoclada* Baker*	Moraceae
Goavy	*Psidium guajava* L.	Myrtaceae

Goavy tsinahy	*Psidium cattleianum* Afzel. ex Sabine	Myrtaceae
Grenadelle ala	*Passiflora subpeltata* Ortega	Passifloraceae
Hazota	*Phyllanthus fuscoluridus* var. *villosus* (Leandri) Ralim. & Petra Hoffm.*	Pyllanthaceae
Kilela	*Passiflora edulis* Sims	Passifloraceae
Kilenga	*Kalanchoe miniata* Hils. & Bojer ex Tul.*	Crassulaceae
Kimba	*Symphonia clusioides* Baker*	Clusiaceae
Kindaindaivola	*Gladiolus andringitrae* Goldblatt*	Iridaceae
Kisira kisira	*Oxalis corniculata* L.	Oxalidaceae
Kitonda	*Medinilla torrentum* Jum. & H. Perrier*	Melastomataceae
Lamoty	*Flacourtia ramontchi* L'herit	Salicaceae
Lanary	*Plagioscyphus stelechantus* (Radlk.) Capuron*	Sapindaceae
Longoza	*Hedychium coronarium* J.Koenig	Zingiberaceae
Magnesy	*Galinsoga parviflora* Cav.	Asteraceae
Manga	*Mangifera indica* L.	Anacardiaceae
Matanandro	*Centella asiatica* (L.) Urb.	Apiaceae
Melo hazo	*Phytolacca americana* L.	Phytolaccaceae
Menahy	*Erythroxylum nitidum* Baker*	Erythroxylaceae
Nakasimba	*Toddalia asiatica* (L.) Lam.	Rutaceae
Nonoka	*Ficus reflexa* Thunb.*	Moraceae
Paiso	*Prunus persica* (L.) Stokes	Rosaceae
Paoma	*Malus domestica* Baumg.	Rosaceae
Petity	*Pyracantha angustifolia* (Franch.) C.K.Schneid.	Rosaceae
Pibas	*Eriobotrya japonica* (Thunb.) Lindl.	Rosaceae
Raketa	*Opuntia monacantha* (Willd.) Haw.	Cactaceae
Roimbosa	*Lantana camara* L.	Verbenaceae
Rotsy	*Syzygium cumini* (L.) Skeels	Myrtaceae
Rotsy bory	*Syzygium bernieri* (Drake) Labat & G.E. Schatz*	Myrtaceae
Sakoa	*Sclerocarya birrea* (A.Rich.) Hochst.	Anacardiaceae
Seva	*Solanum mauritianum* Scop.	Solanaceae
Sevafotsy	*Buddleja madagascariensis* Lam.*	Scrophulariaceae
Singilofo	*Cynorkis speciosa* Ridl.*	Orchidaceae
Trakavola	*Bidens pilosa* L.	Asteraceae
Tsipoaka	*Bengt-jonsellia laurentii* (Jonsel) Al-Shehbaz*	Brassicaceae
Tsitsitrotroka	*Tristemma mauritianum* J.F.Gmel.	Melastomataceae
Vahobe	*Aloe conifera* H.Perrier*	Asphodelaceae
Voafotsy	*Aphloia theiformis* (Vahl) Benn.	Aphloiaceae
Voalady	*Psychotria* cf *isalensis* (Bremek.) A.P.Davis & Govaerts*	Rubiaceae
Voaloboka	*Cissus vitiginea* L.	Vitaceae

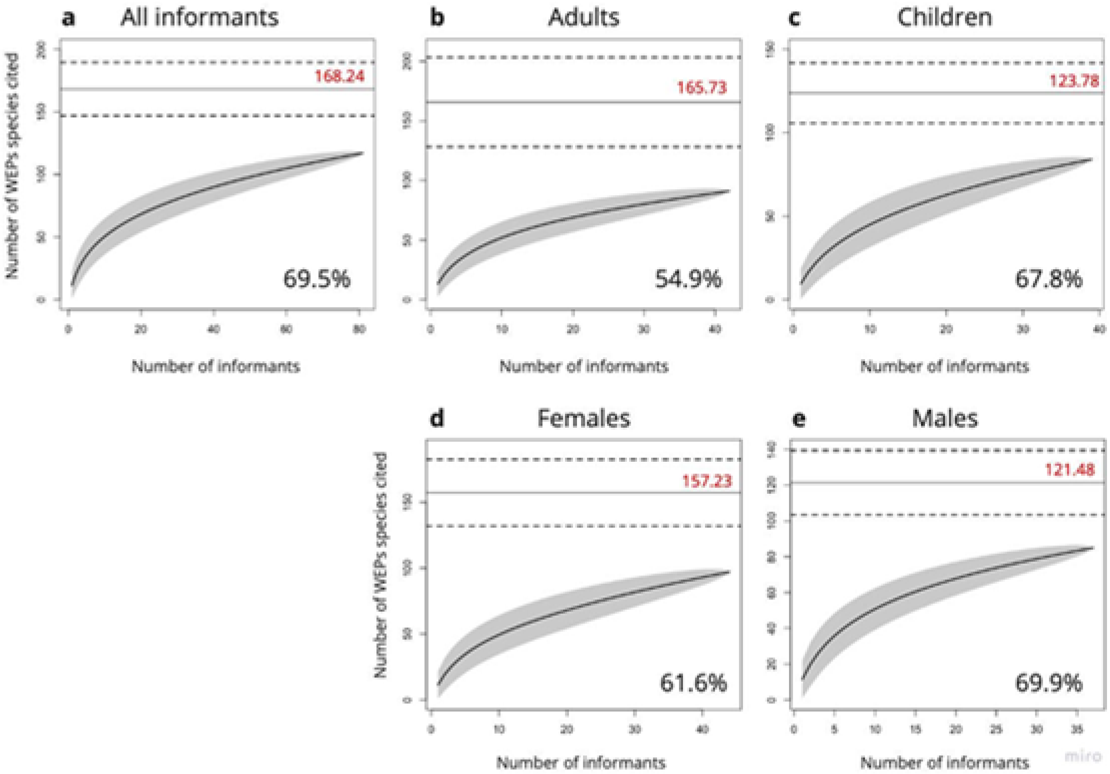
Voamorondrano	*Sorghum arundinaceum* (Desv.) Stapf	Poaceae
Voanaka	*Physalis peruviana* L.	Solanaceae
Voarafy	*Maesa lanceolata* Forssk.	Primulaceae
Voaroifotsy	*Rubus apetalus* Poir.	Rosaceae
Voaroihazo	*Morus alba* L.	Moraceae
Voaroitsaka	*Rubus rosifolius* Sm.	Rosaceae
Voaroy	*Rubus myrianthus* Baker*	Rosaceae
Voasary	*Citrus aurantiac*a Swingle	Rutaceae
Voatabiahazo	*Solanum insanum* L.	Solanaceae
Voatsitakajaza	*Vaccinium secundiflorum* Hook.*	Myrtaceae
Zamborizany	*Syzygium jambos* (L.) Alston	Myrtaceae
Non-WEP species represented (n=4)		
Belatsy	*Stephanotis floribunda* Brongn.* (**UC**)	Apocynaceae
Koaky	*Abrus precatorius* L.	Fabaceae
Tarambito	[Ethno.sp], brittle wood	Malvaceae
Vatsila	*Neocussonia longipedicellata* (Lecomte) Lowry, G.M.Plunkett, Gostel & Frodin*	Araliaceae
Animal species represented (n=19)		
Amboanala	*Hapalemur griseus* (Link, 1795)*	Lemuridae (Mammalia)
Amboanala	*Eulemur cinereiceps* (A.Grandidier & A.Milne-Edwards, 1890)* ♀ or *Eulemur rufifrons* (Bennett, 1833)*♀	Lemuridae (Mammalia)
Maki	*Lemur catta* Linnaeus, 1758*	Lemuridae (Mammalia)
Maroantrano	*Rattus rattus* (Linnaeus, 1758)	Muridae (Mammalia)
Fody laly	*Foudia madagascariensis* (Linnaeus, 1766)* ♂	Ploceidae (Aves)
Fody Favy	*Foudia madagascariensis* (Linnaeus, 1766)* ♀	Ploceidae (Aves)
Fona manga	*Alectroenas madagascariensis* (Linnaeus, 1766)*	Columbidae (Aves)
Fotsymaso	*Zosterops maderaspatanus* (Linnaeus, 1766)*	Zosteropidae (Aves)
Papanga	*Milvus migrans* (Boddaert, 1783)	Accipitridae (Aves)
Tsikirova	*Hypsipetes madagascariensis* (Statius Muller, 1776)*	Pycnonotidae (Aves)
Tsiotsiolady, Sohimanga	*Cinnyris sovimanga* (Gmelin, 1788)* ♂	Nectariniidae (Aves)
Voromdreo	*Atelornis crossleyi Sharpe*, 1875*	Brachypteraciidae (Aves)
Sitry	*Oplurus quadrimaculatus* Duméril & Bibron, 1851*	Opluridae (Squamata)

Tanalahy	*Furcifer lateralis* (Gray, 1831)	Chamaeleonidae (Squamata)
Angidina	-	Libellulidae (Insecta)
Bikitse	cf *Crematogaster* Lund, 1831	Formicidae (Insecta)
Landibe	*Borocera cajani* Vinson, 1863*	Lasiocampidae (Insecta)
Lolo	-	Papilionidae (Insecta)
Renitantely	*Apis mellifera* Linnaeus, 1758	Apidae (Insecta)
Tataro	*Phymateus saxosus* Coquerel, 1861*	Pyrgomorphidae (Insecta)

A.3 Supplementary material Chapter IV

A3.S1 Table. Habitat variable description.

Shrubby Secondary Vegetation (SSV)	Including a mosaic of secondary regrowth vegetation both woody and shrubby mainly open and colonized by ferns.
Grassy Secondary Vegetation (GSV)	including village surroundings, home garden, pastures and crops fields.
Mountain Forest (MF)	including moist altitude dense forest (1500 - 1800m) and sclerophyllous moist forest (1800 – 2000m).
Highland Vegetation (HV)	including altimontane meadows, ericoid thickets (2100m) and rupicolous vegetation (2500m).
Wetland (WET)	including paddy rice, pond and canal.



A3.S1 Figure. Accumulation curves of WEPs species and sampling completeness. a. full dataset with all informants, b. adults, c. children, d. females and e. males. The red number indicates the richness expected, calculated with Chao2 estimator. The percentage indicates the sampling completeness i.e., the ratio between observed and expected richness.

A3.S2 Table. Relation between habitat and the biogeographical characteristic of the WEPs (MANOVA)

Factor	Df	Sum of Squares	Mean Square	F value	p-value
Endemic					
HV	1	147.000	147.000	53.5186	1.266e-09 ***
MF	1	252.039	252.039	91.7607	3.063e-13 ***
SSV	1	24.504	24.504	8.9213	0.004232 **
Introduced					
HV	1	62.946	62.946	29.2018	1.509e-06 ***
SSV	1	125.000	125.000	57.9899	4.135e-10 ***
GSV	1	180.348	180.348	83.6663	1.456e-12 ***
Native					
HV	1	46.667	46.667	24.8868	6.672e-06 ***
MF	1	66.255	66.255	35.3328	2.096e-07 ***
SSV	1	10.843	10.843	5.7827	0.01964 *
GSV	1	45.100	45.100	24.0515	8.989e-06 ***

A3.S3 Table. Multivariate analysis of variance (MANOVA) of characteristics of the WEPs cited with gender and life stage of informants. MF=mountain forest, SSV=shrubby anthropogenic vegetation.

Variables	Factors	Df	Sum of Squares	Mean Square	F value	p-value
Plant life forms						
Shrubs	life stage	1	9.539	9.5391	4.5735	0.03564 *
	gender	1	2.465	2.4650	1.1819	0.28037
	life stage*gender	1	6.952	6.9517	3.3330	0.07178 .
Herbaceous	life stage	1	33.33	33.333	4.5521	0.03606 *
	gender	1	25.51	25.514	3.4842	0.06576 .
	life stage*gender	1	30.60	30.600	4.1788	0.04435 *
Tree	life stage	1	28.484	28.4835	9.4054	0.002984 **
	gender	1	4.066	4.0663	1.3427	0.250136
	life stage*gender	1	0.262	0.2617	0.0864	0.769593
Climbers	life stage	1	7.704	7.7038	4.5352	0.0364 *
	gender	1	1.818	1.8183	1.0704	0.3041

	life stage*gender	1	2.670	2.6696	1.5716	0.2138
Part consumed						
Fruit	life stage	1	46.73	46.730	6.0180	0.01642 *
	gender	1	10.77	10.768	1.3868	0.24258
	life stage*gender	1	9.50	9.501	1.2235	0.27211
Leaves	life stage	1	13.493	13.4931	9.6538	0.002646 **
	gender	1	0.119	0.1185	0.0848	0.771686
	life stage*gender	1	2.420	2.4197	1.7312	0.192165
Tuber	life stage	1	15.176	15.1763	15.6736	0.0001665 ***
	gender	1	2.994	2.9940	3.0921	0.0826481 .
	life stage*gender	1	0.260	0.2604	0.2690	0.6055089
Whole	life stage	1	3.651	3.6511	1.2407	0.26880
	gender	1	28.855	28.8545	9.8055	0.00246 **
	life stage*gender	1	5.599	5.5989	1.9026	0.17178
New shoots	life stage	1	0.2692	0.269231	1.7891	0.1850
	gender	1	0.0315	0.031487	0.2092	0.6487
	life stage*gender	1	0.1118	0.111849	0.7432	0.3913
Seeds	life stage	1	0.0043	0.004341	0.0369	0.8482
	gender	1	0.1921	0.192108	1.6327	0.2052
	life stage*gender	1	0.2496	0.249563	2.1210	0.1494
Nectar	life stage	1	0.0570	0.057048	0.8097	0.37102
	gender	1	0.0737	0.073704	1.0461	0.30961
	life stage*gender	1	0.2466	0.246583	3.4998	0.06518
Habitats						
MF	life stage	1	73.369	73.369	30.5634	4.25e-07 ***
	gender	1	2.857	2.857	1.1901	0.2787
	life stage*gender	1	0.587	0.587	0.2447	0.6223

SSV	life stage	1	11.795	11.7955	5.8688	0.01776 *
	gender	1	2.220	2.2198	1.1044	0.29658
	life stage*gender	1	0.113	0.1135	0.0564	0.81283
GSV	life stage	1	2.55	2.5530	0.3063	0.5816
	gender	1	14.50	14.4958	1.7390	0.1912
	life stage*gender	1	6.52	6.5232	0.7825	0.3791
HV	life stage	1	1.292	1.2918	1.1067	0.29610
	gender	1	0.880	0.8797	0.7536	0.38803
	life stage*gender	1	3.502	3.5022	3.0003	0.08725 .
WET	life stage	1	0.0299	0.029915	0.1891	0.6648
	gender	1	0.0131	0.013106	0.0829	0.7742
	life stage*gender	1	0.0009	0.000859	0.0054	0.9414
Biogeography						
Endemic	life stage	1	166.56	166.564	30.3341	4.626e-07 ***
	gender	1	33.45	33.452	6.0922	0.0158 *
	life stage*gender	1	1.79	1.794	0.3268	0.5692
Native	life stage	1	17.026	17.0263	4.5473	0.03616 *
	gender	1	2.027	2.0268	0.5413	0.46413
	life stage*gender	1	1.528	1.5278	0.4080	0.52486
Introduced	life stage	1	1.18	1.1819	0.1822	0.6707
	gender	1	10.81	10.8114	1.6664	0.2006
	life stage*gender	1	0.01	0.0055	0.0008	0.9768

A.4 Supplementary material Chapter V

Supplementary Method S1. Guideline for the free listing and semi-structured interviews.

<u>Step 1: Free listing</u>
Because people of the study area do not have a unique term for the concept "wild edible plants'', our prompt for free listing was: "Which non-cultivated plants do you know that are *edible*?" We used the word *sakafo*, which means food, meal or edible.

The informant gives a list of WEP species, e.g.: "*sp* a", "*sp* b", "*sp* c", "*sp* d", "*sp* e"...

<u>Step 2: semi structured interviews</u>
The semi structured interviews conducted right after the free listing aim to collect two different type of information 1) on botanical knowledge et on 2) practical knowledge.

1) Botanical knowledge:
- Could you name the different part consumed of the WEP you just cited?
- and explain me whether they provided food, water, or both? (For all the WEP cited).

2) practical knowledge:
- Among the different WEP you just cited, could you tell me which are the three most important to you?

The informant gives a list of the tree most important WEP species, e.g.: "*sp* b", "*sp* c" and "*sp* e"

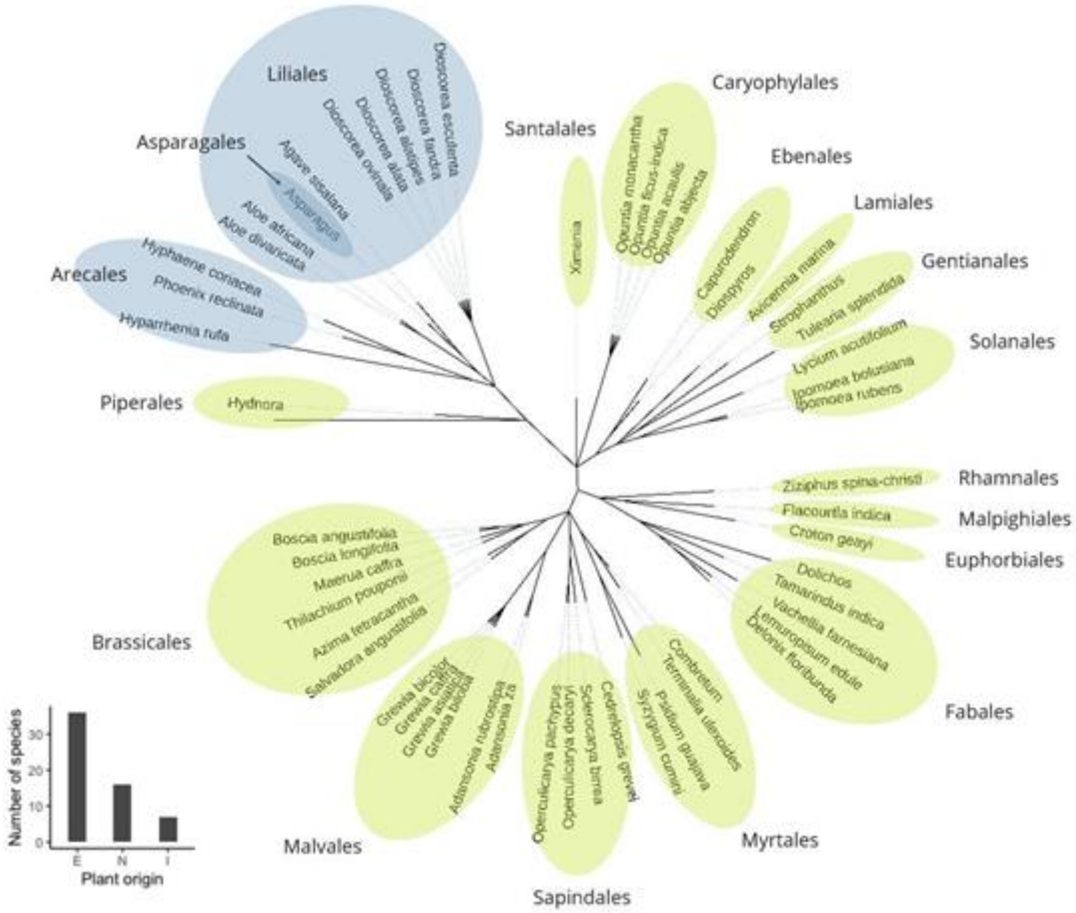
Then for each of the tree WEP, we ask the following question:
- Why this WEP is to most important according to you?
- Could you explain me how do you collect this plant?
- And how do you prepare this plant?

A4.S1 Table. Wild edible plants known by subsamples. C= children, A=adults, F=females, M=males. (x) indicates when a WEP species is known by a subsample. (*) indicates endemic species. [ ] indicates when the local name designates the whole genus.

Local name	species	Family	C	A	F	M
Kasy	*Acacia farnesiana* (L.) Willd.	Fabaceae		x	x	
Fony	*Adansonia rubrostipa* Jum. & H.Perrier*	Malvaceae	x	x	x	x
Za	*Adansonia za* Baill.*	Malvaceae		x	x	
Laloasy	*Agave sisalana* Perrine	Asparagaceae		x		x
Sosy	*Aloe antandroi* (R.Decary) H. Perrier*	Xanthorrhoeaceae	x			x
Vahomdrandro	*Aloe divaricata* A. Berger*	Xanthorrhoeaceae	x			x
Fio	*Asparagus calcicola* H. Perrier*	Asparagaceae		x		x
Afiafy	*Avicennia marina* (Forssk.) Vierh.	Acanthaceae	x			x
Tsingilo	*Azima tetracantha* Lam.	Salvadoraceae	x	x	x	x

Lalangy	*Boscia angustifolia* A.Rich.	Capparaceae	x	x	x	x
Paky	*Boscia longifolia* Hadj-Moust.*	Capparaceae	x	x	x	x
Hozondragy	*Capurodendron* sp.*	Sapotaceae		x		x
Katrafay	*Cedrelopsis grevei* Baill.*	Rutaceae	x	x		x
Kapiknala, Tamenaky	*Combretum grandidieri* Drake*	Combretaceae	x	x		x
Pisopiso	*Croton geayi* Leandri*	Euphorbiaceae		x		x
Fengoky	*Delonix floribunda* (Baill.) Capuron*	Fabaceae	x	x	x	x
Ovy	*Dioscorea alatipes* Burk. & H. Perr.*	Dioscoreaceae	x	x	x	x
Baboky	*Dioscorea bemandry* Jum. & H.Perrier*	Dioscoreaceae	x	x	x	x
Andraha	*Dioscorea fandra* H.Perrier*	Dioscoreaceae		x		x
Fandra	*Dioscorea nako* H.Perrier*	Dioscoreaceae	x	x	x	x
Angily	*Dioscorea ovinala* Baker*	Dioscoreaceae		x	x	x
Raiboky	*Diospyros humbertiana* H. Perrier*	Ebenaceae	x			x
Fivikakanaga	*Diospyros manampetsae* H.Perrier*	Ebenaceae		x		x
Sasimotsy	*Diospyros* sp.*	Ebenaceae	x	x		x
Fangitsy	*Dolichos fangitsa* R.Vig *	Fabaceae		x		x
Lamoty	*Flacourtia indica* (Burm. f.) Merr.	Salicaceae	x	x	x	x
Malimatsy	*Grewia barorum* Capuron*	Malvaceae		x		x
Selim-pasy	*Grewia cyclea* Baill.*	Malvaceae	x	x	x	x
Sely	*Grewia leucophylla* Capuron**Grewia humblotii* Baill.*	Malvaceae	x	x	x	x
Fotilambo	*Grewia humblotii* Baill.*	Malvaceae	x		x	
Hazofoty	*Grewia microcyclea* (Burret) Capuron & Mabb.*	Malvaceae	x	x	x	x
Voantany	*Hydnora esculenta* Jum. & H. Perrier	Hydnoraceae	x	x	x	x
Sy	*Hyparrhenia rufa* (Nees) Stapf*	Poaceae	x		x	
Lohagogo	*Hyphaene coriacea* Gaertn.*	Arecaceae	x		x	
Moky	*Ipomoea bolusiana* Schinz*	Convolvulaceae	x	x	x	x
Korimoky	*Ipomoea longituba* Hallier f.	Convolvulaceae		x		x

Velahy	*Ipomoea rubens* Choisy	Convolvulaceae	x	x	x	x
Tara	*Lemuropisum edule* H.Perrier*	Fabaceae		x		x
Tsikororova	*Lycium acutifolium* E. Mey. ex Dunal	Solanaceae	x	x	x	x
Somangy	*Maerua filiformis* Drake*	Capparaceae	x	x	x	x
Jabihy	*Operculicarya decaryi* H. Perrier*	Anacardiaceae	x			x
Boritotsy	*Opuntia dillenii* (Ker Gawl.) Haw.	Cactaceae	x	x		x
Raketa	[*Opuntia* Mill.]	Cactaceae	x	x	x	x
Viro, Viro mena	*Opuntia monacantha* (Willd.) Haw.	Cactaceae	x	x	x	x
Vilovilo	*Opuntia streptacantha* Lem.	Cactaceae	x			x
Raketa mena, Mavozoloky	*Opuntia stricta* (Haw.) Haw.	Cactaceae	x	x	x	x
Asendry	*Phoenix reclinata* Jacq.	Arecaceae	x	x	x	
Goavy	*Psidium guajava* L.	Myrtaceae		x		x
Sakoa Komoky	*Poupartia minor* (Bojer) L. Marchand*	Anacardiaceae	x	x	x	x
Lalondo	*Roupellina boivinii* (Baill.) Pichon*	Apocynaceae	x			x
Sasavy	*Salvadora angustifolia* Turill	Salvadoraceae	x	x	x	x
Sakoa (diro / manga)	*Sclerocarya birrea* (A.Rich.) Hochst.	Anacardiaceae	x	x	x	x
Rotsy, Motsoky	*Syzygium cumini* (L.) Skeels	Myrtaceae	x	x	x	x
Kily	*Tamarindus indica* L.	Fabaceae	x	x	x	x
Fatra	*Terminalia ulexoides* H. Perrier*	Combretaceae	x	x	x	x
Kororoky	*Thilachium pouponii* Aubrév. & Pellegr.*	Capparaceae	x	x	x	x
Falianara	*Tulearia splendida* De Block*	Rubiaceae	x		x	
Tabozebozety	unknow	unknow	x		x	
Tavenala	unknow	unknow		x		x
Kotro	*Ximenia perrieri* Cavaco & Keraudren*	Ximeniaceae		x		x
Tsinefo	*Ziziphus spina-christi* (L.) Willd.	Rhamnaceae	x	x	x	x
Total of WEP species known by groups			45	49	#	#



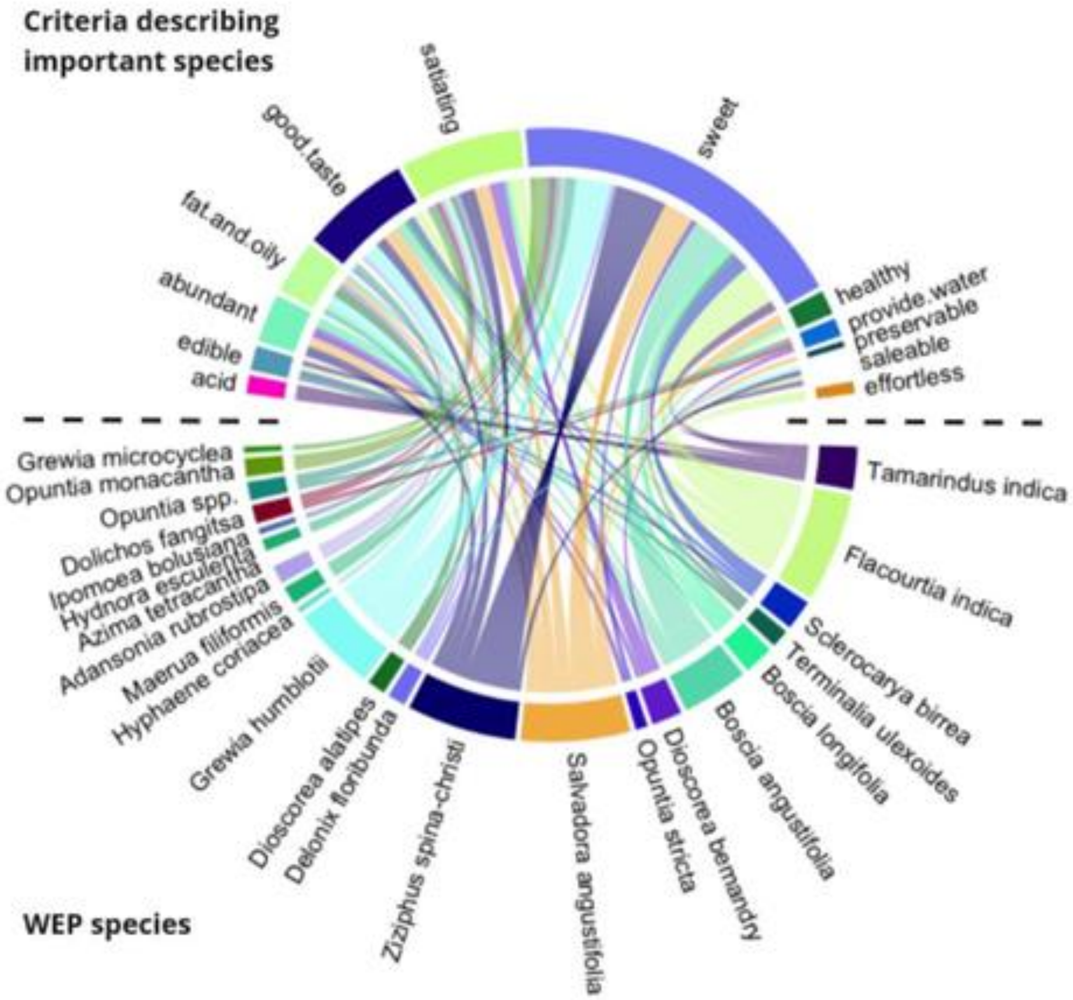
A4.S1 figure. Taxonomic diversity and origin of wild edible plant species known by Tanalana people. Unrooted phylogenetic tree based on the NCBI taxonomy database, generated with phyloT. Each ellipse represents a distinct order. Blue ellipses indicate monocots (Liliopsida). Bar plot displaying the proportion of (E) endemic (n=36 sp), (N) native (n=16 sp) and (I) introduced species (n=7sp).

A4.S2 Table. Sampling completeness results for each estimator. With Jack1=first-order Jackknife and jack2=second-order jackknife. We chose to keep the bootstrap estimator closer to reality; the other estimators were too sensitive to the small sample, despite the bias correction, displaying a higher expected richness for children.

Estimators	**Chao2**	Chao2 .se	**Jack1**	Jack1 . se	**Jack2**	**Bootstrap**	Bootstrap .se
Adults	70.05	11.04	69.05	5.99	77.47	60.34	3.71
Children	184.52	111.27	71.58	9.23	91.11	58.05	4.45
Female	52.36	8.33	53.23	4.77	58.91	46.73	2.93
Male	90.22	17.96	80.72	8.11	94.47	68.40	4.36

A4.S3 Table. Chi-squared results for WEP characteristics distribution between gender and life stages.

Characteristics	Subsamples	Chi-squared	df	p-value
Life forms	Life stages	12.286	8	0.1389
	Gender	11.607	8	0.1696
Water	Life stages	7.081	6	0.3134
	Gender	3.4451	3	0.3281
Food	Life stages	11.541	8	0.1729
	Gender	13.311	8	0.1016



A4.S2 figure. Chord diagram of WEP species locally considered as important and the criteria used to describe them. The chord diagram has been made using the R package ethnobotanyR.

A4.S4 Table. Criteria defining WEP as important. Frequency of citation of terms used by category, life stages and gender.

	Life stages		Gender	
Criteria	**Children**	**Adults**	**Female**	**Male**
Organoleptic	**42**	**42**	**27**	**37**
sweet	20	25	22	23
acid	1	1	0	2
good taste	11	6	5	12
Nutritional	**10**	**27**	**12**	**25**
edible	3	1	0	4
fat and oily	4	4	3	5
satiating	3	15	8	10
healthy	0	4	1	3
provide water	0	3	0	3
Food accessibility	**1**	**9**	**1**	**9**
abundant	0	8	1	7
effortless	1	1	0	2
Economic	**0**	**3**	**2**	**1**
saleable	0	3	2	1
Food security	**0**	**1**	**1**	**0**
preservable	0	1	1	0

A4.S5 Table. Preparation methods

	Description of the preparation method	**Species**
P1	The whole is eaten raw. The non-edible part is removed with no specific technique (ex: peel off the skin with a knife or twigs for the *Opuntia* spp.).	*Boscia angustifolia* A.Rich.
		Boscia longifolia Hadj-Moust.
		Capurodendron sp.
		Delonix floribunda (Baill.) Capuron
		Dioscorea bemandry Jum. & H.Perrier
		Diospyros manampetsae H.Perrier
		Diospyros sp.
		Flacourtia indica (Burm. f.) Merr.
		Grewia cyclea Baill.
		Grewia leucophylla Capuron

		Grewia microcyclea (Burret) Capuron & Mabb. *Hyphaene coriacea* Gaertn. *Ipomoea longituba* Hallier f. *Lycium acutifolium* E. Mey. ex Dunal *Maerua filiformis* Drake [*Opuntia* Mill.] *Opuntia monacantha* (Willd.) Haw. *Opuntia stricta* (Haw.) Haw. *Phoenix reclinata* Jacq. *Salvadora angustifolia* Turill *Sclerocarya birrea* (A.Rich.) Hochst. *Tamarindus indica* L. *Terminalia ulexoides* H. Perrier *Ximenia perrieri* Cavaco & Keraudren *Ziziphus spina-christi* (L.) Willd.
P2	The juice is pressed out of the fruit and drunk without specific techniques or preparation.	*Salvadora angustifolia* Turill
P3	The juice is collected in a bucket after letting the fruit open for a few days. During this phase, the fruit rips by itself until melting and giving a drinkable juice. This juice can be consumed with rice or cassava.	*Boscia longifolia* Hadj-Moust.
P4	When the fruits are still green, they can be eaten after being ground between two stones to obtain a coarse powder and add a little salt. The powder can be mixed with water or eaten as a condiment on top of staple food.	*Delonix floribunda* (Baill.) Capuron *Tamarindus indica* L.
P5	The tubers are grilled or roasted. The skin can be removed before or after cooking, this changes the taste of the flesh of the tuber.	*Dioscorea bemandry* Jum. & H.Perrier *Dioscorea nako* H.Perrier *Dolichos fangitsa* R.Vig. *Ipomoea bolusiana* Schinz

P6	The "water tubers" are pressed until the water comes out. This can be done by pressing it in a bucket using the sugar cane press (between two crenellated wooden rollers). The water is used for drinking, showering and washing dishes. One hundred tubers of *Dolichos fangitsa* can produce 50-60 liters of water.	*Dolichos fangitsa* R.Vig *Dioscorea bemandry* Jum. & H.Perrier
P7	The fruit of *Tamarindus indica* is used as a fermentation agent to coagulate goat's milk. The ripe fruit coating is removed by hand before the fruit pulp is bottled with the goat milk. After a few days to a week (depending on the temperature), the fruit pulp is removed from the bottle and the curd can be consumed.	*Tamarindus indica* L.
P8	To ripen *Phoenix reclinata* fruits: The green fruits are harvested, put in a bucket with water, and placed in the sun for one day. The fruits then become softer and can be eaten.	*Phoenix reclinata* Jacq.
P9	The ripe fruits of the jujube are washed and put in the basket with sugar and dried 2 to 3 days in the sun before being consumed.	*Ziziphus spina-christi* (L.) Willd.
P10	After peeling the skin of the tuber. The consumed part is boiled for several hours, sometimes overnight, to detoxify the tuber (ex: *Ipomoea bolusiana* see P11).	*Dioscorea alatipes* Burk. & H. Perr. *Dioscorea bemandry Jum. & H.Perrier* *Ipomoea bolusiana* Schinz
P11	After pounding the skin of the tuber of *Ipomoea bolusiana*, it is boiled for several hours to detoxify it. Once finished, the tuber can be consumed with goat's milk to give it a better taste.	*Ipomoea bolusiana* Schinz
P12	The fruits of *Ziziphus spina-christi* can be cooked with water and sugar for several hours to make a marmalade. Locally appreciated, this jujube jam can be stored for several months once canned.	*Ziziphus spina-christi* (L.) Willd.
P13	Preparation of the unripe tuber of *Hydnora esculata*. First the part of the tuber (gynoecium) is cleaned, the lower part connected to the stem and the upper part (rest of the flower) is removed. With a knife, the tuber is dug, and the flesh is removed and cut into small pieces. The cubed white flesh is put back into the empty tuber, mixed with milk and eaten with a spoon.	*Hydnora esculata* Jum. & H. Perrier
P14	The dry seeds and flesh are put in a plastic bottle and soaked with water and ash or white clay or sugar (there are several complex versions), then shaken before being drunk without the seeds. The purpose of this preparation is to reduce the acidity of the fruit such as *Tamarindus indica*.	*Tamarindus indica L.*

P15	Preparation of a "takoly": The fruits are squeezed in a bucket to extract the juice while adding a little water, then the juice is filtered to remove lumps and cooked only after four days. Once cooked, the juice becomes solid and can be eaten with cassava or rice as a dish. In this solid form, *Takoly* can be stored for over a year.	*Boscia angustifolia* A.Rich. *Salvadora angustifolia Turill*
P16	Making alcohol from "lamoty": Fresh green fruits are harvested, pressed and the seeds removed. Then they are mixed with a little sugar and water and left to ferment for 4-5 days in the bucket. After that, the distillation process can begin without a home-made still. The alcohol is then bottled and can be stored for years. *Flacourtia indica*, is also used as a medicinal plant. The branches are boiled, and the broth is drunk by the woman after giving birth to newborns to recover.	*Flacourtia indica* (Burm. f.) Merr.

A.5 List of Publications

Besides the three chapters of this dissertation, during my PhD I have led or participated as co-author in the following four scientific publications (peer-reviewed articles and book chapters):

Schunko, C., Li, X., Klappoth, B., Lesi, F., **Porcher, V**., Porcuna-Ferrer, A., & Reyes-García, V. (2022). Local communities' perceptions of wild edible plant and mushroom change: a systematic review. Global Food Security, 32, 100601.

Miara, M. D., Negadi, M., Tabak, S., Bendif, H., Dahmani, W., Ait Hammou, M., Sahnoun, T., Snorek, J., **Porcher, V.**, Reyes-García, V., & Teixidor-Toneu, I. (2022). Climate change impacts can be differentially perceived across time scales: A study among the Tuareg of the Algerian Sahara. GeoHealth, 6(11), e2022GH000620.

Reyes-García, V., Álvarez-Fernández, S., Benyei, P., García-del-Amo, D., Junqueira, A. B., Labeyrie, V., Li, X., **Porcher, V.**, Porcuna-Ferrer, A., Schlingmann, A., & Soleymani, R. (2023). Local indicators of climate change impacts described by indigenous peoples and local communities: Study protocol. *PloS one*, *18*(1), e0279847.

Chambon, M., Minarro, S., Alvarez Fernandez, S., **Porcher, V**., Reyes-Garcia, V., Tonalli Drouet, H., & Ziveri, P. (2023). A Synthesis of Women's Participation in Small-Scale Fisheries Management: Why Women's Voices Matter. *Fish and Fisheries* (accepted, pending minor revisions)

En argot les hommes appellent les oreilles des feuilles
c'est dire comme ils sentent que les arbres connaissent la musique
mais la languie verte des arbres est un argot bien plus ancien
Qui peut savoir ce qu'ils disent lorsqu'ils parlent des humains
Les arbres parlent arbre comme les enfants parlent enfant
Quand un enfant de femme et d'homme adresse la parole à un arbre

l'arbre répond
l'enfant l'entend
Plus tard l'enfant
parle arboriculture
avec ses maîtres et ses parents
Il n'entend plus la voix des arbres
il n'entend plus leur chanson dans le vent

Jacques Prévert (1900 – 1977)