DIVERSITY AND ORIGINS OF CANARY ISLANDS PSYLLOIDEA

SASKIA BASTIN

CHARGÉ DE PROJET SCIENTIFIQUE ET TECHNIQUE EN ENTOMOLOGIE ET BOTANIQUE
UNITÉ ENTOMOLOGIE ET BOTANIQUE
LABORATOIRE DE LA SANTÉ DES VÉGÉTAUX
AGENCE NATIONALE DE SÉCURITÉ SANITAIRE DE L'ALIMENTATION, DE L'ENVIRONNEMENT ET DU TRAVAIL

Psyllids

- Order: Hemiptera
  - Suborder: **Sternorrhyncha**
    - Superfamilly: **Psylloidea**

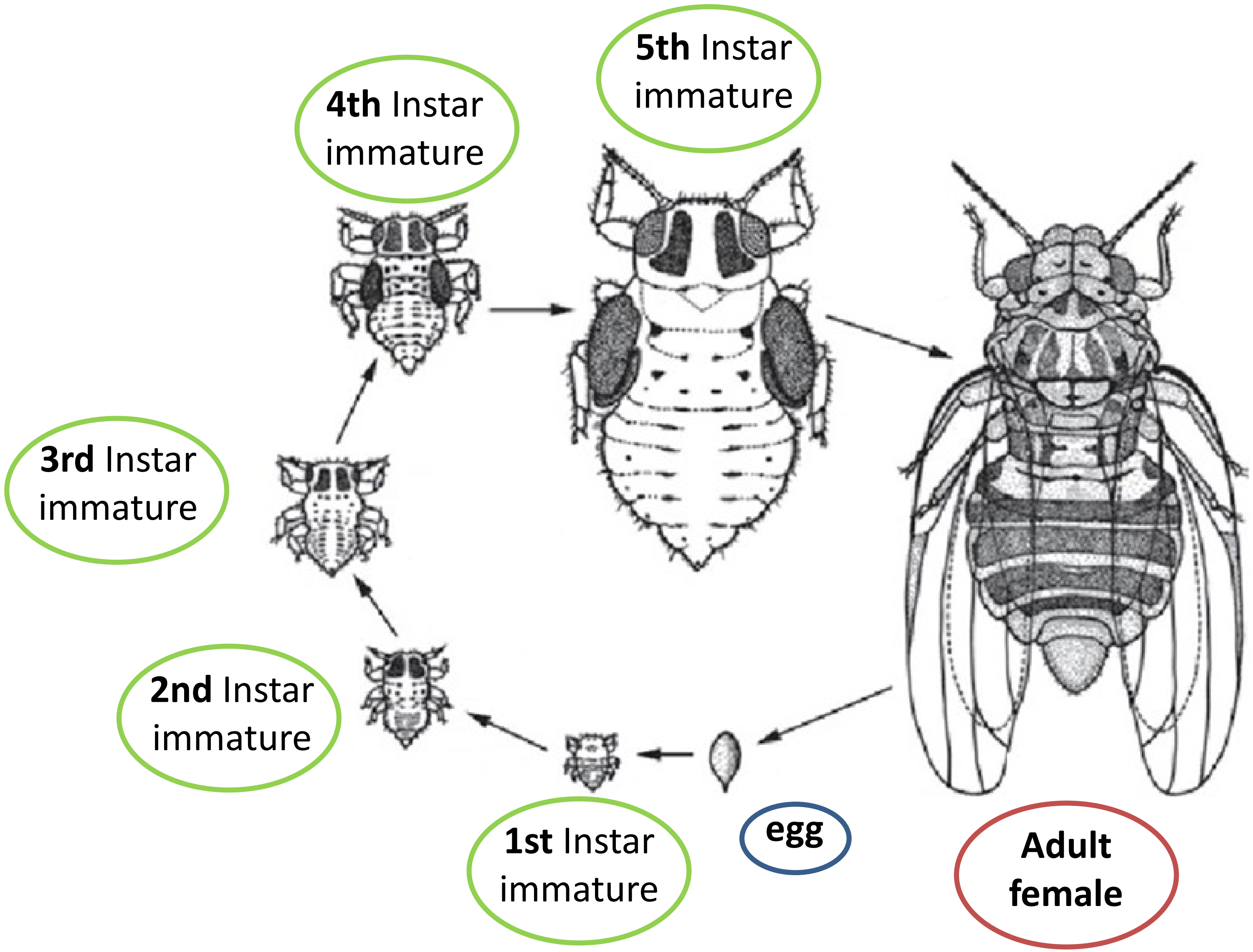
- **Small phloem-feeding insects** (1-10 mm)

- ca. **4000** described species worldwide

- **Highly host specific**
  (>> monophagous, > oligophagous,
  <<<< polyphagous)

- **Closely related** psyllid species develop on **closely related** host plants

Life cycle



egg

1st Instar immature

2nd Instar immature

3rd Instar immature

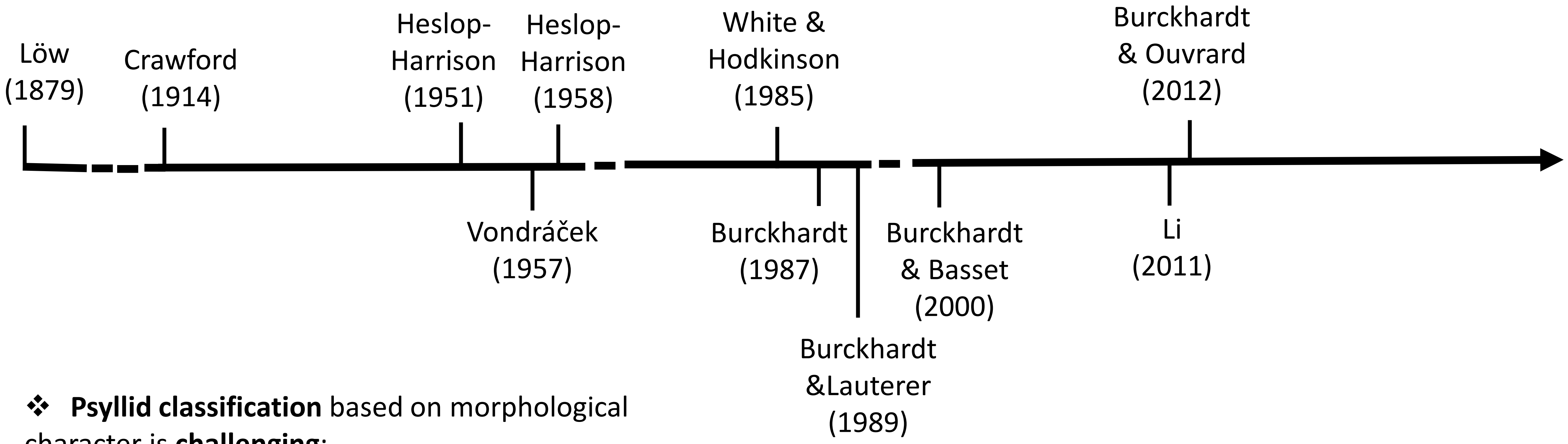
4th Instar immature

5th Instar immature

Adult female

Psyllids

Systematic



❖ **Psyllid classification** based on morphological character is **challenging**:

→ **lack of** clear morphological **synapomorphies**

→ **high level of homoplasy** in morphological characters

Need molecular data to resolve phylogeny of psyllids

Introduction

Löw (1879)

Crawford (1914)

Heslop-Harrison (1951)

Vondráček (1957)

Heslop-Harrison (1958)

White & Hodkinson (1985)

Burckhardt (1987)

Burckhardt &Lauterer (1989)

Burckhardt & Basset (2000)

Li (2011)

Burckhardt & Ouvrard (2012)

Percy et al., (2018)

Cho et al., (2019)

Burckhardt et al. (2021)

First extensive molecular phylogeny across all families of Psylloidea

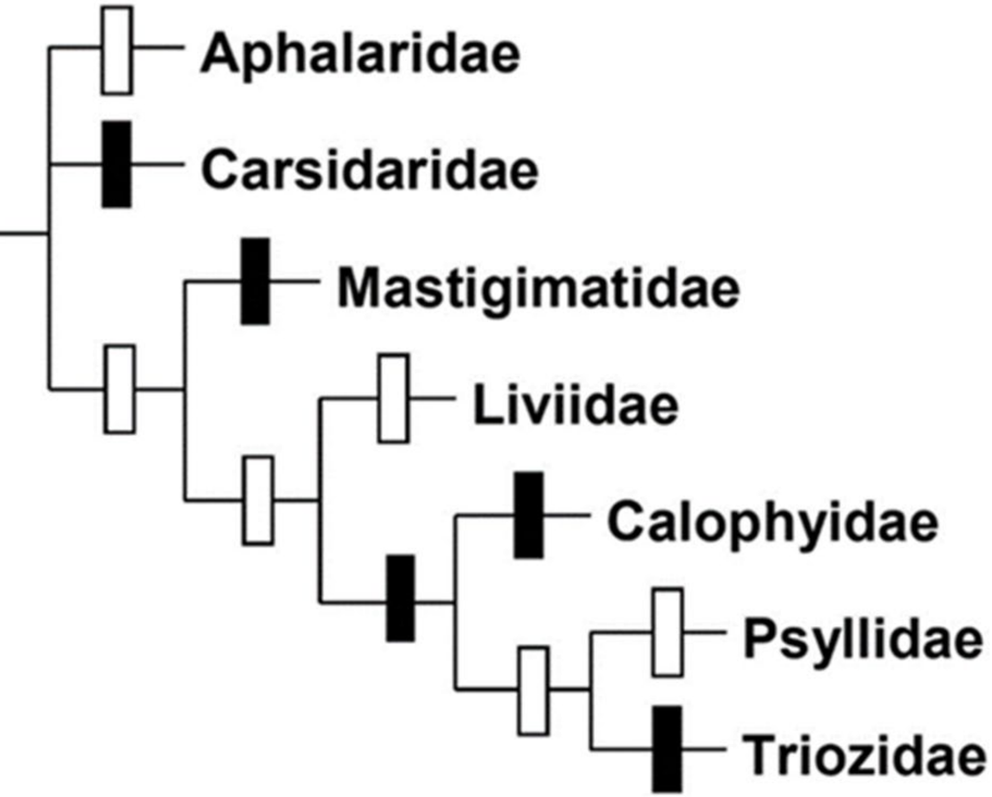
Percy et al., (2018) 400 species from almost 100 genera in all the families of psyllids

Cho et al., (2019) 56 species focused on east Palaearctic/Oriental taxa

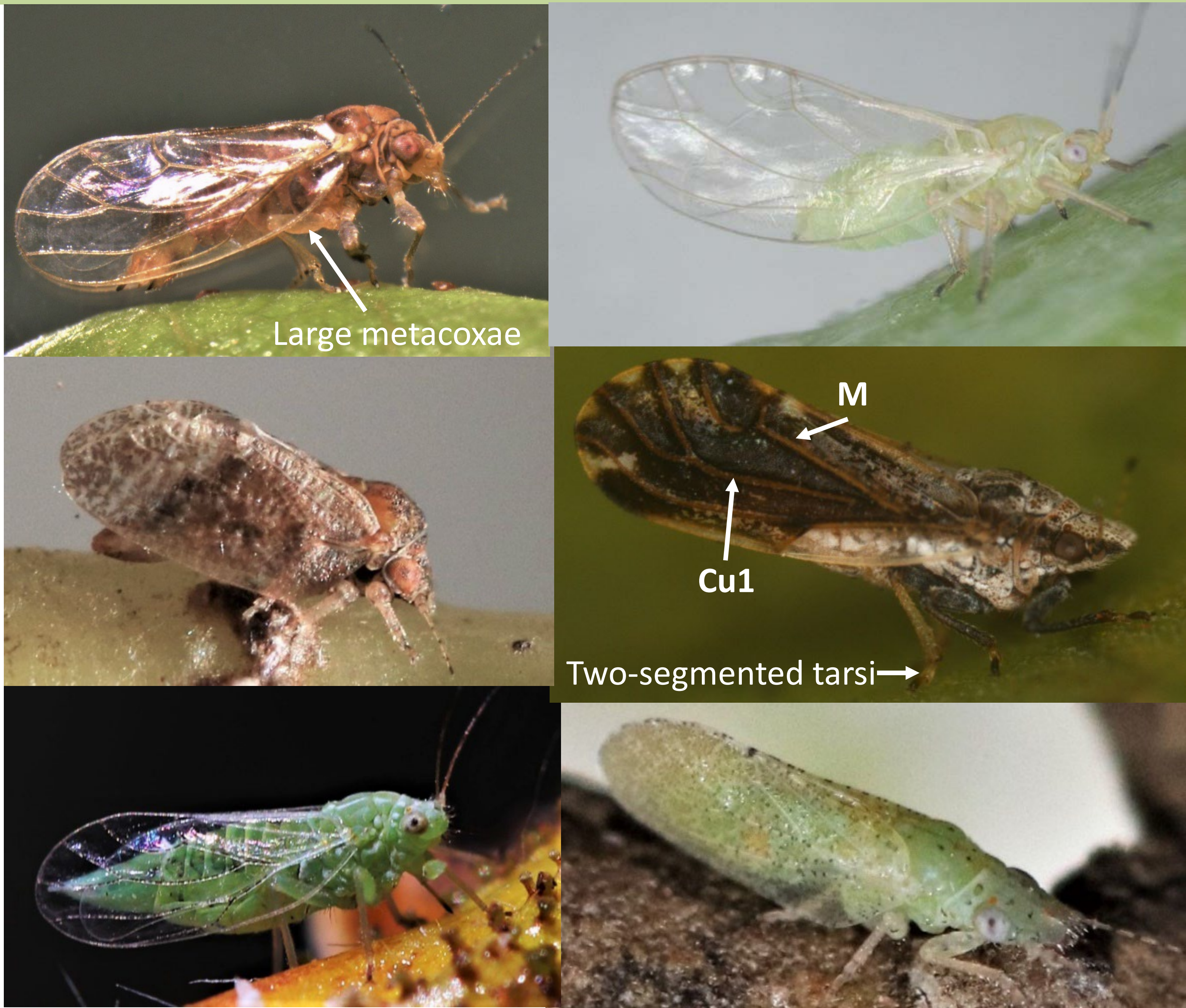
→ Importance of host plant associations

Introduction

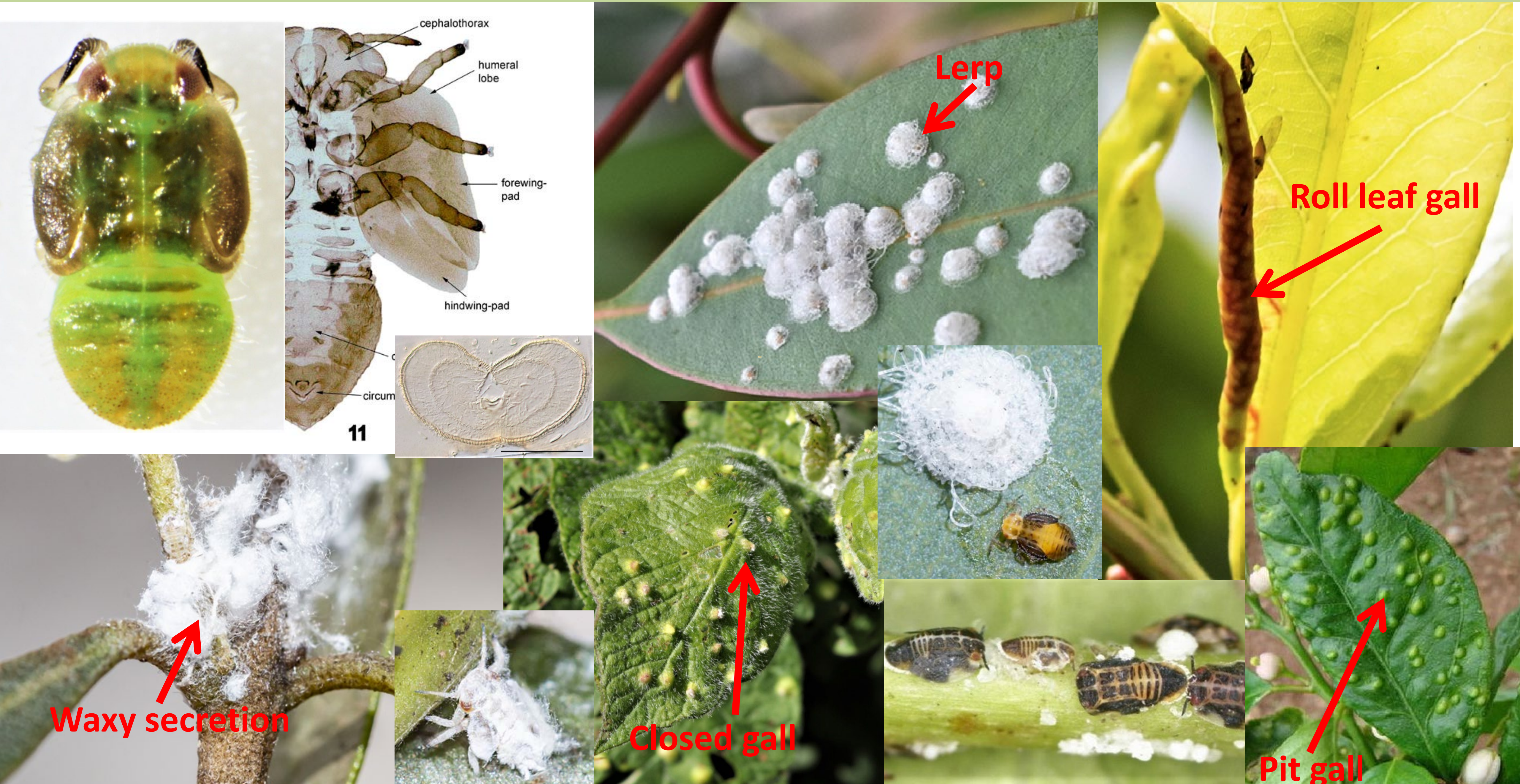
Currently 7 families



Cladogram representation of the classification of Psylloidea (**Burckhardt et al., 2021**)



Introduction

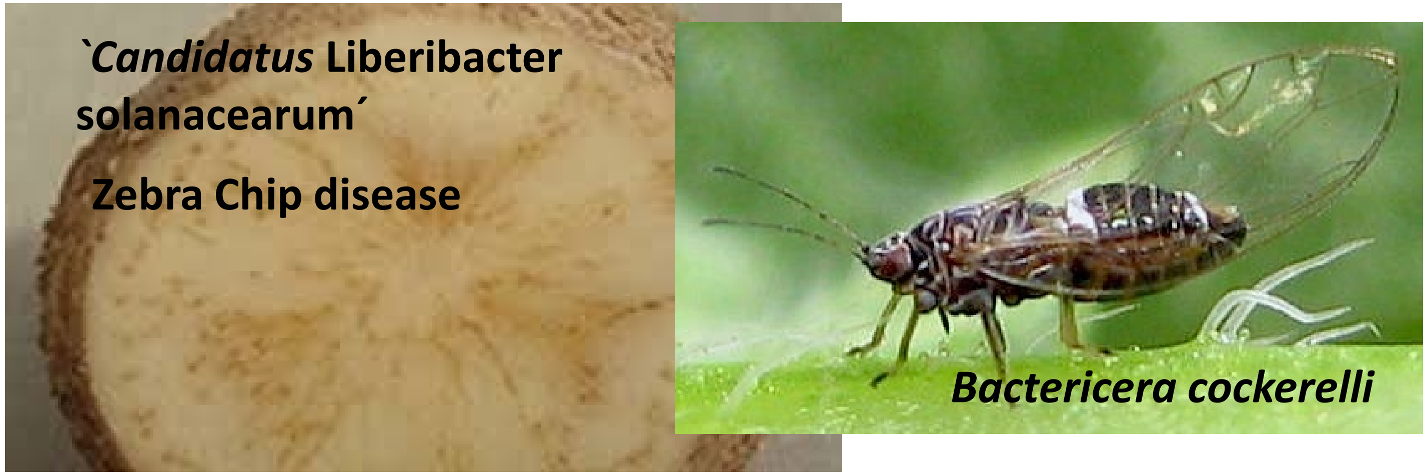


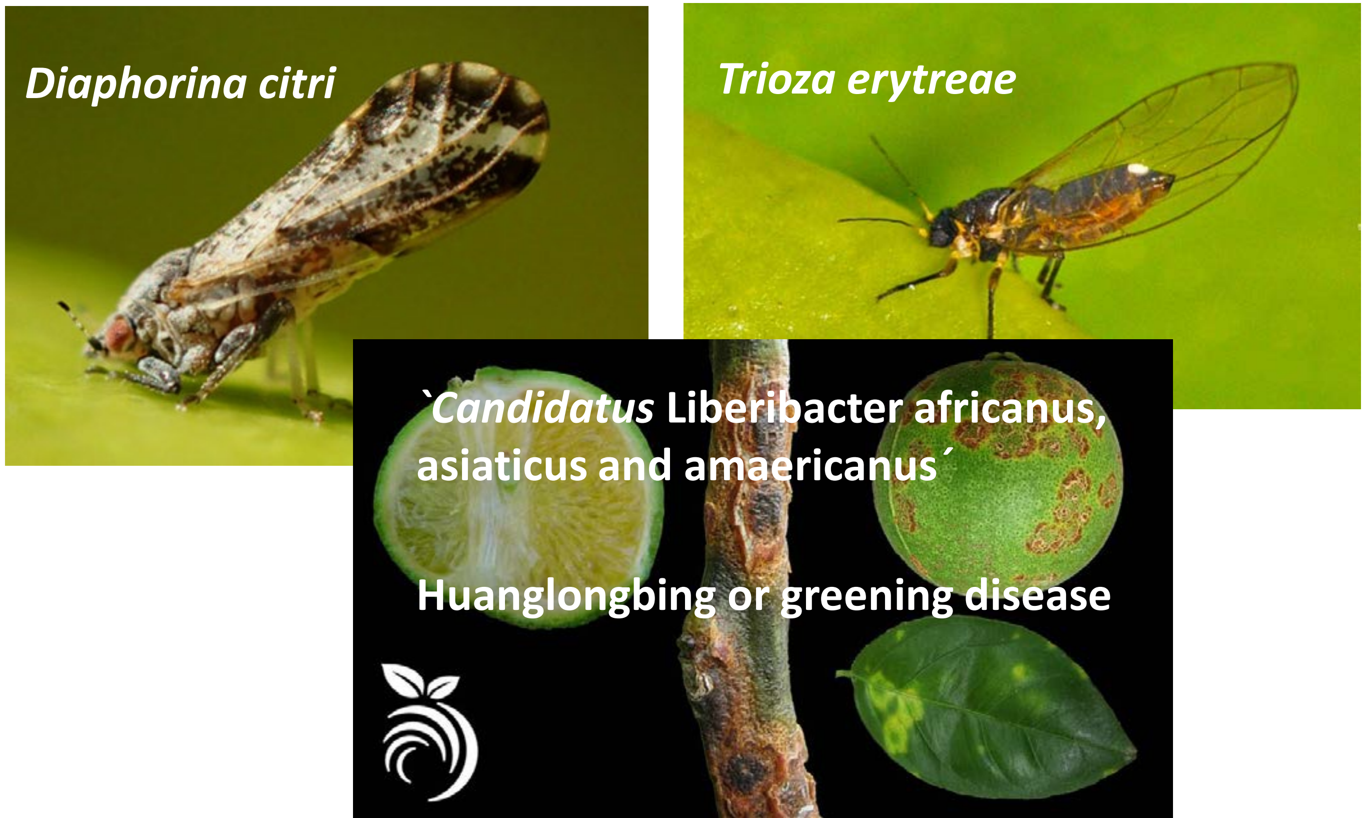
Introduction

- ❖ Many minor pests with local or temporary occurrence
- ❖ Economic importance ↗ <u>past 20 years</u>
  - - Most devastating pest wordwide
  - - Vector plant pathogen `***Candidatus* Liberibacter´= restricted phloem bacteria**
  - - Three psyllid species are listed as EU quarantine pests

Pests known to occur in the Union territory: *Trioza erytreae*

Pests not known to occur in the Union territory: *Diaphorina citri* and *Bactericera cockerelli*

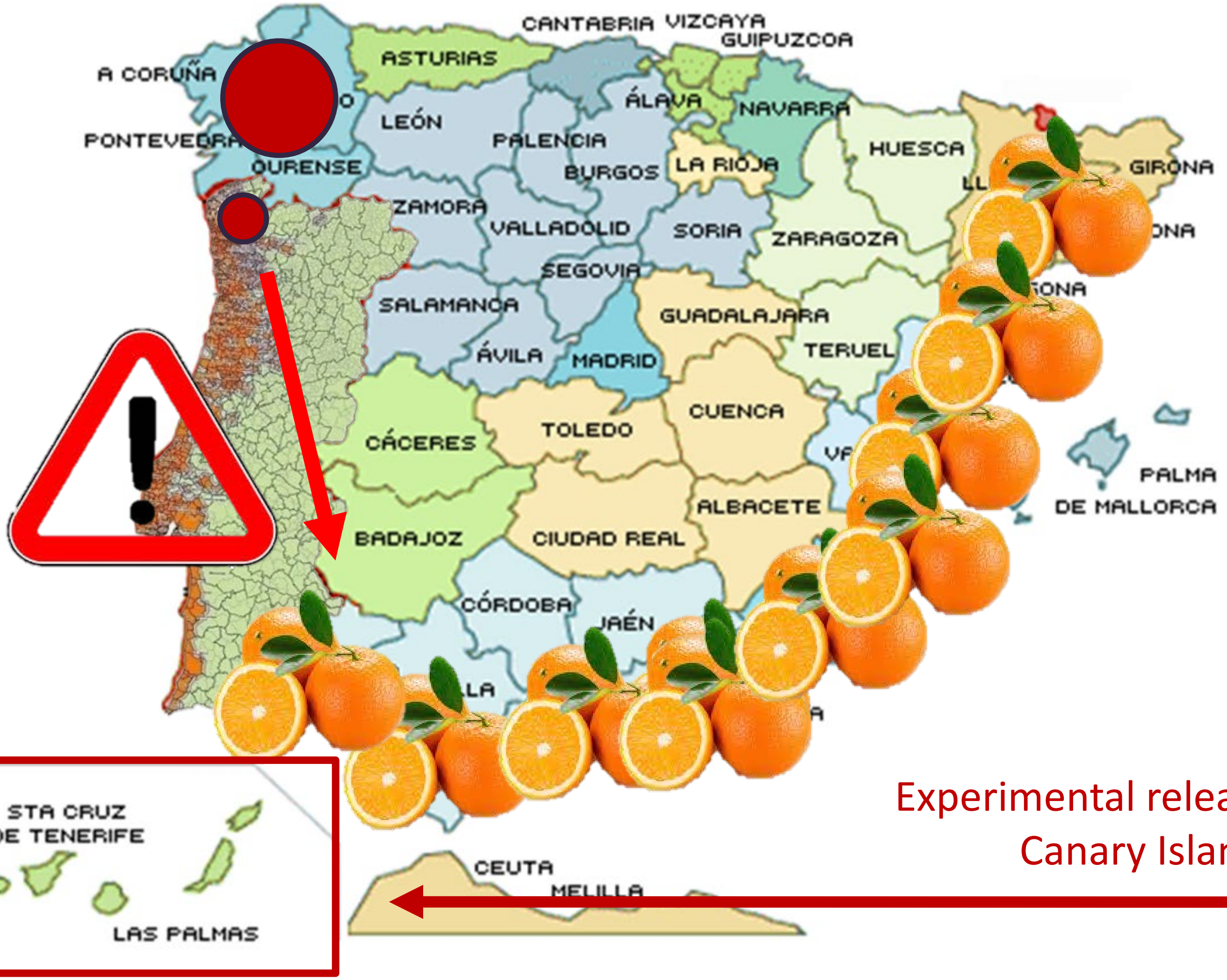




Introduction

- 2014: *Trioza erytreae* is detected in northwest Iberian Peninsula.

Spain:
- 6th largest producer in the world and 1st in the EU
- 1st global exporter of fresh fruit



In 2014, a biological control program for the vector was launched as part of a national project

→ Introduction of *Tamarixia dryi* to control *Trioza erytreae*

Experimental released in the Canary Islands

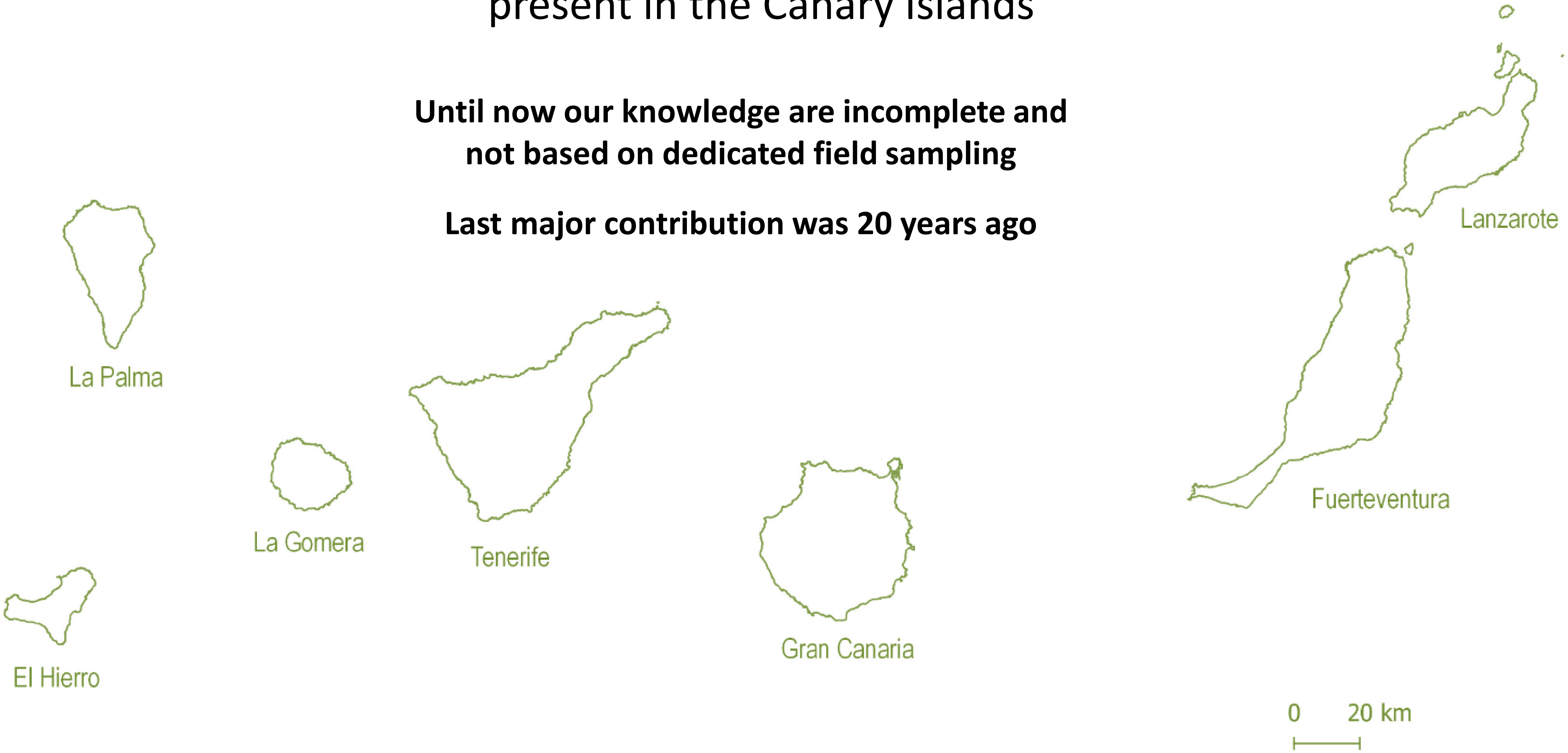

Tamarixia dryi

Introduction

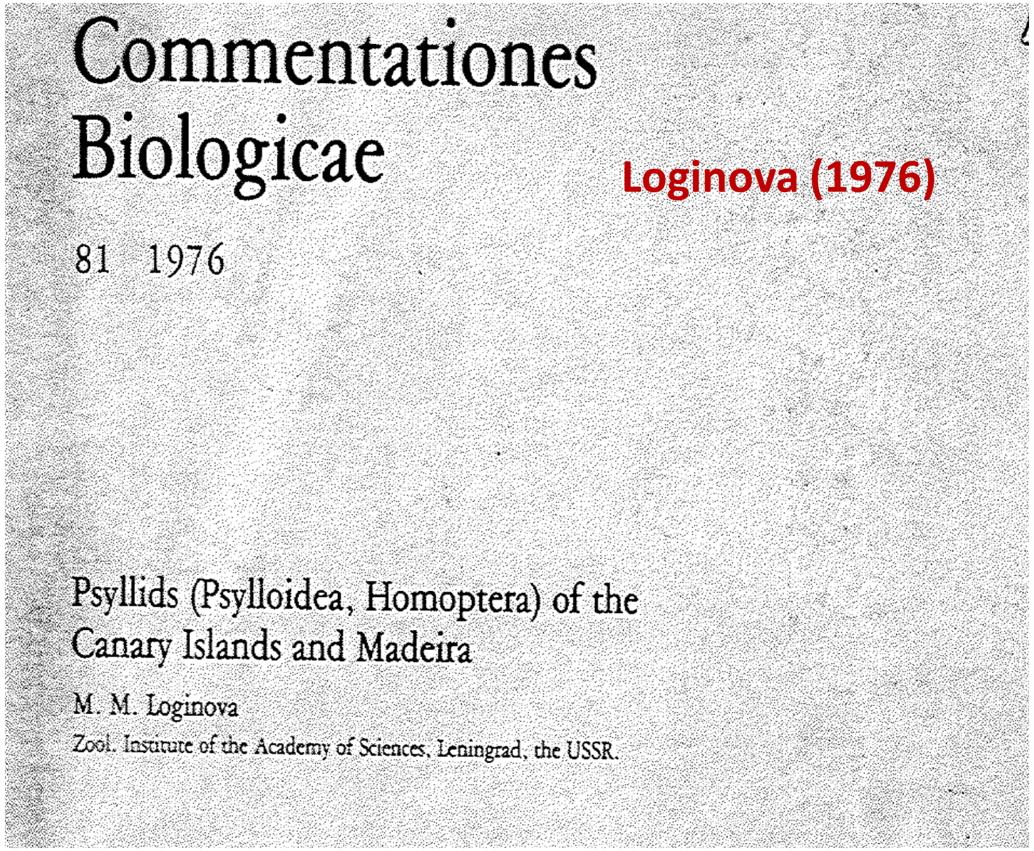
Need to know which psyllid species are present in the Canary Islands

Until now our knowledge are incomplete and not based on dedicated field sampling

Last major contribution was 20 years ago



Introduction



Commentationes Biologicae

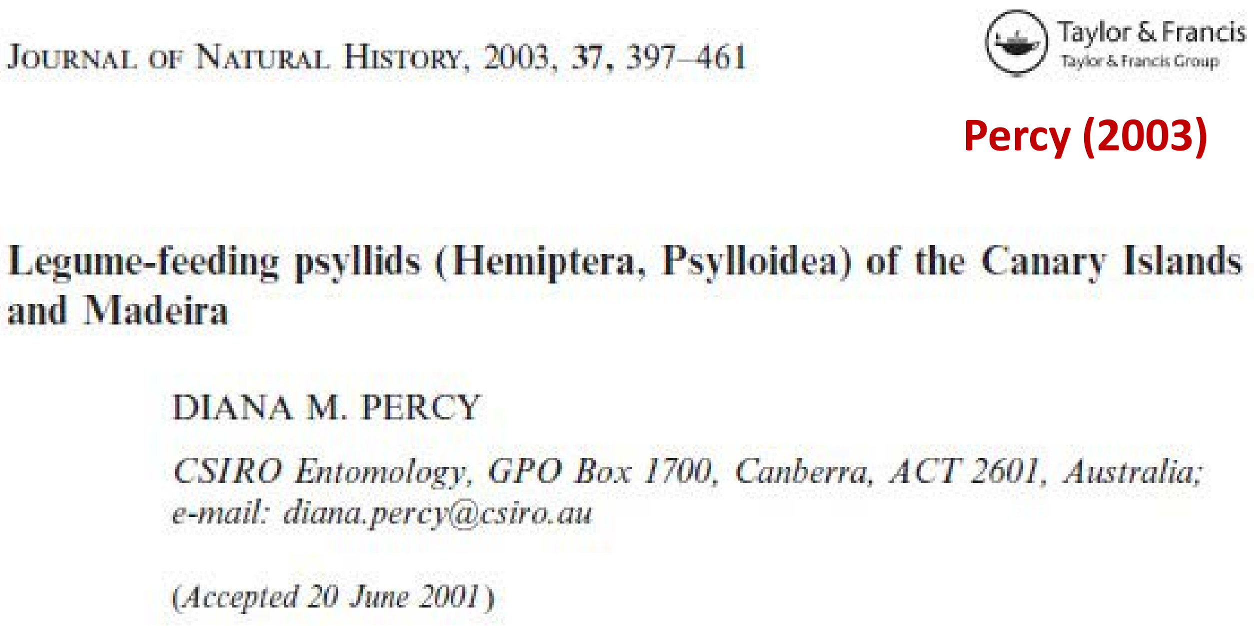
81 1976

Psyllids (Psylloidea, Homoptera) of the Canary Islands and Madeira

M. M. Loginova

Zool. Institute of the Academy of Sciences, Leningrad, the USSR.

Loginova (1976)



Journal of Natural History, 2003, 37, 397–461

Taylor & Francis
Taylor & Francis Group

Legume-feeding psyllids (Hemiptera, Psylloidea) of the Canary Islands and Madeira

DIANA M. PERCY

CSIRO Entomology, GPO Box 1700, Canberra, ACT 2601, Australia; e-mail: diana.percy@csiro.au

(Accepted 20 June 2001)

Percy (2003)

- ❖ Described 1 new genus and 10 new species
- ❖ Based on material from museums with few information on host plant and immatures

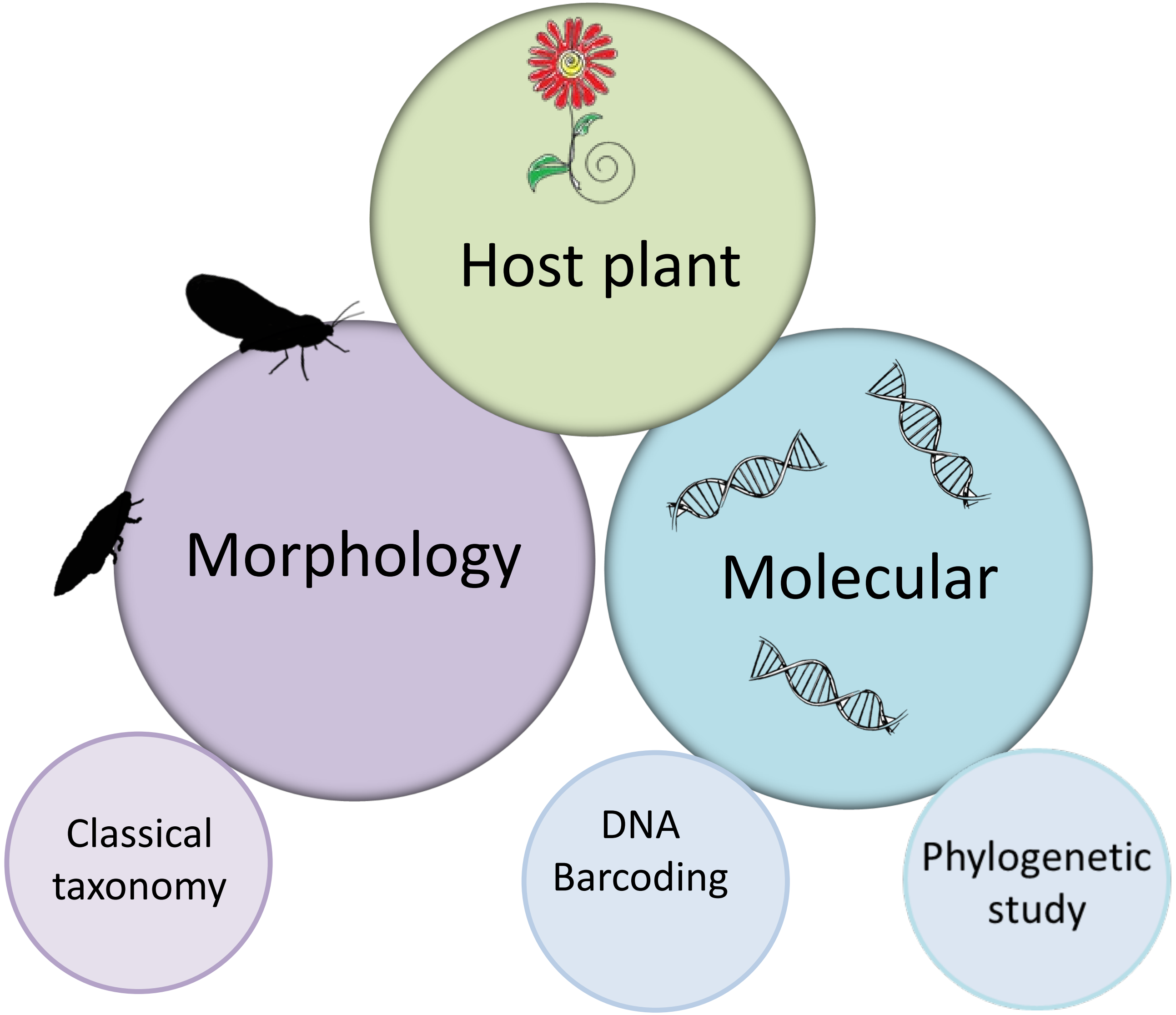
- ❖ Described 2 new genera, 15 new species and 1 subspecies
  - Targeted field work
  - Combined molecular and morphological data

→ Review the legume feeding psyllids (Genisteae)

Introduction

Main objectives :

1. To **improve our knowledge** of the **diversity** of psyllid species present in the Canary Islands
2. To **enhance the identification** of psyllid **species** in the Canary Islands
3. To **investigate** the **origins** and **evolutionary processes** that have shaped **psyllid diversification** in the Canary Islands



Host plant

Morphology

Molecular

Classical taxonomy

DNA Barcoding

Phylogenetic study

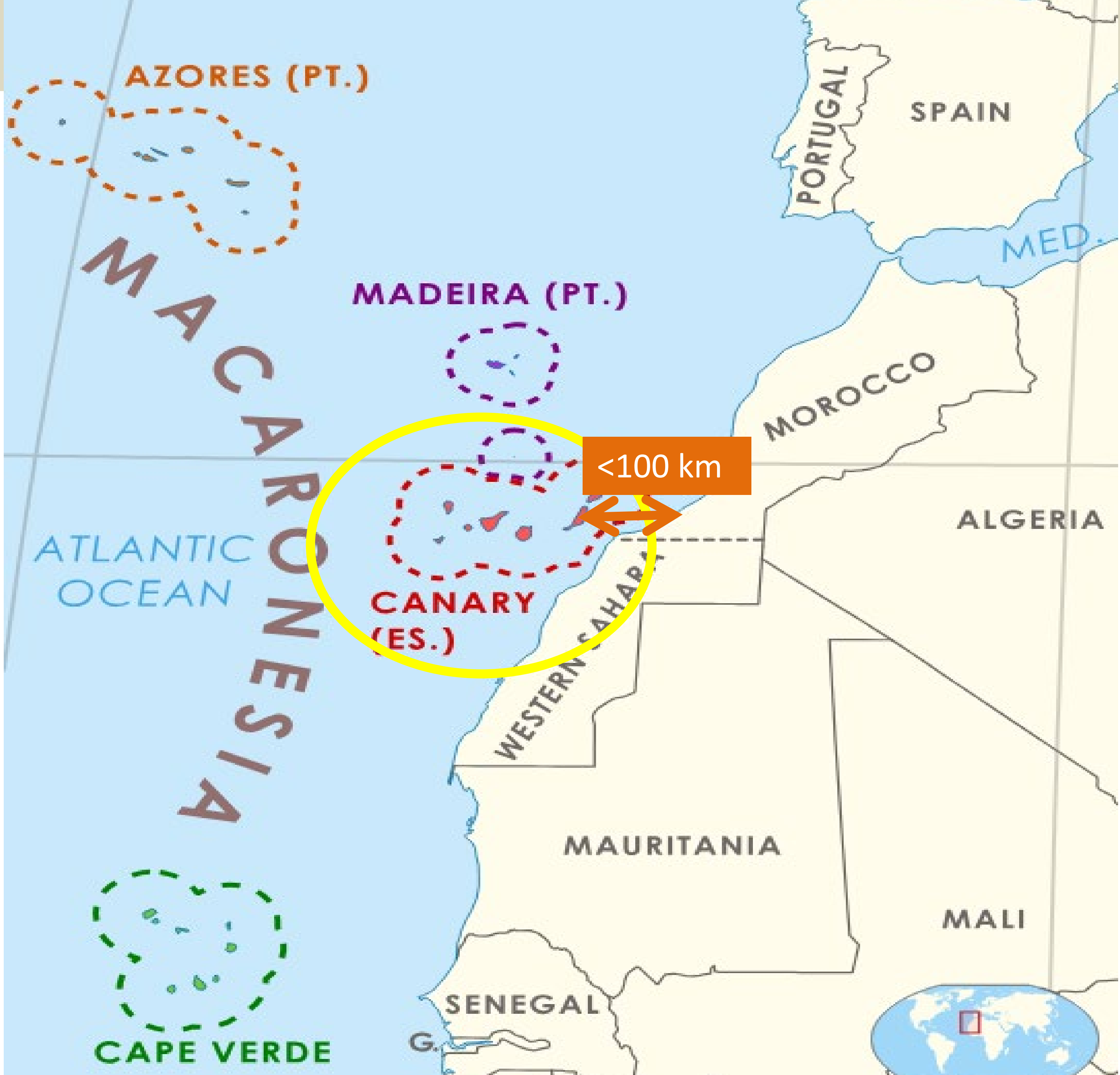
Canary Islands framework (study area)

- **Volcanic** archipelago

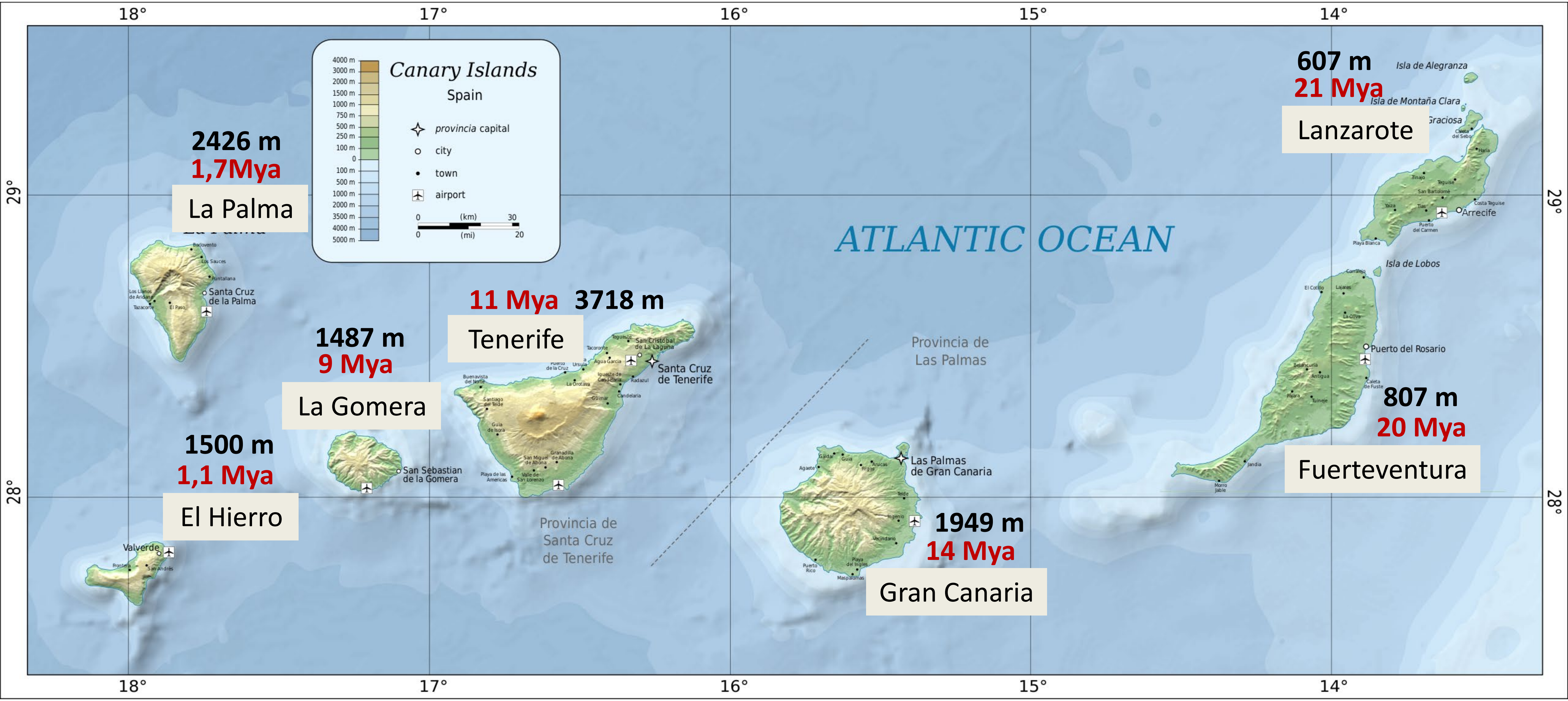
- Belong to **Macaronesian** biogeographical region

- **Close to mainland**

- Species richness is high with **high level endemism**:
  - → 40% of the native vascular flora
  - → 45% of the arthropod fauna



Canary Islands framework (study area)



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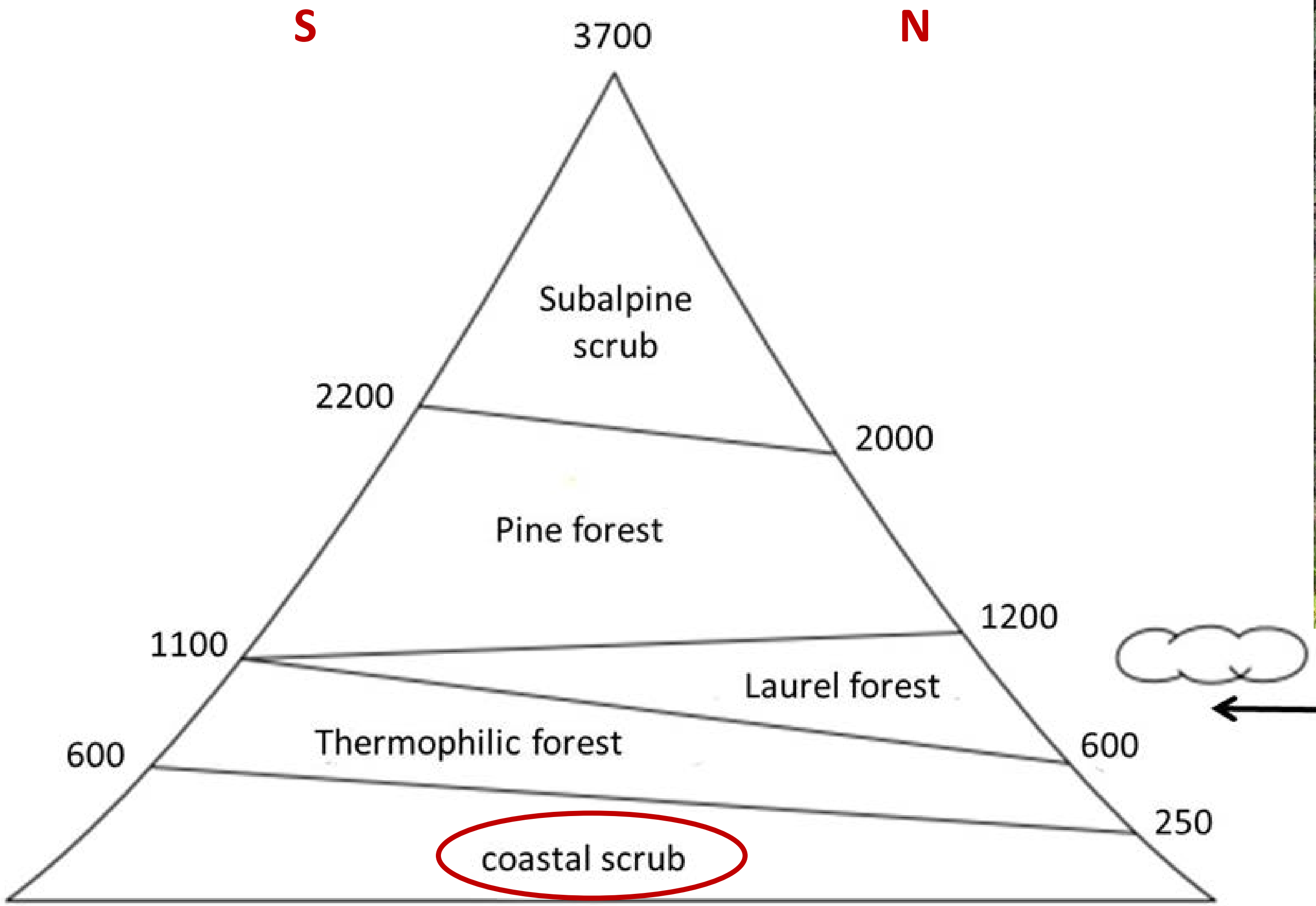


S

3700

N

Subalpine scrub

2200

2000

Pine forest

1200

1100

Laurel forest

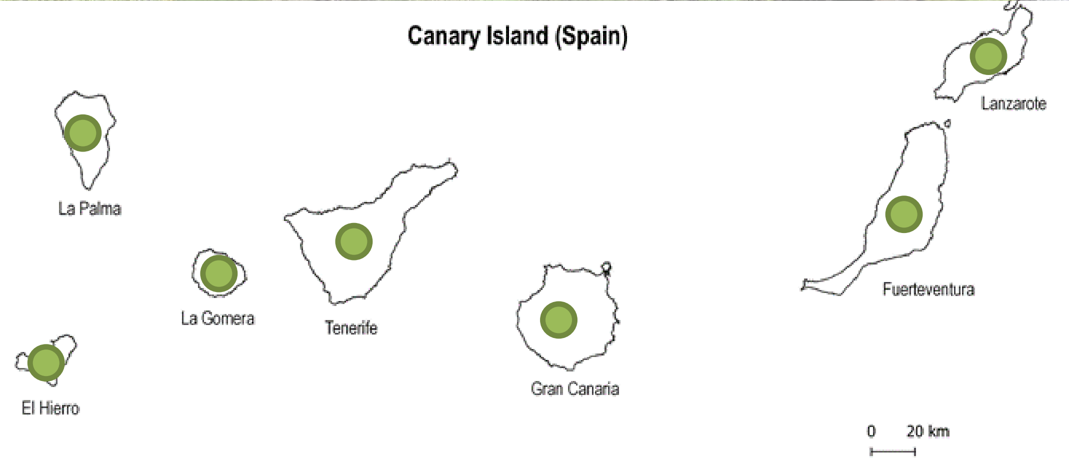
Thermophilic forest

600

600

250

coastal scrub



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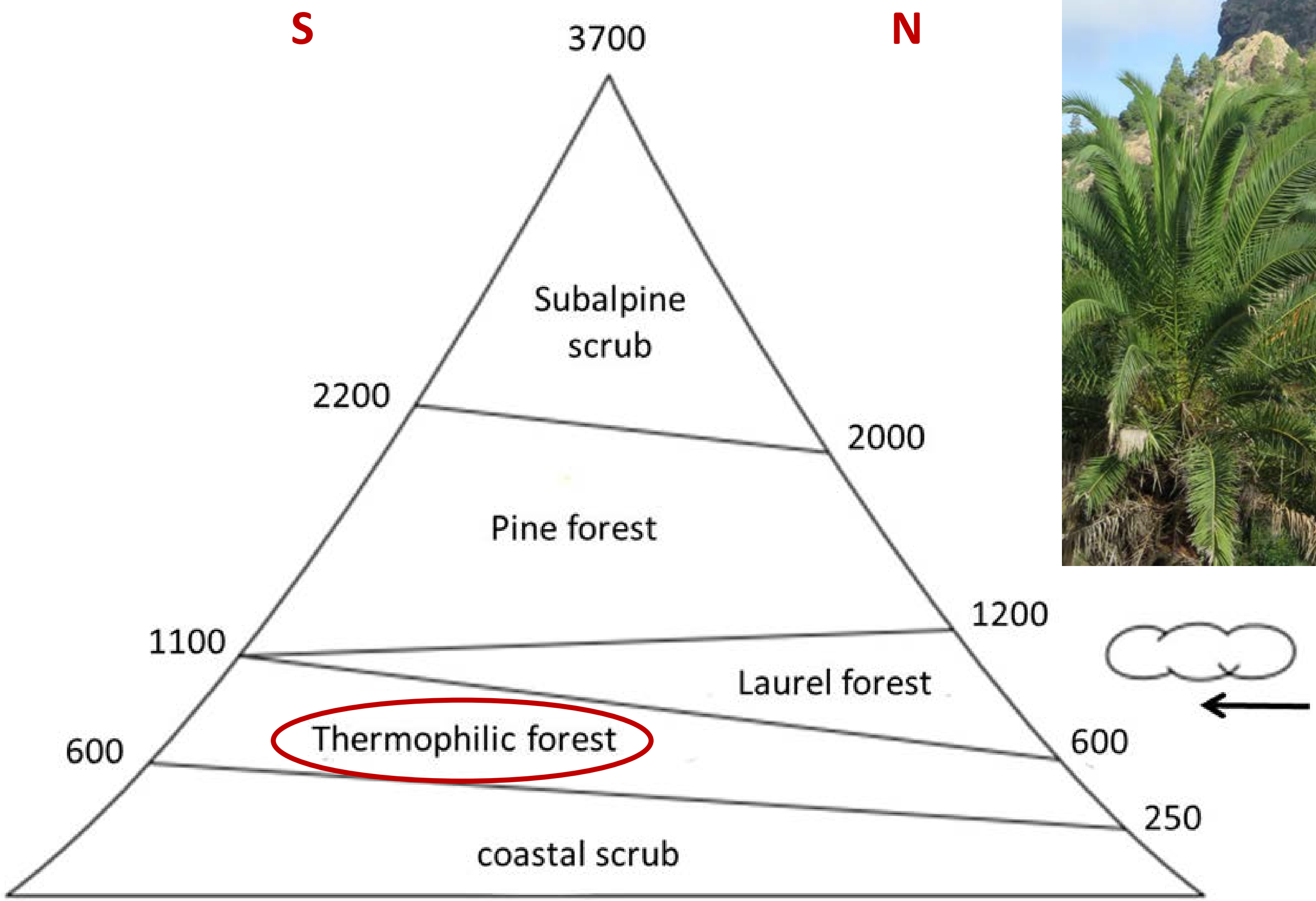

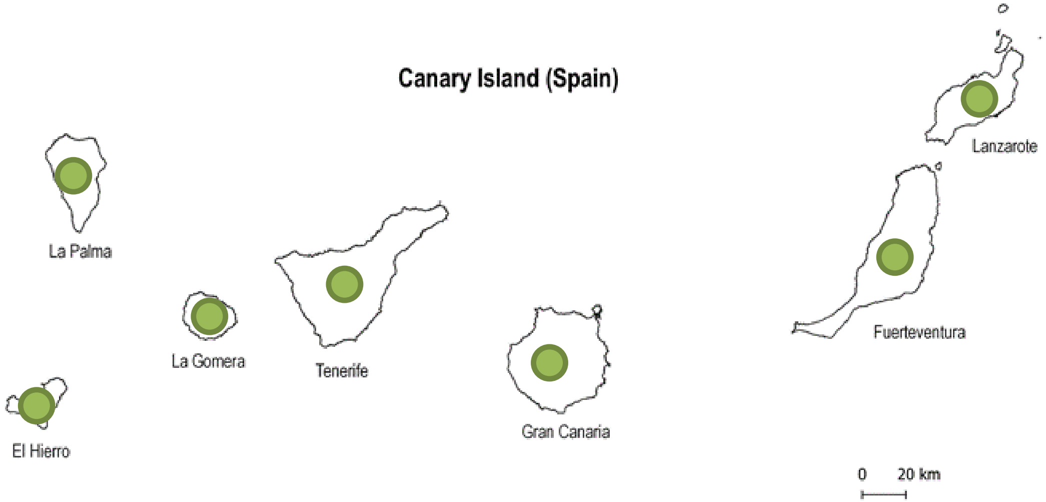

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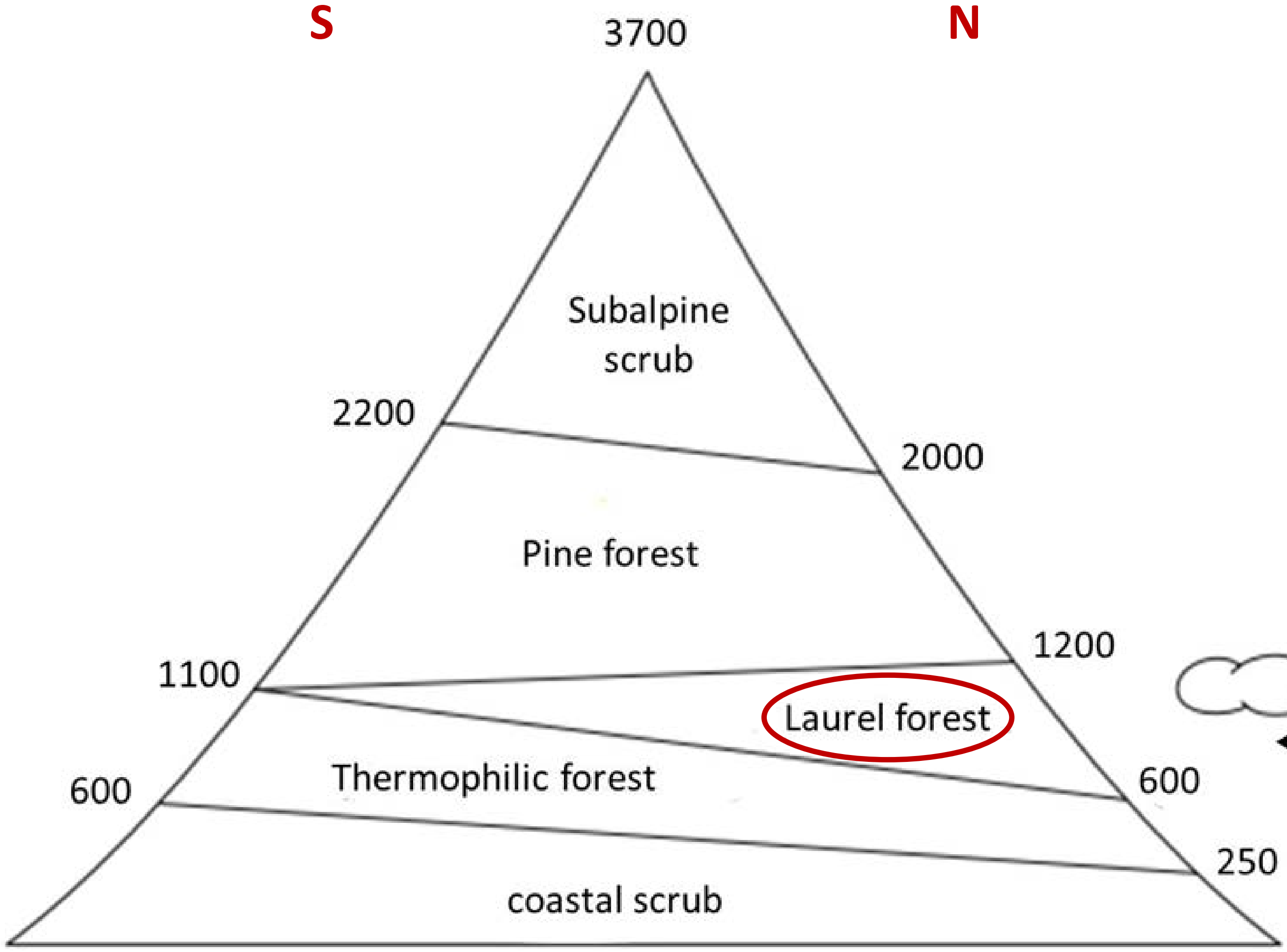

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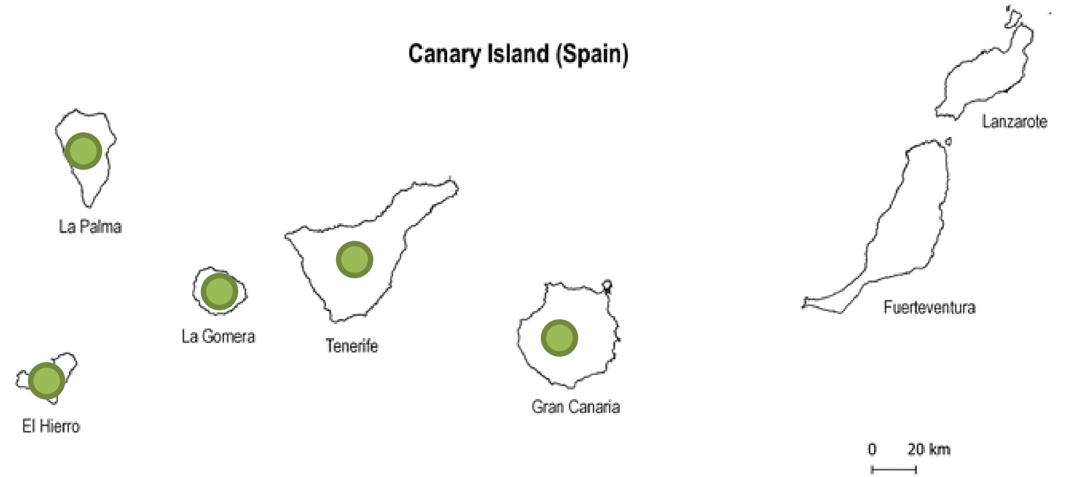
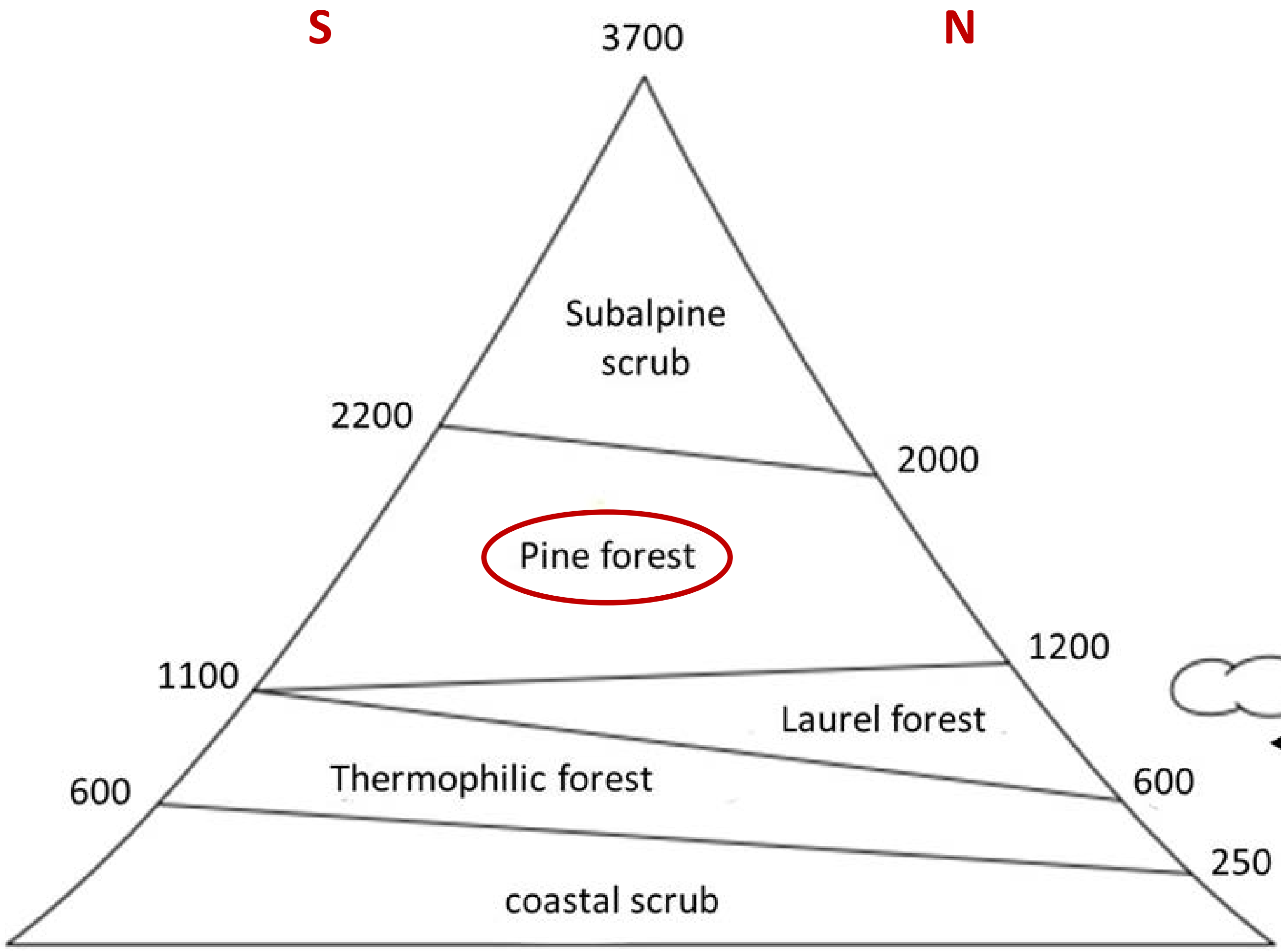
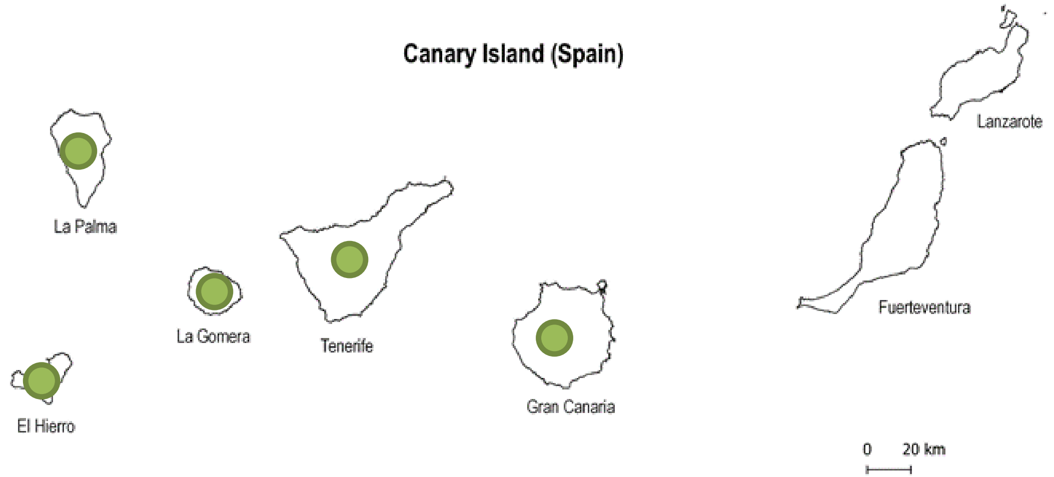
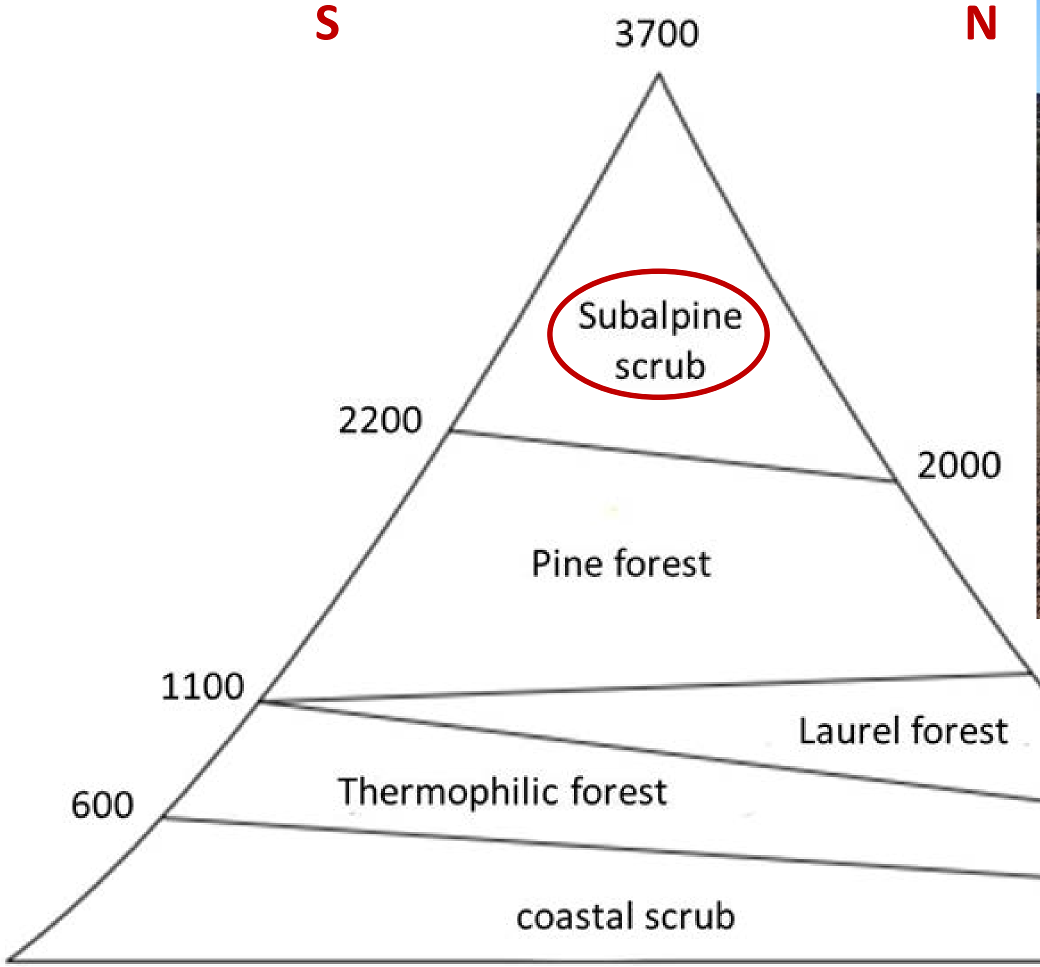


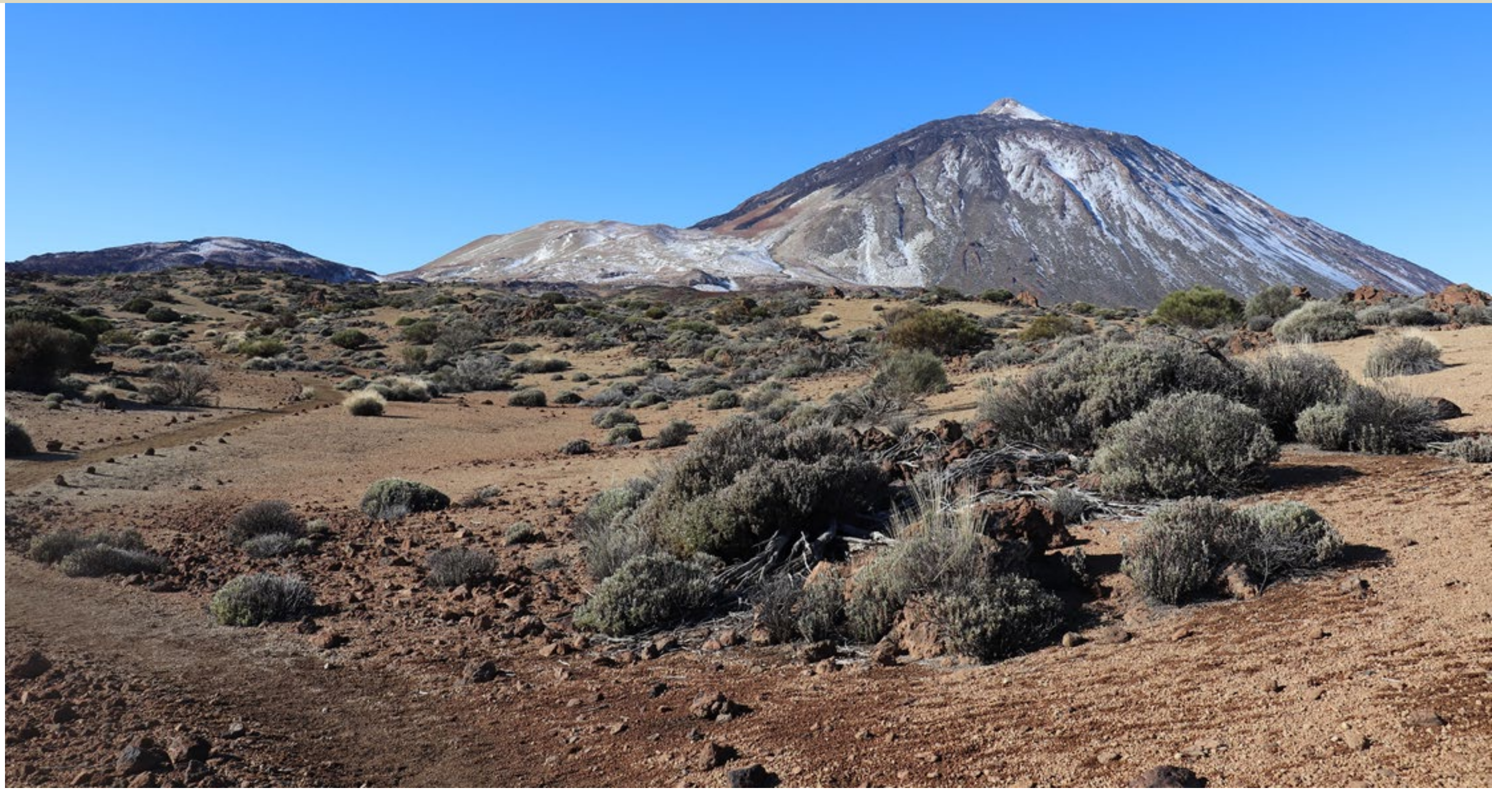
Canary Islands framework (study area)

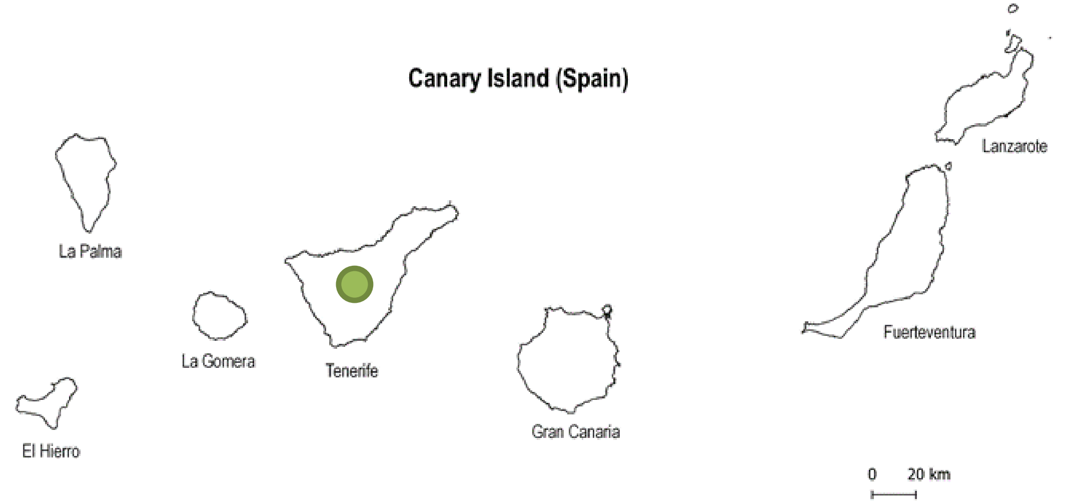




Canary Islands framework (study area)



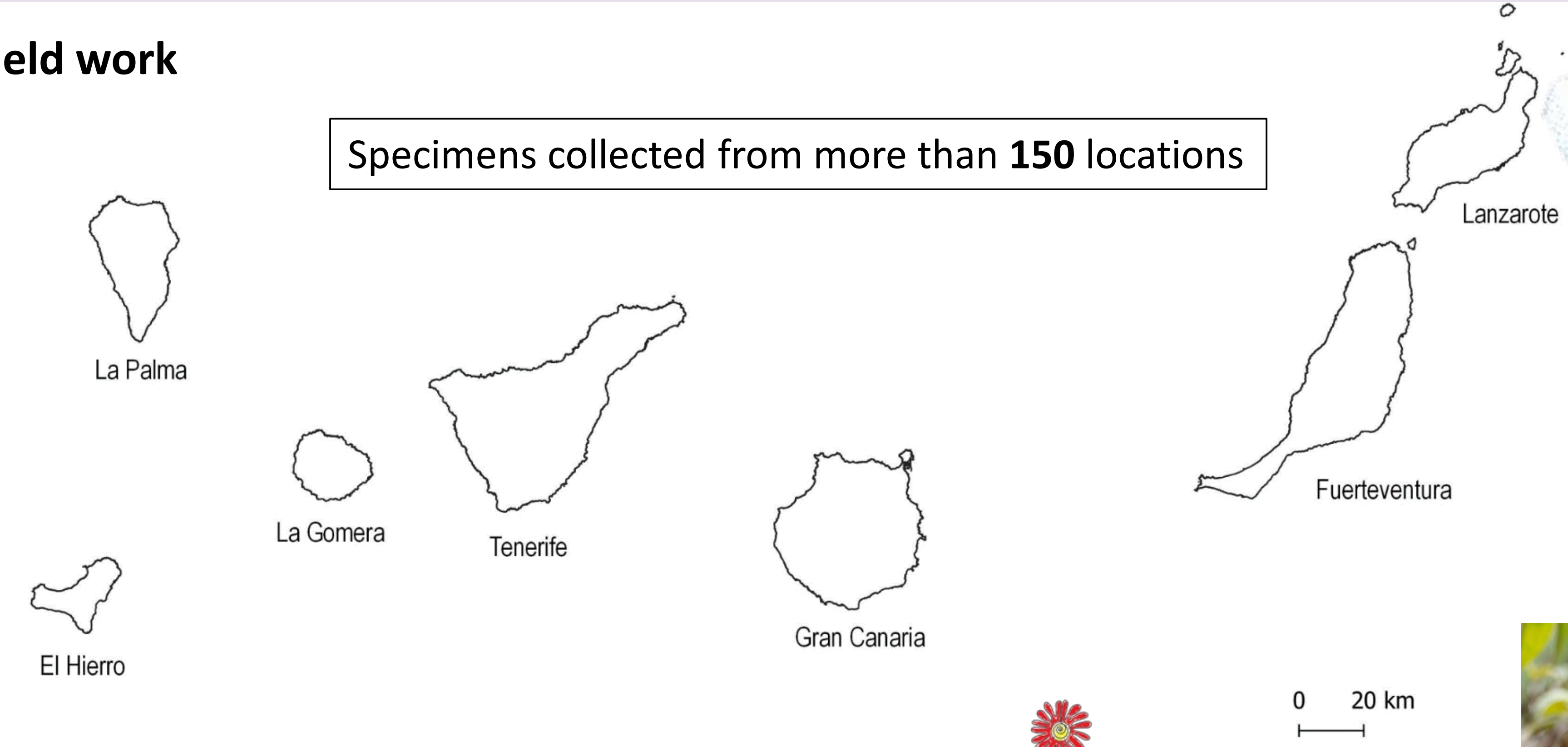


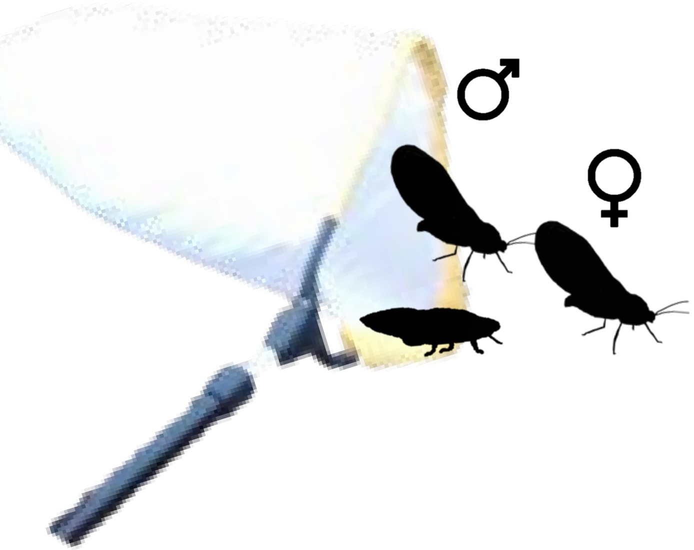


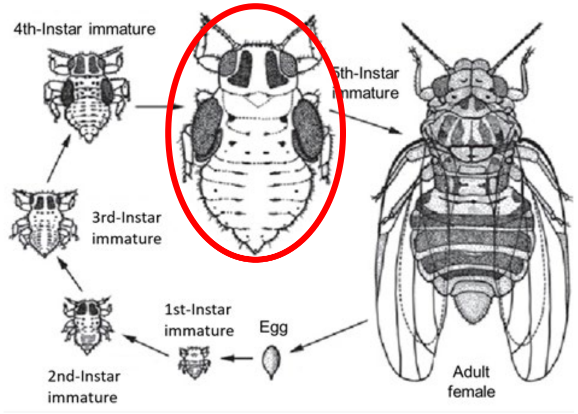
Material and methods

Field work

Specimens collected from more than **150** locations







Host plant association

1. Identification directly in the field
2. Confirmation with an experimented botanist

Biological interaction with parasitoids and predators

Material and methods

University of British Columbia

Finnish Museum of Natural History

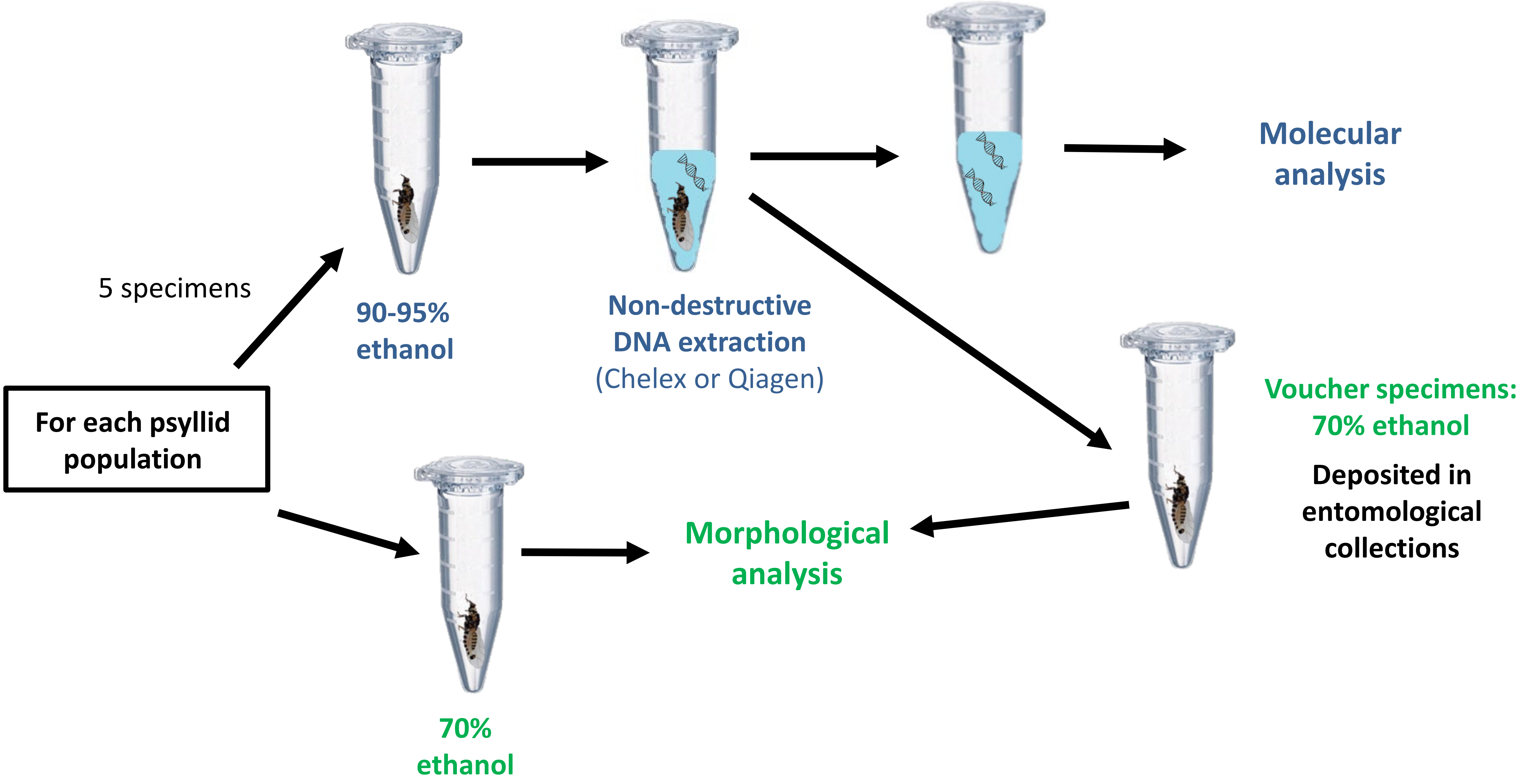
Moravian Museum, Brno

Instituto Canario de Investigaciones Agrarias (ICIA)

Naturhistorisches Museum, Basel

Muséum d'histoire naturelle, Geneva

Material and methods



For each psyllid population

5 specimens

90-95% ethanol

Non-destructive DNA extraction
(Chelex or Qiagen)

Molecular analysis

Voucher specimens: 70% ethanol

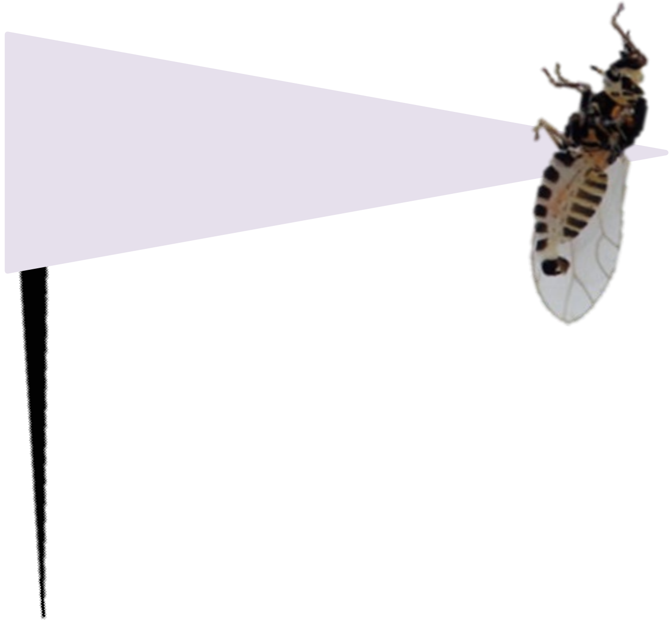
Deposited in entomological collections

70% ethanol

Morphological analysis

Morphological analysis

70%
ethanol



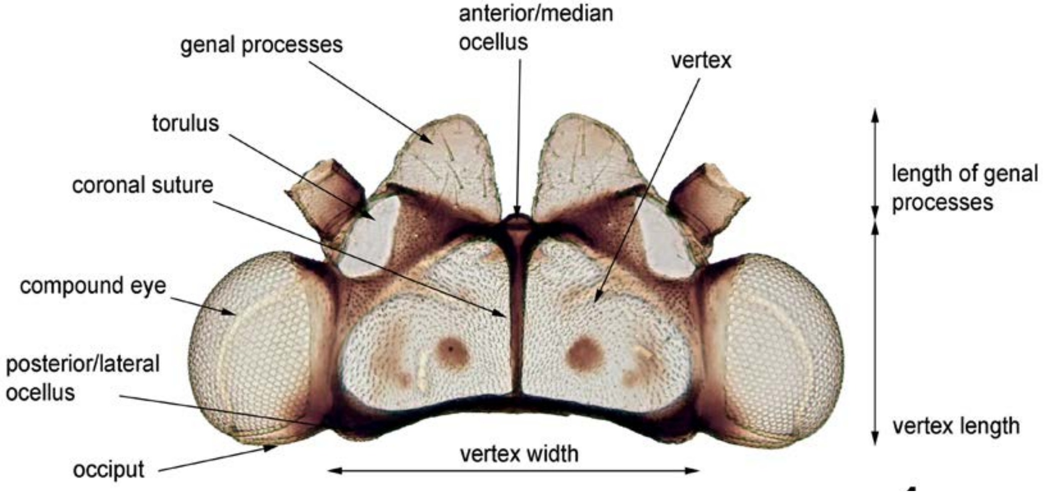
Dry mounted

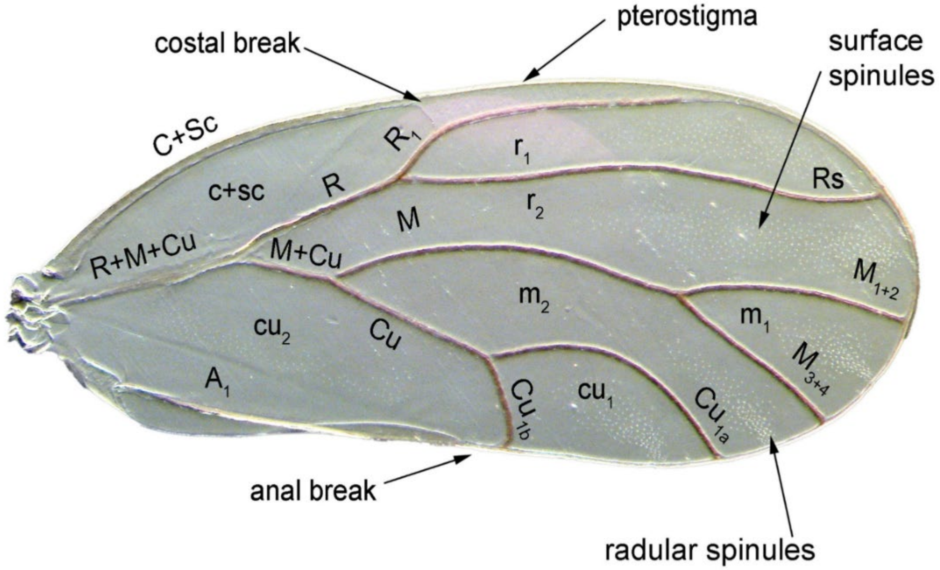
Slide mounted in
Canada Balsam

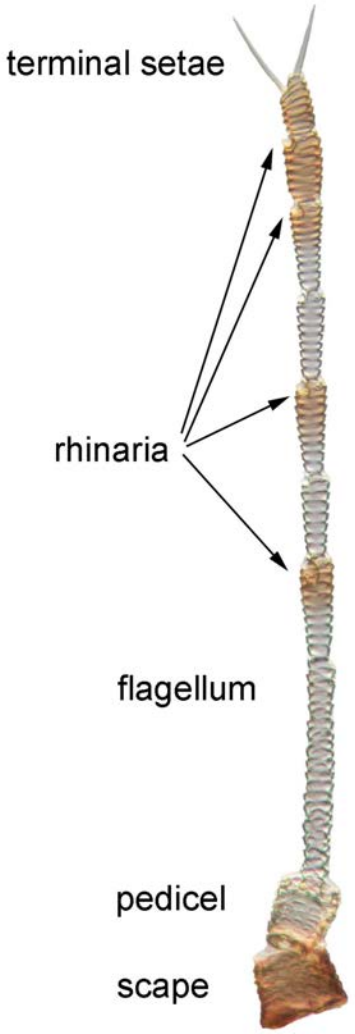
Material and methods

Morphological analysis

Examination of important taxonomic characters

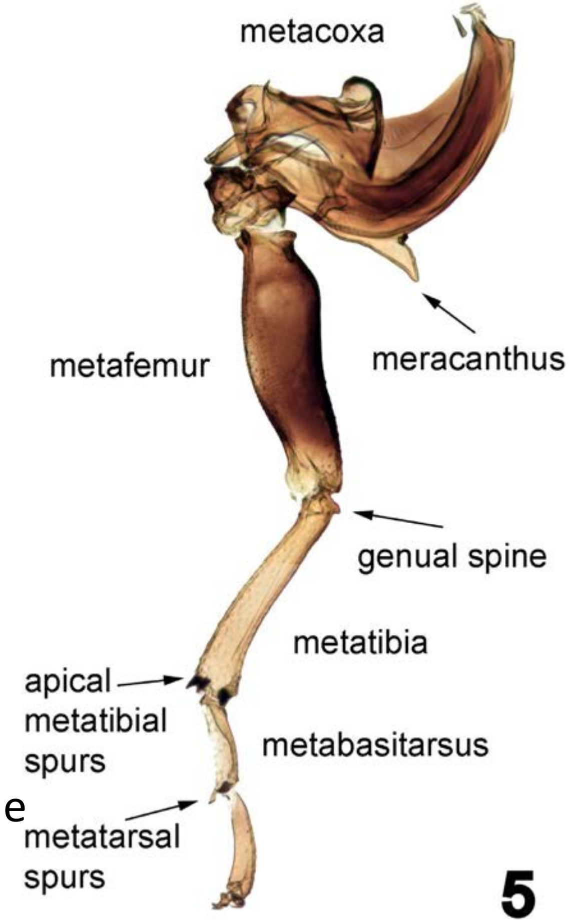






Size and shape of antenna and segments as well as terminal setae and rhinaria

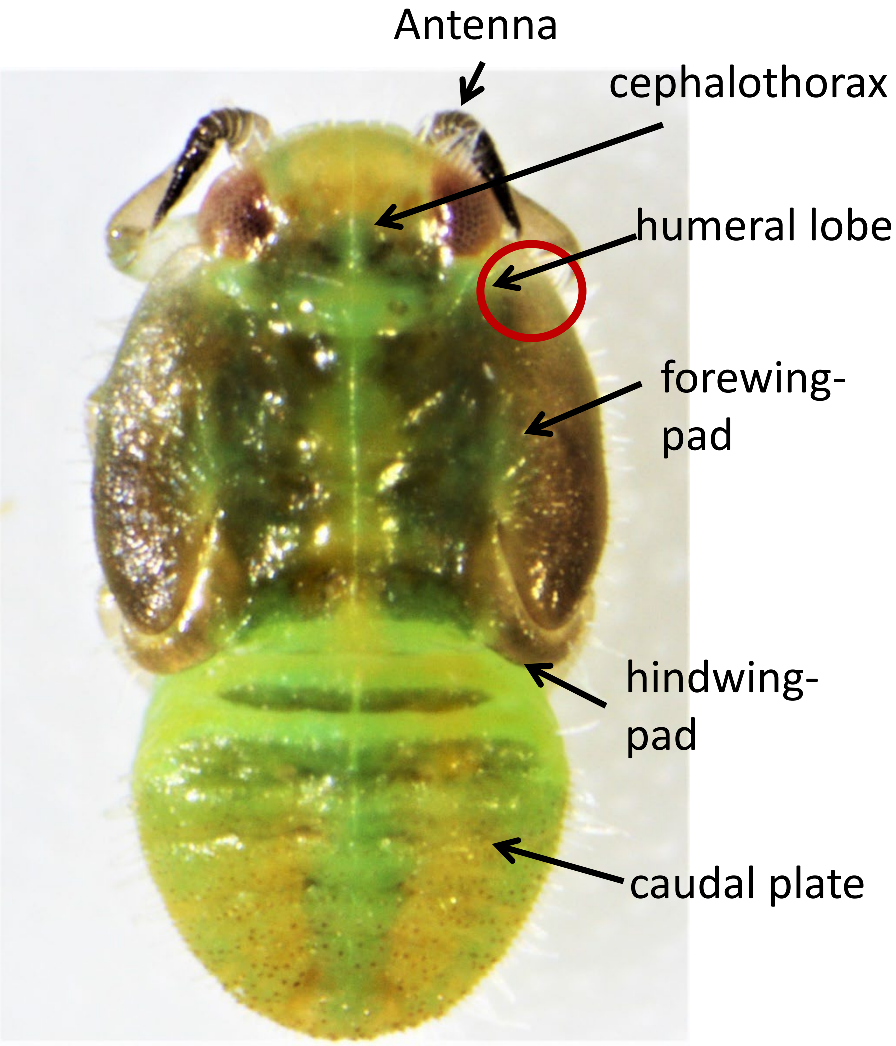
Presence and shape of meracanthus and number of genual spines, apical metatibial and metatarsal spurs

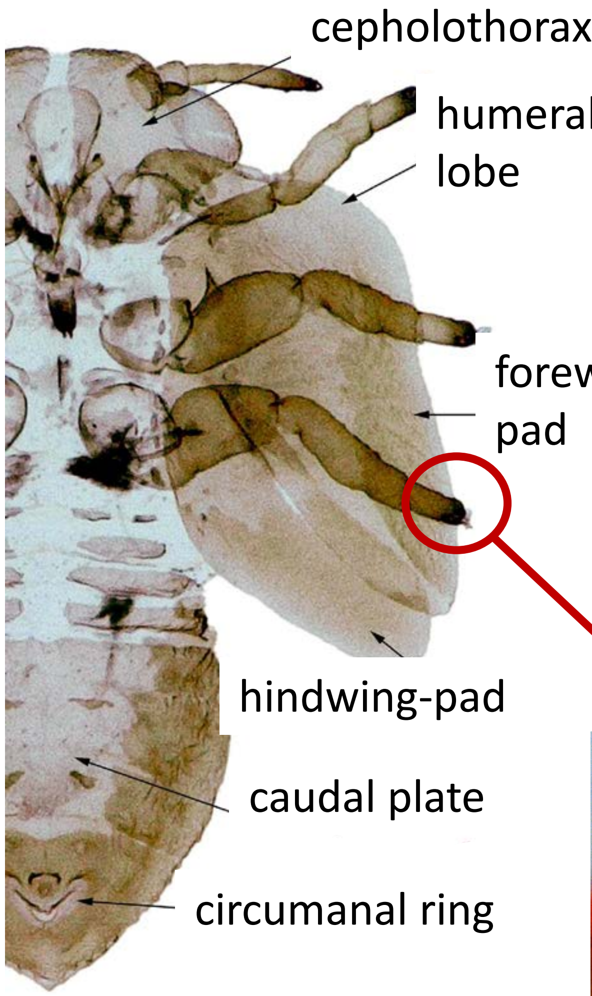


Material and methods

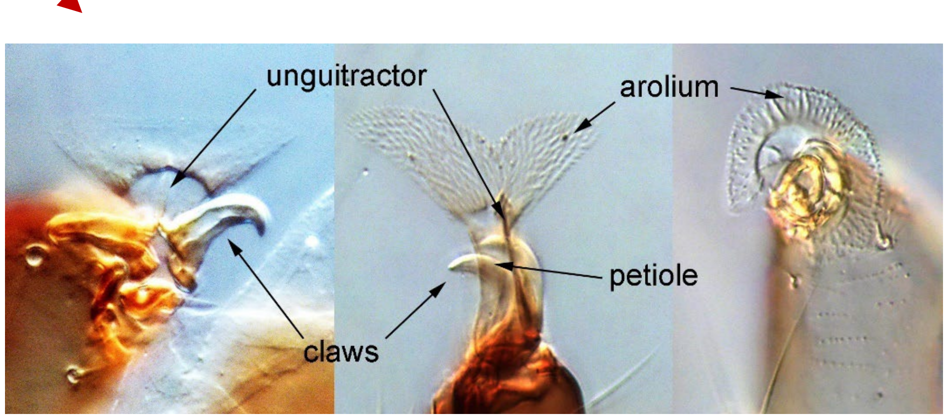
Morphological analysis

1. Examination of important taxonomic characters





- Presence of humeral lobe
- Structure between claws of tarsus
- Position of anus and circumanal pore field
  - Type, shape, distribution and number of margin setae

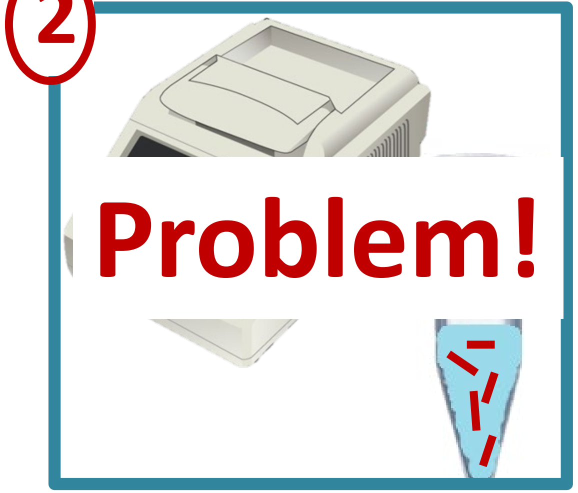


Molecular analysis

①

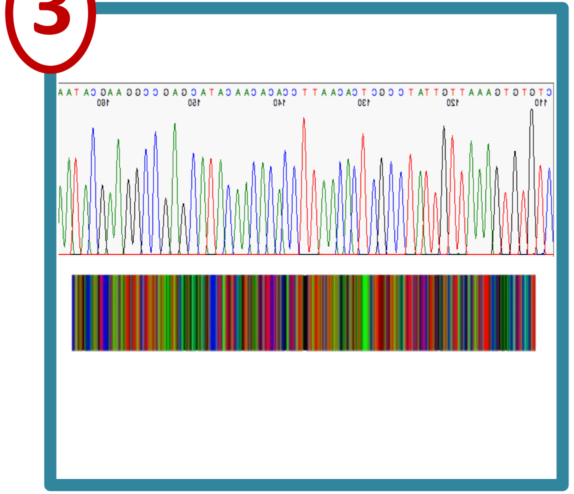
Non-destructive
DNA extraction
(Chelex or Qiagen)

②

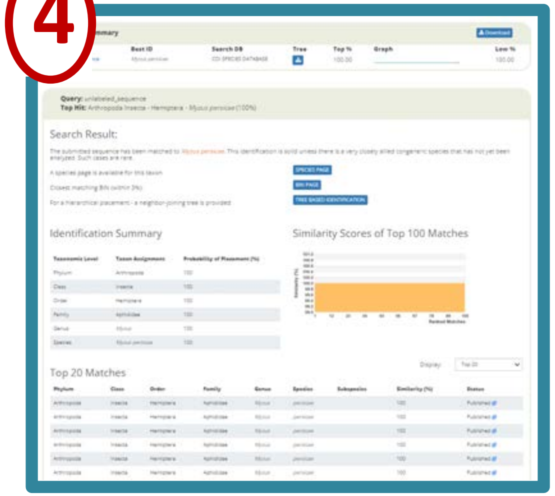


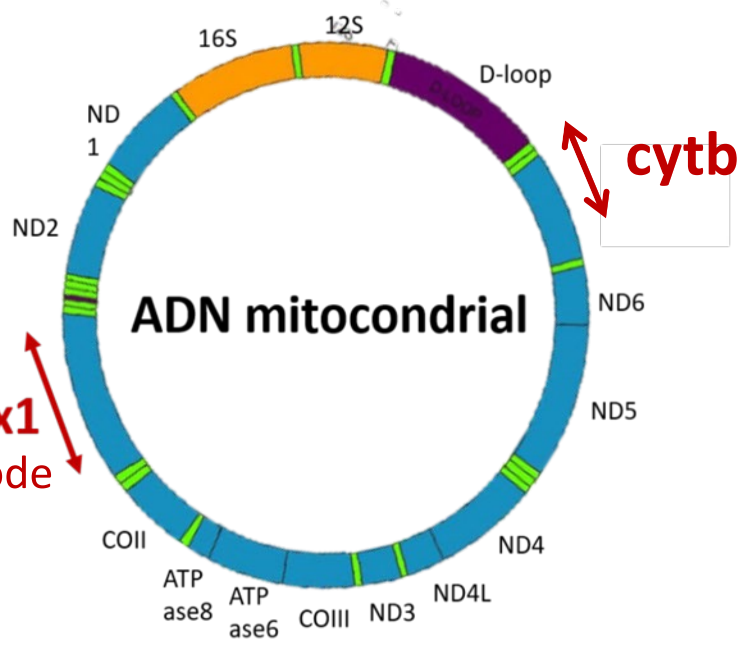
Problem!

③



④



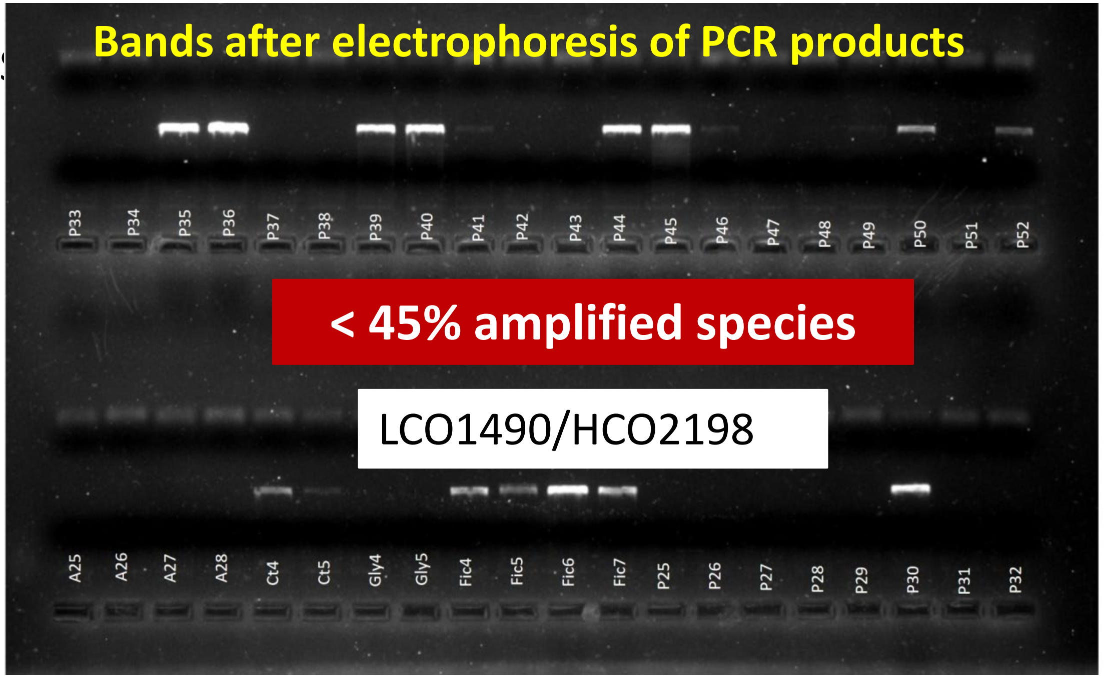


ADN mitocondrial

cytb

cox1
DNA Barcode

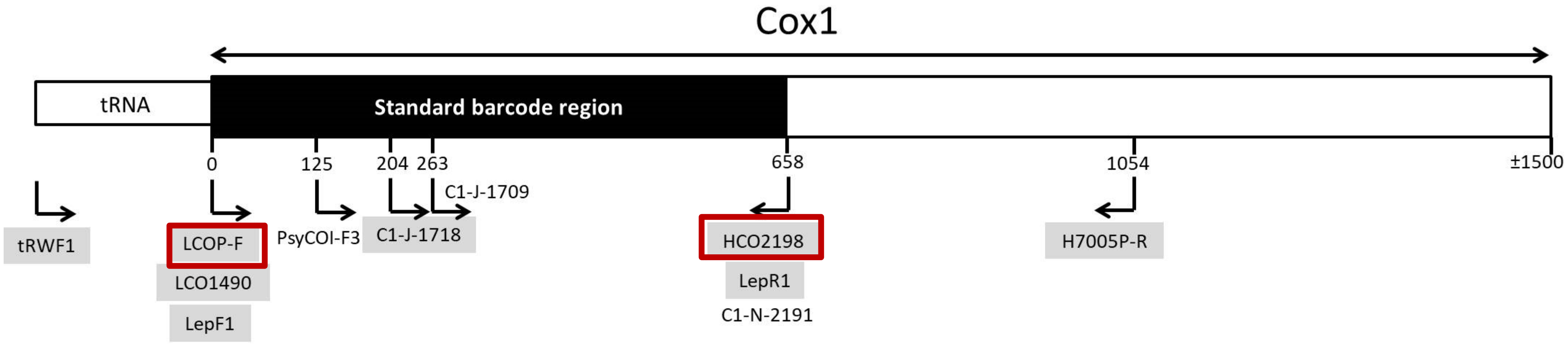
Bands after electrophoresis of PCR products



< 45% amplified species

LCO1490/HCO2198

Molecular analysis



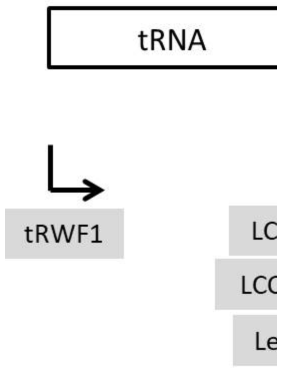
- ❖ Checked DNA Barcodes of psyllid taxa in databases (GenBank and Bold Systems):

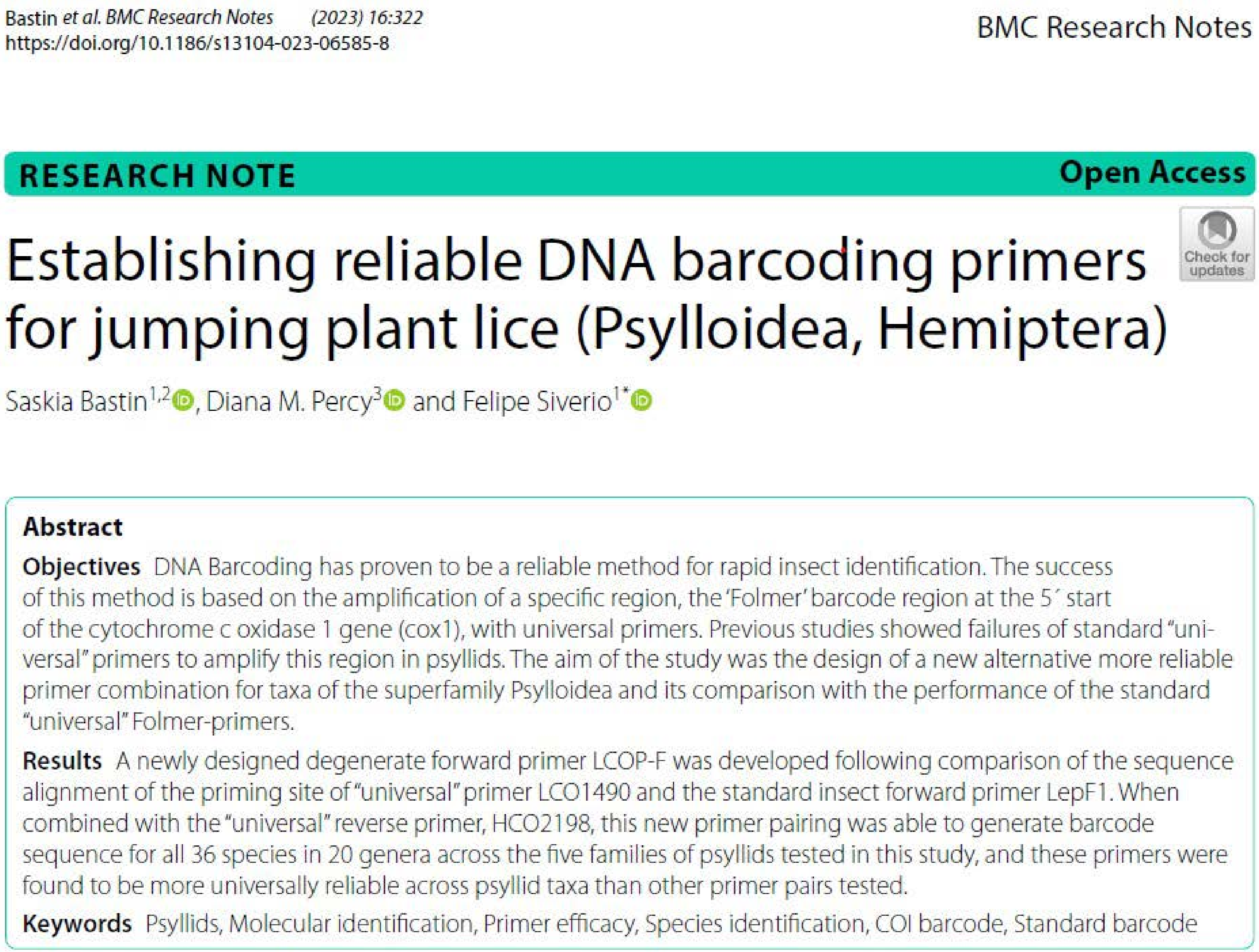
- Less than 30% psyllid species had cox1 sequences with a length **> 500 bp**

Primer pair	No. Specimens tested	No. Species tested	No. Genera tested	No. Families tested	No. Species amplified	% Species amplified	No. Specimens amplified	% Specimens amplified
LCOP-F/ HCO2198	154	36	20	5	36	100	146	95
C1-J-1718/ H7005P-R	143	36	20	5	35	97	119	83
LCO1490/ HCO2198	54	26	18	5	9	35	24	44
LepF1/ LepR1	27	24	18	5	3	13	3	11
tRWF1/ LepR1	60	25	16	4	18	72	47	78

Material and methods

Molecular analysis





Bastin *et al. BMC Research Notes* (2023) 16:322
https://doi.org/10.1186/s13104-023-06585-8

BMC Research Notes

RESEARCH NOTE **Open Access**

Establishing reliable DNA barcoding primers for jumping plant lice (Psylloidea, Hemiptera)

Saskia Bastin[1,2], Diana M. Percy[3] and Felipe Siverio[1*]

Abstract

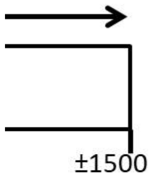
Objectives DNA Barcoding has proven to be a reliable method for rapid insect identification. The success of this method is based on the amplification of a specific region, the 'Folmer' barcode region at the 5′ start of the cytochrome c oxidase 1 gene (cox1), with universal primers. Previous studies showed failures of standard "universal" primers to amplify this region in psyllids. The aim of the study was the design of a new alternative more reliable primer combination for taxa of the superfamily Psylloidea and its comparison with the performance of the standard "universal" Folmer-primers.

Results A newly designed degenerate forward primer LCOP-F was developed following comparison of the sequence alignment of the priming site of "universal" primer LCO1490 and the standard insect forward primer LepF1. When combined with the "universal" reverse primer, HCO2198, this new primer pairing was able to generate barcode sequence for all 36 species in 20 genera across the five families of psyllids tested in this study, and these primers were found to be more universally reliable across psyllid taxa than other primer pairs tested.

Keywords Psyllids, Molecular identification, Primer efficacy, Species identification, COI barcode, Standard barcode

- Checked DNA Ba
psyllid taxa in da
(GenBank and B

- Less than 30% p
cox1 sequences
500 bp

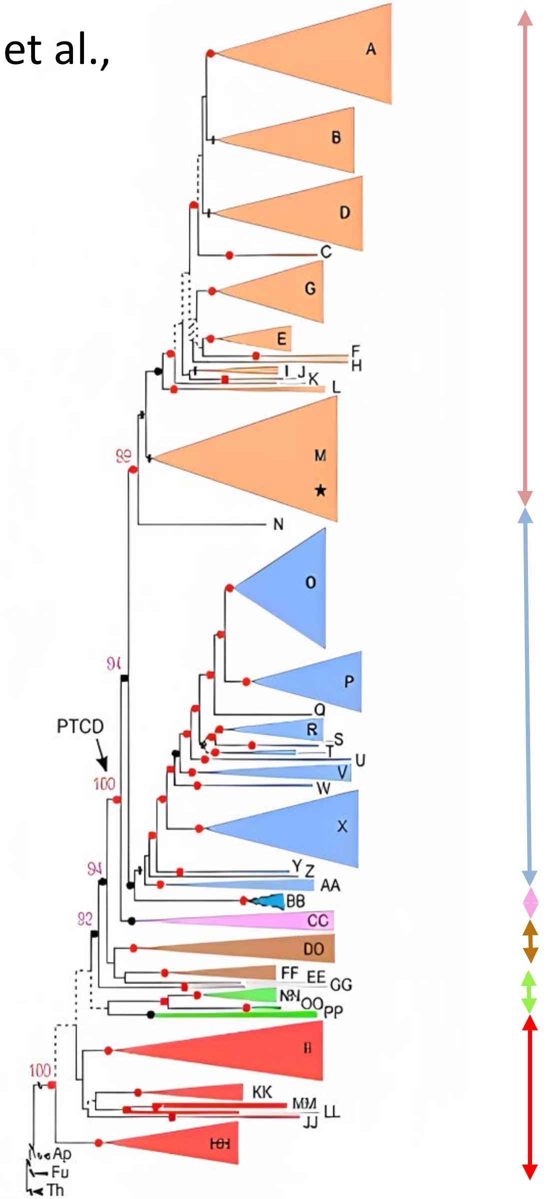


% Specimens amplified
95
83
44
11
78

Material and methods

Molecular analysis

Percy et al., 2018



Triozidae

Psyllidae

Calophyidae

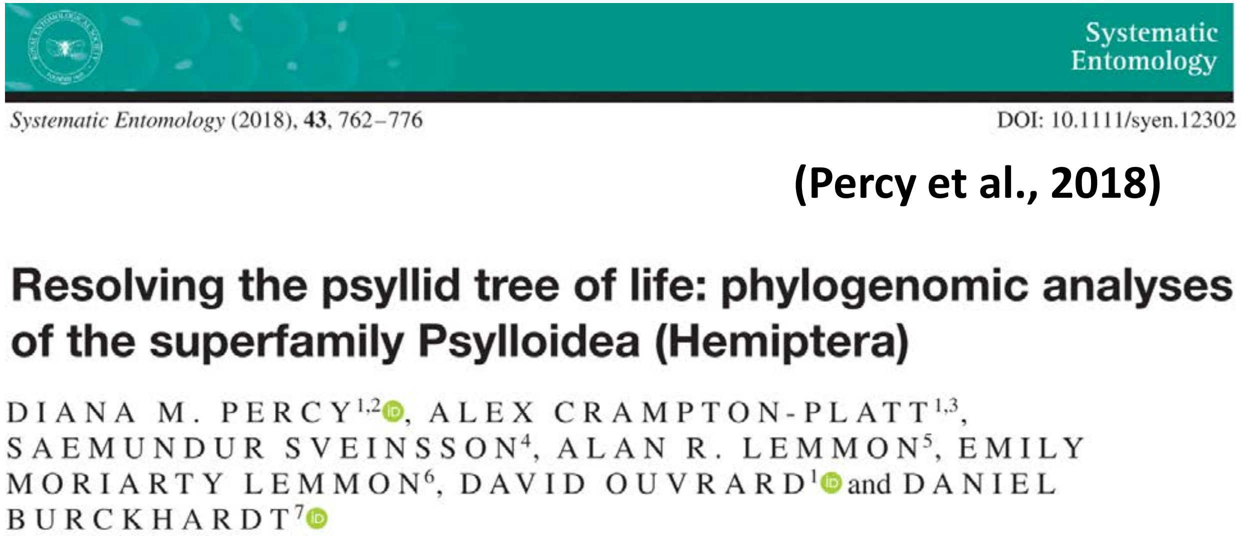
Liviidae

Mastigimatidae

Carsidaridae

Aphalaridae

- ❖ The constraint tree = Psylloidea mitogenome tree presented in Percy et al., 2018


Systematic Entomology

Systematic Entomology (2018), **43**, 762–776

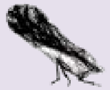
DOI: 10.1111/syen.12302

(Percy et al., 2018)

Resolving the psyllid tree of life: phylogenomic analyses of the superfamily Psylloidea (Hemiptera)

DIANA M. PERCY[1,2], ALEX CRAMPTON-PLATT[1,3], SAEMUNDUR SVEINSSON[4], ALAN R. LEMMON[5], EMILY MORIARTY LEMMON[6], DAVID OUVRARD[1] and DANIEL BURCKHARDT[7]

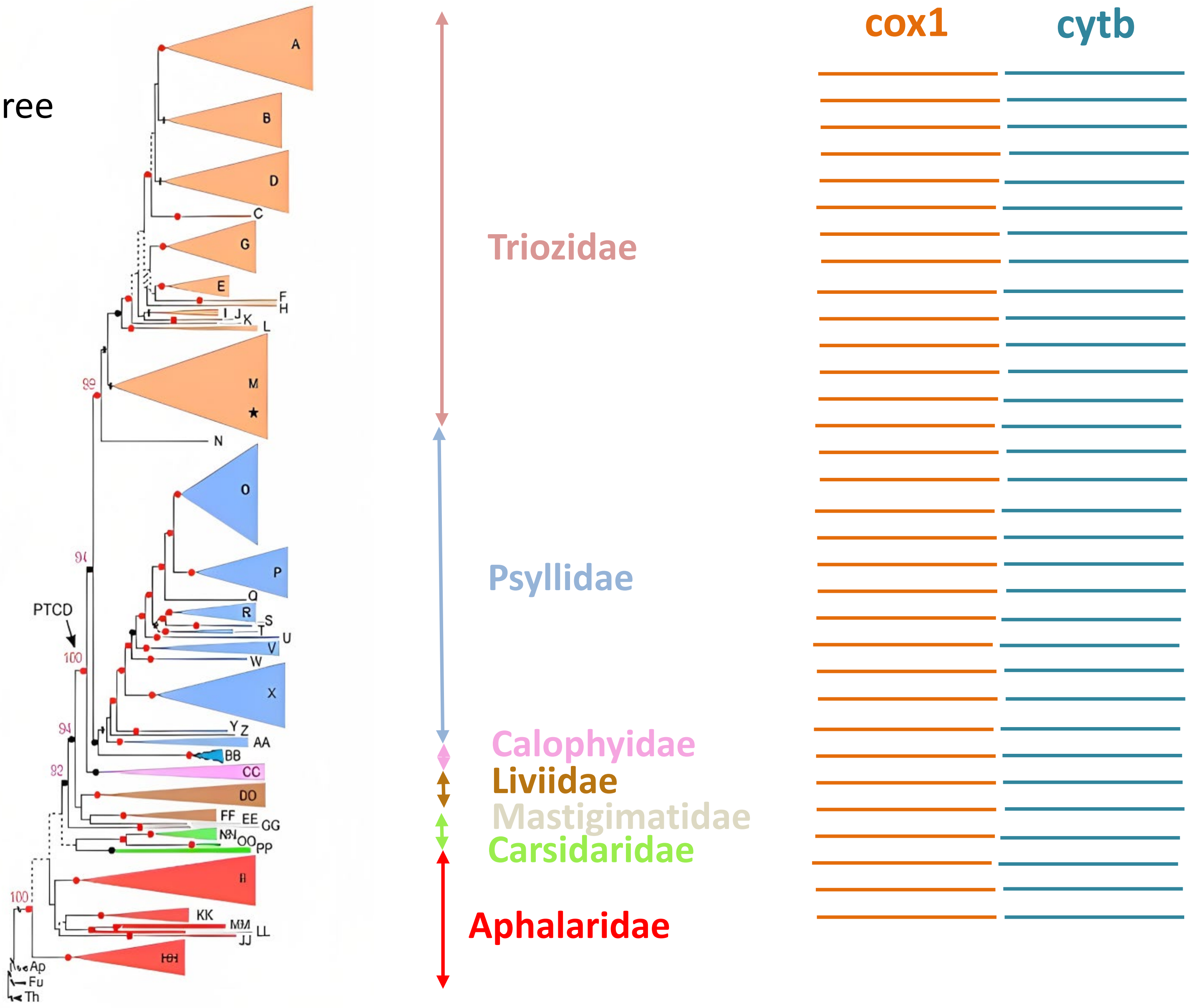
Complete mitogenomes of 400 species from almost 100 genera in all the families of psyllids



Material and methods

Molecular analysis

Psylloidea
Superfamily tree



Triozidae

Psyllidae

Calophyidae

Liviidae

Mastigimatidae

Carsidaridae

Aphalaridae

cox1

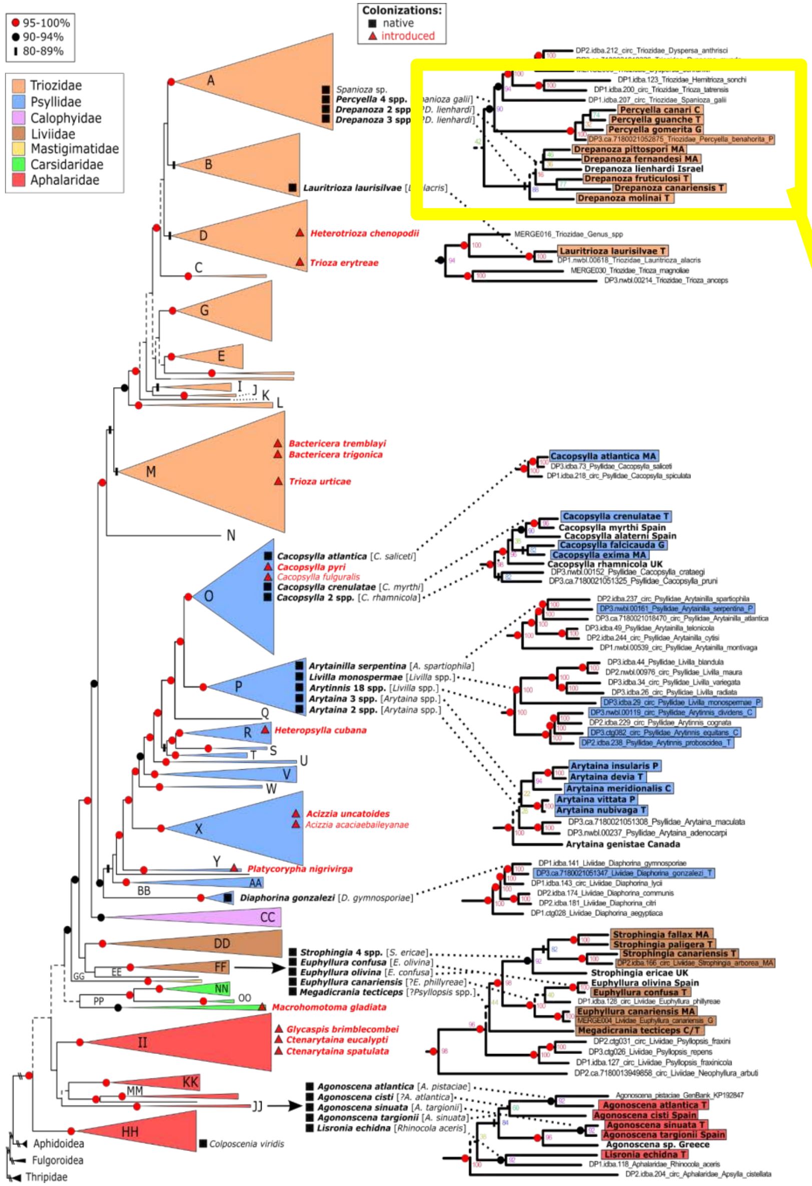
cytb

(Percy et al., 2018)

Maximum likelihood constraint analysis

To place all native psyllid lineages within Psylloidea Superfamily tree

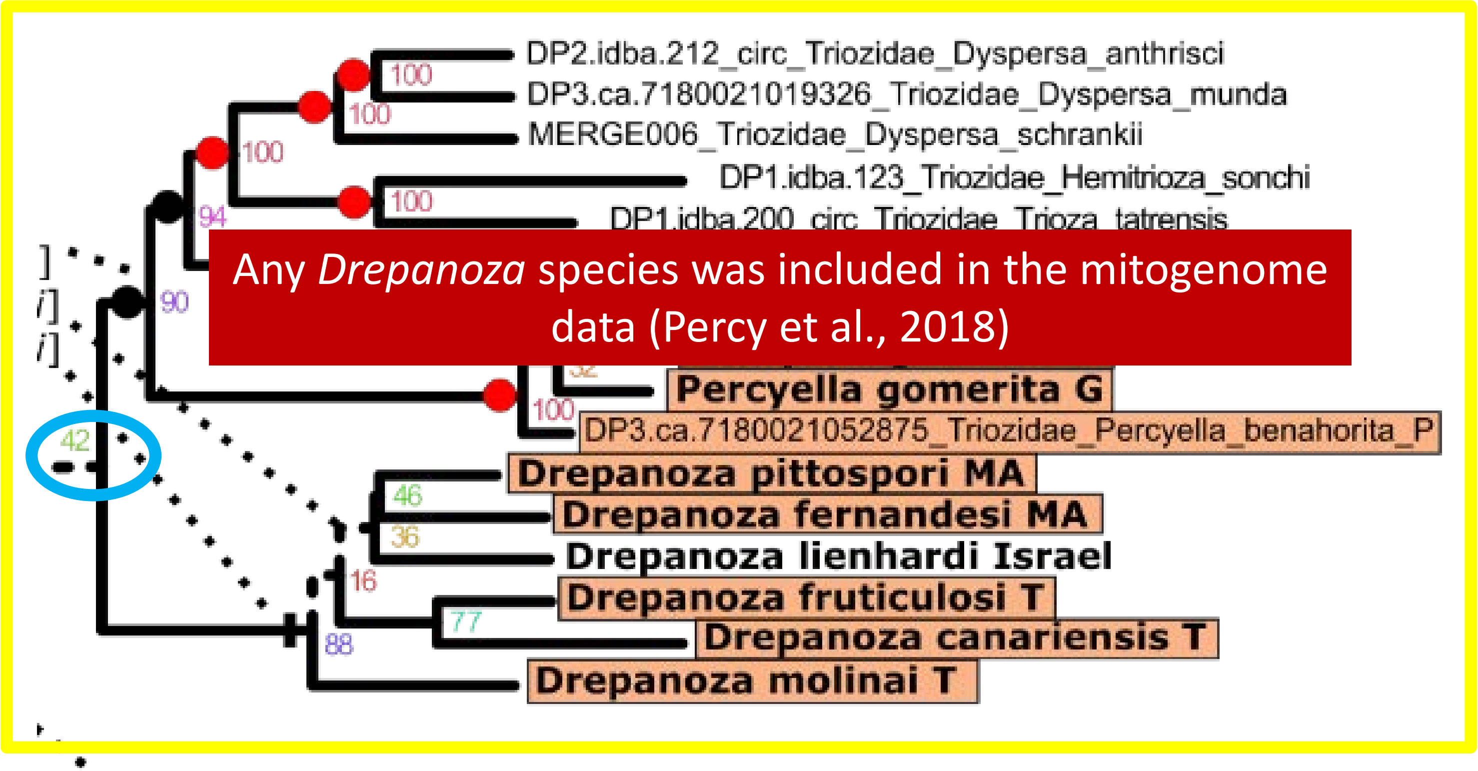
Results



- ML backbone constraint analysis:

- Placements of the lineages were moderately to well supported (with bootstrap > 80%)

Except *Drepanoza*



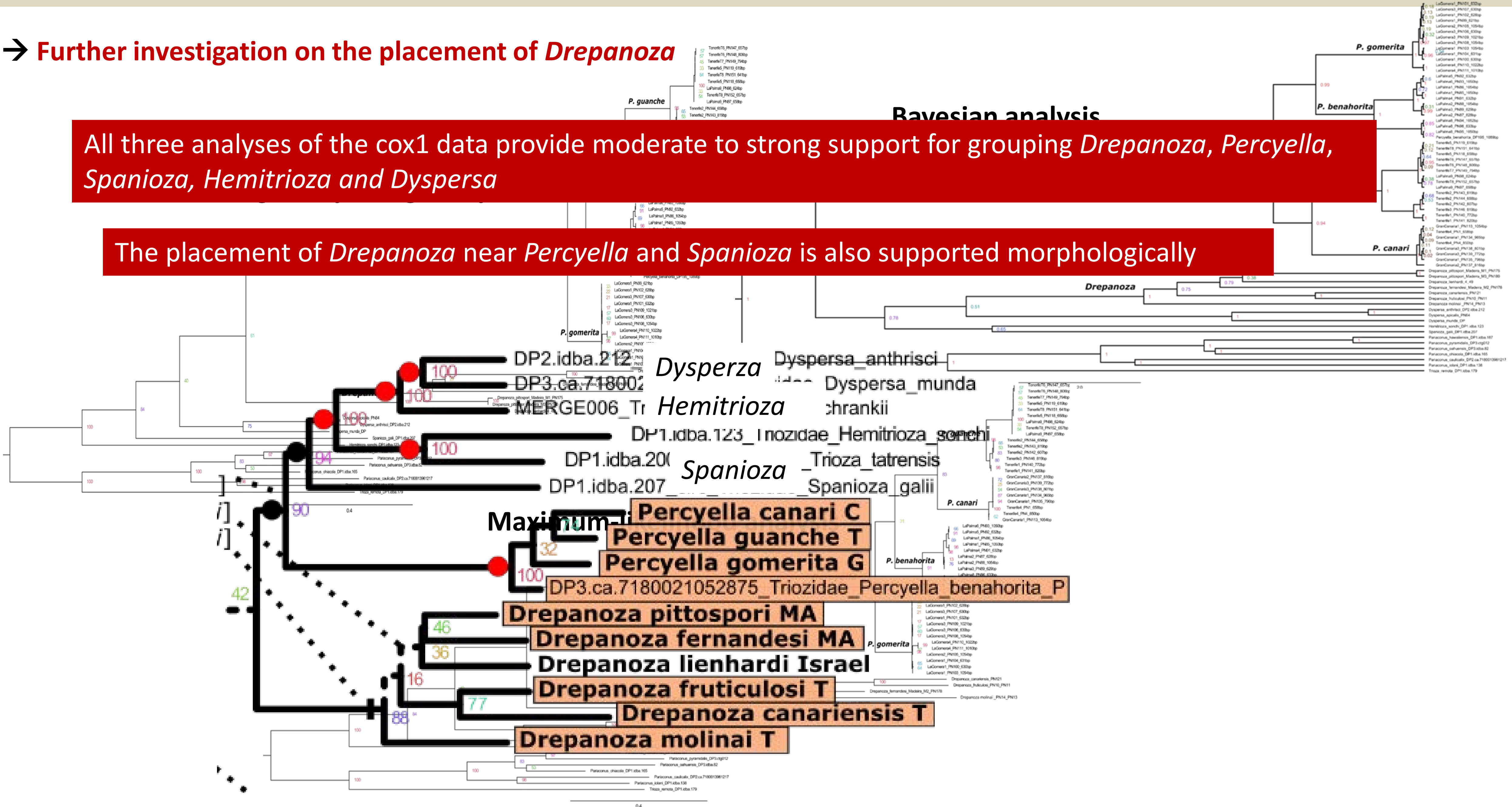
Any *Drepanoza* species was included in the mitogenome data (Percy et al., 2018)

Results

→ Further investigation on the placement of *Drepanoza*

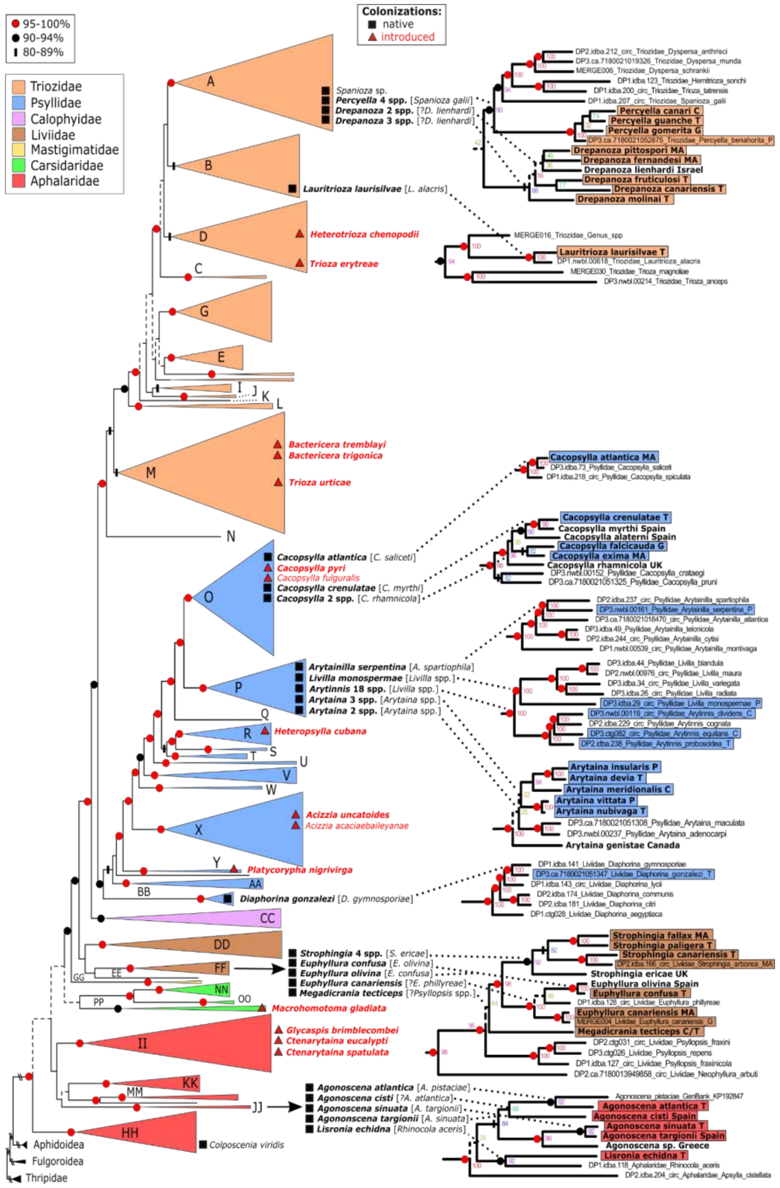
All three analyses of the cox1 data provide moderate to strong support for grouping *Drepanoza*, *Percyella*, *Spanioza*, *Hemitrioza and Dyspersa*

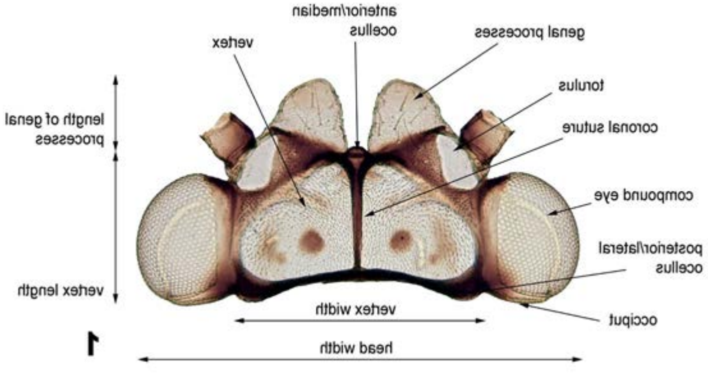
The placement of *Drepanoza* near *Percyella* and *Spanioza* is also supported morphologically

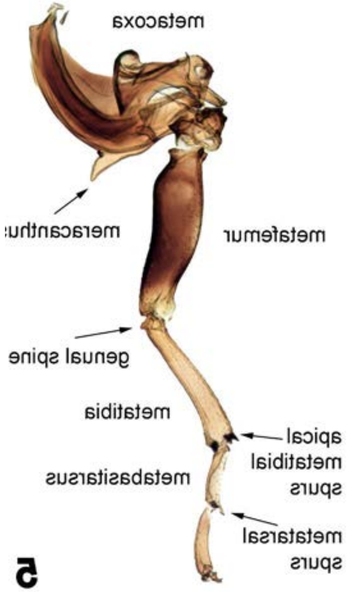


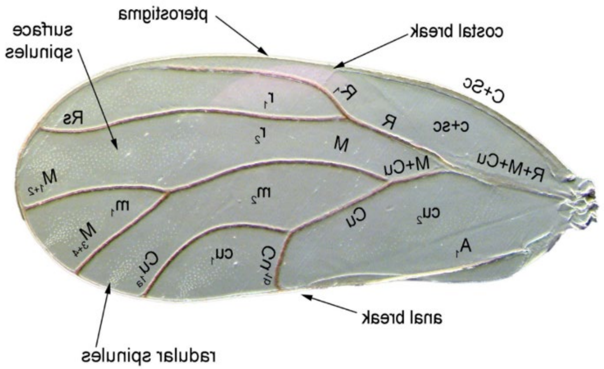
Results

- ➢ Confirmed, in most cases, the placement based on morphological characters





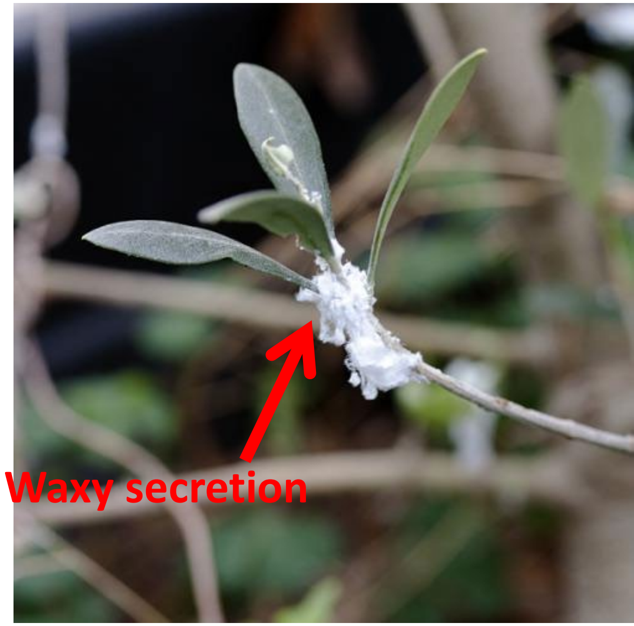




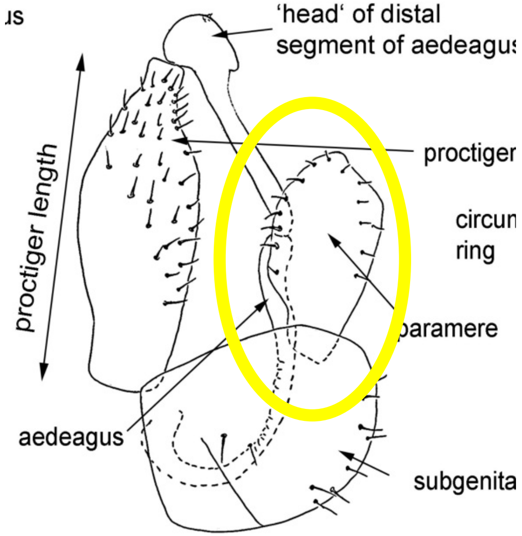
Results

+ cox1 divergence: **3,8%**

Olea europeae

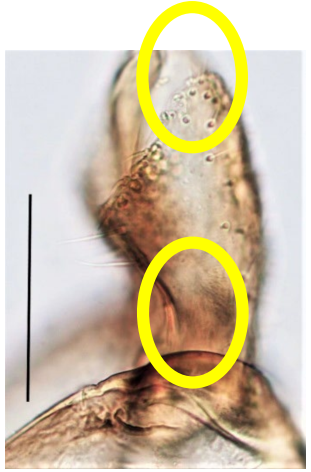


A relatively recent diversification



Male terminalia

E. confusa



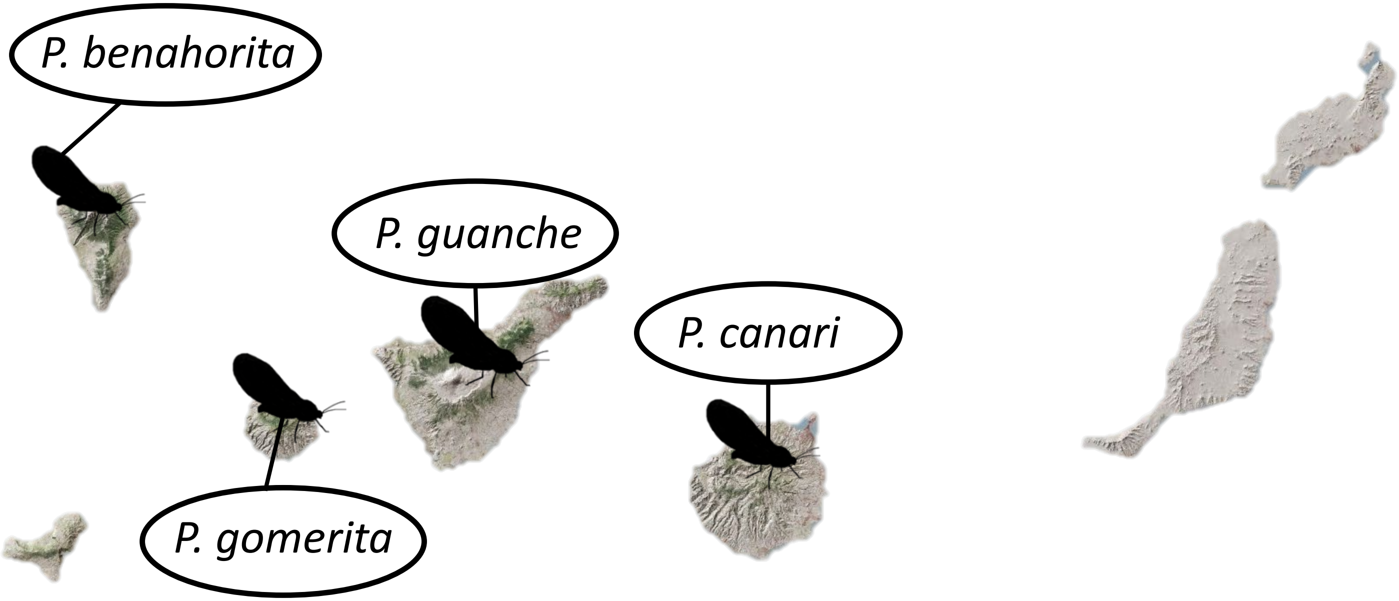
E. olivina

Example of allopatric speciation without host switch

Results

- **2 new genera:** ***Percyella*** (Triozidae) **Endemic genus**

Convolvulus floridus



Example of allopatric speciation

Results

- **2 new genera:** ***Percyella*** (Triozidae)
  Drepanoza (Triozidae)

3 endemic new species: *D. canariensis*, *D. fruticulosi*, *D. molinai*

1 endemic species: *Drepanoza (Trioza) montanetana*

2 species endemic of Madeira Islands: *Drepanoza (Trioza) pittospori, Drepanoza (Trioza) fernandesi*

1 continental specie: *Drepanoza (Trioza) fernandesi*

Results

- **2 new genera:** ***Percyella*** (Triozidae)
  Drepanoza (Triozidae)
- **16 new species** → 13 not previously known

4 *Percyella*: *P. guanche, P. canari, P. gomerita, P. benahorita*

3 *Drepanoza*: *D. canariensis, D. fruticulosi, D. molinai*

2 *Agonoscena*: *A. atlantica, A. sinuata* (Aphalaridae)

1 *Euphyllura*: *E. confusa* (Liviidae)

1 *Arytaina*: *A. meridionalis* (Psyllidae)

1 *Cacopsylla*: *C. falcicauda* (Psyllidae)

1 *Diaphorina*: *D. gonzalezi* (Psyllidae)

Strophingia canariensis and ***S. paligera*** (Liviidae)
→ misidentified as *S. arborea* Loginova (1976)

Cacopsylla crenulatae (Psyllidae)
→ misidentified as *Psylla alaterna* Loginova (1976)

Results

- **2 new genera:** ***Percyella*** (Triozidae)
  Drepanoza (Triozidae)
- **16 new species** → 13 not previously known
- ***Arytaina devia insularis*** is elevated to species rank: ***A. insularis***
- *Trioza laurisilvae* is transferred from *Trioza* to *Lauritrioza*
- Report for the first time of ***Colposcenia aliena*** and ***Agonoscena targioni***
- New data on **host plants** and **distribution**


252


24

Results

Enemies natural

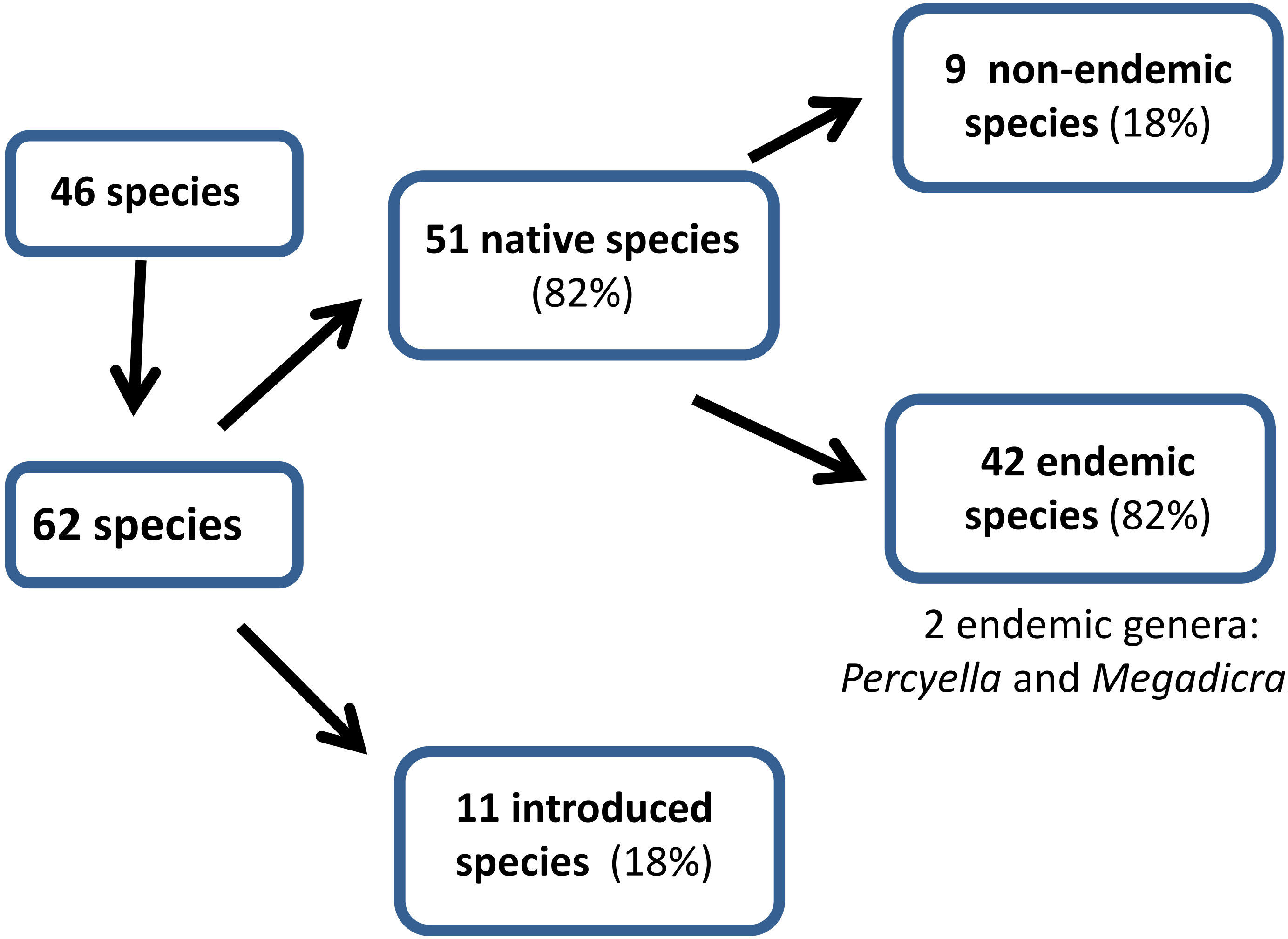
- Parasitoids and hyperparasitoids are reported for
  - **6 introduced species**
  - **10 endemic species**
- 5 generalist predators are reported for
  - **5 species in Triozidae**
- Ectoparasitic mite (Trombidiidae) are reported for
  - **5 endemic species**

Parasitoid of *Bactericera tremblayi*

Anthocoris salicis in the gall of *Percyella gomerita*

Ectoparasitic mite on *Percyella guanche*

62 species from 24 genera in 5 families



46 species

62 species

51 native species (82%)

11 introduced species (18%)

9 non-endemic species (18%)

- 4 Central Macaronesian
- 2 West Mediterranean
- 1 Mediterranean
- 2 West Palaearctic

42 endemic species (82%)

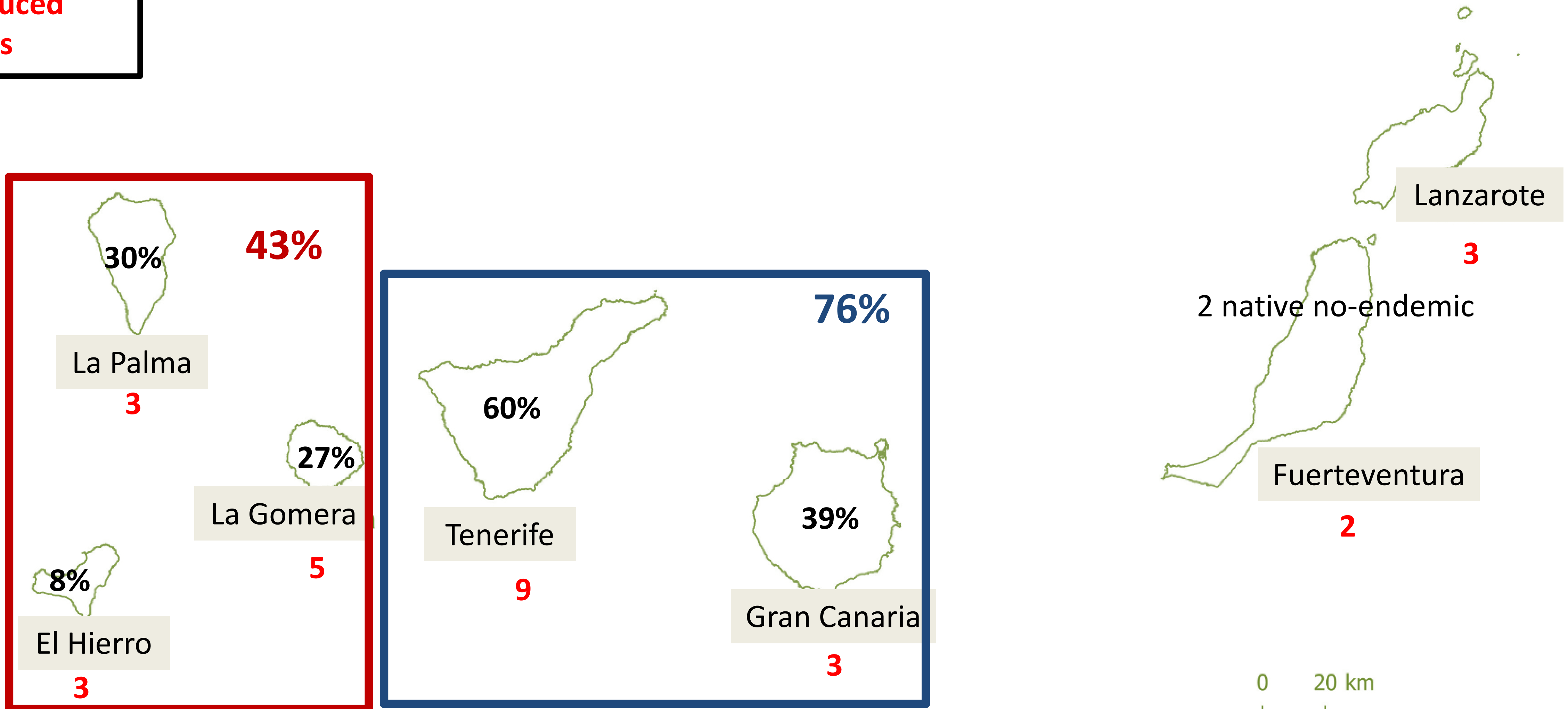
→ All but three endemic species have endemic host plant species

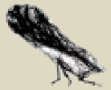
2 endemic genera:
Percyella and *Megadicrania*

Island distribution

<u>% native psyllid species</u>

number introduced species





Results

Number of colonization events

<u>% native psyllid species</u>

number introduced species

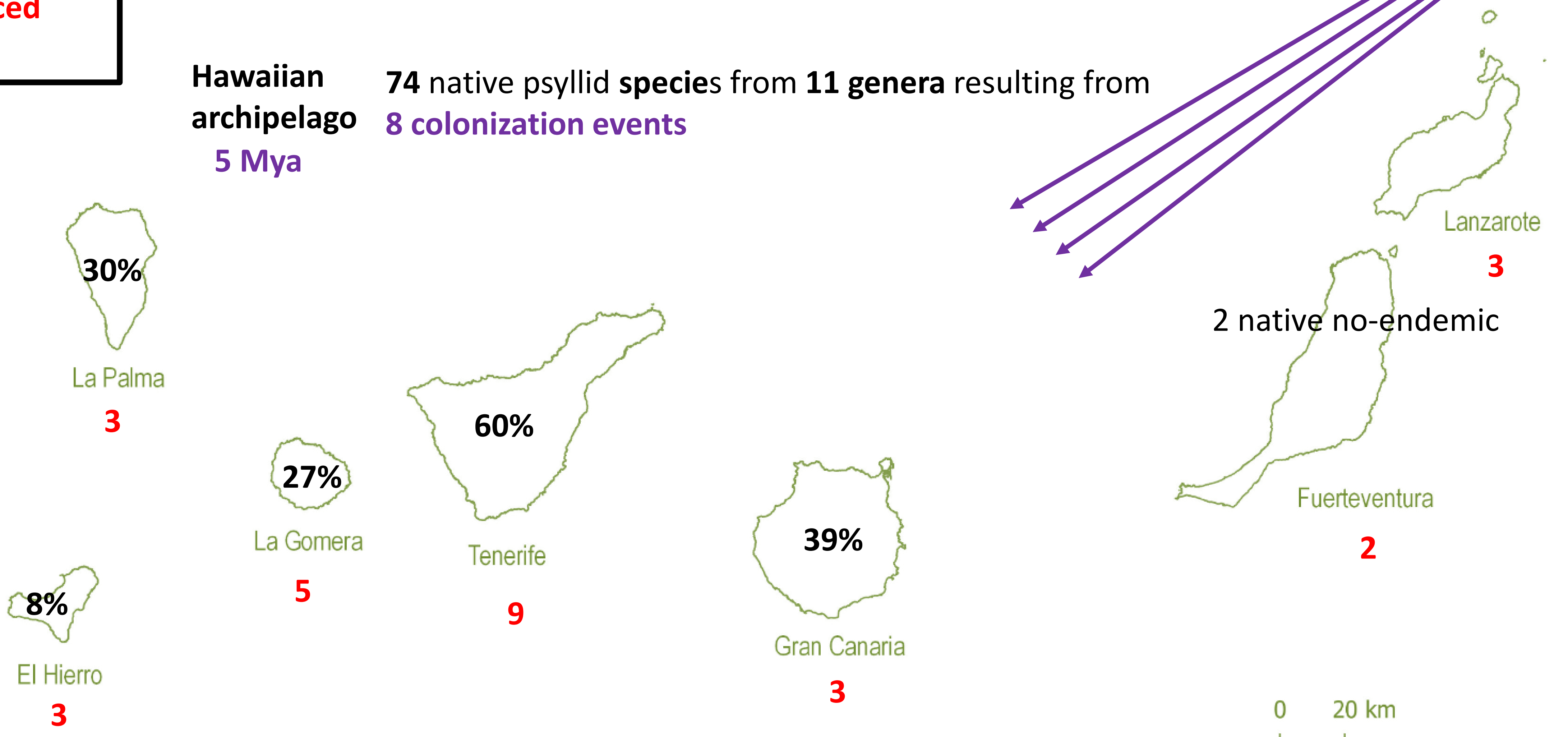
Canary Islands
21Mya

51 native psyllid **species** from **24 genera**

- →18 resulted in a single species
- →7 resulted in 2, 3 or 4 species
- →1 resulted in 16 species (*Arytinnis* radiation)

Hawaiian archipelago
5 Mya

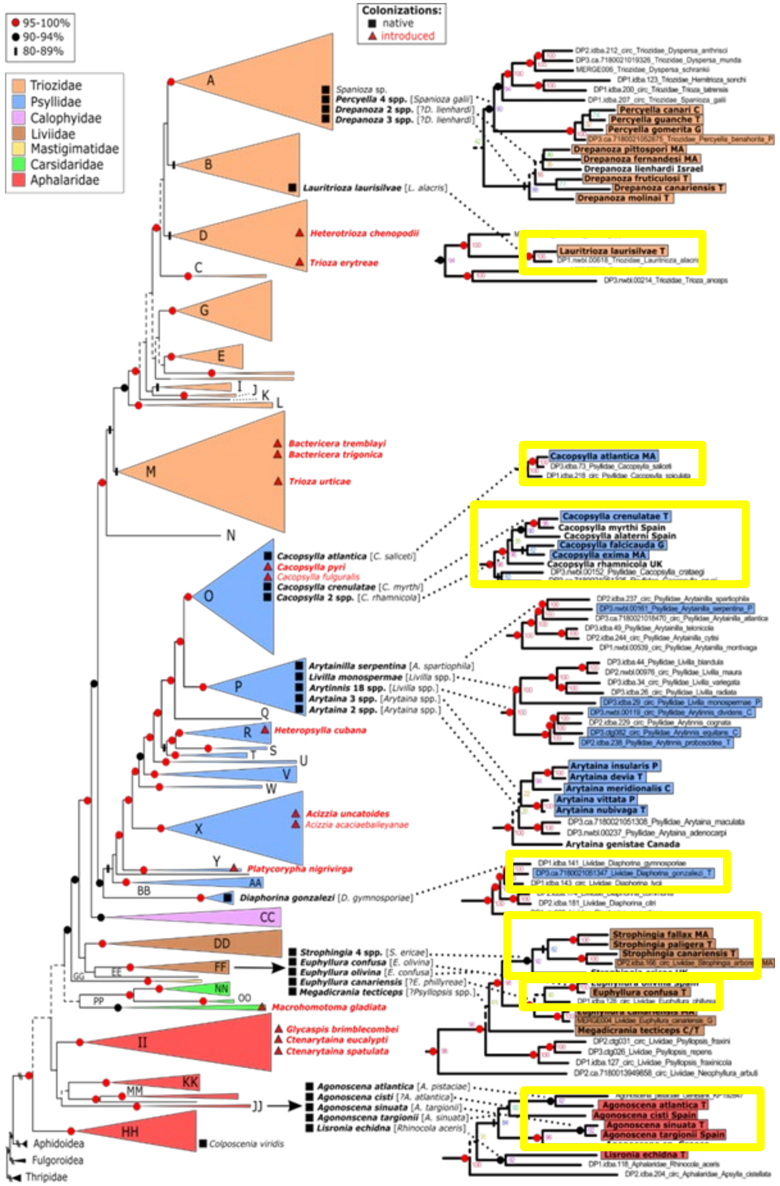
74 native psyllid **species** from **11 genera** resulting from **8 colonization events**

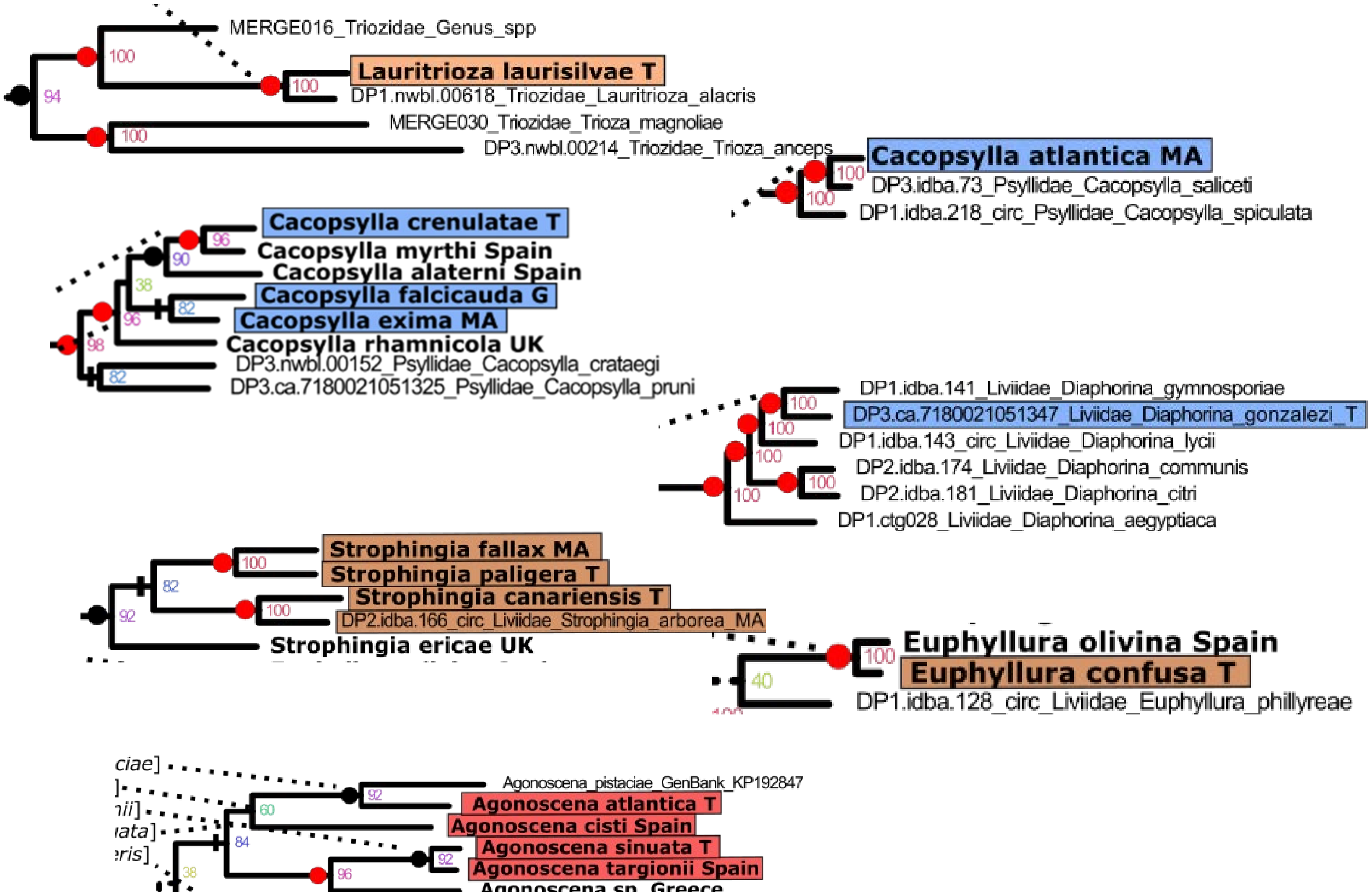


Results

Host plant associations

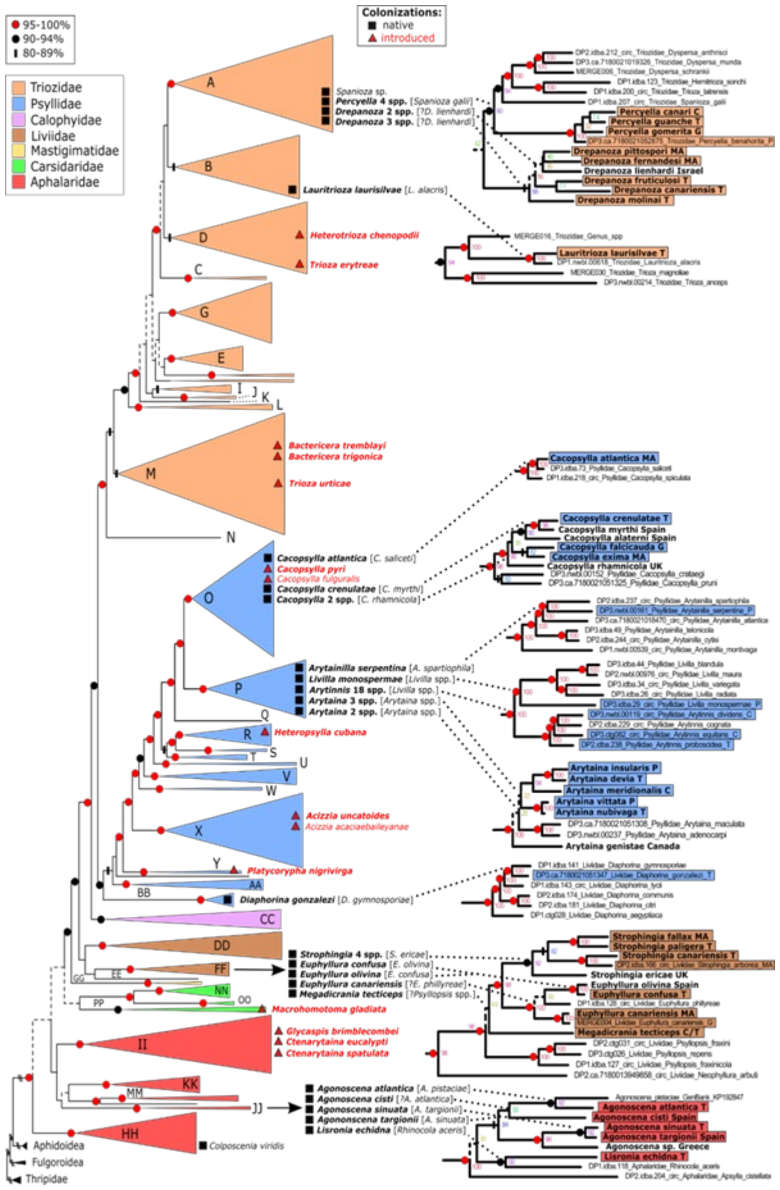
- ❖ Most of the colonizations involved use of the same host plant species, or same host plant genus as continental relatives

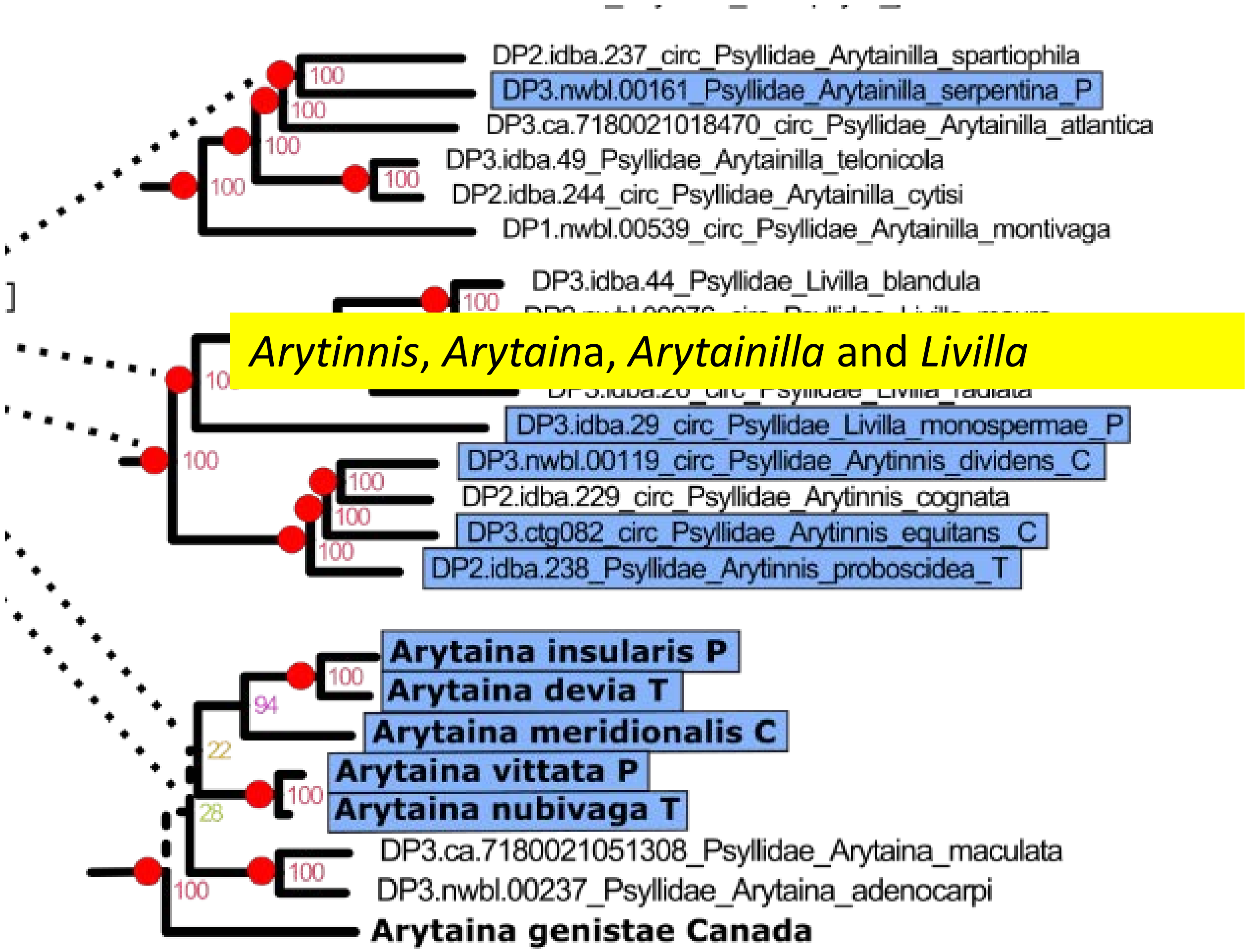




Results **Host plant associations**

- Most of the colonizations involved use of the same host plant genus as continental relatives
- The genistoid legume psyllid lineages are all examples of host switch to related genus

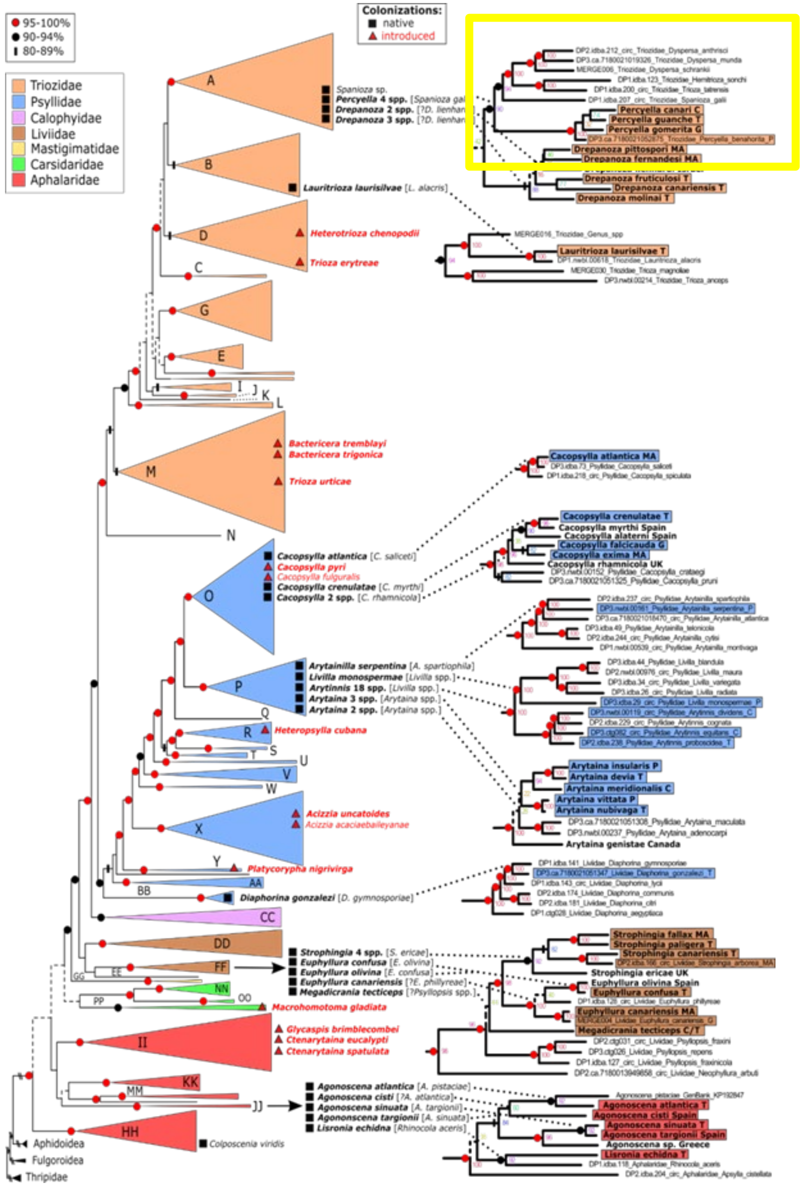




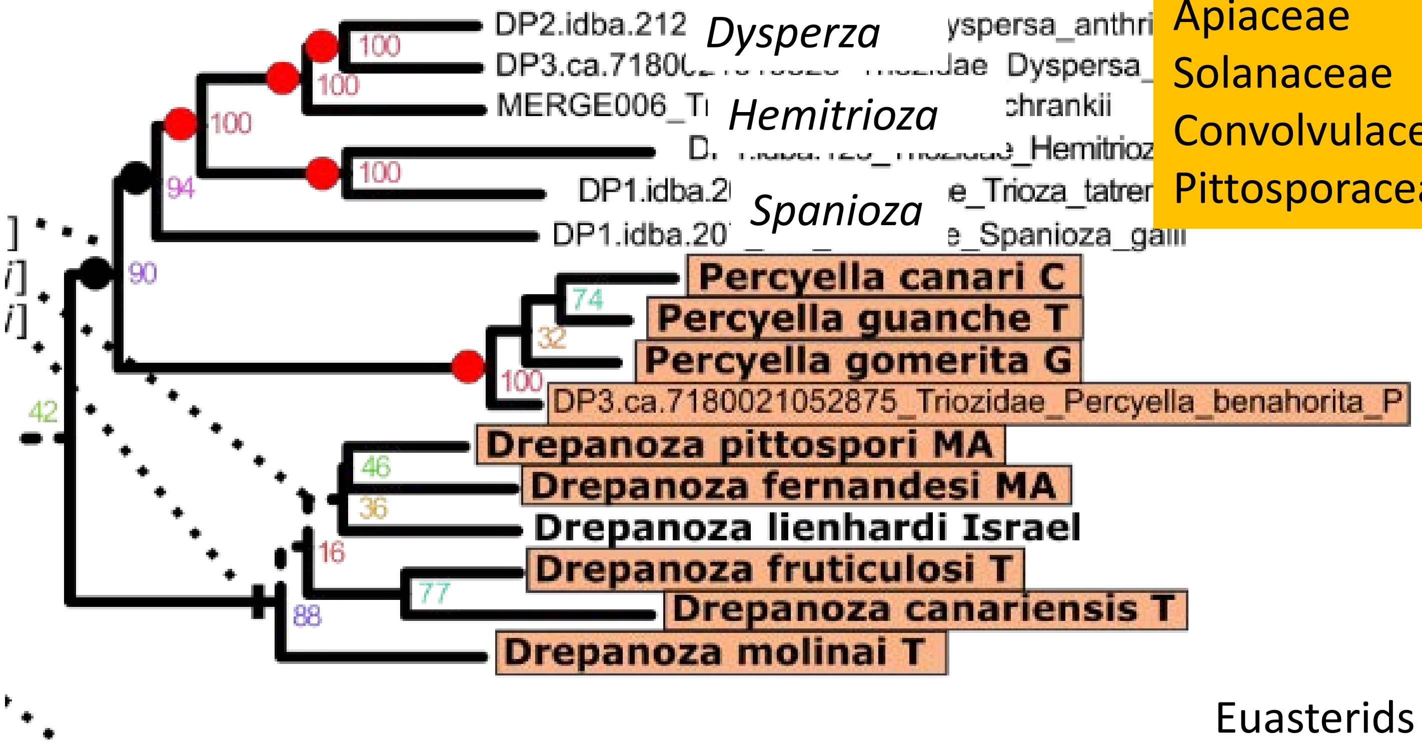
Arytinnis, *Arytaina*, *Arytainilla* and *Livilla*

Results

Host plant associations



- ❖ Most of the colonizations involved use of the same host plant genus as continental relatives
- ❖ The legume psyllid lineages are all examples of host switch to related genus
- ❖ Two colonizations involved host switch to different family



Asteraceae
Apiaceae
Solanaceae
Convolvulaceae
Pittosporaceae

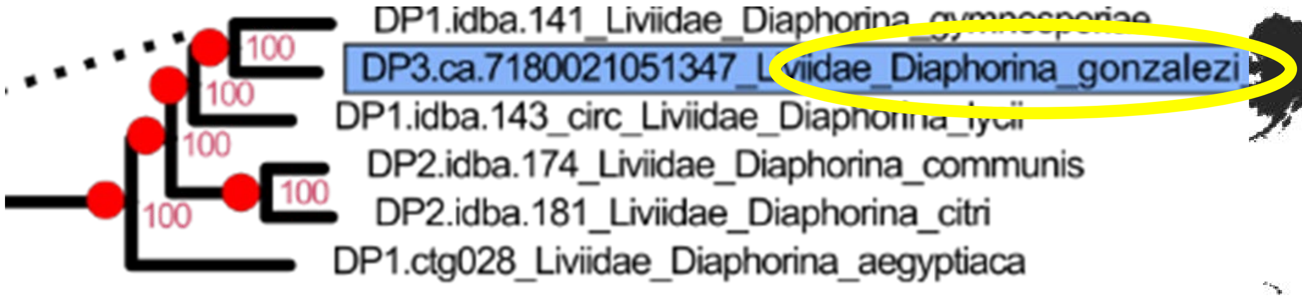
Euasterids

Origins

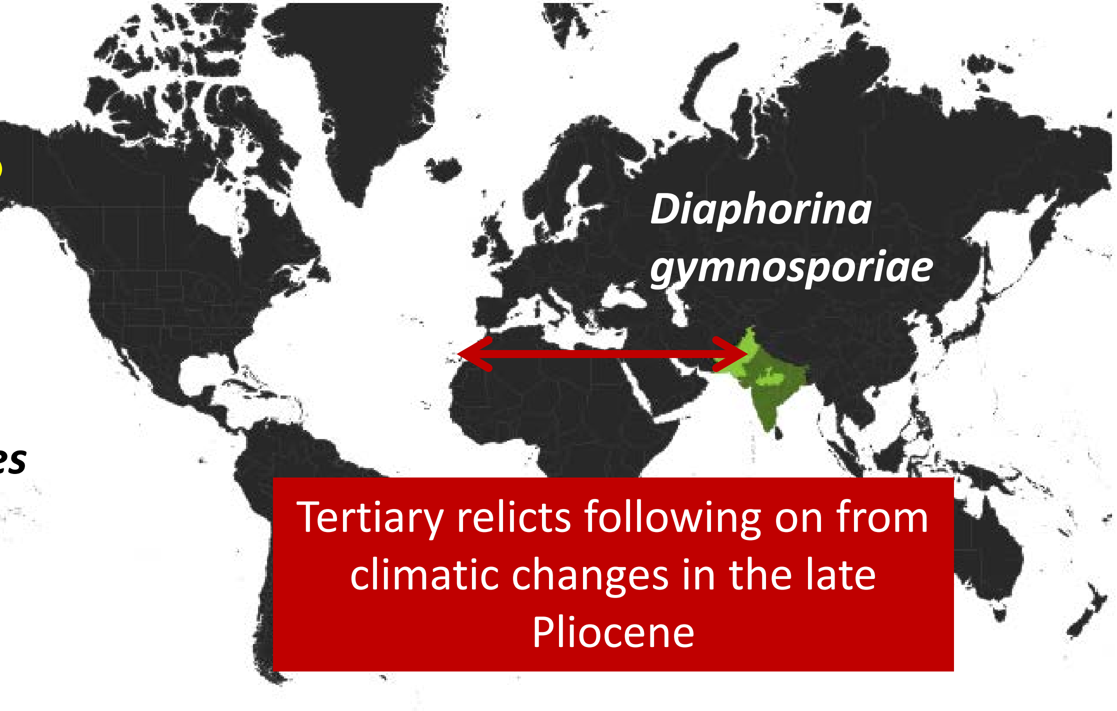
- ❖ All lineages have continental relatives from near or adjacent continental regions

  → Origins from proximal Mediterranean regions, southern Europe and north Africa

  → Except *Diaphorina gonzalezi*

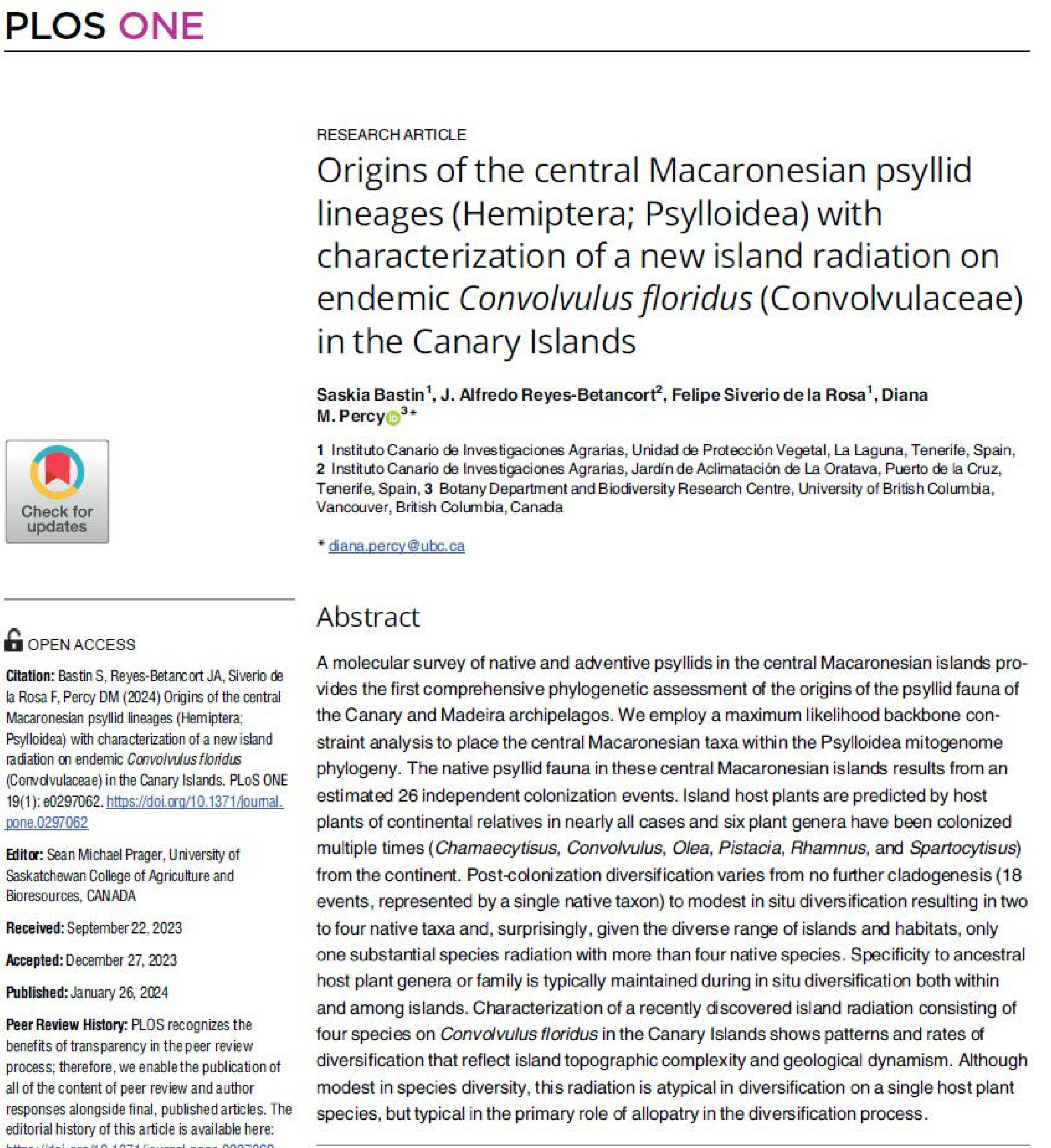


Host plant: *Gymnosporia cassinoides*



Tertiary relicts following on from climatic changes in the late Pliocene

Results



PLOS ONE

RESEARCH ARTICLE

Origins of the central Macaronesian psyllid lineages (Hemiptera; Psylloidea) with characterization of a new island radiation on endemic *Convolvulus floridus* (Convolvulaceae) in the Canary Islands

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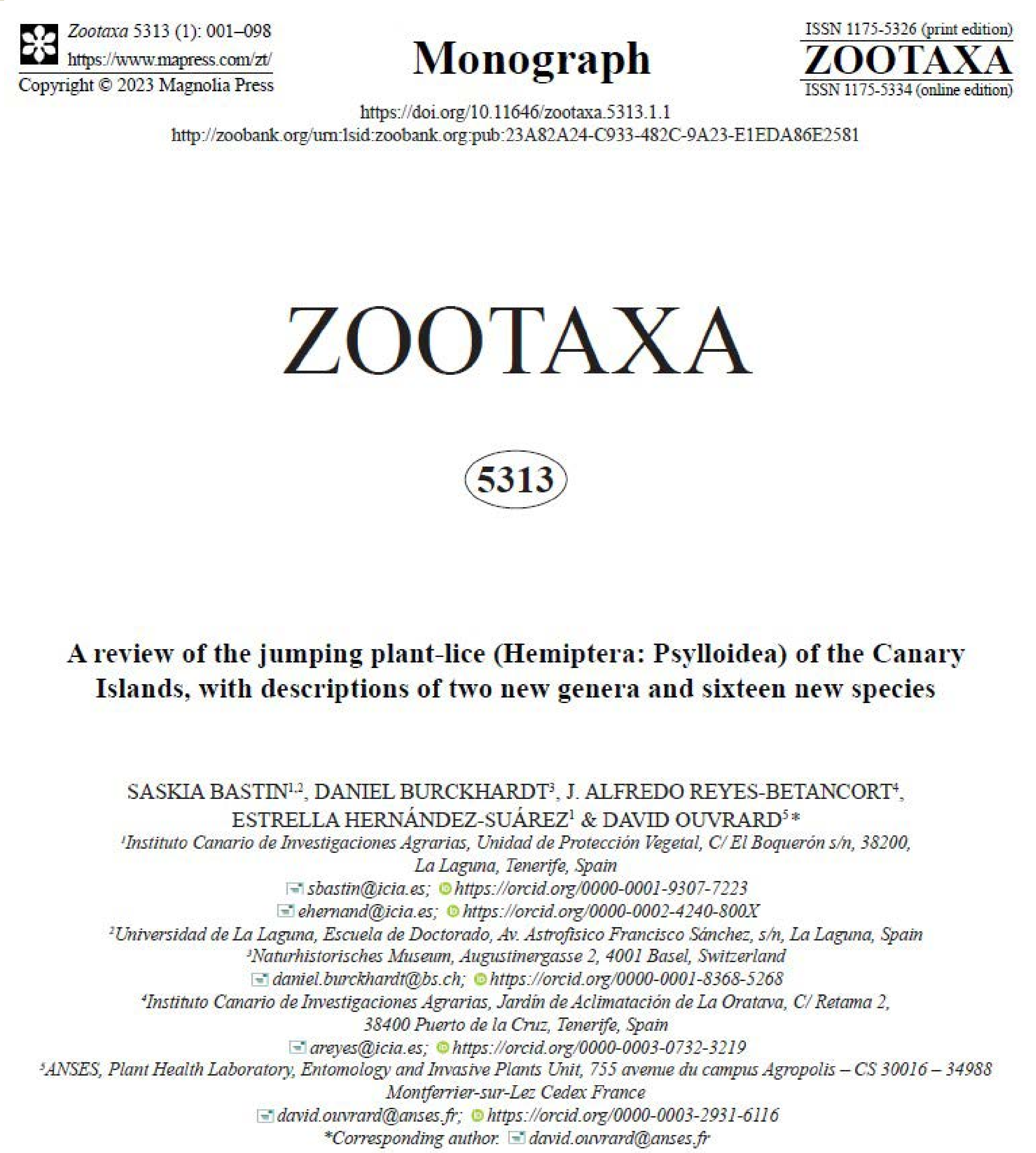
Abstract

A molecular survey of native and adventive psyllids in the central Macaronesian islands provides the first comprehensive phylogenetic assessment of the origins of the psyllid fauna of the Canary and Madeira archipelagos. We employ a maximum likelihood backbone constraint analysis to place the central Macaronesian taxa within the Psylloidea mitogenome phylogeny. The native psyllid fauna in these central Macaronesian islands results from an estimated 26 independent colonization events. Island host plants are predicted by host plants of continental relatives in nearly all cases and six plant genera have been colonized multiple times (*Chamaecytisus*, *Convolvulus*, *Olea*, *Pistacia*, *Rhamnus*, and *Spartocytisus*) from the continent. Post-colonization diversification varies from no further cladogenesis (18 events, represented by a single native taxon) to modest in situ diversification resulting in two to four native taxa and, surprisingly, given the diverse range of islands and habitats, only one substantial species radiation with more than four native species. Specificity to ancestral host plant genera or family is typically maintained during in situ diversification both within and among islands. Characterization of a recently discovered island radiation consisting of four species on *Convolvulus floridus* in the Canary Islands shows patterns and rates of diversification that reflect island topographic complexity and geological dynamism. Although modest in species diversity, this radiation is atypical in diversification on a single host plant species, but typical in the primary role of allopatry in the diversification process.



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ZOOTAXA

5313

A review of the jumping plant-lice (Hemiptera: Psylloidea) of the Canary Islands, with descriptions of two new genera and sixteen new species

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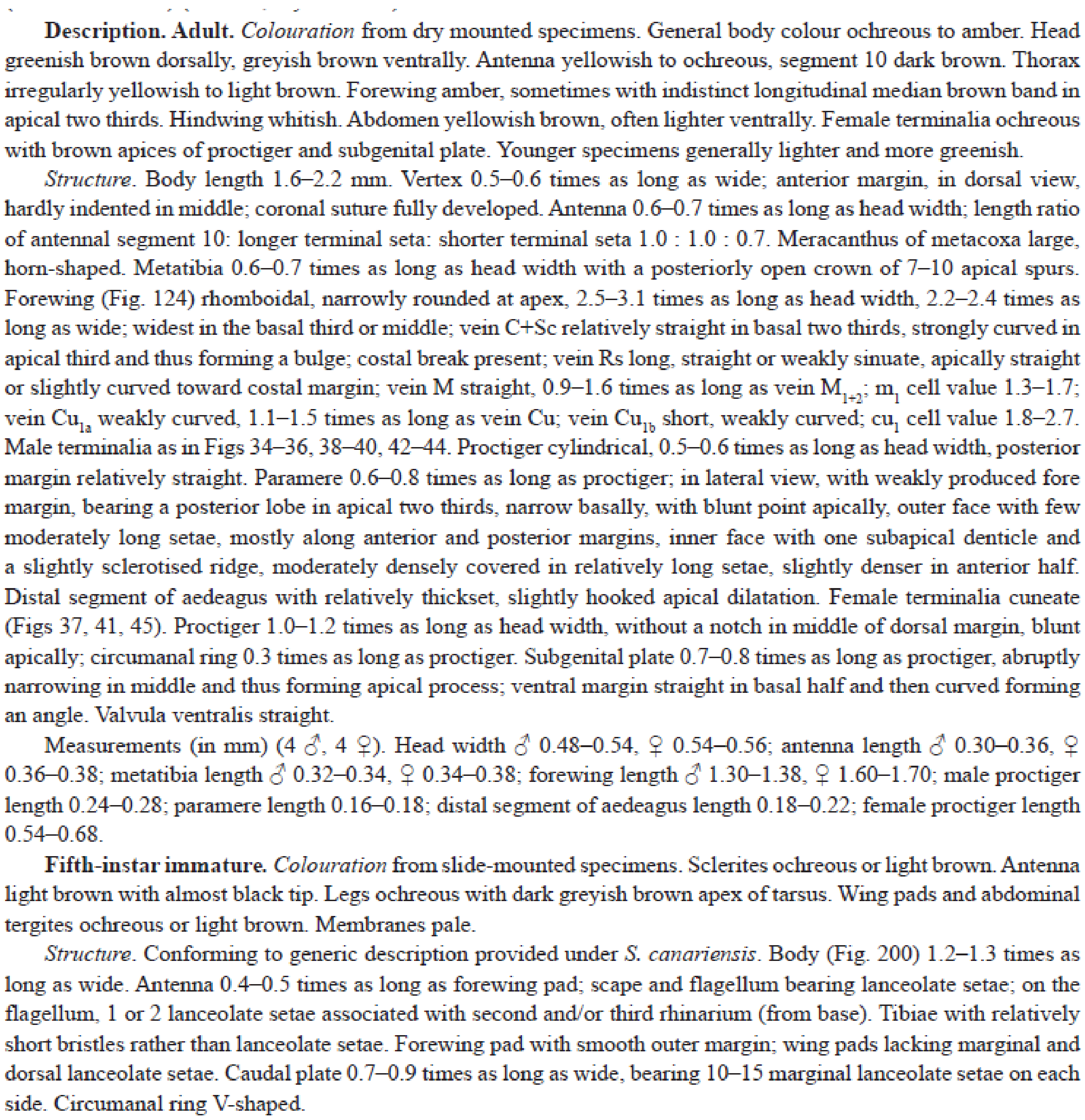
**Corresponding author. david.ouvrard@anses.fr*

Results



Description. Adult. *Colouration* from dry mounted specimens. General body colour ochreous to amber. Head greenish brown dorsally, greyish brown ventrally. Antenna yellowish to ochreous, segment 10 dark brown. Thorax irregularly yellowish to light brown. Forewing amber, sometimes with indistinct longitudinal median brown band in apical two thirds. Hindwing whitish. Abdomen yellowish brown, often lighter ventrally. Female terminalia ochreous with brown apices of proctiger and subgenital plate. Younger specimens generally lighter and more greenish.

Structure. Body length 1.6–2.2 mm. Vertex 0.5–0.6 times as long as wide; anterior margin, in dorsal view, hardly indented in middle; coronal suture fully developed. Antenna 0.6–0.7 times as long as head width; length ratio of antennal segment 10: longer terminal seta: shorter terminal seta 1.0 : 1.0 : 0.7. Meracanthus of metacoxa large, horn-shaped. Metatibia 0.6–0.7 times as long as head width with a posteriorly open crown of 7–10 apical spurs. Forewing (Fig. 124) rhomboidal, narrowly rounded at apex, 2.5–3.1 times as long as head width, 2.2–2.4 times as long as wide; widest in the basal third or middle; vein C+Sc relatively straight in basal two thirds, strongly curved in apical third and thus forming a bulge; costal break present; vein Rs long, straight or weakly sinuate, apically straight or slightly curved toward costal margin; vein M straight, 0.9–1.6 times as long as vein M_{1+2}; m_1 cell value 1.3–1.7; vein Cu_{1a} weakly curved, 1.1–1.5 times as long as vein Cu; vein Cu_{1b} short, weakly curved; cu_1 cell value 1.8–2.7. Male terminalia as in Figs 34–36, 38–40, 42–44. Proctiger cylindrical, 0.5–0.6 times as long as head width, posterior margin relatively straight. Paramere 0.6–0.8 times as long as proctiger; in lateral view, with weakly produced fore margin, bearing a posterior lobe in apical two thirds, narrow basally, with blunt point apically, outer face with few moderately long setae, mostly along anterior and posterior margins, inner face with one subapical denticle and a slightly sclerotised ridge, moderately densely covered in relatively long setae, slightly denser in anterior half. Distal segment of aedeagus with relatively thickset, slightly hooked apical dilatation. Female terminalia cuneate (Figs 37, 41, 45). Proctiger 1.0–1.2 times as long as head width, without a notch in middle of dorsal margin, blunt apically; circumanal ring 0.3 times as long as proctiger. Subgenital plate 0.7–0.8 times as long as proctiger, abruptly narrowing in middle and thus forming apical process; ventral margin straight in basal half and then curved forming an angle. Valvula ventralis straight.

Measurements (in mm) (4 ♂, 4 ♀). Head width ♂ 0.48–0.54, ♀ 0.54–0.56; antenna length ♂ 0.30–0.36, ♀ 0.36–0.38; metatibia length ♂ 0.32–0.34, ♀ 0.34–0.38; forewing length ♂ 1.30–1.38, ♀ 1.60–1.70; male proctiger length 0.24–0.28; paramere length 0.16–0.18; distal segment of aedeagus length 0.18–0.22; female proctiger length 0.54–0.68.

Fifth-instar immature. *Colouration* from slide-mounted specimens. Sclerites ochreous or light brown. Antenna light brown with almost black tip. Legs ochreous with dark greyish brown apex of tarsus. Wing pads and abdominal tergites ochreous or light brown. Membranes pale.

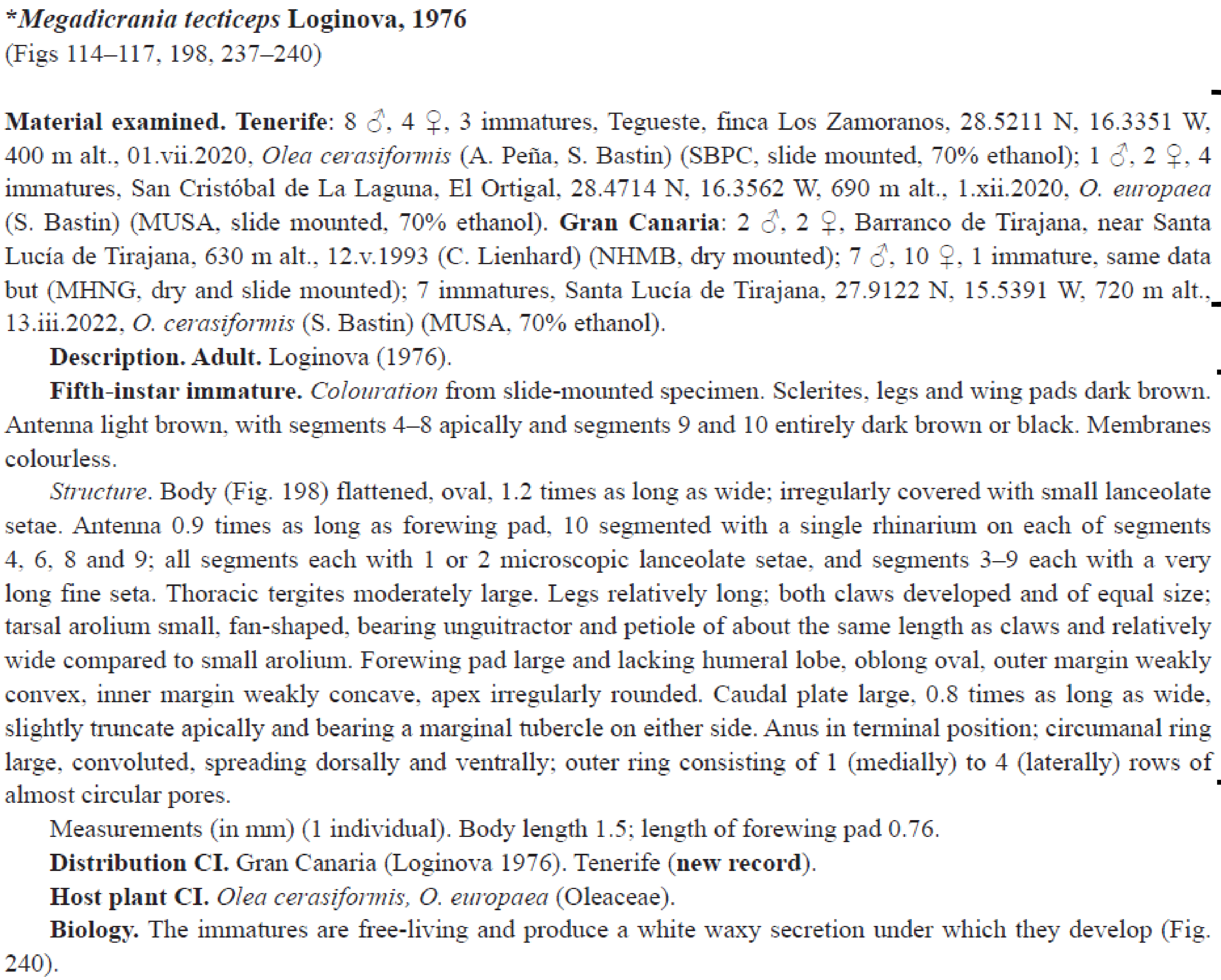
Structure. Conforming to generic description provided under *S. canariensis*. Body (Fig. 200) 1.2–1.3 times as long as wide. Antenna 0.4–0.5 times as long as forewing pad; scape and flagellum bearing lanceolate setae; on the flagellum, 1 or 2 lanceolate setae associated with second and/or third rhinarium (from base). Tibiae with relatively short bristles rather than lanceolate setae. Forewing pad with smooth outer margin; wing pads lacking marginal and dorsal lanceolate setae. Caudal plate 0.7–0.9 times as long as wide, bearing 10–15 marginal lanceolate setae on each side. Circumanal ring V-shaped.

For new species:

Description of female and male adult

Description of fifth-instar immature

Comparison to closely related species



Megadicrania tecticeps* **Loginova, 1976
(Figs 114–117, 198, 237–240)

Material examined. Tenerife: 8 ♂, 4 ♀, 3 immatures, Tegueste, finca Los Zamoranos, 28.5211 N, 16.3351 W, 400 m alt., 01.vii.2020, *Olea cerasiformis* (A. Peña, S. Bastin) (SBPC, slide mounted, 70% ethanol); 1 ♂, 2 ♀, 4 immatures, San Cristóbal de La Laguna, El Ortigal, 28.4714 N, 16.3562 W, 690 m alt., 1.xii.2020, *O. europaea* (S. Bastin) (MUSA, slide mounted, 70% ethanol). **Gran Canaria**: 2 ♂, 2 ♀, Barranco de Tirajana, near Santa Lucía de Tirajana, 630 m alt., 12.v.1993 (C. Lienhard) (NHMB, dry mounted); 7 ♂, 10 ♀, 1 immature, same data but (MHNG, dry and slide mounted); 7 immatures, Santa Lucía de Tirajana, 27.9122 N, 15.5391 W, 720 m alt., 13.iii.2022, *O. cerasiformis* (S. Bastin) (MUSA, 70% ethanol).

Description. Adult. Loginova (1976).

Fifth-instar immature. *Colouration* from slide-mounted specimen. Sclerites, legs and wing pads dark brown. Antenna light brown, with segments 4–8 apically and segments 9 and 10 entirely dark brown or black. Membranes colourless.

Structure. Body (Fig. 198) flattened, oval, 1.2 times as long as wide; irregularly covered with small lanceolate setae. Antenna 0.9 times as long as forewing pad, 10 segmented with a single rhinarium on each of segments 4, 6, 8 and 9; all segments each with 1 or 2 microscopic lanceolate setae, and segments 3–9 each with a very long fine seta. Thoracic tergites moderately large. Legs relatively long; both claws developed and of equal size; tarsal arolium small, fan-shaped, bearing unguitractor and petiole of about the same length as claws and relatively wide compared to small arolium. Forewing pad large and lacking humeral lobe, oblong oval, outer margin weakly convex, inner margin weakly concave, apex irregularly rounded. Caudal plate large, 0.8 times as long as wide, slightly truncate apically and bearing a marginal tubercle on either side. Anus in terminal position; circumanal ring large, convoluted, spreading dorsally and ventrally; outer ring consisting of 1 (medially) to 4 (laterally) rows of almost circular pores.

Measurements (in mm) (1 individual). Body length 1.5; length of forewing pad 0.76.

Distribution CI. Gran Canaria (Loginova 1976). Tenerife (**new record**).

Host plant CI. *Olea cerasiformis, O. europaea* (Oleaceae).

Biology. The immatures are free-living and produce a white waxy secretion under which they develop (Fig. 240).

For each species:

Material examined

Reference of the scientific literature in which adult and fifth instar immature are described

Description of fifth-instar immature, if not provided in the existing literature

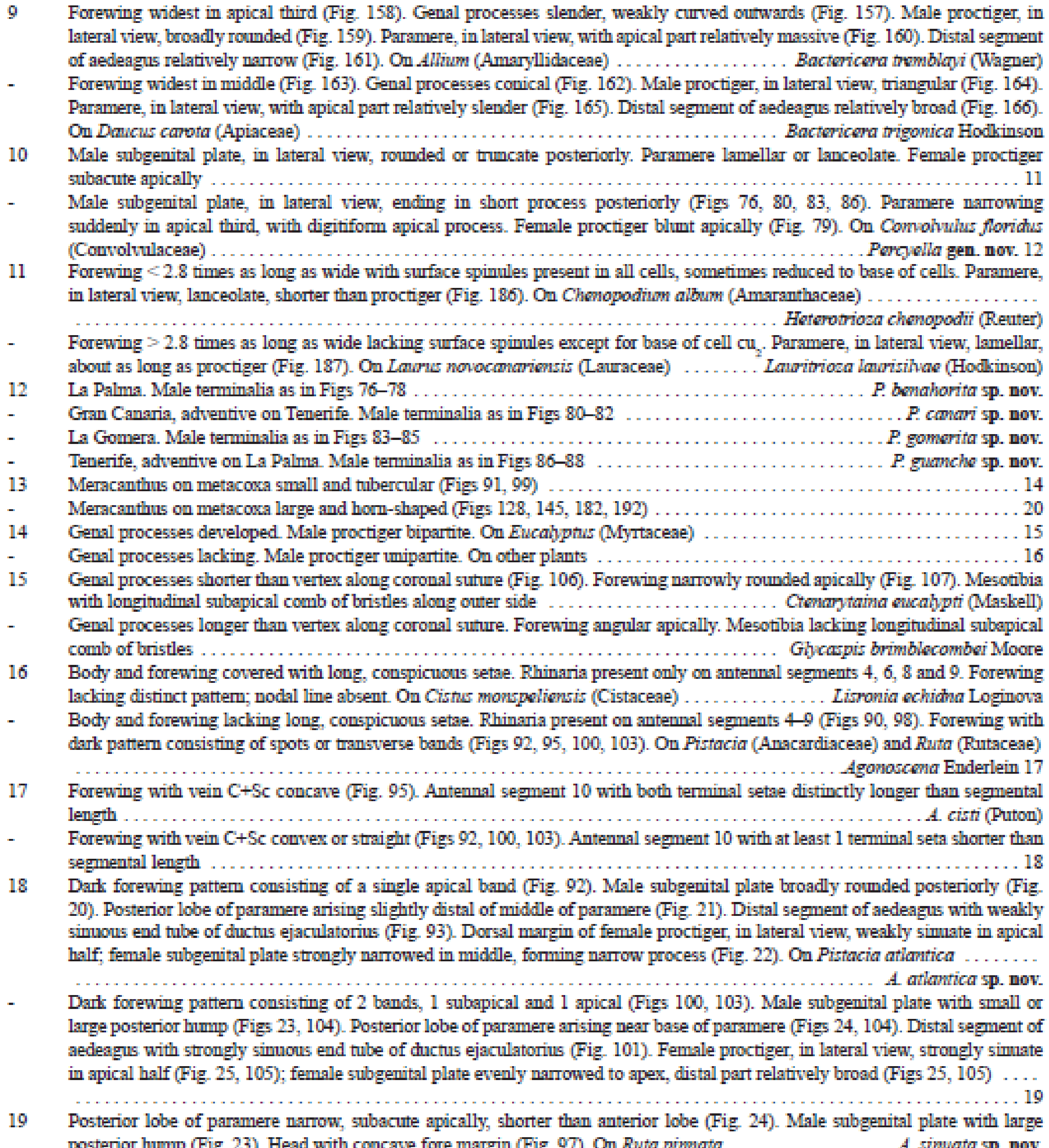
Distribution in the Canary Islands

Host plant in the Canary Islands

Biology (galls description, interaction with parasitoids and predators)

Results

- Keys for the identification of adults and last instar immatures of species present in the Canary Islands



9 Forewing widest in apical third (Fig. 158). Genal processes slender, weakly curved outwards (Fig. 157). Male proctiger, in lateral view, broadly rounded (Fig. 159). Paramere, in lateral view, with apical part relatively massive (Fig. 160). Distal segment of aedeagus relatively narrow (Fig. 161). On *Allium* (Amaryllidaceae) . . . . *Bactericera tremblayi* (Wagner)

\- Forewing widest in middle (Fig. 163). Genal processes conical (Fig. 162). Male proctiger, in lateral view, triangular (Fig. 164). Paramere, in lateral view, with apical part relatively slender (Fig. 165). Distal segment of aedeagus relatively broad (Fig. 166). On *Daucus carota* (Apiaceae) . . . . *Bactericera trigonica* Hodkinson

10 Male subgenital plate, in lateral view, rounded or truncate posteriorly. Paramere lamellar or lanceolate. Female proctiger subacute apically 11

\- Male subgenital plate, in lateral view, ending in short process posteriorly (Figs 76, 80, 83, 86). Paramere narrowing suddenly in apical third, with digitiform apical process. Female proctiger blunt apically (Fig. 79). On *Convolvulus floridus* (Convolvulaceae) . . . . *Percyella* **gen. nov.** 12

11 Forewing < 2.8 times as long as wide with surface spinules present in all cells, sometimes reduced to base of cells. Paramere, in lateral view, lanceolate, shorter than proctiger (Fig. 186). On *Chenopodium album* (Amaranthaceae) . . . . *Heterotrioza chenopodii* (Reuter)

\- Forewing > 2.8 times as long as wide lacking surface spinules except for base of cell cu_2. Paramere, in lateral view, lamellar, about as long as proctiger (Fig. 187). On *Laurus novocanariensis* (Lauraceae) . . . . *Lauritrioza laurisilvae* (Hodkinson)

12 La Palma. Male terminalia as in Figs 76–78 . . . . *P. benahorita* **sp. nov.**

\- Gran Canaria, adventive on Tenerife. Male terminalia as in Figs 80–82 . . . . *P. canari* **sp. nov.**

\- La Gomera. Male terminalia as in Figs 83–85 . . . . *P. gomerita* **sp. nov.**

\- Tenerife, adventive on La Palma. Male terminalia as in Figs 86–88 . . . . *P. guanche* **sp. nov.**

13 Meracanthus on metacoxa small and tubercular (Figs 91, 99) 14

\- Meracanthus on metacoxa large and horn-shaped (Figs 128, 145, 182, 192) 20

14 Genal processes developed. Male proctiger bipartite. On *Eucalyptus* (Myrtaceae) 15

\- Genal processes lacking. Male proctiger unipartite. On other plants 16

15 Genal processes shorter than vertex along coronal suture (Fig. 106). Forewing narrowly rounded apically (Fig. 107). Mesotibia with longitudinal subapical comb of bristles along outer side . . . . *Ctenarytaina eucalypti* (Maskell)

\- Genal processes longer than vertex along coronal suture. Forewing angular apically. Mesotibia lacking longitudinal subapical comb of bristles . . . . *Glycaspis brimblecombei* Moore

16 Body and forewing covered with long, conspicuous setae. Rhinaria present only on antennal segments 4, 6, 8 and 9. Forewing lacking distinct pattern; nodal line absent. On *Cistus monspeliensis* (Cistaceae) . . . . *Lisronia echidna* Loginova

\- Body and forewing lacking long, conspicuous setae. Rhinaria present on antennal segments 4–9 (Figs 90, 98). Forewing with dark pattern consisting of spots or transverse bands (Figs 92, 95, 100, 103). On *Pistacia* (Anacardiaceae) and *Ruta* (Rutaceae) . . . . *Agonoscena* Enderlein 17

17 Forewing with vein C+Sc concave (Fig. 95). Antennal segment 10 with both terminal setae distinctly longer than segmental length . . . . *A. cisti* (Puton)

\- Forewing with vein C+Sc convex or straight (Figs 92, 100, 103). Antennal segment 10 with at least 1 terminal seta shorter than segmental length 18

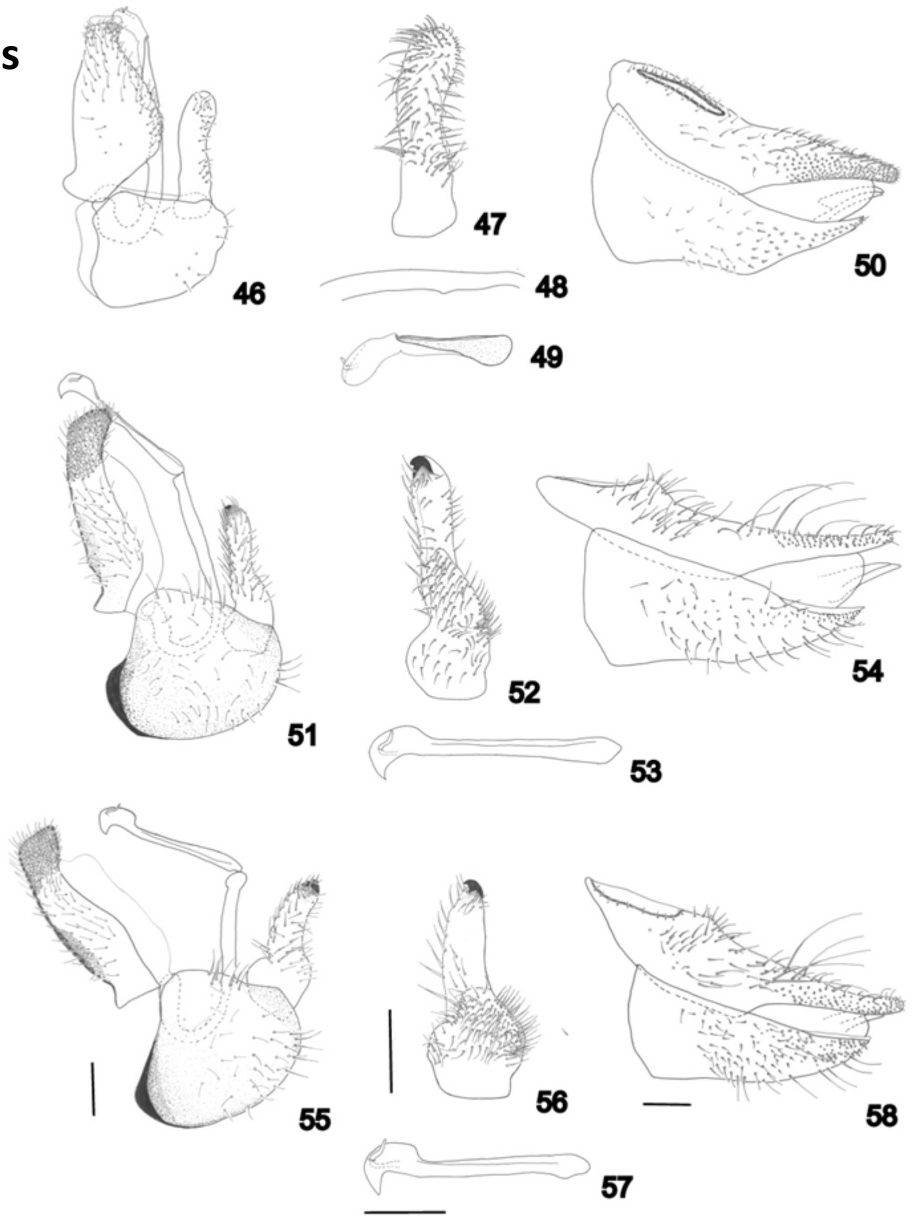
18 Dark forewing pattern consisting of a single apical band (Fig. 92). Male subgenital plate broadly rounded posteriorly (Fig. 20). Posterior lobe of paramere arising slightly distal of middle of paramere (Fig. 21). Distal segment of aedeagus with weakly sinuous end tube of ductus ejaculatorius (Fig. 93). Dorsal margin of female proctiger, in lateral view, weakly sinuate in apical half; female subgenital plate strongly narrowed in middle, forming narrow process (Fig. 22). On *Pistacia atlantica* . . . . *A. atlantica* **sp. nov.**

\- Dark forewing pattern consisting of 2 bands, 1 subapical and 1 apical (Figs 100, 103). Male subgenital plate with small or large posterior hump (Figs 23, 104). Posterior lobe of paramere arising near base of paramere (Figs 24, 104). Distal segment of aedeagus with strongly sinuous end tube of ductus ejaculatorius (Fig. 101). Female proctiger, in lateral view, strongly sinuate in apical half (Fig. 25, 105); female subgenital plate evenly narrowed to apex, distal part relatively broad (Figs 25, 105) 19

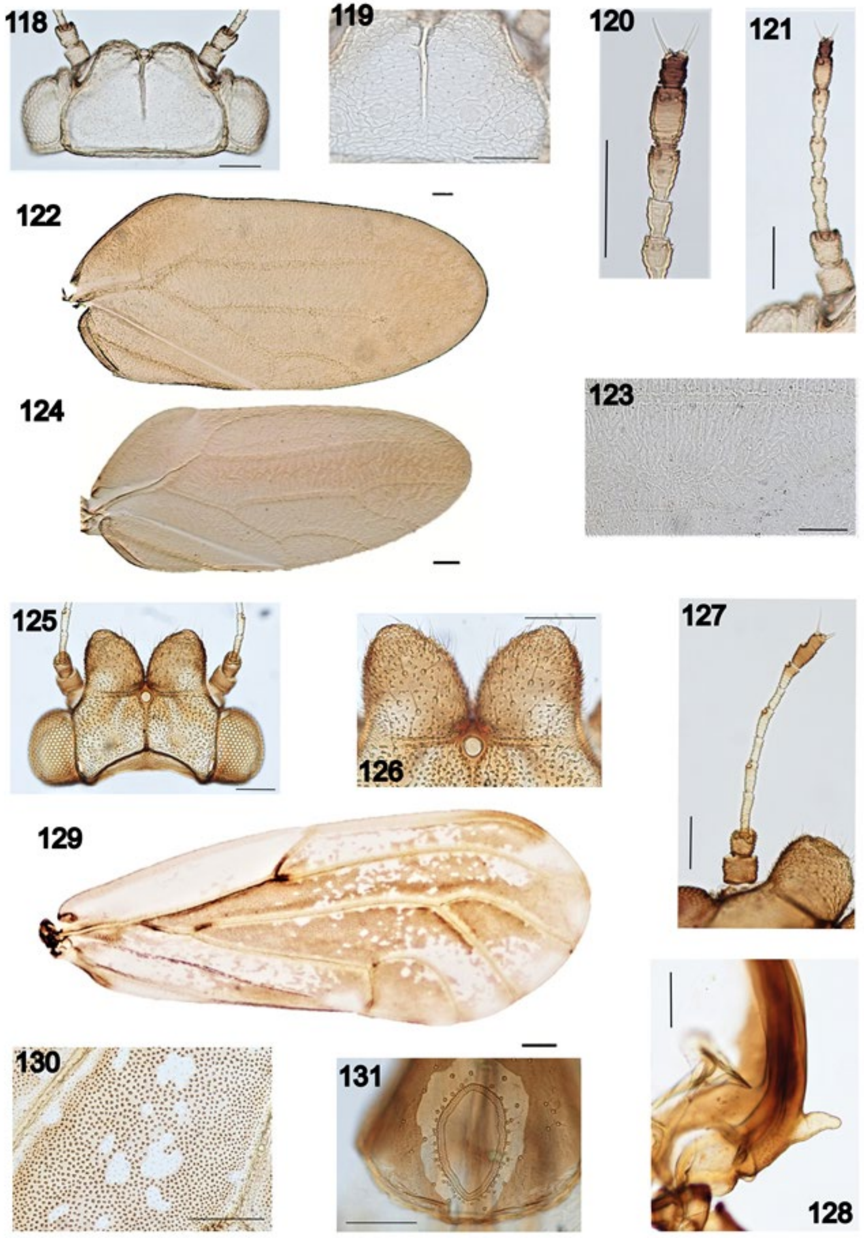
19 Posterior lobe of paramere narrow, subacute apically, shorter than anterior lobe (Fig. 24). Male subgenital plate with large posterior hump (Fig. 23). Head with concave fore margin (Fig. 97). On *Ruta pinnata* . . . . *A. sinuata* **sp. nov.**

Results

Drawings

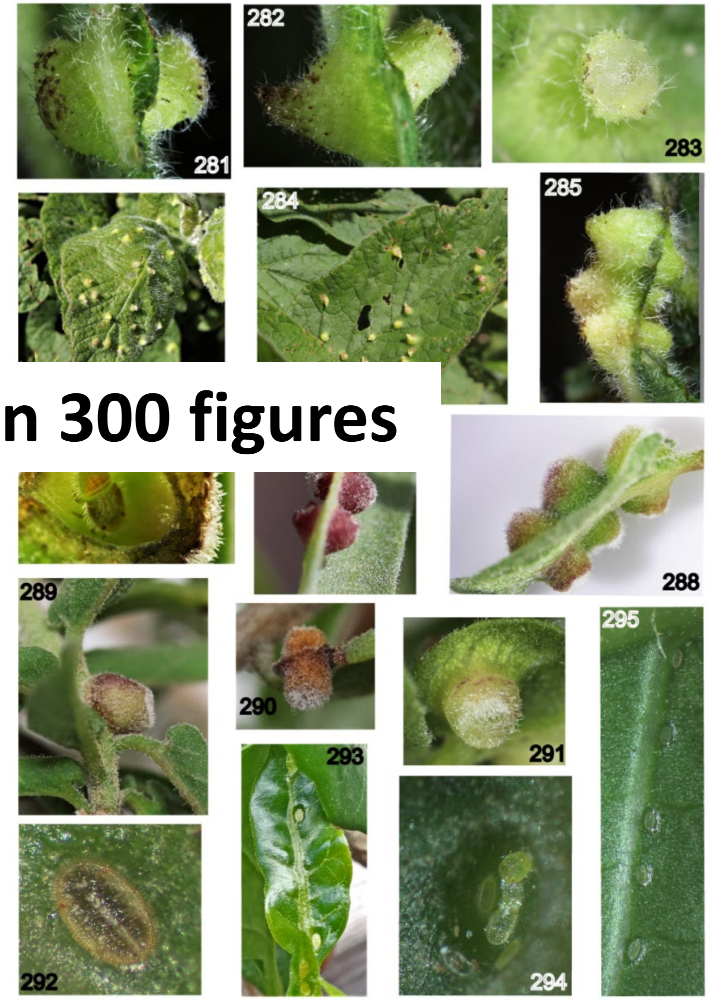


Microphotographs

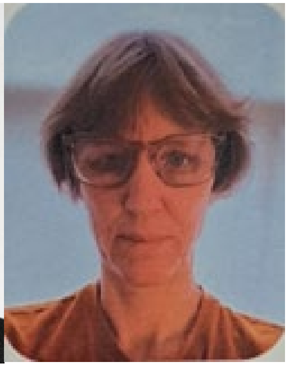


Results

More than 300 figures




Harry Potter
BOSTON
EST. 1963
DIVISION
DENIM CO.

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Thank you for your attention

Results

The Central Macaronesian islands has a greater taxonomic diversity:
58 native species from 17 genera in 5 families
resulting from **26 colonization** events

→18 resulted in a single species
→7 resulted in 2, 3 or 4 species
→1 resulted in 18 species (*Arytinnis* radiation)

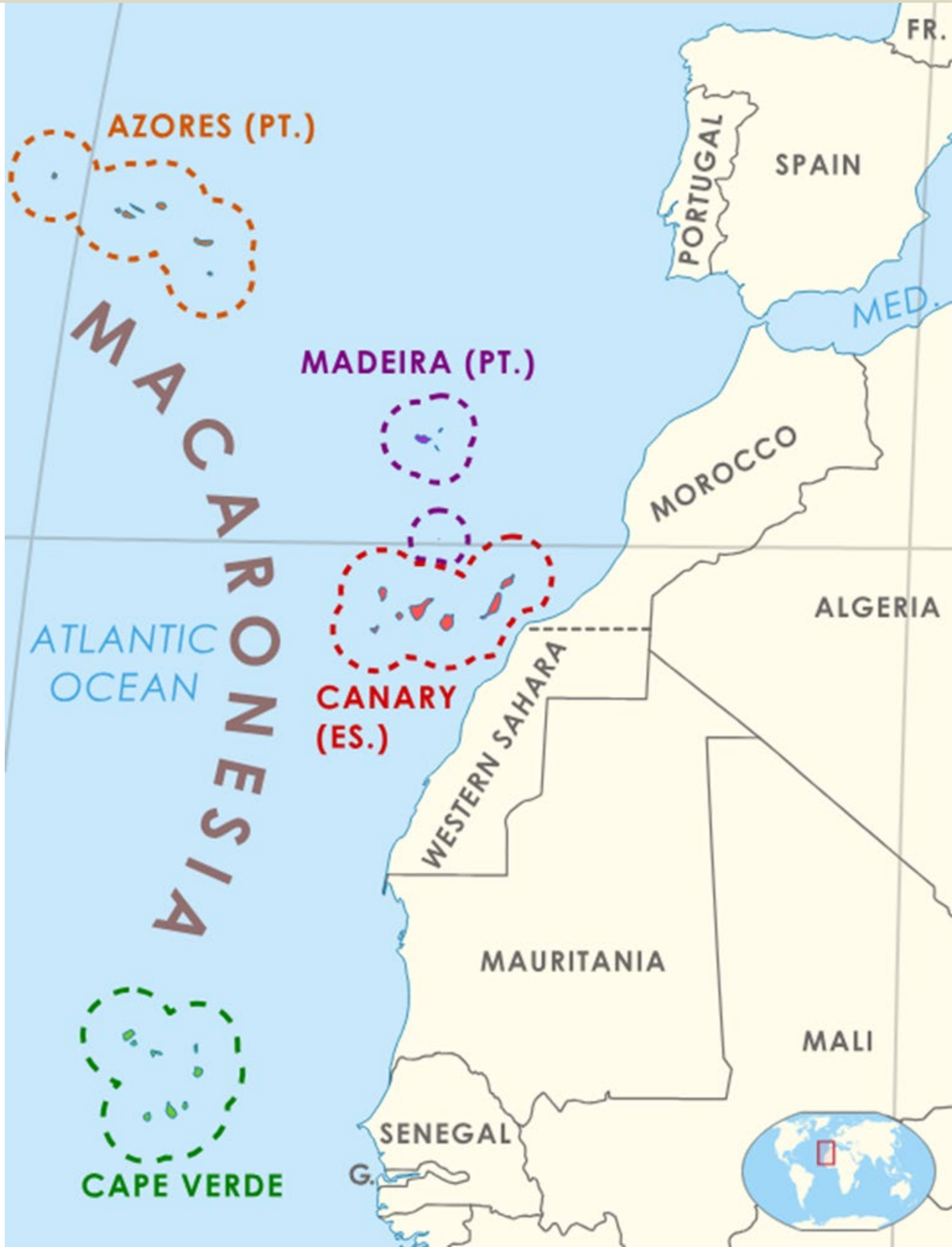
Why do so many colonizations (70%) result in a single species and only three in more than 3 species ?

1. Relative proximity to the source areas
2. Similarity of the floras in Macaronesia and source areas

→ Preadaptation of psyllids to the same or closely related host plants

→ Colonizer fill ecological niches (Host plant) faster than is possible via in situ evolution

2. Limited diversity in host plant lineage



Chapter 3. Origins of the central Macaronesian psyllid lineages

2. Limited diversity in host plant lineage

Host plant genus	**Canarian endemic species**	**Macaronesian endemic species**	**non-endemic species**	**Psyllid species hosted**
Pistacia			2	2
Ruta	4		2	1
Cistus	8		2	1
Picconia	1			1
Olea	1		1	2
Erica	1	1		2
Chamaecytisus	1		1	4
Spartocytisus	2			3
Teline	9			14
Adenocarpus	3			2
Salix		1		1
Rhamnus	2	1	1	3
Gymnosporia	2			1
Retama	1			1
Convolvulus	9		5	6
Laurus	1		1	1
Withania	1		2	1

➢ Psyllid radiation involve switching to closely related plant species

Why have only 3 *Convolvulus* species been colonised by psyllids ?

4 Percyella species on Convolvulus floridus

2 Drepanoza species on 2 Convolvulus species

→ uncommon host group for psyllids (<10 species worlwide)

→ no closely relativies on Convolvulaceae species in source areas

- Most of the plant families hosting native psyllids are well represented among psyllid hosts worldwide

- 4 host families are globally poorly represented:

Oleaceae < 30 species worldwide

Celastraceae → 1 species

Cistaceae

Convolvulaceae

} < 10 psyllid species worldwide

Host: 6 endemic species:
- 2 *Drepanoza* species
- All the *Percyella* species

Plant families hosting the most psyllid genera worldwide (no. genera)	**No. CI endemic plant spp.**	**No. CI non-endemic plant spp.**	**No. CI native psyllid spp. hosted**
Fabaceae (40)	50	159	23
Myrtaceae (26)	0	22	0
Asteraceae (17)	138	180	0
Rutaceae (16)	4	3	1
Anacardiaceae (16)	0	5	1
Moraceae (15)	0	7	0
Lauraceae (14)	2	4	1
Sapindaceae (13)	0	3	0
Malvaceae (12)	2	21	0
Rosaceae (12)	7	20	0
Rhamnaceae (12)	2	2	2
Meliaceae (12)	0	1	0
Ulmaceae (10)	0	2	0
Amaranthaceae (9)	1	20	0
Euphorbiaceae (8)	9	35	0
Ericaceae (8)	2	2	2
Solanaceae (8)	4	40	1
Salicaceae (8)	0	3	1
Santalaceae (8)	5	2	0
Fagaceae (7)	0	5	0

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Picconia	1			1
Olea	1		1	2
Erica	1	1		2
Chamaecytisus	1		1	4
Spartocytisus	2			3
Teline	9			14
Adenocarpus	3			2
Salix		1		1
Rhamnus	2	1	1	3
Gymnosporia	2			1
Retama	1			1
Convolvulus	9		5	6
Laurus	1		1	1
Withania	1		2	1

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