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Review Article

Notes of Changes in Biodiversity in the Exploited Populations of *Cistus Ladanifer* L., (Cistaceae) from SW Iberian Peninsula

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Francisco MG, David GA and Francisco MVP*

Plant Biodiversity Unit, Spain

***Corresponding author:** Francisco María Vázquez Pard, Plant Biodiversity Unit/ CICYTEX-La Orden/ Ctra Madrid-Lisboa km 372/ 06187 Guadajira (Badajoz, Spain)

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Abstract

The traditional exploitation of *Cistus ladanifer* L. (Cistaceae) species such as medicinal and aromatic plant (MAP) was studied for show the biodiversity changes associated to harvest and posterior regeneration. The results show significant increase of the species richness in all conditions with special high first year after harvest (>31 units), and in the Poaceae and Fabaceae families. Also, the geophytes habit increases and the reproductive capacities of the species. Globally the MAP exploitation of *C ladanifer* is beneficious for the biodiversity of ecosystem.

Key words: Cistus; Richness; Biodiversity; Aromatic; Medicinal exploitation

Introduction

Medicinal, aromatic and condimental species (MAP) are a constant source of consumption in indigenous populations and in rural areas far from large cities. Much of the origin of these natural products comes from wild collections in areas close to human settlements. In addition, they come from unique species that are often threatened and limited in their conservation, with plant species lost in some territories as a result of massive collections due to medicinal use and consumption [1,2]. Not all species exploited for medicinal purposes of wild origin are threatened, and their collection is a danger to the stability of the species or even to the habitat it occupies as can occur with species such as gentian, arnica, or mountain chamomile in the mountains of the Iberian Peninsula [3]. *Cistus ladanifer* L. is a specie of huge applications in the pharmaceutical, cosmetic and perfumery industries. The origin of the production of C ladanifer destined for industry in all cases is wild. In the last decade the productions of C. ladanifer, in the Mediterranean basin has been c. 10 t of essential oil [4,5]. The use of the rockrose in Iberian Peninsula dates to the prehistoric era [6-8] the Neolithic settlers used the seeds of *C ladanifer* in their domestic economy, being used to date [9]. Although the testimonies of its medicinal use in the Iberian Peninsula appear in the 16th century [10] when it describes the process of extraction of the labdanum gum in the Sierra de Guadarrama mountains (Spain). The manual or mechanized harvesting of *C ladanifer* L. implies an increase in resources of great interest to the rural areas where is developed, together with an elimination of active biomass that can encourage natural fires in the Mediterranean forest and scrub. In addition, these collections are systematically been carried out on an annual basis in many locations of the SW of the Iberian Peninsula, promoting the over-exploitation of the natural cover of the scrubland and the potential losses of biodiversity in the territory, as has been shown in other areas where natural resources were overexploited. The aim of this contribution is to facilitate an approximation of knowledge on changes in biodiversity in the wild populations of *C ladanifer* L., which are traditionally harvested for exploitation as a medicinal, cosmetic or perfume plant.

Data of Approach to Study

The area occupied by *C ladanifer* populations susceptible to MAP harvesting in the countries where it is distributed (Algeria, France, Morocco, Portugal, Spain) [11] can reach more than 5 million ha, although the area traditionally used annually in wild collections does not exceed 3500ha, mainly (>70%) in the southern half of the border strip between Portugal and Spain. Harvesting takes place between July and September, being collected annually in Spain between 10000-20000 tonnes [12] with a performance in essential oil ranging from 0.1-0.15%. In addition, there is a use of the labdanum gum, obtained by immersion of the leaves and stems in warm carbonated water (55-60 ºC) followed by acidification of the medium [13]. The harvesting is carried out in the upper third/half of the plants, always leaving a rest of the plants on the ground. Harvesting actions facilitate a loss of cover and shading capacity of the rockrose on the ground ranging from 30-65%, increasing the degree of illumination of the soil surface. Along with the increase in the illuminated surface, the collections affect the survival of the plants, promoting plant losses between 10-22%. *C ladanifer*, has allelopathic compounds in the leaves that inhibit the growth of vegetables, functioning as natural herbicides [14-18] With the information provided we can understand the phenomena that occur on changes in biodiversity on the populations of *C ladanifer*, used to obtain products intended for the pharmaceutical, cosmetic and perfume industries (essential oil and labdanum).

Changes in the Biodiversity of the Exploited Populations of *Cistus Ladanifer* L.

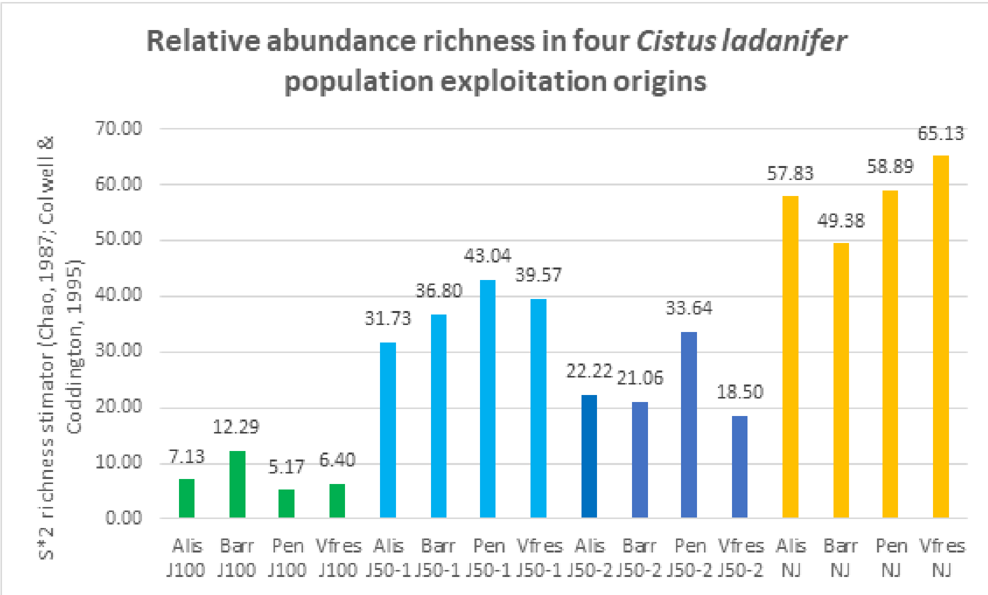

Figure 1: Relative abundance richness in four *Cistus ladanifer* population exploitation origins. Populations Alis: Aliseda (Spain); Barr: Barrado (Portugal); Pen: Penamacor (Portugal); Vfres: Villanueva del Fresno (Spain). Explotation J100: Not harvest; J50-1: Harvest after 1 year; J50-2: Harvest after 2 years; NJ: Poor *Cistus ladanifer* presence

The populations studied during the years 2019-2020-2021 are located in the municipalities of Aliseda (Spain) (A), Barrado (Portugal) (B), Penamacor (Portugal) (P) and Villanueva del Fresno (Spain) (Vf). In all cases the upper fraction of the masses of *C ladanifer* have been harvested during the months of July to August, leaving the lower fraction of the plants rooted in the ground. Data collection was carried out during the months of May and June looking for plant species that grow in the masses of C. ladanifer, prior to harvest, and then the following year after harvesting in the same period. In addition, data have been collected on plant species appearing in adjacent areas with poor *C ladanifer* presence (<10% cover). In all cases and situations studied, we have proceeded to evaluate the species richness based on the estimator for knowledge of richness in populations on the basis of capture and recapture of data, support on the works: [19-22] supported by the collection of information from [19], with an average number of samples in each case and period of X= 44-53 samples. Statistical analysis of means between the different population structures of *C ladanifer* (Not harvest (J100); Harvest after 1 year (J50-1); Harvest after 2 years (J50-2); Poor *C ladanifer* presence (NJ)) with a not parametric analysis Kruskal-Wallis test [23]. Globally, 81 different plant species have been detected in the monitoring zones and periods, dominating the annual species of therophytes, typical of open spaces and poor soils in the SW half of the Iberian Peninsula (Table 1) [24]. The results provide an overview of the effect of the wild collections of *C ladanifer* in the SW of Iberian Peninsula, where it has a flora-specific richness (S2*) ranging from S2*=5.1-12.3 for homogeneous unexploited (collected) populations, up to S2*>31 in the same populations after one year of exploitation. After two years of exploitation the estimated richness decreases significantly, although it does not vary significantly from the increase observed in the first year (Figure 2). However, in cases where *C lanadifer* has been reduced wealth increases considerably reached S2*= 49.3-65.1 units (Figure 1). The exploitation of *C* *ladanifer* as MAP represents a reduction of at least 20% in the leaf-producing fraction [25] and allelopathic substances inhibiting the growth of accompanying vegetation [14,17] especially herbaceous substances. After the collection of the upper fraction of the *C ladanifer* specimens there is an increase in the insolation of the soil [25-28], which may represent an increase of more than 50% compared to the time before the harvest. In addition, there is an increase in the rate of water from the rain that reaches the areas of the soil surface where a fraction of the allelopathic principles produced by *C ladanifer* [14,18] are washed. The sum of these last two effects activates the sleeping seed bank and facilitates a more vigorous growth of the flora, increasing the specific richness and improving the biodiversity of the environment.

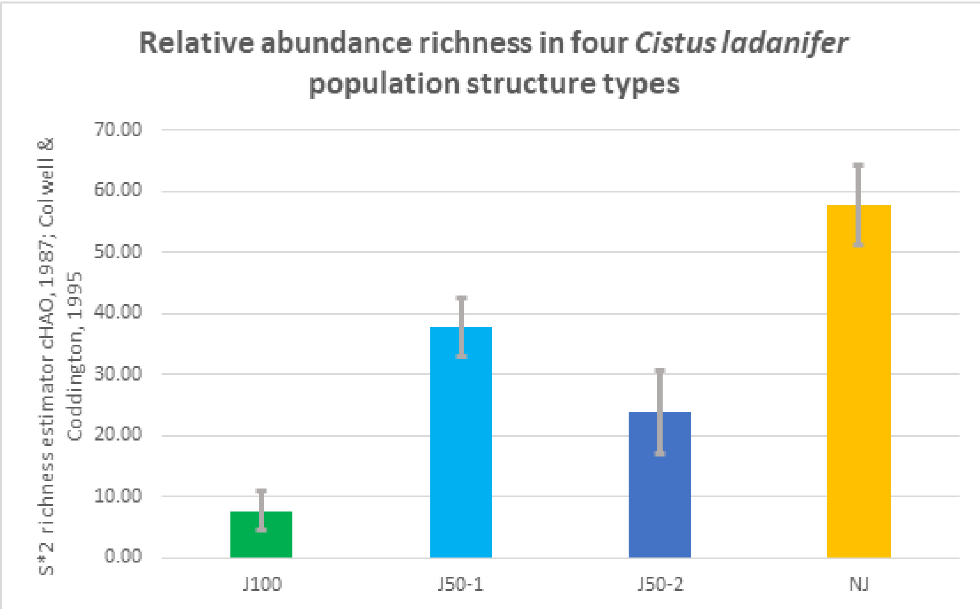

Figure 2: Relative abundance richness in four *Cistus ladanifer* population structure types. J100: Not harvest; J50-1: Harvest after 1 year; J50-2: Harvest after 2 years; NJ: Poor *Cistus ladanifer* presence. **a, b, c**; indicate significant differences between samples (p<0,001) (Kruskal Wallis test)

It should be noted that the presence of species of the Poaceae families (23.46% representation), Fabaceae (16.50% representation) and Asteraceae (11.00% representation) (Table 1). Additionally, geophytes are observed in flowering of the families Orchidaceae (3.70% representation) and Liliaceae (4.94% representation), which usually only presented leaves when the masses of *C ladanifer* covered more than 80% of the soil cover. The increase in specific richness, together with the emergence of reproductive structures in geophytes contribute even more to the increase in the global biodiversity of the environment. Based on the follow up findings of the exploitation of *C ladanifer*, as a MAP species in the SW of the Iberian Peninsula, it can be stated that there are positive elements in total biodiversity increased of the exploited areas and the removal of biomass [29] in these ecosystems with high risk of fires [30]. The regular harvesting directly promotes the conservation of biodiversity: increasing specific richness, facilitating reproduction in plant species; increasing the rate of generative propagules in the seed bank and contributing to the promotion of other living beings dependent on plant diversity [31-32].

Table 1: Distribution of plant species in the four populations and structures studied. The habit (Hab) and family (Fam) are indicant. Note. J100: Not harvest; J50-1: Harvest after 1 year; J50-2: Harvest after 2 years; NJ: Poor Cistus ladanifer presence. A: Therophyte; B: Biennial; C: Camephyte; G: Geophyte; P: Perennial herb; S: Shrub.

Species	Hab	Fam	Aliseda (Spain)				Barrado (Portugal)				Penamacor (Portugal)				Villanueva Fresno (Spain)			
			A100	A501	A502	ANJ	B100	B501	B502	BNJ	P100	P501	P502	PNJ	V100	V501	V502	VNJ
Anacamptis champagneuxii (Barnéoud) R.M.Batem., Pridg. Chase	G	ORCH	-	-	-	+	-	-	-	-	-	-	+	+	-	-	-	+
Anacamptis picta (Loisel.) R.M.Bateman	G	ORCH	-	+	-	+	-	-	-	-	-	-	+	+	-	-	-	+
Anarrhinum bellidifolium (L.) Willd.	B	SCRO	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	+

Andryala integrifolia L.	B	ASTE	-	-	-	+	-	+	-	+	-	-	-	-	-	+	-	+
Andryala laxiflora DC.	A	ASTE	-	-	-	+	-	+	-	+	-	-	-	-	-	-	-	-
Arrhenatherum album (Vahl) Clayton	P	POAC	+	-	-	-	-	-	+	+	-	+	-	-	-	+	-	-
Avena barbata Pott ex Link	A	POAC	-	-	-	+	+	+	-	-	-	+	+	+	-	+	+	+
Avena sterilis L.	A	POAC	-	+	+	-	+	+	-	+	-	+	-	+	-	+	+	+
Biserrula pelecinus L.	A	FABA	-	-	-	+	-	+	+	-	-	-	-	+	-	-	-	-
Brachypodium distachyon (L.) P.Beauv.	A	POAC	-	+	+	+	-	-	-	-	-	-	-	+	-	+	-	+
Brassica barrelieri (L.) Janka	A	BRAS	-	-	-	-	-	-	+	-	-	+	+	+	+	+	+	+
Bromus hordeaceus L.	A	POAC	-	+	-	-	-	-	-	-	-	+	-	+	-	-	-	-
Bromus madritensis L.	A	POAC	-	-	-	+	-	-	-	+	-	-	-	+	-	-	-	+
Bromus rubens L.	A	POAC	-	-	-	+	-	+	-	-	-	+	-	+	-	+	-	+
Bromus tectorum L.	A	POAC	-	+	-	+	-	+	+	-	-	+	+	+	-	+	-	-
Calendula arvensis L	A	ASTE	-	-	-	-	-	-	+	+	+	+	+	+	-	-	-	+
Capsella bursa-pastoris (L.) Medik.	A	BRAS	-	-	+	+	-	+	-	+	-	-	+	+	-	+	-	+
Centaurea ornata Willd.	P	ASTE	-	-	-	-	-	+	-	+	-	-	-	+	-	-	-	-
Cistus crispus L.	C	CIST	+	-	-	+	-	-	-	+	-	+	+	+	-	+	-	+
Cistus ladanifer L.	S	CIST	+	+	+	+	-	+	-	-	-	-	-	+	+	+	-	+
Cistus salviifolius L.	C	CIST	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cleome violacea L.	A	CLEO	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Crepis capillaris (L.) Wallr.	A	ASTE	-	+	-	-	-	-	-	-	-	-	-	-	-	+	+	+
Dactylis glomerata L.	P	POAC	+	+	+	+	-	+	-	-	-	+	-	+	-	+	-	+
Dipcadi serotinum (L.) Medik.	G	LILI	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+
Diplotaxis católica (L.) DC.	A	BRAS	-	-	-	-	+	-	-	+	-	-	-	+	-	+	-	+
Drimia maritima (L.) Stearn	G	LILI	-	+	+	+	-	+	-	+	-	+	+	+	-	-	-	+
Echium plantagineum L.	A	BORA	-	-	+	-	+	-	-	+	-	+	-	+	-	+	+	+
Erodium aethiopicum (Lam.) Brumh. & Thell.	A	GERA	-	-	-	+	-	+	-	+	-	+	-	-	-	+	+	+
Erodium botrys (Cav.) Bertol.	A	GERA	-	-	-	+	-	+	+	-	-	-	+	+	-	+	-	+

Galactites tomentosus Moench	A	ASTE	-	+	-	+	-	+	+	+	-	+	-	+	-	+	-	+
Genista hirsuta Vahl	S	FABA	-	-	-	-	-	+	+	+	+	+	+	+	-	+	-	+
Hedypnois cretica (L.) Dum.Cours.	A	ASTE	-	+	-	+	+	-	+	-	-	-	-	-	-	-	-	-
Hymenocarpos hispanicus Lassen	A	FABA	-	+	-	-	-	+	-	-	-	-	-	+	-	-	-	-
Lamarckia aurea (L.) Moench	A	POAC	-	-	-	+	-	-	-	+	-	+	+	-	-	-	-	+
Lavandula pedunculata (Mill.) Cav.	C	LAMI	+	+	+	+	-	-	-	+	-	-	-	+	-	+	+	+
Lavandula stoechas L.	C	LAMI	+	-	+	+	+	+	-	+	-	+	+	+	-	-	-	-
Lavatera cretica L.	A	MALV	-	+	-	-	-	-	-	-	+	+	+	+	+	+	-	+
Leontodon taraxacoides (Vill.) Willd. ex Mérat	A	ASTE	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-
Lolium rigidum Gaudin	A	POAC	-	-	-	-	-	-	-	+	-	+	-	+	-	+	+	+
Lotus parviflorus Desf.	A	FABA	-	-	-	+	-	+	-	+	-	-	-	-	-	-	-	+
Malva sylvestris L.	A	MALV	-	-	-	+	-	-	-	+	-	-	-	+	-	-	-	+
Medicago minima (L.) Bartal.	A	FABA	-	+	-	-	-	-	-	+	-	-	-	+	-	-	-	+
Mibora minima (L.) Desv.	A	POAC	-	-	-	+	-	+	+	-	-	-	-	-	-	+	+	+
Misopates orontium (L.) Raf.	A	SCRO	-	+	-	-	-	-	+	+	-	+	+	+	-	+	-	+
Molineriella minuta (L.) Rouy	A	POAC	-	-	-	+	-	-	+	+	-	-	-	-	-	+	-	+
Mucizonia hispida A.Berger	A	CRAS	-	-	+	+	-	-	-	+	-	+	-	+	-	-	-	+
Ornithopus compressus L.	A	FABA	-	+	+	+	-	-	-	+	-	-	+	+	-	-	-	-
Paronychia argentea Lam.	P	CARY	-	-	-	+	-	-	-	-	-	+	+	+	-	-	-	+
Phagnalon saxatile (L.) Cass.	C	ASTE	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
Plantago bellardii All.	A	PLAN	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	+
Plantago coronopus L.	B	PLAN	-	+	-	+	-	-	-	+	-	-	-	+	-	-	-	+
Plantago lagopus L.	A	PLAN	-	-	-	-	+	-	-	+	-	+	+	+	-	+	+	+
Rostraria cristata (L.) Tzvelev	A	POAC	-	-	-	-	-	+	-	-	-	+	+	-	-	-	-	+
Rumex bucephalophorus L.	A	POLY	-	+	-	-	-	-	-	+	-	-	-	+	-	+	-	+
Ruta montana (L.) L.	C	RUTA	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	+
Sanguisorba hybrida (L.) Font Quer	P	ROSA	-	+	-	+	-	-	-	+	-	-	-	-	-	-	-	+

Sanguisorba minor Scop.	P	ROSA	+	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-
Scilla autumnalis L.	G	LILI	-	+	-	+	-	+	+	+	-	+	+	+	-	+	+	+
Scilla monophyllos Link	G	LILI	-	+	-	+	-	-	-	-	-	-	-	+	-	-	-	+
Sedum andegavense (DC.) Desv.	A	CRAS	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Serapias parviflora Parl.	G	ORCH	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+
Silene colorata Poir.	A	CARY	-	+	+	+	-	-	-	+	-	-	-	-	-	-	-	+
Spergula arvensis L.	A	CARY	-	+	-	-	-	+	+	+	-	+	-	+	-	+	+	+
Spergularia rubra (L.) J.Presl & C.Presl	A	CARY	-	-	-	+	-	+	-	-	-	+	+	+	-	-	-	+
Stipellula capensis (Thunb.) Röser & Hamasha	A	POAC	-	+	+	+	-	+	+	+	-	+	+	+	-	+	-	+
Tolpis barbata (L.) Gaertn.	A	ASTE	-	-	-	+	-	+	-	+	-	+	+	+	-	+	+	+
Tolpis umbellata Bertol.	A	ASTE	-	-	-	-	-	-	-	+	-	+	+	+	-	-	-	+
Trifolium angustifolium L.	A	FABA	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	+
Trifolium arvense L.	A	FABA	-	+	+	+	-	+	+	+	-	+	+	+	-	+	-	+
Trifolium campestre Schreb.	A	FABA	-	-	-	+	+	-	-	+	-	-	-	-	-	+	-	+
Trifolium cherleri L.	A	FABA	-	+	+	+	-	+	-	+	-	+	+	+	-	-	-	+
Trifolium stellatum L.	A	FABA	-	+	+	+	-	-	-	+	-	+	+	+	-	-	+	+
Trifolium striatum L.	A	FABA	-	-	-	+	-	+	+	+	-	+	+	+	-	+	-	+
Tripodion tetraphyllum (L.) Fourr.	A	FABA	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Trisetaria panicea (Lam.) Paunero	A	POAC	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Tuberaria guttata (L.) Fourr.	A	CIST	-	+	+	+	-	+	-	-	-	+	+	+	-	-	-	+
Tuberaria macrosepala (Salzm. ex Boiss.) Willk.	A	CIST	-	+	+	+	+	+	+	+	-	+	-	+	-	+	+	+
Vulpia ciliata Dumort.	A	POAC	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	+
Vulpia geniculata (L.) Link	A	POAC	-	-	+	+	-	-	-	+	-	-	+	+	-	-	-	+
Vulpia myuros (L.) C.C.Gmel.	A	POAC	-	+	+	+	-	-	+	+	-	+	+	+	-	-	-	+

Conclusion

The results show an immediate benefit in the richness and biodiversity of homogeneous populations of *Cistus ladanifer* when they are exploited as an AMP species, for the extraction of essential oil or/and labdanum in SW Iberian Peninsula. The increase in specific richness in the area is immediate and after the first year there is an increase in plant richness. However, the regenerative capacity of *Cistus ladanifer* decisively influences the progressive reduction of specific richness two years after exploitation. The effects of *Cistus ladanifer* biomass exploitation, have shown that the soils where *Cistus ladanifer* develops homogeneously and almost unispecific, preserves an important seed bank that can manifest itself when disappears or decreases the *Cistus ladanifer* influence. Globally we can indicate that the use of *Cistus ladanifer* L., in the SW of the Iberian Peninsula is beneficial for biodiversity.

Acknowledgment

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