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Impact of the phytophagous insect and mite cornplex associated with cones of Junipers (*Juniperus phoenicea* L. and *J.* Cedrus Webb and Berth.) in the Canary islands

Impact des insectes et acariens phytophages associés aux cônes de genévriers (*Juniperus phoenicea* L. et *J. cedrus* Webb and Berth.) dans les iles Canaries

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ABSTRACT

Five stands of the Phoeniciaii juniper, *Juniperus phoenicea*, and 2 of the endemic *J. cedrus* were surveyed in 4 islands of the Caiiarian archipelago for cone and seed pest damage. A total of 4 phytophagous species, 3 insects and 1 mite, were observed in cones of the Phoenician juniper while those of *J. cedrus* hosted the samespecies excepta cone moth. A cone weevil was the dominant pest in both junipers but differcnces in cone colonization wereobserved among the surveyed islands. The Canarian eiitomofauiia was not endernic and seemed comparatively poor with respect to that observed in southem Europe aiid north Africa. Pests significantly decreased the mean nurnber of seeds and the mean number of filled seeds per cone in both juniper species. Because the two junipers differed by the nurnber of seeds per cone, pest damage resultcd in a differeiit impact oii the potential of juniper regeneration. The consequences of pest attack on the survival of *J. cedrus*, a species under protection that usually produces only 1 filled seed per cone, are discussed.

KEYWORDS: Cone, seed, insect pest, juniper, Canary islands

RESUME

Les dégâts dus aux ravageurs des cónes et des graines ont été inventoriés dans 5 peuplements de genévrier de Phénicie, *Juniperus phoenicea*, et 2 peuplements de l'espèce endémique, *J. cedrus*, situés dans 4 iles différentes de l'archipel des Canaries. Au total, 4 espèces phytophages, soit 3 insectes et 1 acarien, ont été observées dans les cónes de genévrier de Phénicie alors que ceux de *J. cedrus* présentaient la même faune a l'exception d'un lépidoptère. Le principal ravageur des 2 espèces de genévriers est un charançon des cónes. mais des différences de colonisation des cônes ont été observées entre les iles. L'entomofaunc des genévriers canaricns était nettement plus limitée que celle observée sur les genévriers du sud de l'Europe et d'Afrique du Nord. Les ravageurs ont réduit de maniere significative le nombre moyen dc graines par cône et le nombre rnoyen de graincs pleines par cbiie. Les 2 espèces végétales différant par leur nombre moyende graines pleines par cône, l'impact des insectes sur les potentialités de régénération se traduit de maniere différenciée. Les conséquences des attaques d'insectes sur la survie dc *J. cedrus*, espèce protégée dont les cónes ne coiitiennent généralement qu'une graine pleine, sont discutées.

MOTS-CLES : Cônc, semence, insecte parasite, genévrier, îlcs Canaries

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INTRODUCTION

Among the factors affecting the natural regeneration of conifer forests, insects are now considered the most important seed predators during the predispersal phase of seed development. Although extensive surveys of cone and seed pests were carried out in economically important species of the family Pinaceae (e.g., *Abies*, *Larix*, *Picea*, *Pinus*, and *Pseudotsuga* spp.), knowledge of the entomofauna exploiting seed cones of Cupressaceae is still limited (TURGEON *et al.*, 1994). Detailed reviews of cone and seed pests were published for *Juniperus communis* L. in Poland (BORUSIEWICA *et al.*, 1948), Great Britain (WARD, 1977; WARD *et al.*, 1977), and France (ROQUES, 1983; ROQUES *et al.*, 1984), for *J. phoenicea* L., *J. nana* Willd. and *J. sabina* L. in France (ROQUES, 1983; ROQUES *et al.*, 1984), for *J. oxycedrus* L. in Algeria (BOUAZIZ, 1993), France (ROQUES *et al.*, 1984) and Morocco (EL HASSANI *et al.*, 1986), for *J. thurifera* L. in France (CLEU, 1957; ROQUES *et al.*, 1984) and Morocco (EL HASSANI *et al.*, 1986; EL ALAOUI EL FELS *et al.*, in press), for *J. excelsa* Bieb. in Turkey (ÇANAKÇIOGLÜ, 1969) and Saudi Arabia (HAJAR *et al.*, 1991), for *J. chinensis* L. in Japan (SAITO *et al.*, 1985). Fragmentary information also exists for some other juniper species of North America (KEEN, 1958; HEDLIN *et al.*, 1981; CIBRIAN-TOVAR *et al.*, 1986; FERNANDES *et al.*, 1989), China (WU *et al.*, 1992; ROQUES *et al.*, 1995), and countries of the former USSR (GUSEV, 1931; NIKOL'SKAJA, 1966; STADNITSKII *et al.*, 1978).

Differences in cone entomofauna observed between juniper species did not seem to reflect the taxonomic division of the *Juniperus* genus into the *sabina* (scale-like leaves) and *oxycedrus* (needle-like leaves) sections (DEBAZAC, 1964), but they appeared climate-linked. ROQUES *et al.* (1984) noticed that the cone entomofauna of two Mediterranean junipers, *J. phoenicea* (*sabina* section) and *J. oxycedrus* (*oxycedrus* section), was similar in southern France while cones of the 4 juniper species growing in the subalpine vegetation level of the French Alps hosted a quite identical entomofauna, irrespective of the botanical section (ROQUES, 1983; ROQUES, unpublished observations). The presence of two native juniper species, *J. phoenicea* and *J. cedrus* Webb and Berth. (*oxycedrus* section), in the Canary islands (BRAMWELL *et al.*, 1974, 1987), gave an opportunity to test whether this pattern can be generalized to the peculiar situation and history of the Canaries.

Located in the Atlantic Ocean, about 100 km west of the south Morrocan coast, the Canary Islands consist of an archipelago including 7 main islands (La Palma, Tenerife, Gomera, Hierro, Gran Canaria, Fuerteventura, and Lanzarote; figure 1), plus several smaller ones. Although the geological origin of the islands has been subject of considerable controversy, the two eastern ones, Lanzarote and Fuerteventura, were once probably part of North Africa while the other ones appear to have had a purely volcanic origin (BRAMWELL *et al.*, 1974). As a result, the flora of the Canary islands includes a large number of endemic plants, among them *J. cedrus* (BRAMWELL *et al.*, 1974, 1987; VIDAKOVIC, 1991). Populations of the Phoenician juniper, *J. phoenicea*, growing in the Canary islands also differ from the populations of Morocco and southern Spain by the level in proanthocyanidins (LEBRETON, 1983; LEBRETON *et al.*, 1988). Comparison of the fauna colonizing the Canarian junipers with that of *J. phoenicea* and other congeneric species observed in north Africa and southern Europe may thus provide useful data for understanding the evolutionary relationships between junipers and related cone insects.

Therefore, the objectives of the study were: (1) to inventory the insect and mites damaging cones and seeds of junipers in the Canary islands; (2) to measure the impact of each of the pest species on the seed production of junipers; and, (3) to compare this fauna with that observed in cones of relatives growing in southern Europe and north Africa.

MATERIALS AND METHODS

Distribution of the surveyed juniper species

J. cedrus, «el cedro canario» in local language, occurs in four of the islands: Gran Canaria, Tenerife, La Palma, and Hierro (figure 1). Shrubs or small trees up to 15m typically grow between 500m and 2200m in the pine forest zone, which is characterized by the endemic *Pinus canariensis* Smith (BRAMWELL *et al.*, 1987). The juniper colonizes the high mountains of La Palma (outer rim of the Caldera de Tabouriente, Pico del Cedro) and Tenerife (Agua Mansa and Las Cañadas de Teide), as well as the Montaña del Cedro in Gran Canaria and Roque de Agando in Gomera (BRAMWELL *et al.*, 1974). It has also been planted in some areas in order to avoid extinction.

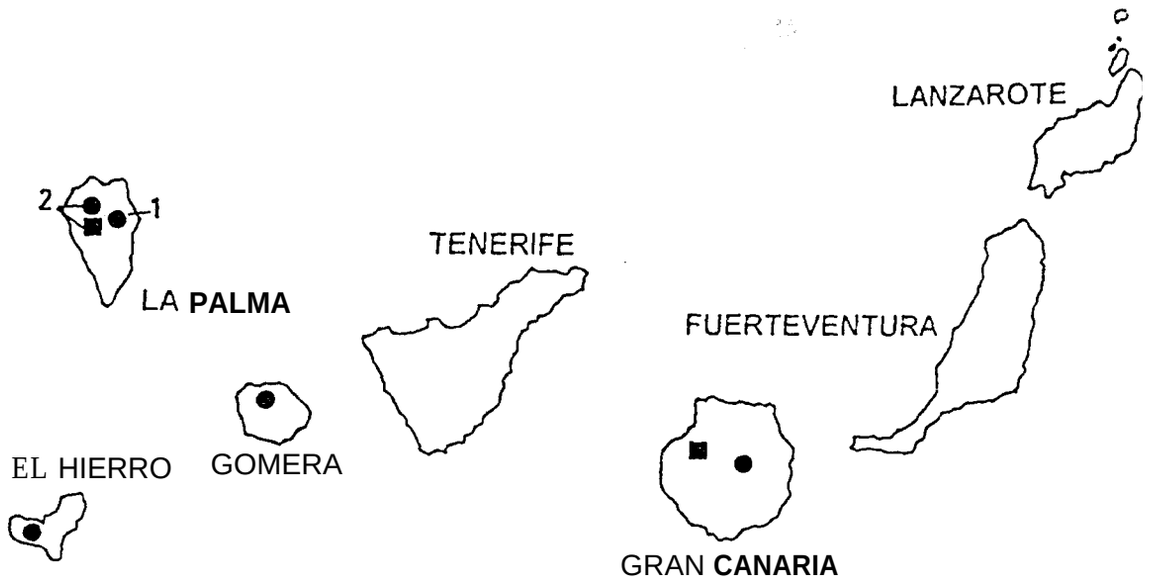

Figure 1.- Location of the juniper stands surveyed in the Canary islands. • *Juniperus phoenicea;* ■: *Juniperus cedrus.*

J. phoenicea, «el sabina)), is a characteristic element of the Mediterranean vegetation level, being partieularly common in the upper part of the xerophytic scrub zone (400-600m) but this species can also enter the upper Mediterranean vegetation level. *J. phoenicea* has a circum-mediterranean distribution, from Israel to the Canary islands which corresponds to its western limit (KRUSSMAN, 1968; **GAUSSEN,** 1968; JALAS *et al.*, 1972; TIMBAL, 1975). However, 2 subspecies have been recognized (LEBRETON, 1981). The subspccies *phoenicea* L. covers Southern France and Spain whereas the subspccies *eumediterranea* Lebr. et Thiv. extends from Portugal to Crete via Maghreb and Corsica, with a littoral and a mountainous form (LEBRETON *et al.*, 1988). Considered as slightly different from the typical subspecies *eumediterranea*, thc Canarian popuiations of *J. phoenicea* are present in all of thc islands, cxcept the eastem ones (Lanzarote and Fuerteventura). Shrubs or small trecs up to 8m are very frequent between 300m and 750m in the northern and northwestern parts of Gomera (Vallehermoso, Agulo), and in the central area of Hierro (El Golfo). In Tenerife, thc juniper is found in numerous locations between 200m and 1900m, e.g. Las Montañas de Teno, Sierra dc Anaga, Las Cañadas, and the whole southem region. Stands are observed at La Caldera de Tabouriente in the island of La Palma, and at Tenteniguada in Gran Canana (BRAMWELL *et al.*, 1974).

Cone collection and analysis

The survey was carried out in **4** of thc Cananan islands: Gomera, Gran Canana, Hierro, and La Palma (figure 1). In both juniper species, berry-like cones were collected according to a standardized procedure. In each of the selected stands, 10 shrubs (or trees, depending on stand structure) were chosen at random. **A** branch beanng mature cones was selected at randorn on each of these trees, and a portion of the branch, about 40 cm long (measured from the branch extremity), was eut. Then, all the cones were separated from the branch and put into plastic bags for further examination. In order to precise the dissection and rearing methods, a preliminary conc collection of *J. phoenicea* was realized on August 25, 1990 at Vallehermoso, Gomera. Then, cone collections were organized from March to June 1992 in typical juniper-growing locations of thc 3 other islands. *J. phoenicea* was sampled in Hierro (El Golfo), Gran Canaria (Tenteniguada), and La Palma (lower and upper part of La Caldera de Tabouriente) whereas *J. cedrus* was sarnplcd in Gran Canana (Montaña del Cedro) and La Palma (upper part of La Caldera de Tabouriente).

In each sample, all the cones (i.e., anumber *n* dcpending on stand cone crop) were first examined individually for external damage. The cones showing exit holes (*h*) were dissected in order to **look** for the consumed tissues and to describe the shape of the inscct galleries. The cones presenting somcparts withunusual coulour (*c*), thus known to host pests (**ROQUES,** 1983), were also dissected to look for the presence of larvae, pupae, and adults. Damage, insect and mite species were identified using the identification keys provided by **ROQUES** (1983). In addition, a constant number of 30 cones which did nòt

show any visible damage from extemai view wcre randoinly chosen in each lo?,and dissccted. The number of cones (*d*) that finally appcarcd damaged within thcse 30 cones was counted and the larvae possibly prcsent within thc cones were identifíed. For cach of the dissccted cones (damagedas well as undamaged), thc total numbcr of seeds was countcd. The sceds wcre then radiographirdusing a Faxitron43855® apparatus (15Kv, 3mA, 4mn) and X-ray sensitive films (Kodak® «Industrex M»). The nurnber of filled, empty and insect-damaged **seeds** per cone was counted. In order to get adult insects which facilitate species identification, the remainder of the collectcd cones of cach sample (i.e., n-[h+c+*30*]) were put into rcanng boxes stored in an outdoor insectary located at Orléans, north-central France (107m altitude). The emcrgence of adult insects was recorded during the **3** years following collection.

From thesedata, we evaluated the following variables for both juniper species: 1) pcrcent of overall cone damage per stand, defined as [(h+c)+(d**30*/n)]/n; 2) percent of cones damaged per inscct species and stand; 3) mean numbcr of total seeds, filled seeds, damaged seeds, and empty seeds per cone and per stand; 4) mean number of total seeds, filled seeds, and empty seeds per sound cone and per stand; ***5)*** mcan number of total seeds, filled seeds, damaged seeds, and empty secds per darnaged cone, per pcst species and per stand; 6) percentage of filled and empty seeds per sound cone; and, 7) perccntage of filled and empty scedsper damaged conc and per inscct species.

To equalizc variances before statistical analyses, the percentage data on insect damage and seed quality were transformed by arcsin N **x.** The data wcre then submitted to an analysis of variance **(ANOVA)** to test fordiffercnces in seed production, cone damage and seed quality betwecn stands of the samejuniper species, and to test for similar differences between juniper species when the two species were present in the same stand. ANOVA was also used to test for differences in sced daniage betweenpcst species.

Table 1
List, host range and distribution of the pest species attacking the cones and seeds of *J. phoenicea* L. **(JP)** and *J. cedrus* Webb and Berth. (JC) within the Canary Islands.

Pest species	JP	JC	Other hosi plants	Damage	Distribution	References
Trisetacus sp. (Acarina Eriophyiidae)	x	x	*Juniperus communis*[1] *Juniperus thurifera*[1] *Juniperus phoenicea*[2] *Juniperus oxycedrus*[2]	cones seeds	Europe, Morocco	ROQUES (1983) ROQUES *et al.* (1984) EL ALAOUI *et* al. (in pr.) ROQUES (unpub. obs.)
Nanodiscus transversus Aubé (Coleoptera Curculionidae)	x	x	*Juniperus oxycedrus* *Cupressus sempervirens* *Tetraclinis articulata*	cones	Algeria. France, Grcece. Italy. Morocco, Spain, Tunisia, Turkcy f. Yugoslavia	CLEU (1957) ROQUES (1983) **ROQUES** *et al.* (1984) EL HASSANI *et al.* (1986) **BOUAZIZ** (1993) **ROQUES** (unpub.obs.)
Brachyacma oxycedrella Mill. (Lepidoptera Gelechiidae)	x	-	*Juniperus oxycedrus* *Juniperus thurifera* *Biota orientalis* *Cupressus* spp. *Tetraclinis articulata*	cones	Algeria, France, Grcece, Italy. Morocco. Spain, Tunisia, f. Yugoslavia	CLEU (1957) ROQUES (1983) ROQUES *et al.* (1984) EL HASSANI *et* al. (1986) **ROQUES** (unpub.obs.)
Pammene oxycedrana Mill. (Lepidoptera Tortricidae)	x	x	*Juniperus oxycedrus* *Juniperus thurifera*	cones sceds	Algeria, France. *Italy.* Morocco, Spain	**CLEU** (1957) **ROQUES** (1983) ROQUES *et al.* (1984) BOUAZIZ (1993) **EL** ALAOUI *et* al. (in **pr.)**

[1] *Trisetacus quadrisetus* Thoms.: [2] *Trisetacus* **sp.**

RESULTS AND DISCUSSION

Inventory of the cone and seed pests of the Canarian junipers

A total of 4 phytophagous species, 3 insects and 1 mite, were found in cones of the Canarian junipcrs (table 1). In addition, two unidentified species of Hymenopteran parasites (1 Eulophidae and 1 Pteromalidae), probably related to Lepidopterans, emerged from the collected cones. The phytophagous species were conophytes, i.e. thcy candevelop only in seed cones (**TURGEON** *et al.*, 1994). All ofthe cone tissues werc exploited. According to the terminology used by **TURGEON** *et al.* (1994), a weevil developcd as conophage in the cone parenchym, 2 cone moths developed as conospermatophages fceding on both the cone tissues and seeds, and a spermatophage mite exploited thc seeds. None of thesc pests wcre endcmic as all were already known to attack other species of Cupressaceae in the Mediterranean range (table 1). The qualitative composition of the phytophagous complexdiffered bothwiththe islands and thejuniper spccies (figure 2). The insect species were observed in the 4 islands while the mite was not observed in Hierro. The cones of *J.* phoenicea hosted 4 phytophage species in La Palma, 3 in Hierro and La Gomcra but only 2 in Gran Canana. Although the two junipers belong to different taxonomic scctions and colonize different vegetation zones, the cone fauna of *J. cedrus* only differed from that of *J. phoenicea* by the absence of a gelechiid moth, *Brachyacma oxycedrella* Mill. However, the two fauna largely differed when the surveycd stands were considered separately. *J. cedrus* cones hosted 2 phytophage species vs. 4 for *J. phoenicea* in La Palma, but 3 vs. 2 in Gran Canaria. Because cone and seed insect populations are subject to large fluctuations with the annual variation in cone crop (**ROQUES,** 1983), the differcnces observed between the two junipers might have been related to specific pattems of cone crop dynamics according to tbe stand.

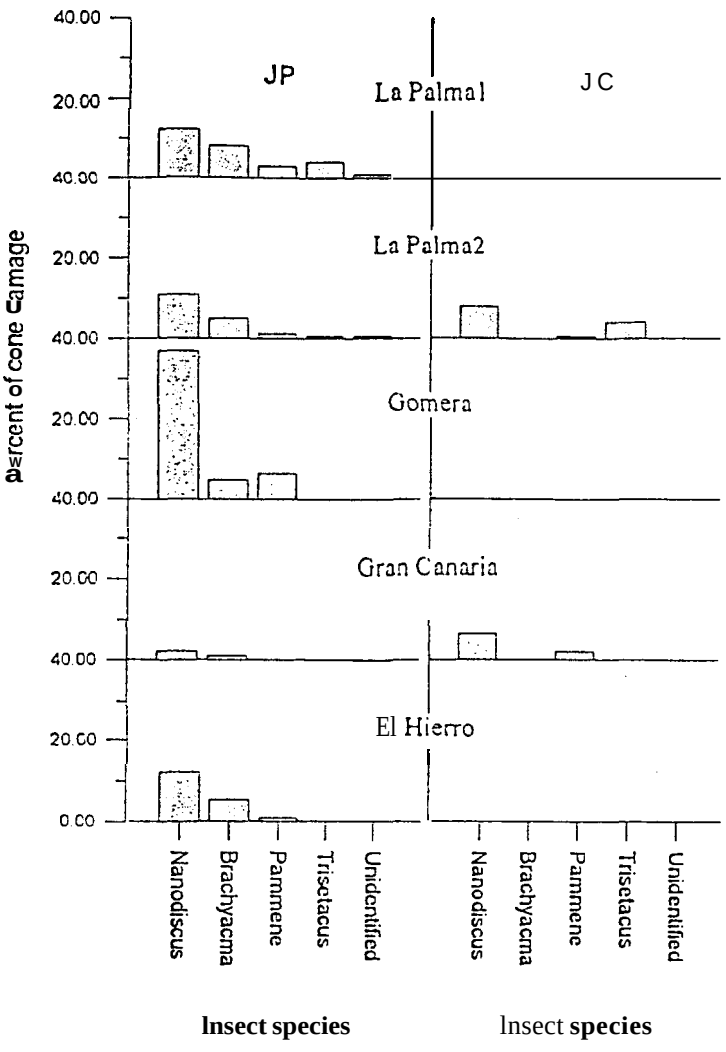

Figure 2.-Insect and mite damage to cones of *Juniperus phoenicea* (JP) and *J. cedrus* (JC) observed in some of the Canary islands in 1990 (Gomcra) and 1992 (other islands).

Although this limited investigation prevcnted any definite conclusion, the pest complex observed in the cones of the Canarian junipers was poor when compared to that recorded in the Mediterranean basin. Of the 6 insect specics observed to attack the cones of *J. phoenicea* in continental France and Corsica (ROQUES *et al.*, 1984), only 3 species were found within the Canary Islands. The apparent absence of a seed chalcid, *Megastigmus amicorum* Boucek, was especially noticeable. The chalcid also constitutes a major componcnt of the entomofauna of *J. phoenicea* in Spain and Portugal (ROQUES, unpublished observations), and attacks both *J. phoenicea* and *J. oxycedrus* in Morocco (EL HASSANI *et al.*, 1986; ROQUES, unpublished observations). In addition, moths of the genera *Blastotere* and *Argyresthia* (Lepidoptera: Plutellidae) that are typical inhabitants of cones of Mediterranean junipers in southern Europe and Maghreb (BOUAZIZ, 1993; CLEU, 1957; EL ALAOUI *et al.*, in press; EL HASSANI *et al.*, 1986; ROQUES, 1983) were not found during the survey. The mite species, *Trisetacus* sp.. observed in the Canaries probably refers to *T. quadrisetus*, that develops in cones of *J. communis* and *J. thurifera* in Europc (ROQUES, 1983) and *J. thurifera* in Morocco (EL ALAOUI *et al.*, in press). Similar mite damage, that typically results in a distortion of the cone and an external protrudance of the seeds, was recently observed in a few stands of *J. phoenicea* and *J. oxycedrus* in southem France but the mite species has not yet been idcntified (ROQUES, unpublished observations).

Pest impact on the seed production of *J. phoenicea*

Figure 2 shows the percentage of cones attacked by each pcst species in the sampled stands. The overall cone damage differed significantly among stands (table 2). It varied from 3.2 % at Gran Canana to 48.5 % at Gomera. By comparison, cone damagc ranged from 6.7 to 83.9 % in southern France and Corsica, where *J. phoenicea* seemed more attacked than other juniper species (ROQUES *et al.*, 1984). Except at Gran Canaria, thc cone weevil, *N. transversus*, was the dominant pest, usually attacking more than 10 % of the cones and up to 37 % in Gomera. Damage due to the cone weevil differed significantly among stands (table 2) while no significant difference was observed for the 3 other pest species, which damaged less than 10 % of the cones in any location.

The seed numbers and the seed quality observed in the 4 surveyed stands are shown in table 3. The number of total, filled, and empty seeds pcr sound cone did not differ significantly among the stands (table 2). The total number of seeds per cone (5.5, on the average) was close to that reported by LEBRETON *et al.* (1988) for littoral populations of the subspecies *eumediterranea* (5.3), but was lower than that observed by the samc authors in mountainous populations (Moroccan Atlas) of the same subspecics (6.9) and in French populations of the subspecies *phoenicea* (8.1). Cornparison of the seed numbers in sound and attacked cones revealed that pest damage reduced by 24.5 % the total number of seeds per conc, which decreased from 5.52 to 4.17 ($p < 0.001$; table 2). Following pest damage, the number of filled seeds per cone also decreased by 54.3 %, from 2.32 to 1.06 ($p < 0.001$: table 2).

When all thc cones were considered, the mean number of damaged seeds per cone did not differ among stands (table 2), irrespective of the significant differences observed in the percentage of cone damage. This likely resulted from differences in feedin; habits of the pest species that dominatcd in the stand. The direct impact of pest species on seed yield differed significantly with regard to the species feeding habits (table 2). The mean number of damaged secds per attacked conc was 2.07 and 1.5 for the conospermatophage *P. oxycedrana* and the spermatophage *Trisetacus* sp., respectively. It decreased to 0.33 for *B. oxycedrella*, which attackcd seeds occasionally, but the conophage *N. transversus* never destroyed any sceds. An average number of 1.3 filled seeds rcrnained per cone following the attack of *B. oxycedrella* and *Trisetacus* sp. *P. oxycedrana*, which was confirmed to bc the most dangerous pest, left only 0.21 filled seeds pcr cone. Comparison of thc seed quality betwecn sound cones and cones damaged by cach pest showed that the percentage of filled seeds dccreased significantly in the cones attackcd by thcse 3 species ($p = 0.01$) but not in those attacked by *N. transversus*. By contrnst, the pcrcentagc of empty seeds did not differ for any pest species. Therefore, it can be suggested that the feeding larvae of *P. oxycedrana* and *B. oxycedrella*, as well as the mites, selected filled seeds rathcr than empty seeds during their development in the cones.

Pest impact on seed production of *J. cedrus*

The pcrcentage of attacked cones was lower than 15 % in the two surveyed stands (figure 2). Cone damagc did not differ between stands (table 2). As for *J. phoenicea*, the weevil *N. transversus* was the dominant pest but it only attacked 6-7 % of the cones. By comparison, cone damage observed in a closely related species,

Table 2
Results of the vanance analysis (ANOVA) of the data collected during the study of cone and seed pests of the Canarian Junipers

Data	Factors	DF effect	DF error	F	p
Juniperus phoenicea					
Presence/absence of cone damage	Stand	4	495	17.59	0.000
Presence/absence of cone damage by *Nanodiscus transversus*	Stand	4	495	16.97	0.000
Presence/absence of cone damage by *Brachyacma oxycedrella*	Stand	4	495	1.55	0.186
Presencelabsence of cone damage by *Pammene oxycedrana*	Stand	4	495	1.92	0.106
Presence/absence of cone damage by *Trisetacus* sp.	Stand	4	495	2.30	0.058
Numbcr of total seeds/sound cone	Stand	4	69	0.33	0.857
Number of filled seeds/sound cone	Stand	4	69	1.13	0.350
Number of empty seeds/sound cone	Stand	4	69	1.45	0.228
Number of total seeds/cone	Presence/abs. damage	1	138	36.77	0.000
Number of **filled** seedslcone	Presence/abs. damage	1	138	26.34	0.000
Number of damaged seeds/cone	Stand	4	134	1.823	0.136
Number of damaged seeds/insect-attacked cone	Pest spccies	3	57	35.293	0.000
Number of filled seeds/insect-attacked cone	Pest species	3	57	3.461	0.221
Percent of filled seeds/insect-attacked cone	Pest species	3	57	3.953	0.125
Perccnt of empty seeds/insect-attacked cone	Pest specics	3	57	2.598	0.061
Juniperus cedrus					
Presence/absence of cone damage	Stand	1	198	1.326	0.251
Presence/absence of cone darnage by *N. transversus*	Stand	1	198	0.567	0.463
Nurnber of total seeds/sound cone	Stand	1	34	55.595	0.000
Number of filled seedslsound cone	Stand	1	34	0.137	0.713
Numbcr of ernpty seeds/sound cone	Stand	1	34	28.256	0.000
Number of fillcd seedslcone	Presence/abs. damage	1	48	3.935	0.050
Number ofdamaged seeds/insect-attacked cone	Pest spccies	2	9	21.750	0.000
Number of filled seeds/insect-attacked cone	Pest species	2	9	0.963	0.417
Comparison of cone damage when Canarian junipers coexisted					
Presence/absence of cone damapc (La Palma 2)	Juniper species	1	199	5.265	0.023

Location	Total cones				Insect-attacked cones				Sound cones		
	Nb	Nb cone	Nb cone	Nb cone	Nb	Nb cone	Nb cone	Nb cone	Nb	Nb cone	Nb cone
El Hierro	5.50	1.96	3.46	0.07	5.20	1.90	3.10	0.20	5.67	2.00	3.67
La Palma 1	4.72	1.87	2.54	0.31	4.00	1.10	2.29	0.56	5.61	2.78	2.83
La Palma2	4.26	1.56	2.33	0.36	3.57	0.90	2.00	0.67	5.22	2.56	2.67
Gran Canaria	5.48	1.62	3.67	0.19	5.00	0.33	3.33	1.33	5.56	1.83	3.72
Gomera*	5.17	1.58	2.58	1.00	5.00	1.11	2.56	1.33	5.67	3.00	2.67

Canaries, and the subsequent contact with *J. cedrus*, could have favoured the shifting of cone pests with large host spectrum from the Phocnician juniper to *J. cedrus*. However, the only pest of Phoenician juniper that was not obscrved on *J. cedrus* was the gelcchiid *Brachyacma oxycedrella*, a large spectrum species that ROQUES *et al.* (1984) considersd as the only Mediterrancan pest capable of shifting from *J. oxycedrus* to the Supramediterrancan *J. thurifera* in Corsica. The reasons of the gelechiid absencc rctnains unknown but might simply have proceedcd from the Iimitation of the sampling. The presence of most of the pcsts in the 4 surveyed islands, that are rather distant, also rcveals that these insccts are likely distributed throughout the Canancs althouph their populations may largely fluctuatc.

Except at Gomera, the attack rates were rather low for both junipers during thc years of observation when compared to values rccorded for other juniper species and other locations (e.g., 75 % of *J. excelsa* cones were regularly áamaged in Krasnodarsk area, Russia: GUSEV, 1931). However, the analysis of the impact of insect pests on the potential of natural regeneration of the 2 Canarian junipers has to consider both the respective seed production and the feeding habits of pest specics. Pest impact was amplified in *J. cedrus* becausc thc cones usually contained only 1 filled seed that disappeared with pest attack, whatever the pcst feeding habit. Conversely, the relatively hiph number of filled seeds present per cone of *J. phoenicea* limited the consequences of pest attack, and the dominant cone weevil did not feed directly on seeds. The persistencc of an archaic character such as a high tiumber of ovules may thereforc be benefitial for this juniper spccies.

In conclusion, we assume that insect and mitcs damaging cones are likely to be a minor limiting factor forthe regcneration of *J. phoenicea* stands in the Cariary Islands. By contrast, at a time whcn stands of *J. cedrus* are disappeanng under natural and human prcssure (e.g., fire), conc pests may becomc a serious problem for the survival of this protectcd specics.

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