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EVIDENCE OF RECENT CLADOGENESIS IN THE CHRYSIDIDAE FAUNA OF SARDINIA AND CORSICA ISLANDS (HYMENOPTERA, CHRYSIDIDAE)

Abstract - The presence in Sardinia island, and not in Corsica, of endemic new species suggest a recent cladogenetic species evolution triggered by the separation between the two islands after the end of the Würm glaciations (13000 years before present). The result is in agreement with the theory of Punctuated Equilibria. In present case the time scale is given by a geological event, and new species has been evolved in less than 13000 years.

Key words - Endemic species, recent Cladogenesis, Punctuated Equilibria, Sardinia.

Riassunto - Evidenza di una recente cladogenesi nella fauna a Chrysididae della Sardegna e della Corsica (Hymenoptera, Chrysididae) - Lo studio degli Imenotteri Crisididi delle isole di Sardegna e Corsica ha rivelato la presenza di specie endemiche in Sardegna derivate per cladogenesi da specie europee, presenti anche in Corsica. Queste specie endemiche non sono presenti in Corsica con una probabilità del 98-99%. Si ha perciò evidenza che esse si sono evolute dopo la separazione della Corsica dalla Sardegna avvenuta al termine dell'ultima glaciazione, circa 13000-14000 anni dal presente. Questo risultato è in accordo con la teoria degli equilibri puntuali e suggerisce che l'isolamento della Sardegna abbia interrotto il periodo di *stasis* in questa isola ed iniziato un periodo di rapida cladogenesi.

Parole chiave - Specie endemiche, cladogenesi, equilibri puntuali, Sardegna.

INTRODUCTION

The Sardinia and Corsica islands (Western Mediterranean) were a refugium for the European continental fauna during the last Würm ice age, forming a single large land as a consequence of the low Mediterranean Sea level (about -130 m) (Grill *et al.*, 2010).

Sardinia and Corsica become separated (13000 ± 1000 years before present) with the opening of the Bonifacio Strait, when the sea level raised by about 130 m as a consequence of the icecap melting (Lambeck & Bard, 2000; Siddall *et al.*, 2003). Since then the allopatric divergence between the isolated populations take over in the two islands, with possible cladogenesis events.

Some widespread species of the European mainland presently survive in Corsica, while are replaced by a new endemic species in Sardinia. Other endemic species, clearly derivate from European mainland fauna, are present in both islands thus suggesting that speciation events occurred prior of islands separation.

MATERIALS AND METHODS

In the frame and stimulus of the European projects Interreg II and III the Chrysididae fauna (Hymenoptera Aculeata) was studied in both islands since 1998. The study was performed by critically reviewing the previous literature data, by repeated visits at most interesting biotopes and by capturing specimens by netting and by operating a number of Malaise traps, active for a total of 2138 days in Corsica and 2438 days in Sardinia (2010 data). The statistical analysis of the captured material evidence that the Chrysididae fauna is to be considered known within 98% for Corsica and 90% for Sardinia (F. Strumia - Hymenoptera Chrysididae of the West-Mediterranean Islands. In preparation). Today we know 137 Chrysididae species or subspecies from the Sardo-Corsican complex. More interesting 18 species (13%) result endemic: 9 in Corsica (3 present only in Corsica but not in Sardinia) and 15 in Sardinia (9 present only in Sardinia), Table 1. This

Tab. 1 - List of the endemic species of Chrysididae found in the Sardinia and Corsica Islands. 9 species are present in Sardinia only, 3 in Corsica only, 6 in either island for a total of 18 endemic species, about 13% of all fauna.

| Endemic species of Sardo-Corse Chrysididae | | Corsica | Sardinia | Sum |
|--|---|---------|----------|-----|
| 1 | <i>Chrysis aurorecta</i> Abeille, 1878 | 1 | 1 | 2 |
| 2 | <i>Chrysis calviensis</i> Kusdas, 1974 | 1 | 1 | 2 |
| 3 | <i>Chrysis melaensis</i> Linsenmaier, 1968 | 1 | 1 | 2 |
| 4 | <i>Chrysis subaequalis</i> Linsenmaier, 1969 | 1 | 1 | 2 |
| 5 | <i>Holopyga sardoia</i> Invrea, 1952 | 1 | 1 | 2 |
| 6 | <i>Philoctetes perraudini</i> (Linsenmaier, 1968) | 1 | 1 | 2 |
| 7 | <i>Chrysis paglianoi</i> Strumia, 1992 | 0 | 1 | 1 |
| 8 | <i>Chrysis pseudogribodoi</i> Linsenmaier, 1959 | 0 | 1 | 1 |
| 9 | <i>Chrysis semistriata</i> Linsenmaier, 1997 | 0 | 1 | 1 |
| 10 | <i>Chrysura sulcata schlaeflei</i> (Linsenmaier, 1997) | 0 | 1 | 1 |
| 11 | <i>Hedychridium sardinum</i> Linsenmaier, 1987 | 0 | 1 | 1 |
| 12 | <i>Hedychridium scutellare sardiniense</i> Linsenmaier, 1959 | 0 | 1 | 1 |
| 13 | <i>Hedychrum rufipes</i> Du Buysson, 1893 | 0 | 1 | 1 |
| 14 | <i>Parnopes grandior linsenmaieri</i> Agnoli, 1995 | 0 | 1 | 1 |
| 15 | <i>Trichrysis baratzensis</i> Strumia, 2008 | 0 | 1 | 1 |
| 16 | <i>Chrysis duplogermari</i> Linsenmaier, 1987 | 1 | 0 | 1 |
| 17 | <i>Chrysis pulcherrima</i> Lepeletier, 1806 ssp. <i>ascoensis</i> Linsenmaier, 1987 | 1 | 0 | 1 |
| 18 | <i>Hedychridium lampadum</i> ssp. <i>austeritatum</i> Linsenmaier, 1997 | 1 | 0 | 1 |

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large fraction of endemic species (large among the Mediterranean Islands) is, possibly, a consequence of the long lasting isolation of this micro plate (Alvarez *et al.*, 1974; Edel *et al.*, 2001).

RESULTS

The Bonifacio strait, with about 13 km of minimum width, may appear a weak barrier for species interchange, but in the case of parasitoid insects, as the Chrysididae, also the presence of the right host in the new arrival site is necessary to establish a new population. Otherwise even a fecundated female cannot establish a new successful population. The probability of crossing the Bonifacio strait is thus the product between the probabilities of the parasitoid and that of his host. Assuming a probability of 0.01/year for each, we obtain 0.0001/year for the parasitoid: just a number compatible with the age of the strait formation.

The theory of «Punctuated Equilibria» in evolutionary biology proposes that most species will exhibit little net evolutionary change for most of their geological history, remaining in an extended state called *stasis*. Significant evolutionary change generally occurs during restricted rare and geologically rapid events, almost sudden in the geological time scale, and then cladogenesis events occur (Eldredge & Gould, 1972; Gould & Eldredge N., 1977; Gould, 2002; Benton, 2003).

In the case of the Sardinia-Corsica separation we knew the rapid geological event with a precise dating. As a consequence the presence of an endemic new species exclusive of only one island gives evidence of the recent cladogenesis and of the interruption of the *stasis* state.

As a result of the study of Aculeata Hymenoptera of the Sardo-Corsican micro plate I observed, among the endemic species exclusive of Sardinia, the presence of two endemism, not present in Corsica, where, on the contrary, the related original European species result still present. This is the case of pairs *Parnopes grandior* (Pallas, 1771) - *Parnopes grandior linsenmaieri* Agnoli, 1995 (Agnoli 1995), and of *Chrysis scutellaris* Fabricius, 1794 - *Chrysis paglianoi* Strumia, 1992 (Strumia 1992).

1 - *Parnopes grandior* (Pallas, 1771) and *Parnopes grandior linsenmaieri* Agnoli, 1995 (Fig. 1 - color picture are available at <http://www.chrysis.net/database/>).

P. grandior is a Turano-European widespread species parasitoid of the Hymenoptera Crabronidae of the genus *Bembix*. It has been captured in several sandy localities of Corsica: Moltifao, Bravone, Marana, Folelli, but never on Sardinia. (<http://www.chrysis.net/database/>).

The ssp. *linsenmaieri* on the contrary was never observed in Corsica, but all over in Sardinia: Fonni



Fig. 1 - Left: *Parnopes grandior* (Pallas, 1771) female from Bravone (Corsica), VI.1997. Right: *Parnopes grandior linsenmaieri* Agnoli, 1995: female, from Platamona Sassari, VI, 2000.

(NU); Monte Spada, m 1300 (NU); Platamona Lido (SS); Natural Reserve of Lago Baratz, (SS); Porto Ferro (SS); Marina di Sorso (SS).

The possible presence of *P. grandior linsenmaieri* in Corsica was repeatedly and unsuccessfully checked during the collecting trips in the years 1998-2005, by visiting all possible sandy biotopes.

As a consequence there is evidence that *P. grandior linsenmaieri* is recently evolved from *P. grandior*, once became isolated in Sardinia.

2 - *Chrysis paglianoi* Strumia, 1992 and *Chrysis scutellaris* Fabricius, 1794 (Fig. 2).

In 1992 I described this new endemic species upon specimens present in the insects collection of the Entomology Institute of Sassari University. Since then *C. paglianoi* was observed all over Sardinia: Domus de Maria (CA); Muravera (CA); Domusnovas (CA); Musei (CA); Santadi (CA); Baratili San Pietro (OR); Chilivani (SS); Olbia (SS); Ploaghe (SS); Porto Torres (SS); Stagno Genano (SS); Marina di Sorso (SS); Tissi (SS); Natural Reserve of Lago Baratz (SS); Berchidda (SS).

On the contrary *Chrysis scutellaris* was captured in several Corsican sites:

Haute-Corse: Albertacce, 850 m; Barrage d'Alzitone; Plage de Bravone; Calvi; Cateraggio; Corte; Folelli; Lozari; Marana; San Pellegrino; Venzolasca. Corse-du-Sud: Aiaccio; Curzo; Cuttoli; Poretto.

C. paglianoi is clearly a species derived from the West-European species *C. scutellaris* (Fig. 2), and evidence the recent cladogenesis event.

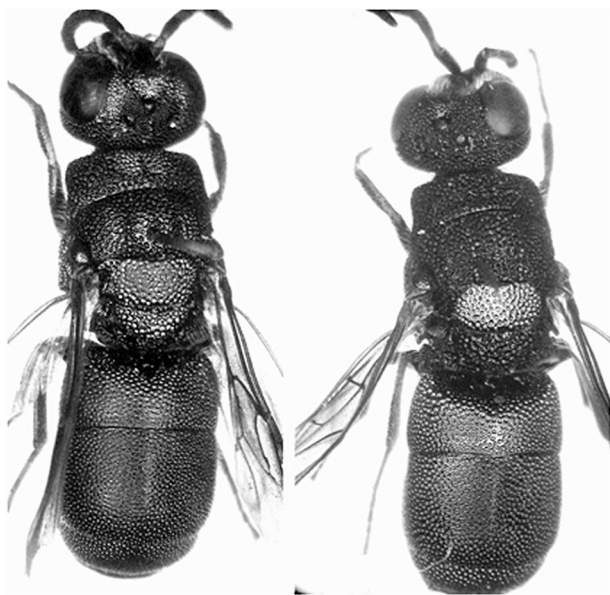


Fig. 2 - Left: male of *Chrysis scutellaris* (Fabricius, 1794), Corte, VII 2002. Right: male of *Chrysis paglianoi* Strumia, 1992, Berchidda (Sassari), VII, 2002.

CONCLUSION

Examples of the fast cladogenesis are known in others few cases, but the estimation of the time-scale was not based on the geological event (Lister, 1993; Goodfriend & Gould, 1996; Losos *et al.*, 1997). In all the above papers the new species appears in few thousand years, in agreement with the result of the present investigation, where in our case the time scale of the geological event interrupting the stasis is well known and independently measured.

Others endemic species are present only in Sardinia, as amphibian (*Speleomantes genei*, *S. flavus*, *S. supramontis*) and butterflies (*Maniola nurag*, *Lysandra coridon gennargentii*), but their age is estimated to be much older and not connected to Bonifacio strait opening (Grill *et al.*, 2010). It is worth to note that all the above species are adapted to specialized biotopes, restricting

their diffusion. If the age could be estimated from the DNA study a possible connection with previous older glaciations could be evidenced.

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