Phylogenetic Relationships of the Italian gekkotan Fauna

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The gekkotan fauna of Italy includes four species: *Cyrtopodion kotschyi* (Steindachner,1870), *Euleptes europaea* (Gené, 1839), *Hemidactylus turcicus* (Linnaeus, 1758), and *Tarentola mauritanica* (Linnaeus, 1758). The latter two are widespread within mainland Italy and all major island groups and have broad Mediterranean distributions, whereas *C. kotschyi* is an eastern Mediterranean species reaching its western limits in Apulia and *E. europaea* is restricted to Sardinia and insular and small mainland areas of Liguria and Tuscany, also occurring extralimitally in southern France, Corsica, and on several islands off the Tunisian coast (Sindaco *et al.* 2006). Although all four taxa are well-studied ecologically, their phylogenetic relations within the Gekkota have not been well investigated. The generic assignment of the two widespread forms has always been non-problematic and recently, the intrageneric relationships of both *Hemidactylus* and *Tarentola* have been resolved on the basis of mitochondrial DNA sequence data (Carranza *et al.* 2002; Carranza & Arnold, 2006). However, the affinities of these two genera to other gekkotans has not been well-established. In the case of *C. kotschyi*, changing generic concepts have resulted in its movement from *Gymnodactylus*, to *Cyrtodactylus*, to *Cyrtopodion* in the 20th century and some controversy remains regarding its correct generic allocation today, with some authors placing the species in *Mediodactylus* or *Tenuidactylus*. The leaf-toed gecko was long considered as part of a widely, but sporadically distributed *Phyllodactylus*, but this genus has been dismantled, relegating it to the monotypic *Euleptes* (Bauer *et al.* 1997). The purpose of this contribution is to place these four well-known gecko species into a broader phylogenetic framework.

As part of a broader phylogenetic analysis of all gekkotan genera we used DNA sequence data to generate hypotheses of relationship among the four Mediterranean gecko genera occurring in Italy. We used PCR to amplify por-

tions of five intronless nuclear protein-coding genes: RAG1, RAG2, ACM4, c-mos, and PDC. Primers used are listed by Gamble *et al.* (2008b). The combined data set was analyzed using maximum parsimony, maximum likelihood, and Bayesian inference, using PAUP (Swofford 2002), GARLI (Zwickl 2006), and MrBayes (Huelsenbeck & Ronquist 2001), respectively.

The four Italian gecko taxa are distributed across three different gekkotan families. Gamble *et al.* (2008a, 2008b) identified two large, deeply divergent clades of geckos that had not been recognized previously. The Sphaerodactylidae includes the five New World genera that have traditionally been regarded as a monophyletic unit (Underwood 1954; Kluge 1967, 1995) as well as one other New World genus, *Aristelliger*, and a diversity of Old World forms. Among the latter is *Euleptes*, which is part of an unresolved polytomy along with the Asian genus *Teratoscincus* and *Quedenfeldtia* (Morrocan) + *Aristelliger* (West Indian). *Tarentola*, which has long been considered as the sister clade of the African *Pachydactylus* group (Russell 1972; Haacke 1976; Bauer 1990; Kluge & Nussbaum 1995) on the basis of their shared hyperphalangy of digit I of the manus and pes, is a member of another newly erected gekkotan family, the Phyllodactylidae (Gamble *et al.* 2008b), which also includes both New (*Phyllopezus*, *Phyllodactylus*, *Homonota*, *Thecadactylus*) and Old World (*Asaccus*, *Ptyodactylus*, *Haemodracon*) genera. The *Pachydactylus* group, on the other hand, is part of the Gekkonidae *sensu stricto*. Within the Phyllodactylidae, intergeneric relationships are poorly resolved, however. Both *Cyrtopodion* and *Hemidactylus* are members of the Gekkonidae. Although these are not sister genera, both are members of a large clade that also includes the tropical Asian *Cyrtodactylus* and a cluster of Palearctic naked-toed geckos.

Both *Euleptes* and *Tarentola* appear to have last shared a common ancestor with other living genera approximately 100 million years ago. On the other hand the clade including both *Hemidactylus* and *Cyrtopodion* probably diverged from other gekkonids only ~50 MY, and divergences within the living radiations of each genus are probably 30 MY or less. The larger clade to which these two genera belong accounts for 20-25% of all gekkotan species and appears to represent a "modern" radiation (relative to other gekkotans) characterized by rapid speciation.

Our results indicate that previously proposed relationships of *Euleptes* to other leaf-toed geckos and *Tarentola* to *Pachydactylus* are incorrect. These findings are not altogether unexpected, however. Joger (1985), based on immunological data suggested that *Tarentola* was highly divergent from the hyperphalangic geckos of southern Africa, and a review of the morphological data that supported earlier groupings reveals not that morphology was inherently misleading, but rather that many earlier interpretations of homologous and homoplastic characters were misguided due to *a priori* assumptions regarding functional significance (Gamble *et al.* 2008a).

Although the Italian and broader Mediterraean gekkotan faunas have never been assumed to represent a single radiation, our results highlight the extremely deep divergences and differing origins of the few taxa involved. Both *Euleptes* and *Tarentola* represent ancient gekkotan clades with trans-Atlantic affinities. *Euleptes*, known from the Miocene of central Europe (Müller 2001; Müller & Mödden 2001), may be a survivor of a once more widespread European lineage of geckos, while *Tarentola mauritanica* is quite clearly a recent arrival from North Africa (Harris *et al.* 2004). Both *Cyrtopodion kotschyi* and *Hemidactylus turcicus* have widespread distributions extending far to the east, and patterns of genetic diversity in both, also argue for recent expansion westwards from the eastern Mediterranean (Kasapidis *et al.* 2005; Carranza & Arnold 2006).

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