**Diversification dynamics of *Agave sensu lato***

Using the phylogenetic branching date information from the whole Agavoideae data set, the diversification dynamics of the Agavoidae family best supported by the data is one with initial low diversification and extinction rates, with a slight increase in speciation rate towards the present (Table 4). On the other hand, the best diversification model of *Agave sensu lato*, suggests that the family has had a very high speciation rate and very low extinction rate, in which the rate of speciation has decreased slightly towards the present, but remains high, at an estimated 1.48 species/Ma at present. Lastly, the best model of diversification for *Furcraea/Beschorneria* predicts a constant rate of speciation and extinction (Table 5). To examine more complex models of diversification, we examined whether the data are more consistent with models in which one, two or three shifts in diversification rate occurred over time in different lineages. The model with the lowest AICc shows two shifts in diversification, one in *Agave sensu lato* and the other in *Furcraea/Beschorneria*; this model had a ΔAICc = 72.53 suggesting strong support (Table 4). The only other models with strong support compared to the null model (no shifts), all included an independent shift in diversification rate in *Agave sensu lato* (Table 4). These models indicate that a shift in the diversification rate occurred ~8 Mya in the stem *Agave sensu lato* lineage as well as in the stem lineage of the *Furcraea/Beschorneria*, with negligible extinction rates persisting in both clades (Tables 4 and 5, Fig. 1, inset). In particular, the diversification rate of *Agave sensu lato* is almost three times higher than for the rest of the Agavoideae (Table 5).

Table .4. Evaluation of shifts in diversification dynamics among clades of Agavoideae *sensu stricto* with RPANDA. nPar = number of paramaetrs in model; logLH = logarithm maximum Likelihood; AICc = second order Akaike Information Criterion. The model best supported by AICc is marked in bold.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Diversification Dynamics Shift Model** | **nPar** | **logLH** | **AICc** |
|  |  |  |  |  |
|  | No shifts in Agavoideae | *3* | *-94.8778* | *196.2890* |
|  |  |  |  |  |
|  | in *Agave s.l.+Furcraea*-*Beschorneria* | *5* | *-89.2925* | *189.9803* |
| One | in Yucca+*Hesperoyucca*-*Hesperalöe* | ***5*** | *-89.1728* | *189.7409* |
| shift | in *Agave s.l.* | *6* | *-89.8342* | *193.6684* |
|  | in *Furcraea*-*Beschorneria* | *5* | *-95.5270* | *202.4494* |
|  | in *Yucca* | *6* | *-92.4539* | *198.907* |
|  | in *Hesperoyucca*-*Hesperalöe* | *5* | *-104.4168* | *220.229* |
|  |  |  |  |  |
|  | in Yucca+*Hesperoyucca*-*Hesperalöe* and in *Agave s.l.* | *8* | *-89.9315* | *199.463* |
|  | in Yucca+*Hesperoyucca*-*Hesperalöe* and in *Furcraea*-*Beschorneria* | *7* | *-88.6429* | *194.0175* |
|  | in *Agave s.l.+Furcraea*-*Beschorneria* and in *Yucca* | *8* | *-86.2422* | *192.0845* |
| Two shifts | in *Agave s.l.+Furcraea*-*Beschorneria* and in *Hesperoyucca*-*Hesperalöe* | *7* | *-88.5339* | *193.7995* |
|  | **in *Agave s.l.* and *Furcraea*-*Beschorneria*** | ***8*** | ***-52.0623*** | ***123.7245*** |
|  | in *Agave s.l.* and in *Yucca* | *8* | *-90.0175* | *199.6349* |
|  | *in* *Agave s.l.*and in *Hesperoyucca*-*Hesperalöe* | *8* | *-88.3214* | *196.2428* |
|  | in *Furcraea*-*Beschorneria* and in *Yucca* | *9* | *-92.6556* | *207.9266* |
|  | in *Furcraea*-*Beschorneria* and in *Hesperoyucca*-*Hesperalöe* | *7* | *-91.9109* | *200.5535* |
|  | in *Yucca* and in *Hesperoyucca*-*Hesperalöe* | *8* | *-56.0393* | *131.6786* |
|  |  |  |  |  |
|  | in *Agave s.l*., *Furcraea*-*Beschorneria* and *Yucca* | *11* | *-52.67375* | *134.4826* |
| Three shifts | in *Agave s.l*., *Furcraea*-*Beschorneria* and *Hesperoyucca*-*Hesperalöe* | *11* | *-52.5885* | *134.312* |
|  | in *Agave s.l*., *Yucca* and *Hesperoyucca*-*Hesperalöe* | *11* | *-56.0604* | *141.256* |
|  | in *Furcraea*-*Beschorneria*, *Yucca* and *Hesperoyucca*-*Hesperalöe* | *10* | *-56.2753* | *138.34* |

Table 5. Parameter values of the best diversification model inferred with Maximum Likelihood for the Agavoideae clade. Two shifts in diversification dynamics were supported by the data: one in *Agave sensulato* and another one in *Furcraea*-*Beschorneria*.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Clades | **Diversification Dynamics** | **Par.** | **Speciation Rate Dynamics** | **Speciation Rate at present\*\*\*UNITS spp/Ma** | **Change in speciation rate** | **Extinction Rate** |
| *Agave sensu lato* | **Variable Speciation -Constant Extinction** | **3** | increasing | 1.4778 | -0.2108 | 5.42E-08 |
| *Furcraea-Beschorneria* | **Constant Speciation and Extinction** | **2** | constant | 0.5638 | NA | 5.65E-07 |
| Other *Agavoideae (Yucca+Hesperoyucca-Hesperalöe)* | **Variable Speciation -Constant Extinction** | **3** | increasing | 0.4731 | 0.0302 | 0.0244 |

DISCUSION

**Diversification Rates Analysis in *Agave sensu lato***

The ML estimate of the diversification rate of *Agave sensu lato* and *Yucca,* the next most species rich genus at present are highly different,1.478 and 0.473spp/MY respectively. The latter appears to be slightly lower than that of *Furcraea/Beschorneria* (0.564spp/MY), the sister group of *Agave sensu lato* (Table 5). These results are in accordance to the estimated two shifts (model best supported by the data) in the rate of diversification driven either by an increase in the rate of speciation or a decline in the rate of extinction (or both). Estimates for both, *Agave sensu lato* and *Yucca* are higher than the values previously reported by Good-Avila et al. (2006), due to the differences in the estimated crown age of each group. Both groups have undergone considerably higher rates of diversification than the two average estimates reported for angiosperms as a whole: 0.089 (Magallón & Sanderson, 2001) and 0.12 - 0.39 (Bremer, 1992), and they are also higher than rapidly evolving groups such as the Asteraceae (Magallón & Sanderson, 2001). Indeed the rate of diversification of *Agave sensu lato* falls within the range (0.56 ± 0.17 spp/MY) of one of the most outstanding island adaptive radiations: the Silversword Alliance in Hawaii (Baldwin & Sanderson, 1998). It was believed that island speciation rates were higher, on average, than continental rates; however similarly high rates of diversification in the western New World genus *Lupinus* (0.6 – 1.1 spp/MY)(Drummond, 2008) and in the Mexican and central American ant associated *Acacia* (0.496 spp/MY) (Gómez-Acevedo et al., 2010) suggest that continental radiations can exhibit very high rates of diversification. Furthermore, the rates of diversification observed in *Agave* and *Yucca* are comparable to the radiation of the Poaceae in the South African Cape Flora (0.12–0.39) (Verboom et al., 2003) which reached a peak rate of diversification (0.87 - 4.18) showing a 2.9 spp/my diversification rate in the start of their radiation (Verboom et al., 2003) while in this study we show that the diversification rate of *Agave sensu lato* was in general 1.48 and increasing at present (Table 5).The high diversification rate in *Agave sensu lato* is coincident with the aridification of central Mexico; the formation of the Sonoran Desert (Axerold, 1979; Van Devender, 2000) occurred when the Mexican Central Basin was divided by the appearance of the Neovolcanic Belt (Morán Zenteno & Sanchez-Barreda, 1994), a biogeographical event which changed rainfall patterns and population isolation resulting in an impressive continental plant radiation.