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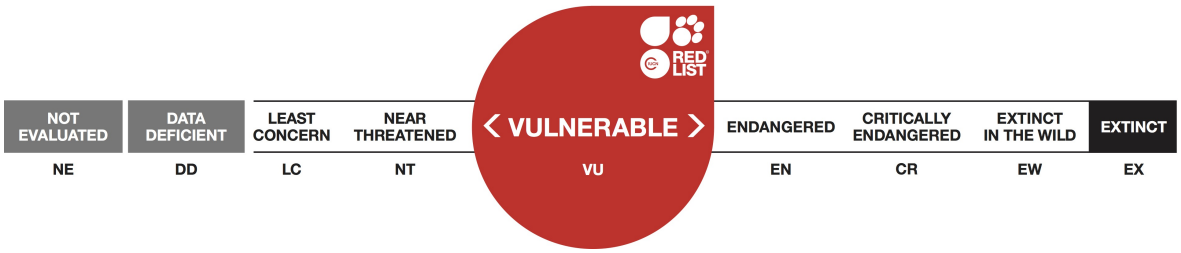
Acantholichen galapagoensis, Galapagos Spiny Gladiator Lichen

Assessment by: Bungartz, F.



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Taxonomy

Kingdom	Phylum	Class	Order	Family
Fungi	Basidiomycota	Agaricomycetes	Corticiales	Corticiaceae

Taxon Name: *Acantholichen galapagoensis* Dal-Forno, Bungartz & Lücking

Common Name(s):

- English: Galapagos Spiny Gladiator Lichen

Taxonomic Source(s):

Dal-Forno, M., Lücking. R., Bungartz, F., Yánez-Ayabaca, A., Marcelli, M.P., Spielmann, A.A., Coca, L.F., Chaves, J.L., Aptroot, A., Sipman, H.J., Sikaroodi, M., Gillevet, P. and Lawrey, J.D. 2016. From one to six: unrecognized species diversity in the genus *Acantholichen* (lichenized Basidiomycota: Hygrophoraceae). *Mycologia* 108(1): 38-55. doi: 10.3852/15-060.

Taxonomic Notes:

F. Bungartz: previously reported as A. pannarioides, but all Galapagos specimens belong to A. galapagoensis

Identification Information:

The genus Acantholichen was first described by Jørgensen (1998), who, at the time, considered the genus to be monotypic [Jørgensen (1998) Acantholichen pannarioides, a new basidiolichen from South America. Bryologist 101:444–447]. Specimens from the Galapagos, collected by Pike in Santiago (OSC), and by Weber and Lanier in Santa Cruz (COLO), were cited by Jørgensen in the protologue, alongside type material of Acantholichen pannarioides P.M. Jørg. from Costa Rica.
Dal-Forno et al. (2016) compared morphology and anatomy of specimens from Galapagos with those collected in Costa Rica, Brazil and Colombia; combined with a molecular analysis. In the genus they thus distinguished six different species, describing the material from Galapagos as Acantholichen galapagoenis Dal-Forno, Bungartz & Lücking, a species endemic to the archipelago [Dal-Forno et. al. (2016) From one to six: unrecognized species diversity in the genus Acantholichen (lichenized Basidiomycota: Hygrophoraceae). Mycologia, 108(1): 38–55].

Assessment Information

Red List Category & Criteria: Vulnerable B1ab(iii)+2ab(iii); D2 ver 3.1

Year Published: 2018

Date Assessed: August 30, 2017

Justification:

This basidiolichen species is endemic to Galapagos. A recent species inventory found only five populations across four different islands. Natural habitats of *Acantholichen galapagoensis* are known from threatened tree ferns and shrub (*Cyathea* - endangered, *Psychotria* - vulnerable) and a vegetation type that is in many parts of Galapagos has deteriorated (*Frullania-Zanthoxylon* forests). Only on Santa

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Cruz thalli of the lichen have established on introduced *Cinchona pubescens* as an alternative habitat. Here, the practice of population reduction of *Cinchona* by chemical control needs to be carefully balanced against survival of refugium populations of *Acantholichen*.

Geographic Range

Range Description:

Endemic to the Galapagos Islands, Ecuador.

Special note from the Author of the assessment: Acknowledgments- Author thanks the Charles Darwin Foundation and the Galapagos National Park as well as a grant from the Mohamed Bin Zayed Species Conservation Fund (project 152510692) and the National Science Foundation (DEB 0841405), who all made this work on *Acantholichen* possible.

Country Occurrence:

Native: Ecuador (Galápagos)

Population

Acantholichen galapagoensis occurs at upper altitudes of the humid zone vegetation [typically from 650 to 900 m, min. 500m, max. 1100 m]. Habitats are known from only four islands (San Cristóbal, Santa Cruz, Santiago, Volcán Alcedo and Cerro Azul on Isabela). Despite intensive surveys the species was not found on other islands that have a fairly well developed humid zone, like Floreana or Pinta. Today the vegetation on these islands generally lacks open, exposed, but nevertheless extremely humid habitat. Historic collections by L.H. Pike (OSC), and W.A. Weber and J. Lanier suggest that this endemic Galapagos basidiolichen was once common in the natural vegetation of the humid Galapagos highlands. Today, the basidiolichen is known from four different islands (San Cristóbal, Santa Cruz, Santiago, Volcán Alcedo and Cerro Azul on Isabela); all locations, where the lichen was found on these islands, are in close proximity [i.e., populations exist at no more than 10 locations, VU B1a; due to the close proximity of all sites on the five islands, even EN B1a might apply]. Particularly specimens on native and endemic trees and shrubs are today typically not well developed (specimen listed as *A. pannarioides* during Galapagos Lichen Inventory: http://www.darwinfoundation.org/datazone/collections/). They are often reduced to few, scant squamules [EN B1biii,v]. This contrasts, however, with exceptionally well developed material growing on *Cinchona pubescens*, an introduced tree that invades shrubland dominated by endemic *Miconia robinsoniana* in the highlands of Santa Cruz Island. There, the lichen is particularly abundant on dead trees left standing from conservation management (chemical control of invasive *Cinchona*). In some instances the basidiolichen here covers up to 1 m length of the tree trunks. This refugium population is, however, known from a single location, the *Miconia* shrub invaded by *Cinchona* between El Puntudo and Cerro Crocker Similarly well developed thalli are otherwise only known from Isabela Island (Cerro Verde, Volcán Cerro Azul), where thalli grow abundantly on leaf sheaths of the endemic tree fern *Cyathea weatherbyana*. *Cyathea* is globally listed as endangered [EN A2a,c,e especially on Santa Cruz populations of *C. weatherbyana* appear threatened by habitat change due to invasion of *Cinchona*; the Cerro Azul populations are assumed to be relatively stable]. Other native habitat is represented by specimens found on the endemic *Psychotria rufipes* [VU B1a,b(iii,v); B2a,b(iii,v)] in the highlands of Santiago, and remnants of *Frullania-Zanthoxylon* forests ("brown zone"-vegetation), where *Acantholichen* grows on isolated *Zanthoxylon* snags along the outer caldera rim of Volcán Alcedo, Isabela Island. Particularly the native lichen populations on *Cyathea* are likely to decline further, if populations of the tree fern continue to deteriorate. Currently, lichen populations established on *Cinchona* in Santa Cruz act as refugia, as long as dead tree stumps are not removed. Overall it can be assumed that these populations remain relatively stable under the current management regime (chemical control, without mechanical removal of dead trees).

However, in the past two years (2015-17) the terrestrial parts of the Galapagos have experienced very unusual and extreme droughts. In the highlands it barely rained during the rainy seasons, farmers started to complain that their cattle were dying from starvation because the otherwise abundant grasslands in the agricultural areas were drying up. During a visit to Santa Cruz for six weeks in February March of 2017 we witnessed these exceptionally dry conditions. Even the most humid parts of the highlands were now without clouds for weeks. The sphagnum bogs in the highlands felt dry, the Sphagnum plants dying off. During an intensive search for *Acantholichen* we were able to find only very few, scant squamules at the locality from which the most abundant populations were previously known. This suggests that under current abnormal climate conditions even the populations previously assumed to provide stable refugia are now declining (Personnel communication with Dr Frank Bungartz).

Current Population Trend: Decreasing

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Habitat and Ecology (see Appendix for additional information)

Acantholichen galapagoensis appears to be relatively substrate unspecific. It grows on hepatics (most commonly *Frullania aculeata*, less commonly on *Frullania brasiliensis*, *Frullania* sp., *Ceratolejeunea* sp., *Omphalanthus filiformis*). Two specimens from Santa Cruz were found on terricolous *Campylopus anderssonii* on open, exposed ground. Well developed thalli of the lichen were also found on dead leaf sheaths of the endemic tree fern *Cyathea weatherbyana*. Despite its ability to inhabit a broad range of substrates the microhabitat of the basidiolichen nevertheless appears very restricted. Characteristic is a combination of factors that rarely occur together: open and exposed, but nevertheless almost continuously humid conditions. The species has generally only been found in the most humid environments, in habitat that throughout the year are is constantly subjected to a fine drizzle or fog (locally known as *'garua'*). At the same time, in these environments *Acantholichen* inhabits only the most exposed, unsheltered sites that receive direct sunlight (sun-, wind- and rain-exposed); it does not occur within closed canopy; thalli are best developed, where they are most exposed. In Santa Cruz, for example, the lichen is not generally found throughout the humid highlands. Instead it is restricted to a relatively small distribution pocket near El Puntudo and Cerro Crocker; an area alomst permanently shrouded in *garua*. Here, thalli are best developed on dead *Cinchona* trees, exfoliated by chemical control. The lichen is much less exuberant on live trees that still bear a relatively open canopy. And, it is generally absent from closed canopy of *Miconia robinsoniana*, an endemic shrub that forms the dominant, characteristic vegetation at this altitude. Only where the canopy of this shrub has not yet closed due to disturbance, the lichen can rarely be found (e.g., one site on San Cristóbal). *Acantholichen* also does not occur where bracken (*Pteridium* hybrids), possibly as a result of anthropogenic fire, dominates the landscape, particularly on Santa Cruz. Among the natural Galapagos vegetation populations of the endemic *Acantholichen* have become extremely rare. In Santiago, the lichen has only been found on liverworts, growing on *Psychotria rufipes*, an endemic shrub listed as vulnerable [VU B1a,b(iii,v); B2a,b(iii,v)] (both historic and recent specimens). On Volcán Alcedo (Isabela) *Acantholichen* grows on liverworts, which inhabit exposed, stunted *Zanthoxylon* trees, a species native to the archipelago; these thorny snags in the humid, exposed highlands along the crater rim are today the only remains of natural vegetation left from grazing by goats (in the past five year recovery of this vegetation has started due to removal of goats, but competition from introduced plants appears problematic for this recovery). Similar habitat occurs on Volcán Cerro Azul, the volcano that receives the highest rainfall in the archipelago (its southern flanks are regularly drenched, when moist sea air rises). Here, *Acantholichen* can no longer be found throughout extensive secondary grasslands, caused by feral cattle and pigs, now dominating the landscape. On Cerro Azul the lichen is therefore restricted to a small remnant population on the tree fern *Cyathea weatherbyana* [EN A2a,c,e], inside the side crater Cerro Verde, where the steep crater flanks are inaccessible to grazing (and populations therefore presumably stable). All other known populations are on introduced trees and shrub, most notably *Cinchona pubescens*, in the Santa Cruz highlands.In Santa Cruz, *Acantholichen* grows on *Campylopus* on the open ground, where shrub and ferns cannot establish because of edaphic reasons (i.e., the extremely thin soils near El Puntudo, but occasionally also where vegetation has been cleared along paths). These populations are, however, rare. The sites where the lichen grows on this terricolous liverwort are all in close proximity of the exceptionally exuberant populations established on *Cinchona* (sexual reproduction of the basidiolichen remains unknown, it is conceivable that here propagules "rain down" from the trees).

Systems: Terrestrial

Threats (see Appendix for additional information)

The natural vegetation of the humid Galapagos highlands has significantly been altered. On islands inhabited by humans (San Cristóbal, Santa Cruz, Southern Isabela, Floreana) drastic changes of the landscape are a direct result of agricultural use throughout the fertile highlands. Historic and present-day land-use includes clearance of vegetation by fire, cutting and grazing, and the planting alien species for human consumption. These practices have significantly changed species composition and structure of natural vegetation types; even sites that were historically not immediately used for cultivation and today often "appear" natural, like *Miconia* shrub around El Puntudo and Cerro Crocker, have in the past suffered from human intervention (fire, grazing, introduction of *Cinchona pubescens* with the intention to sell quinine extracted from its bark). Even on islands that are today uninhabited or where in the past human settlements were very sporadic, the introduction of invasive species has still had a drastic impact on humid highland vegetation. Whalers and pirates originally much decimated the only original grazing animal native to all islands: the Galapagos tortoise. Today many populations of these animals have recovered, though not necessarily to historic levels. How these tortoises affected the natural vegetation at their original densities is therefore difficult, if impossible to assess. It is obvious though that introduced alien animals (goats, cattle, pigs, donkeys), all had a devastating effect on the natural vegetation throughout the islands. As a result of human intervention, natural habitat has thus drastically changed not only for plant species but also for lichens associated with this vegetation. Particularly for epiphytes natural habitat, trees and shrubs, will have disappeared, or at least have become increasingly rare. Fortunately, most lichen species appear relatively unspecific towards their substrate. Particularly species adapted to open, exposed habitat, may initially even have benefited from a more open, moderately disturbed landscape. This may originally have been the case also for *Acantholichen*. In dense *Miconia* shrub the species likely was never particularly abundant, apart from the edges and fringes of this vegetation type; even the native *Frullania-Zanthoxylon* forests ("brown zone") might originally have been quite dense (only the most humid areas of this forests will have been suitable for *Acantholichen* and it is not known how open these forests were, when higher densities of tortoises were present). Some endemic species (*Psychotria*, *Cyathea*) presumed to represent typical native habitat of *Acantholichen* are today threatened. However, the lichen, at least on Santa Cruz, apparently quite successfully switched to alternative habitats. These populations of *Cinchona* are the most exuberant ones today known. Management to control populations of this invasive tree has potentially a direct, drastic detrimental impact on these important refugia populations. It must be carefully balanced (see conservation actions).

Conservation Actions (see Appendix for additional information)

Whereas it must be presumed that the natural populations of the endemic *Acantholichen* have drastically declined, it can also be assumed that populations on introduced *Cinchona* are at least stable or even thriving.With the exceptional 2015-2017 drought this assessment may, however, have to be revised. This highlights the importance of management for this species. Natural populations of the lichen depend on recovery of the natural vegetation. Particularly important appears habitat be represented by species like *Cyathea* or *Psychotria*, possibly also the most humid, open aspects of *Frullania-Zanthoxylon* forests (open, exposed "brown zone" forest). Recovery of the native species in these vegetation types will presumably also result also in a recovery of *Acantholichen* populations. Succession processes on islands where goats have been removed should therefore be monitored. For the lichen at the most humid and most exposed habitat sites appear to be most important. Succession patterns and disturbance from rapid growth of invasive plants, in the absence of high population

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densities of tortoises, may result in very dense, close vegetation. This may directly impact the last remaining, small native populations of *Acantholichen*. Particularly important therefore is the refugium population of *Acantholichen* on *Cinchona pubescens* in *Miconia* shrubland near El Puntudo/Cerro Crocker on Santa Cruz Island. Best developed thalli of *Acantholichen* are found on the dead stumps left standing from chemical control. Current practice of chemical control, not complete eradication, of *Cinchona* without mechanical removal of dead trees appears to be an almost ideal management option. This control of *Cinchona* nevertheless needs to be carefully balanced. It is not known, for example, how long dead trees carpeted in *Frullania* remain standing and are thus available for *Acantholichen*.Regular and frequent control (e.g., the attempt to eliminate most seedlings) may prevent sufficient re-establishment of new adult trees as necessary "repository" for dead stumps. Even if complete *Cinchona* eradication is prohibitively expensive, the National Park may presently attempt to restore natural highland vegetation by cultivating an aspect of closed *Miconia* canopy without *Cinchona* trees left standing, and particularly without new adult trees establishing again. This "perfect scenery" might ironically be considered a more "natural" landscape then scattered dead or even live trees, an idealized goal to remove all trees for the sake of appearances. A management strategy that focuses on species diversity, not an "idealized landscape scenery" must find a compromise. This might not be difficult, because *Acantholichen* is not generally common where *Cinchona* occurs. On the contrary, it appears restricted to few habitat sites. In these distribution pockets a balanced approach that permits establishment of few *Cinchona* trees may be a the most appropriate management option.Ideally at the sites this monitoring program should be combined with monitoring climate (particularly dew and rainfall).

Credits

Assessor(s): Bungartz, F.

Reviewer(s): Scheidegger, C.

Contributor(s): Weerakoon, G.

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External Resources

For Images and External Links to Additional Information, please see the Red List website.

Appendix

Habitats

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Habitat	Season	Suitability	Major Importance?
1. Forest -> 1.9. Forest - Subtropical/Tropical Moist Montane	Resident	Suitable	Yes
3. Shrubland -> 3.6. Shrubland - Subtropical/Tropical Moist	Resident	Suitable	Yes

Threats

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Threat	Timing	Scope	Severity	Impact Score
12. Other options -> 12.1. Other threat	Ongoing	Majority (50-90%)	Causing/could cause fluctuations	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.2. Ecosystem degradation 1. Ecosystem stresses -> 1.3. Indirect ecosystem effects		
8. Invasive and other problematic species, genes & diseases -> 8.1. Invasive non-native/alien species/diseases -> 8.1.1. Unspecified species	Ongoing	Majority (50-90%)	Causing/could cause fluctuations	Medium impact: 6
	Stresses:	1. Ecosystem stresses -> 1.1. Ecosystem conversion 1. Ecosystem stresses -> 1.2. Ecosystem degradation		

Conservation Actions Needed

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Conservation Actions Needed
2. Land/water management -> 2.1. Site/area management
2. Land/water management -> 2.2. Invasive/problematic species control
5. Law & policy -> 5.2. Policies and regulations

Research Needed

(http://www.iucnredlist.org/technical-documents/classification-schemes)

Research Needed
1. Research -> 1.2. Population size, distribution & trends
1. Research -> 1.5. Threats
2. Conservation Planning -> 2.1. Species Action/Recovery Plan
2. Conservation Planning -> 2.2. Area-based Management Plan

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Research Needed
3. Monitoring -> 3.1. Population trends
3. Monitoring -> 3.4. Habitat trends

Additional Data Fields

Distribution
Estimated area of occupancy (AOO) (km²): 20-250
Extreme fluctuations in area of occupancy (AOO): Unknown
Estimated extent of occurrence (EOO) (km²): 500-1000
Extreme fluctuations in extent of occurrence (EOO): Unknown
Number of Locations: 10
Extreme fluctuations in the number of locations: Unknown
Lower elevation limit (m): 500
Upper elevation limit (m): 1100
Habitats and Ecology
Continuing decline in area, extent and/or quality of habitat: Yes

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