
TRICHOME MORPHOLOGY IN *HEDERA* (*ARALIACEAE*)

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Trichomes of *Hedera* L. taxa have long been used as an important character in delimiting species. *Hedera* exhibits two distinct trichome types: scale-like and stellate. This study examined the trichome variation in sixteen currently recognized *Hedera* taxa using scanning electron microscopy. Measurements of trichome morphology were taken, and variation among taxa compared. Of the taxa with scale-like trichomes, *H. maderensis* Rutherford subsp. *maderensis* has the largest overall length, longest rays, and largest fusion of rays. Of the species with stellate trichomes, *H. helix* has the largest overall, and also has the longest rays and widest rays.

Keywords. *Araliaceae*, *Hedera*, ivy, trichomes.

INTRODUCTION

The ivy genus *Hedera* L. (Araliaceae) includes approximately 16 taxa distributed throughout Europe and Asia. The trichomes of *Hedera* fall into two groups: those with stellate trichomes and those with scale-like trichomes (McAllister, 1981). The taxa with stellate trichomes are: *H. azorica* Carr., *H. helix* L. subsp. *helix*, *H. helix* L. forma *poetarum* (Nyman) McAllister & Rutherford, *H. helix* L. subsp. *rhizomatifera* McAllister, and *H. hibernica* (Kirch.) Bean. The taxa with scale-like trichomes are: *H. algeriensis* Hibberd, *H. canariensis* Willd., *H. colchica* (K. Koch) K. Koch, *H. cypria* McAllister, *H. maderensis* K. Koch ex Rutherford subsp. *iberica* McAllister, *H. maderensis* K. Koch ex Rutherford subsp. *maderensis*, *H. maroccana* McAllister, *H. nepalensis* K. Koch, *H. nepalensis* K. Koch var. *sinensis* Rehder, *H. pastuchovii* Woronow, and *H. rhombea* (Miq.) Bean.

Lum & Maze (1989) performed a multivariate analysis on the trichomes of *Hedera*. Since this analysis, new taxa such as *H. cypria*, *H. helix* subsp. *rhizomatifera*, and *H. maderensis* subsp. *iberica* have been described by Rutherford *et al.* (1993). In addition, Lum and Maze (1989) were unable to examine the trichomes of *H. pastuchovii*.

Trichome morphology has been widely used as a taxon delimiting character in *Hedera* (Seeman, 1868; Hibberd, 1893; Tobler, 1912; Lawrence & Schultze, 1942; McAllister, 1981; Rose, 1996). Therefore, it is important to understand the variation that exists and the major characteristics of the trichomes when identifying *Hedera* species. This study examined the trichomes of currently recognized *Hedera* taxa to determine the variation that exists between taxa. In addition, attempts were made to identify unique characters for the trichomes of each taxon.

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MATERIALS AND METHODS

The material used in the study was obtained from both herbarium specimens and living material. The living material was obtained through the American Ivy Society, Lewis Ginter Botanic Garden, and Dr Hugh McAllister at Ness Gardens. The leaves most suitable for use in the study were located two or three leaves down on the plant. Both the abaxial and adaxial leaf surfaces of juvenile plants were studied. No discernable differences in measurements were found between the abaxial and adaxial trichomes.

Samples of approximately 7×7 mm were taken from herbarium specimens and leaf samples (see Table 1 for sample origin). These were attached to an aluminium stub with double-sided tape, and coated with gold using a Hummer VII Sputtercoater. Living material was attached

TABLE 1. Origin of leaf samples

Species	Sample origin	
	1	2
<i>H. algeriensis</i>	American Ivy Society #93-130	Cultivated at Ness Gardens
<i>H. azorica</i>	NY; P. Silva 316; Santa Maria, Pico Alto; 20 May	Cultivated at Ness Gardens
<i>H. canariensis</i>	B; Det. by R. Raus; Spain	American Ivy Society #94-052
<i>H. colchica</i>	B; E. Kohler 475; Caucasia	Cultivated at Ness Gardens
<i>H. cypria</i>		
<i>H. helix</i> subsp. <i>helix</i>	NY; from Sweden no. 90460	Cultivated at Ness Gardens
<i>H. helix</i> forma <i>poetarum</i>	B; G. Gellanda 53.1.1; Naples	American Ivy Society (no number)
<i>H. helix</i> subsp. <i>rhizomatifera</i>	Cultivated at Ness Gardens	American Ivy Society #88-372
<i>H. hibernica</i>	CS; Personal Collection; Owens Eu2; Penmon Pt., Wales	NY; E. C. Marquand; Avoca, Ireland; 13 September 1936
<i>H. maderensis</i> subsp. <i>iberica</i>	American Ivy Society #82-253	Cultivated at Ness Gardens
<i>H. maderensis</i> subsp. <i>maderensis</i>	American Ivy Society #91-097	Cultivated at Ness Gardens
<i>H. maroccana</i>	American Ivy Society #88-008	Cultivated at Ness Gardens
<i>H. nepalensis</i>	H; R. R. Stewart 1532	American Ivy Society #88-258
<i>H. nepalensis</i> var. <i>sinensis</i>	American Ivy Society #88-259	H; N. Yuman 4997
<i>H. pastuchovii</i>	Cultivated at Ness Gardens	American Ivy Society #82-118
<i>H. rhombea</i>	American Ivy Society #88-260	Lewis Ginter B. G., Richmond, VA #220

to stubs with silver paste and allowed to air dry for 24h before being coated with gold. The samples were observed using a Philips 505 Scanning Electron Microscope.

The measurements taken from the trichomes (see Fig. 1) were as follows: A, radius of raised centre; B, length of ray from edge of raised centre; C, length of fusion of rays from edge of raised centre; D, length of base; and E, ray width. Calculation $2(A + B)$ was used as the total length of the trichome. Three measurements of each length were taken on the same trichome. At least 10 trichomes on each leaf sample were measured. Two samples of each trichome were examined (Table 1), except in the case of *H. cypria* where material was limited. MINITAB (1997) was used for all statistical analyses.

RESULTS AND DISCUSSION

Table 2 lists the measurements taken for the *Hedera* species examined. For the scale-like trichomes (Fig. 2), there are various key characters that can be used to separate trichomes of several taxa. *Hedera cypria* can be easily distinguished from other taxa as its trichomes only appear on the abaxial leaf surfaces. This is the only taxon in which the trichomes are not distributed on both the adaxial and abaxial leaf surfaces. The trichomes of *H. colchica* are also easily distinguished from other scale-like trichomes as they have the largest centre length (0.036–0.048mm), which is readily seen under a light microscope. These trichomes also usually have the highest number of rays (up to 20) present in any scale-like trichomes. *Hedera maderensis* subsp. *maderensis* has the largest average overall size (0.225–0.377mm), longest rays (0.088–0.164mm), and greatest fusion of rays (0.025–0.052mm) of the scale-like trichomes. The trichomes of *H. maderensis* subsp. *iberica* have a larger raised centre (up to 0.094mm across) than those of *H. maderensis* subsp. *maderensis*.

The trichomes of *H. maroccana* can be distinguished from those of *H. maderensis* subsp. *iberica* and *H. maderensis* subsp. *maderensis* because the centre of the trichome is generally not raised. The trichomes of *H. rhombea* were the smallest overall (0.105–0.215mm) and have rounded ray tips instead of acute tips as in the other taxa with scale-like trichomes. Trichomes of another member of the Araliaceae family, *Brassaiopsis hainla* (Buch.-Ham.) Seem., were examined for outgroup

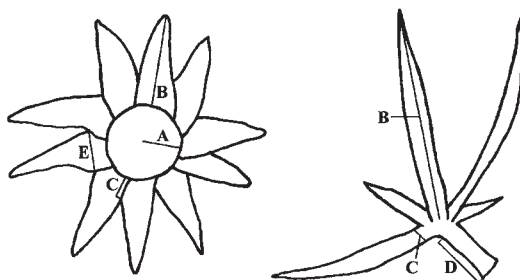


FIG. 1. Measurement details for scale (left) and stellate (right) trichomes: A, radius of raised centre; B, length of ray from edge of raised centre; C, length of fusion of rays from edge of raised centre; D, length of base; E, ray width.

TABLE 2. *Hedera* trichome measurements (mm): averages given with ranges in parentheses

Taxon	A: centre radius	B: ray length	C: fusion length	2 (A + B): overall length	D: base length	E: ray width	Location	
							Adaxial	Abaxial
<i>H. algeriensis</i>	0.0188** (0.0188)	0.1108 (0.0875–0.13)	0.024 (0.0125–0.0375)	0.259 (0.1996–0.2976)	0	0.0172 (0.0125–0.02)	x	x
<i>H. azorica</i>	0	0.344 (0.275–0.425)	0.024 (0.02–0.025)	0.678 (0.55–0.85)	0.019 (0.0188–0.02)	0.0276 (0.02–0.0333)	x	x
<i>H. canariensis</i>	0.0192 (0.0188–0.02)	0.106 (0.075–0.125)	0.0269 (0.0188–0.0375)	0.25 (0.1876–0.29)	0	0.02 (0.0126–0.025)	x	x
<i>H. colchica</i>	0.0448* (0.036–0.048)	0.0892 (0.0625–0.125)	0.0342 (0.025–0.056)	0.268 (0.219–0.344)	0	0.02 (0.0156–0.03)	x	x
<i>H. cypria</i>	0.025 (0.025)	0.063 (0.0438–0.1)	0.019** (0.0188–0.0219)	0.175 (0.1625–0.25)	0	0.0162 (0.015–0.0188)		x
<i>H. helix</i> subsp. <i>helix</i>	0	0.466*** (0.375–0.531)	0.036*** (0.025–0.05)	0.933*** (0.75–1.062)	0.043 (0.035–0.05)	0.031*** (0.025–0.0375)	x	x
<i>H. helix</i> <i>poetarum</i>	0	0.415 (0.3–0.5)	0.021**** (0.0188–0.031)	0.831 (0.65–1.0)	0.054*** (0.0479–0.0625)	0.025**** (0.023–0.03)	x	x
<i>H. helix</i> subsp. <i>rhizomatifera</i>	0	0.46 (0.3525–0.5625)	0.0261 (0.0208–0.03)	0.923 (0.705–1.125)	0.049 (0.0474–0.05)	0.027 (0.025–0.0333)	x	x
<i>H. hibernica</i>	0	0.288**** (0.2–0.4375)	0.028 (0.025–0.0313)	0.576**** (0.4–0.875)	0.016**** (0.0125–0.025)	0.029 (0.02–0.0375)	x	x
<i>H. maderensis</i> subsp. <i>iberica</i>	0.0329 (0.025–0.0469)	0.1089 (0.0625–0.1927)	0.0303 (0.0208–0.0417)	0.285 (0.175–0.3854)	0	0.026* (0.0125–0.0313)	x	x
<i>H. maderensis</i> subsp. <i>maderensis</i>	0.0254 (0.025–0.026)	0.134* (0.0875–0.1635)	0.048* (0.025–0.052)	0.318* (0.225–0.377)	0	0.0182 (0.0125–0.025)	x	x
<i>H. maroccana</i>	0.0297 (0.025–0.0375)	0.1 (0.05–0.175)	0.0328 (0.025–0.0375)	0.259 (0.175–0.4)	0	0.02 (0.0188–0.025)	x	x
<i>H. nepalensis</i>	0.0257 (0.025–0.027)	0.0918 (0.075–0.15)	0.0287 (0.021–0.0375)	0.235 (0.179–0.3)	0	0.015** (0.0125–0.0188)	x	x
<i>H. nepalensis</i> var. <i>sinensis</i>	0.0283 (0.026–0.0333)	0.0654 (0.0375–0.125)	0.026 (0.0167–0.05)	0.187 (0.129–0.3166)	0	0.0166 (0.0125–0.025)	x	x
<i>H. pastuchovii</i>	0.0354 (0.027–0.05)	0.0945 (0.075–0.1325)	0.0346 (0.0188–0.025)	0.26 (0.204–0.319)	0	0.0218 (0.0188–0.025)	x	x
<i>H. rhombea</i>	0.0199 (0.0125–0.026)	0.0573** (0.04–0.0875)	0.0247 (0.0125–0.0375)	0.154** (0.105–0.215)	0	0.0235 (0.0188–0.0313)	x	x

*, largest scale measurement; **, smallest scale measurement; ***, largest stellate measurement; ****, smallest stellate measurement.

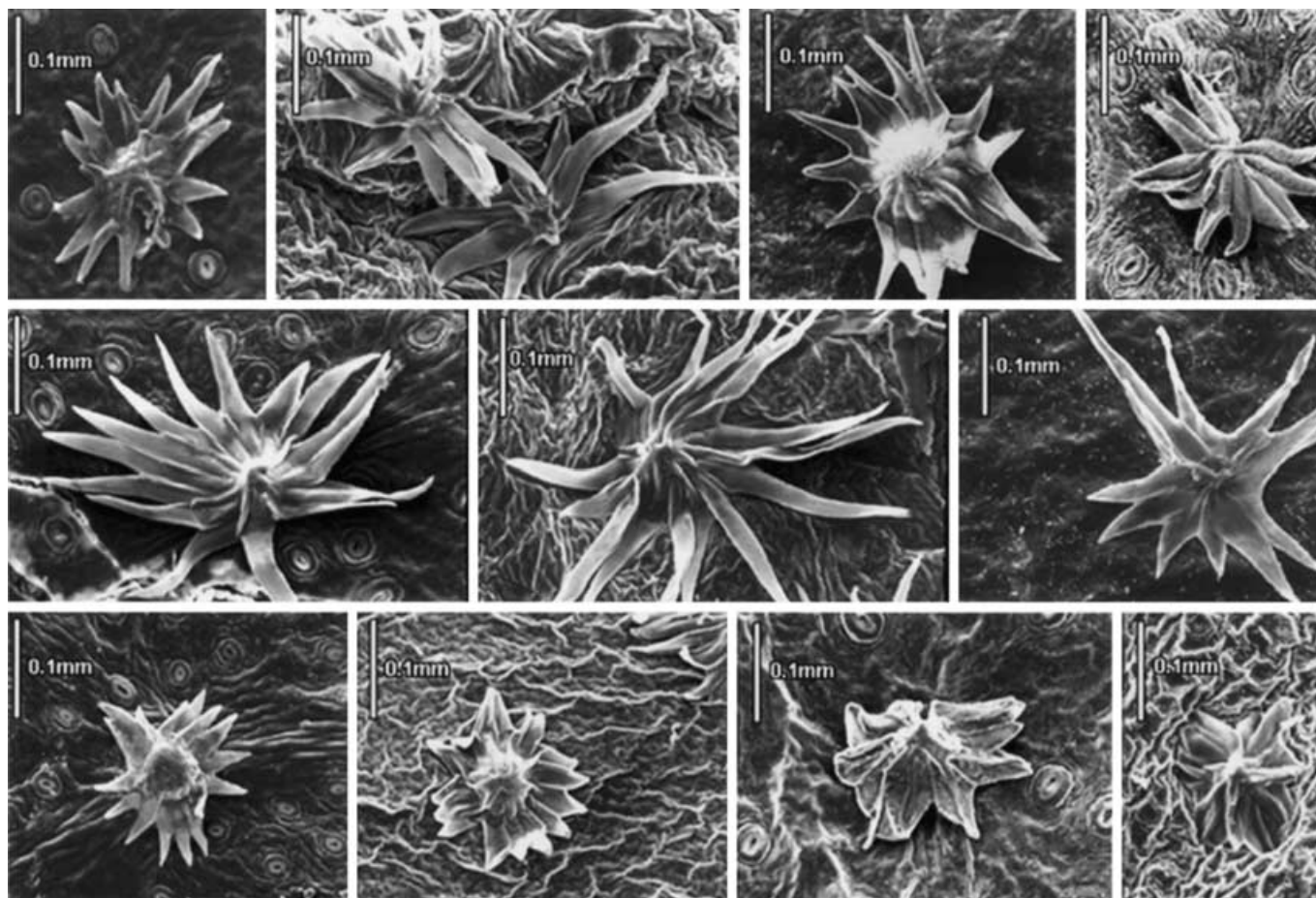


FIG. 2. Scale-like trichomes (all at $\times 312$). Top row (left to right): *H. algeriensis*, *H. canariensis*, *H. colchica*, *H. cypria*. Middle row (left to right): *H. maderensis* subsp. *iberica*, *H. maderensis* subsp. *maderensis*, *H. maroccana*. Bottom row (left to right): *H. nepalensis*, *H. nepalensis* var. *sinensis*, *H. pastuchovii*, *H. rhombea*.

comparison. These trichomes most closely resembled the scale trichomes, but lacked a definite centre (Fig. 3).

However, not all species with scale-like trichomes can be distinguished on trichome morphology. *Hedera canariensis* and *H. algeriensis* have very similar trichomes and cannot be separated on trichome characters alone. The trichomes of both these species have small centres (<0.05mm in diameter) and an average overall length of approximately 0.25mm. Likewise, the trichomes of *H. nepalensis*, *H. nepalensis* var. *sinensis*, and *H. pastuchovii* are all very similar and difficult to separate. The trichomes of all these taxa all have large centres (>0.05mm in diameter) and are relatively small in overall length (<0.25mm).

In contrast, taxa with stellate trichomes (Fig. 3) can be separated solely on trichome morphology. *Hedera helix* forma *poetarum* can be recognized from closely related taxa by the long base (generally >0.05mm) attaching the trichome to the leaf surface. The trichomes of *H. helix* subsp. *rhizomatifera* can be easily distinguished from other stellate trichomes because they almost always have only four rays arranged opposite each other, giving the trichome a cruciform appearance. The trichomes also lie more adpressed to the leaf surface than those of the typical subspecies. Trichomes of *H. azorica* have a short base (<0.02mm long).

Distinguishing between *H. helix* and *H. hibernica* is generally difficult, but one of the few characters that can be used to separate them is the position of the trichomes on the leaf surface. Results confirm the findings of McAllister (1990) that the trichomes of *H. hibernica* generally lie parallel to the leaf surface while those of *H. helix* are erect and more bristly in appearance. Furthermore, the trichomes of *H. helix* are generally much larger overall (0.75–1.062mm) than those of *H. hibernica* (0.4–0.875mm), and the base of *H. helix* trichomes are longer (0.035–0.05mm) compared with *H. hibernica* trichomes (0.013–0.025mm).

These results have been used to create the following key:

Key to the species of Hedera based on trichome morphology

- 1a. Trichomes <10-rayed, >0.5mm long, white, rays adpressed or not _____ (stellate type) 2
- 1b. Trichomes >10-rayed, <0.5mm long), red or white, rays always adpressed to the leaf surface _____ (scale type) 6
- 2a. Rays adpressed to the surface of the leaf _____ 3
- 2b. Rays not adpressed to the surface of the leaf _____ 4
- 3a. Rays 4, arranged like an X, overall length 0.7–1.13mm _____ **H. helix** subsp. **rhizomatifera**
- 3b. Rays >4, overall length 0.4–0.7(–0.9)mm _____ **H. hibernica**
- 4a. Trichome base >0.02mm long, rays elevated on the base _____ 5
- 4b. Trichome base <0.02mm long, rays radiating from towards the bottom of the base _____ **H. azorica**

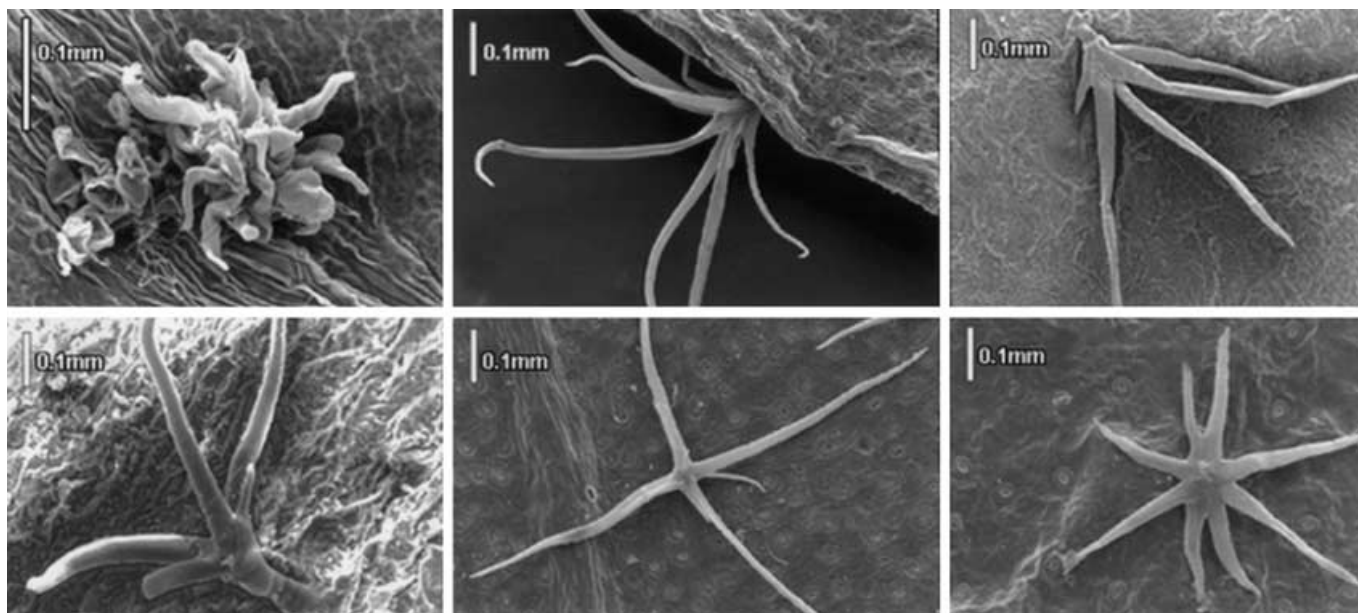


FIG. 3. Stellate trichomes. Top row (left to right): *Brassaiopsis hainla* ($\times 312$), *H. azorica* ($\times 156$), *H. helix* subsp. *helix* ($\times 156$). Bottom row (left to right): *H. helix* forma *poetarum* ($\times 156$), *H. helix* subsp. *rhizomatifera* ($\times 156$), *H. hibernica* ($\times 156$).

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- 5a. Trichome base >0.054mm long _____ **H. helix** forma **poetarum**
 5b. Trichome base <0.054mm long _____ **H. helix** subsp. **helix**
- 6a. Trichomes only on the abaxial surface of the leaf _____ **H. cypria**
 6b. Trichomes on both the abaxial and adaxial surfaces of the leaf _____ 7
- 7a. Trichomes small (0.1–0.2mm diam.), ray tips rounded instead of acute,
 rays short (~0.06mm), trichomes can appear semi-sunken in the leaf _____
 _____ **H. rhombea**
 7b. Trichomes not as above, larger and ray tips acute _____ 8
- 8a. Centre of trichome <0.05mm across _____ **H. canariensis** or **H. algeriensis**
 8b. Centre of trichome >0.05mm across _____ 9
- 9a. Centre of trichome very large (c.0.1mm diam.) and raised very high, rays up
 to 20 _____ **H. colchica**
 9b. Trichomes not as above _____ 10
- 10a. Trichomes small (overall length mostly <0.25mm) _____
 _____ **H. nepalensis**, **H. nepalensis** var. **sinensis**, or **H. pastuchovii**
 10b. Trichomes large (overall length >0.25mm) _____ 11
- 11a. Trichome centre generally not raised _____ **H. maroccana**
 11b. Trichomes centre raised _____ 12
- 12a. Trichomes large (overall length mostly >0.35mm), rays long (generally
 >0.13mm), centre <0.052mm across _____ **H. maderensis** subsp. **maderensis**
 12b. Trichomes smaller (overall length mostly <0.35mm), rays shorter (generally
 <0.13mm), centre to 0.094mm across _____ **H. maderensis** subsp. **iberica**

Species with similar trichomes are usually closely distributed geographically. For instance, the trichomes of four pairs of closely distributed taxa *H. colchica* and *H. pastuchovii*, *H. canariensis* and *H. algeriensis*, *H. nepalensis* and *H. nepalensis* var. *sinensis*, and *H. maderensis* subsp. *iberica* and *H. maderensis* subsp. *maderensis* are very similar and confirm their close relationship.

This study has shown the usefulness of trichome morphology in *Hedera* for delimiting taxa. Although there are taxa which cannot be determined solely using on trichome morphology, trichome characters can be a very useful tool in distinguishing between many of the currently recognized *Hedera* taxa.

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