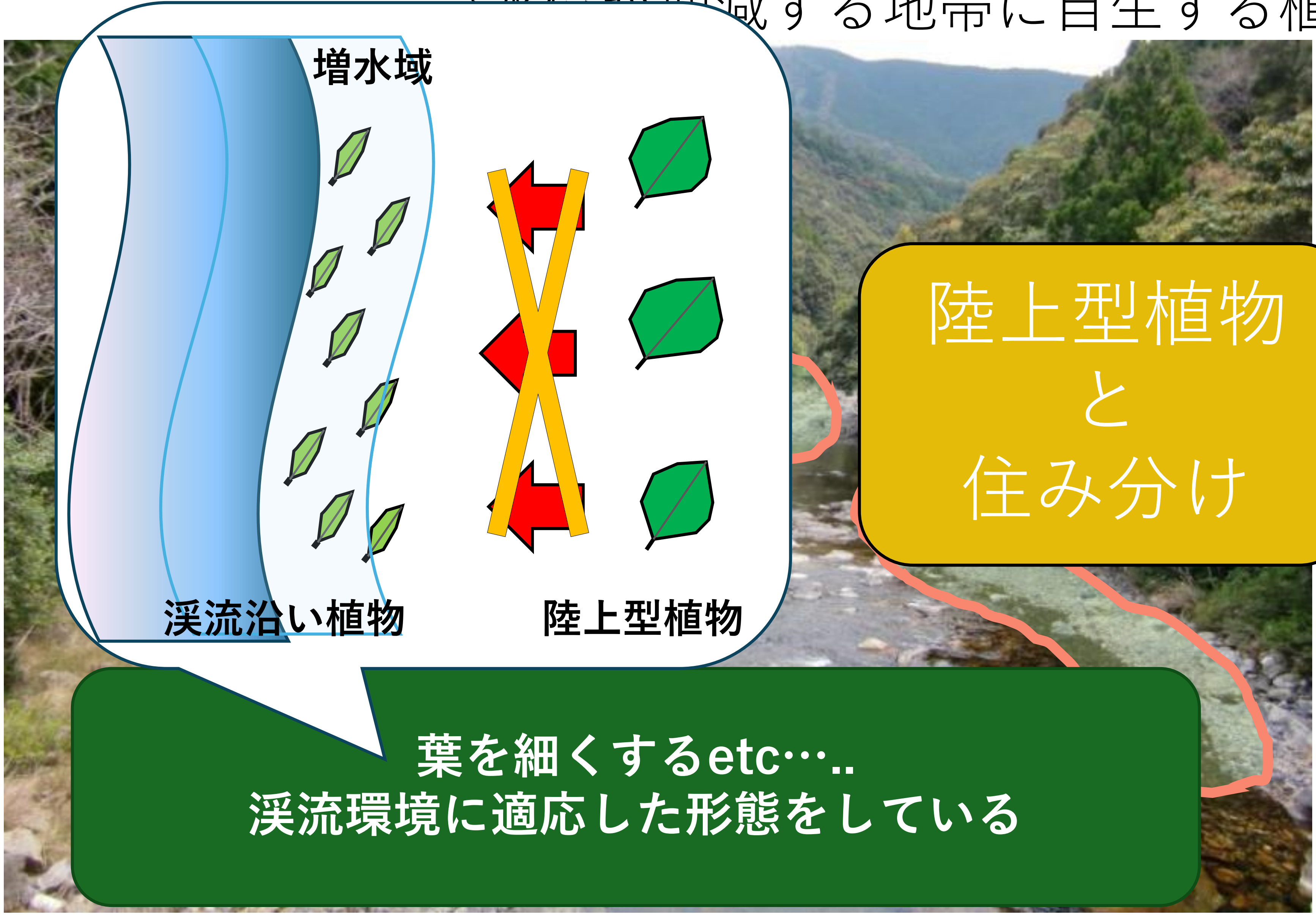
三好ジオパーク研究助成報告会

吉野川水系における渓流沿い植物群の形態学的解析

東京都市大学理工学部
自然科学科生物多様性研究室
福田達哉

渓流沿い植物とは

→水位が増減する地帯に自生する植物



陸上型植物
と
住み分け

葉を細くするetc…..
渓流環境に適応した形態をしている

背景～水流ストレス環境における葉身の適応例～

ツリガネニンジンの渓流種と内陸種

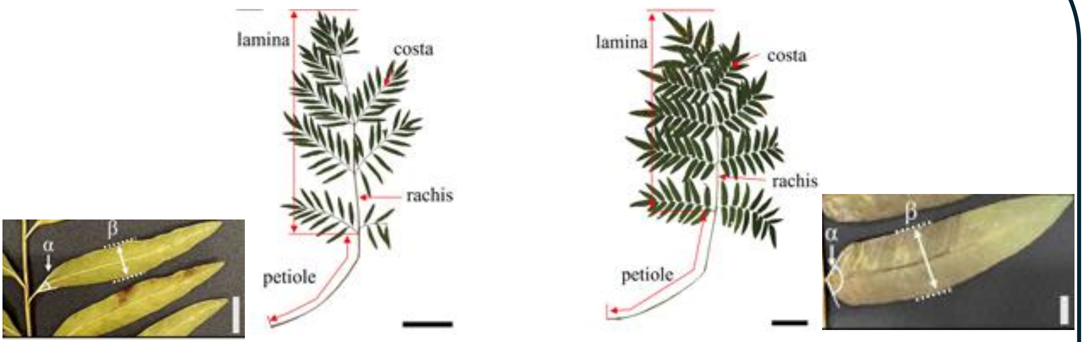
渓流型

内陸型

狭葉化

(Ohga et al., 2012)

ヤシャゼンマイとゼンマイ



bar=10mm　bar=10cm

ヤシャゼンマイ

ゼンマイ

狭葉化

(Imaichi and Kato, 1992)

ヒサカキの渓流型と内陸型

渓流型

bar=1cm

内陸型

小型化

(Shiba et al., 2021)

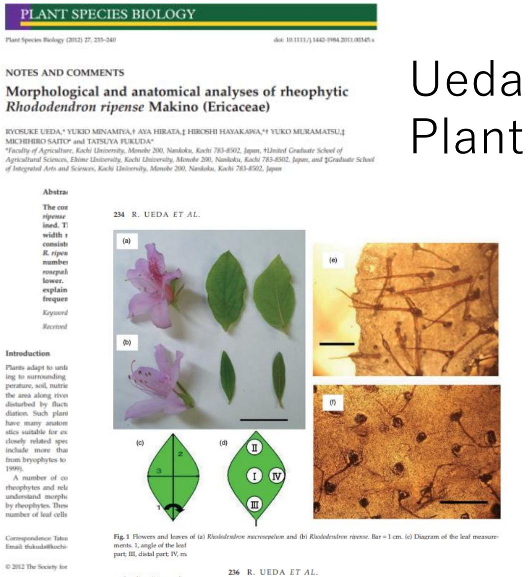
地上部全体が水流ストレスを受ける

↓

葉身と**支持器官**による適応を統合的に評価

実際に研究例は？

なぜ吉野川水系？



PLANT SPECIES BIOLOGY

Plant Species Biology (2012) 27, 233–240

doi: 10.1111/j.1442-1984.2011.00345.x

NOTES AND COMMENTS

Morphological and anatomical analyses of rheophytic *Rhododendron ripense* Makino (Ericaceae)

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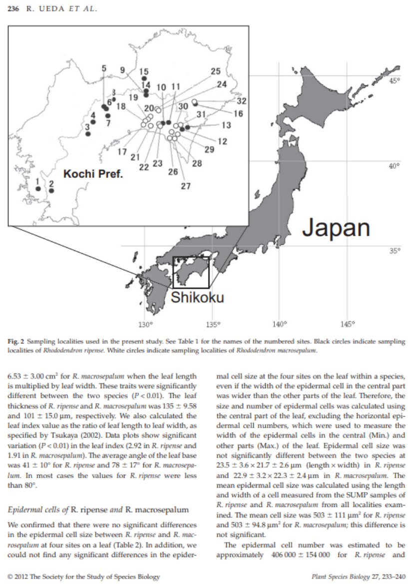
234 R. UEDA *ET AL.*



236 R. UEDA *ET AL.*

Ueda et al. (2012)
Plant Species Biology 27: 233-240

吉野川水系の
特徴的な植物を
多数報告

American Journal of Plant Sciences, 2012, 3, 805-809
http://dx.doi.org/10.4236/ajps.2012.36097 Published Online June 2012 (http://www.SciRP.org/journal/ajps)

Comparative Morphology and Anatomy of Non-Rheophytic and Rheophytic Types of *Adenophora triphylla* var. *japonica* (Campanulaceae)

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Received April 10th, 2012; revised April 30th, 2012; accepted May 18th, 2012

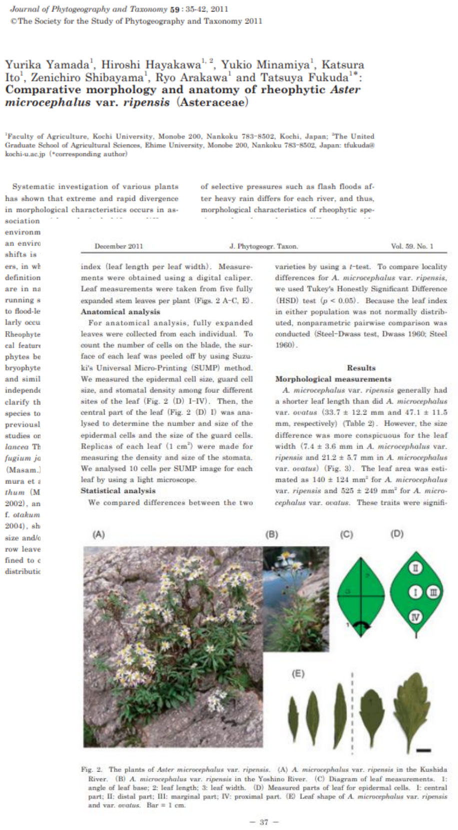
ABSTRACT

The morphology and anatomy of leaves of rheophytic and non-rheophytic types of *Adenophora triphylla* (Thunb.) ADC var. *japonica* (Regel) H. Hara were compared in order to clarify how leaf characteristics differ. Our results revealed that the leaf of the rheophytic type of *A. triphylla* var. *japonica* was narrower than the leaf of the non-rheophytic type because of fewer cells that were also smaller. Moreover, surprisingly, the rheophytic ecotype of *A. triphylla* var. *japonica* was thinner than that of the non-rheophytic type, although the general tendency is that the rheophytic leaf is thicker than the closely related non-rheophytic species, suggesting that the rheophytic type of *A. triphylla* var. *japonica* adapts differently, as compared to other rheophytic plants, to solar radiation and evaporation.

Keywords: Rheophyte; Leaf; Ecotype; *Adenophora triphylla* var. *japonica*

1. Introduction

Ohga et al. (2012)
American Journal of Plant Sciences 3: 805-809



Journal of Phytogeography and Taxonomy **59** : 35-42, 2011
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Yurika Yamada[1], Hiroshi Hayakawa[1, 2], Yukio Minamiya[1], Katsura Ito[1], Zenichiro Shibayama[1], Ryo Arakawa[1] and Tatsuya Fukuda[1*]: **Comparative morphology and anatomy of rheophytic *Aster microcephalus* var. *ripensis* (Asteraceae)**

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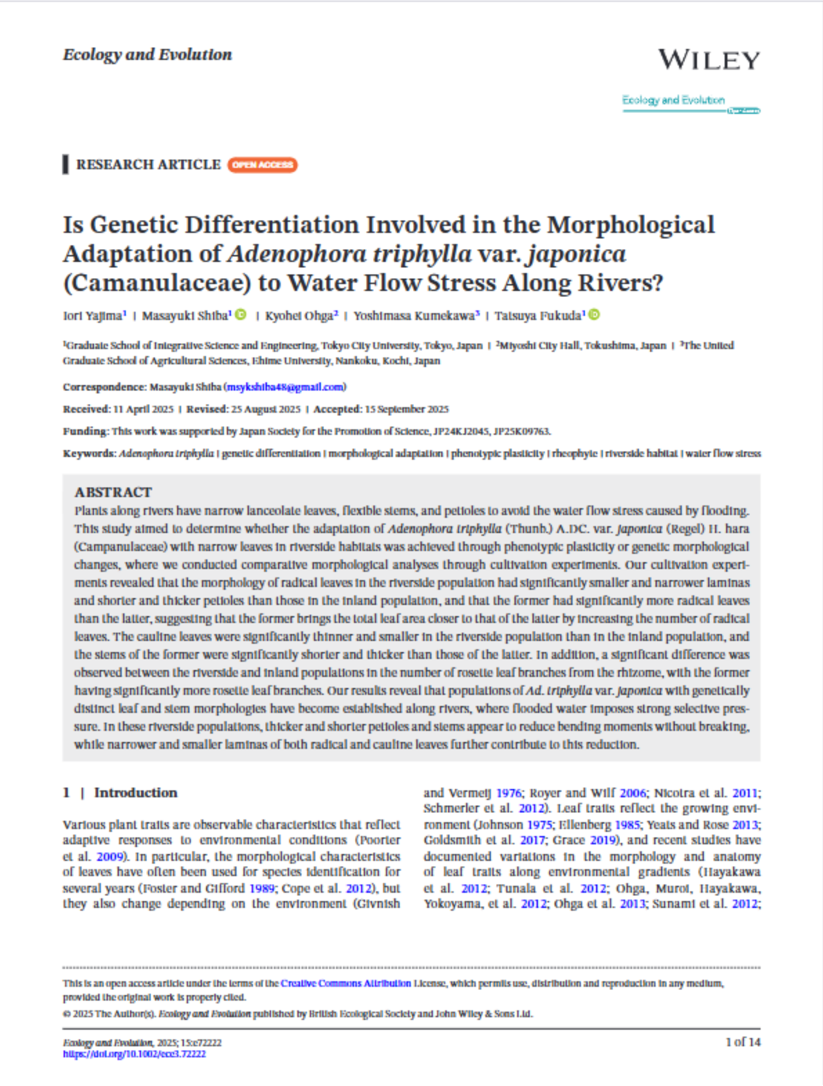
Systematic investigation of various plants has shown that extreme and rapid divergence in morphological characteristics occurs in as- … of selective pressures such as flash floods after heavy rain differs for each river, and thus, morphological characteristics of rheophytic spe-

December 2011 J. Phytogeogr. Taxon. Vol. 59, No. 1

Yamada et al. (2011)
Journal of Phytogeography and Taxonomy 59: 35-42

吉野川水系の植物の面白さ



Ecology and Evolution

WILEY

RESEARCH ARTICLE OPEN ACCESS

Is Genetic Differentiation Involved in the Morphological Adaptation of *Adenophora triphylla* var. *japonica* (Camanulaceae) to Water Flow Stress Along Rivers?

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Keywords: *Adenophora triphylla* | genetic differentiation | morphological adaptation | phenotypic plasticity | rheophyte | riverside habitat | water flow stress

ABSTRACT

Plants along rivers have narrow lanceolate leaves, flexible stems, and petioles to avoid the water flow stress caused by flooding. This study aimed to determine whether the adaptation of *Adenophora triphylla* (Thunb.) A.DC. var. *japonica* (Regel) H. hara (Campanulaceae) with narrow leaves in riverside habitats was achieved through phenotypic plasticity or genetic morphological changes, where we conducted comparative morphological analyses through cultivation experiments. Our cultivation experiments revealed that the morphology of radical leaves in the riverside population had significantly smaller and narrower laminas and shorter and thicker petioles than those in the inland population, and that the former had significantly more radical leaves than the latter, suggesting that the former brings the total leaf area closer to that of the latter by increasing the number of radical leaves. The cauline leaves were significantly thinner and smaller in the riverside population than in the inland population, and the stems of the former were significantly shorter and thicker than those of the latter. In addition, a significant difference was observed between the riverside and inland populations in the number of rosette leaf branches from the rhizome, with the former having significantly more rosette leaf branches. Our results reveal that populations of *Ad. triphylla* var. *japonica* with genetically distinct leaf and stem morphologies have become established along rivers, where flooded water imposes strong selective pressure. In these riverside populations, thicker and shorter petioles and stems appear to reduce bending moments without breaking, while narrower and smaller laminas of both radical and cauline leaves further contribute to this reduction.

1 | Introduction

Various plant traits are observable characteristics that reflect adaptive responses to environmental conditions (Poorter et al. 2009). In particular, the morphological characteristics of leaves have often been used for species identification for several years (Foster and Gifford 1989; Cope et al. 2012), but they also change depending on the environment (Givnish and Vermeij 1976; Royer and Wilf 2006; Nicotra et al. 2011; Schmerler et al. 2012). Leaf traits reflect the growing environment (Johnson 1975; Ellenberg 1985; Yeats and Rose 2013; Goldsmith et al. 2017; Grace 2019), and recent studies have documented variations in the morphology and anatomy of leaf traits along environmental gradients (Hayakawa et al. 2012; Tunala et al. 2012; Ohga, Muroi, Hayakawa, Yokoyama, et al. 2012; Ohga et al. 2013; Sunami et al. 2012;

FIGURE 1 | *Adenophora triphylla* var. *japonica*. Cultivation of (A) riverside and (B) inland. Wild of (C) riverside and (D) inland. Scale bar = 10 cm.

and the racemes form at the apex of the stem. The pale purple to white, 1.5–2 cm long, bell-shaped flowers grow in whorls slightly downwards, with fused sepals that are five-lobed, and the sepal lobes are linear and 3–5 mm long (Okazaki 1993). Yamanaka and Takezaki (1959) reported that populations with narrow lanceolate leaves of *Ad. triphylla* var. *japonica* are found along several rivers in Japan. Ohga, Muroi, Hayakawa, Ito, et al. (2012) reported that the riverside population of *Ad. triphylla* var. *japonica* adapts to riverside environments as a rheophytic ecotype by forming narrow lanceolate leaves and decreasing both the size and number of leaf cells. The question then arises as to whether the narrow lanceolate leaves of the riverside populations of *Ad. triphylla* var. *japonica* are phenotypic plasticity, influenced by water flow stress during leaf growth, or whether this group has genetically narrow lanceolate leaves. Therefore, this study aimed to clarify the adaptive morphological characteristics of *Ad. triphylla* var. *japonica* associated with riverside adaptation, using wild population data from Ohga, Muroi, Hayakawa, Ito, et al. (2012) and cultivated populations from this study.

2 | Materials and Methods

2.1 | Seed Collection and Cultivation Conditions

The seeds of the rheophytic ecotype of *Adenophora triphylla* var. *japonica* used in this study were collected from a population along the Yoshino River in Motoyama, Motoyama-cho, Nagaoka-gun, Kochi Prefecture (33°76′N, 133°60′ E), the same site as the population used by Ohga, Muroi, Hayakawa, Ito, et al. (2012). The seeds of the inland population were collected from a population in Shitoridoi, Minamiawaji City, Hyogo Prefecture (34°20′N, 134°48′ E).

On April 6, 2023, a cultivation experiment was conducted at Tokyo City University. Seeds from both groups were sown in vertically oriented pots with a capacity of 1,600 mL filled with black soil. The study was conducted until the second year, when stem and cauline leaf formation occurred. The total number of samples used in this study was 35 individuals from the riverside population and 92 individuals from the inland population.

2.2 | Morphological Measurements

Morphological measurements were conducted in September 2024. Radical and cauline leaves were photographed using a digital camera (Tough TG-6; OM Digital Solutions Corporation, Tokyo, Japan). Lamina length (mm), lamina width (mm), angle at lamina base (°), and lamina area (mm^2) were analyzed using the image analysis software ImageJ. The leaf index was calculated as the ratio of lamina length to lamina width. Petiole length (mm) was measured three times using a 15 cm ruler (model 14,001; Shinwa Rules Co. Ltd., Niigata, Japan), and the average value was calculated. The basal diameter of the petiole (mm) was measured three times using a digital caliper (CD-15APX; Mitutoyo Corporation, Kanagawa, Japan), and the average value was calculated. The number of leaves per individual was also counted. Stem length (cm) was measured using a 60 cm ruler (model 14,036; Shinwa Rules Co. Ltd., Niigata, Japan). The basal stem diameter (mm) was measured using a digital caliper (CD-15APX; Mitutoyo Corporation, Kanagawa, Japan). In addition, the number of rosette-leaf branches per individual was also counted.

To determine whether the morphological phenotypes of cauline leaves and stems are genetically fixed, a comparison was made with the values from the field populations of Ohga, Muroi, Hayakawa, et al. (2012).

2.3 | Statistical Analysis

Statistical comparisons between two samples were conducted using Microsoft Excel. An F-test was first used to assess the homogeneity of variances between the two samples. Based on the results of the *F*-test, a *t*-test was performed under the assumption of either equal or unequal variances. Relationships between two continuous variables were analyzed using the statistical software R. The coefficient of determination (R^2) and the regression equation were calculated, followed by regression analysis. To evaluate the applicability of ANCOVA between two groups, the normality of the data was tested.

3 | Results

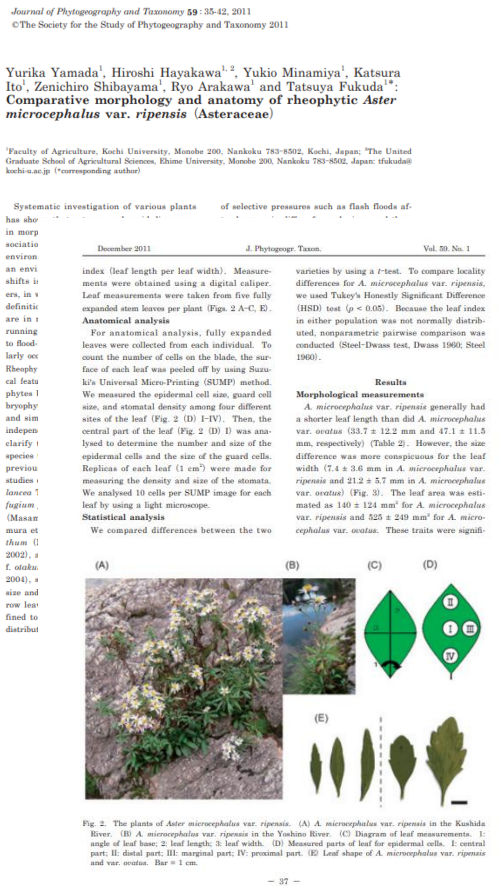
In the relationship between the two variables, a natural logarithmic transformation was applied to improve normality. After

吉野川

吉野川水系の遺伝的に
変化した植物を報告

Yajima et al. (2025)
Ecology and Evolution 15: e72222

河川ごとに変わる葉の形態



Journal of Phytogeography and Taxonomy **59** : 35-42, 2011
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Yurika Yamada[1], Hiroshi Hayakawa[1, 2], Yukio Minamiya[1], Katsura Ito[1], Zenichiro Shibayama[1], Ryo Arakawa[1] and Tatsuya Fukuda[1*]: **Comparative morphology and anatomy of rheophytic *Aster microcephalus* var. *ripensis* (Asteraceae)**

[1]Faculty of Agriculture, Kochi University, Monobe 200, Nankoku 783-8502, Kochi, Japan; [2]The United Graduate School of Agricultural Sciences, Ehime University, Monobe 200, Nankoku 783-8502, Japan: tfukuda@kochi-u.ac.jp (*corresponding author)

Systematic investigation of various plants

of selective pressures such as flash floods af-

December 2011 J. Phytogeogr. Taxon. Vol. 59. No. 1

index (leaf length per leaf width). Measurements were obtained using a digital caliper. Leaf measurements were taken from five fully expanded stem leaves per plant (Figs. 2 A-C, E).

Anatomical analysis

For anatomical analysis, fully expanded leaves were collected from each individual. To count the number of cells on the blade, the surface of each leaf was peeled off by using Suzuki's Universal Micro-Printing (SUMP) method. We measured the epidermal cell size, guard cell size, and stomatal density among four different sites of the leaf (Fig. 2 (D) I-IV). Then, the central part of the leaf (Fig. 2 (D) I) was analysed to determine the number and size of the epidermal cells and the size of the guard cells. Replicas of each leaf (1 cm^2) were made for measuring the density and size of the stomata. We analysed 10 cells per SUMP image for each leaf by using a light microscope.

Statistical analysis

We compared differences between the two varieties by using a t-test. To compare locality differences for *A. microcephalus* var. *ripensis*, we used Tukey's Honestly Significant Difference (HSD) test ($p < 0.05$). Because the leaf index in either population was not normally distributed, nonparametric pairwise comparison was conducted (Steel-Dwass test, Dwass 1960; Steel 1960).

Results

Morphological measurements

A. microcephalus var. *ripensis* generally had a shorter leaf length than did *A. microcephalus* var. *ovatus* (33.7 ± 12.2 mm and 47.1 ± 11.5 mm, respectively) (Table 2). However, the size difference was more conspicuous for the leaf width (7.4 ± 3.6 mm in *A. microcephalus* var. *ripensis* and 21.2 ± 5.7 mm in *A. microcephalus* var. *ovatus*) (Fig. 3). The leaf area was estimated as 140 ± 124 mm^2 for *A. microcephalus* var. *ripensis* and 525 ± 249 mm^2 for *A. microcephalus* var. *ovatus*. These traits were signifi-

Fig. 2. The plants of *Aster microcephalus* var. *ripensis*. (A) *A. microcephalus* var. *ripensis* in the Kushida River. (B) *A. microcephalus* var. *ripensis* in the Yoshino River. (C) Diagram of leaf measurements. 1: angle of leaf base; 2: leaf length; 3: leaf width. (D) Measured parts of leaf for epidermal cells. I: central part; II: distal part; III: marginal part; IV: proximal part. (E) Leaf shape of *A. microcephalus* var. *ripensis* and var. *ovatus*. Bar = 1 cm.

– 37 –

増水頻度や、増水の際の水流と関連
→水流ストレスが強いほど葉が細くなる
↓
吉野川水系で葉の形が変わるのではないか？

吉野川水系の植物の面白さ

葉の細さ＝葉形指数＝葉の長さ/葉の細さ

葉形指数が大きいほど細い

Yamada et al. (2011)
Journal of Phytogeography and Taxonomy 59: 35-42

背景～水流ストレス環境における支持器官適応例～

(Shiba and Fukuda, 2024; 2025)

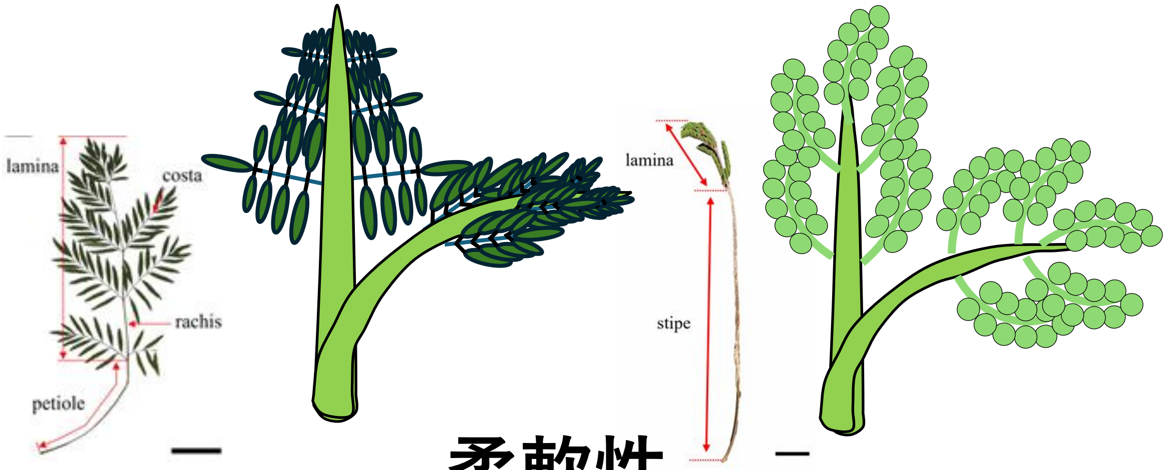
雑種を形成するほど近縁

(Yatabe et al., 1999；Kato, 2007)

渓流沿い

ヤシャゼンマイ(*Osmunda lancea*)

葉柄(栄養葉)　　**花茎(胞子葉)**



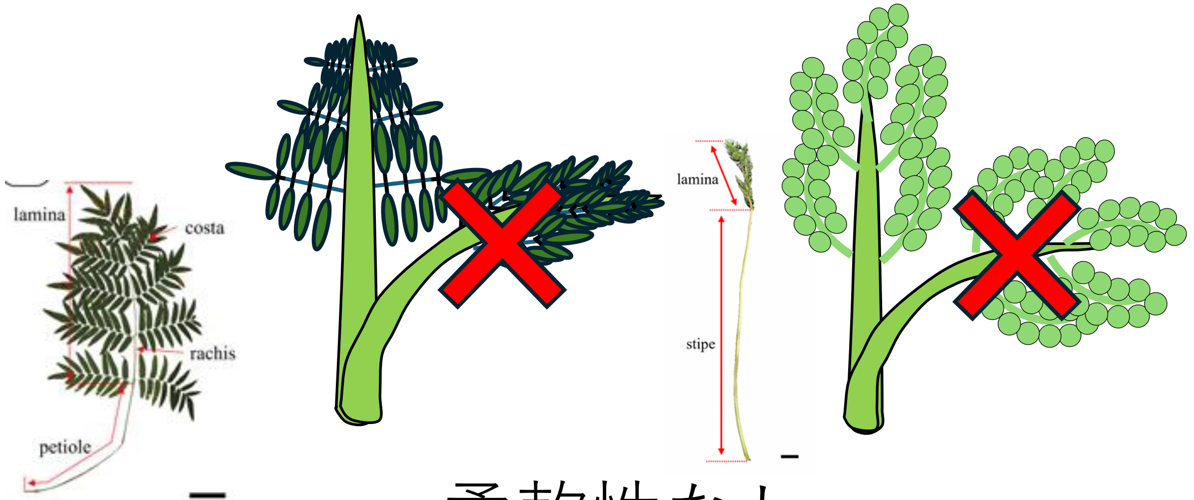
柔軟性

bar=5cm

陸

ゼンマイ(*O. japonica*)

葉柄(栄養葉)　　**花茎(胞子葉)**



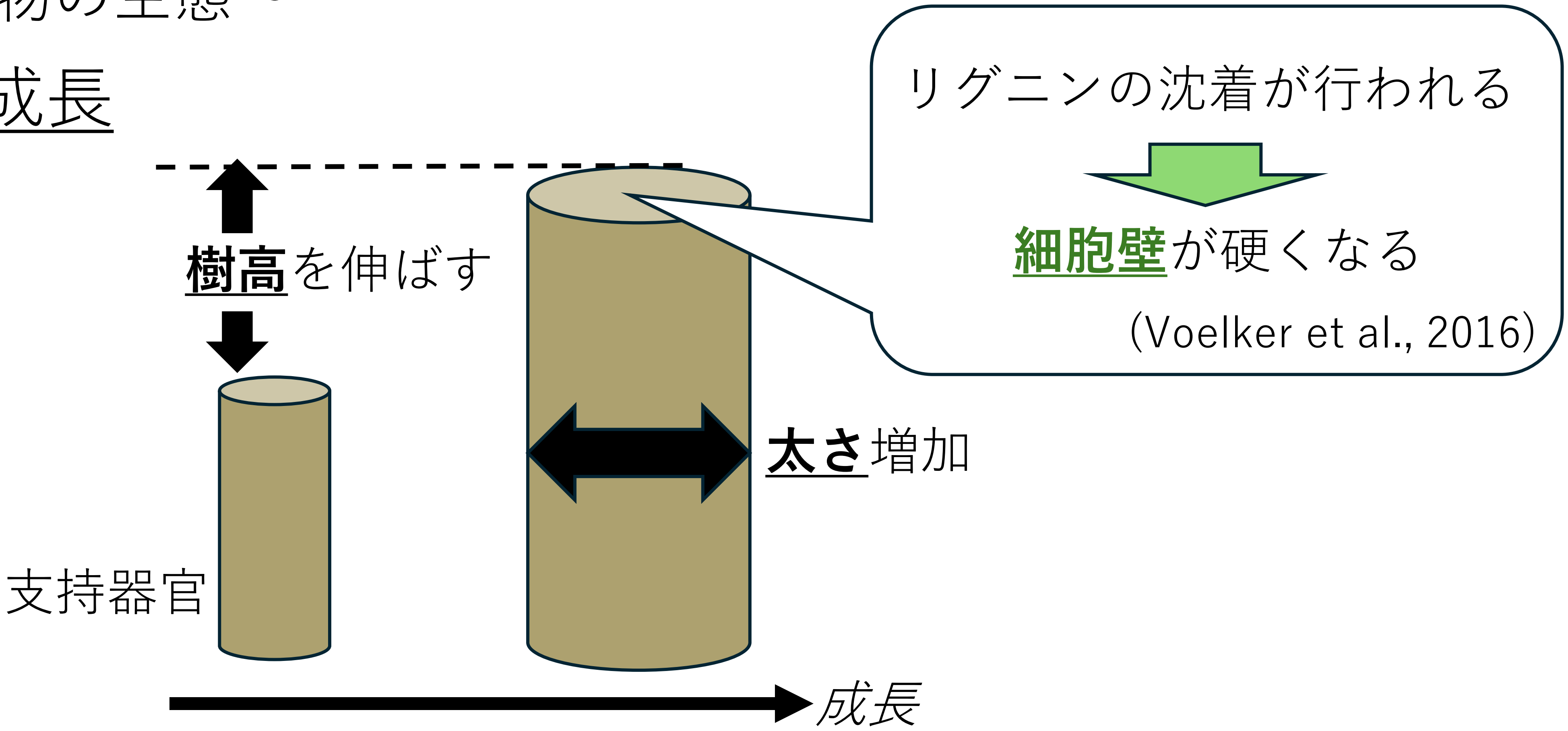
柔軟性なし

支持器官で柔軟性を獲得して地上部全体でストレス低減

木本植物にもあてはまる？

背景～木本植物の生態～

- <u>木本植物の成長</u>



成長とともに**太さ**を増加、**樹高**を伸ばす

(Franceschini et al., 2016)

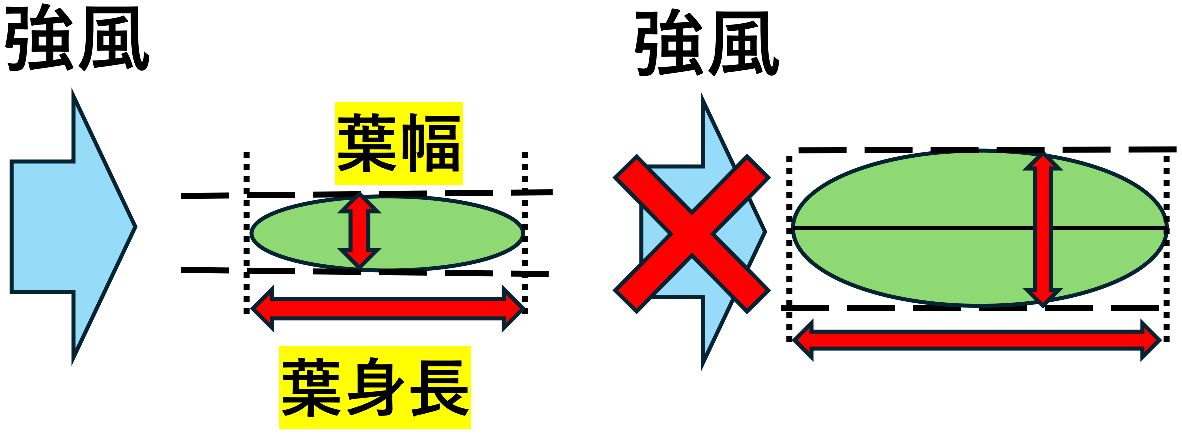
強度に特化するように成長

背景～木本植物の強風ストレス環境における適応～

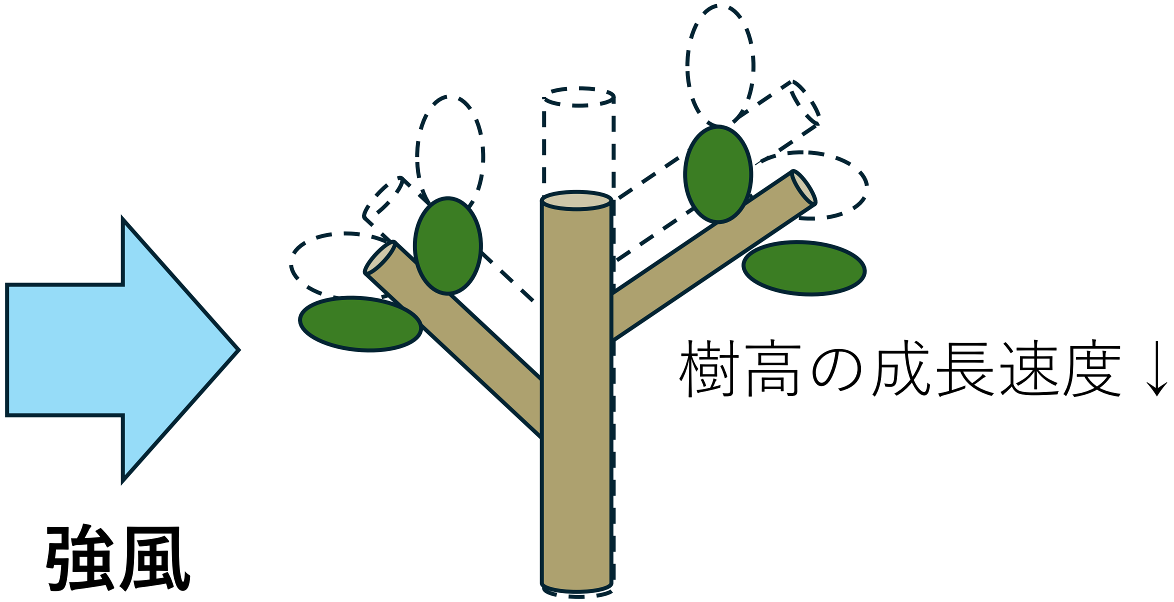
(Wu et al., 2016)

- 強風ストレス環境（海岸地）

８種のナラ属(*Quercus*)



葉身：小型化



支持器官：太く強固

樹高を維持しながら太く強固にする**強風耐性**

水流ストレス環境下ではどう考えられる？

背景 ～木本植物の水流ストレス環境における適応～

- 増水による水流ストレス環境（渓流沿い）

ヒサカキの**渓流型**と**内陸型**

渓流型

bar=1cm

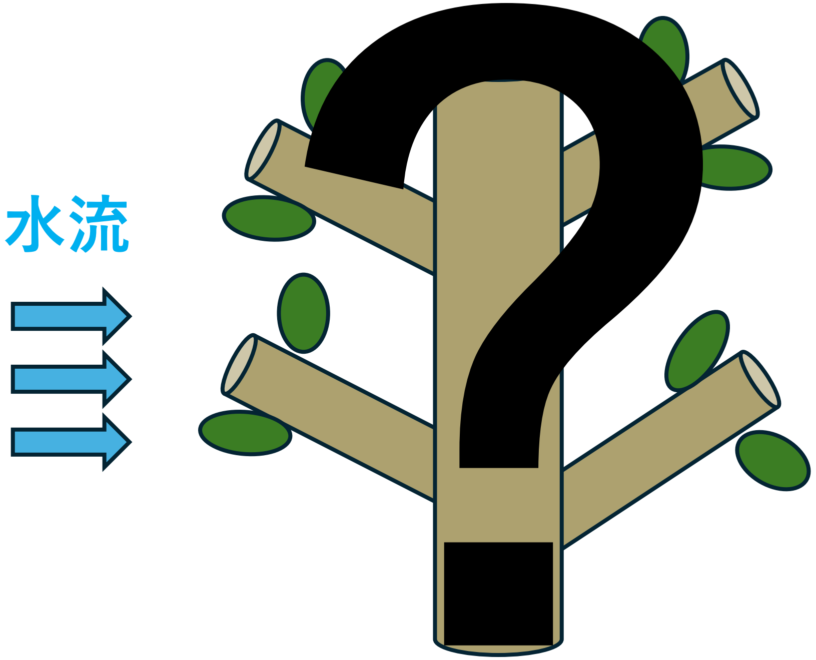
内陸型

小型化

(Shiba et al., 2021)

葉身における適応

支持器官



仮説：渓流沿いでも強固にしている？
（耐性）

今回どのような植物を用いて行うべき？

背景～水流ストレス環境における葉身の狭葉化例(木本植物)～

ヒサカキの渓流型と内陸型

渓流型

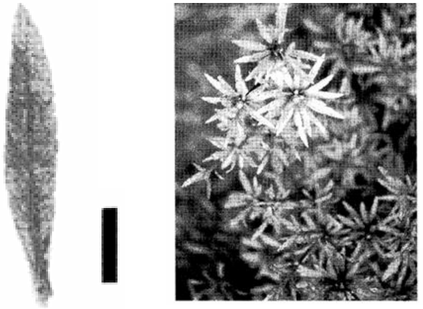
内陸型

bar=1cm

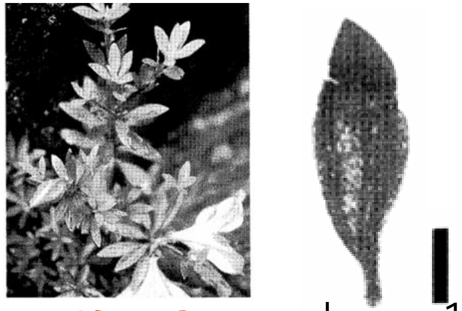
小型化

(Shiba et al., 2021)

オタクミツツジとサツキ



オタクミツツジ



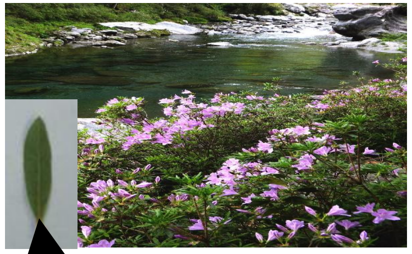
サツキ

bar＝1cm

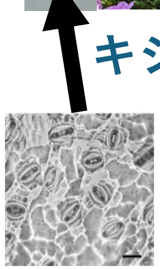
狭葉化

(Setoguchi and Kajimaru, 2004)

キシツツジとモチツツジ



キシツツジ



気孔数の増加

モチツツジ

bar＝1cm

狭葉化

(Ueda et al., 2012)

雑種を形成するほど近縁

(Yokoyama et al., 2012)

葉身における適応が明らか

＋

近縁種間での比較

研究材料

渓流

キシツツジ　(*Rhododendron ripense*)

・中国、四国、九州の一部（大分県）の**河川**の上・中流域に分布

雄しべ１０本以上

内陸

モチツツジ (*R.macrosepalum*)

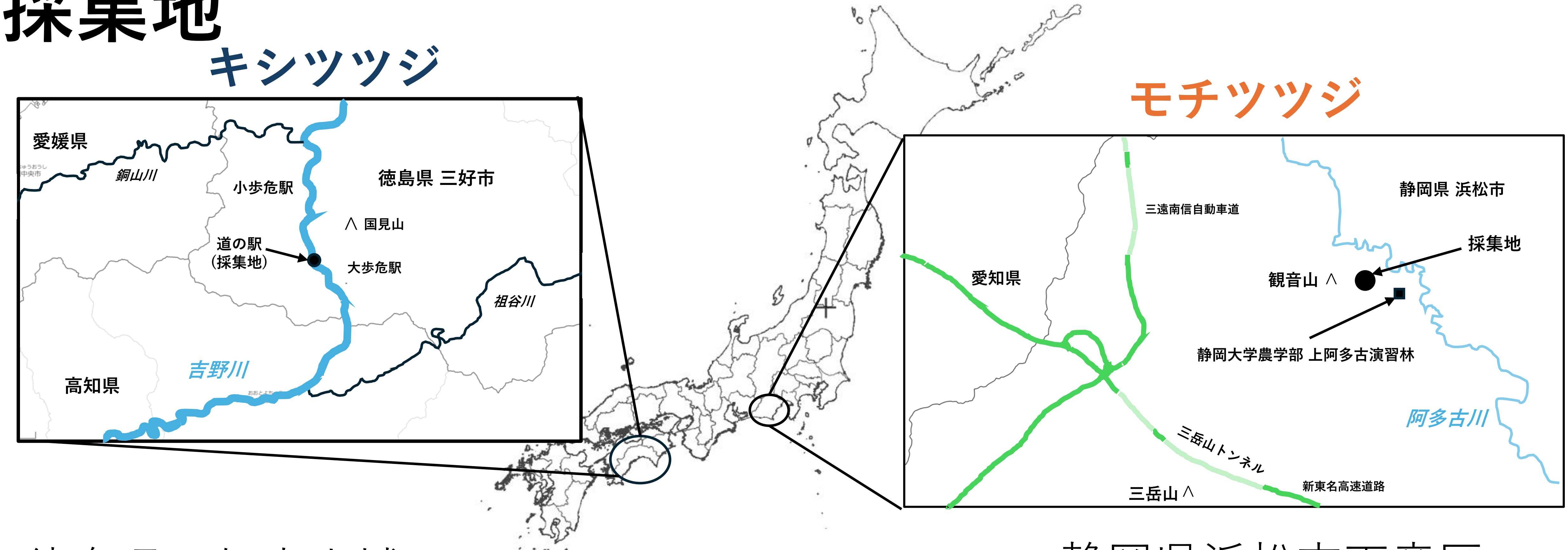
・本州（静岡県・山梨県～岡山県）と四国の**内陸**に分布

雄しべ 5本

目的

吉野川水系のキシツツジを用いて
支持器官の水流ストレス適応メカニズムを明らかにする

採集地



キシツツジ

徳島県三好市山城町

33°52′51.6N 133°45′38.2E

109本の枝(支持器官)を採集

モチツツジ

静岡県浜松市天竜区

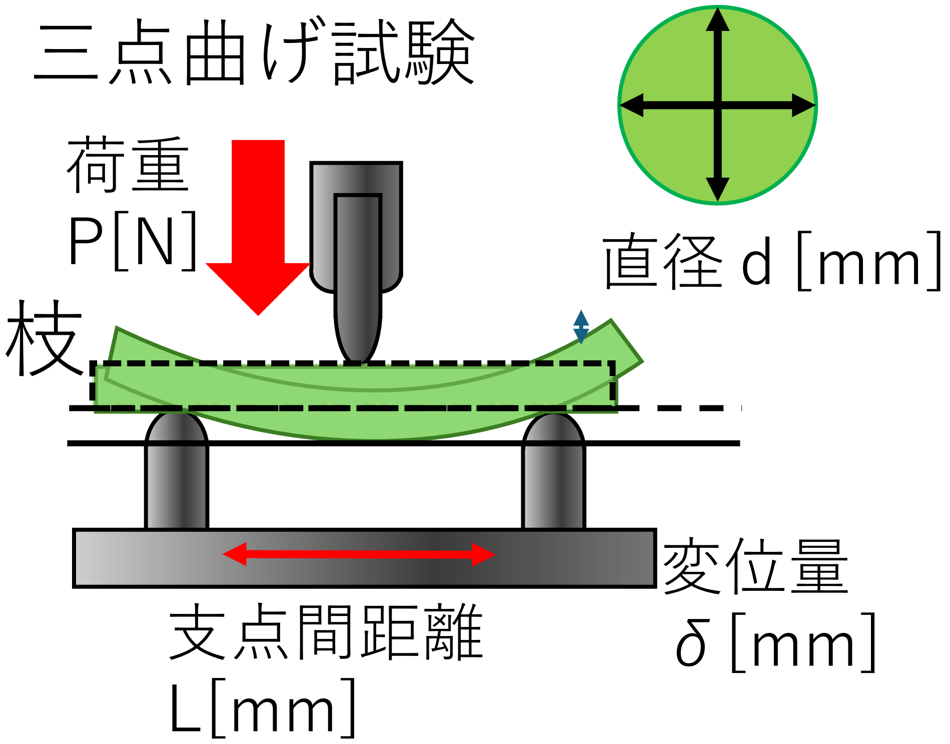
34°54′22.2N 137°44′39.7E

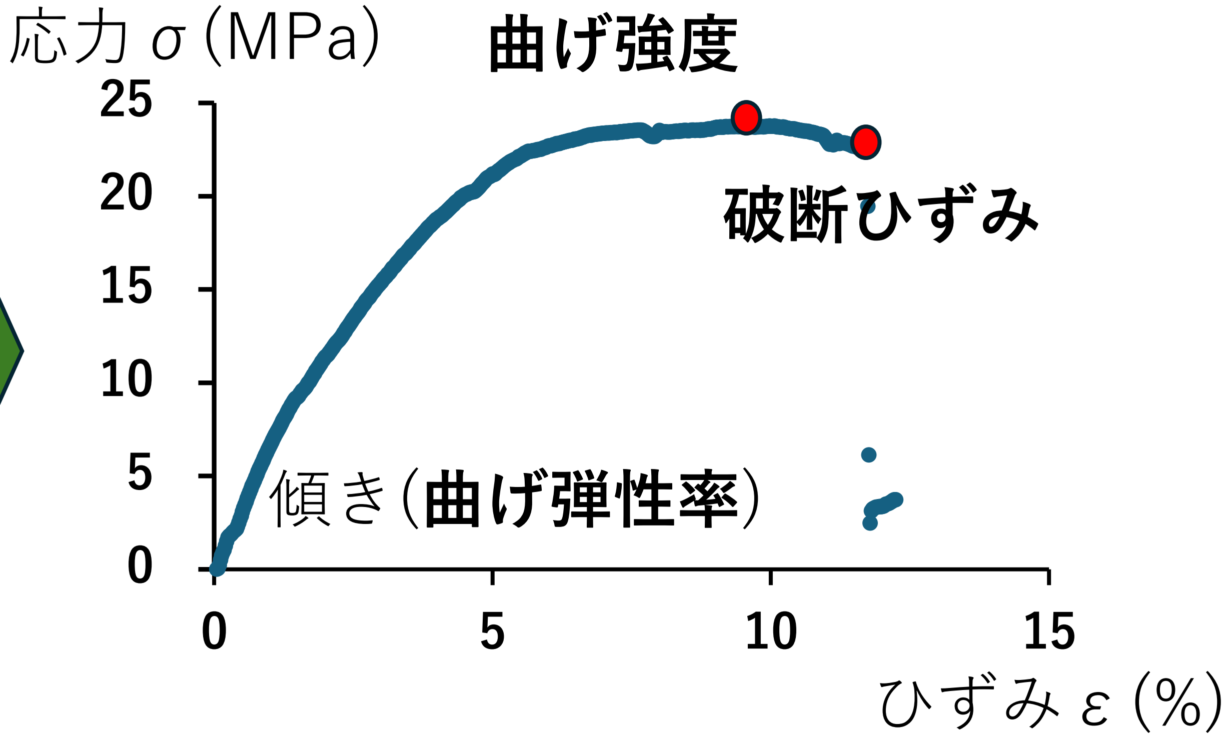
80本の枝(支持器官)を採集

方法 ～力学的解析～

応力ひずみ曲線

- 三点曲げ試験





- **条件**

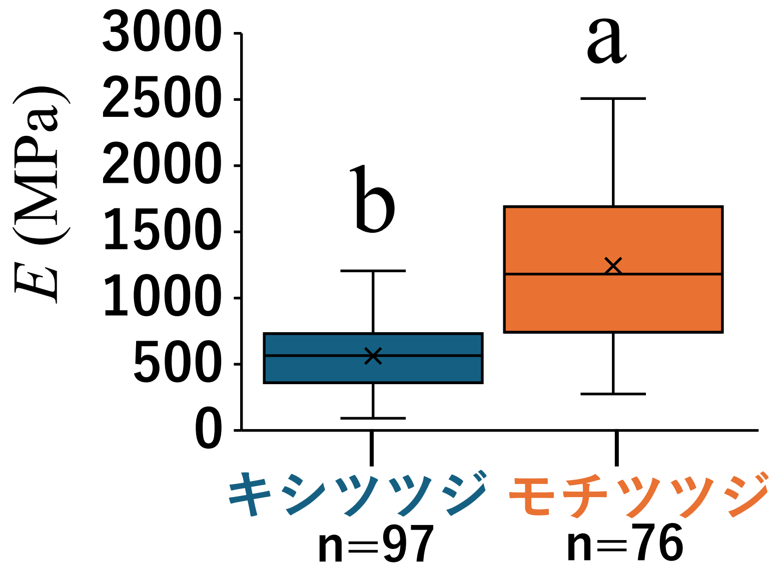
$$\frac{L^3}{I} = 20000$$

$\frac{L^3}{I}$ …太さに対してどれくらい長い距離で曲げているか

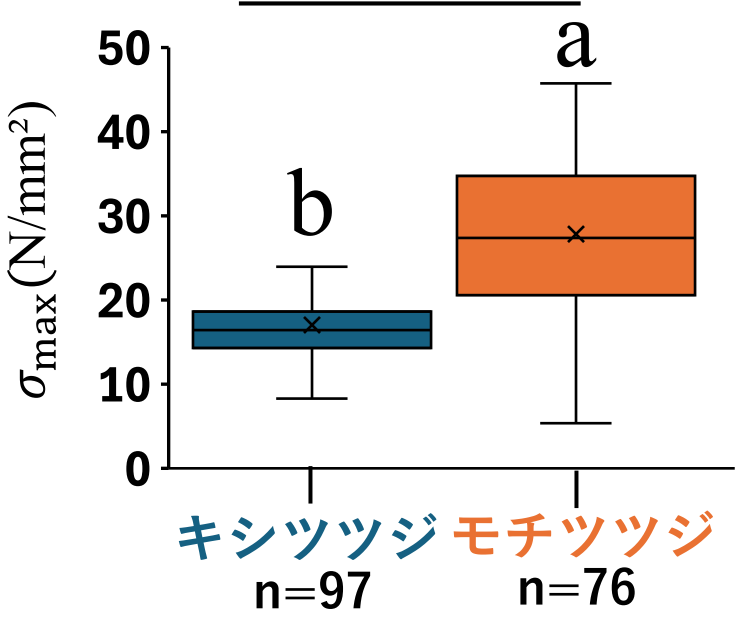
$I = \frac{\pi d^4}{64}$ …どれだけ曲がりにくい形状か
（断面二次モーメント）

結果～力学的解析～

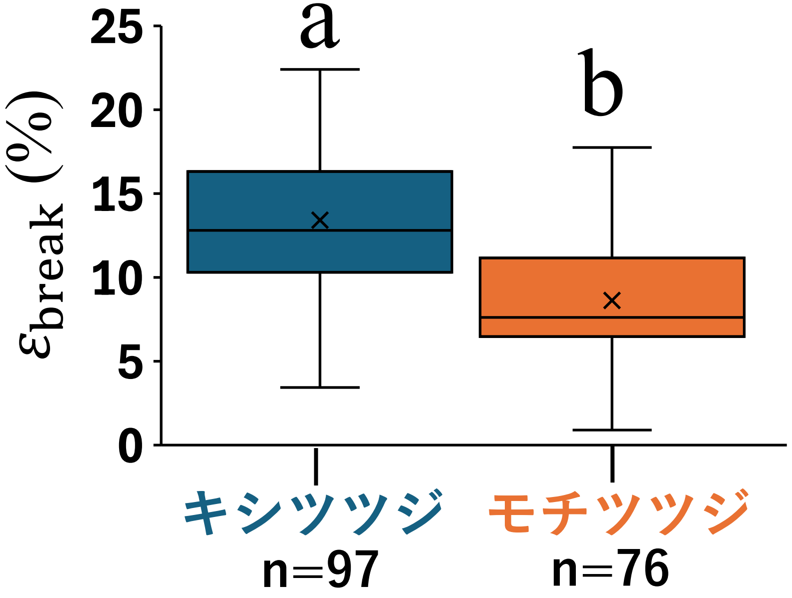
(p<0.05)



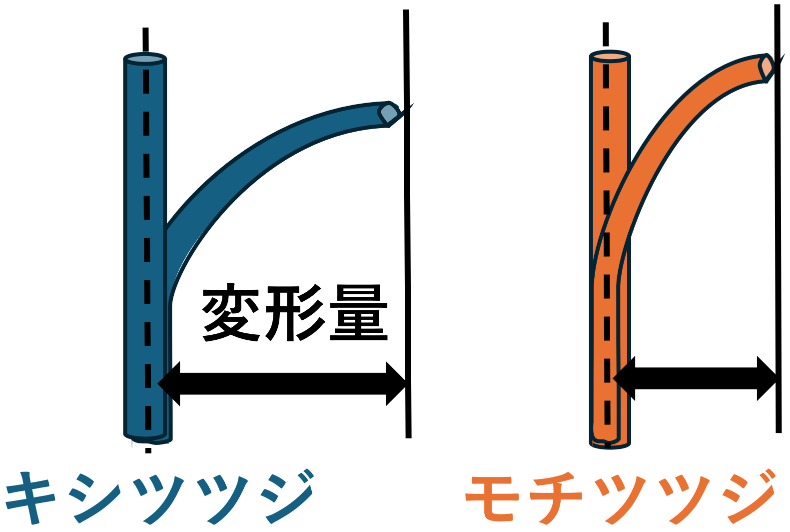
曲げ弾性率



曲げ強度



破断ひずみ



・小さな力で変形

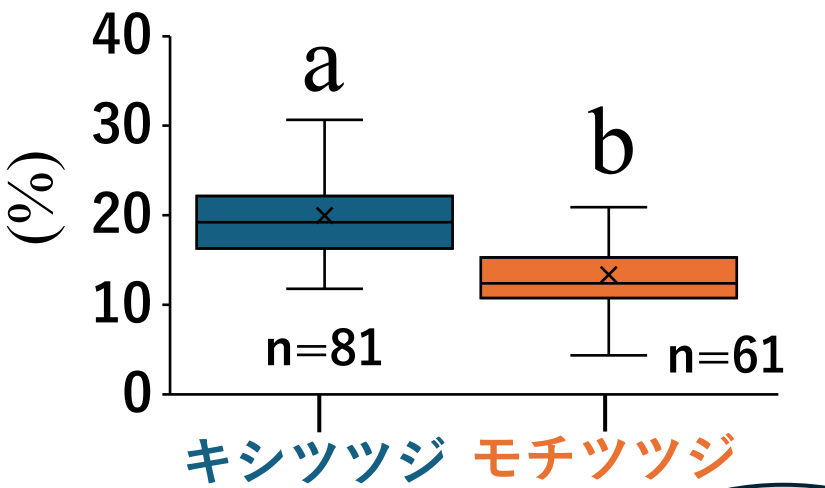
・受けられる力は小さい

・外力に対して柔軟な変形

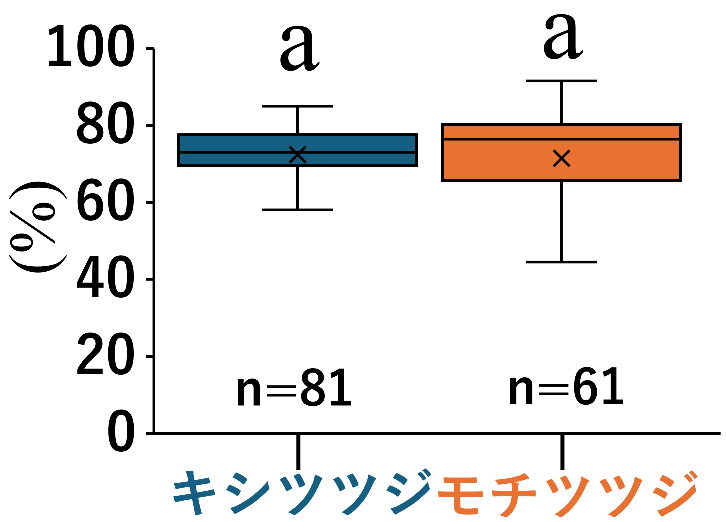
結果 ～解剖学的解析結果～

（p<0.05）

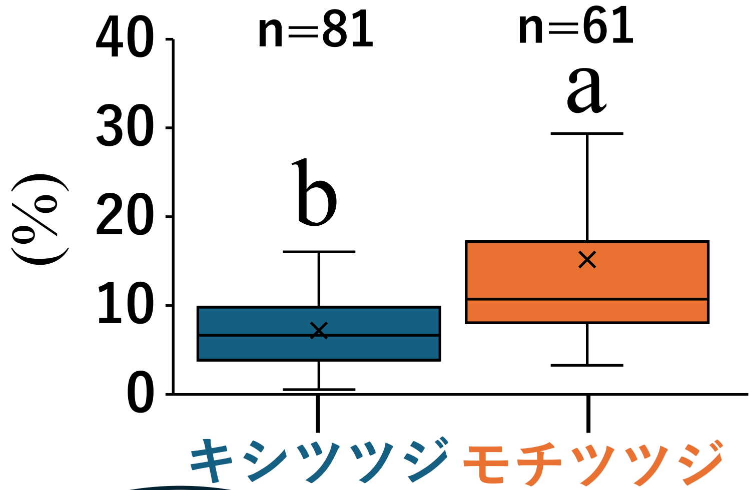
皮層面積率

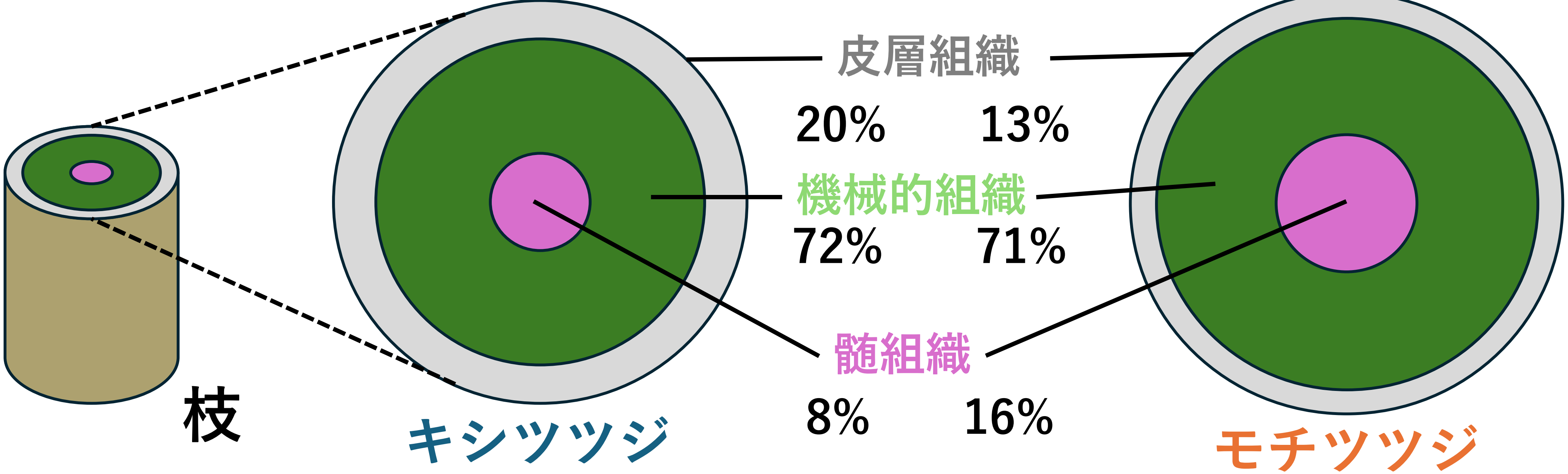


機械的組織面積率



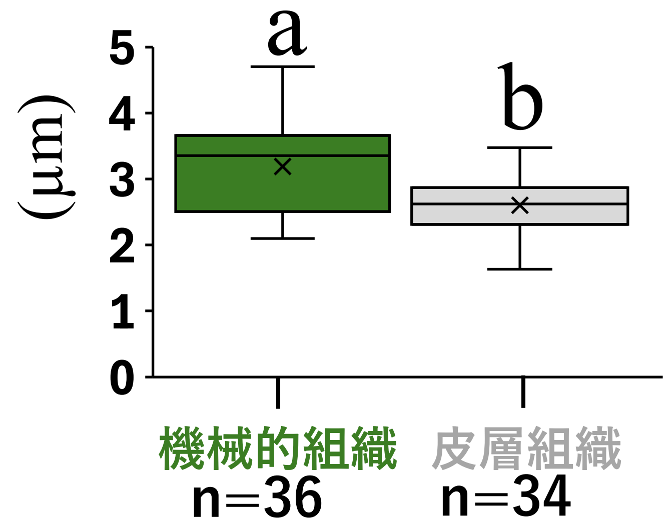
髄組織面積率



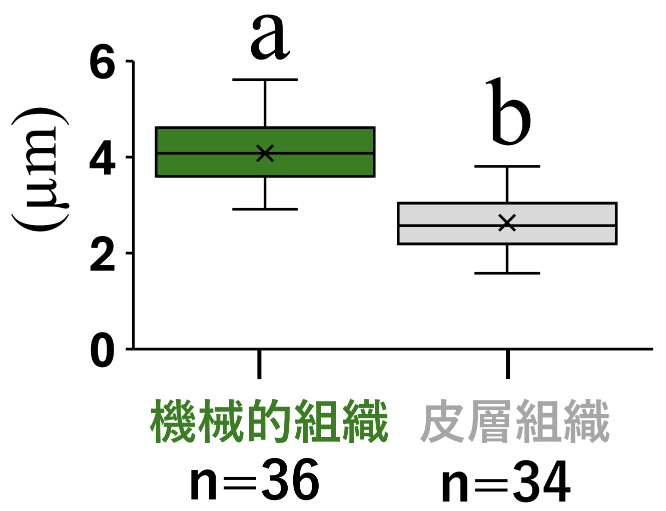


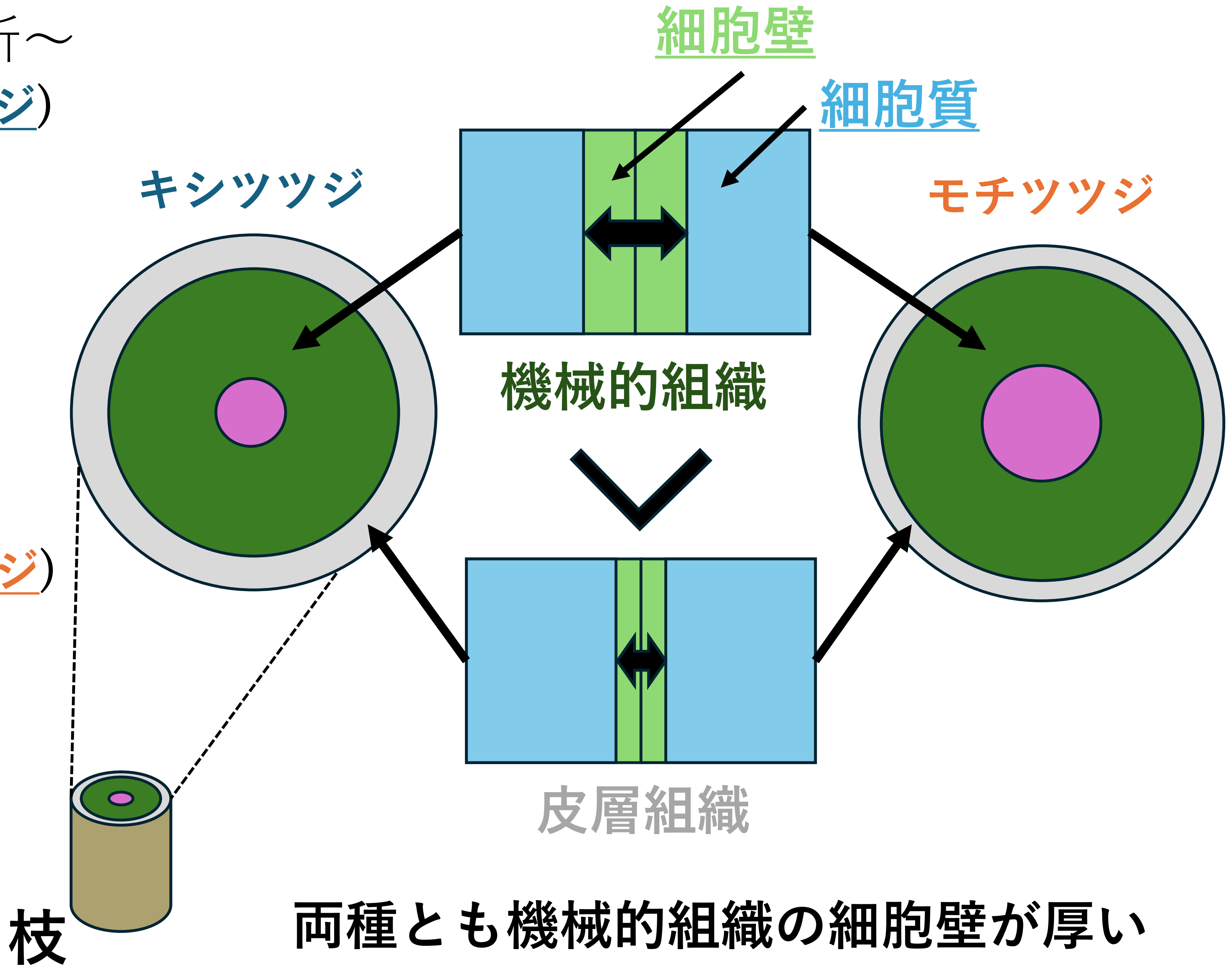
結果～解剖学的解析～

二細胞壁間距離(キシツツジ)



二細胞壁間距離(モチツツジ)

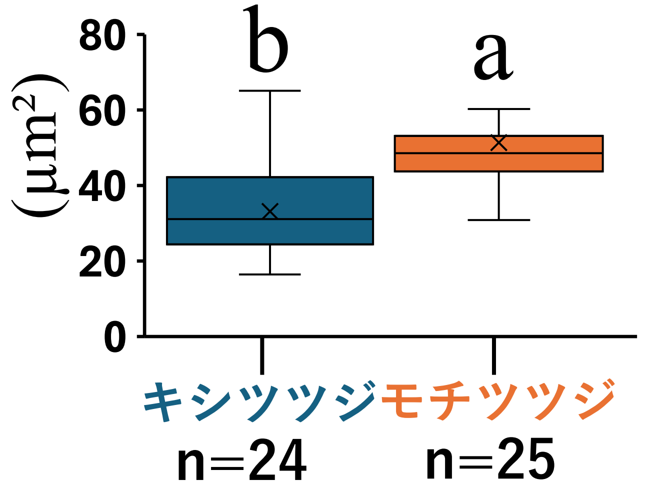




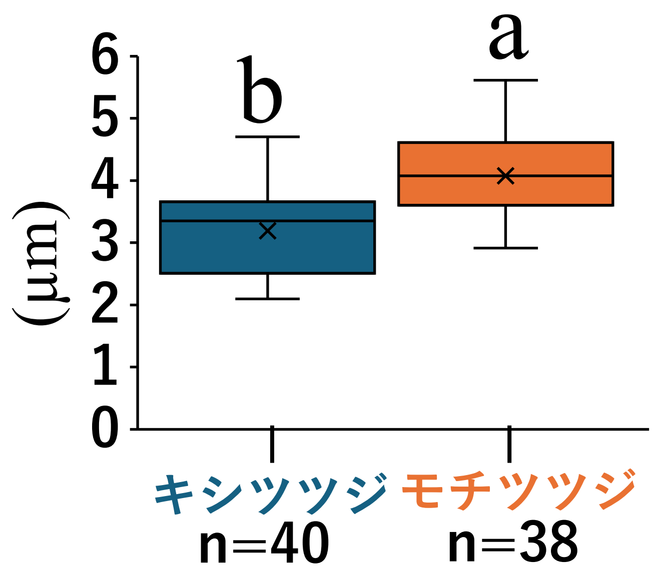
両種とも機械的組織の細胞壁が厚い

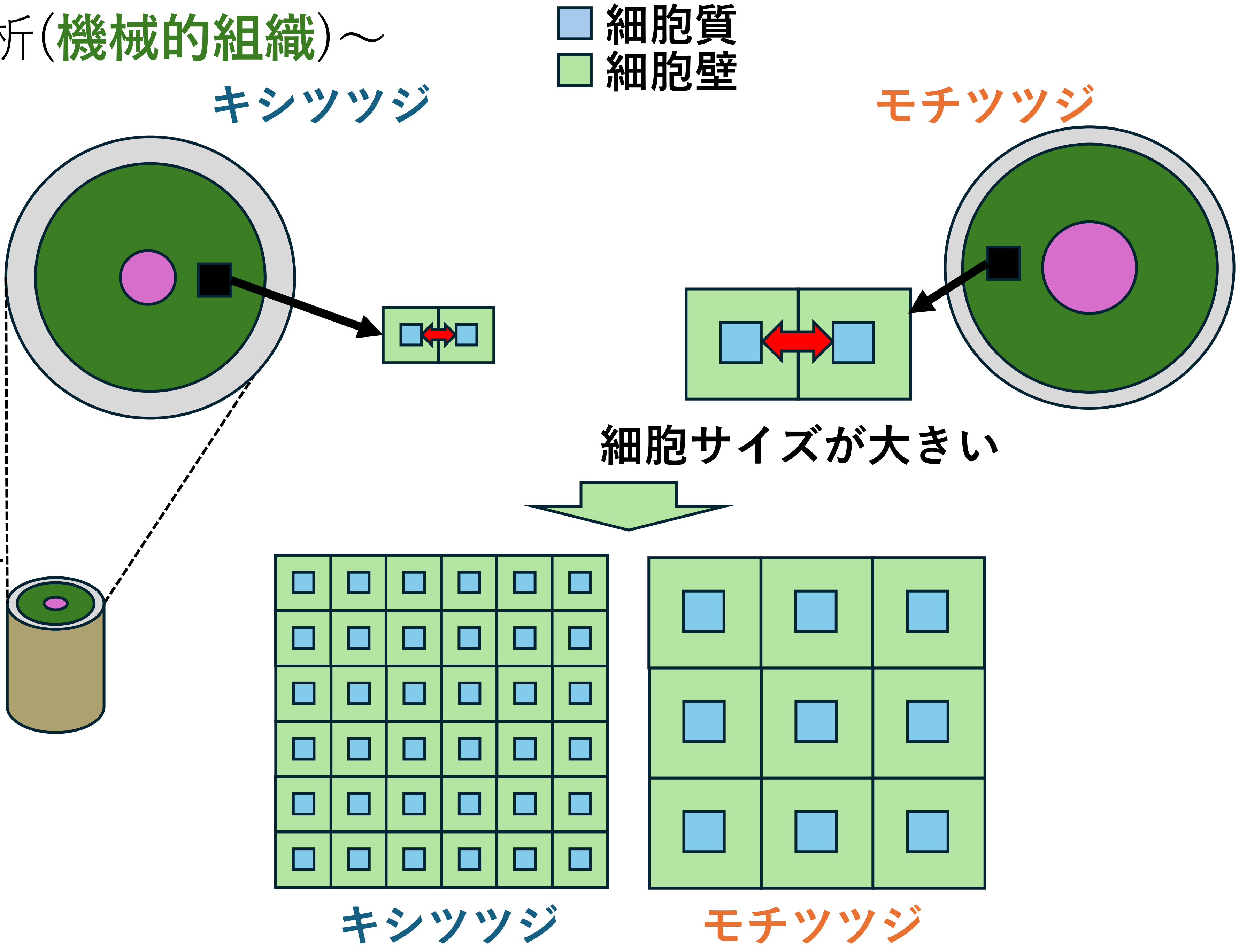
結果～解剖学的解析(機械的組織)～

細胞質面積



二細胞壁間距離(機械的組織)





🟦 細胞質
🟩 細胞壁

キシツツジ

モチツツジ

細胞サイズが大きい

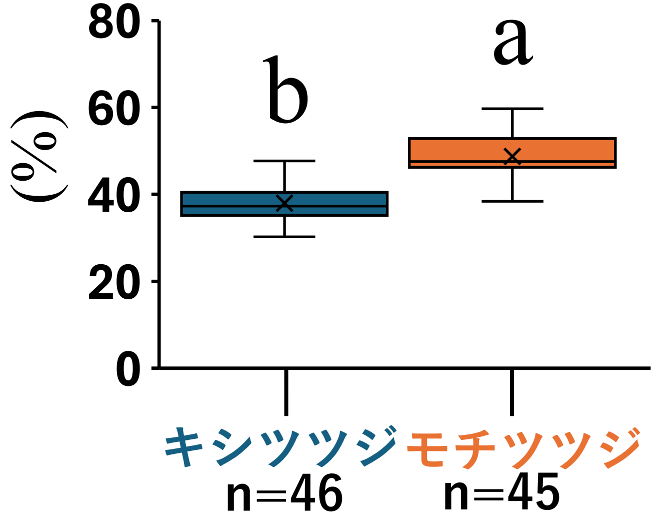
キシツツジ

モチツツジ

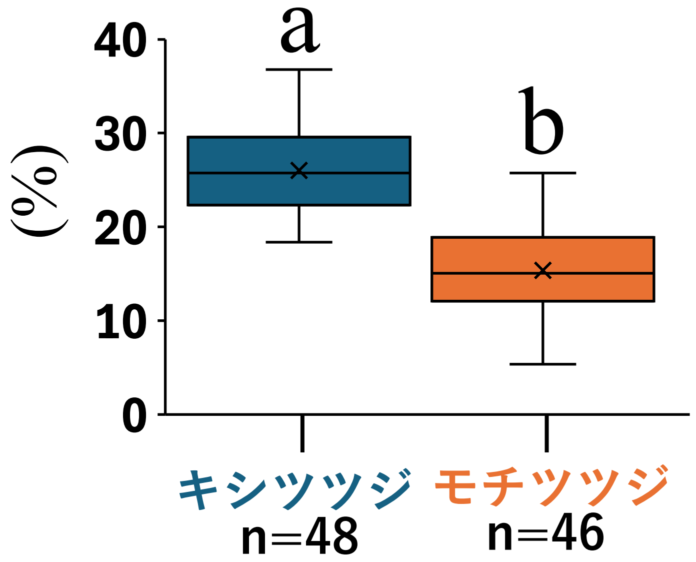
結果〜解剖学的解析(**機械的組織**)〜

(p<0.05)

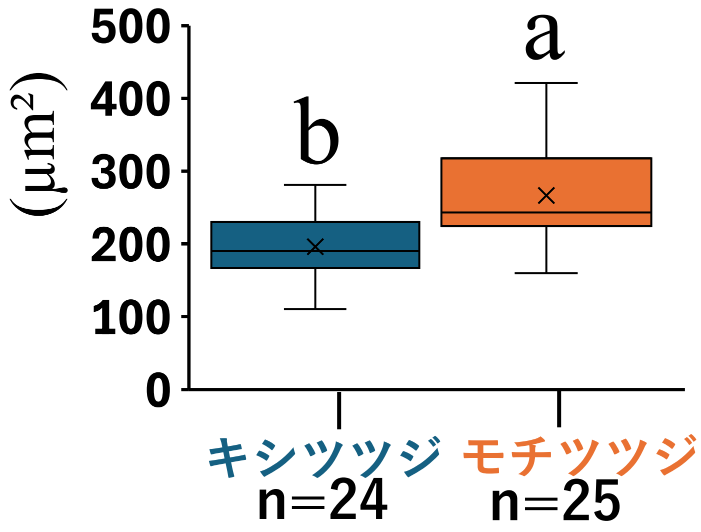
単位面積あたりの細胞壁面積率



単位面積あたりの道管細胞質面積率



道管細胞質面積

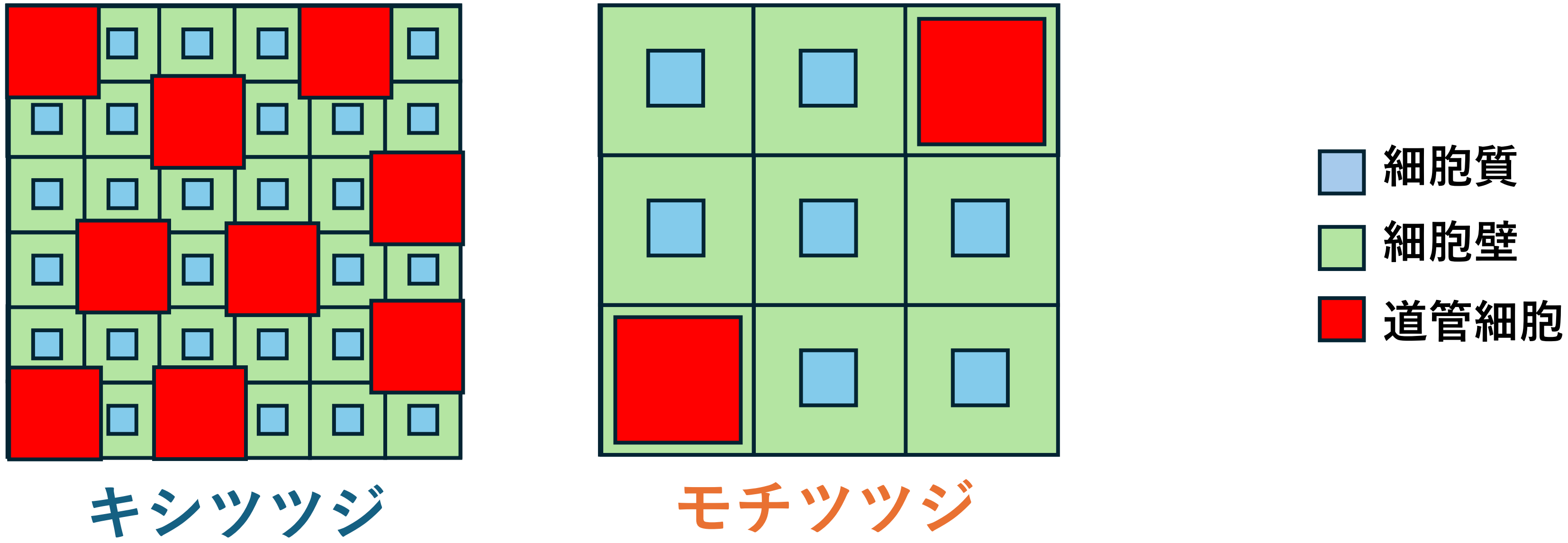


- **キシツツジ**

道管細胞を増加

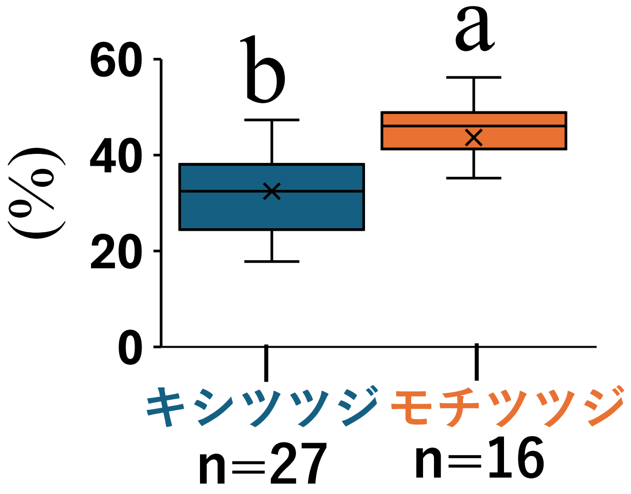
↓

細胞壁量が減少

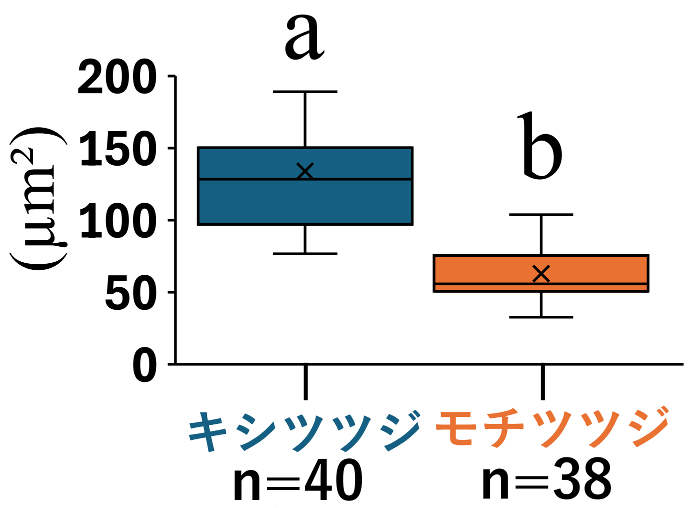


結果～解剖学的解析結果(**皮層組織**)～

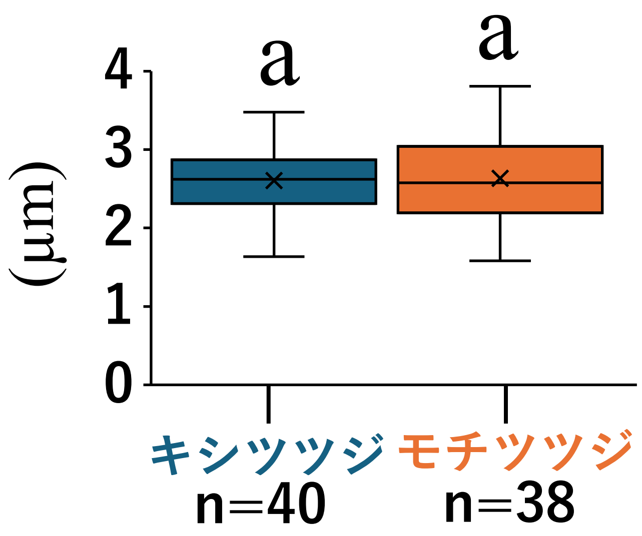
単位面積あたりの細胞壁面積率

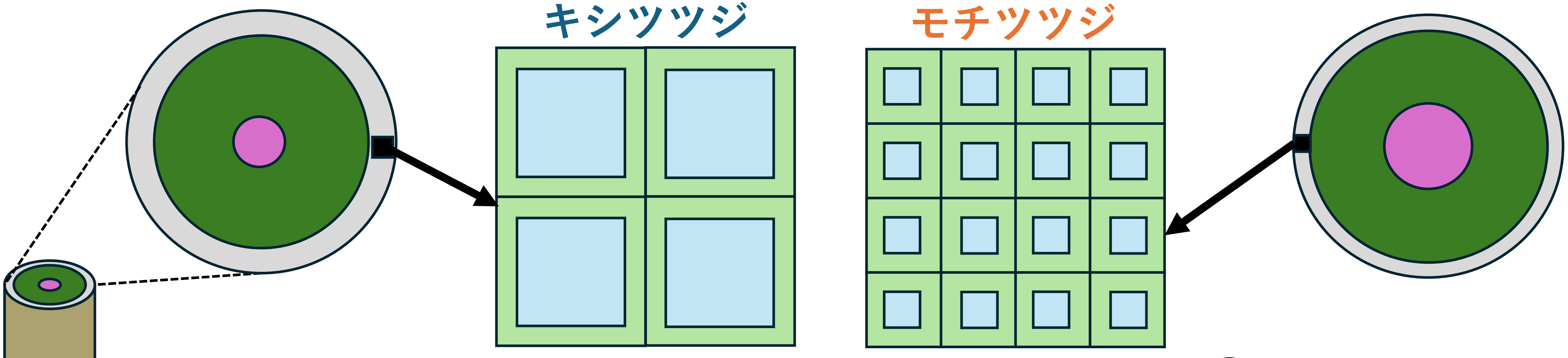


細胞質面積



二細胞壁間距離

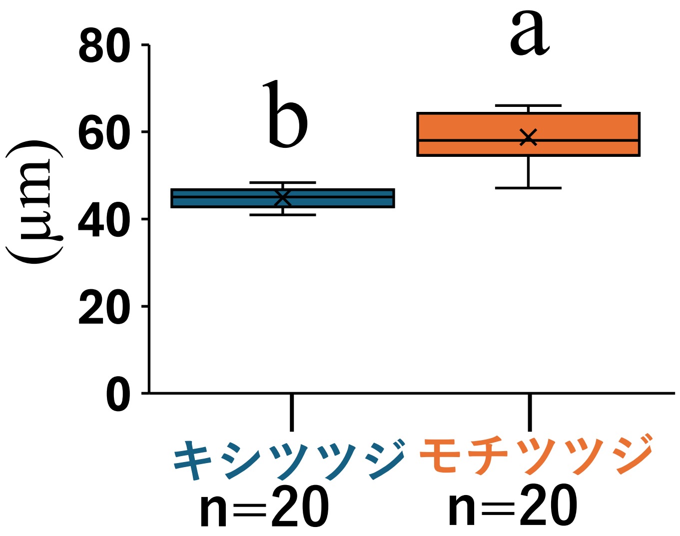




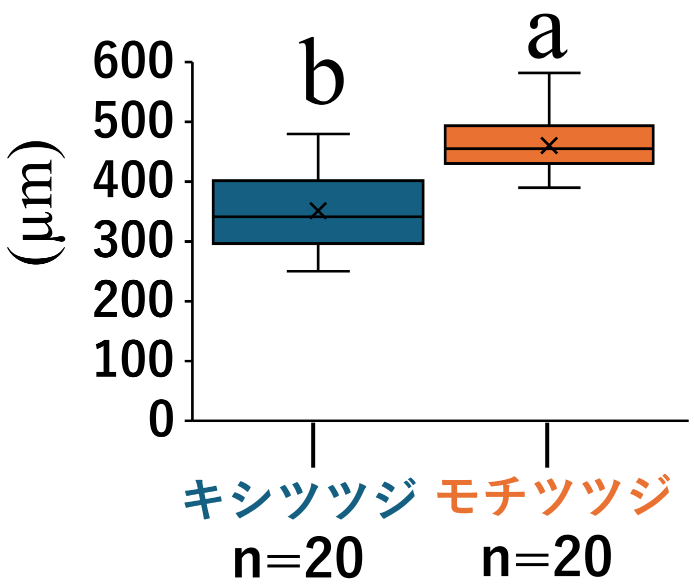
細胞質(大)細胞壁量(少) 細胞質(小)細胞壁量(多)

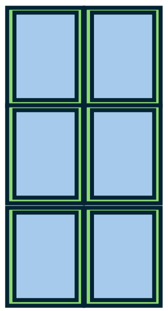
解析結果（**細胞長**）～

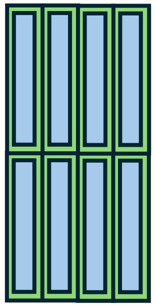
皮層組織細胞長

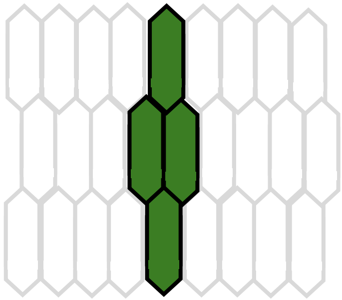


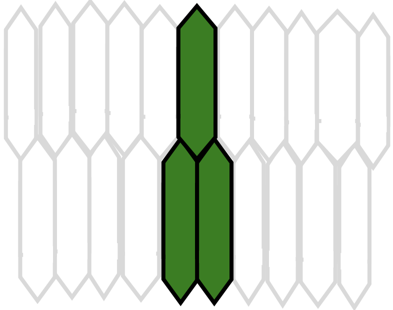
機械的組織細胞長











キシツツジ **モチツツジ** **キシツツジ** **モチツツジ**

考察 ～木本植物の水流ストレス環境における適応～

- 増水による水流ストレス環境（渓流沿い）

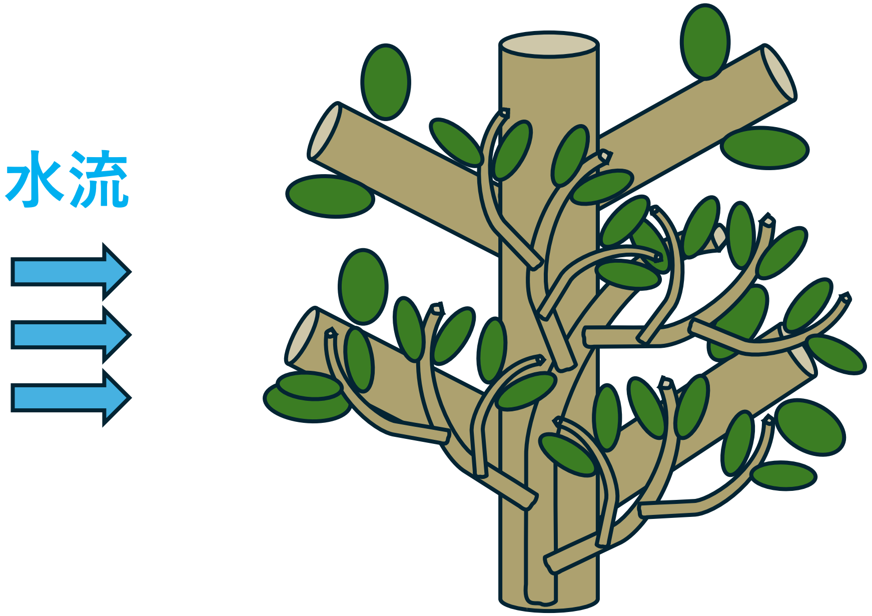
ヒサカキの**渓流型**と**内陸型**

小型化

(Shiba et al., 2021)

葉身における適応

支持器官



仮説：渓流沿い[illegible]強固に[illegible]ている？

（耐性）

柔軟性を獲得

仮説は支持されなかった

考察 ～力学的特性の獲得～

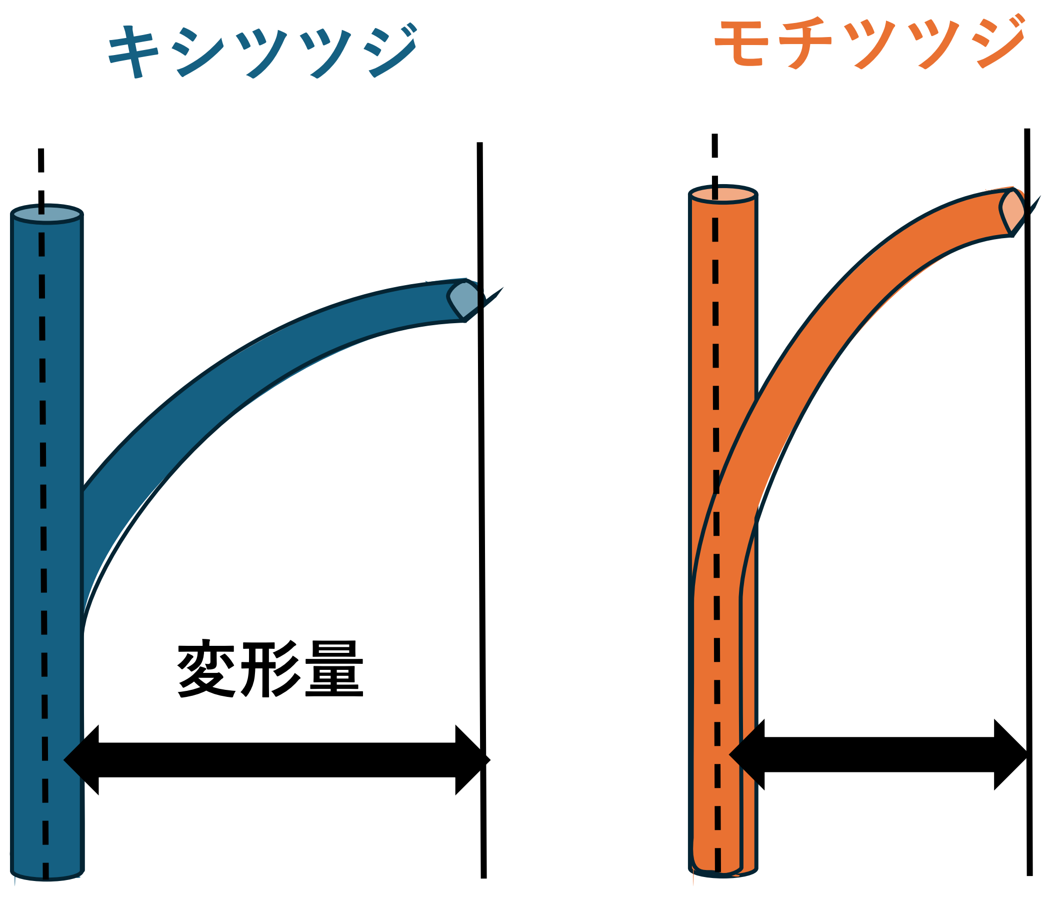
仮説：支持されなかった

曲げ弾性率・曲げ強度
（変形しやすさ）（耐荷重性）

キシ＜**モチ**

破断ひずみ
（変形割合）

キシ＞**モチ**

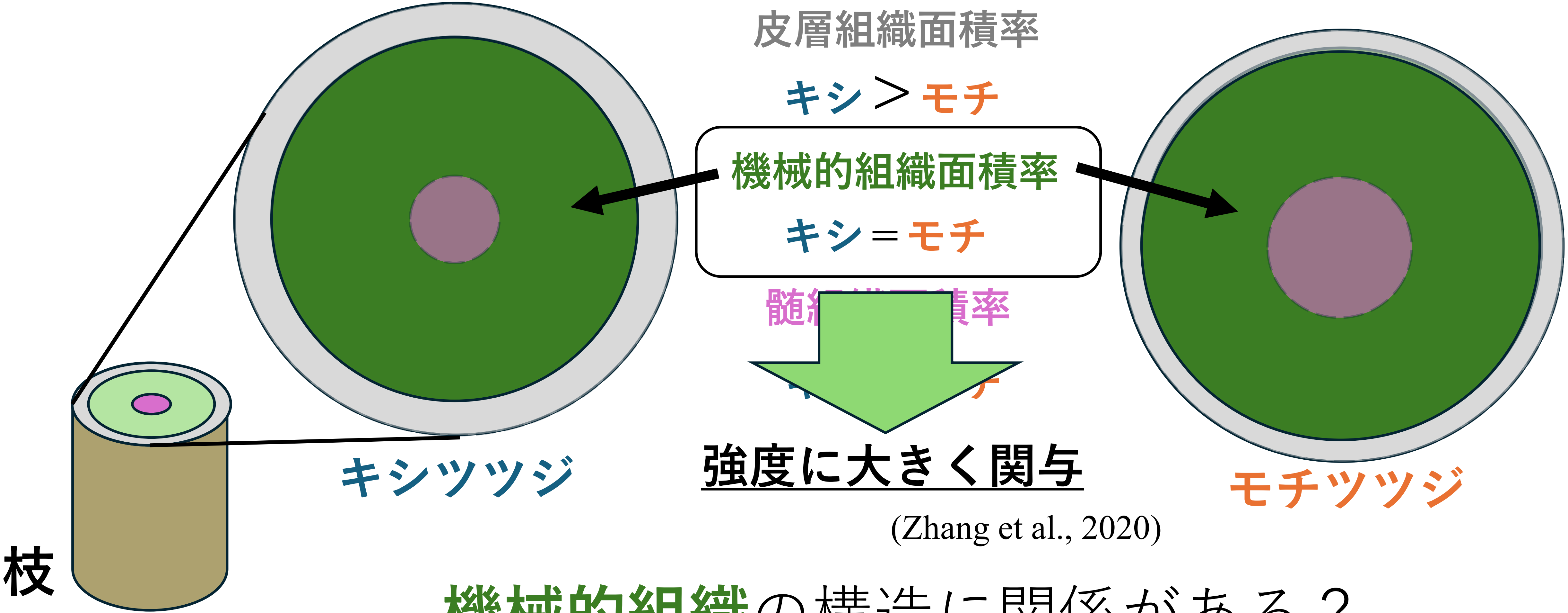


キシツツジは**変形しやすい柔軟な枝**を獲得

➡ **なぜこのような結果が得られた？**

考察 ～力学的特性の獲得～

曲げ弾性率・**曲げ強度**　キシ＜モチ　　　**破断ひずみ**　キシ＞モチ



皮層組織面積率
キシ＞モチ

機械的組織面積率
キシ＝モチ

強度に大きく関与

(Zhang et al., 2020)

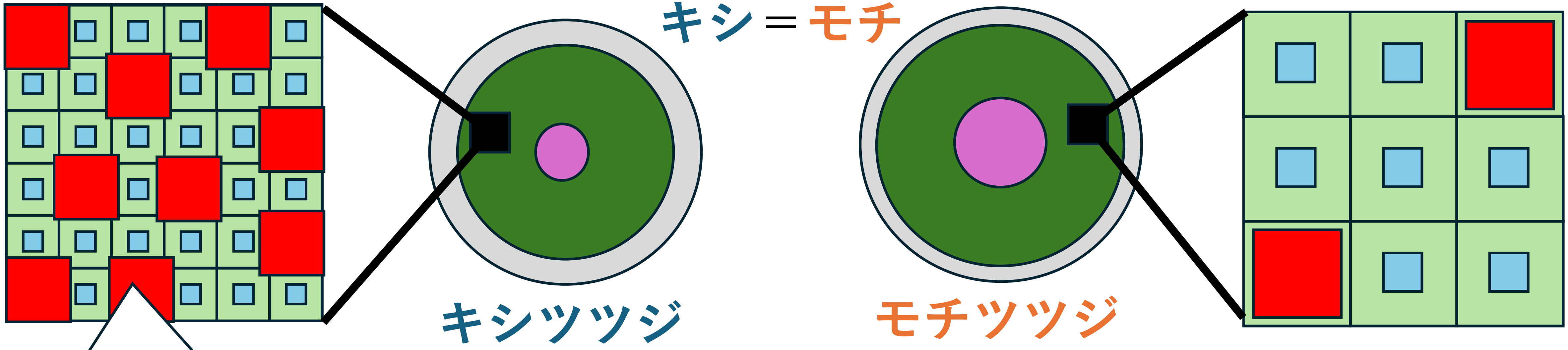
機械的組織の構造に関係がある？

考察 ～機械的組織の構造～

🟦 細胞質
🟩 細胞壁
🟥 道管細胞

曲げ弾性率・曲げ強度　キシ＜モチ　破断ひずみ　キシ＞モチ

機械的組織面積割合
キシ＝モチ



キシツツジ　モチツツジ

道管細胞

細胞壁の薄い細胞
↓
壁が内側にたわみ、形状が崩れる

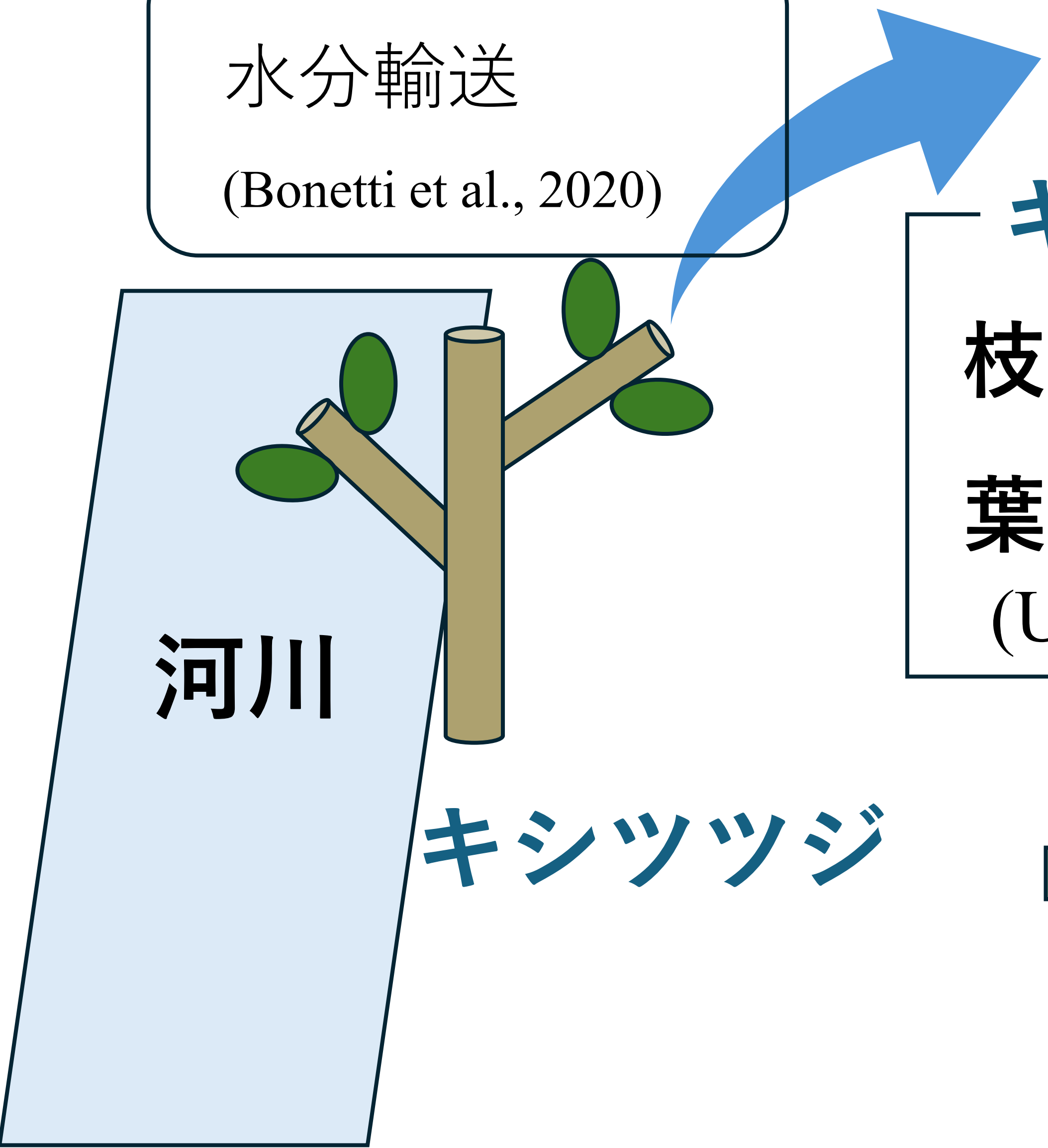
(Jacobsen et al., 2005)

道管細胞数 増 → 細胞壁量 少

⇒ **変形しやすさ**に寄与

なぜ道管を増加？

考察 ～なぜキシツツジは道管を増やす？～



道管

水分輸送

(Bonetti et al., 2020)

大量の水利用可能

キシツツジ

枝：道管数 多

葉：気孔数 多

(Ueda et al., 2012)

→光合成効率 高

(Brodribb et al., 2006; Tanaka et al., 2013)

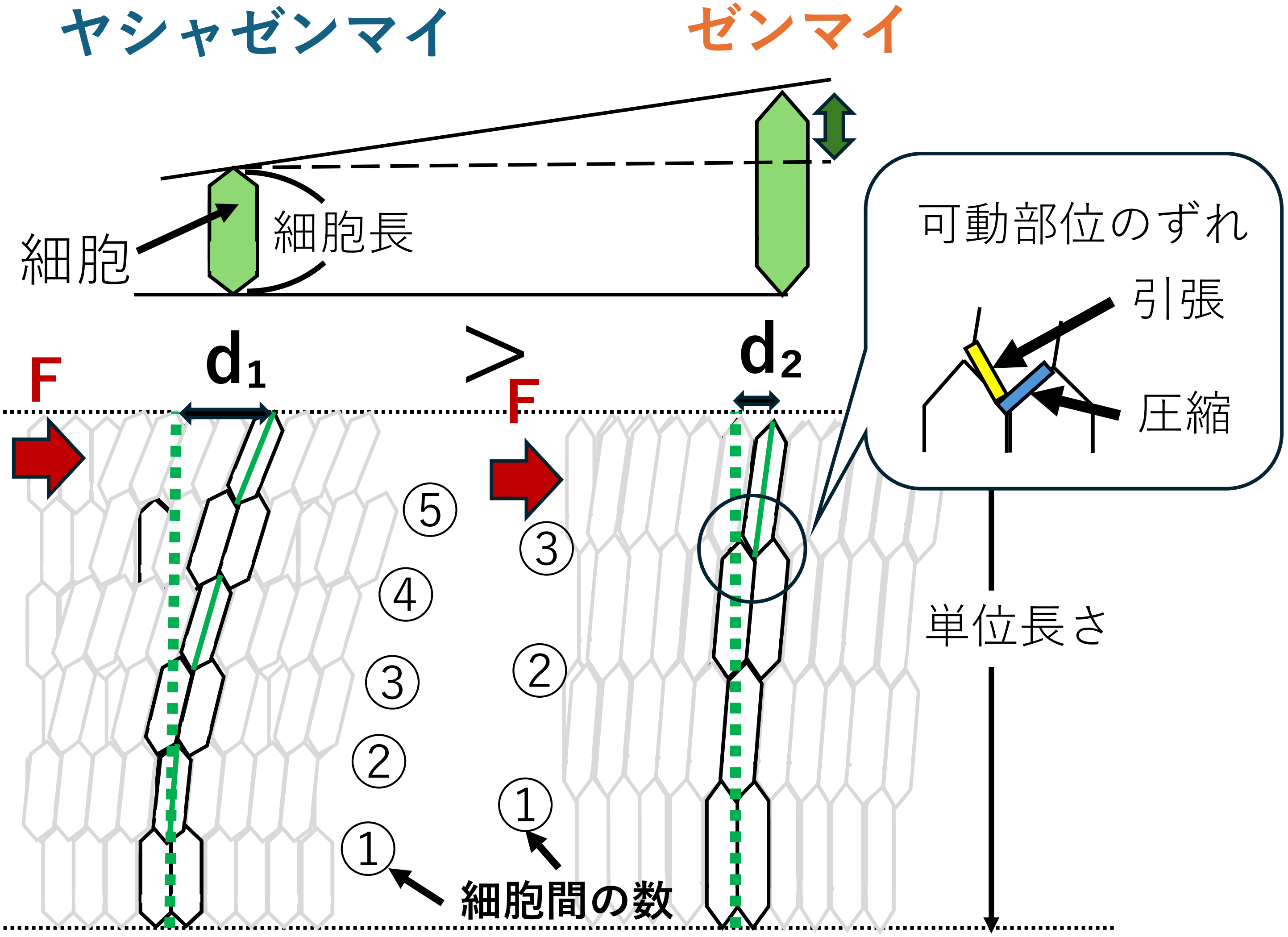
水利用特性変化→成長促進

機械的組織の支持性を犠牲

柔軟性は？

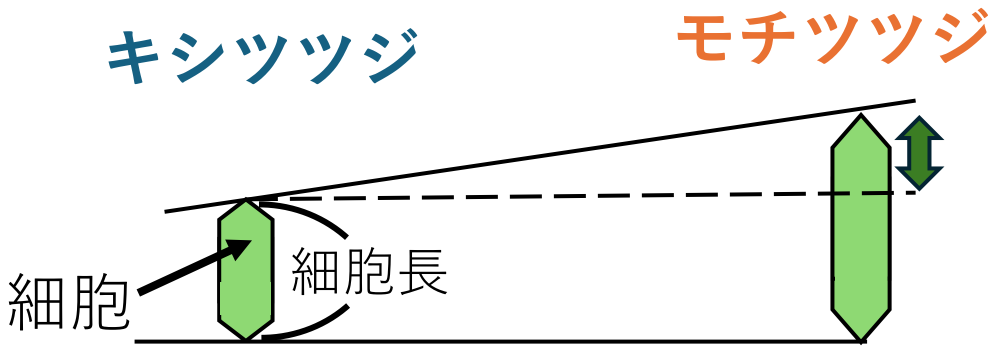
考察 ～外力に対する変形仮説(**機械的組織**)～

- <u>細胞間のずれ仮説</u> (Shiba and Fukuda, 2025)



<u>細胞長の短小化が柔軟性獲得を示唆</u>

本研究

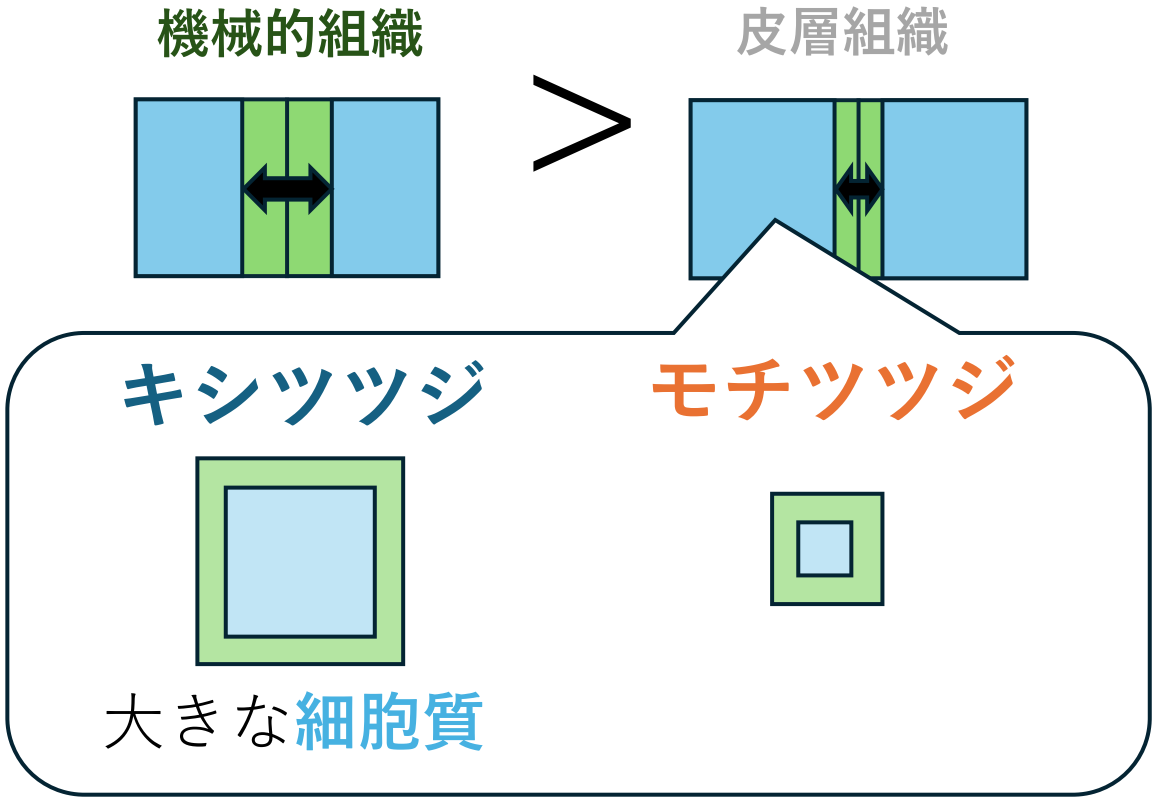


同様のメカニズムを適応

<u>細胞長の短小化が柔軟性獲得を示唆</u>

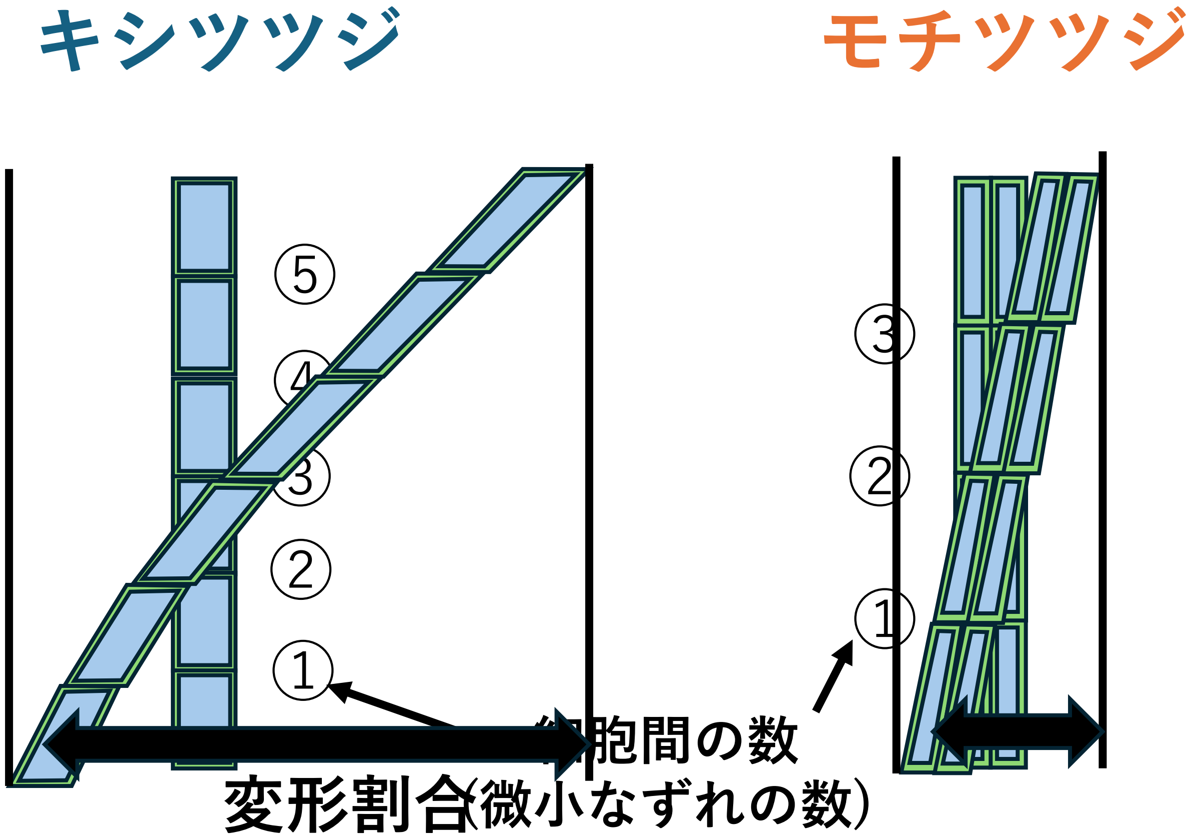
考察 ～皮層組織の変形仮説モデル～

二細胞壁間距離（細胞壁の厚さ）



→ **大きな変形を許容**

(Niklas, 1992; Gibson and Ashby, 1997)

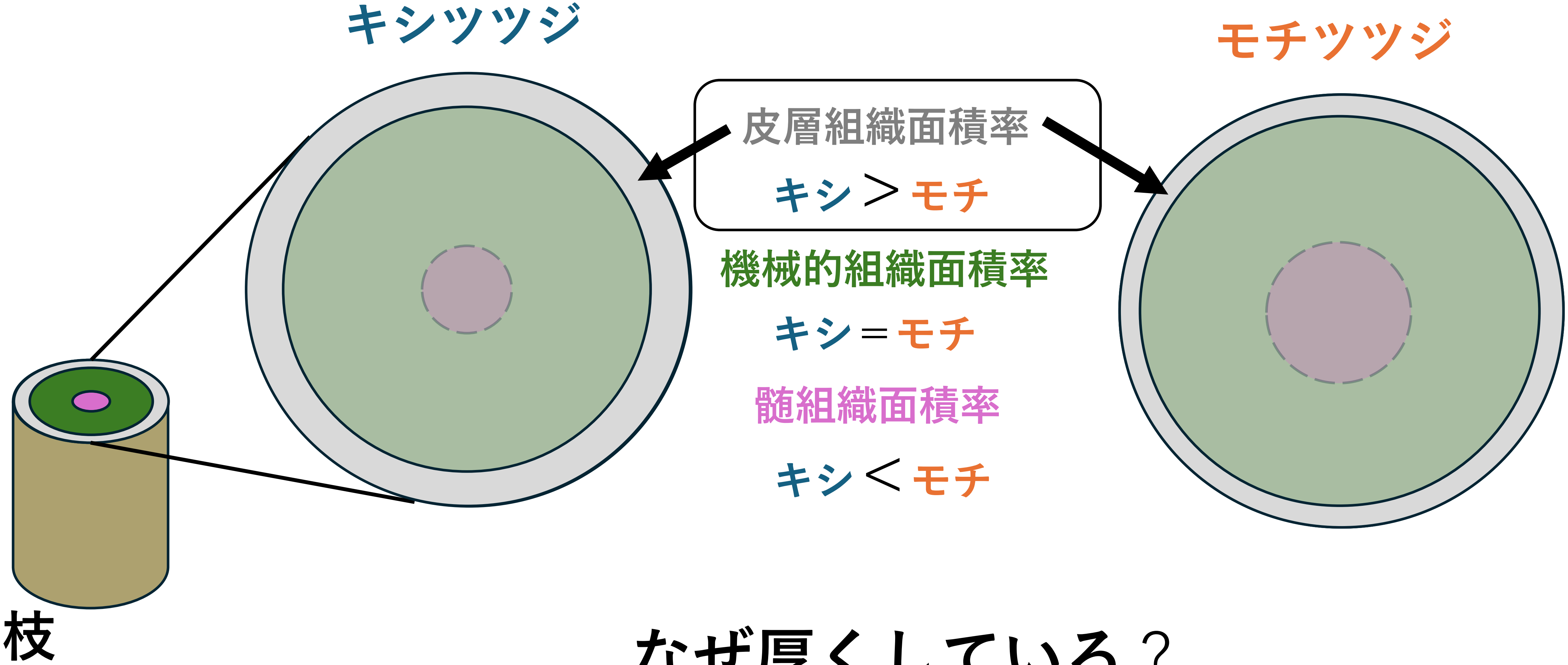


- 短い縦細胞
- 大きな細胞質

→**大きな変形**

キシツツジの皮層組織は機械的組織の柔軟な変形を支持

考察 ～組織面積率の解析結果～



皮層組織面積率

キシ＞モチ

機械的組織面積率

キシ＝モチ

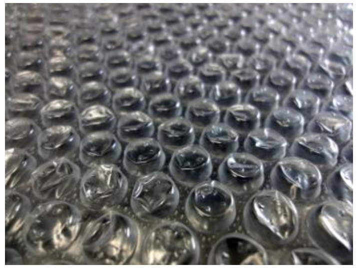
髄組織面積率

キシ＜モチ

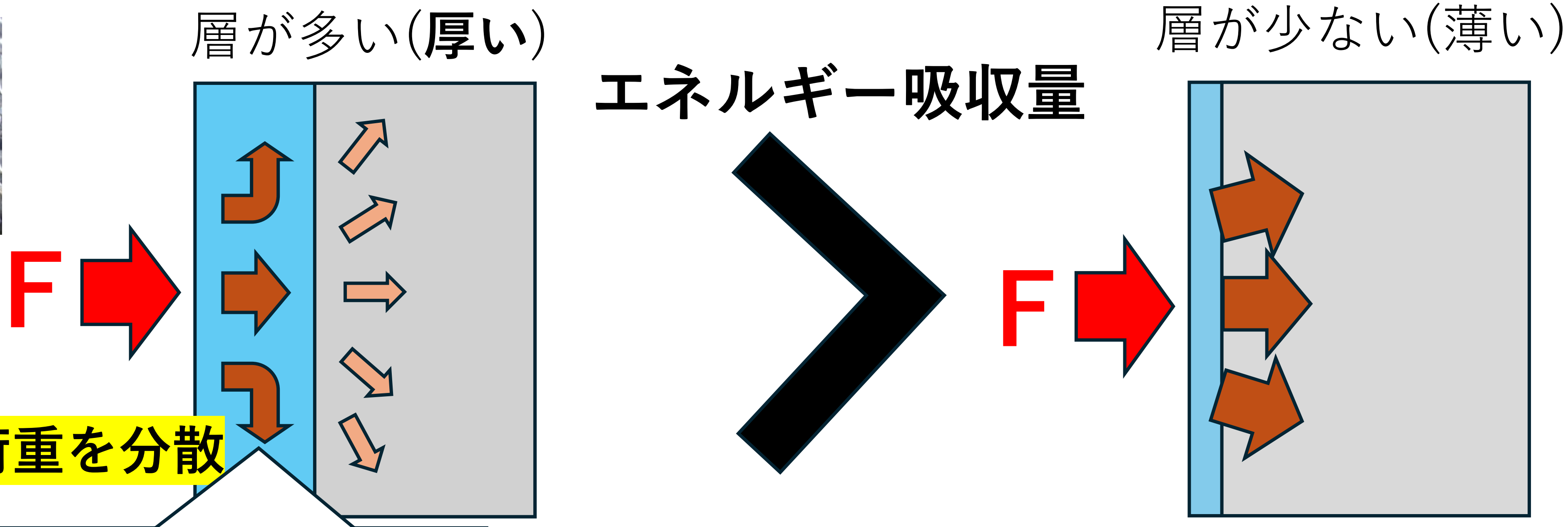
なぜ厚くしている？

考察 ～なぜキシツツジは皮層組織を厚くしている？～

工学分野(Malasri, 2013a)



気泡緩衝材

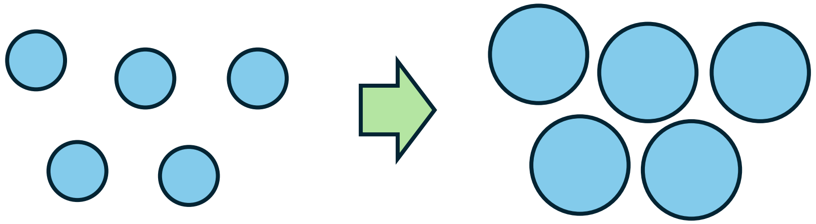


層が多い(**厚い**)

エネルギー吸収量

層が少ない(薄い)

局所的な荷重を分散



泡サイズが大きい

エネルギー吸収量が多い

(Malasri, 2013b)

キシツツジの皮層組織：厚く、大きな細胞質

外力を分散

外力による植物の内側からの破損を抑制

考察 ～木本植物の水流ストレス環境適応～

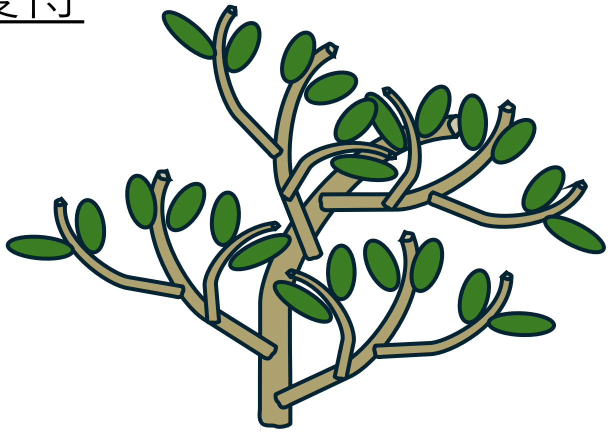
葉

- 狭葉化
- 水利用特性の獲得

＋

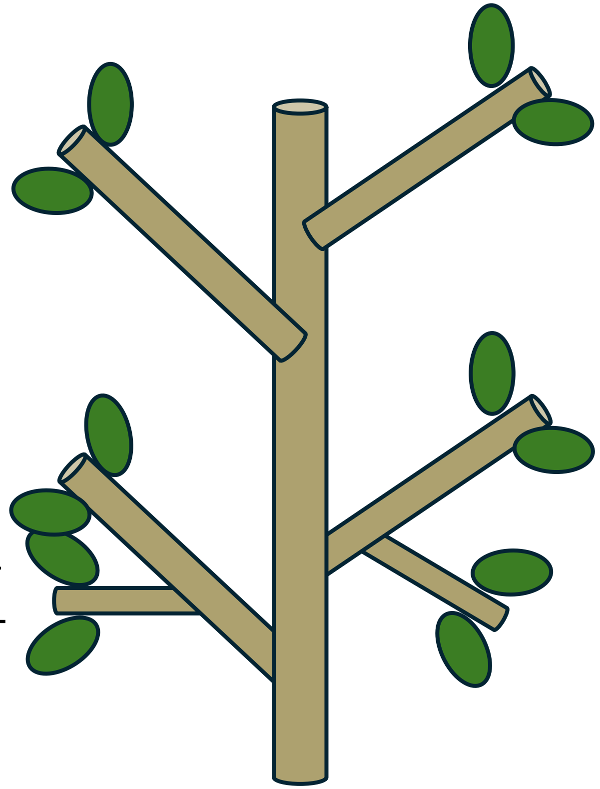
支持器官(枝)

- 低い樹高
- 柔軟性の獲得
- 水利用特性の獲得



支持器官(枝)

- 強度を維持した高い樹高

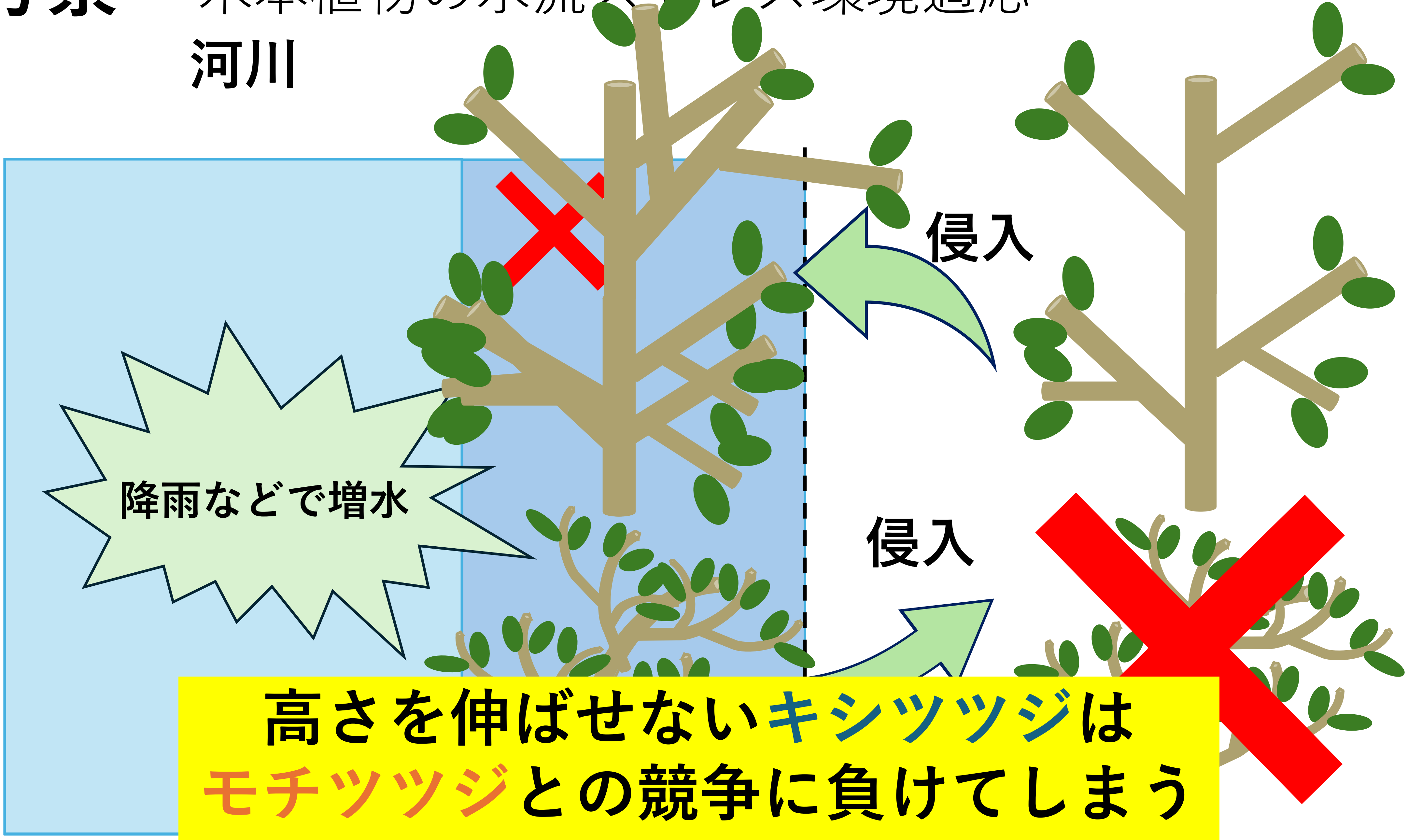


水流ストレス環境に適応

高さで**資源獲得能力**を確保

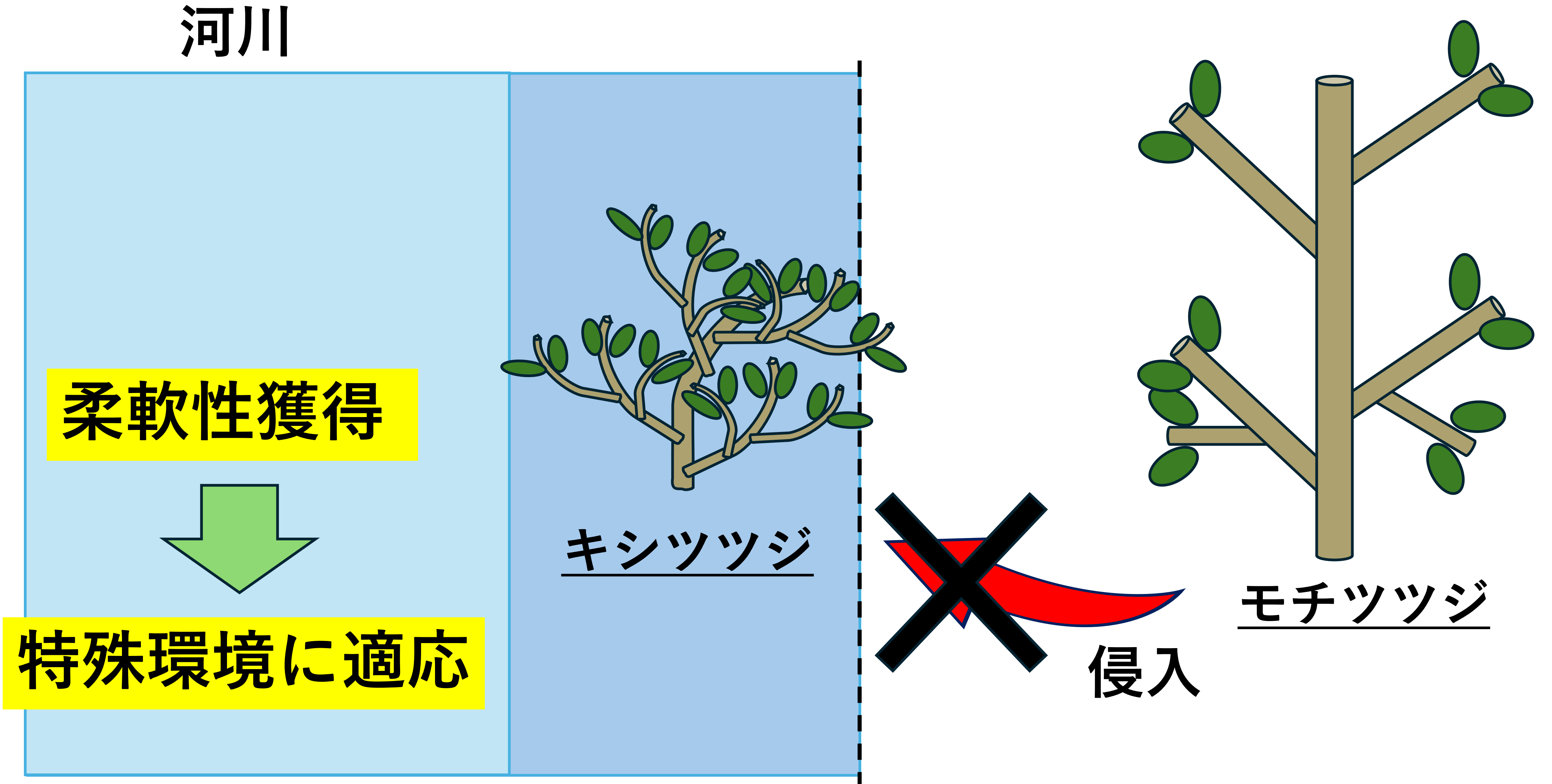
実際の渓流沿い環境で考えると？

考察 ～木本植物の水流ストレス環境適応～



高さを伸ばせないキシツツジは
モチツツジとの競争に負けてしまう

考察 ～木本植物の水流ストレス環境適応～



河川

柔軟性獲得

特殊環境に適応

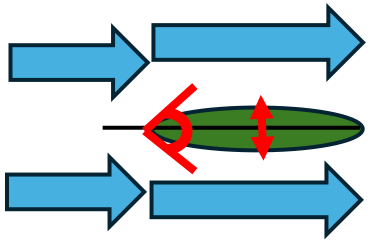
キシツツジ

モチツツジ

侵入

まとめ ～渓流沿い植物の水流ストレス環境適応～

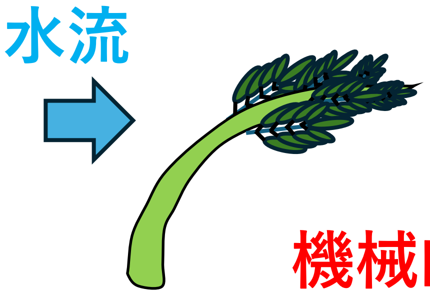
草本植物



狭葉化

(Imaichi and Kato, 1992)

＋

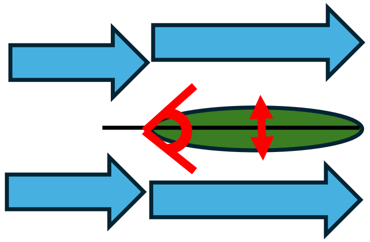


支持器官の**柔軟化**

機械的組織の細胞長の短小化

(Shiba and Fukuda, 2024; 2025)

木本植物



狭葉化

(Ueda et al., 2012)

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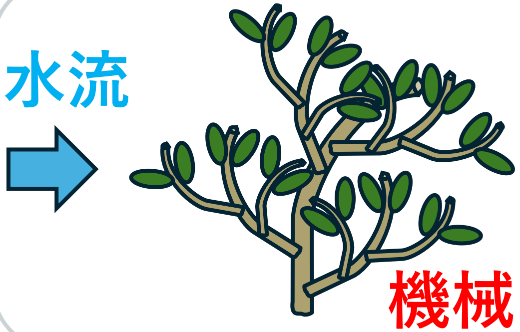
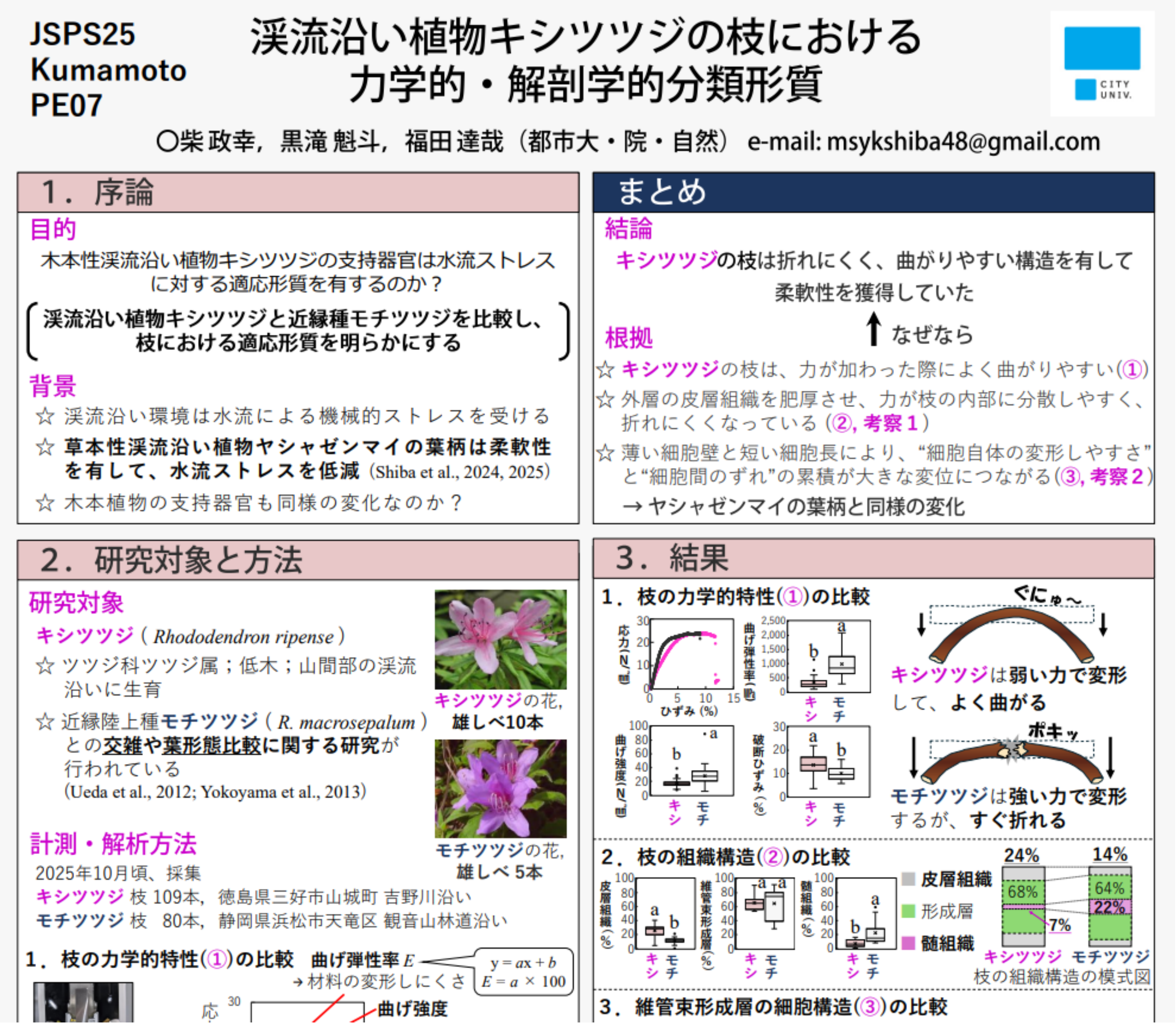


支持器官の**柔軟化**

機械的組織の細胞長の短小化

類似した形質を獲得することでストレスを低減させ適応

本研究の成果



JSPS25
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渓流沿い植物キシツツジの枝における力学的・解剖学的分類形質

〇柴 政幸，黒滝 魁斗，福田 達哉（都市大・院・自然） e-mail: msykshiba48@gmail.com

1．序論

目的

木本性渓流沿い植物キシツツジの支持器官は水流ストレスに対する適応形質を有するのか？

（**渓流沿い植物キシツツジと近縁種モチツツジを比較し、枝における適応形質を明らかにする**）

背景

☆ 渓流沿い環境は水流による機械的ストレスを受ける

☆ **草本性渓流沿い植物ヤシャゼンマイの葉柄は柔軟性を有して、水流ストレスを低減**（Shiba et al., 2024, 2025）

☆ 木本植物の支持器官も同様の変化なのか？

2．研究対象と方法

研究対象

キシツツジ（*Rhododendron ripense*）

☆ ツツジ科ツツジ属；低木；山間部の渓流沿いに生育

☆ 近縁陸上種**モチツツジ**（*R. macrosepalum*）との**交雑**や**葉形態比較に関する研究**が行われている
（Ueda et al., 2012; Yokoyama et al., 2013）

キシツツジの花，**雄しべ10本**

モチツツジの花，**雄しべ 5本**

計測・解析方法

2025年10月頃、採集
キシツツジ 枝 109本，徳島県三好市山城町 吉野川沿い
モチツツジ 枝 80本，静岡県浜松市天竜区 観音山林道沿い

1．枝の力学的特性(①)の比較 **曲げ弾性率** E
→材料の変形しにくさ

$y = ax + b$
$E = a \times 100$

曲げ強度

まとめ

結論

キシツツジの枝は折れにくく、曲がりやすい構造を有して柔軟性を獲得していた

↑ なぜなら

根拠

☆ **キシツツジ**の枝は、力が加わった際によく曲がりやすい(①)

☆ 外層の皮層組織を肥厚させ、力が枝の内部に分散しやすく、折れにくくなっている（②, **考察 1**）

☆ 薄い細胞壁と短い細胞長により、“細胞自体の変形しやすさ”と“細胞間のずれ”の累積が大きな変位につながる(③, **考察 2**)

→ ヤシャゼンマイの葉柄と同様の変化

3．結果

1．枝の力学的特性(①)の比較

キシツツジは**弱い力で変形**して、**よく曲がる**

モチツツジは**強い力で変形**するが、**すぐ折れる**

2．枝の組織構造(②)の比較

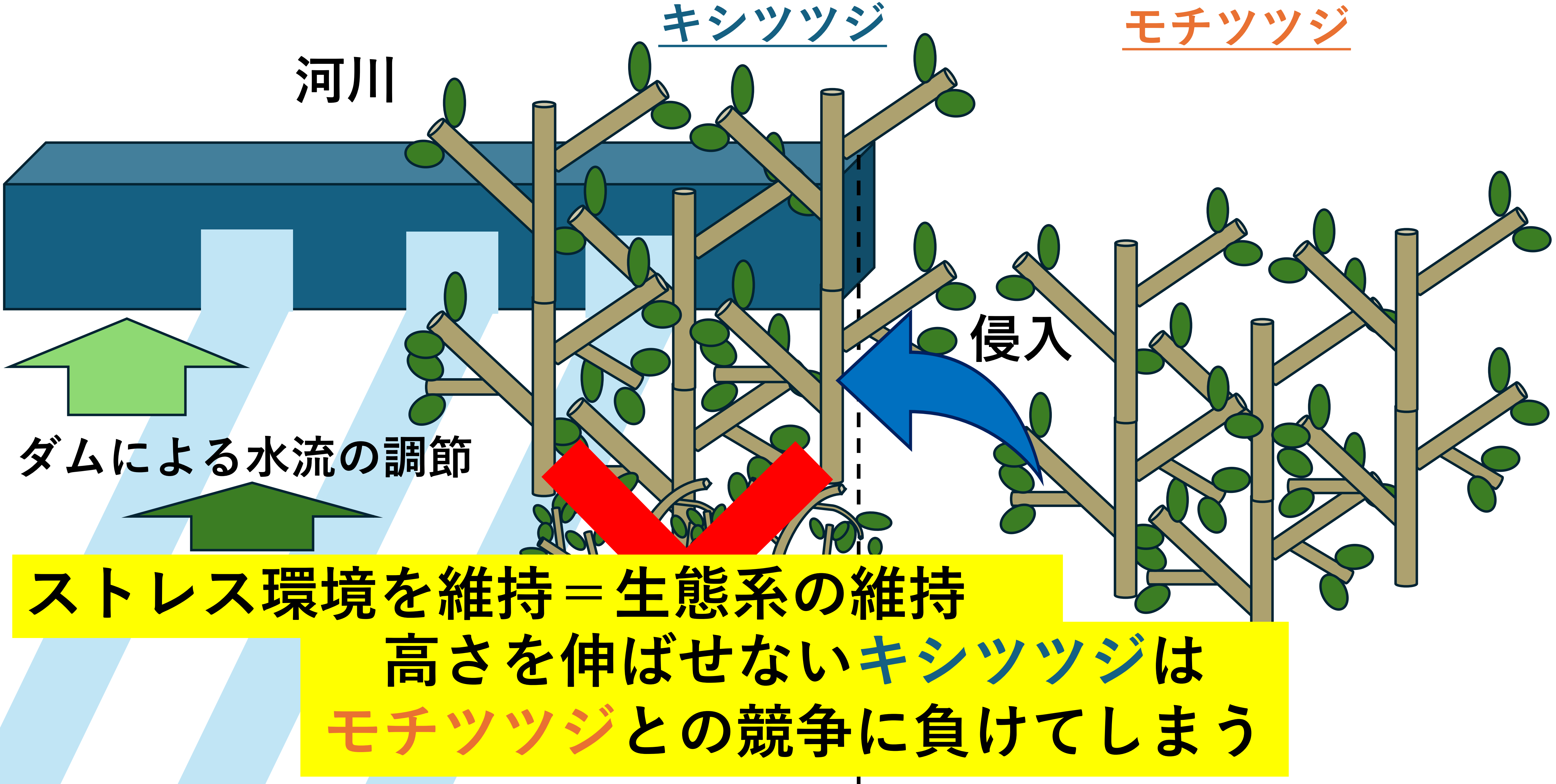
枝の組織構造の模式図

3．維管束形成層の細胞構造(③)の比較

日本植物分類学会にて報告

2026年3月5日－3月8日　於：熊本大学

考察 ～木本植物の水流ストレス環境適応～



ストレス環境を維持＝生態系の維持
高さを伸ばせないキシツツジは
モチツツジとの競争に負けてしまう

ご清聴ありがとうございました

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