UDC 581.4 : 519.28

41. **Yasuhisa Saiki** : Application of Statistics on the Field of Plant Internal Morphology. III.*[1] On Japanese Aconites. (1).

(*Shizuoka College of Pharmacy**[2])

Aconites distribute widely in northern hemisphere of the earth reaching to arctic zone from warm and temperate one. Hitherto, these tuberous roots have been known to be famous plant poisons and to be essental important drugs possessing many remedial effects in each regions of the world, especially in China.

In Japan, though these plants grow widely in whole districts too, but their classifications are quite obscure. According to Nakai[1] there are about 70 species in this country, so their distinctions are not easy.

Chemical studies on their components were carried out by Majima,[2] Suginome,[3] Ochiai[4] and their co-workers. According to their works, many difficult questions exist in the components, for alkaloids of aconitine and atisine types vary widely by kinds and habitats, so the pharmacological and toxic actions of native aconites are thought to be different by each origin. Furthermore, their toxicities are different by preparations, and their exact toxic and effective doses are unknown, so Japanese aconites are considered to be very dangerous. Thus the study of Japanese aconites is one of the problems in pharmacy and social hygiene,

The author planned the study of internal structure of Japanese aconites as an aid to the solution of these questions, and collected from many localities each species, and explored their structures.

However, these structures resemble well each other, and are difficult to distinguish. Then, statistical methods were introduced for them and as the results following consequences were obtained.

Internal Structure of Tuberous Roots

At first, internal structure of tuberous root of aconites in cross section is expressed briefly. Most external part is covered with epidermis.*[3] Beneath of it, cortex consists of about 10 layers of parenchyma which includes many scattered stone cells commonly. Inside of cortex, endodermis distinctly observs. Central cylinder surrounded by endodermis occupies most parts of tuberous root, and consisted mainly of parenchymatous cells of fundamental tissue, containing xylem and phloem and does not include other lignificated cell commonly. Phloem is scattered in othside portion of cambium ring and consists of smaller celles in diameter than ohter cells. Xylem consists of vessels and xylem parenchyma that is obscure at border, and is arranged inside of cambium.

Cambium ring, as showh in Fig. 2, appears different and in this feature several studies were performed, for example Indian aconites[5] were classified by this, moreover

*1 This paper constitutes part of a series entitled "Application of Statistics on the Field of Plant Internal Morphology" by the late Toshikazu Harada. Part II : Yakugaku Zasshi, **79**. 1310(1959).

*2 Oshika, Shizuoka (斎木保久).

*3 In many literatures, this part is written to be metaderm except Youngken's "Text Book of Pharmacognosy" and Gathercoal & Wirth's "Pharmacognosy." The author maintains theory of endodermis from observation of growing process.

1) T. Nakai : Bulletin of Natl. Sci. Museum (Tokyo), **32**, 1 (1953).
2) Majima, Morio : Nippon Kagaku Zasshi, **51**, 200 (1930), etc.
3) Suginome, *et al.* : Proc. Jap. Acad., **22**, 119, 122 (1950), etc.
4) E. Ochiai, *et al.* : Yakugaku Zasshi, **72**, 816 (1952); **75**, 545, 550, 634, 990 (1955), etc.
5) Kirtikar, Basu : "Indian Medicinal plants." Part I, 9~34.

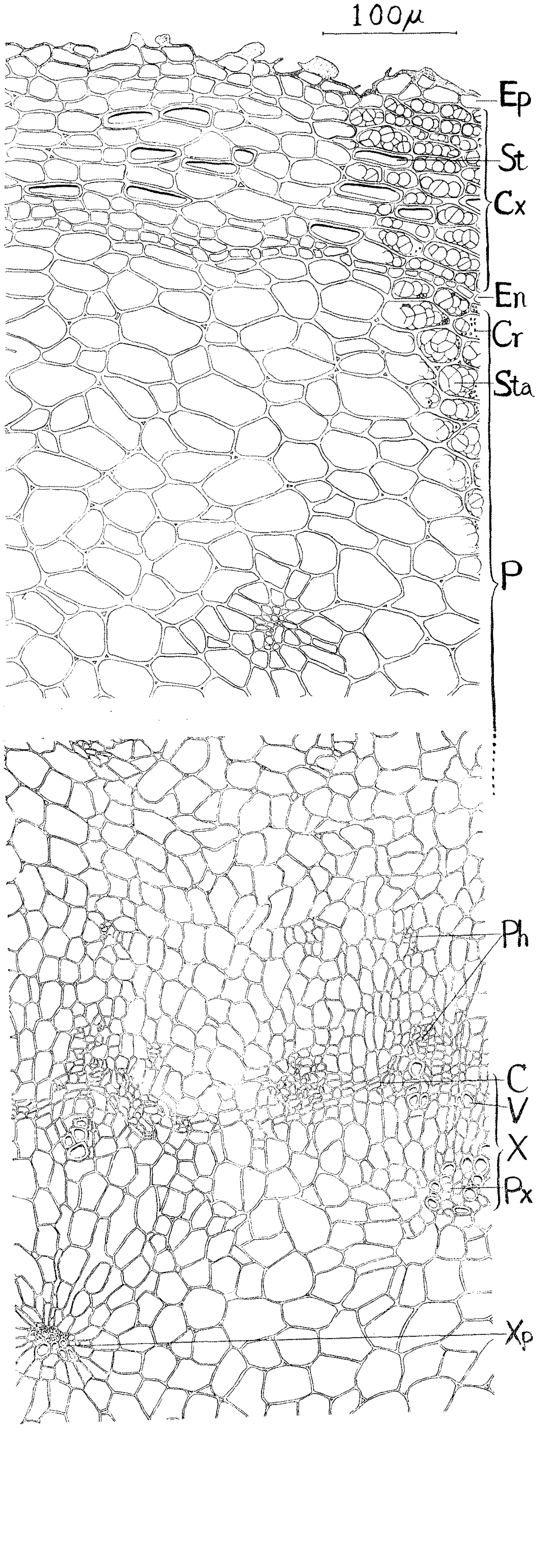

Fig. 1. The Cross Section of Tuberous root of *Aconitum yesoense* NAKAI.

Ep : epidermis
Cx : cortex
St : stone cell
En : endodermis
P : parenchymatous cell of fundamental tissue
Ph : phloem
C : cambium
X : xylem
Xp : protoxylem
V : vessel
Px : xylem parenchyma
Cr : crystal
Sta : starch grain

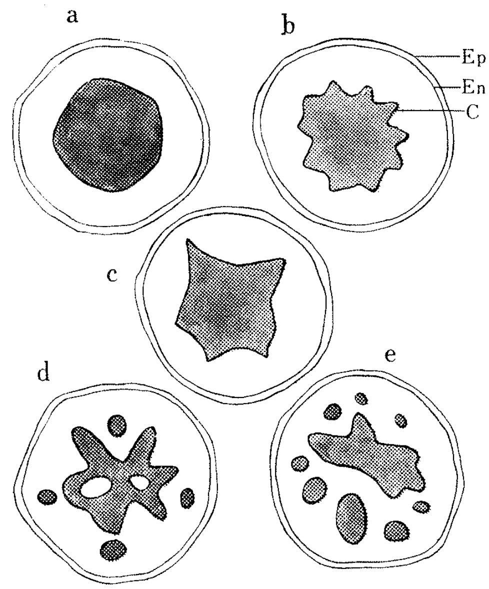

Fig. 2. Schematic diagrams about Forms of Cambium rings

a : circular ring
b : sinuate circular ring
c : polygonal ring
d : state possessing of small isolated rings
e : state separated in several small rings
Ep : epidermis
En : endodermis
C : cambium

developmental history of abnormal cambium reported in detail by Kumazawa.[6] However this feature differs by individuals, diameter and cut portion of root, furtheamore intermediate form is appeared, so that cambium rings do not seem to be of strict distinction. The author tried to treat this feature mathematically as following.

Statistical Methods

Measuring the Form of Cambium——Concerning the form of cambium next two specific values are used.

When E, C and S are decided as following in a cross section of root;

E……area surrounded by endodermis

C……area surrounded by cambium rings (gray-colored portion in Fig. 2)

S……total length of surroundings of cambium rings,

that are E/C and $\log_{10}(S^2/C)$, are calculated from these values. But in case of measuring of C,area surrounded by isolated cambium ring is plus in occurrence of outside of main cambium, while is minus in occurrence of inside. Bisides populations of E/C and $\log_{10}(S^2/C)$ are assumed to belong to normal distribution in each tested material.

Sampling Method——Difference of values of E/C and $\log_{10}(S^2/C)$, produced by various sectional levels in a tuberous root, are as shown in experimental of this report. According to this, E/C are not different by cut portion, but $\log_{10}(S^2/C)$ has tendency to become small generally in case of small diameter, however is observed little distinction when cut portion is sampled from an interval between the largest portion and one of 2/3 of the largest in diameter of root. So the author took sample of a section at random in above mentioned portion.

Moreovər, mother and daughter roots are treated similarly, for their internal structures which seem to be same from result of stochastical study as shown in experimental. And differenence among mother and daughter roots does not exist in consideration of growing process of tuberous root.

Stochastical calculation——Two specific values E/C and $\log_{10}(S^2/C)$ are treated mathematically with one pair in a section. As this method, distribution range of these

6) Kumazawa : Botan. Mag. Tokyo, **44**, 914~925 (1937).

paired values are calculated by mean of rejectancial ellipse.[7] And averages of these values are also calculated by method of fiducial ellipse.[8] Thus ellipses can easily be drawn and are compaired each other.

Result and Conclusion

Real statistical values of Japanese aconites collected in each locality are shown in experimental part, and the results of calculation are listed in Table I, moreover are illustrated in Figs. 3 and 4.

TABLE I. Rejectancial and Fiducial Ellipses about Abnormality of Cambium rings (in confidence 95%)

Name of plant	Coordinate of centre ($\bar{x}$)	($\bar{y}$)	Inclination of axis (θ)	Standard form of Ellipses: Rejectancial	Fiducial
Aconitum sachalinense	3.75	1.18	45′	$x^2/2.42^2+y^2/0.21^2=1$	$x^2/0.37^2+y^2/0.032^2=1$
A. yesoense	3.21	1.17	85.5°	$x^2/0.31^2+y^2/1.84^2=1$	$x^2/0.038^2+y^3/0.22^2=1$
A. lucidusculum	3.75	1.20	89.3°	$x^2/0.22^2+y^2/2.24^2=1$	$x^2/0.028^2+y^2/0.29^2=1$
A. subcuneatum	3.62	1.72	45′	$x^2/3.33^2+y^2/0.59^2=1$	$x^2/0.47^2+y^2/0.084^2=1$
A. Zuccarinii	2.89	1.27	30′	$x^2/0.51^2+y^2/0.39^2=1$	$x^2/0.087^2+y^2/0.068^2=1$
A. aizuense	3.03	1.25	1.3°	$x^2/0.96^2+y^2/0.64^2=1$	$x^2/0.15^2+y^2/0.10^2=1$
A. Mazimai	3.06	1.45	4.5°	$x^2/2.89^2+y^2/0.73^2=1$	$x^2/0.36^2+y^2/0.090^2=1$
A. Okuyamai	3.10	1.23	8.6°	$x^2/1.21^2+y^2/0.20^2=1$	$x^2/0.24^2+y^2/0.039^2=1$
A. iwatekense	3.60	1.20	4.7°	$x^2/2.26^2+y^2/0.20^2=1$	$x^2/0.36^2+y^2/0.032^2=1$
A. spp. (Shimoburo)	3.67	1.24	95.3°	$x^2/0.20^2+y^2/1.03^2=1$	$x^2/0.037^2+y^2/0.31^2=1$
A. spp. (Iwaya)	3.32	1.41	3.8°	$x^2/1.30^2+y^2/0.82^2=1$	$x^2/0.26^2+y^2/0.16^2=1$
A. spp. (Akataki)	3.55	1.17	10′	$x^2/1.40^2+y^2/0.17^2=1$	$x^2/0.38^2+y^2/0.047^2=1$
A. spp. (Sōma)	3.73	1.33	1.3°	$x^2/1.84^2+y^2/0.55^2=1$	$x^2/0.39^2+y^2/0.093^2=1$
A. japonicum	4.46	1.19	0°	$x^2/2.77^2+y^2/0.29^2=1$	$x^2/0.34^2+y^2/0.035^2=1$
A. deflexum	4.63	1.19	1.1°	$x^2/3.54^2+y^2/0.26^2=1$	$x^2/0.75^2+y^2/0.055^2=1$
A. senanense	3.57	1.26	88.7°	$x^2/0.19^2+y^2/1.83^2=1$	$x^2/0.047^2+y^2/0.46^2=1$
A. sanyoense	3.49	1.27	2.3°	$x^2/2.29^2+y^2/0.33^2=1$	$x^2/0.41^2+y^2/0.059^2=1$
A. grossidentatum	2.73	1.28	78.2°	$x^2/0.47^2+y^2/1.39^2=1$	$x^2/0.14^2+y^2/0.42^2=1$
var. *shikokianum*	3.39	1.16	85.5°	$x^2/0.17^2+y^2/1.35^2=1$	$x^2/0.022^2+y^2/0.18^2=1$
A. crassipes	3.69	1.23	88.1°	$x^2/0.36^2+y^2/0.99^2=1$	$x^2/0.090^2+y^2/0.25^2=1$
A. kiusianum	5.02	1.19	35′	$x^2/5.00^2+y^2/0.17^2=1$	$x^2/0.88^2+y^2/0.030^2=1$

Next, as considering the experimental, results all rejectancial ellipses are intricate in each species, so Japanese aconites are considered to be difficult in distinction by forms of cambium, and it is almost impossible usually to distinguish anatomically by a few samples of each aconite. However in several kinds the values differ considerably in ranges of ellipses from the other species, for example coordinate of two means of *Aconitum subcuneatum* NAKAI are pointed out of rejectancial ellipses of many other kinds.

Method of fiducial ellipse can congress of ability of distinction using mean values even when individuals can not be determined.

Furthermore, as considering experimental using this method, many following facts are recognized. At first, inaconites of Hokkaidō district, *A. subcuneatum* NAKAI has so large values of $\log_{10}(S^2/C)$ that it can be distinguished easily from other *nse* FR. SCHM. species; distinctions among *A. lucidusculum* NAKAI, *A. yesoense* NAKAI and *A. sachaline-* are obscure, latter two kinds are however distinguished roughly each other by values of E/C. Next, in kinds of northern Honshu, as shown in Fig. 3, *A. subcune- atum* NAKAI is most abnormal in its cambium; followingly *A. Mazimai* NAKAI, *A. Zuccarinii*

7) This method is found in many works of statistics, for example, Torii, Takahashi, Doi: "Suikeigaku," 64~74 (1957). Tōdai-Shuppankai. Tokyo.
8) *Idem*: *Ibid.*, 73 (1957), Tōdai-Shuppankai, Tokyo.

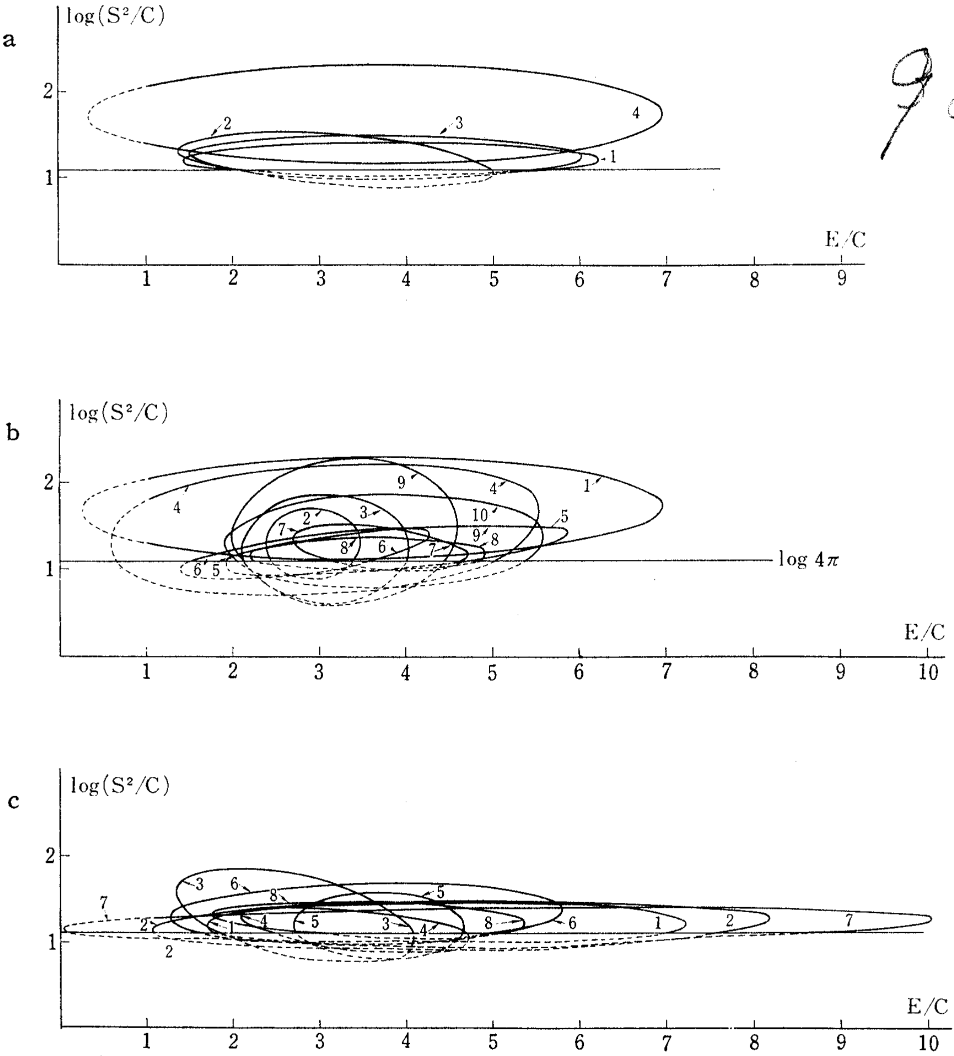

Fig. 3. Rejectancial ellipses of Each species at Confidence, 95%

a····natives in Hokkaidō district

1 : *Aconitum sachalinense* Fr. Schmidt 2 : *A. yesoense* Nakai
3 : *A. lucidusculum* Nakai 4 : *A. subcuneatum* Nakai

b····natives in Northern Honshū

1 : *A. subcuneatum* Nakai 2 : *A. Zuccarinii* Nakai
3 : *A. aizuense* Nakai 4 : *A. Mazimai* Nakai
5 : *A. Okuyamai* Nakai 6 : *A. iwatekense* Nakai
7 : *A. spp.* (Shimoburo) 8 : *A. spp.* (Akataki)
9 : *A. spp.* (Iwaya) 10 : *A. spp.* (Sōma)

c····natives in Southern Japan

1 : *A. japonicum* Thunb 2 : *A. deflexum* Nakai
3 : *A. grossidentatum* Nakai 4 : *A. grossi.* var. *shikokianum* Nakai
5 : *A. crassipes* Nakai 6 : *A. sanyoense* Nakai,
7 : *A. kiusianum* Nakai 8 : *A. senaense* Nakai

(However, smaller values of E/C than 1.0 and smaller values of $\log_{10}(S^2/C)$ than $\log 4\pi$ do not exist theoretically)

Nakai and unidentified species of Sōma area belong to a little abnormal group, and are distiguishable each other by E/C; then the other species of this district do not exhibit abnormality usually, and their distinctions are very diffcult. At last in kinds of southern Japan, all kinds do not possess abnormal cambium usually, and may be separated into three groups by values of E/C,——(1) group of <3, (2) group of $3\sim4$, and (3) group of >4.

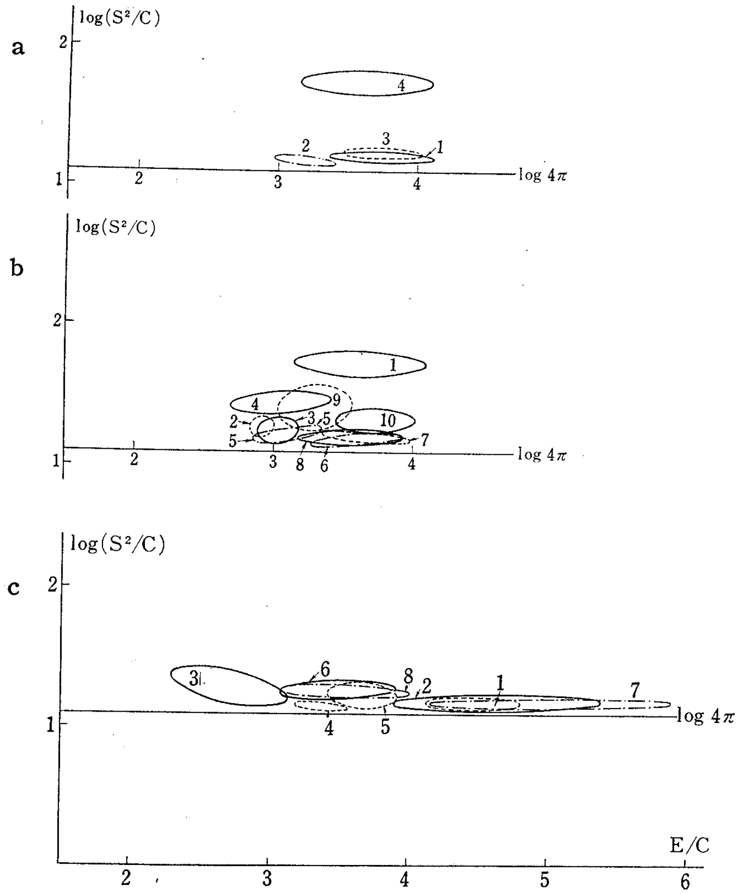

Fig. 4. Fiducial ellipses of Each species at Confidence, 95%

a····natives in Hokkaidō b····natives in Northern Honshū natives in Southern Japan

To (1) *A. grossidentatum* Nakai belongs, to (3) *A. japonicum* Thunb., *A. deflexum* Nakai and *A. kiusianum* Nakai do, and to (2) the other species of this district do, moreover the distinctions within these groups are impossible.

Combining the above deductions, Japanese aconites are separable roughly into five groups,——(2) of southern Japan are added by may species of normal cambiums in other districts; *A. subcuneatum* Nakai belongs to (4) for abnormal cambium; and to (5) *A. Mazimai* Nakai, *A. ZuccSrinii* Nakai and unidentified species of Sōma, for considerable abnormal cambium.

However, in above mentioned deductions, some kinds are little considered of variations concerning to habitats, for their localities are selected in order to prevent confusion of similar kinds, so above conclusion may involve with a little variation produced by habitats.

Experimental

Determination of Specific Values——Dried tuberous roots (or crude drug) are cut so as to get homogeneous thin transverse sections (20～40 μ in thickness) by using a sliding microtome. Thus perfect transverse sections are placed on slide glass, and are colored by phloroglucinol-HCl reagent, which simultaneously become limpid by vanishing of starch grains and are recovered in raw states by expansion, afterwards preparations are made by enclosing with glycerol-water.

Next, these preparations are projected on drawing paper at optional magnification by use of epidiascope or book-microreader, and figures of endodermis and cambium rings are drawn. Through these prepared figures, magnified E and C are measured by planimeter, and magnified S is done by curvimeter. At last, specific values of E/C and $\log_{10}(S^2/C)$ are obtained by calculations from values of magnified E, C and S.

Variation of Specific Values by Sectional levels——Studied materials are tuberous roots of *A. Mazimai* NAKAI; a root is measured from sectional intervals of *ca.* 1 mm. gradually from thickest portion to root tip. Following values show orderly each maximum of diameter (mm.), E/C and $\log_{10}(S^2/C)$ in each bracket.

(22, 2.99, 1.40)	(20, 2.84, 1.28)	(20, 2.73, 1.26)	(21, 2.41, 1.21)	(20, 2.63, 1.28)
(19, 2.73, 1.29)	(17, 3.27, 1.27)	(17, 3.17, 1.29)	(17, 2.75, 1.31)	(16, 2.84, 1.36)
(16, 2.66, 1.47)	(12, 3.16, 1.15)	(12, 3.23, 1.17)	(11, 3.26, 1.15)	(10, 3.19, 1.18)
(9, 3.17, 1.11)	(9, 3.84, 1.65)	(9, 4.10, 1.11)	(8, 3.13, 1.19)	(7, 3.11, 1.20)
(7, 3.09, 1.15)	(6, 2.91, 1.12)	(6, 2.68, 1.10)	(6, 2.55, 1.16)	(5, 2.70, 1.15)
(5, 2.71, 1.13)	(5, 2.52, 1.11)	(4, 1.79, 1.10)		

On Mother and Daughter Roots——Results of studies on *A. japonicum* THUNB. growing in Mt. Takakusa of Shizuoka Prefecture, are following.

E/C : { mother root $\bar{x}$····4.59 s^2···1.02 n····34 $\sum(x-\bar{x})^2$····33.47
daughter root $\bar{x}$···4.29 s^2····1.00 n····15 $\sum(x-\bar{x})^2$····14.05

Test of variance ratio : $F=1.02/1.00=1.02 \ll F^{33}_{14}(0.05)=2.27$ ∴ non-significant.

Test of means : $t=\dfrac{4.59-4.29}{\sqrt{\dfrac{1}{34}+\dfrac{1}{15}}\cdot\sqrt{\dfrac{33.47+14.05}{34+15-2}}}=0.94 \ll t_{47}(0.05)=2.00$ ∴ non-significant

$\log_{10}(S^2/C)$: { mother root $\bar{y}$····1.20 s^2····0.0161 n···34
daughter root $\bar{y}$····1.20 s^2····0.0129 n····15

Distinction of variances and means are so non-significant that their calculation is not needed.

Statistics of Specific Values in each Species——Thereafter, experimental value of E/C is described with x, and one of $\log_{10}(S^2/C)$ is done with y, furthermore n shows number of samples, $\bar{x}$ and $\bar{y}$ show the mean values of each x and y, and $\sum$ does a sum. And then many values described in Table I are skipped.

Aconitum sachlinenese FR. SCHMIDT[*4]

Localities of studied materials : Uryū Kitamoshiri and Wakkanai in Hokkaidō,

n····43 $\phi_{11}=\sum(x-\bar{x})^2$····34.94 $\phi_{22}=\sum(y-\bar{y})^2$····0.28

$\phi_{12}=\sum xy-n\bar{x}\bar{y}$····0.48 $\Delta=\phi_{11}\phi_{22}-\phi_{12}^2$····9.56 $F^2_{41}(0.05)=3.22$

from these values, $a_{11}=\dfrac{(n-2)n\cdot\phi_{22}}{2(n+1)\cdot F^2_{41}(0.05)\cdot\Delta}=0.182$ $a_{12}=\dfrac{-(n-2)n\cdot\phi_{12}}{2(n+1)\cdot F^2_{41}(0.05)\cdot\Delta}=-0.312$

$a_{22}=22.76$ $\tan 2\theta=\dfrac{2a_{12}}{a_{11}-a_{22}}=0.0276.$

When original point of coordinate is moved at point $(\bar{x},\bar{y})$, and rotated θ, formula of rejectancial ellipse is acquired as follows :

Formula to get coefficients of ellipse is

$$\lambda^2-(a_{11}+a_{22})\lambda+(a_{11}\cdot a_{22}-a_{12}^2)=0$$

and its two roots are coefficients.

In this material, $\lambda_1=0.17$ $\lambda_2=22.77$, formula of rej. ellipse, $0.17x^2+22.77y^2=1$.

Aconitum yesoense NAKAI

Localities of studied materials : Sapporo, Oshima-Mori, Hidaka-Urakawa and Iburi-Kutchan in Hokkaidō,

n····64 ϕ_{11}····33.6 ϕ_{12}····-2.61 ϕ_{22}····1.16 Δ····32.16 $F^2_{62}(0.05)$····3.14

a_{11}····0.362 a_{12}····10.5 a_{22}····0.815 $\tan 2\theta$····-0.161 formula of R. E.····$10.55x^2+0.295y^2=1$.

Aconitum luciduscullum NAKAI

Localities of studied materials : Jōzankei, Kitami-Shirataki, Kitami-Oketo, Ishikari-Kanayama and Furano in Hokkaidō.

n····58 ϕ_{11}····42.7 ϕ_{12}····-0.55 ϕ_{22}····0.41 Δ····17.2 $F^2_{56}(0.05)$····3.17

a_{11}····0.207 a_{12}····0.278 a_{22}····21.5 $\tan 2\theta$····-0.0278 formula of R. E.····$21.5x^2+0.20y^2=1$.

Aconitnm subcuneatum NAKAI

Localities of studied materials : Yoichi Hokkaidō, Fukaura and Imabetsu in Aomori Pref.

n····49 ϕ_{11}····337.3 ϕ_{12}····10.6 ϕ_{22}····4.4 Δ····1372 $F^2_{47}(0.05)$····3.20

a_{11}····0.0902 a_{12}····-0.0375 a_{22}····2.87 $\tan 2\theta$····0.0269 formula of R. E.····$0.09x^2+2.87y^2=1$.

Aconitum Zuccarinii NAKAI

Locality of studied materials : Hibara Pref. Fukushima.

n····33 ϕ_{11}····3.97 ϕ_{12}····0.03 ϕ_{22}····0.512, Δ····2.00 $F^2_{31}(0.05)$····3.31

[*4] For only this species method of calculation is described, else are omitted.

a_{11}····1.16 a_{12}····-0.068 a_{22}····9.03 $\tan 2\theta$····0.0173 formula of R. E.····$3.86x^2+6.44y^2=1$.

Aconitum aizuense NAKAI

Localities of studied materials: Sukayu and Towada in Aomori Pref.

n····38 ϕ_{11}····9.8 ϕ_{12}····1.43 ϕ_{22}····2.02 Δ····17.75 $F^2_{36}(0.05)$····3.26

a_{11}····0.612 a_{12}····-0.344 a_{22}····2.36 $\tan 2\theta$····0.393 formula of R. E.····$1.09x^2+2.42y^2=1$.

Aconitum Mazimai NAKAI

Localities of studied materials: Sado-Nyūkawa-Mt.Donden in Nīgata Pref. and Commercial product from Sado.

n····64 ϕ_{11}····85.0 ϕ_{12}····6.22 ϕ_{22}····6.00 Δ····471.3 $F^2_{62}(0.05)$····3.15

a_{11}····0.131 a_{12}····-0.136 a_{22}····1.86 $\tan 2\theta$····0.157 formula of R. E.····$0.120x^2+1.88y^2=1$.

Aconitum Okuyamai NAKAI

Localities of studied materials: Oku-yamadera and Hirashimizu in Yamagata Pref.

n····25 ϕ_{11}····4.64 ϕ_{12}····0.68 ϕ_{22}····0.235 Δ····0.626 $F^2_{23}(0.05)$····3.42

a_{11}····1.21 a_{12}····-3.51 a_{22}····24.0 $\tan 2\theta$····0.309 formula of R. E.····$0.065x^2+25.1y^2=1$.

Aconitum iwatekense NAKAI

Localities of studied materials: Kawai, Tōno and Miyako in Iwate Pref.

n····38 ϕ_{11}····28.1 ϕ_{12}····2.32 ϕ_{22}····0.416 Δ····6.31 $F^2_{36}(0.05)$····3.26

a_{11}····0.355 a_{12}····-1.98 a_{22}····24.0 $\tan 2\theta$····0.168 formula of R. E.····$0.195x^2+24.1y^2=1$.

Aconitum spp. A*5

Locality of studied materials: Shimoburo, Shimokita Peninsula in Aomori Pref.

n····27 ϕ_{11}····3.77 ϕ_{12}····-0.30 ϕ_{22}····0.163 Δ····0.525 $F^2_{25}(0.05)$····3.38

a_{11}····1.11 a_{12}····2.04 a_{22}····25.6 $\tan 2\theta$····-0.167 formula of R. E.····$25.7x^2+0.95y^2=1$.

Aconitum spp. B*5

Locality of studied materials: Iwaya, Shimokita Peninsula in Aomori Pref.

n····25 ϕ_{11}····5.37 ϕ_{12}····0.33 ϕ_{22}····2.23 Δ····11.9 $F^2_{23}(0.05)$····3.42

a_{11}····0.606 a_{12}····-0.090 a_{22}····1.46 $\tan 2\theta$····0.133 formula of R. E.····$0.594x^2+1.48y^2=1$.

Aconitum spp. C*5

Locality of studied materials: Akataki, Shimokita Peninsula in Aomori Pref.

n····20 ϕ_{11}····4.71 ϕ_{12}····0.011 ϕ_{22}····0.072 Δ····0.338 $F^2_{18}(0.05)$····3.55

a_{11}····0.514 a_{12}····-0.079 a_{22}····3.37 $\tan 2\theta$····0.0047 formula of R. E.····$0.51x^2+3.37y^2=1$.

Aconitum spp. D*6

Localities of studied materials: Namie and Ishikawa in Fukushima Pref. (Province of Sōma)

n····34 ϕ_{11}····15.7 ϕ_{12}····0.32 ϕ_{22}····1.41 Δ····22.03 $F^2_{32}(0.05)$····3.30

a_{11}····0.298 a_{12}····-0.0676 a_{22}····3.32 $\tan 2\theta$····0.0447 formula of R. E.····$0.295x^2+3.33y^2=1$.

Aconitum japonicum THUNB.

Localities of studied materials: Mt. Takakusa in Shizuoka Pref. and Mt. Hakone in Kanagawa Pref.

n····67 ϕ_{11}····76.9 ϕ_{12}····0.04 ϕ_{22}····0.857 Δ····65.9 $F^2_{65}(0.05)$····3.14

a_{11}····0.133 a_{12}····-0.0062 a_{22}····11.9 $\tan 2\theta$····0.00105 formula of R. E.····$0.13x^2+11.9y^2=1$.

Aconitum deflexum NAKAI

Locality of studied materials: Lake Suwa in Nagano Pref.

n····21 ϕ_{11}····33.5 ϕ_{12}····0.65 ϕ_{22}····0.190 Δ····5.94 $F^2_{19}(0.05)$····3.52

a_{11}····0.0824 a_{12}····-0.282 a_{22}····14.53 $\tan 2\theta$····0.039 formula of R. E.····$0.08x^2+14.5y^2=1$.

Aconitum senannnse NAKAI

Localities of studied materials: Mt. Shirouma in Pref. Niigata, Mt. Shōzu and Mt. Tateyama in Toyama Pref.

n····15 ϕ_{11}····6.81 ϕ_{12}····-0.14 ϕ_{22}····0.06 Δ····0.389 $F^2_{13}(0.05)$····3.80

a_{11}····0.248 a_{12}····0.576 a_{22}····28.1 $\tan 2\theta$····-0.0464 formula of R. E.····$28.0x^2+0.30y^2=1$.

Aconitum sanyoense NAKAI

Locality of studied materials: Mt. Mafuji in Shizuoka Pref.

n····30 ϕ_{11}····22.6 ϕ_{12}····0.90 ϕ_{22}····0.476 Δ····9.91 $F^2_{28}(0.05)$····3.34

a_{11}····0.194 a_{12}····-0.369 a_{22}····9.28 $\tan 2\theta$····0.0812 formula of R. E.····$0.19x^2+9.28y^2=1$.

Aconitum crassipes NAKAI

Locality of studied materials: Mt. Ibuki in Shiga Pref.

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*5 These kinds are difficult to distinguish from *Aconitum Zuccarinii* NAKAI by external appearences, neverthless their components differ, so are treated tentatively to be another species.

*6 This species resembles to *A. yesoense* NAKAI ane *A. kiusianum* NAKAI.

n····15 ϕ_{11}····10.8 ϕ_{12}····-0.37 ϕ_{22}····0.201 Δ····2.03 $F^{2}_{13}(0.05)$····3.80

a_{11}····0.158 a_{12}····0.292 a_{22}····-8.52 tan 2θ····0.070 formula of R. E.····$7.67x^2+1.01y^2=1$.

Aconitum grossidentatum NAKAI

Locality of studied materials: Tanigumi in Gifu Pref.

n····10 ϕ_{11}····1.52 ϕ_{12}····-0.28 ϕ_{22}····0.236 Δ····0.280 $F^{2}_{8}(0.05)$····4.46

a_{11}····0.686 a_{12}····0.814 a_{22}····4.42 tan 2θ····-0.436 formula of R. E.····$4.59x^2+0.516y^2=1$.

Aconitum grossidentatum NAKAI var. *shikokianum* NAKAI

Localities of studied materials: Motoyama in Kōchi Pref. and Saijō in Ehime Pref.

n····57 ϕ_{11}····15.3 ϕ_{12}····-1.19 ϕ_{22}····0.33 Δ····3.63 $F^{2}_{25}(0.05)$····3.17

a_{11}····0.775 a_{12}····2.79 a_{22}····35.9 tan 2θ····-0.159 formula of R. E.····$36.1x^2+0.55y^2=1$.

Aconitum kiusianum NAKAI

Localiteis of studied materials: Kakutō in Miyazaki Pref. and Takeda in Ōita Pref.

n····31 ϕ_{11}····149.8 ϕ_{12}····1.50 ϕ_{22}····0.25 Δ····35.2 $F^{2}_{29}(0.05)$····3.33

a_{11}····0.030 a_{12}····-0.18 a_{22}····18.0 tan 2θ····0.020 formula of R. E.····$0.04x^2+35.9y^2=1$.

Variation Produced due to Different Localities.

Studied material I;

Kind: *Aconitum iwatekense* NAKAI

E/C: { Miyako $\bar{x}$····4.24 s^2····0.346 n····19
Kawai $\bar{x}$····3.01 s^2····0.379 n····15

Test of variances: $F=0.379/0.346=1.10 \ll F^{14}_{18}(0.05)=2.29$ ∴ non-significant.

Test of means: $t=5.19 \gg t_{32}(0.01)=2.73$ ∴ significant distinction.

$\log_{10}(S^2/C)$: { Miyako $\bar{y}$····1.16 s^2····0.010 n····19
Kawai $\bar{y}$····1.24 s^2····0.0174 n····15

Test of variances: $F=1.70 \ll F^{14}_{18}(0.05)=2.29$

Test of means: $t=2.01 < t_{32}(0.05)=2.04$ ∴ non-significant.

Studied Material II

Kind: *Aconitum Mazimai* NAKAI

E/C: { Nyūkawa $\bar{x}$····3.55 s^2····0.559 n····14
Commercial (unknown Loc.) $\bar{x}$····2.92 s^2····0.218 n····50

Test of variance: $F=0.559/0.218=2.56=F^{13}_{49}(0.01)=2.56$ ∴ a little significant

Test of means (When above result is neglected of significance)

$t=3.87 > t_{62}(0.01)=2.66$ ∴ significant

$\log_{10}(S^2/C)$: { Nyūkawa $\bar{y}$····1.61 $s^2$0.173 n····14
Commercial $\bar{y}$····1.40 s^2····0.0635 n····50

Test of variance: $F=0.173/0.0635=2.72 > F^{13}_{59}(0.01)=2.56$

Variances seem to differ by each locality.

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Summary

Many kinds of Japanese aconites resemble well each other in internal structure of their tuberous roots. As the structural feature, the author aimed at the form of cambium, and created two specific values namely E/C and $\log_{10}(S^2/C)$ to study on these forms stochastically. For their statistical calcutation rejectancial and fiducial ellipses are selected and as a result Japanese aconites are divided into five types roughly by averages.

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