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BITE PATTERNS OF TAIWAN VENOMOUS AND NON-VENOMOUS SNAKES[1]

Part II

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ABSTRACT

Both 100-pacer and Russell's viper are solenoglyphous snakes. Their fang-tilting mechanism is exactly the same as in the rattlesnake as described by Klauber; in typical patterns their fang punctures are always a little anterior to the small-teeth marks of the upper jaw. To distinguish the patterns made by these two kinds of snakes is comparatively easy, because the distance between the fang punctures of the 100-pacer is in general greater than that of Russell's viper. With the help of the bite patterns and symptoms caused by different kinds of venomous snakes (100-pacer—hemotoxic, Russell's viper—hemotoxic and neurotoxic), the physician may easily determine by which kind of snake the victim has been attacked. The bite pattern made by the common paddy snake, with six rows of small-teeth marks, is similar to that of the Taiwan rat snake; rarely the puncture made by the rear fangs can be seen. The present study has verified that the Taiwan solenoglyphs not only employ a pure stab but sometimes also a true bite, whereas the krait and cobra always bite and chew as some non-venomous snakes do.

Part I of my study of the bite patterns was published in 1966, and dealt with the habu, bamboo snake, krait, cobra, and Taiwan rat snake (1). The experiments reported in Part I proved to be informative. The bite patterns of the remaining common venomous snakes of this island, the 100-pacer (*Agkistrodon acutus*), Russell's viper (*Vipera resselli formosensis*), and the common paddy snake (*Enhydris plumbea*) are treated herein.

The common paddy snake is a member of the rear-fanged group, sometimes known as the opisthoglypha (with fangs at the posterior end of maxilla). Its bite pattern is noticeably different from those of the proteroglyphous and solenoglyphous snakes, in which the fang is located at the anterior end of the maxilla.

MATERIALS AND METHODS

The individuals used for producing the bite patterns are shown in TABLE I.

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TABLE I

Number, sex, and measurement of individuals used for bite patterns

Name of snake	No. of specimen	Sex	Locality	Total length (cm)
I 100-pacer	No. 1	♀	Taitung	99.5
	No. 2	〃	〃	87.0
	No. 3	〃	〃	71.0
II Russell's viper	No. 1	♀	Pingtung	93.5
	No. 2	♂	〃	81.5
III Common paddy snake	No. 1	♀	Taoyuan	48.5
	No. 2	〃	〃	46.0

For determination of the normal dentition, the method used in preparing the skulls was the same as in Part I (1). The same is true of the permoplast cylinders and hands that were used.

RESULTS

I. *The Skull and Normal Dentition*

The cranial elements of the skull for each kind of snake are shown in *Figs. 1-6.* The normal dentition for each species is tabulated in the following tables, in which I=functional fang; +=diastema; O=without small solid maxillary teeth at the posterior end of the maxilla; L=left; R=right.

TABLE II

Number of teeth in Agkistrodon acutus

No. of specimen	Maxillary	Palatine	Pterygoid	Dentary
No. 1 ♂	I+0 (L) I+0 (R)	– (L) – (R)	16 (L) 16 (R)	17 (L) 16 (R)
No. 2 ♀	I+0 (L) I+0 (R)	– (L) 4 (R)	15 (L) 15 (R)	15 (L) 16 (R)
No. 3 ♀	I+0 (L) I+0 (R)	4 (L) 4 (R)	14 (L) 14 (R)	16 (L) 16 (R)
No. 4 ♂	I+0 (L) I+0 (R)	4 (L) 4 (R)	16 (L) 16 (R)	16 (L) 16 (R)
No. 5 ♀	I+0 (L) I+0 (R)	4 (L) 4 (R)	14 (L) 13 (R)	16 (L) 16 (R)

The maxilla bears one functional fang. Palatine teeth are invariably 4, subequal; pterygoid teeth 13-16, subequal; dentary teeth 15-17, gradually decreasing in size posteriorly.

TABLE III

Number of teeth in Vipera russelli formosensis

No. of specimen	Maxillary	Palatine	Pterygoid	Dentary
No. 1 ♀	1+0 (L) 1+0 (R)	2 (L) 2 (R)	9 (L) 9 (R)	12 (L) 12 (R)
No. 2 ♂	1+0 (L) 1+0 (R)	2 (L) 2 (R)	9 (L) 9 (R)	– (L) 12 (R)
No. 3 ♂	1+0 (L) 1+0 (R)	3 (L) 2 (R)	9 (L) 9 (R)	13 (L) 13 (R)
No. 4 ♂	1+0 (L) 1+0 (R)	3 (L) 3 (R)	7 (L) 7 (R)	12 (L) 12 (R)

The maxilla bears one functional fang. Palatine teeth 2-3, subequal; pterygoid teeth 7-9, subequal; dentary teeth 12-13, gradually decreasing in size posteriorly.

TABLE IV

Number of teeth in Enhydris plumbea

No. of specimen	Maxillary	Palatine	Pterygoid	Dentary
No. 2 ♀	15+2 (L) 15+2 (R)	10 (L) 9 (R)	24 (L) – (R)	19 (L) 18 (R)
No. 3 ♀	15+2 (L) 15+2 (R)	9 (L) 9 (R)	24 (L) 24 (R)	19 (L) 18 (R)
No. 4 ♀	15+2 (L) 15+2 (R)	9 (L) 9 (R)	– (L) – (R)	18 (L) 19 (R)
No. 5 ♀	15+2 (L) 15+2 (R)	9 (L) 9 (R)	24 (L) 24 (R)	19 (L) 19 (R)
No. 6 ♀	15+2 (L) 15+2 (R)	9 (L) 9 (R)	24 (L) 24 (R)	19 (L) 19 (R)

The maxilla bears 15 small teeth, gradually decreasing in size posteriorly, and 2 enlarged grooved fangs at its posterior end. The number of palatine teeth is 9-10, subequal; pterygoid teeth 24, gradually decreasing in size posteriorly; dentary teeth 18-19, those at both ends smaller, others subequal.

II. *The bite patterns*

Numerous bite patterns were obtained. The patterns described below are almost perfect, common, and typical.

1. Bite patterns of 100-pacer

The cylinders (dia. 4 cm, length 15 cm) and hands ($22 \times 10 \times 2.5$ cm) were held horizontally or vertically in front of the snake.

Figs. 7-8 are almost perfect patterns, produced by specimens Nos. 3 and 1 with the cylinder held horizontally. In these two pictures the fang punctures and the small-teeth marks of both jaws are clearly seen. The shaded area in front of the left fang puncture in *Fig. 7* represents the ejaculated venom. *Fig. 9* represents two bites made by specimen No. 2 on a horizontal cylinder. The lower two fang punctures were made by the first bite, the upper two by the second bite. During the second bite the small-teeth of the upper jaws pierced the paper and the impression of the lower jaws duplicated that of the first bite. *Fig. 10* was produced by specimen No. 3 on a horizontal cylinder. The lower right fang puncture was made by the first bite; during this bite the left fang did not touch the cylinder, due probably to the rapidity of the strike. The upper two fang punctures and the small-teeth marks of the right upper jaw were made by the second bite. The left upper jaw did not pierce the paper. One can imagine that during the strike the lower jaws came only in slight contact with the paper, few small-teeth marks appearing on the paper. The scratch on the right clearly indicates that the right lower jaw was pulled upward. *Fig. 11* was left by specimen No. 3 on a vertical cylinder. In this pattern only the fang punctures can be seen, the lower two representing the first bite, the upper two the second. This pattern is of course a pure stab; there are no small-teeth marks. Special attention should be paid to the lower fang puncture on the right side of *Fig. 12*. It was not produced by the first bite as in the case described above. Actually it was caused by the right fang pulling the cylinder backward during the seizure. The longitudinal slit continuing anteriorly clearly indicates the track of scratching of the fang point. A similar result would be obtained if a victim drew back his arm or leg quickly when bitten. The small-teeth marks in both jaws are distinct. This pattern was produced by specimen No. 1 on a horizontal cylinder. The pattern on the hand (*Fig. 13*) was obtained when it was bitten twice by specimen No. 1; the hand was held horizontally.

2. Bite patterns of Russell's viper

The bite patterns of this snake were all struck by specimen No. 1. The cylinders and hands used for the 100-pacer were repeatedly used for this snake after cleaning. All of the cylinders and hands were held horizontally except the one that produced *Fig. 16*, which was held obliquely.

Fig. 14 may be regarded as an almost perfect pattern, since it shows fang punctures and small-teeth marks of the upper and lower jaws. *Fig. 15* resulted from three bites: the lower left fang puncture was left by the first bite; the middle two and the small-teeth marks of the upper jaws were made by the second bite; and in the third bite only two fang punctures were left. When the snake made the second and third bites, the lower jaws duplicated impressions and, judging from the torn paper on the right side, obviously the right lower jaw vigorously pulled the paper upward. A few small-teeth marks appearing in *Fig. 16* may be due to the fact that the cylinder was held obliquely. The lower two fang punctures in *Fig. 17* cannot be explanied as being produced by the first bite. The curving scratch in front of each puncture distinctly indicates that they are produced exactly in the same way as explained in *Fig. 12*. In this pattern only two small-teeth marks of the left lower jaw appeared. *Fig. 18* is an almost perfect pattern on the hand.

3. Bite patterns of common paddy snake

This snake is rarely over 50 cm long, therefore its mouth is small. For demonstration of a satisfactory bite pattern, a thinner plate ($15 \times 3.4 \times 1.5$ cm) and hands ($22 \times 10 \times 2.5$ cm) were held horizontally in front of the snake.

The bite pattern of this snake is very similar to that of the Taiwan rat snake, which was described in Part I (1). *Fig. 19* may be recognized as a typical pattern; it shows four rows of small-teeth marks of the upper jaw, behind each of the outer rows a large puncture is evident; two lower rows of small-teeth marks of the lower jaw complete the picture. Each large puncture in this pattern was no doubt made by one of the two enlarged, grooved fangs, locating at the posterior end of the maxilla. *Fig. 20* can be easily distinguished from *Fig. 19* by lack of the large fang puncture behind each outer row in the upper group. It may also be noted that the number of the small-teeth marks in each row is reduced; evidently the mouth of the snake was not widely opened. In the experiments it was found that the large fang puncture did not appear in most of the bites. This phenomenon may be due to the location of the enlarged fangs at the rear extremity of the maxilla. In *Fig. 21* the small-teeth marks both in the upper and lower groups seem to be much fewer than those of *Fig. 20*. The three rows of the small-teeth marks in the upper group show that the left upper jaw did not touch the paper. When the snake (No. 1) seized the cylinder and the cylinder was quickly pulled backward, *Fig. 22* was produced. The pattern (*Fig. 23*) on the index finger was made by specimen No. 1.

DISCUSSION

Both the 100-pacer and Russell's viper are solenoglyphous. In Part I the tilting mechanism of the fang in rattlesnakes as explained by Klauber (2) was discussed. Why the patterns produced by the solenoglyphs show the fang punctures always a little ahead of the small-teeth marks of the upper jaw has also been explained. According to *Poisonous Snake Of The World* (3), the distance between fang punctures may reveal the generic identity and the size of the snake. For this purpose, the measurements between fang punctures of the patterns made by the above two kinds of snakes are tabulated as follows.

TABLE V

Distance between fang punctures correlated with body length for 100-pacer and Russell's viper

Name	No. of specimen	Distance (mm)	Body length (cm)
100-pacer	No. 1	22	99.5
	No. 2	21	87.0
	No. 3	18	71.0
Russell's viper	No. 1	19	93.5
	No. 2	13	81.5

The 100-pacer listed in TABLE V may be regarded as of average size; Maki's (4) range for this species in Taiwan is 54.0-125.0 cm. The distances between fang punctures reported here may therefore be regarded as an average.

As to the measurement of the Russell's vipers in TABLE V, there should be no doubt about considering them to represent large specimens; Maki (4) gives the dimensions as 51.4-89.2 cm. Thus the distance between the fang punctures of this snake will sometimes be smaller than the records here reported.

The distance between small-tooth mark of the upper jaw and the fang puncture also correlates with the body length, as the following measurements (TABLE VI) show for the 100-pacer and Russell's viper.

TABLE VI

Distance between small-tooth marks of upper jaw and fang puncture correlated with body length in 100-pacer and Russell's viper

Name	No. of specimen	Distance (mm)	Body length (cm)
100-pacer	No. 1	8	99.5
	No. 2	7	87.0
	No. 3	6	71.0
Russell's viper	No. 1	7	93.5
	No. 2	6	81.5

The bite pattern of the common paddy snake, with its six rows of small-teeth marks, is very similar, as stated before, to that of the Taiwan rat snake. In most cases the enlarged fang puncture behind each outer row of the upper group cannot be seen. From examination of the bite pattern alone, often it is not possible to be sure that the bite was made by a rear-fanged snake.

To demonstrate the nature of the venomous snake bite, Van Riper (5) has done a series of experiments to show that the Prairie rattlesnake usually stabs instead of bites. It has been found that the pure stab, sticking only the fangs into the target, was frequently employed by Taiwan solenoglyphs (100-pacer, habu, bamboo snake, and Russell's viper), resulting in a wound of one or two fang punctures. Moreover, the Taiwan solenoglyphs also employ the true bite, seizing the target by both the upper and lower jaws. All of the patterns of the solenoglyphs presented in Parts I and II were obtained from real bites. Pope and Perkins (6) also stated that the pit vipers of the United States bite as effectively as most innocuous snakes; in no sense do they merely stab. The true bite and chewing are generally employed by the krait and cobra. No stabs have ever been found to be used among them.

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LEGEND OF FIGURES

Figs. 1-6. Dorsal and ventral views of cranial elements of the skull for each species of the snake. *Figs. 1-2,* 100-pacer; *Figs. 3-4;* Russell's viper; *Figs. 5-6,* common paddy snake.

Figs. 7-23. Bite patterns. Natural size except those on the hands. See text for explanations. *Figs. 7-13,* 100-pacer; *Figs. 14-18,* Russell's viper; *Figs. 19-23,* common paddy snake.

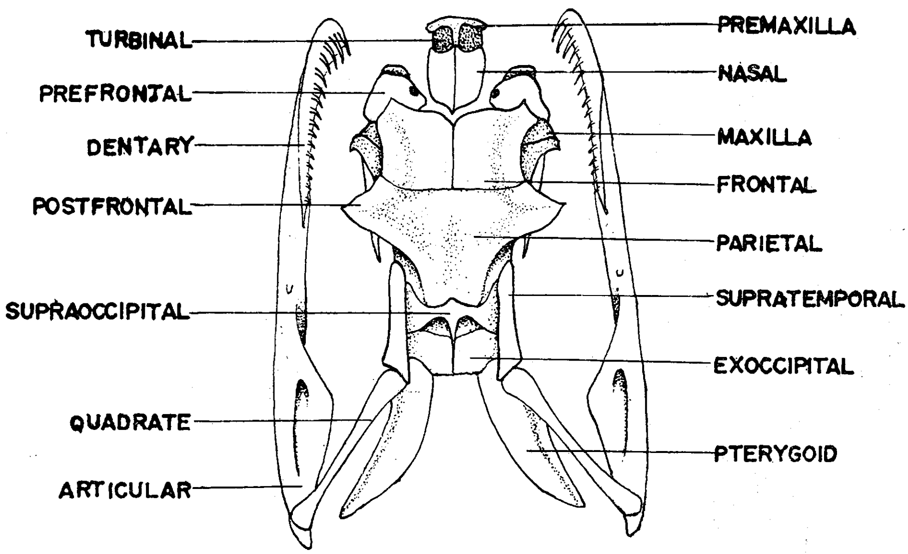
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Fig. 1

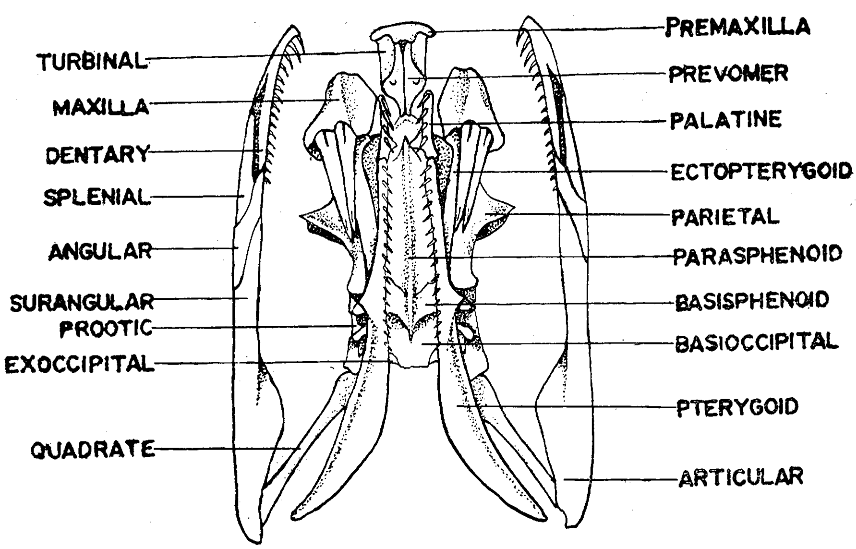
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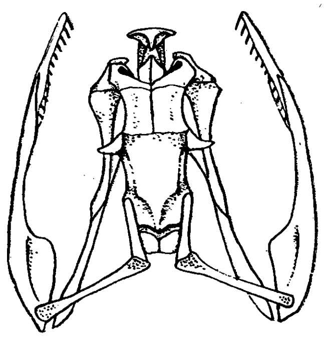
Fig. 2



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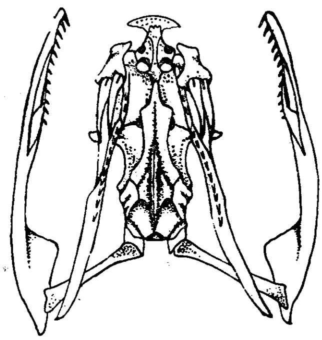

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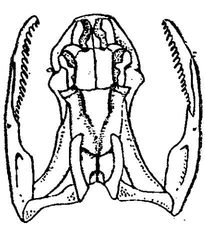

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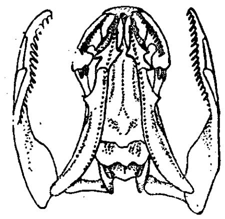

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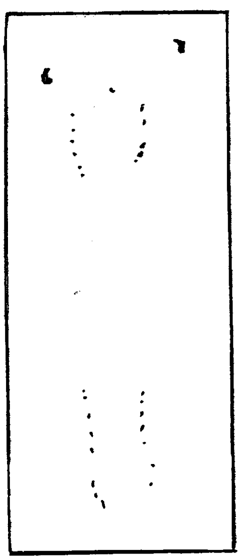

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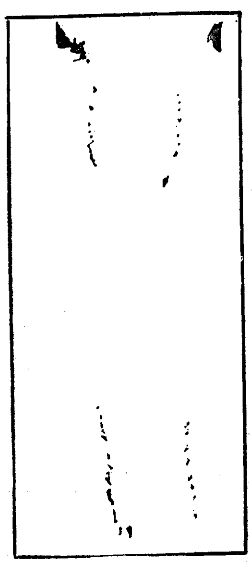

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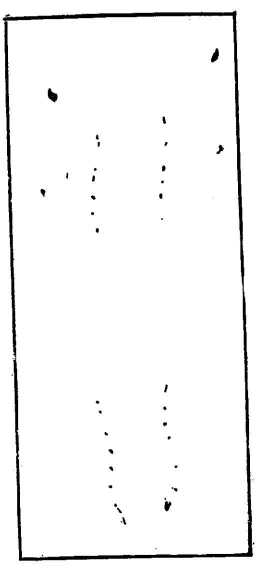

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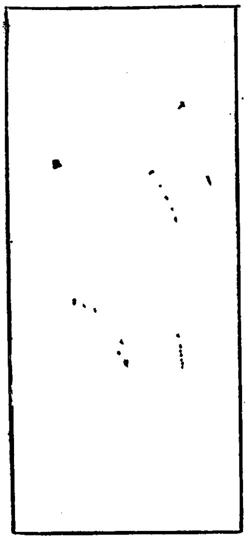

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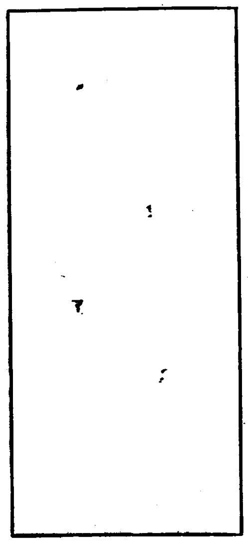

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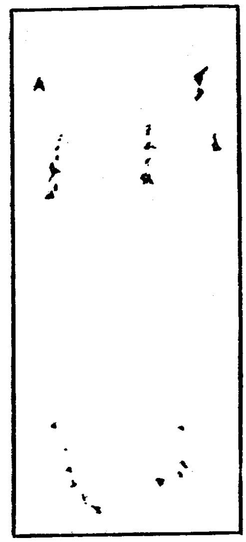
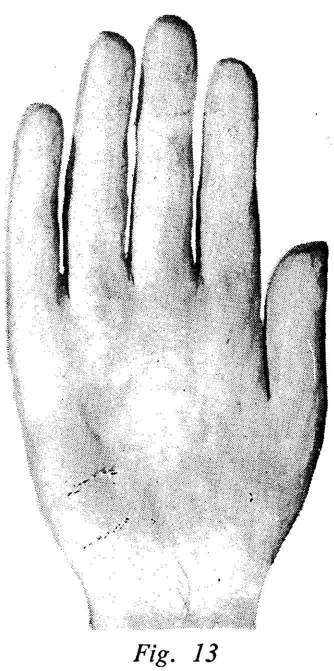


Fig. 12

Fig. 13



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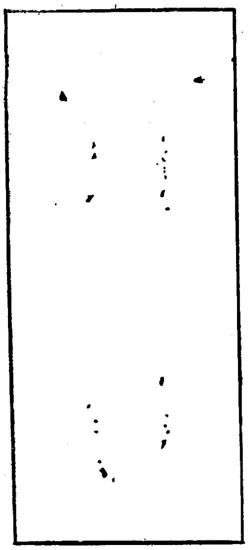

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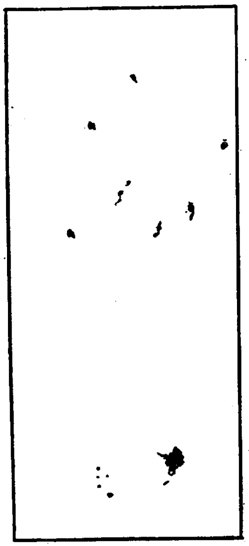

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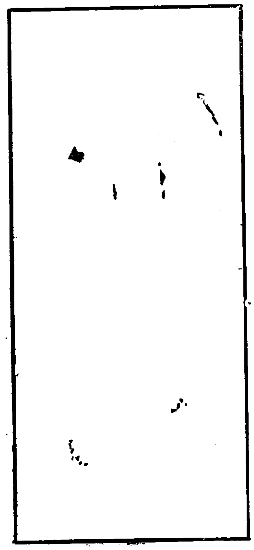

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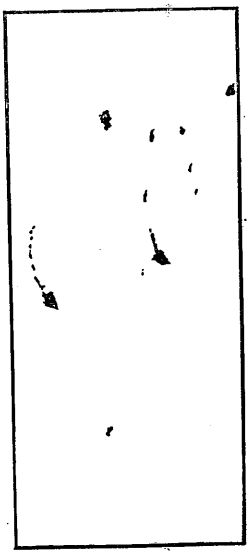

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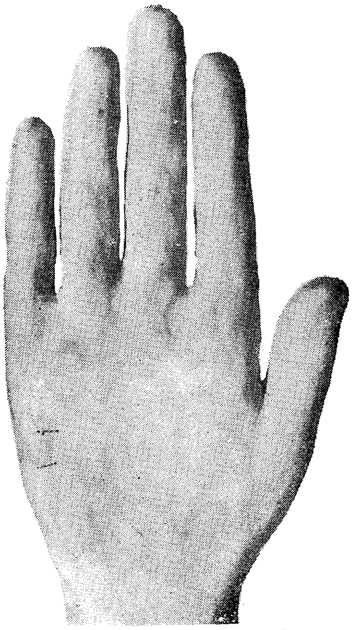

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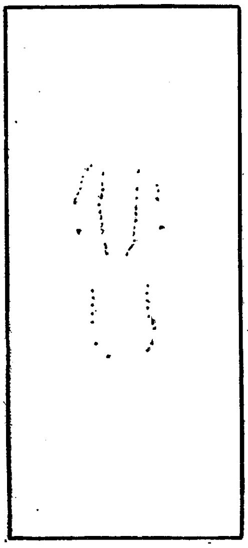

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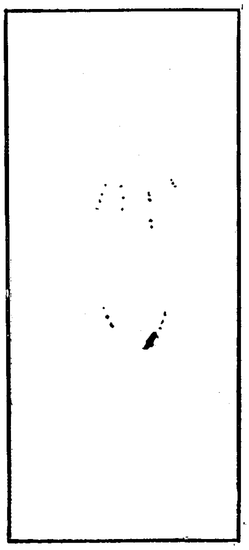

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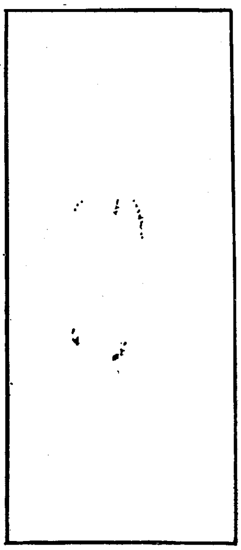

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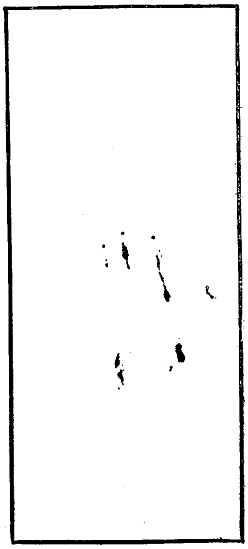

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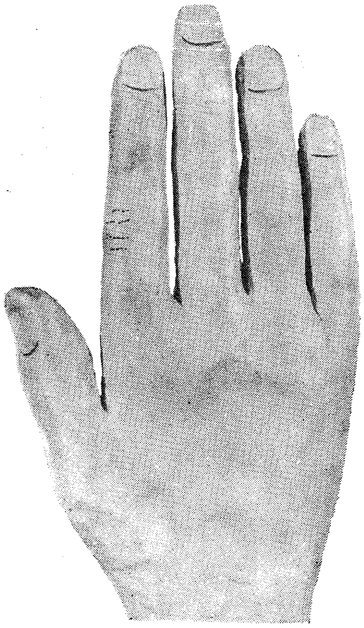

Fig. 23

Fig. 23