Microstructures on the Surfaces of Some Spider Species

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INTRODUCTION

Spiders have been paid attention from the standpoints of such their important roles as predators in both agricultual and forestry practices in Japan and as an indispensable factor in the food chains of natural or agricultual ecosystem. Yaginuma[9] highly evaluated the predatory ability of spiders in fields, stating that in the flow of energy within a ecosystem, spiders occupy their positions as a secondary consummer, so the sorts and numbers of spiders in a local area may be a kind of indicator of energy abundance in the area.

In the field of morphological and physiological studies on spiders, some reports have been published recently as follows: Studies on structures of simple eye of spiders[4], and some observations on spiders through a scanning-electron microscope[6]. This paper deals with the surface microstructure of some spicies of spider observed by a scanning electron microscope. The author hopes the pictures of micro structure will become a mile stone in spider research.

MATERIALS AND METHODS

Spiders observed in this report are as follows and all of them were sampled at Ami-machi, Ibaragi:

1. *Myrmarachne japonica (KARSCH),*
2. *Menemerus confusus BOES. et STR.,*
3. *Araneus ventricosus (L. KOCH),*
4. *Argiope bruennichii (SCOPLI),*
5. *Agelena limbata THORELL,*
6. *Plexippus setipes KARSCH,*
7. *Araneus cornutus CLERCK,* and
8. *Nephila clabata L. KOCH.*

Sampled spiders were washed by physiological salt solution soon after sampling, immersed and fixed in cold 1% glutaraldehyde solution in 0.1M phospate buffer at PH7.3 for about 24 hours, washed again by salt solution, then dissected into pieces for microscopic observations. The sample pieces were dehydrated through a series of 50, 70, 80, 90, 95, and 100% ethanol for 5 to 15 minutes, immersed into 100% iso-amyl acetate, dried by the critical-point drying method in HCP-1 type dryer, and then coated by the Au-ion-spatter coating method.

Observations and taking pictures were carried out with a scanning electron microscope, MINI-SEM, at an accelerating voltage of 15kv and at maximum resolving power of 2000Å.

RESULTS AND DISCUSSION

Myrmarachne japonica (Salticidae) is similar to ants in morhological appearances. We can hardly recognize it until it comes down from a plant leaf spinning its thread[9]. It seems to have fairly good visual sense because their cornea may be able to focus into an image. However, as shown in Fig. 1 and 2, their anterior median eyes are ocellus of head light type, the cornea of which are covered with a number of fine wrinkled ribs, and therefore the surface structures of it are so full of varieties that it is not considered their visual images are so simple[6]. The surface of anterior lateral eyes have a few wrinkles, just like the surface of the earth, and it is easy for it to focus an image (Fig. 1-3).

Menemerus confusus (Salticidae) has a big and welldeveloped anterior median eye, the cornea surface of which is smooth and lens type. Matsumoto[3] reported some pictures on which several images of a human hand through an anterior median eye of Marpissa romer STRAND were simulated. In addition to above, it should be noted that this species has well developed brush type tentacles (Fig. 4).

Plexippus setipes (Salticidae). It is pointed as one of characteristics of the species that fleecy suckers, which can produce a vacuum space instantly at their contact surface, are developed at the end of walking legs, so that it may walk vertically even on such smooth surfaces as window glass and go around to and fro with agility and without any threads (Fig. 5).

Araneus ventricosus has such a pecuriar habit that it weaves its web in the morning and shut up in the evening. It has much developed spinning organs and is a representative among spider species making their web. The thread is considered as some excretion discharged from spider body. The spiders make use of the threads very ingeniously in many cases. This species has three pairs of spinneret. There is a pair of big spigot tubules at the anterior spinneret from which radius, scaffold threads and frame threads are spun and they are several ten times as thick as the threads spun from spool spinning tubule. The states, in which insect vorous mucous thread was being spun, were observed clearly through the images of the electron scanning microscope. A number of groups of spinning gland caecum were observed at the inner backwards of abdomen and from each gland a thread was introduced to a exit of spinneret through a thin membrane pipe[6] (Fig. 6 and 8-11).

Araneus cornutus is a typical spider living in the northern part of Japan and usually found to the north from the isothermal line of -3.5°C of the lowest year temperature. This spider has a well arranged spinning organ[8] (Fig. 7).

Argiope bruennichii and the other spiders can walk freely on the threads of web. Yaginuma [8] stated that some oil substances secreted from the leg and body might keep their legs from sticking to the web thread. In addition to this, he[8] wrote that a kind of web-making spider selected and bit its food into pieces, cleaned tentacles and walking legs, and smeared oil on the body with the lower jaw. However, this statement does not explain completely how to smear oil all over their body, though some possibilities of existence of other kinds of oil glands on the body surface were pointed out. Some observations were executed in detail on the surface of body. According to our observations, all surface structures of the body, legs, claws, and bundles of hair are not smooth. The body surface of *Agelena limbata* is delicately waved and the head surface of *Myrmarachne japonica* is rich in seales. Some fine ditches runs on the surface of claw and a number of vertical ditches are observed on the surface of hair on the tarsus and metatarsus. So it is guessed that these ditches make the area contacted to sticky substances so narrow that the friction resistance of the organs mentioned above is extremely decreased, and they offer some sites to diffuse and store oil substances (Fig.13, 14 and 16).

Agelena limbata weaves such a infundibular web as a shelf net among trees or heges.[9] It has a long posterior spinneret as a feature of this spider. Especially, the surface of body is beautifully full of variations.

It seems to depend on the structure of body surface with numerous ditches that this spider can walk quickly and nimbly even on the complicate web (Fig. 12).

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Summary

The micro structures of body surface of spiders were compared with each other by means of a scanning electron microscope.

1) *Myrmarachne japonica (Salticidae)* has well developed anterior eyes, the micro surface structure of the corner of which is covered with a number of creases. It is suggested that a visual image through such complicate cornea is not so simple.

2) Both *Menemerus confusus* and *Myrmarachne japonica* have smooth corneas, which seem to have a good ability enough to focus a clear images.

3) In *Araneus ventricosus* well developed spinning organs have been observed and the real state, where web threads was spun from a thin pipe of spinning gland at the rear abdomen, were shown on pictures.

4) In addition to above, such a physical microstructures on the body surface as creases and ditches were observed. It is concluded that they may be useful in order to decrease the friction resistance of contact surface between legs and threads of web.

Titles of photographs

Fig. 1 Front face of *M. japonica (KARSCH)* x100.
Fig. 2 Surface of anterior median eye lens of *M. japonica (KARSCH)*, x2000.
Fig. 3 Surface of anterior lateral eye lens of *M. japonica (KARSCH)*, x2000.
Fig. 4 Surface of anterior median eye lens of *M. confusus BOES. et STR.*, x600.
Fig. 5 Tarsus and two claws of *P. setipes KARSCH*, x1400.
Fig. 6 Spool spinneret and spinning state of *A. ventricosus (L. KOCH)*, x1000.
Fig. 7 Threads being spun from left and right big spigots of *A. cornutus CLERCK*, x1400.
Fig. 8 Anterior spinneret and spigot of *A. ventricosus (L. KOCH)*, x1400.
Fig. 9 Spinning glands of *A. ventricosus (L. KOCH)*, x500.
Fig. 10 Leading thread from each spinning gland to spinnerets of *A. ventricosus (L. KOCH)*, x2000.
Fig. 11 Leading thread from each spinning gland to spinnerets of *A. ventricosus (L. KOCH)*, x2500.
Fig. 12 Surface structure of *A. limbata THORELL*, x700.
Fig. 13 Surface structure of *N. clabata L. KOCH*, x2000.
Fig. 14 Surface structure of head of *M. japonica (KARSCH)*, x2000.
Fig. 15 Tip part of fang and poison opening of *A. ventricosus (L. KOCH)*, x500.
Fig. 16 A claw of *A. bruennichii (SCOPLI)*, x800.

クモ類各部の微細構造について

鈴木　幹男

要　　約

従来，各種顕微鏡では解像しえなかった微細構造をクモ類においては，わが国最初の試みとして走査電子顕微鏡により観察を行った。クモ類は生態系の中では第2次消費者として，主に昆虫類を補食して生活する一群である。なおどのクモにも共通しているのは糸を出すことであって，牙をはじめとする諸器官はクモの行動機能において特有のものであり，それぞれの種においても特徴のある形態を具備している。これら各部の微細構造の中に隠されているメカニズムを究明しようとした。

① ハエトリ科に属するアリグモでは単眼がよく発達しているが角膜の表面構造はシワ状を呈し，単純なものでない。結像に関しては，今後の課題としたい。反面同じ科のシラヒゲハエトリ，ミズジハエトリ両種の角膜は平滑であり結像能力が充分あることがわかった。またミスジハエトリの跗節末端毛束は綿毛切口状を呈しており，平滑面を自在に行動することが理解出来た。

② 造網性クモ類の代表的な種ともいえるオニグモではその出糸器官が発達し，吐糸管からの出糸状態と腹内後方にある糸腺嚢からうすい膜状のパイプを通って送り出されている状態をリアルに観察することが出来た。

③ クモが自分の出した糸に付着しない説として，ある器官から分泌される油性物質が塗布されているためであると解説されているが，特に体表皮背面にまで及ぶことを考えるとはこの説では充分ではなく，他に分泌腺が開口するか，または体表面の物理的微細構造により，接触面の摩擦抵抗を小さくしているなどもかんがえられる。これは各部の溝やシワ状構造から伺われた。両者の相互作用の有無を観察の中から推察した。

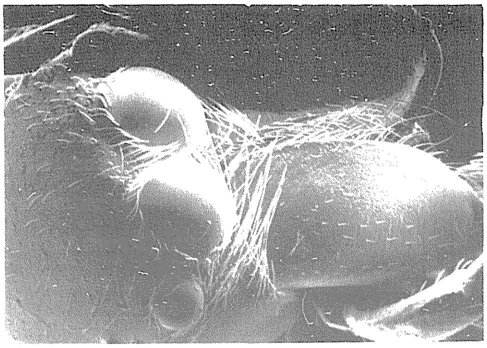

Fig. 1

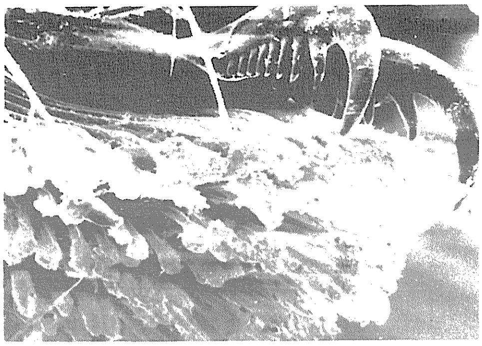

Fig. 5

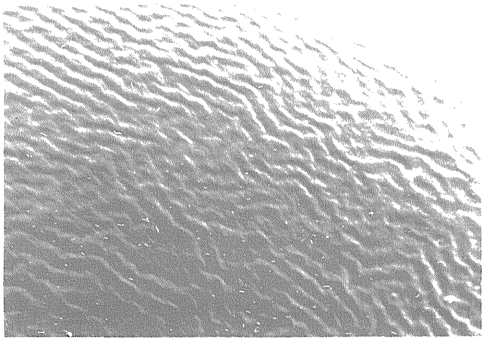

Fig. 2

Fig. 6

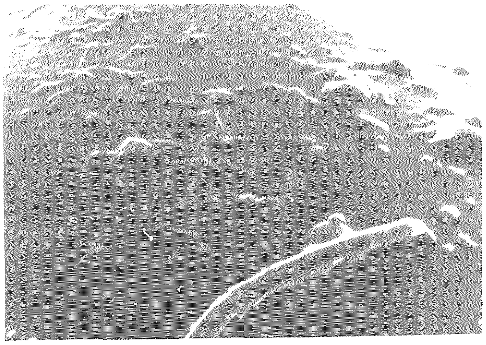

Fig. 3

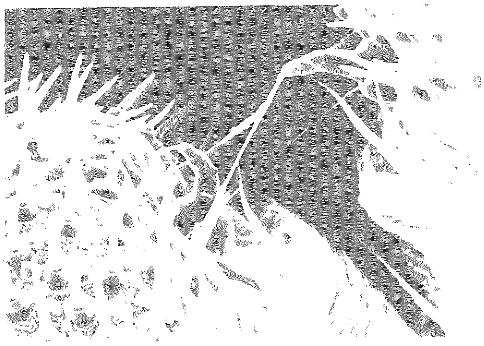

Fig. 7

Fig. 4

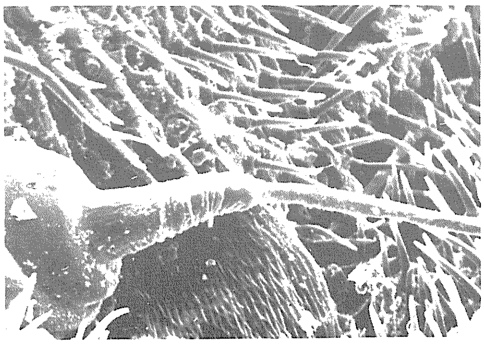

Fig. 8

Fig. 9

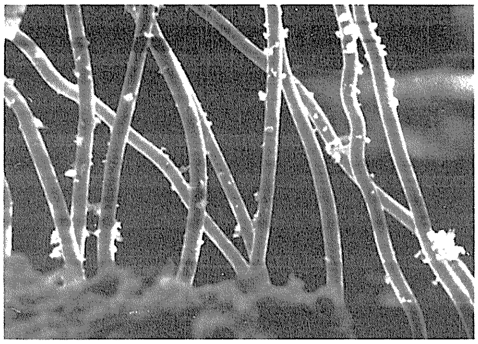

Fig. 10

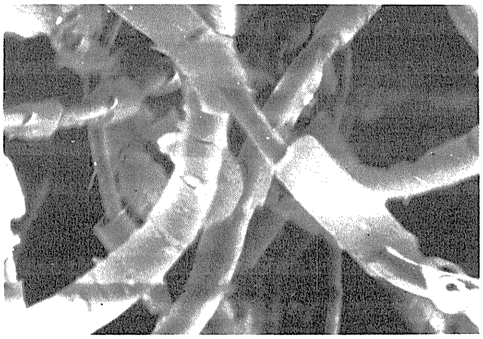

Fig. 11

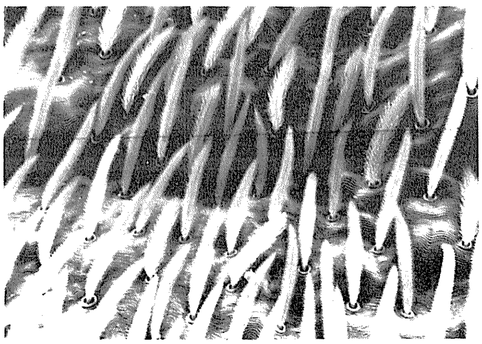

Fig. 12

Fig. 13

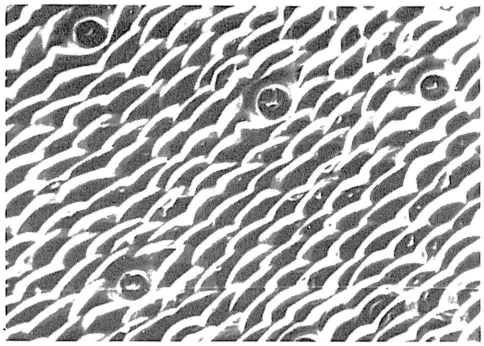

Fig. 14

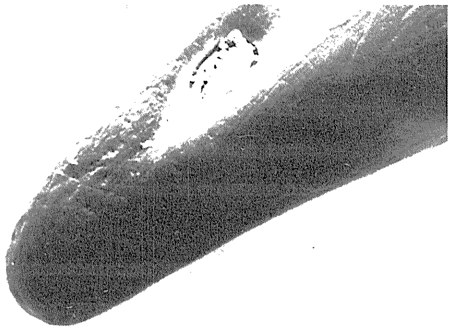

Fig. 15

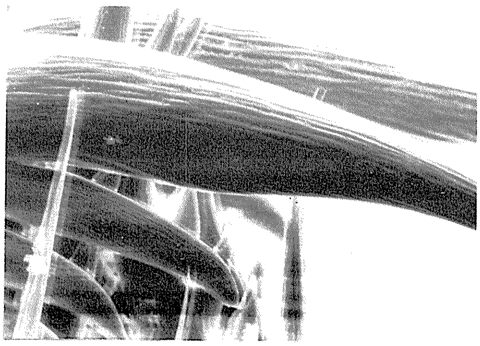

Fig. 16