Variations of the Sea-star, *Asterias amurensis* Lütken, Due to Growth Stages[1]

By

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(*With Plates I–II, 2 Tables, and 10 Textfigures*)

In 1889 Sladen, who studied the sea-stars collected by the Challenger Expedition, first suggested in the description of *Asterias amurensis*, "It is probable that some of the starfishes from Japan which have been referred to *Asterias rubens* belong either to *Asterias amurensis* or *Asterias versicolor*." Recently Fisher (1930) pointed out in his monograph that, "There is little doubt that perfect intergradation exists between *A. amurensis* and *A. amurensis rollestoni*." With the view of settling these problems, the writer, at the suggestion of Prof. T. Uchida that *A. rollestoni* is probably a synonym for *A. amurensis*, examined a number of specimens belonging to the genus *Asterias* from several localities of Japan and came to the conclusion that several forms of *Asterias* described under different names are due to individual variations of the single species, *Asterias amurensis*, according to growth stages and localities. Before going further, the writer must express his cordial thanks to Prof. Tohru Uchida for his kind guidance and permission to make use of his materials and photographs of the species, and he is also indebted to Mr. M. Iwasa for showing him great kindness in various ways during the preparation of this paper.

Description. The description is mainly based on specimens collected in the vicinity of the Akkeshi Marine Biological Station in water from 1 to 8 fathoms in depth; the largest specimen R 230 mm, r 73 mm, arm base 81 mm and the smallest R 45 mm, r

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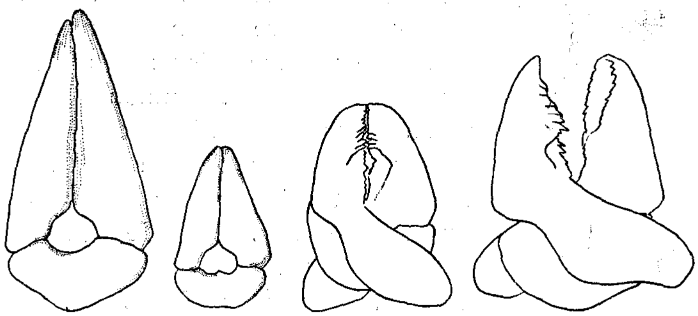
10 mm, arm base 13 mm. These proportions vary with age, but larger examples are similar in general appearance. The following description is based on an example (R 180 mm, r 47 mm, arm base 51 mm).

Abactinal side low-arched and composed of open-meshed skeletons beset with numerous small robust spines, which are compressed at the tip, slightly gouge-shaped, and outlining papular areas, with length from 1 to 1.5 mm (Pl. I, Fig. 3 & Textfig. 8). Many small finger-like papulae situated in papular areas. Carinal row represented by an indistinct wavy line. Lateral abactinal spines arranged in irregular longiseries. Superomarginal plates situated at the angular margin of the ray, each with 6 to 9 spines forming a cheveux-de-frise. The spines, from 2.5 to 3.0 mm long, spatulate or gouge-shaped in form, 2 or 3 times larger than the dorsolateral spines (Pl. II, Figs. 1, 3 & Textfig. 8). Madreporite situated near the centre of the disc, large, circular, slightly convex, traversed by numerous grooves on the surface.

Actinal side flat, with double rows of inferomarginal spines, which are separated from superomarginal spines by a conspicuously broad intermarginal channel and from adambulacral spines by the actinal channel, the 2 channels being densely covered with papulae. Intermarginal channel, broader than the actinal one, with a series of intermarginal spines in the proximal part shorter than a half of the ray. Inferomarginal spines, from 3 to 4.7 mm long, spatulate or goupe-shaped in form and broader at the tip than at the base. Actinal plates rudimentary and destitute of spines. Adambulacral spines much longer than inferomarginal spines, from 4.5 to 5.5 mm long, arranged in 3 longiseries along the ambulacral furrow (Pl. II, Figs. 1, 3, 4 & Textfig. 8). Furrow spines, tapering or with a blunt head, forming the innermost longiseries of spines, situated on alternate plates. Subambulacral spines, arranged in 2 series, compressed at the tip or gouge-shaped, being grooved on the outer side. In the proximal and middle portions of the ray 2 subambulacral spines present and in the distal part only 1. Thus along the proximal part of the ray 2 and 3 adambulacral spines situated in alternate positions and in the distal part 1 and 2 adambulacral spines similarly situated. Adambulacral spines variable in number and form according to stages. Mouth plates sunken, bent down towards the actinostome. Oral angles composed of 6 paired adoral adambulacral plates, each with 2 spines (Pl. II, Fig. 3). The first plate usually bears 2 spines, one long and the other short, while the second and the third mostly only 1 long spine. When 2 spines are present in the second and third one of them short and slender. The first adambulacral plate conspicuously larger than the second, the second than the third; the second about three-fourths the size of the first, the third about three-fourths the size of the second, the fourth about three-fourths the size of the third, but the fifth and the succeeding plates about the same size as the fourth. The furrow spine appears first on the ninth or tenth plate. It sometimes occurs on the seventh or eighth.

Pedicellariae very abundant. Small straight pedicellariae, from 0.3 to 0.5 mm long, scattered all over the abactinal surface, among them some large ones often reaching 0.7 mm in length (Fig. 1).



A B C D

Fig. 1. *Asterias amurensis* (R 180 mm). A, actinal straight pedicellaria, 30×; B, abactinal straight pedicellaria, 30×; C, abactinal crossed pedicellaria, 100×; D, actinal crossed pedicellaria, 100×.

Straight pedicellariae also observed on the superomarginal, inferomarginal plates and at the base of their spines. On the adambulacral and mouth plates, and on the adambulacral spines are also situated straight pedicellariae. Pedicellariae on the actinal surface about twice as large as the abactinal pedicellariae, especially those in the intermarginal channel which are often from 0.9 to 1.2 mm in length (Fig. 1). Near the end of the furrow spines a cluster of about 9 to 13 straight pedicellariae is observed (Fig. 2). Small crossed pedicellariae are found on the abactinal and actinal surfaces. Abactinal crossed pedicellariae, with rounded tips and ranging from 0.24 to 0.27 mm in length, are located around the base of the spines (Fig. 1). Crossed pedicellariae on the actinal surface are attached in clusters to the upper and outer sides of all marginal or subambulacral spines. Furrow spines lack crossed pedicellariae. Actinal crossed pedicellariae, larger than those of the abactinal ones, and those on the inferomarginal spines are from 0.26 to 0.39 mm in length (Fig. 1).

From the general agreement of the characters of the Japanese specimens with the diagnosis of *Asterias amurensis* Lütken, they are most probably to be referred to this species.

Internal anatomy. The internal anatomy belongs to the *Asterias*-group. Peristome circular, cardiac stomach associated with 5 large cardiac pouches, and furnished with 5 paired retractor muscles. Pyloric stomach flat and pentagonal in form. Voluminous hepatic caeca are given off in a pair from each corner of the pyloric stomach into each ray cavity through a common duct. Intestine rudimentary. Rectal sac composed of lobular caeca, each with short branches. The lumen of the sac opens exteriorly through the anus. Tube-feet arranged in 4 series, each with a suctorial disc and an ampulla. Polian vesicle absent. In regard to the number of Tiedemann's bodies the following variation is noticeable. Out of 84 specimens examined by the writer, 68 specimens had 10 Tiedemann's bodies, 2 in each interradius, while 16 specimens had 9 Tiedemann's bodies, paired in each interradius except the madreporic interradius, in which only a single one is found as reported in *Asterias rubens.* The writer could not recognize any distinct difference in their external characters between these 2 groups. So far as he know, the variation of number in Tiedemann's bodies occurring in a species is not recorded in the sea-stars. It has often been reported that the gastric haemal tufts are connected with the wall of the cardiac stomach, but according to the writer's observations they are in communication with the aboral surface of the pyloric stomach. Gonads, of racemose type, with the opening on the dorsal side.

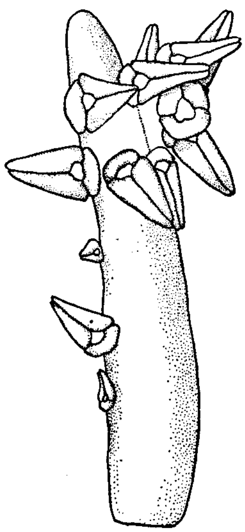


Fig. 2. *Asterias amurensis* (R 180 mm). Furrow spine, 15×.

Variations due to growth stages and localities

The specimens examined were mainly those collected from Notoro Creek, measuring from 30 to 120 mm in R, and those from Akkeshi Bay, ranging from 47 to 230 mm in R.

The young. A large number of young specimens of the species from Mutsu Bay, measuring from 4 to 7 mm in R, were found in Uchida's collection. The following description is based upon a specimen with the diameter of 5 mm.

Abactinal surface slightly convex, madreporite indistinct. The actinal surface of the ray is almost occupied with a well-opened ambulacral furrow. Abactinal and actinal spinelets exceedingly acute and slender. Carinal row composed of about 15 spinelets ranged in a series. A series of abactinal intermediate spinelets present, extending to the tip of the ray. The series separated from both the carinal and superomarginal series by a row of papular areas, each with a papula. The spinelets of the superomarginal and inferomarginal plates situated along the margin of the ray, parallel to each other. A series of papular areas, each containing a papula, present between them. Superomarginal plates each bear a single spinelet, while inferomarginal plates each 2 spinelets placed in transversed position. Spinelets of the latter slightly larger than those of the former. Close to the inferomarginal series is situated a distinct series of adambulacral spinelets along the margin of the ambulacral furrow, 1 for each plate. They are slightly more slender than those of the inferomarginals. Furrow spinelet not yet differentiated. Oral angles, not sunken, composed of 2 paired adoral adambulacral plates, each with 1 spinelet. Tube-feet arranged in 2 rows. Small crossed pedicellariae from 0.13 to 0.15 mm in length situated around the base of abactinal and actinal spinelets, except adambulacral spinelets. Straight pedicellariae not found.

The writer's observations on the young specimens closely agree with Sladen's description of *Asterias versicolor,* in which R measures 10 mm.

Further changes due to growth stages and localities are described as follows. From the results of observation on specimens the forms given in Table I seem to be united to *Asterias amurensis* Lütken: The Table I shows the relation between the body-size and the number of spines in these forms. As is indicated in the table, spines

TABLE I

Examined by	Species	Number of superomarginal spines on each plate	Number of inferomarginal spines on each plate	Number of adambulacral spines	Localities
SLADEN (1879)	*Ast. rubens* v. *migratum* (R 16 mm)	1	2	1, 2, 1, 2	Korean Straits
SLADEN (1889)	*A. versicolor* (R 10 mm)	1	2	1, 1, 1, 1	Kobe and Awadjisima
SLADEN (1889)	*A. versicolor* (R 71 mm)	1 (2, 3)	2	1, 2, 1, 1	Kobe and Awadjisima
HAYASHI	*A. amur.* v. *versicolor* (R 55 mm)	1 (2, 3)	2	1, 2, 1, 2	Toyama Bay
DÖDERLEIN (1902)	*A. rollestoni* (R 27 to 89 mm)	2 (1, 3)	2	1, 2, 1, 2	Yenoshima and Tango
VERRILL (1914)	*Allas. forficulosa* (R 58 mm)	2–3	2	1, 2, 1, 2	Japan (Sagami Bay?)
VERRILL (1914)	*Allas. rathbuni nortonensis* (R 82 mm)	4–6	2 or 3	2, 3, 2, 3	Norton Sound
VERRILL (1914)	*Allas. anomala* (R 87 mm)	5–6	2 or 3	2, 3, 2, 3	St. Michael, Alaska
VERRILL (1914)	*Allas. rathbuni* (R 100 mm)	5–10	2	2, 2, 2, 2 or 2, 3, 2, 3	Unalaska, Bering Sea
FISHER (1930)	*A. amurensis* (R 115 mm)	8–9	2	2, 2, 2, 2	Amur Bay
FISHER (1930)	*A. amurensis* (R 195 mm)	6–8	2	2, 3, 2, 3	Bristol Bay
FISHER (1930)	*A. amurensis* (R 12 to 19 mm)	1	2	1, 2, 1, 2	Bristol Bay
HAYASHI	*A. amurensis* (R 30 mm)	2–3	2	1, 2, 1, 2	Notoro Creek
HAYASHI	*A. amurensis* (R 50 mm)	4	2	1, 2, 1, 2	Notoro Creek
HAYASHI	*A. amurensis* (R 90 mm)	6–7	2	2, 3, 2, 3	Notoro Creek
HAYASHI	*A. amurensis* (R 47 mm)	2–3	2	1, 2, 1, 2	Akkeshi Bay
HAYASHI	*A. amurensis* (R 65 mm)	3–5	2	2, 2, 2, 2	Akkeshi Bay
HAYASHI	*A. amurensis* (R 100 mm)	7–9	2	2, 2, 2, 2	Akkeshi Bay
HAYASHI	*A. amurensis* (R 170 mm)	8–11	2	2, 3, 2, 3	Akkeshi Bay
HAYASHI	*A. amurensis* (R 4 to 6 mm)	1	2	1, 1, 1, 1	Mutsu Bay
HAYASHI	*A. amurensis* (R 60 mm)	2–3	2	1, 2, 1, 2	Mutsu Bay
HAYASHI	*A. amurensis* (R 75 mm)	2–3	2	1, 2, 1, 2	Yoichi, Hokkaido
HAYASHI	*A. amurensis* (R 110 mm)	3–4	2	1, 2, 1, 2	Mutsu Bay

increase in number with growth, though variable in number according to localities.

Abactinal spines. In examples from Notoro Creek abactinal spines generally short, slender and acute. They are not compressed at the tip and are arranged in irregular longiseries (Pl. I, Fig. 4). In an example (R 50 mm) the spines about 0.6 mm in length, and in an example (R 95 mm) about 1.3 mm in length (Figs. 3 & 4). In examples from Mutsu Bay the spines generally short and acute but more or less bluntly pointed at the tip and thick at the base. The spines arranged in regular longiseries, with a comparatively distinct carinal row. In one example (R 110 mm) the spines are about 1.5 mm in length (Fig. 5), but in another example (R 55 mm) from Akkeshi Bay the spines robust, truncate, and from 0.55 to 0.6 mm

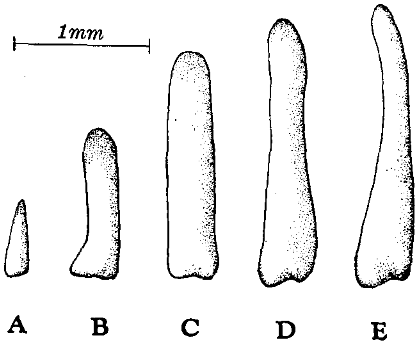


Fig. 3. *Asterias amurensis* (R 50 mm) from Notoro Creek. A, abactinal spine, 20× ; B, superomarginal spine, 20× ; C, inferomarginal spine, 20× ; D, subambulacral spine, 20× ; E, furrow spine, 20×.

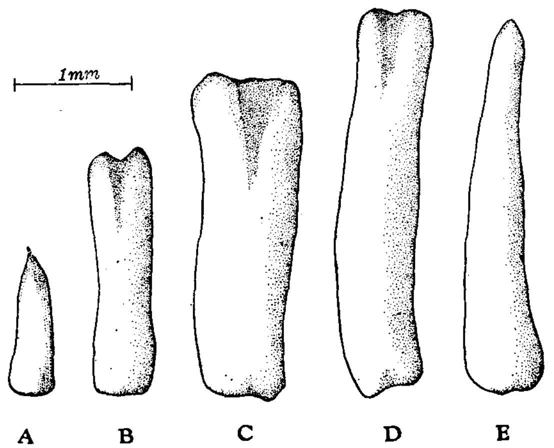


Fig. 4. *Asterias amurensis* (R 95 mm) from Notoro Creek. A, abactinal spine, 15× ; B, superomarginal spine, 15× ; C, inferomarginal spine, 15×; D, subambulacral spine, 15×; E, furrow spine, 15×.

long (Fig. 6). They are abundant in number, compared with those on examples similar in size from Mutsu Bay and Notoro Creek. Carinal row indistinct, and intermediate abactinal spines arranged in irregular longiseries, bordering papular areas (Pl. I, Fig. 5). These spines gradually increase in number and size, and become changed in form. In an example (R 95 mm) the spines compressed at the tip with shallow groove and about 1.2 mm long (Fig. 7). In a large example (R 170 mm) the spines about 1.8 mm long, gouge-shaped and broader at the tip than at the base (Fig. 8). The variation of form in the spines is most remarkable in examples from Akkeshi Bay. The length of the abactinal and actinal spines is in proportion with the diameter of specimens as indicated in Table II.

TABLE II

Specimen	Dorsal spines in length	Superomarginal spines in length	Inferomarginal spines in length	Subambulacral spines in length	Furrow spines in length	Localities
amurensis (R 50 mm)	0.6 mm	1.2 mm	1.7 mm	2.0 mm	2.1 mm	Notoro Creek
amurensis (R 95 mm)	1.3 mm	2.1 mm	2.8 mm	3.3 mm	3.2 mm	Notoro Creek
amurensis (R 110 mm)	1.5 mm	1.8 mm	2.4 mm	2.9 mm	2.7 mm	Mutsu Bay
amurensis (R 55 mm)	0.55 mm	0.9 mm	1.2 mm	1.5 mm	1.6 mm	Akkeshi Bay
amurensis (R 95 mm)	1.2 mm	1.9 mm	2.5 mm	3.4 mm	3.0 mm	Akkeshi Bay
amurensis (R 170 mm)	1.8 mm	2.7 mm	3.7 mm	4.8 mm	4.2 mm	Akkeshi Bay

Superomarginal spines. As shown in Table I, the superomarginal spines increase in number with growth. Though the number of the spines has often been enumerated as a character distinguishing species, it increases in larger specimens. The spines are variable in number in specimens from different localities: an example (R 100 mm) from Akkeshi Bay has 7–8 spines, while an example (R 90 mm) from Notoro Creek has 6–7 spines, and an example (R 110 mm) from Mutsu Bay 3–4 spines. The spines are also changeable in form. They are acute in young specimens but gradually become robust, truncate, spatulate and finally gouge-shaped, with the tip broader than the base. In examples from Akkeshi the form variation of the spines is most conspicuous (Figs. 3–8).

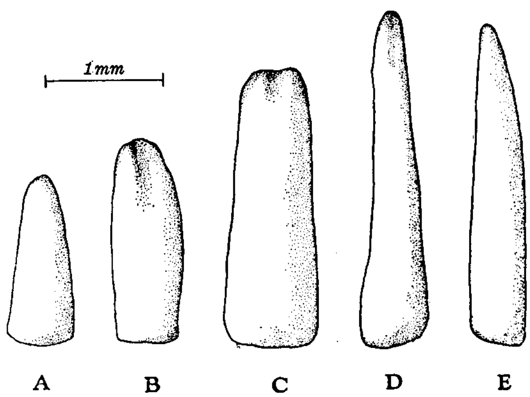


Fig. 5. *Asterias amurensis* (R 110 mm) from Mutsu Bay. A, abactinal spine, 15×; B, superomarginal spine, 15×; C, inferomarginal spine, 15×; D, subambulacral spine, 15×; E, furrow spine, 15×.

Inferomarginal spines. The inferomarginal plates generally each bear 2 spines through life, but large examples often have 3 spines at the proximal plates of the arm. As shown in Table II, the spines become long and changed in form as in the superomarginal spines (Figs. 3–8). They are acute and slender in young specimens but become larger and thicker, and compressed at the tip and finally gouge-shaped, with a groove on the outer side. The modification of the form of the spines is distinct in examples from Akkeshi.

Adambulacral spines. The adambulacral spines are also variable in number and form according to growth stages. As already described, the young examples from Mutsu Bay have adambulacral spines each arising from a single plate, arranged in a longiseries. The examples from Notoro Creek, with R from 30 to 50 mm, bear 1 or 2 spines on alternative plates. They are arranged in 2 series, the inner series being furrow spines. Several plates of the proximal portion of the ray are often equipped with more subambulacral spines, each plate then having 2 spines. Examples larger than the former have 2

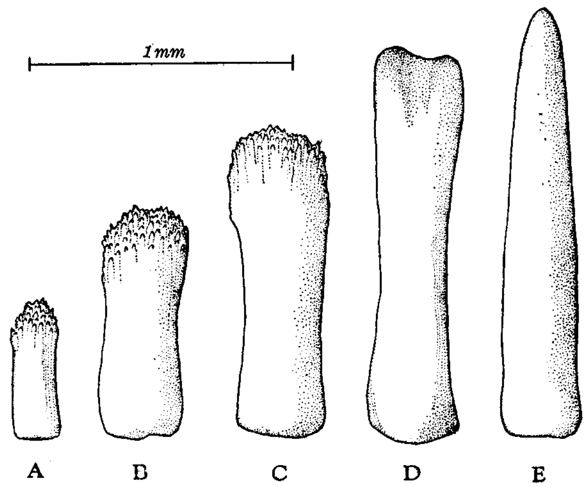


Fig. 6. *Asterias amurensis* (R 55 mm) from Akkeshi Bay; A, abactinal spine, 35×; B, superomarginal spine, 35×; C, inferomarginal spine, 35×; D, subambulacral spine, 35×; E, furrow spine, 35×.

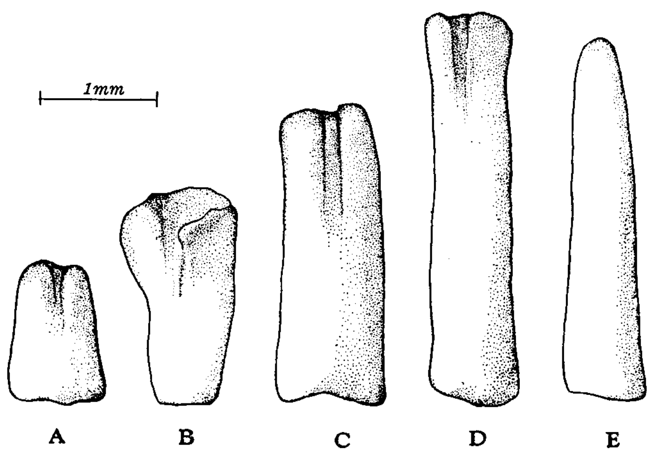


Fig. 7. *Asterias amurensis* (R 95 mm) from Akkeshi Bay; A, abactinal spine, 15×; B, superomarginal spine, 15×; C, inferomarginal spine, 15×; D, subambulacral spine, 15×; E, furrow spine, 15×.

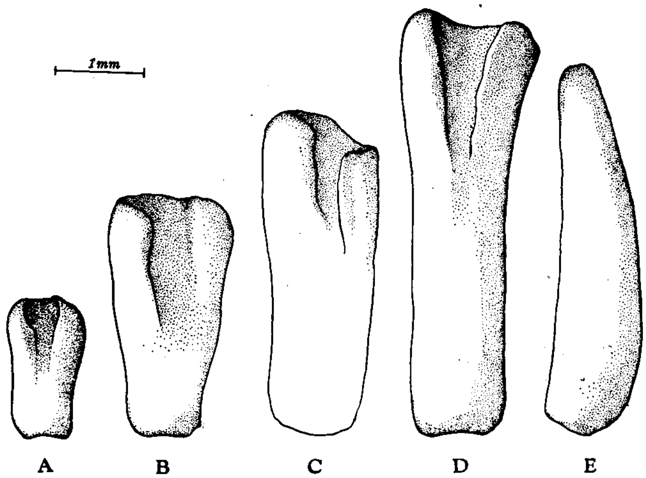


Fig. 8. ***Asterias amurensis*** **(R 170 mm) from Akkeshi Bay. A, abactinal spine, 12×; B, superomarginal spine, 12×; C, inferomarginal spine, 12×; D, subambulacral spine, 12×; E, furrow spine, 12×.**

adambulacral spines in the proximal and middle portions of the ray, but 1 or 2 spines in alternate plates in the proximal portion of the arm, 2 on each plate in the middle portion and 1 or 2 spines alternate in the distal portion. The relation between the number of the spines and the body-size is observable in several sea-stars recorded as different species (Table I). In examples from Mutsu Bay the spines are not so numerous as in the specimens above mentioned; a large example, with R of 120 mm, has 1 or 2 spines situated in alternate positions. In examples from Akkeshi the spines increase in number with growth as shown in Table I. As their number increases, the spines gradually change in form as shown in Textfigures 3–8. In young specimens the spines are acute and slender, but become robust, bluntly pointed, spatulate, gouge-shaped, and channelled at the tip. The spines, however, are always bluntly pointed, not channelled or spatulate, and are smaller in size than subambulacral spines. In examples from Mutsu Bay the spines are smaller in size and less variable in form, compared with those in the examples from Notoro Creek and Akkeshi Bay. The following graph and diagram are based on the results obtained from examples from Akkeshi Bay and young specimens from Mutsu Bay. Close relations can be observed between the body-size and the number and arrangement of the spines.

in alternative positions in the distal portion. An example (R 120 mm) from the same locality bears 2 or 3 spines

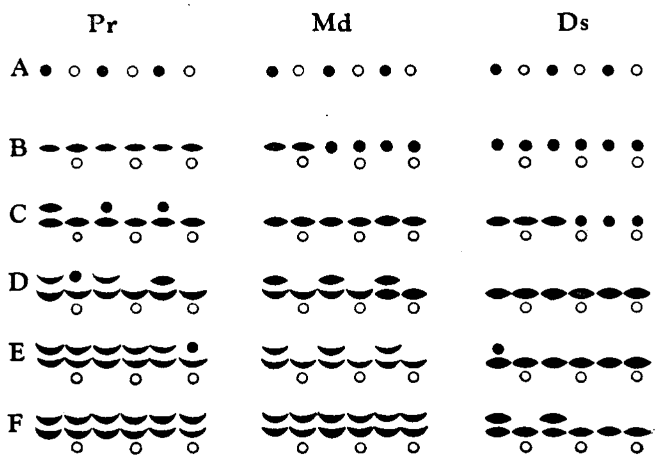


Fig. 9. *Asterias amurensis.* Diagram showing the variations of adambulacral spines due to growth stages (A, B, C, D, E, F). Pr, proximal portion of ray; Md, middle portion of ray; Ds, distal portion of ray; ○ furrow spine; ● acute or bluntly pointed subambulacral spine; subambulacral spine compressed at the tip or spatulate; gouge-shaped subambulacral spine.

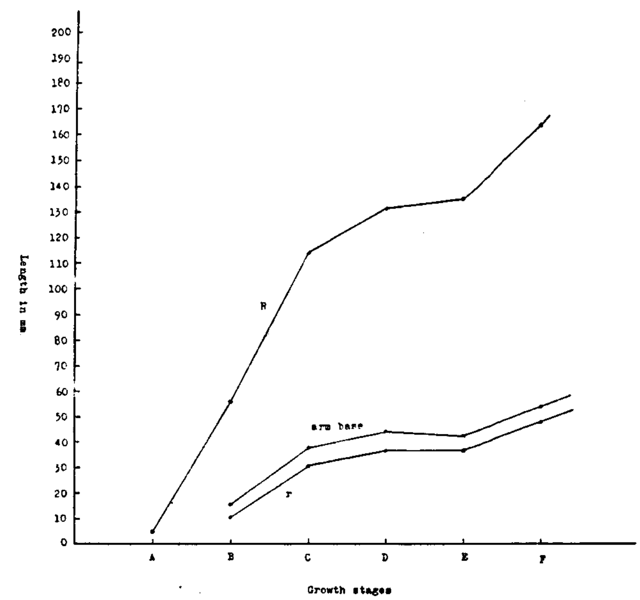


Fig. 10. *Asterias amurensis.* Graph showing relation between growth stages and body size. A, B, C, D, E, F, growth stages. cf. Fig. 9.

Subambulacral spines tend to increase from the proximal portion of the ray, and new spines are placed on the outer side of the old spines. The F-stage shows the most advanced arrangement of adambulacral spines of sea-stars examined by the writer.

Pedicellariae. The pedicellariae also increase in number and size in larger specimens. The measurements of actinal crossed pedicellariae in different specimens are as follows:

amurensis (R 65 mm), Akkeshi Bay, 0.235 mm (0.21 to 0.26 mm)
amurensis (R 105 mm), Akkeshi Bay, 0.294 mm (0.26 to 0.34 mm)
amurensis (R 180 mm), Akkeshi Bay, 0.312 mm (0.26 to 0.39 mm)
amurensis (R 70 mm), Korean coast, 0.291 mm (0.26 to 0.31 mm)
amurensis (R 83 mm), Notoro Creek, 0.315 mm (0.3 to 0.32 mm)
amurensis (R 5 mm), Mutsu Bay, 0.142 mm (0.13 to 0.15 mm)
amurensis (R 110 mm), Mutsu Bay, 0.263 mm (0.25 to 0.28 mm)
amurensis var. *versicolor* (R 55 mm), Toyama Bay, 0.30 mm (0.29 to 0.32 mm)

Abactinal crossed pedicellariae are smaller in size than the actinal ones. The measurements of several specimens are as follows:

amurensis (R 65 mm), Akkeshi Bay, 0.191 mm (0.17 to 0.22 mm)
amurensis (R 105 mm), Akkeshi Bay, 0.204 mm (0.19 to 0.22 mm)
~~*amurensis* (R 180 mm), Korean~~ coast, 0.242 mm (0.22 to 0.26 mm)
amurensis (R 83 mm), Notoro Creek, 0.272 mm (0.26 to 0.29 mm)
amurensis (R 5 mm), Mutsu Bay, 0.14 mm (0.13 to 0.15 mm)
amurensis (R 110 mm), Mutsu Bay, 0.244 mm (0.23 to 0.25 mm)
amurensis var. *versicolor* (R 55 mm), Toyama Bay, 0.257 mm (0.25 to 0.27 mm)

The pedicellariae of specimens from Mutsu Bay are smaller than those of examples from Notoro Creek and Akkeshi Bay, but larger than Fisher's specimens (*rollestoni*) from Muroran. The crossed pedicellariae of examples from Akkeshi Bay are smaller than those of examples from Notoro Creek, and rather similar in size to those of examples from Amur Bay examined by Fisher (1930). Examples from Korea have larger crossed pedicellariae than those of examples from Akkeshi Bay. The size of crossed pedicellariae is variable in different localities; and the writer's observation seems to support Fisher's opinion that size of pedicellariae is variable in different localities.

Tube-feet and the others. The tube-feet are arranged in 2 rows in young specimens (R 4–7 mm) from Mutsu Bay, though they are in 4 rows in the adults. In small examples disc convex, rays swollen,

amurensis (R 180 mm), Akkeshi Bay, 0.261 mm (0.24 to 0.29 mm)
amurensis (R 70 mm), Korean coast, 0.242 mm (0.22 to 0.26 mm)

thick at the base and 2 marginal rows situated at the marginal position of the arm. As the sea-star grows, the body becomes depressed, actinal surface flat, and the actinal and intermarginal channels widened, then the inferomarginal row translocates towards the actinal side from the marginal, leaving the actinal channel narrower than the intermarginal one (Pl. II, Figs. 1, 3–7). The madreporite, at first situated near the middle position between the centre of the disc and the margin, translocates towards the centre of disc.

Remarks. The species is widely distributed around the Japanese coasts from Hokkaido to Kyushu and is common in Korea. The Japanese sea-stars belonging to the genus *Asterias* have hitherto been reported as several different species mainly because of their disparity and the different forms of spines. As described in this paper, however, these differences are due to different growth stages, though they are somewhat variable in different localities. So the following reduction of the species seems to be necessary. Döderlein (1902) describing *A. rollestoni* from Yenoshima, Tango and Kagoshima states, "Adambulacralplatte abwechselnd mit je 1 u. 2 Furchenstacheln" and "*A. amurensis,* die mir von de Castries-Bay vorliegt, ist sehr ähnlich, hat aber auf allen Adambulacralplatten je 2, oder abwechselnd 2 und 3 Furchenstacheln." From this descriptions Döderlein's *rollestoni* is represented by a stage of *amurensis.* The specimens of *A. rollestoni* from Mutsu Bay reported by Uchida (1928) are referable to *amurensis.* Regarding *Allasterias forficulosa* Verrill, of which the type specimen is from Japan, probably from Sagami Bay, Fisher (1930) remarks that "*Allasterias forficulosa* Verrill is a form of *Asterias amurensis rollestoni* Bell." It also appears to me that this species is nothing but a stage of *amurensis,* according to Verrill's description and figures.

Fisher (1930) for *Asteracanthion rubens* var. *migratum* Sladen describes that "It is consequently too small to compare with adult specimen. It is likely a form of *amurensis. A. amurensis* might be expected in the cold area of the Straits of Korea." The writer examined several specimens of the species from Korea, measuring from 58 to 120 mm in R. Sladen's description agrees with my young specimens of *amurensis,* so there is no doubt that *A. amurensis migrata* (Sladen) is merely a young stage of *amurensis.*

Fisher (1930) points out that *A. amurensis anomala* differs from *amurensis* in having thicker, heavier spines and larger pedicellariae. He says further that "the species intergrades with *rollestoni*." As the spines and pedicellariae are variable in size and form in different localities and growth stages, the subspecies can hardly be separated from the type species.

The writer examined 1 specimen closely allied to *amurensis* from Toyama Bay, measuring 55 mm in R (Pl. II, Fig. 2). The external characters are as follows:

Abactinal surface convex, actinal surface flat. Abactinal spines robust, widely spaced, isolated, often channelled at the tip, and carinal series more or less clearly indicated, intermediate irregular longiseries present. Each inferomarginal plate with 2 spines in 1 double longiseries, and superomarginal plates each with 1 robust spine, channelled at the tip or gouge-shaped, but some of plates with 2 or 3 spines. Adambulacral spines compressed or channelled at the tip, and 1 or 2 in alternate plates. Madreporite situated nearer the margin than the centre of the disc. The above mentioned diagnosis closely agrees with *Asterias versicolor* Sladen. The spines of the sea-star resemble in number and arrangement those of the young *amurensis*, but their form is similar to that of the adult *amurensis*. The writer is of the opinion that the specimen is identified with *A. versicolor* Sladen which probably constitutes a variety of *A. amurensis* Lütken.

Therefore the following species and subspecies seem to be united to *Asterias amurensis* Lütken: *Asterias amurensis migrata* (Sladen), *Asteracanthion rubens* var. *migratum* Sladen, *Asterias amurensis rollestoni* Bell, *Asterias rollestoni* Bell, *Allasterias forficulosa* Verrill, *Allasterias rathbuni* Verrill, *Allasterias rathbuni nortonensis* Verrill, *Asterias amurensis* forma *anomala* (Verrill), *Allasterias anomala* Verrill, only *A. versicolor* Sladen forming a variety of the species.

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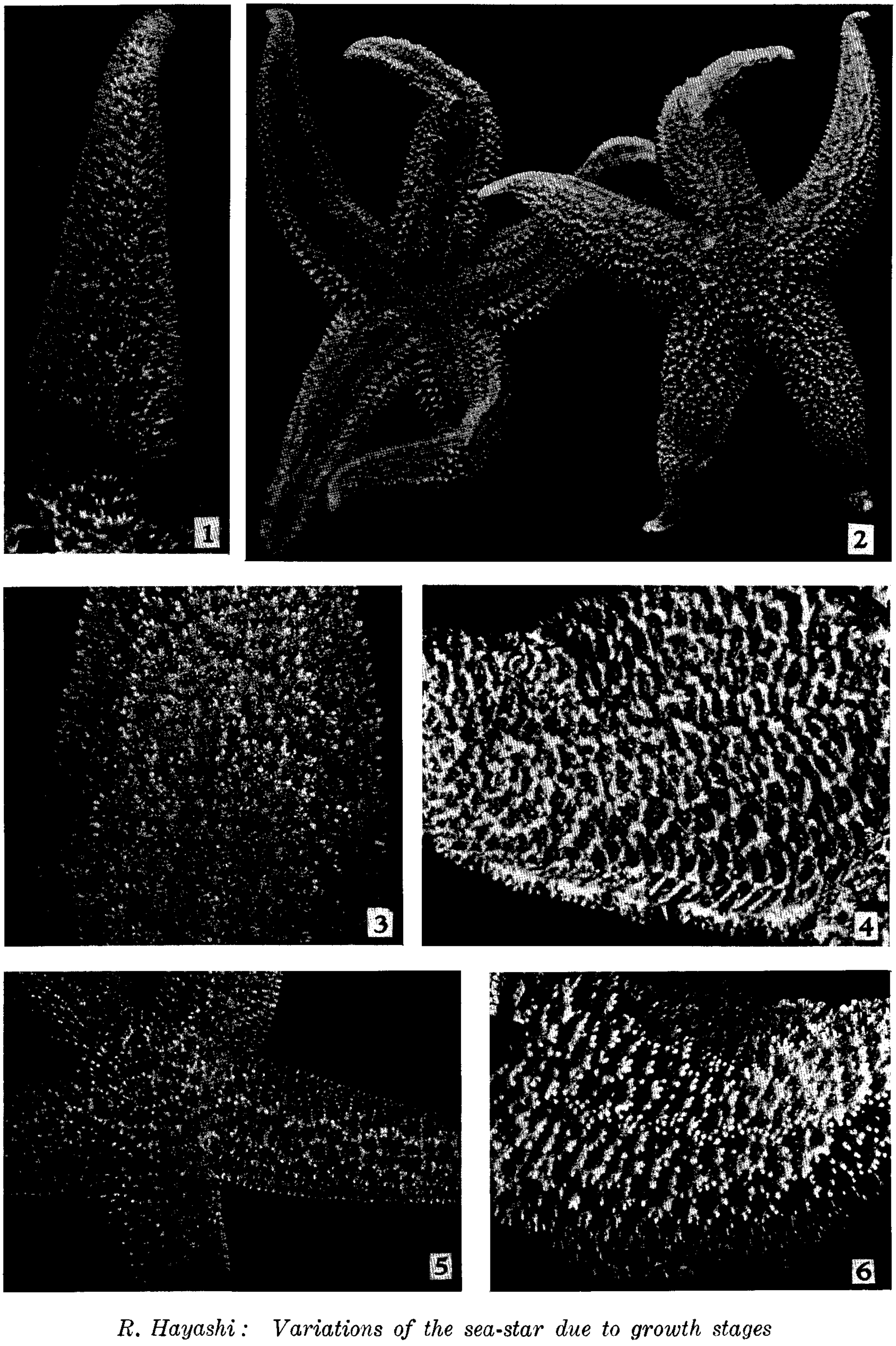
Explanation of Plate I

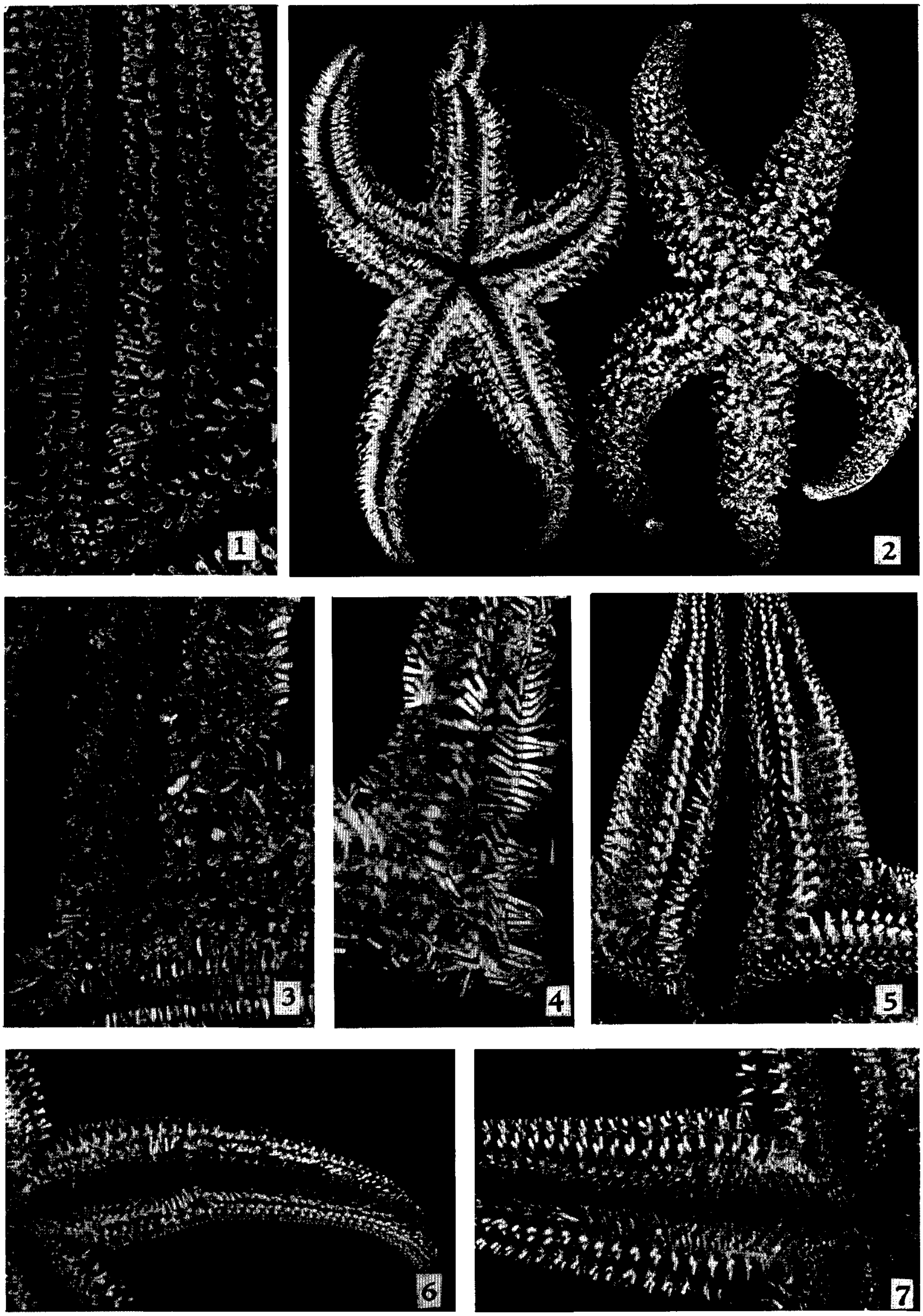
Fig. 1. *Asterias amurensis* (R 64 mm), Akkeshi Bay; abactinal side of ray. 1.5 ×
Fig. 2. *Asterias amurensis* (R 50 mm), Northern Pacific coast of Honsyu (Prof. T. Uchida's original); abactinal and actinal sides. 1 ×.
Fig. 3. *Asterias amurensis* (R 175 mm), Akkeshi Bay; abactinal side of proximal portion of ray. 1 ×.
Fig. 4. *Asterias amurensis* (R 120 mm), Notoro Creek; abactinal side of ray. 2 ×.
Fig. 5. *Asterias amurensis* (R 52 mm), Akkeshi Bay; abactinal side. 1.5 ×.
Fig. 6. *Asterias amurensis* (R 95 mm), Akkeshi Bay; abactinal side of ray. 2 ×.

Explanation of Plate II

Fig. 1. *Asterias amurensis* (R 165 mm), Akkeshi Bay; a part of proximal portion of ray. 1 ×.
Fig. 2. *Asterias amurensis* var. *versicolor* (R 55 mm), Toyama Bay; abactinal and actinal sides. 3/5 ×.
Fig. 3. *Asterias amurensis* (R 175 mm), Akkeshi Bay; a part of actinal side of ray. 1 ×.
Fig. 4. *Asterias amurensis* (R 120 mm), Notoro Creek; a part of actinal side of ray. 2 ×.
Fig. 5. *Asterias amurensis* (R 95 mm), Akkeshi Bay; actinal side of ray. 1 ×.
Fig. 6. *Asterias amurensis* (R 52 mm), Akkeshi Bay; actinal side of ray. 1.5 ×.
Fig. 7. *Asterias amurensis* (R 64 mm), Akkeshi Bay; actinal side of ray. 1.5 ×.



R. Hayashi: Variations of the sea-star due to growth stages



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